City of Unalaska

Powerhouse Exhaust Gas Waste Heat to Energy Project

Final Report

EPS Project No. 10-0159

October 22, 2012

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Summary of Changes

Revision Number	Revision Date	Revision Description
1	October 22, 2012	Initial Release

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1. Summary

The City of Unalaska has requested that Electric Power Systems, Inc. (EPSI) provide feasibility design services for the installation of an exhaust gas waste heat to electric energy reclamation project. This report explores the feasibility for the various economic and technical solutions available for implementation.

Upon investigation, EPSI found that the exhaust gas waste heat reclamation system will require an additional waste heat line between the old and new power plants, three exhaust stack boiler units (one on each exhaust stack), necessary higher temperature ORC units, associated seawater cooling and heat exchanging system, supplemental radiator system, associated valving and instrumentation package, one 480V 3 phase feeder stepped up to 4160V and connect into existing Unit 8 and 9 (after Unit 8/9 removal) power lines, and a remote monitoring SCADA interface.

The exhaust gas waste heat project is economically feasible once Unalaska town loads reach minimum continuous year round base loads of 7.5 to 8 MW. Economic feasibility may also become a reality if fuel prices sustain an average price of over $4/gallon. As any one of these factors increase over time the economic feasibility will become more compelling. This conclusion is based on the current available boiler and ORC manufacture data being accurate, conformance to all current and future environmental constraints, and all technical/design issues being appropriately addressed.

The environmental constraints that this report's conclusions are bounded by concern both air and seawater. It is understood that the current ADEC air permit temperature constraints have been relaxed to allow for the use of exhaust gas stack boiler units such that final stack outlet temperatures to atmosphere do not drop below 350F. However, it should be noted that current ADEC/EPA permitting increases to seawater outlet temperatures have not been permitted to be raised to adequate levels. To support the needs of an exhaust gas waste heat project the ADEC/EPA would need to review and permit elevated seawater outlet temperatures before the project could be considered viable. If such permitting cannot be achieved then a costly supplemental radiator system will need to be implemented. For the purposes of this report the cost of supplemental radiators was included.

Performance data, prices, drawings, parts, service, warranty, and lead time information was collected from ORC and exhaust gas boiler unit manufacturers. Below are the manufacturers that have been contacted, equipment reviewed, and evaluated for this report. Below each manufacturer listed is a brief synopsis of their equipment. A more detailed discussion follows further within this report. This report does not focus on ranking and comparing various ORC manufacturers for selection purposes but only gives a cursory review of likely vs unlikely candidates for further investigation. This report will tend to focus on the exhaust gas boiler manufacturer's pros/cons of each and base pricing upon a select manufacturer solely for the purpose of cost to benefit evaluation.

- Electratherm (ET) Green Machine

  This ORC manufacturer produces 50 to 65 kW units. These units were tested at the University of Alaska Fairbanks Mechanical Engineering

Department and yielded 5.5%, 7%, and 7.5% total net efficiencies at operating temperatures of 155F, 195F, and 215F, at various flow rates, respectively. Given the flows, temperature differentials, and total available BTUs for the jacket water system at Unalaska it is expected that each Wartsila or Cat will operate two 50 kW machines (plumbed in parallel) at a net output of 39 kW each. This expected net output has been confirmed both by UAF testing and Electratherm trials and calculations. Temperature differentials are not sufficiently high enough to justify the installation of the more expensive 65 kW machines.

- United Technologies Corp (Carrier) (UTC/Pratt Whitney)

  This ORC manufacturer primarily focuses on 1 MW unit sizes and larger. However, they do make a 250 kW unit that has only become readily available in the last 5 years. Its optimal operating temperatures are also found to be higher than the 195F that Unalaska can deliver. However, the unit can operate to a limited degree at these lower temperatures. Furthermore, Pratt/Whitney is only willing to sell the 250 kW unit size in lots of ten which is well outside of the scope and budget of this project.

- Infinity Turbine LLC

  This ORC manufacturer offers promise in the 200 to 300 kW unit sizes but also has difficulty working with the temperatures. Additionally, they require a money down payment before they will divulge any necessary design information to determine feasibility. AEA grant funding restrictions generally do not allow such payments without proper feasibility reviews.

- Ormat

  This exhaust gas and ORC manufacturer produces units that operate at 1000F+ temperatures and utilizes unit sizes much larger in scale than Unalaska would necessitate.

- Ener-G-Rotors

  This ORC manufacturer is currently beta testing their 35 to 60 kW units that use a special ORC refrigerant that produces highest efficiencies at lower temperatures around 185F. They do not expect a fully functional unit for sale until the end of 2013.

- GE

  GE currently makes a higher temperature ORC unit that grosses 125 kW output. The technology utilizes a hermetically sealed 125 kW high-speed generator and turbine in a single package. It has no external rotating seals and no gearbox. It also uses magnetic bearing technology that creates nearly zero friction losses and minimizes maintenance. It utilizes power electronics to convert high frequency to DC power which is then reconditioned to 60 Hz usable power output. This unit may have application for the exhaust gas waste heat reclamation project. The minimum operating evaporator temperatures require 300+F which can be achieved from the exhaust gas boilers reviewed in this report.

- TAS

  This ORC manufacturer produces their smallest units at 800 kW which is of a much higher scale and output than Dutch Harbor can support.

- Turbo Thermal LLC

  This ORC manufacturer produces units in the 80 kW size and can bundle 3 or 4 units together in a modular package for a total maximum net output (after pump load is subtracted) of 225 to 300 kW. The R123 refrigerant they use in their units yield a theoretically calculated 7.6% and 11% efficiencies based on the total available jacket water heat and exhaust gas heat sources @ 195F and 300F, respectively. This ORC manufacturer appears to have the most comprehensive calculation foundation upon which their efficiency numbers are based. These efficiencies are also in agreement with Electratherm's actual tested performance values.

- Echogen

  This ORC manufacturer produces 200 to 300 kW units that operate in the 450F to 1000F operating temperatures. This will not work for this project as 300F temperatures are the maximum available temperatures that can be delivered at Dutch Harbor.

- Calinetix

  This ORC manufacturer is no longer in business having been recently purchased by GE. Some of the Calinetix technology may have been adopted by GE.

- Cain Industries, Inc.

  This exhaust gas boiler unit manufacturer produces a unit than can provide hot water temperatures in the 215F to 230F range where most ORC manufacturers prefer to operate. The Cain is least expensive and largest of the exhaust gas boiler units evaluated. It has several advantages that make it the most affordable of all units throughout its life. Cain provides a complete self-monitoring and self-cleaning low maintenance product that would suit the needs of the project. The controls package monitors in/out exhaust gas temperatures to avoid condensation of sulfuric acid. It also monitors exhaust gas back pressure (to avoid compromising engine efficiency) and provides regular self-cleaning cycles utilizing either steam or compressed air. Maintenance access points are readily available, includes integral exhaust bypass valve and valve controls, and there is good relatively local support of this product. Approximate material cost (not including installation labor) per boiler with all controls included is $235,000.

- Maxim

  This exhaust gas boiler unit manufacturer produces a unit that can provide hot water temperatures in the 215F to 230F range where most ORC manufacturers prefer to operate. They do not offer the same built-in ready-to-go self-monitoring package that Cain does and would thus require additional cost to integrate a controls package to be comparable

to the Cain unit. Furthermore, maintenance service for this unit is very difficult as maintenance access is only available with major disassembly, cleaning, and reassembly of the unit. This would also require crane time and coordination. Support, however, is available relatively locally.

- Aalborg

  This exhaust gas boiler unit manufacturer produces a unit that can provide hot water temperatures that would be needed for this project. Aalborg makes a low weight, compact, easy to maintain, highly efficient, proven design, tailor-made for specific requirements, designed for diesel applications, vibration resistant units. They can provide many references for similar installations. However, Aalborg does not offer an integral exhaust bypass valve and check valve for use with existing exhaust systems. Also, a third party controls/monitoring instrumentation package would need to be developed and integrated into this boiler unit adding further cost and complexity. Approximate material cost only per boiler plus third party controls is $320,000.

2. Facility Evaluation

2.1 Existing Powerhouse Concrete (Old) and Steel (New)

EPSI looked at each of the existing generator units at each powerhouse to determine if the individual heat inputs to the "system" would be viable sources to size the ORC units to be as large as possible. There are two heat sources from which the waste heat project is being developed 1) Engine jacket 2) Exhaust Gas. Both heat sources will require the use of ORC units. While there is much more heat energy to reclaim through the exhaust gas than engine jacket the exhaust gas system will require additional equipment over the engine jacket system. Currently, Units 10, 11, and 13 (new plant) are connected through common engine jacket water waste heat lines and are available for electric conversion according to the BTU amounts shown below in this section of the report.

In the old powerhouse building, Units 1 through 6 have been decommissioned and removed. Units 8 and 9 in the old powerhouse and Units 10, 11, and 13 in the new powerhouse are currently in service. All are of a size to provide sources for the ORC units to a certain degree especially with the addition of an exhaust heat recovery system. However, units 8 and 9 are not connected to the existing engine jacket waste heat lines and are expected to be decommissioned and removed in the near future. Therefore, units 8 and 9 are not evaluated for waste heat reclamation potential within this report. Currently, units 10 or 11 are typically base load units, with Units 8 or 9 supporting the remaining loads. Therefore only Units 10 and 11 are considered for exhaust gas waste heat evaluation within this report. In the future, it may be further beneficial to expand the exhaust waste heat system to include additional units as they are run on a more regular basis. Town loads need to be consistently around 7 MW minimum before unit 13 with unit 10 or 11 OR both Wartsila's would need to be regularly dispatched. Current loading still remains between 5 MW to 7.5 MW where 7.5 MW is rarely approached.

The actual building heating loads for the concrete and steel powerhouses currently extract up to 500,000 BTU/hr from the engine jacket water waste heat system. EPSI recommends continuing to serve the building heating loads from the existing jacket water waste heat system.

EPSI, through facility personnel and manufacturers data, was able to determine normal operating conditions for the following units. All evaluation calculations will be based upon 75% unit loading. Units 8 and 9 are not included in this evaluation but are factored into the unit dispatch schedule to support the town loads such that Units 10, 11, 13 only turn on when 75% loading on these units can be expected.

- Unit 10 – Wartsilla 12V32
  - Hours per year operation: 4,380
  - Typical operating load: 75% - 4 MW
  - Heat Rejected to Jacket Water @ 75% loading: 3,586,000 BTU/hr
  - Jacket Water peak temperature and flow at ORC: 195F @ 440 GPM
  - Heat Rejected to Exhaust Gas @ 75% loading: 5,775,000 BTU/hr
  - Exhaust Gas peak temperature and flow at ORC: 300F @ 221 GPM
- Unit 11 – Wartsilla 12V32
  - Hours per year operation: 4,380
  - Typical operating load: 75% - 4 MW
  - Heat Rejected to Jacket Water @ 75% loading: 3,586,000 BTU/hr
  - Jacket Water peak temperature and flow at ORC: 195F @ 440 GPM
  - Heat Rejected to Exhaust Gas @ 75% loading: 5,775,000 BTU/hr
  - Exhaust Gas peak temperature and flow at ORC: 300F @ 221 GPM
- Unit 13 – Cat C280
  - Hours per year operation: 1,000
  - Typical operating load: 75% - 3.3 MW
  - Heat Rejected to Jacket Water @ 75% loading: 2,798,000 BTU/hrJacket
  - Jacket Water peak temperature and flow at ORC: 195F @ 440 GPM
  - Heat Rejected to Exhaust Gas @ 75% loading: 5,789,000 BTU/hr
  - Exhaust Gas peak temperature and flow at ORC: 300F @ 221 GPM
- Total plant operating heat capacity (all units jacket water + all units exhaust gas @ 75% loading): **27,309,000 BTU/hr**
- Total plant heat capacity (Total plant operating heat capacity minus building heat load) for ORC: **26,809,000 BTU/hr**.
- Actual current available heat (based on today's town system electrical loads = one Wartsila jacket water plus one Wartsila exhaust gas minus building heat loads) for ORC: **8,861,000 BTU/hr**.

- Actual current available heat only from Wartsila or Cat exhaust gas energy conversion at the gas boiler **5,775,000 or 5,789,000 BTU/hr, respectively** (building heat to be supported on jacket water system).
- Exhaust gas boiler is conservatively estimated at 90% efficient. This means that **5,197,500 BTU/hr** of waste heat energy can be expected to be delivered to the ORC units from each Wartsila and **5,210,100 BTU/hr** from the Cat.
- Current energy production reports reveal that Unalaska is produces 15.5 to 16 kWh per gallon of fuel consumed. This report will use 16 kWh/gal for evaluation purposes.

From correspondence with Electratherm and Turbo Thermal LLC technical representatives for Units 10, 11, and 13 it appears that at most the following waste heat energy could be reclaimed from each of the indicated units:

- Wartsila or Cat C280 jacket water only: Expected ORC output 78 kW after building heat is served (39 kW on each of two separate Green Machines)
- Wartsila or Cat C280 generator exhaust via exhaust stack boiler: 167 kW per unit (11% ORC efficiency and 90% boiler efficiency).
- Recommended plant operating Temperatures:
  - Exhaust boiler supply temperature (hot): 300 degrees F
  - Exhuast boiler return temperature (cold): 250 degrees F or as recommended by boiler manufacturer
- Waste heat System operating:
  - To ORC: 300 degrees F
  - Building Heat: 250 Degrees F

Concrete powerhouse building structural

Generator units 1 through 6 have been removed from the first floor back room of the old power plant building, leaving space for installation of the new ORC units on this concrete slab-on-grade floor, making structural analysis unnecessary. Additionally, construction on the first floor will be the least expensive as all hot water, cold water, and electrical connection points are located on the first floor.

Preliminary evaluation has shown that the second floor can bear up to 100 lbs/sq. ft. Detailed structural design will be needed to determine and avoid compromising the rebar. The UTC 250 kW unit weights appear to fall below this weight restriction and can be therefore safely assumed that most any manufacturer of this size unit will also meet the weight restrictions.

For the purposes of this report costs will be focused only on the first floor construction.

Electrical Integration of either ORC Unit(s)

The electrical modifications required for the installation of the ORC units are rather limited in scope as they do not require many modifications to the existing facilities.

The ET Green Machine may be custom ordered to generate at various voltage ratings. The intent will be to order the ORC in the standard 480V 3-phase configuration and connect it to the existing 480V building service in the concrete power plant. This will allow the ORCs to serve all

480V loads in the steel and concrete power plant buildings as well as export any surplus to the 4160V new plant generation bus for delivery to the distribution system.

The maximum allowable power that can be exported to the steel building is 332 kW via the available 400A 3 phase 480V plant-to-plant station service feeder between each MDP. Refer to electrical one-line in Appendix A. Should the need arise for more than this amount then the existing 4160V concrete plant system would need to be upgraded or Units 8 or 9 be removed to accommodate. Calculations show that when all units sustain 75% loading (utilizing exhaust gas and jacket water less building heat) approximately 600 to 650 kW of ORC power could become available. This level of loading would require sustained electrical town loads of 11 MW which is over 100% of current day town loading.

3. ORC Evaluation

Given the many technical design constraints EPSI has determined that both waste heat systems (engine jacket and exhaust gas) are ideally suited (both electrically and physically) for ORC units in the 40 kW to 80 kW range and would be capable of operating around 190F to 300F continuously. This restricts the selection process to only a very few ORC manufacturers today which include Ener-G-Rotors, Electratherm, Turbo Thermal LLC, and GE. Many other manufacturers were considered but were eliminated from the "potential candidates" list for this project because of lack of interest, operating temperature problems, or unit size scaling issues. Ener-G-Rotors is still currently in beta testing mode and does not expect to produce a commercially available 35 kW to 50 kW unit until December 2013. Electratherm produces the commercially available Green Machine Series 4000 unit that is a 50 kW unit which is ideally suited for use on the jacket water system and/or exhaust gas heat system. Turbo Thermal LLC produces a 240 kW or 320 kW ORC unit that can be broken down into three or four 80 kW units which appear to be more ideally suited for the exhaust gas system. GE Clean Cycle units are 125 kW units that may also work in leau of the Turbo Thermal units on the exhaust gas system.

The engine jacket water waste heat to energy project was evaluated in the EPSI 2008 report. During the 2011 Request for Qualifications process only Pratt/Whitney UTC responded. Unfortunately, Pratt/Whitney UTC will now only sell a minimum lot of ten units per order which eliminates them from the "potential candidates" list for this project.

Below is a brief description of the Electratherm and Turbo Thermal ORC units and the rationale for their further consideration. The summary of this report lists each of the other manufacturers not mentioned within this section. The reasons for their elimination from the "potential candidates" list are briefly outlined in the summary of this report.

3.1 Electratherm Green Machine

The Electratherm (ET) units are more customizable than any other ORC vendor information to date. ET, through their website and communication with the ET representative, has two standard models which fit a variety of applications and unit (heat source) sizes. The electrical output range is also ideally suited to run two 50 kW units for each engine jacket.

The ET Green Machine 4000 is a 50 kW unit that consists of a 480V 3 phase 100 HP screw compressor operating in reverse process. The generator consists of a Marathon 50 kW

induction motor run in reverse operation. The induction motor makes for an inherently safe concept such that no export of power is possible should there be loss of AC power on the prime power source side. Additionally, this eliminates the need of synchronization equipment. The entire assembly (including control panel) sits on one skid and has a physical footprint size of approximately 6' x 8' x 8'.

The first floor space, where recently retired units 1 through 6 resided, is physically restricted to only accommodate units of this size or smaller. Up to three separate units can fit within this existing space. Room for a fourth unit may be provided if the old operator's office becomes available for renovation to accommodate.

Electratherm is willing to customize any of its units to meet the needs of the facility. For this reason information concerning the "base" units has been provided. Customization of the units to optimize the recovery would cause the price to adjust accordingly. Titanium or cupro-nickle in shell and tube configuration heat exchangers are options for use with the sea water cooling system at additional cost.

Maintenance & Operation – The ET ORC has three moving parts which require maintenance. In general, ET recommends that the turbine drive belt, should be changed annually even though it is rated for over 20,000 hours of operation. The cost of the drive belt is $300. ET has determined that each unit would require 1.5 cents per kW-hr for maintenance over a one year period. This cost would include periodic inspection of the unit (lubrication, seals, performance) and cleaning of the units' sea water heat exchanger and replacement of the drive belt.

ET is a new company/manufacturer and unfortunately does not have years of previous ORC experience to be able to adequately predict the longevity of their units. But, from a design perspective, their unit has 3 moving parts. Based on this fact alone, we would anticipate that the unit should have well over a 20 year life expectancy.

3.2 Turbo Thermal LLC

This ORC manufacturer makes two different sizes of units that could work well for this project. The first size is a 240 kW unit which consists of 3 (three) 480V 3 phase 80 kW rated expander/generators working in unison. The second size is a 320 kW unit which consists of 4 (four) 480V 3 phase 80 kW rate expander/generators working in unison. The optimal operating temperatures are at 300F but can also run at the expected 230F temperatures at the expense of efficiency as mentioned below.

Both units (240 kW and 320 kW) each fit within a 20 foot shipping container and can be broken down and refitted to most any space. The largest pieces of gear consist of three major components: 1) Three or Four expander/Generator skids each @ 30"W x 30"H x 72"L; 2) One common surge tank @ 72"H x 48" diameter; 3) One common control panel @ 72"H x 48"W x 30"D (double door).

Approximately every 25F above 230F up to 300F an extra percentage point of efficiency is achieved. For example, at 225F output to the Turbo Thermal ORCs one can expect 8% efficiency. At 250F one can expect 9% efficiency, 10% efficient @ 275F, and 11% efficient @ 300F. For this analysis it is assumed that the exhaust gas boilers can be turned up to 300F output to the ORC units to achieve 11% efficiency from the Turbo Thermal ORC units.

All generators are Westinghouse Premium efficiency (SF = 1.15) 480V 3 phase 100 HP induction motors. This makes for simplification of controls and a safe electrical system.

Maintenance & Operation – Turbo Thermal has determined that each unit would require 1.0 cents per kW-hr for maintenance over a one year period. This cost would include periodic inspection of the unit (lubrications, seals, performance) and cleaning of the units' sea water heat exchanger and replacement of the drive belt.

3.3 GE Clean Cycle

These higher temperature ORC units are compact, relatively light weight, and can be broken down and rebuilt to allow for installation in smaller spaces. However, the evaporator and condenser components would have to be provided by the customer at additional cost. The estimated efficiencies are between 9.5% and 10.5% at 300F/55F hot/cold for the given flows and waste heat energy available from each of the Wartsila and Cat exhaust gas stacks.

It's estimated that each Wartsila @ 75% loading can energize 1.1 (137.5 kW) ORCs. It's also estimated that the Cat @ 75% loading can energize 1.4 (175 kW) ORCs.

4. Exhaust Gas Boiler Evaluation and Integration at Powerhouse

Below are the design and construction constraints that should be considered when implementing the exhaust gas waste heat reclamation project.

1. The existing waste heat system, as designed, is connected and in common to the engine jacket water systems for Units 10, 11, and 13, and currently provides up to 195F water temperature. This temperature is too low for many ORC units to operate effectively, some manufacturers' such as Electrotherm and potentially Ener-G-Rotors, can operate at reasonable efficiencies that can still economically justify the project. Modifications to the system flow rates will need to be implemented such that the waste heat peak temperature could be raised to 195F where these ORCs can be operate at better efficiencies. This modification could be implemented at any time at little to no cost.
2. During construction of the steel powerhouse new 8-inch waste heat transfer piping was installed between the steel powerhouse and the concrete powerhouse to allow for transfer of waste heat to the seawater heat exchanger and the then-future ORC units. However, higher temperature waste heat from the exhaust stack boiler may require the installation of new heat transfer piping from the exhaust gas boilers to the ORCs, which are to be installed on the first and/or second floor of the concrete powerhouse building.
3. Since the exhaust gas boiler lines could operate at much hotter temperatures (around 230 - 300F) than the engine jackets could handle it further suggests that a separate exhaust gas waste heat line be installed.
4. It was considered that the existing jacket water waste heat lines be cut, intercepted, and rerouted to the new gas boilers to save cost. However, after reviewing available BTU outputs from each heat source it was clear that removing the engine jacket waste heat lines would severely limit the availability of waste heat extraction as a whole. Therefore, since a substantial amount of the entire waste heat project centers around the engine jacket system it is critical to leave it intact and develop new higher temperature waste heat lines for the exhaust gas system.

5. As part of the detailed design for the ORC's a revision to the facility sea water cooling permit may be required to allow for a more elevated discharge seawater temperature than originally permitted. Preliminary data from the ORC vendors indicates a sea water temperature increase of 20F. No sea water temperature restriction was provided to the ORC vendors. Something to consider is that as waste heat is converted to electricity the amount of waste heat/cooling water which requires cooling will be reduced. When the ORC's are operating at their peak output, the sea water discharge temperature could decrease. If the sea water permit cannot be successfully modified then a supplemental radiator will be needed to remove excess heat prior to dumping remaining heat back into the seawater.
6. According to Wartsila 12V32 design information (from original 2005-2007 design effort) the units are designed to allow a total exhaust restriction of 12 inches of water column. It's currently estimated that the total system back pressure with the exhaust gas boiler will be 11.35 inches of water column. This is a worst case operating point without detailed design. As such the gas boiler control package should include differential pressure monitoring and alarming.
7. One or two motor operated valves to control sea water flow to the heat exchangers and the bypass around the heat exchangers will be required. This is only a preliminary look at the system, during the detailed design; this strategy would have to be verified.
8. The ORCs operate best at steady state conditions and are not suited for operation on a peak-shaving or back-up unit. This would best be provided by the Wärtsilä units as the base loaded machines. Currently, only one Wartsila or the other is used on a nearly 24/7/365 basis. Eventually, as the town loads increase the Cat C280 will be utilized in a similar fashion at which point another exhaust gas stack boiler could be implemented.
9. It's suggested that a 50/50 Dowfrost HD/Water solution be used to transport the 300F exhaust gas boiler outlet temperatures expected. This will provide the optimal heat transfer, eliminate chemical breakdown, satisfy environmental requirements, and contain the needed corrosion inhibitors.

5. Conclusion and Recommendations

EPSI recommends that the engine jacket water waste heat project be fully constructed to completion so as to reap the most immediate and rewarding benefits possible. This should be accomplished through the installation of 4 (four) 50 kW Electratherm Green Machines installed on the lower floor of the concrete plant where units 1, 2, 3, 4, 5, and 6 used to reside. Since plant operating procedure is based on maintaining N-1 unit contingency (plant always allows for one of the largest units to be offline at all times) it is not necessary to evaluate for loading above N-1 plant capacity.

As funds become available the project could be expanded to include the use of an exhaust gas waste heat system. EPSI recommends that this be accomplished via the use of two 240 kW Turbo Thermal LLC ORC units (or any equivalently sized units capable of effectively handling 230F to 300F heat transfer fluid) installed on the second floor of the concrete plant building after demolition of units 8 and 9 is accomplished. This will open up the needed floor space for any supplemental radiator system, 480:4160V step-up transformer and 4160V cabling needed while maximizing the use of the available exhaust gas waste heat available for electric conversion.

EPSI recommends that one Cain Industries gas boiler unit be installed on each of the three steel plant exhaust stacks (Units 10, 11, and 13). Cain Industries boilers are chosen because

they provide the most complete package including all necessary controls and monitoring that other manufacturer's do not offer. Furthermore, by comparison the Cain units are much easier to maintain, ensuring long project life. Below are the costs, fuel displacements, and estimated payback periods for both waste heat systems now and into the future.

Project Phase I (Engine Jacket Heat Only – 4 x 50 kW Electratherm Green Machines)

One Wartsila running @ 4 MW + Units 8 and/or 9 (Current Day loads)

Initial Cost: **$1,889,381** (reduced from previous estimate based on different units and installation moved to first floor from second floor).

Annual Cost: **$10,000**

Total Annual net energy payback @ 8,322 hours = **649,116 kWh**

Total Annual Fuel Displacement Payback (based on 16 kWh/gallon) = **40,570 gallons**

Approximate Payback Period with fuel @ $3.80/gallon = **13 years**

Approximate Payback Period with fuel @ $4.80/gallon = **10.5 years**

Wartsilas or Wart/Cat running (Town load minimums approximately 8 MW throughout year)

Annual Cost: **$20,000**

Total Annual net energy payback @ 8,322 hours = **1,298,232 kWh**

Fuel Displacement Payback (based on 16 kWh/gallon) = **81,140 gallons**

Approximate Payback Period with fuel @ $3.80/gallon = **6.5 years**

Approximate Payback Period with fuel @ $4.80/gallon = **5.5 years**

Project Phase II (Exhaust Gas Heat Only)

One Wartsila running @ 4 MW + Units 8 and/or 9 (Current Day loads)

Initial Cost: **$4,948,365**

Annual Cost: **$21,000**

Total Annual net energy payback @ 8,322 hours = **1,389,774 kWh**

Total Annual Fuel Displacement Payback (based on 16 kWh/gallon) = **86,860 gallons**

Approximate Payback Period with fuel @ $3.80/gallon = **16 years**

Approximate Payback Period with fuel @ $4.80/gallon = **12.5 years**

Wartsilas or Wart/Cat running (Town load minimums approximately 8 MW throughout year)

Annual Cost: **$42,000**

Total Annual net energy payback @ 8,322 hours = **2,779,548 kWh**

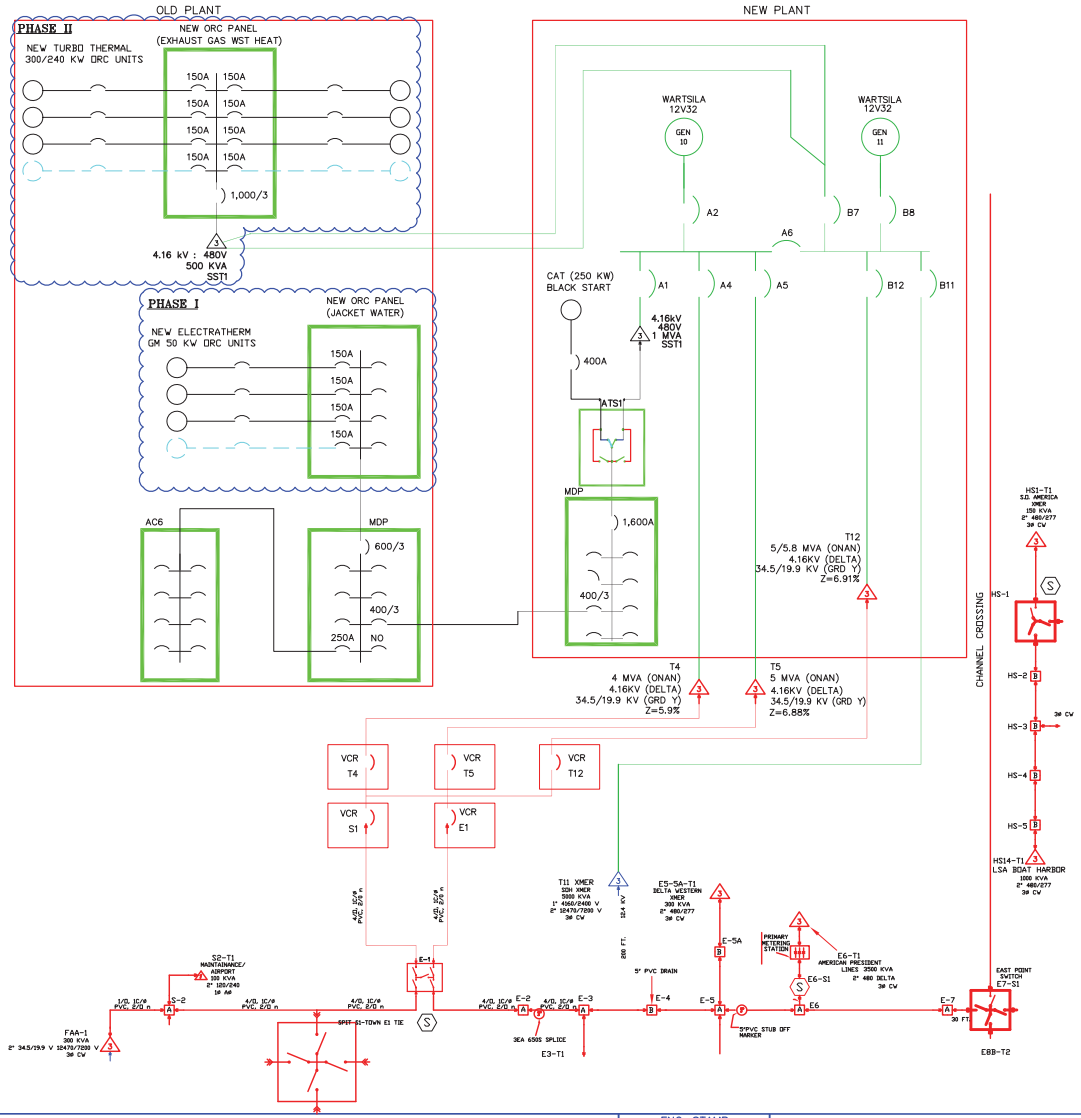
Fuel Displacement Payback (based on 16 kWh/gallon) = **173,722 gallons**

Approximate Payback Period with fuel @ $3.80/gallon = **8 years**

Approximate Payback Period with fuel @ $4.80/gallon = **6 years**

6. Appendices

6.1 Schematics & Plans



NOTES:

1. CONTRACTOR TO TERMINATE BOTH CABLE ENDS BETWEEN E1 AND THE NEW PLANT SUBSTATION. OWNER TO TERMINATE BOTH CABLE ENDS BETWEEN E1 AND THE EXISTING DISTRIBUTION SYSTEM.

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION
1	E1.00	5/35 KV ONE LINE DIAGRAM

PROJECT: POWERHOUSE RENOVATION PROJECT #03301

DESIGNER/PROJECT ENGINEER: EARL GEORGE/DAVID W BURLINGAME – EPS W.O. #:

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

DRAWING NAME:

UNALASKA, AK POWER PLANT-TO-PLANT 15/35 KV DISTRIBUTION SYSTEM INTERCONNECT ONE LINE DIAGRAM

e1.02.dwg

REF DWG(S):

DRAWING NO.: EX.XX

SHEET X OF X

REVISIONS				
REV.	ECN	DESCRIPTION	DATE	APPROVED
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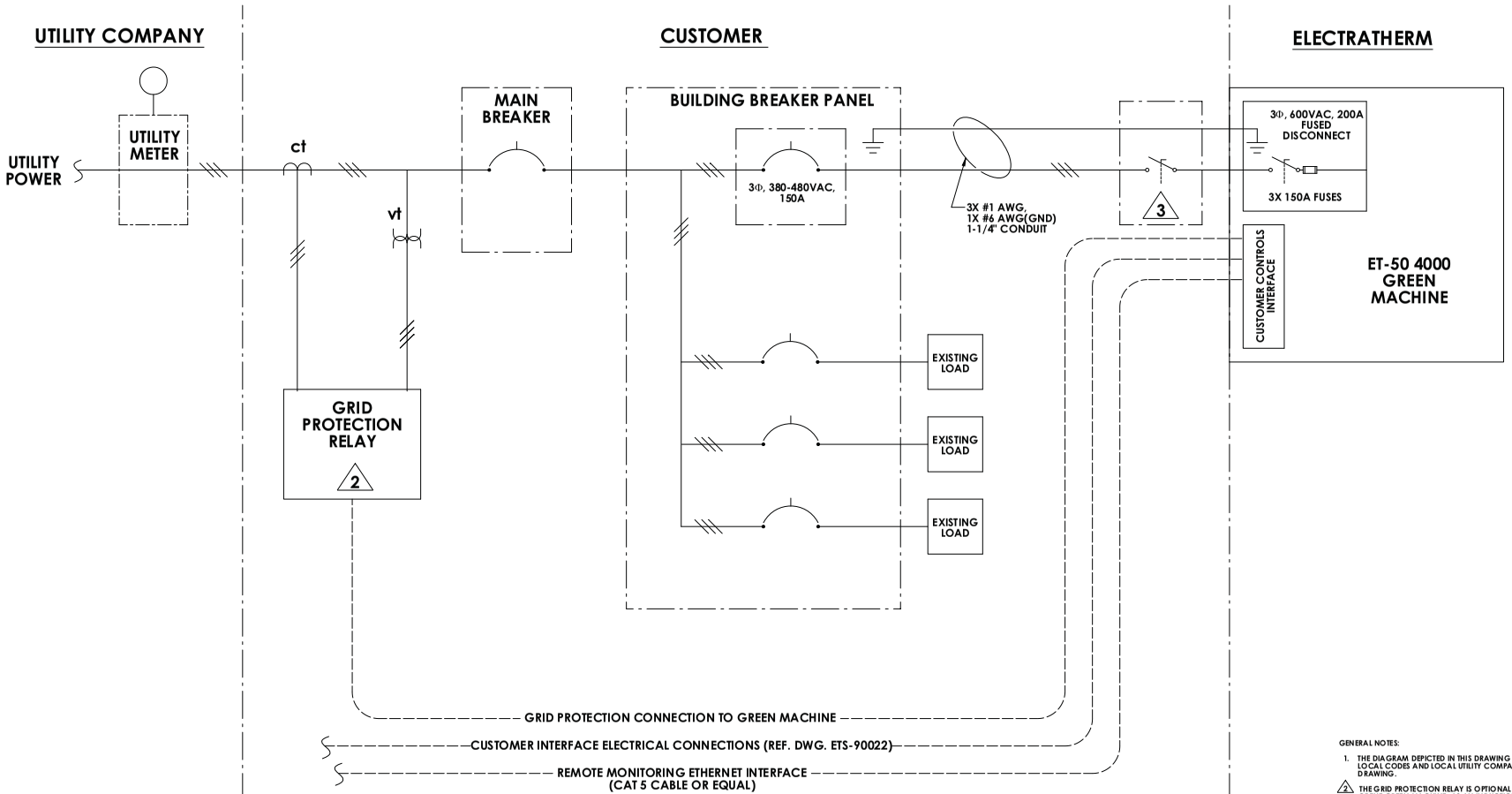


GENERAL NOTES:

1. THE DIAGRAM DEPICTED IN THIS DRAWING IS FOR A TYPICAL INSTALLATION. LOCAL CODES AND LOCAL UTILITY COMPANY REQUIREMENTS CAN SUPERSEDE THIS DRAWING.

2. THE GRID PROTECTION RELAY IS OPTIONAL AND IS NOT REQUIRED FOR THE OPERATION OF THE GREEN MACHINE. AS AN INDUCTION GENERATOR-BASED MACHINE THE GREEN MACHINE IS INHERENTLY SAFE AGAINST FORMING A "GENERATOR ISLAND". SOME UTILITY COMPANIES, HOWEVER, MAY REQUIRE THIS ACCESSORY FOR DISTRIBUTED GENERATION FACILITIES REGARDLESS OF THEIR CHARACTERISTICS. TYPICAL PROTECTION REQUIREMENTS ARE ESTABLISHED BY EACH INDIVIDUAL UTILITY COMPANY. THE GRID PROTECTION RELAY INPUT WILL DISCONNECT THE GREEN MACHINE'S GRID CONNECTION WHEN A FAULT IS DETECTED BY THE GRID PROTECTION RELAY. THE GRID PROTECTION RELAY MONITORS THE GRID AT THE P.C.C. (POINT OF COMMON COUPLING). THE P.C.C. MAY BE DETERMINED BY THE LOCAL UTILITY COMPANY.

3. AN EXTERNAL, VISIBLE, LOCKABLE SWITCH MAY BE REQUIRED TO DISCONNECT THE GREEN MACHINE FROM THE GRID. THE REQUIREMENTS FOR THE TYPE AND PLACEMENT OF THE SWITCH ARE DETERMINED BY THE LOCAL CODES AND THE LOCAL UTILITY COMPANY.

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES [MM]
TOLERANCES:
FRACTIONAL ± 1/16
ANGULAR: MACH ± .5° BEND ± 1°
2 PLACE DECIMAL ± .10 [2.5]
3 PLACE DECIMAL ± .030 [0.80]
INTERPRET GEOMETRIC TOLERANCING PER: ANSI Y14.5M-1982
MATERIAL: N/A
FINISH: N/A
NEXT ASSY | USED ON
APPLICATION

	NAME	DATE
DRAWN	GJM	21 DEC 11
CHECKED	TEB	
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

ELECTRA THERM
4750 TURBO CIRCLE RENO, NV 89502 (775) 398-4680

TITLE: Diagram, 1-Line, Intrcnct, Water Cooled

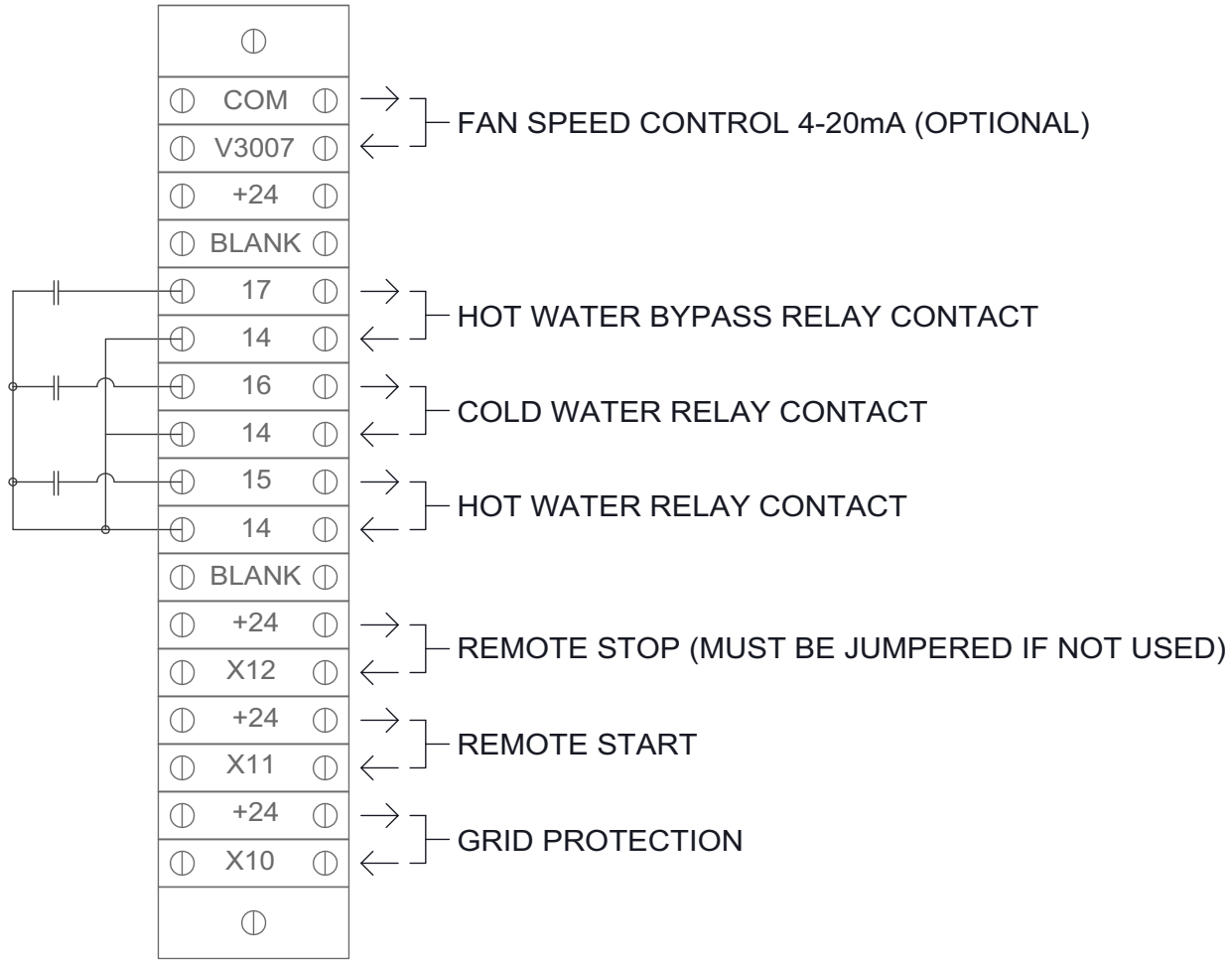
SIZE	DWG. NO.	REV
D	ETS-90018	A

SCALE: N/A | WT: N/A | SHEET 1 OF 1

D ETS-90018 A

REVISIONS				
REV.	ECN	DESCRIPTION	DATE	APPROVED
A	100145	REVIEW DRAFT	27 DEC 11	TEB
B	100145	PRODUCTION RELEASE	11 JAN 12	TEB

CUSTOMER INTERFACE TERMINAL STRIP



NEXT ASSY	USED ON	
APPLICATION		

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES[MM]
TOLERANCES:
FRACTIONAL ± 1/16"
ANGULAR: MACH ± .5° BEND ±1°
2 PLACE DECIMAL ± .10[2.5]
3 PLACE DECIMAL ± .030[0.80]
MATERIAL N/A
FINISH N/A
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	TEB	27 DEC 11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

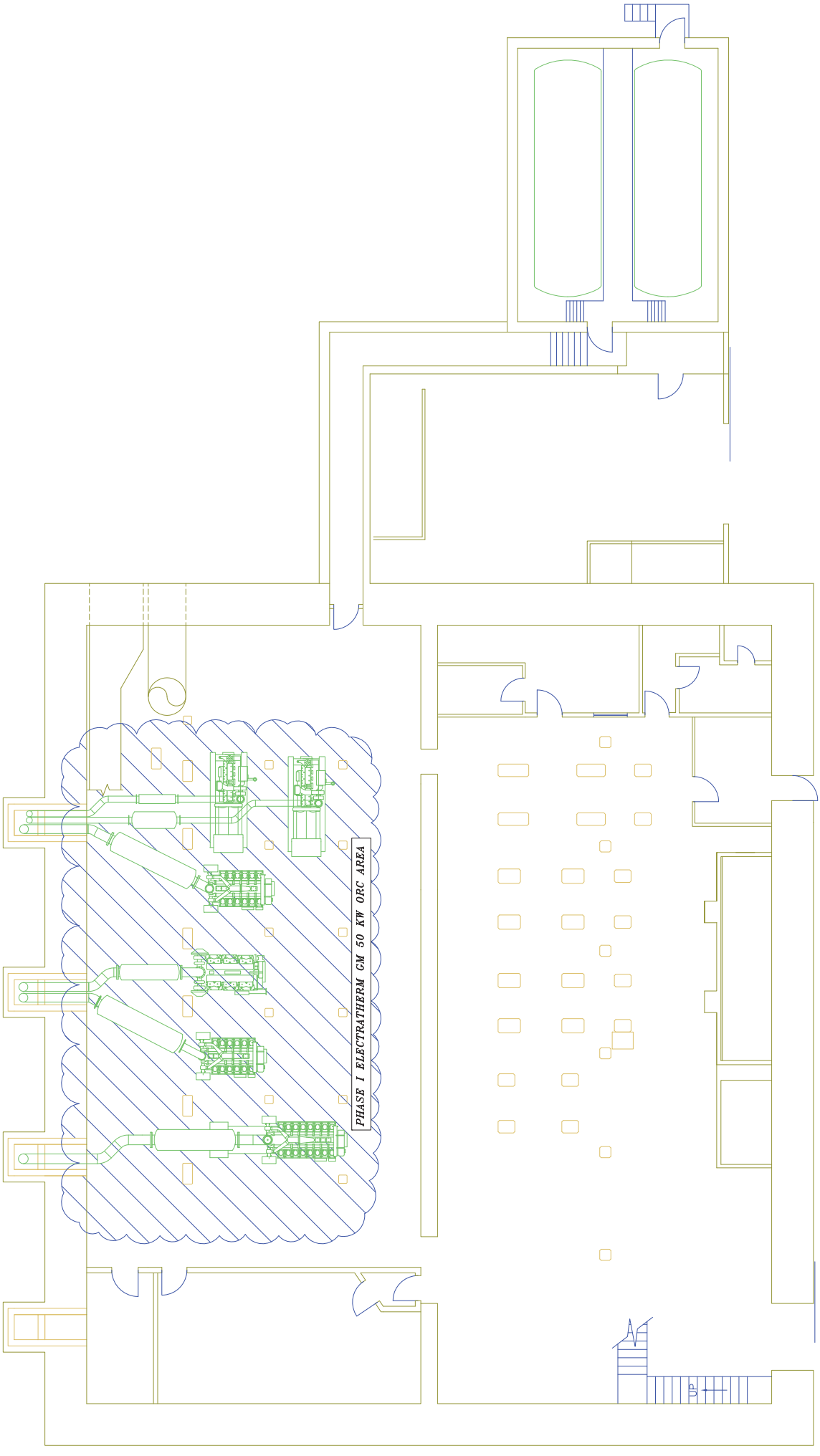
COMMENTS:

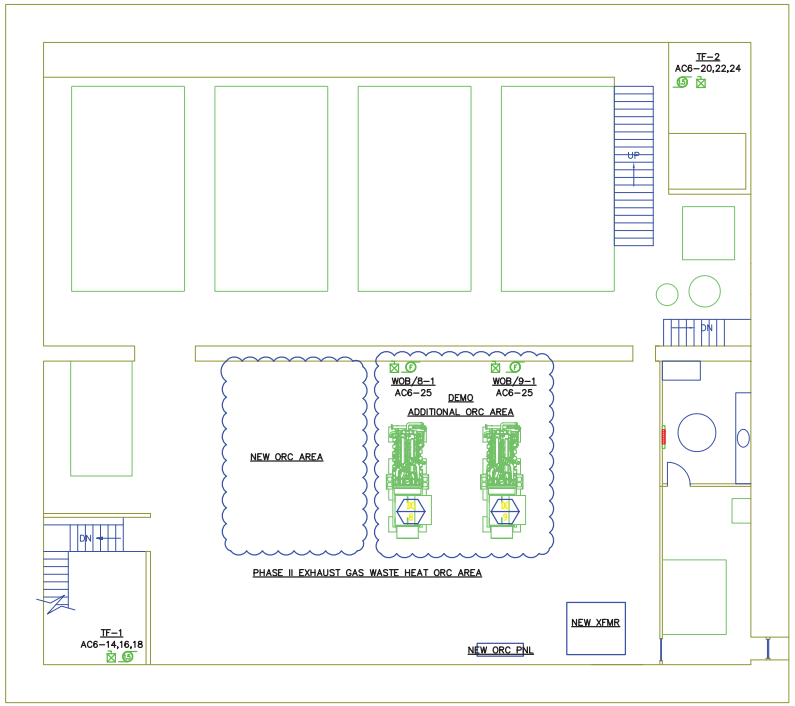
ELECTRATHERM
4750 TURBO CIRCLE RENO, NV 89502 (775) 398-4680

Diagram, Trmnl Strip, Interface, ET-50 4000

SIZE	DWG. NO.	REV.
A	ETS-90020	B

SCALE:N/A | WEIGHT: N/A | SHEET 1 OF 1


PHASE I ELECTRATHERM GM 50 KW ORC AREA



1 SECOND FLOOR PLAN

LEGEND

CIRCUIT DESIGNATORS

XXX - X

PANEL + CKT #

EXAMPLE

"AC3-8" INDICATES CIRCUIT DESTINATION TO PANEL "AC3" CIRCUIT NUMBER 8.

J = JUNCTION BOX

= GENERAL PURPOSE 120V DUPLEX RECEPTACLE

GFI
= RECEPTACLE WITH GROUND FAULT INTERUPTER

W, GFI
= RECEPTACLE WITH GROUND FAULT INTERUPTER IN A WEATHERPROOF HOUSING.

3 PHASE MOTOR WITH HP RATING

F SINGLE PHASE MOTOR: F INDICATES FRACTIONAL HP MOTOR PROVIDE MOTOR RATED DISCONNECT AT EACH MOTOR.

COMBINATION DISCONNECT/STARTER: NEMA RATED TO START ASSOCIATED MOTOR WITH HOA SWITCH AND AUXILARY START CONTACT.

1 SNOW MELT CONTROL AND PUMPS: PROVIDE MOTOR RATED DISCONNECT SWITCH AT EACH CONTROL PANEL/PUMP COMBO.

2 EXISTING GENERATOR PRE-HEAT UNIT. VERIFY ELEC REQUIREMENTS.

FUSED DISCONNECT

DISCONNECT

8 0 8 16 FEET

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION
1	E0.17	480 & 120 VOLT AC PANEL SCHEDULES
2	E1.10	STATION SERVICE ONE LINE DIAGRAM

PROJECT: POWERHOUSE RENOVATION PROJECT #03301
DESIGNER/PROJECT ENGINEER: EARL GEORGE/DAVID BURLINGAME - EPS W.O. #: 03301

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	ISSUED FOR CONSTRUCTION	KER/06-06-2007	DWB/06-06-2007	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

DRAWING NAME:
POWERHOUSE RENOVATION PROJECT #03301
ELECTRICAL SECOND FLOOR
SECOND FLOOR LAYOUT

ee1.20.dwg

REF DWG(S):

DRAWING NO.: EE1.20

SHEET 3 OF 3

6.2 Engine Data

3.5 Wärtsilä 12V32

Wärtsilä 12V32		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2
Engine speed **Cylinder output**	**RPM** **kW/cyl**	**720** **480**	**750** **500**	**750** **500**	**720** **550**	**750** **580**	**750** **580**
Engine output	kW	5760	6000	6000	6600	6960	6960
Mean effective pressure	MPa	2.49	2.49	2.49	2.85	2.88	2.88
Combustion air system (Note 1)							
Flow at 100% load	kg/s	9.86	10.44	10.41	12.4	13.13	13.13
Temperature at turbocharger intake, max.	°C	45	45	45	45	45	45
Air temperature after air cooler (TE 601)	°C	55	55	55	55	55	55
Exhaust gas system (Note 2)							
Flow at 100% load	kg/s	10.17	10.76	10.76	12.75	13.5	13.5
Flow at 85% load	kg/s	9.65	10.2	9.92	11.06	11.97	11.83
Flow at 75% load	kg/s	8.7	9.23	8.7	9.72	10.46	10.32
Flow at 50% load	kg/s	6.3	6.53	7.43	6.81	7.37	8.1
Temperature after turbocharger, 100% load (TE 517)	°C	384	379	379	360	360	360
Temperature after turbocharger, 85% load (TE 517)	°C	331	325	331	340	335	335
Temperature after turbocharger, 75% load (TE 517)	°C	330	325	350	348	345	355
Temperature after turbocharger, 50% load (TE 517)	°C	354	345	317	380	380	340
Backpressure, max.	kPa	3.0	3.0	3.0	3.0	3.0	3.0
Calculated pipe diameter for 35m/s	mm	828	848	848	910	936	936
Heat balance (Note 3)							
Jacket water, HT-circuit	kW	949	1008	1008	904	960	960
Charge air, HT-circuit	kW	915	960	960	1300	1460	1460
Charge air, LT-circuit	kW	728	795	795	830	880	880
Lubricating oil, LT-circuit	kW	690	728	728	777	794	794
Radiation	kW	170	170	170	170	170	170
Fuel system (Note 4)							
Pressure before injection pumps (PT 101)	kPa	700±50	700±50	700±50	700±50	700±50	700±50
Fuel flow to engine, approx.	m³/h	5.8	6.1	6.1	6.6	7.0	7.0
HFO viscosity before engine	cSt	16...24	16...24	16...24	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140	140	140
MDF viscosity, min	cSt	2.0	2.0	2.0	2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	45	45	45
Fuel consumption at 100% load	g/kWh	182	183	183	182	183	183
Fuel consumption at 85% load	g/kWh	180	180	180	180	180	180
Fuel consumption at 75% load	g/kWh	180	181	180	180	181	180
Fuel consumption at 50% load	g/kWh	191	191	189	191	191	189
Clean leak fuel quantity, MDF at 100% load	kg/h	22.0	23.0	23.0	25.2	26.7	26.7
Clean leak fuel quantity, HFO at 100% load	kg/h	4.4	4.6	4.6	5.0	5.3	5.3
Lubricating oil system							
Pressure before bearings, nom. (PT 201)	kPa	500	500	500	500	500	500
Suction ability main pump, including pipe loss, max.	kPa	40	40	40	40	40	40
Priming pressure, nom. (PT 201)	kPa	50	50	50	50	50	50
Suction ability priming pump, including pipe loss, max.	kPa	35	35	35	35	35	35
Temperature before bearings, nom. (TE 201)	°C	63	63	63	63	63	63
Temperature after engine, approx.	°C	81	81	81	81	81	81
Pump capacity (main), engine driven	m³/h	115	120	120	115	120	120
Pump capacity (main), stand-by	m³/h	106	110	110	106	110	110
Priming pump capacity, 50Hz/60Hz	m³/h	38.0 / 45.9	38.0 / 45.9	38.0 / 45.9	38.0 / 45.9	38.0 / 45.9	38.0 / 45.9
Oil volume, wet sump, nom.	m³	3.0	3.0	3.0	3.0	3.0	3.0
Oil volume in separate system oil tank, nom.	m³	7.8	8.1	8.1	8.9	9.4	9.4
Oil consumption (100% load), approx.	g/kWh	0.5	0.5	0.5	0.5	0.5	0.5
Crankcase ventilation flow rate at full load	l/min	165	165	165	180	180	180
Crankcase ventilation backpressure, max.	kPa	0.4	0.4	0.4	0.4	0.4	0.4
Oil volume in turning device	liters	8.5...9.5	8.5...9.5	8.5...9.5	8.5...9.5	8.5...9.5	8.5...9.5
Oil volume in speed governor	liters	1.9	1.9	1.9	1.9	1.9	1.9
Cooling water system							
High temperature cooling water system							
Pressure at engine, after pump, nom. (PT 401)	kPa	250 + static	250 + static	250 + static	250 + static	250 + static	250 + static
Pressure at engine, after pump, max. (PT 401)	kPa	530	530	530	530	530	530
Temperature before cylinders, approx. (TE 401)	°C	85	85	85	85	85	85

Wärtsilä 12V32		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2
Engine speed **Cylinder output**	**RPM** **kW/cyl**	**720** **480**	**750** **500**	**750** **500**	**720** **550**	**750** **580**	**750** **580**
HT-water out from engine, nom (TE432)	°C	96	96	96	96	96	96
Capacity of engine driven pump, nom.	m³/h	100	100	100	100	100	100
Pressure drop over engine, total	kPa	150	150	150	150	150	150
Pressure drop in external system, max.	kPa	60	60	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.74	0.74	0.74	0.74	0.74	0.74
Low temperature cooling water system							
Pressure at engine, after pump, nom. (PT 451)	kPa	250 + static	250 + static	250 + static	250 + static	250 + static	250 + static
Pressure at engine, after pump, max. (PT 451)	kPa	530	530	530	530	530	530
Temperature before engine (TE 451)	°C	25 ... 38	25 ... 38	25 ... 38	25 ... 38	25 ... 38	25 ... 38
Capacity of engine driven pump, nom.	m³/h	100	100	100	100	100	100
Pressure drop over charge air cooler	kPa	35	35	35	35	35	35
Pressure drop over oil cooler	kPa	20	20	20	20	20	20
Pressure drop in external system, max.	kPa	60	60	60	60	60	60
Pressure from expansion tank	kPa	70 ... 150	70 ... 150	70 ... 150	70 ... 150	70 ... 150	70 ... 150
Starting air system (Note 5)							
Pressure, nom.	kPa	3000	3000	3000	3000	3000	3000
Pressure at engine during start, min. (20°C)	kPa	1500	1500	1500	1500	1500	1500
Pressure, max.	kPa	3000	3000	3000	3000	3000	3000
Low pressure limit in air vessels	kPa	1800	1800	1800	1800	1800	1800
Consumption per start at 20°C, (successful start)	Nm³	1.0	1.0	1.0	1.0	1.0	1.0
Air consumption per start	Nm³	3.0	3.0	-	3.0	3.0	-
Air consumption per start without propeller shaft engaged	Nm³	-	-	3.0	-	-	3.0
Air consumption with automatic start and slowturning	Nm³	-	-	-	4.5	4.5	4.5
Air consumption per start with propeller shaft engaged	Nm³	-	-	4.8	-	-	4.8
Air consumption with automatic start and high inertia slowturning	Nm³	-	-	-	6.3	6.3	6.3

Notes:

Note 1 At ISO 3046-1 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Tolerance 5%.

Note 2 At ISO 3046-1 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5% and temperature tolerance 10°C.

Note 3 At ISO 3046-1 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Tolerance for cooling water heat 10%, tolerance for radiation heat 30%. Fouling factors and a margin to be taken into account when dimensioning heat exchangers.

Note 4 According to ISO 3046/1, lower calorific value 42 700 kJ/kg, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%. Load according to propeller law for mechanical propulsion engines (ME).

Note 5 Automatic (remote or local) starting air consumption (average) per start, at 20°C for a specific long start impulse (DE/AUX: 2...3 sec, CPP/FPP: 4...6 sec) which is the shortest time required for a safe start.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Subject to revision without notice.

Wartsila - 12V32

% Load	Jacket Water (BTU/min)	Oil Cooler (BTU/min)	After Cooler (BTU/min)	Exhaust Gas Flow Rate (ACFM)	Exhaust Gas Flow @ STD P/T (SCFM)	Exhaust Stack Temperature (°F)
50	27,567	26,833	16,279	22,660	10,241	698
75	59,767	33,200	24,988	32,915	15,362	662
85	72,617	34,283	28,631	36,578	17,127	658
100	92,467	36,167	34,095	42,128	19,597	666

Design % Load	Jacket Water (BTU/min)	Oil Cooler (BTU/min)	After Cooler (BTU/min)	Exhaust Gas Flow Rate (ACFM)	Exhaust Gas Flow (SCFM)	Exhaust Stack Temperature (°F)
70	**53,214**	**31,980**	**23,235**	**30,884**	**14,394**	**669**

WÄRTSILÄ

Generating set performance at site conditions

Power Plants

PERF Version 11.4 (20042005)

Project name:	Project number:	Handled by:	Date:	Time:
Unalaska power house	P/04064	T.Holmnäs	05.9.28	16:07:50

Heat balance at site conditions

60°F Inside Power-house
95°F Outlet temp of Raw water cooler

Heat flow unit	kW	Massflow unit	kg/s	Volume flow unit	m^3/h
		Load:	100%	85%	75%	50%
Alternator power		kW	5211	4424	3900	2592
Pre-heating of combustion air		kW	0	0	0	0
Lubricating oil						
Flow through engine		m^3/h	120	kg/s	27,9	
Heat flow	+-10%	kW	640	597	550	520
Temperature in to engine		C	63,0	63,0	63,0	63,0
Temperature out of engine		C	74,1	73,3	72,5	72,0
LT charge air						
Air flow		kg/s	10,0	8,7	7,8	5,3
Heat flow	+-10%	kW	553	465	409	270
Air temperature in to cooler		C	105,2	100,5	97,8	92,1
Air temperature out of cooler		C	50,7	48,1	46,4	42,0
LT circuit						
Flow through engine		m^3/h	100	kg/s	27,6	
Total heat flow	+-10%	kW	1193	1062	959	790
Temperature in to engine		C	35,0	35,0	35,0	35,0
Temperature after LTCA cooler		C	39,4	38,6	38,1	36,9
Temperature out of LO cooler		C	44,9	43,8	42,9	41,4
Jacket water						
Flow through engine		m^3/h	100	kg/s	26,8	
Heat flow from cylinders	+-10%	kW	808	673	606	495
Temperature in to cylinders		C	75,8	79,4	81,5	85,7
Temperature out of cylinders		C	83,0	85,4	86,9	90,1
HT charge air						
Air flow		kg/s	10,0	8,7	7,8	5,3
Heat flow from HTCA	+-10%	kW	897	626	461	96
Air temperature in to cooler		C	192,7	170,7	155,5	109,8
Air temperature out of cooler		C	105,2	100,5	97,8	92,1
HT circuit						
Flow through engine		m^3/h	100	kg/s	26,8	
Total heat flow HT circuit	+-10%	kW	1704	1299	1067	590
Temperature in to engine		C	75,8	79,4	81,5	85,7
Temperature after cylinders		C	83,0	85,4	86,9	90,1
Temperature out of engine		C	91,0	91,0	91,0	91,0

Engine Model: Wartsila 12V32, 5.2MW nominal.

Exhaust Properties

Exhaust Temperature:	666	°F	Fuel Type:	Diesel #2
Exhaust Gas Density:	0.03516874	lb/ft^3		
Exhaust Gas Flow Rate:	42,128	cfm		

Exhaust Configuration

Pipe Size:	36	in	Gas Velocity:	6172.001	ft/min
Pipe Schedule	10				
Total Length of Pipe:	154.00	ft		102.87	ft/sec
Turbo Outlet Adapter:	2.5	$in\text{-}H_2O$			
Turbo Exhaust Flex:	1.6	$in\text{-}H_2O$			
Raincap BP:	0	$in\text{-}H_2O$			
Silencer BP:	3.14	$in\text{-}H_2O$	Silencer + Exhaust Boiler		
Total Flex BP:	0.6	$in\text{-}H_2O$			

Pipe Fittings

No. Short Radius 90° Ells:	1	Equivelant Length:	99.00	ft
No. Long Radius 90° Ells:	4	Equivelant Length:	240.00	ft
No. 45° Ells:	2	Equivelant Length:	90.00	ft
No. Square Ells:	0	Equivelant Length:	0.00	ft
		Total Fittings:	429.00	ft

Total Exhaust Backpressure: 11.35 $in\text{-}H_2O$

Notes:
1. Use 36" schedule 10 pipe as directed by environmental
2. Will have an exhaust gas boiler with 1.6 in wc from cain.
3. Existing Wartsila exhaust silencer documentation indicates silencer has 1.54" wc pressure drop. Ref to wartsila drawing daab464054_-_3es2663.pdf
4. Wartsila exhaust gas maximum backpressure allowed per specifications 12" wc

Electric Power Systems inc.
Consulting Engineers

Project Title: City of Unalaska - Powerhouse Renovation	
Subject: Exhaust Backpressure Calculation - exhaust boiler check	
By: WBT	Checked:
Date: 9/11/2012	Sheet ____ of ____

6.3 Cost Estimate

Electric Power Systems, Inc.
3305 Arctic Blvd.
Suite 201
Anchorage, AK 99503

Proposal

PHONE: 907-522-1953
FAX 907-522-1182
Email: wtaylor@epsinc.com

Description - Materials	**Quantity**		**Unit**	**Cost**	**Total**
Building Plumbing	1		lot	$0.00	$0.00
Not Used	1		lot	$0.00	$0.00
			Building HVAC & Plumbing Materials		*$0.00*
Mechanical System	1		lot	$1,273,583.34	$1,273,583.34
Electrical System Installation	1		lot	$57,074.50	$57,074.50
Not Used	1		lot	$0.00	$0.00
Not Used	1		lot	$0.00	$0.00
Not Used	1		lot	$0.00	$0.00
Not used	1		lot	$0.00	$0.00
Not Used	1		lot	$0.00	$0.00
Not Used	1		lot	$0.00	$0.00
Not Used	1		lot	$0.00	$0.00
			Generation Mechanical Materials:		*$1,330,657.84*
				Materials Subtotal:	**$1,330,657.84**
Description - Labor	**Quantity**		**Unit**		**Total**
Building Plumbing	0		Hours		$0.00
Not Used	0		Hours		$0.00
Building HVAC & Plumbing Labor	*0*		*Hours*		*$0.00*
Mechanical System	1669		Hours		$241,733.38
Electrical System Installation	387		Hours		$71,653.05
Not Used	0		Hours		$0.00
Not Used	0		Hours		$0.00
Not Used	0		Hours		$0.00
Not used	0		Hours		$0.00
Not Used	0		Hours		$0.00
Not Used	0		Hours		$0.00
Not Used	0		Hours		$0.00
Mechanical Labor Sub total	*2056*		*Hours*		*$313,386.43*
Labor Hours Total:	*2056*			**Labor Cost Total:**	**$313,386.43**
Incidental Items to Project					
Material procurement & consolidation	Percent of Material Subtotal			(3%)	$39,919.74
Insurance	Percent of Material Subtotal			(1%)	$13,306.58
Bond	Percent of Material & Labor			(3%)	$49,321.33
Contingency	Percent of Material & Labor Subtotal			(33%)	
Certified Payroll	Percent of Labor Subtotal			(1%)	$3,133.86
Profit	Percent of Material & Labor Subtotal			(10%)	
Overhead	Percent of Material & Labor Subtotal			(18%)	
Equipment	1		Lot	$ -	$0.00
Tools	1		Lot	$ -	$0.00
Freight	1		$/lb	58,636	$75,053.75
Startup, Commissioning, Testing	1		Lot	$ -	$0.00
Submittal/O&M Manuals - Eng	1		Lot		$0.00
As-built - Eng	1		Lot		$0.00
HVAC/Plumbing Per Diem	0		Day	$ 245.00	$0.00
Mechanical Per Diem (10hr/day)	206		Day	$ 245.00	$64,601.60
Engineering (Design/Construction)					$0.00
				Subtotal	**$245,336.85**
Total incidental items					**$245,336.85**
Total materials					**$1,330,657.84**
Labor Hours					**$313,386.43**
Owner Furnished Materials					
Owner Furnished Equipment & Fuel					
				Total	**$1,889,381.12**

Item	Description	Quantity	Com. Type	Material Unit Cost	Labor (Hr)	Unit Weight	Labor Cost (per hour)	Material Total	Labor Hours	Labor Total	Sub Total	Profit Materials	Overhead Materials	Contingency Material	Material Loaded Sub Total	Profit Labor	Overhead Labor	Contingency Labor	Labor Loaded Sub Total	Construction Sub Total
	Mechanical System											10%	18%	33%		10%	18%	33%		
1	Electratherm (50kW each,at 100 lbs per kW)	3	ea.	$ 212,816.00	40	5000	$ 89.99	$ 638,448.00	120	$ 10,798.56	*$ 649,246.56*	$ 63,844.80	$ 114,920.64	$ 210,687.84	*$ 1,027,901.28*	$ 1,079.86	$ 1,943.74	$ 3,563.52	*$ 17,385.68*	$ 1,045,286.96
2	4" piping (CS ASTM A53, std sch)	400	ft	$ 31.84	1	10	$ 89.99	$ 12,736.00	400	$ 35,995.20	*$ 48,731.20*	$ 1,273.60	$ 2,292.48	$ 4,202.88	*$ 20,504.96*	$ 3,599.52	$ 6,479.14	$ 11,878.41	*$ 57,952.26*	$ 78,457.22
3	4" flexible connector (Teguflex W/ Vanstone Flanges) Jacket Water	6	ea.	$ 337.78	1	10.79	$ 89.99	$ 2,026.68	6	$ 539.93	*$ 2,566.61*	$ 202.67	$ 364.80	$ 668.80	*$ 3,262.95*	$ 53.99	$ 97.19	$ 178.18	*$ 869.28*	$ 4,132.24
4	4" ANSI class 150 RF WN Flange	30	ea.	$ 37.00	3	7	$ 89.99	$ 1,110.00	90	$ 8,098.92	*$ 9,208.92*	$ 111.00	$ 199.80	$ 366.30	*$ 1,787.10*	$ 809.89	$ 1,457.81	$ 2,672.64	*$ 13,039.26*	$ 14,826.36
5	4" Bolt & Gasket set	30	ea.	$ 9.34	0.5	4	$ 89.99	$ 280.05	15	$ 1,349.82	*$ 1,629.87*	$ 28.01	$ 50.41	$ 92.42	*$ 450.88*	$ 134.98	$ 242.97	$ 445.44	*$ 2,173.21*	$ 2,624.09
6	4" 90 Deg Ell (CS, butt weld, std sch, long radius)	34	ea.	$ 30.00	4	5	$ 89.99	$ 1,020.00	136	$ 12,238.37	*$ 13,258.37*	$ 102.00	$ 183.60	$ 336.60	*$ 1,642.20*	$ 1,223.84	$ 2,202.91	$ 4,038.66	*$ 19,703.77*	$ 21,345.97
7	4" butterfly valve (lugged, end service, ANSI 150, Buna N)	8	ea.	$ 225.30	1.5	10	$ 89.99	$ 1,802.40	12	$ 1,079.86	*$ 2,882.26*	$ 180.24	$ 324.43	$ 594.79	*$ 2,901.86*	$ 107.99	$ 194.37	$ 356.35	*$ 1,738.57*	$ 4,640.43
8	Glycol: Ethylene (Straight)	4	55gal	$ 623.15	1	440	$ 89.99	$ 2,492.60	4	$ 359.95	*$ 2,852.55*	$ 249.26	$ 448.67	$ 822.56	*$ 4,013.09*	$ 36.00	$ 64.79	$ 118.78	*$ 579.52*	$ 4,592.61
9	Grout	1	lot	$ 1,000.00	24	1000	$ 89.99	$ 1,000.00	24	$ 2,159.71	*$ 3,159.71*	$ 100.00	$ 180.00	$ 330.00	*$ 1,610.00*	$ 215.97	$ 388.75	$ 712.70	*$ 3,477.14*	$ 5,087.14
10	6"x4" Tee (CS, butt weld, std sch)	8	ea.	$ 90.00	6	8	$ 89.99	$ 720.00	48	$ 4,319.42	*$ 5,039.42*	$ 72.00	$ 129.60	$ 237.60	*$ 1,159.20*	$ 431.94	$ 777.50	$ 1,425.41	*$ 6,954.27*	$ 8,113.47
11	Pipe Support	1	lot	$ 15,000.00	150	35	$ 89.99	$ 15,000.00	150	$ 13,498.20	*$ 28,498.20*	$ 1,500.00	$ 2,700.00	$ 4,950.00	*$ 24,150.00*	$ 1,349.82	$ 2,429.68	$ 4,454.41	*$ 21,732.10*	$ 45,882.10
12	6" AMOT Control Valve	1	ea.	$ 8,000.00	6	250	$ 89.99	$ 8,000.00	6	$ 539.93	*$ 8,539.93*	$ 800.00	$ 1,440.00	$ 2,640.00	*$ 12,880.00*	$ 53.99	$ 97.19	$ 178.18	*$ 869.28*	$ 13,749.28
13	6" piping (CS ASTM A53, std sch)	30	lf	$ 95.00	1	35	$ 89.99	$ 2,850.00	30	$ 2,699.64	*$ 5,549.64*	$ 285.00	$ 513.00	$ 940.50	*$ 4,588.50*	$ 269.96	$ 485.94	$ 890.88	*$ 4,346.42*	$ 8,934.92
14	6" ANSI class 150 RF WN Flange	20	ea.	$ 65.00	3	4	$ 89.99	$ 1,300.00	60	$ 5,399.28	*$ 6,699.28*	$ 130.00	$ 234.00	$ 429.00	*$ 2,093.00*	$ 539.93	$ 971.87	$ 1,781.76	*$ 8,692.84*	$ 10,785.84
15	6" Bolt & Gasket set (CS)	24	ea.	$ 5.50	0.5	4	$ 89.99	$ 132.00	12	$ 1,079.86	*$ 1,211.86*	$ 13.20	$ 23.76	$ 43.56	*$ 212.52*	$ 107.99	$ 194.37	$ 356.35	*$ 1,738.57*	$ 1,951.09
16	6" 90 Deg Ell (CS, butt weld, std sch, long radius)	10	ea.	$ 54.00	4	2	$ 89.99	$ 540.00	40	$ 3,599.52	*$ 4,139.52*	$ 54.00	$ 97.20	$ 178.20	*$ 869.40*	$ 359.95	$ 647.91	$ 1,187.84	*$ 5,795.23*	$ 6,664.63
17	6" butterfly valve (lugged, end service, ANSI 150, Buna N)	3	ea.	$ 220.00	1.5	2	$ 89.99	$ 660.00	5	$ 404.95	*$ 1,064.95*	$ 66.00	$ 118.80	$ 217.80	*$ 1,062.60*	$ 40.49	$ 72.89	$ 133.63	*$ 651.96*	$ 1,714.56
18	6" HDPE Pipe	250	lf	$ 6.81	0.5	1	$ 89.99	$ 1,702.50	125	$ 11,248.50	*$ 12,951.00*	$ 170.25	$ 306.45	$ 561.83	*$ 2,741.03*	$ 1,124.85	$ 2,024.73	$ 3,712.00	*$ 18,110.08*	$ 20,851.11
19	6" HDPE 90 Deg Ell	20	ea.	$ 39.46	3	400	$ 89.99	$ 789.20	60	$ 5,399.28	*$ 6,188.48*	$ 78.92	$ 142.06	$ 260.44	*$ 1,270.61*	$ 539.93	$ 971.87	$ 1,781.76	*$ 8,692.84*	$ 9,963.45
20	6" HDPE Flange	32	ea.	$ 63.88	1	5	$ 89.99	$ 2,044.16	32	$ 2,879.62	*$ 4,923.78*	$ 204.42	$ 367.95	$ 674.57	*$ 3,291.10*	$ 287.96	$ 518.33	$ 950.27	*$ 4,636.18*	$ 7,927.28
21	6" HDPE Butterfly Valve	8	ea.	$ 843.00	2	25	$ 89.99	$ 6,744.00	16	$ 1,439.81	*$ 8,183.81*	$ 674.40	$ 1,213.92	$ 2,225.52	*$ 10,857.84*	$ 143.98	$ 259.17	$ 475.14	*$ 2,318.09*	$ 13,175.93
22	6" Bolt & Gasket set (HDPE)	20	ea.	$ 10.00	0.5	4	$ 89.99	$ 200.00	10	$ 899.88	*$ 1,099.88*	$ 20.00	$ 36.00	$ 66.00	*$ 322.00*	$ 89.99	$ 161.98	$ 296.96	*$ 1,448.81*	$ 1,770.81
23	Airfare	12	ea.	$ 1,100.00	0	50	$ 89.99	$ 13,200.00	0	$ -	*$ 13,200.00*	$ 1,320.00	$ 2,376.00	$ 4,356.00	*$ 21,252.00*	$ -	$ -	$ -	*$ -*	$ 21,252.00
24	insulation	1	lot	$ 12,000.00	60	1000	$ 89.99	$ 12,000.00	60	$ 5,399.28	*$ 17,399.28*	$ 1,200.00	$ 2,160.00	$ 3,960.00	*$ 19,320.00*	$ 539.93	$ 971.87	$ 1,781.76	*$ 8,692.84*	$ 28,012.84
25	8" HDPE Pipe	200	ea.	$ 10.29	0.5	5	$ 89.99	$ 2,058.00	100	$ 8,998.80	*$ 11,056.80*	$ 205.80	$ 370.44	$ 679.14	*$ 3,313.38*	$ 899.88	$ 1,619.78	$ 2,969.60	*$ 14,488.07*	$ 17,801.45
26	8" HDPE 90 Deg Ell	20	ea.	$ 53.74	3	20	$ 89.99	$ 1,074.80	60	$ 5,399.28	*$ 6,474.08*	$ 107.48	$ 193.46	$ 354.68	*$ 1,730.43*	$ 539.93	$ 971.87	$ 1,781.76	*$ 8,692.84*	$ 10,423.27
27	8" HDPE Flange	10	ea.	$ 90.00	1.5	20	$ 89.99	$ 900.00	15	$ 1,349.82	*$ 2,249.82*	$ 90.00	$ 162.00	$ 297.00	*$ 1,449.00*	$ 134.98	$ 242.97	$ 445.44	*$ 2,173.21*	$ 3,622.21
28	8" HDPE Butterfly Valve	4	ea.	$ 843.00	2	40	$ 89.99	$ 3,372.00	8	$ 719.90	*$ 4,091.90*	$ 337.20	$ 606.96	$ 1,112.76	*$ 5,428.92*	$ 71.99	$ 129.58	$ 237.57	*$ 1,159.05*	$ 6,587.97
29	8" Bolt & Gasket set (HDPE)	10	ea.	$ 15.00	0.5	4	$ 89.99	$ 150.00	5	$ 449.94	*$ 599.94*	$ 15.00	$ 27.00	$ 49.50	*$ 241.50*	$ 44.99	$ 80.99	$ 148.48	*$ 724.40*	$ 965.90
30	Consumables	1	lot	$ 10,000.00	20	5000	$ 89.99	$ 10,000.00	20	$ 1,799.76	*$ 11,799.76*	$ 1,000.00	$ 1,800.00	$ 3,300.00	*$ 16,100.00*	$ 179.98	$ 323.96	$ 593.92	*$ 2,897.61*	$ 18,997.61
31	Crane	1	months	$ 8,000.00	0	16000	$ 89.99	$ 8,000.00	0	$ -	*$ 8,000.00*	$ 800.00	$ 1,440.00	$ 2,640.00	*$ 12,880.00*	$ -	$ -	$ -	*$ -*	$ 12,880.00
32	Camp Days (4 man crew, 10 hours per day)	179.135	days	$ 216.00	0		$ 89.99	$ 38,693.16	0	$ -	*$ 38,693.16*	$ 3,869.32	$ 6,964.77	$ 12,768.74	*$ 62,295.99*	$ -	$ -	$ -	*$ -*	$ 62,295.99
33							$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
34							$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
35							$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
36							$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
37							$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
38							$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
39							$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
40							$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
41							$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
42							$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
43								$ -	0			$ -	$ -	$ -	*$ -*					
							Section Totals:	$ 791,045.55	1,669	$ 150,144.96	***$ 941,190.51***	$ 79,104.56	$ 142,388.20	$ 261,045.03	***$ 1,273,583.34***	$ 15,014.50	$ 27,026.09	$ 49,547.84	***$ 241,733.38***	$ 1,515,316.72
	Electrical System Installation																			
1	Power cable, 350 MCM CU, XHHW-2, 3 conductor w/ground, Corrugatec	200	ft.	$ 30.00	0.5	4.8	$ 115.00	$ 6,000.00	100	$ 11,500.00	*$ 17,500.00*	$ 600.00	$ 1,080.00	$ 1,980.00	*$ 9,660.00*	$ 1,150.00	$ 2,070.00	$ 3,795.00	*$ 18,515.00*	$ 28,175.00
2	Cable Tray System (includes support system and tray)	1	ea.	$ 3,000.00	32	150	$ 115.00	$ 3,000.00	32	$ 3,680.00	*$ 6,680.00*	$ 300.00	$ 540.00	$ 990.00	*$ 4,830.00*	$ 368.00	$ 662.40	$ 1,214.40	*$ 5,924.80*	$ 10,754.80
3	Core Drilling Through Floor and Wall	2	ea.	$ -	2	0	$ 115.00	$ -	4	$ 460.00	*$ 460.00*	$ -	$ -	$ -	*$ -*	$ 46.00	$ 82.80	$ 151.80	*$ 740.60*	$ 740.60
4	Terminating Cable Ends	6	ea.	$ 50.00	1	3.33333	$ 115.00	$ 300.00	6	$ 690.00	*$ 990.00*	$ 30.00	$ 54.00	$ 99.00	*$ 483.00*	$ 69.00	$ 124.20	$ 227.70	*$ 1,110.90*	$ 1,593.90
5	Conduit System (bushings, seal-tite, floor/wall sleeves, fire stopping, etc.)	1	ea.	$ 2,000.00	24	400	$ 115.00	$ 2,000.00	24	$ 2,760.00	*$ 4,760.00*	$ 200.00	$ 360.00	$ 660.00	*$ 3,220.00*	$ 276.00	$ 496.80	$ 910.80	*$ 4,443.60*	$ 7,663.60
6	Grounding (bonding jumpers, ground grid connections)	1	ea.	$ 150.00	12	10	$ 115.00	$ 150.00	12	$ 1,380.00	*$ 1,530.00*	$ 15.00	$ 27.00	$ 49.50	*$ 241.50*	$ 138.00	$ 248.40	$ 455.40	*$ 2,221.80*	$ 2,463.30
7	Demolition of Unit #2	1	ea.	$ -	80	0	$ 115.00	$ -	80	$ 9,200.00	*$ 9,200.00*	$ -	$ -	$ -	*$ -*	$ 920.00	$ 1,656.00	$ 3,036.00	*$ 14,812.00*	$ 14,812.00
8	Mob/Demob	1	ea.	$ 15,000.00	120	0	$ 115.00	$ 15,000.00	120	$ 13,800.00	*$ 28,800.00*	$ 1,500.00	$ 2,700.00	$ 4,950.00	*$ 24,150.00*	$ 1,380.00	$ 2,484.00	$ 4,554.00	*$ 22,218.00*	$ 46,368.00
9	Per Diem (lodging, meals, incidentals)	3	ea.	$ 3,000.00	3	0	$ 115.00	$ 9,000.00	9	$ 1,035.00	*$ 10,035.00*	$ 900.00	$ 1,620.00	$ 2,970.00	*$ 14,490.00*	$ 103.50	$ 186.30	$ 341.55	*$ 1,666.35*	$ 16,156.35
10							$ 115.00	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
11							$ 115.00	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
12							$ 115.00	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
13							$ 115.00	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
14							$ 115.00	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
15							$ 115.00	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
16							$ 115.00	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
17							$ 115.00	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
18							$ 115.00	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
19							$ 115.00	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
20							$ 115.00	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
21							$ 115.00	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
22							$ 115.00	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
							Section Total:	$ 35,450.00	387	$ 44,505.00	***$ 79,955.00***	$ 3,545.00	$ 6,381.00	$ 11,698.50	***$ 57,074.50***	$ 4,450.50	$ 8,010.90	$ 14,686.65	***$ 71,653.05***	$ 128,727.55
	Not Used																			
1			ea.			1	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
2			ea.			1.5	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
3			ea	$ 86.00	0.5	0.5	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
4			ea.	$ 7.00	0.5	0.25	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
5			ea	$ 22.00	0.5	0.25	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
6			ft	$ 2.27	0.05	0.2	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
7			ft	$ 1.95	0.25	1.68	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
8			ea.	$ 40.00	0.5	2	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
9			ea.	$ 75.00	1	4	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
10			ea.	$ 8.00	1.25	3	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
11			ea.	$ 6.00	1	2	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
12			ea.	$ 32.00	1	2	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
13			ft	$ 3.05	0.25	2.72	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
14			ea.	$ 50.00		5	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
15			ea.	$ 40.00	0.5	3	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
16			ea.	$ 82.00	0.5	3	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
17			ea.	$ 33.00	0.5	2	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
18			ea.	$ 30.00	0.5	1	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
19			ft.	$ 1.35	0.25	1.13	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
20			ea.	$ 45.00	0.5	4	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
21							$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
22			ea.	$ 38.00	1	9	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
23			ea		6		$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
24							$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
25							$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
26			ea.	$ 1,152.00	6		$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
27			ea.	$ 2,000.00	1.5		$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
28			ea	$ 82.00	0.5	3	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
29			ea		6		$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
30			ea.		6		$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
							Section Total:	$ -	0	$ -	***$ -***	$ -	$ -	$ -	***$ -***	$ -	$ -	$ -	***$ -***	$ -
	Not Used																			
1			ea		0.5		$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -
2			ea	$ 49.00	1.75	13	$ 89.99	$ -	0	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -	$ -	$ -	*$ -*	$ -

wage class		Straight JW	Straight FM	Straight GEN FM	Overtime JW	Overtime FM	Overtime GEN FM
		35.58	40.03	44.03		1.5	
JW		$36.65	$41.23	$45.35	$54.97	$61.85	$68.03
H&W		$7.72	$7.72	$7.72	$7.72	$7.72	$7.72
AK Pension		$6.80	$6.80	$6.80	$6.80	$6.80	$6.80
National Pension		$0.85	$0.85	$0.85	$0.85	$0.85	$0.85
367 Supp 401K		$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
Training Fund		$1.50	$1.50	$1.50	$1.50	$1.50	$1.50
Contract Admin		$0.20	$0.20	$0.20	$0.20	$0.20	$0.20
Total APTL 367 Contract Costs		$53.97	$58.55	$62.67	$72.29	$79.17	$85.35
SS	6.20%	$2.27	$2.56	$2.81	$3.41	$3.83	$4.22
Medicare	1.45%	$0.53	$0.60	$0.66	$0.80	$0.90	$0.99
FUTA	0.80%	$0.29	$0.33	$0.36	$0.44	$0.49	$0.54
SUTA	4.00%	$1.47	$1.65	$1.81	$2.20	$2.47	$2.72
Worker's Comp	13.57%	$4.97	$5.60	$6.15	$4.97	$5.60	$6.15
Liability	3.13%	$1.15	$1.29	$1.42	$1.15	$1.29	$1.42
Hiring Hall Dues	5.00%	$1.83	$2.06	$2.27	$1.83	$2.06	$2.27
Travel	5.00%	$1.83	$2.06	$2.27	$1.83	$2.06	$2.27
Fuel	3.00%	$1.10	$1.24	$1.36	$1.10	$1.24	$1.36
Small Tools	10.00%	$3.66	$4.12	$4.54	$3.66	$4.12	$4.54
Total indirect Costs		$19.11	$21.50	$23.65	$21.39	$24.07	$26.47

		JM	FM	Gen FM
40	hr week (ST)	$ 73.08	$ 80.05	$ 86.32
50	hr week (1.5)	$ 77.20	$ 84.69	$ 91.42
60	hr week (1.5)	$ 79.95	$ 87.78	$ 94.82
70	hr week (1.5)	$ 81.91	$ 89.99	$ 97.25
	Profit	10%	Overhead	18%
40	hr week (ST) + O & P	$ 93.54	$ 102.47	$ 110.49
50	hr week (1.5)+ O & P	$ 98.82	$ 108.40	$ 117.02
60	hr week (1.5)+ O & P	$ 102.33	$ 112.36	$ 121.37
70	hr week (1.5)+ O & P	$ 104.84	$ 115.18	$ 124.48

JM	3
FM	4
Gen FM	5

6.4 Cutsheets, Quotes, Resumes

AALBORG
INDUSTRIES

High and consistent performance
Comprehensive design and engineering know-how – reinforced by advanced production technology and ISO 9001 quality assurance systems – guarantee the high quality of our products and reliable, short delivery times.

More than 75 years of know-how in development, production and world-wide marketing and support of advanced steam systems make Aalborg Industries one of the leading suppliers of waste heat recovery systems in the world.

For further information please contact any local Aalborg Industries subsidiary.

Visit our Internet web site:
www.aalborg-industries.com

Product Centre:
Aalborg Industries Oy
P. O. Box 9,
FIN-26101 Rauma, Finland
Tel. +358 2 838 3100
Fax +358 2 823 1133
E-mail: rau@aalborg-industries.fi
http://www.aalborg-industries.com

Your contacts:

- UK: Tel. +44 1904 557640
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- Singapore: Tel. +65 261 9898
- Indonesia: Tel. +62 21 461 0569
- Turkey: Tel. +90 212 265 7674
- Denmark: Tel. +45 99 30 40 00
- Japan: Tel. +81 78 271 5720
- USA: Tel. +1 814 897 7000

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AALBORG
INDUSTRIES

Diesel Engine
Exhaust Gas Boiler

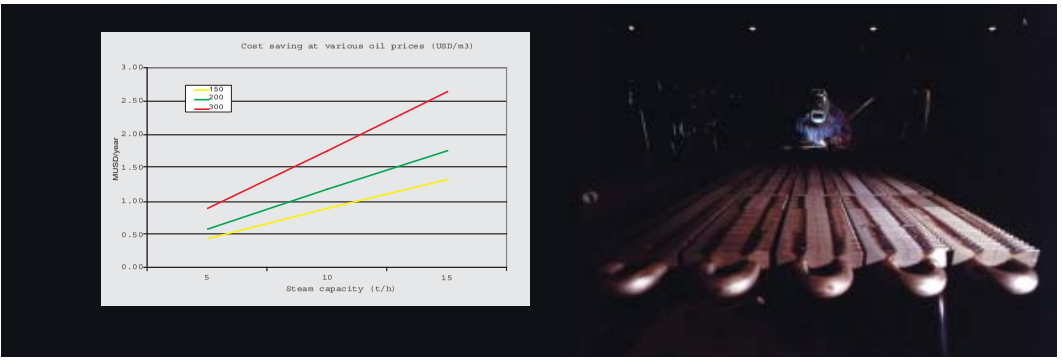
AV-6N

AV-6N is a robust, highly efficient water tube boiler, designed to improve your plant's total efficiency by recovering the heat from the exhaust gas of diesel engines. The AV-6N boiler is flexible and easy to install - even in existing facilities.

In addition to traditional forced circulation AV-6N exhaust gas boiler is available also as a natural circulation model.

AV-6N

Reliable and cost-effective operation



Waste heat recovery

AV-6N is the optimum solution for high-performance heat recovery systems.

Designed with extended heating surface, the AV-6N is compact and cost-effective. The possibility of cleaning during operation minimises the need for engine shutdowns and increases overall plant availability.

Unique boiler construction by Aalborg Industries

A unique supporting arrangement without end plates - enhanced by computerised analyses - ensures a vibration- and themal stress-free boiler construction.

Natural circulation

In addition to traditional forced circulation boilers, Aalborg Industries offers a reliable natural circulation solution.

Natural circulation without circulation water pumps gives the following advantages:

- Reliability
- Less power consumption
- Cost effectiveness
- Fast site installation
- Reduced foundation work and minimised piping and cabling
- Minimal foot print

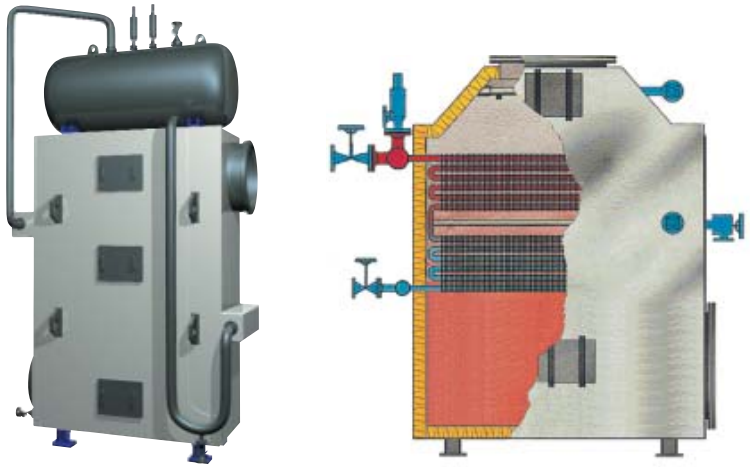
Easy to clean

The tube arrangement of the AV-6N boiler's heating surface ensures easy maintenance and service. AV-6N boilers can be cleaned during operation, reducing the need for engine shut-down. In addition to standard steam soot blowers, water and air can also be applied.

Years of experience

Aalborg Industries has a long experience with waste heat recovery, and devotes constant attention to development and innovation within this area.
We have installed a large number of boilers and heat exchangers, and we have a large team of experienced service experts who will provide quick response on any request.

Suitable for all applications



Typical examples of AV-6N boilers for Natural circulation and Forced circulation

Customer benefits with AV-6N:

- Compact heating surface, specially designed for diesel applications
- Vibration resistant
- Shop assembled
- Easy to clean on flue gas side due to in-line configuration and parallel fins
- Short delivery time
- High efficiency
- Natural or forced circulation
- Proven design
- Many references
- Tailor-made for specific requirements
- Small foot print
- Low weight

Technical data for AV-6N
Gas amount: No limits
Gas temperature: Norm. < 400°C. Up to 530°C in standard execution
Pinch point: Norm. 15-20°C. Min. 5°C, limited by feasibility only
Design pressure: Norm. < 25barg. Max. 80barg in standard execution
Steam temperature: Up to 400°C in standard execution
Circulation: Forced or natural
Tubes: Double gilled fin tubes

Suitable for all applications

There are no restrictions neither on pressure nor on capacity in practical diesel power plant applications. Small water volume inside the boiler allows it to respond quickly to load changes.
AV-6N can handle large capacities and is applicable in all types of plant.

Bankers:
J.P Morgan Chase Bank
Branch 741995
ABA: 267084131
Swift: CHASUS33
Account: 975899048

Alfa Laval Aalborg, Inc.
3118 Commerce Parkway
Miramar, FL 33025, USA
http://www.aalborg-industries.com

QUOTATION

Company: Electric power systems
Attn.: Bob Whealy
Email.: bwhealy@epsinc.com
Pages Incl. this: 4 +T&C's

Ref: **RQ 12-322589**
Email: info.florida@alfalaval.com
Tel: (954) 435 5999
Fax: (954) 435 5490
Date:Wednesday, October 03, 2012

Dear Sir(s)

With reference to your inquierie for the waste heat recovery project in Alaska, we are pleased to quote a budgetary price as follows.

Scope of supply

Alfa Laval Aalborg (hereafter ALA) will design and manufacture the following main items related to the exhaust gas heat recovery system after gas engine for purpose of hot water generation based on the received input data from buyer.

Note:

The scope of supply includes all necessary valves and fittings for the main items of the system according to Alfa Laval Aalborg standard solution.

Connection pipes and cables between items are assumed to be customers delivery if not other wise stated in the following summary.

Item 1: **2 PCs exhaust gas boilers Unex AV-6N for Wartsila 12V32 Engine.**

- ✓ For heat transfer from exhaust gas to 50% water/inhibited propylene glycol solution (heat transfer fluid is assumed to be customer delivery)
- ✓ Horizontal 1.draft type smoke tube boiler
- ✓ Including insulation
- ✓ Including inlet and outlet boxes
- ✓ Including exhaust gas counter flanges
- ✓ Including valves and fittings, according to ALA standards
- ✓ Including automatic rake type pressure air sootblower (compressed air for the soot blowing system from clients system)
- ✓ **Output @100% engine load 7627MBtu/Hr (2235 Kw)**
- ✓ Detailed performance values at 100%/75%/50% in attached Excel sheets

Item 2: **Exhaust gas boiler Unex AV-6N for CAT C280-16 engine**

- ✓ For heat transfer from exhaust gas to 50% water and 50% inhibited propylene glycol solution (heat transfer fluid is assumed to be customers delivery)
- ✓ Horizontal 1.draft type smoke tube boiler
- ✓ Including insulation
- ✓ Including inlet and outlet boxes
- ✓ Including exhaust gas counter flanges
- ✓ Including valves and fittings, according to ALA standards
- ✓ Including automatic rake type pressure air sootblower (compressed air for the soot blowing system from clients system)
- ✓ **Output @100% engine load 5706 MBtu/Hr (1672 Kw)**
- ✓ Detailed performance values at 100%/75%/50% in attached Excel sheets

Budgetay price for above descripted delivery is **US$ 705.600/-**

Conditions:

Payment terms : 30% upon order, 20% after one month progress, balance before delivery

Delivery : Exhaust gas boiler ex works Vietnam other equipment ex Rauma Finland

Delivery time : 6 Months +/- 2 months to be agreed upon

Cancelation clause

ALA is entitled for full compensation of all raised material, manufacturing,engineering and administration cost in the event that the project or any parts of it is cancelled or considerably postponed or the contract is terminated. All such cost will be paid by buyer. In this event ownership of those materials will shift to buyer.

Classification

All pressurized parts are designed, manufactured and inspected according to the requirements as per ASME, marking is included for pressure vessels

Warranty

The warranty time granted to units and components under alfa Laval Aalborg scope of supply is 12 vmonths after commissioning, however maximum 18 months calculated from the time of delivery.

The validity of the waaranty and guaranteed performance presumes that all instructions and common carefulness are followed at any time and that only educated service personel is used.

The warranty/guarantee does not apply to exhaust gas explosions or for mechanical parts which can be regarded as normal consumable spare parts nor breakage due to defective use.

Supervision,commissioning, testing and site training.

The optional daily rate of one ALA service engineer or a local hired supervisor is US$ 1.950 for max 10 Hrs per day, same applies for waiting/travel days.

Validity : 3 months

Conditions otherwise according to the "Terms & Conditions" of Alfa Laval Aalborg , January 2012

Additional remarks to Alfa Laval Aalborg "Terms and Conditions" 2012

Delay:
In case of delay caused by Alfa Laval Aalborg, Alfa Laval Aalborg shall pay liquidated damages by * (0.5 percent for every week or part of week, however not in excess of *(7.5 percent).
In the event that maximum liquidated damages have accrued, the customer entitled to cancel the contact and claim compensation for any direct loss, which however cannot together with liquidated damages for non-performance exceed 15 per cent of the contract sum.
Apart from this, the customer has no other remedies.

Defects prior to delivery:
Alfa Laval Aalborg has a right and a duty to repair, in case this is not possible, the customer is entitled to cancel the contract and claim compensation for any direct loss suffered, provided Alfa Laval Aalborg has acted negligently. Any such compensation cannot, however exceed 15 per cent of the contract sum, including any liquidated damages for non-performance and DKK 10 Million at a maximum.
Apart from the above , the customer has no other remedies.

Defects during the warranty period:
Alfa Laval Aalborg a right and duty to repair. In case repair has not been made within a reasonable period, the customer is entitled subject to a prior written notice to let such repair be made at Alfa Laval Aalborg's account, though at the customer's own risk. Alfa Laval Aalborg shall pay all direct costs incidental thereto.
In case repair cannot be made , the customer is entitled to cancel the contract and claim compensation in accor dance with the rules stipulated above under" Defects prior to delivery"
Apart from the above , the customer has no other remedies.

Product Liability:
Unless other statutory provisions apply, the following shall govern Alfa Laval Aalborg's product liability:
Alfa Laval Aalborg shall be liable for personal injury only if it is proven that such injury was caused by negligence on the part of Alfa Laval Aalborg or others for whom Alfa Laval was responsible.
Alfa Lava Aalborg shall not be liable for damages to property occurring whilst Alfa Laval Aalborg products are in the customer's possession, nor shall Alfa Laval Aalborg be liable for damage to products manufactured by the customer or to products or services of which the customer's products form part.
In no event , Alfa Laval Aalborg's liability shall exceed DKK 10 Million.

The above limitations in Alfa Laval Aalborg's liability shall not apply where Alfa Laval Aalborg has been guilty of gross negligence.
If a claim for damages as described in this clause is lodhed by a third party against Alfa Laval Aalborg or the customer, that party shall forthwith inform the other party thereof in writing.

Alfa Laval Aalborg and the customer shall be obliged to let themselves be summoned by the court or arbitration tribunal hearing any claims for damages lodged against one of them on the basis of any allegedly caused by Alfa Laval Aalborg works or products.

Other damage, including third party liability:
For any other damage, including liability for personal injury and damage to property/third party, Alfa Laval Aalborg is only liable for direct damage up to a maximum amount of 15 per cent pf the contract sum and DKK 10 Million at a maximum.

The customer shall indemnify Alfa Laval Aalborg against any claims in excess of the maximum amount which may be claimed from Alfa Laval Aalborg.

Insurance:
The customer shall ensure that Alfa Laval Aalborg is co-insured in the customer's project insurance/hull insurance.

We trust our quotation is according to your requirements and should be pleased to be at your service with further information, if required

Yours sincerely
Alfa Laval Aalborg Inc

Marcel van de Rijt

Repair sales manager

Boelo Lussenburg

President

Terms & Conditions

Alfa Laval Aalborg

January 2012

1.0 Validity of these Terms and Conditions

1.1 An order for delivery of work, i.e. products, materials, services, equipment, tools, personnel, etc., from a company within the Alfa Laval group of companies, hereinafter referred to as AL, presupposes acceptance by the Buyer of these Terms and Conditions, regardless of the form in which the order is given. These Terms and Conditions are valid until otherwise notified to the Buyer by AL.

1.2 Price lists for service assistance, tools, etc. are subject to special terms and shall be enclosed with and form an integral part of these Terms and Conditions. In case of discrepancy between them, the price lists shall prevail.

1.3 These Terms and Conditions are divided into two main sections:

I GENERAL CONDITIONS, articles 2-8

II TERMS FOR ASSISTANCE BY AL'S PERSONNEL, articles 9-15

I GENERAL CONDITIONS

2.0 Invoicing

2.1 The invoice for the work will be forwarded as soon as possible after completion of AL's work and shall be paid by the Buyer within 30 days of the date of invoice.

2.2 Work or products delivered by AL shall remain the property of AL until paid for in full to the extent that the applicable law permits such retention of property.

2.3 If payment is not received on the due date, interest will be charged from that date until payment is effected. Interest shall be added to the invoiced amount on the basis of LIBOR for USD plus 6% p.a.

2.4 If the Buyer wishes to transfer the order to a third party, such transfer requires AL's prior acceptance. In this situation, the Buyer shall remain liable for payment to AL.

3.0 Delays

3.1 If AL is delayed in delivery or in the work for reasons caused solely or partly by the Buyer or any of his representatives, employees, officers, subcontractors, or agents, AL shall not only be allowed the necessary extra time but also compensation for extra costs that AL may incur.

3.2 If AL is delayed in delivery or in the work by its own fault, AL shall be liable for compensation or liquidated damages only if such written agreement has been stipulated directly in the Contract entered between AL and the Buyer. Liability for damages does not include consequential or indirect damages, irrespective of the nature of such damages. In no event shall the indemnity exceed 7.5% of the contract sum. The Buyer is not entitled to any other remedies and may not cancel the contract due to delays on the part of AL.

4.0 Liability against defects

4.1 All agreements shall be made on the basis of the limited liability provisions set forth herein. Other or more extensive liability, including the right to cancel a contract or claim damages beyond the extent stated herein, shall be valid only if a written agreement stating the nature and extent thereof has been entered before acceptance of delivery of the work and if the price is adjusted to include the costs of appropriate additional insurance or additional exposure.

4.2 AL's liability for defects in materials delivered shall be limited to procuring and supplying replacement materials free of charge.

4.3 For repair work and other work, AL's liability for defects shall be limited to repair of the defect in question. AL shall cover only the direct costs of labour and materials for such repair. AL disclaims any other cost, whether direct, indirect, consequential, or otherwise. Payment for travelling time, waiting time, travelling expenses, hotel, and meals shall be for the account of the Buyer and shall be invoiced accordingly.

4.4 AL shall be liable for damage only if caused by gross negligence or intent on the part of AL's personnel. AL's liability shall be limited to repair of the direct damage and shall cover neither consequential costs nor indirect loss, irrespective of the nature of such loss. In no event shall AL's aggregate liability arising out of a contract exceed the total value of the contract or the equivalent amount in local currency. In no event can the amount exceed the amount of the contract, the maximum being DKK 10 million.

The Buyer agrees to indemnify AL with respect to any liability in excess of this amount.

4.5 AL shall make its best effort to pass on to the Buyer all manufacturers' warranties for machinery and equipment procured by AL for the work. In no event shall AL's warranties/liability for machinery and equipment procured by AL be more extensive than the manufacturer's warranties.

4.6 Where ALA has merely supervised the commissioning of the equipment and has not carried out the installation/repair, ALA shall incur no liability in respect of damage caused by defects in connection with such installation/repair. ALA shall be liable only for damage directly related to gross negligence or intent on the part of ALA's personnel with a view to improper commissioning procedures.

4.7 AL assumes no liability for defective materials or workmanship, loss, or damage once the work has been accepted by the representative of the classification society or the Buyer. In no event shall ALA be liable unless the defective materials or workmanship are detected and presented to ALA in writing within thirty (30) days of the Buyer's detecting the defects, or the work has ceased for whatever reason, or products have been returned to ALA, whichever occurs first.

5.0 Force majeure

5.1 In case AL is hindered by an event of force majeure from carrying out the agreed work within the agreed time, then AL shall be allowed the necessary extra time from the point in time when the event of force majeure ceases. AL shall not be liable for loss, damage, or delay caused by an event of force majeure.

5.2 Force majeure shall be taken to include, but not be limited to, acts of God, strikes, lockouts, general disturbance, major traffic disturbance in international transportation, inclement weather conditions, and other circumstances beyond AL's control.

6.0 Product liability

6.1 Unless other statutory provisions apply, the following shall govern AL's product liability:

6.2 AL shall be liable for personal injury only if it is proved that such injury was caused by negligence on the part of AL or others for whom AL was responsible.

6.3 AL shall not be liable for damage to property occurring whilst AL's products are in the Buyer's possession. Nor shall AL be liable for damage to products manufactured by the Buyer or to products or services of which the Buyer's products form a part.

6.4 In no event shall AL be liable for loss of production, loss of profit, or any other consequential damages or indirect loss.

6.5 In no event shall AL's liability exceed DKK 10 million.

6.6 To the extent that AL incurs product liability to a third party, the Buyer shall indemnify AL as far as AL's liability has been limited by the four preceding paragraphs.

6.7 The above limitations in AL's liability shall not apply where AL has been guilty of gross misconduct.

6.8 If a claim for damages as described in this clause is lodged by a third party against AL or the Buyer, that party shall forthwith inform the other party thereof in writing.

6.9 AL and the Buyer shall be obliged to let themselves be summoned to the court or arbitration tribunal that examines claims for damages lodged against one of them on the

basis of damage allegedly caused by AL's work or products.

7.0 Disclaimer

7.1 AL disclaims any liability that is not covered by these Terms and Conditions. AL specifically disclaims all warranties of merchantability and fitness of AL's work or products for a particular purpose.

8.0 Venue and applicable law

8.1 All deliveries from AL shall be subject to CISG. Any dispute between the parties regarding a situation arising out of or in connection with an agreement governed by these Terms and Conditions shall be subject to the law of the country in which the contracting AL company is domiciled without giving effect to the principle of conflict of the laws thereof. Any dispute shall be settled by the commercial court of the country in which the contracting AL company is domiciled.

II TERMS FOR ASSISTANCE BY AL'S PERSONNEL

9.0 Working hours – time sheets

9.1 A normal week comprises 5 working days and 2 weekend days. A normal working day comprises 8 working hours, and hours exceeding 8 working hours shall be considered as overtime hours.

9.2 All working hours on weekend days and AL personnel's national holidays shall be considered as overtime hours.

9.3 AL personnel can only undertake working hours exceeding 12 hours per day or work on Sundays against the Buyer's representative's written approval. Reasons for overtime hours exceeding 12 hours per day and written approval shall be given on the time sheet.

9.4 The Buyer or his authorised representative is requested to follow the progress of the work closely.

9.5 Time sheets showing the time during which AL's personnel have carried out work for the Buyer shall be filled in daily and shall be countersigned by the chief engineer/work foreman or any other authorised representative of the Buyer.

9.6 If the Buyer's representative fails to countersign the time sheets, or if the representative does not approve of the time sheets that have been filled in by AL's personnel, the Buyer's representative or the Buyer himself shall immediately inform the AL company responsible for the job by telefax or E-mail of the reason for the refusal. If a time sheet has not been countersigned in accordance with this article, or if the Buyer has not given due notice of the unapproved time sheets to the relevant AL company, then AL shall be entitled to reject any objections regarding invoices based upon time charged to the Buyer.

9.7 The effective working time is defined as the time from the commencement of work by AL's personnel until they leave the job, less the time spent on meal breaks.

9.8 If AL's personnel are not provided accommodations on board a ship where they are carrying out a job, the working time starts at the time AL's personnel leave their hotel and ends at their return to the hotel.

10.0 Waiting time

10.1 Waiting time caused by lack of work due to circumstances beyond the control of AL's personnel shall be invoiced at the rate valid for normal working hours. AL's personnel are prepared to undertake other kinds of work than originally intended in order to compensate for waiting time.

10.2 Waiting time shall be charged daily between 8 a.m. and 8 p.m. A maximum of 10 hours of waiting time can be charged per day.

11.0 Allowances and travelling and transport expenses

11.1 Travelling, hotel, allowances, and other expenses paid by AL, including telephone calls, telefaxes, etc. shall be invoiced to the Buyer at cost plus 15% overhead charges.

11.2 Travelling time shall be invoiced at the rates for normal working hours with max. 12 hours/day.

11.3 Accommodation shall be of a reasonable standard.

12.0 Conditions when staying on board a ship, at a building site, or similar

12.1 Accommodation shall be of a reasonable standard. AL's personnel shall have access to shower with hot and cold water.

12.2 AL's personnel shall have purchasing facilities for daily requirements such as food, beverages, etc. AL's personnel shall have access to a refrigerator.

12.3 Payment for beverages etc. bought on board the ship or at the site should preferably be settled with AL's personnel before they leave.

13.0 Permits, licences, and certificates

13.1 It is the sole responsibility of the Buyer to advise and, whenever necessary, to obtain permissions, permits, passes, licences, or certificates from the appropriate authorities or classification societies for work to be carried out by AL.

14.0 Tools and equipment

14.1 If requested, AL shall supply tools and equipment, subject to a separate agreement.

14.2 Rental of tools from an AL company shall be charged from the day that the tools leave that company until they are received back at the same company.

14.3 After use, AL's tools shall be packed in AL's tool box(es) under the supervision of the Buyer or his representative. Any shortages, damage, etc. shall be noted and the tool box(es) locked.

14.4 The Buyer shall arrange for transportation of the tool box(es) to their point of origin. The Buyer shall arrange for insurance against loss or damage.

14.5 The tools shall be received by AL no later than 90 days after termination of the work. If the tools are not received within this time, they shall be considered lost and shall be charged to the Buyer. Damaged tools shall also be charged to the Buyer.

14.6 Upon request AL shall supply industrial gases at the Buyer's expense. If the Buyer does not specifically request AL to supply such gases, the Buyer shall be expected to supply them.

14.7 Provided no other arrangements are made, the following supplies and services are not included in AL's work and shall be made available to AL's personnel:

- Assistance for transport of materials to and from the work site.
- Necessary scaffolding.
- Overhead cranes, blocks, fall wires, and shackles.
- General assistance for cleaning, etc.
- Supplies of electricity, compressed air for working and personnel protection equipment, water and fuel, and necessary lighting.

15.0 The Buyer's liability and insurance

15.1 The Buyer shall pay compensation and indemnify AL in case of damage to AL's property or injury or death of personnel employed by AL or any third party when and to the extent that such injury or death is caused by the Buyer's negligence, whether direct or indirect. Such negligence may be constituted by lack of necessary instructions concerning the work to be carried out by AL's personnel.

15.2 The Buyer is obliged to inform AL on any material containing asbestos. AL cannot in any way, whatsoever, be held liable for the contents of any such material, including for any financial consequences thereof or consequences of safety or as regards time. The Buyer undertakes to indemnify AL for all costs, expenses and consequences caused by any such contents of asbestos.

EXHAUST HEAT RECOVERY

Gas & Diesel Cogeneration Systems

cain industries
heat recovery systems

Exhaust Steam Generator Series – ESG1

Heat Recovery Silencer Radial Series – HRSR

U-Tube Heat Recovery Series – UTR

Heat Recovery Silencer Axial Series – HRSA

"Manufacturing Waste Heat Transfer Products To Save Energy"

HEAT TRANSFER SYSTEMS FOR ENGINE EXHAUST RECOVERY

INTRODUCTION

This catalog covers the Cain Industries Product lines for the gas and diesel engines, gas turbines, and micro turbine generator retrofit applications. For these applications, we offer over 500 standard products to choose from, and can typically provide a comprehensive analysis and quotation to fit your exact needs within 24 hours. Our equipment can be adapted and assembled to fit any application or complete installation.

COGEN APPLICATIONS

- Hospitals
- Manufacturing Plants
- Schools
- Office Buildings
- Shopping Malls
- Drilling Platforms
- Oil & Gas Plants
- Marine

EQUIPMENT VARIETY

- Exhaust steam generators
- Large exhaust recovery silencers
- Smaller specialized exhaust recovery silencers
- Special heat transfer configurations
- Recirculating engine jacket water boilers

SYSTEM FUNCTION

Btu is transferred from the exhaust stream to heat sinks such as water, glycol, therminol fluids, or steam production. Suitable fuel types for combustion sources include natural gas, propane, digester gas, diesel fuel, and light to heavy fuel oils.

PROPOSAL CONSIDERATIONS

- Large or irregular exhaust connections
- High or varying exhaust temperatures
- Particular pinch point requirements
- Exhaust or liquid control
- Special heat sink requirements
- Special heat transfer metallurgy requirements
- Specific maintenance concerns
- Optional equipment requirements
- Installation space and weight concerns
- Package system requirements

ANTICIPATED RESULTS

- Tremendous fuel savings typically pay for equipment and installation within 1 to 3 years of average use.
- Pollution reduction due to lowered annual fuel usage.
- Lower exhaust temperatures and significantly reduced sound output levels (final sound attenuation is typically 15 - 25 dBA).

EXHAUST STEAM GENERATOR

The fully packaged ESG1 is selected from 48 pre-engineered standard models with output capabilities of 20 to 500 boiler hp and operating steam pressures from 3 to 450 psig. The ESG1 is shipped complete, ready for operating as either a primary or supplementary steam source.

The ESG1 package is made up of three basic sections:
- finned tube heat transfer section
- steam flash circulating drum assembly
- modulating full port exhaust bypass system

Full operating steam pressure from a cold start in less than 10 minutes.

OPERATION & CONTROL

The integral forced circulating water pump continually circulates high temperature water from the steam flash drum assembly to the heat transfer core assembly. Btu is transferred from the exhaust to a high flow superheated water/steam mixture. The super-heated water is returned to the steam drum which contains dry pipe, baffles, and lance assemblies, where it flashes into 99% dry stream as its exits out to the system.

As the water is generated into steam and exits the boiler, the modulating boiler feedwater system controls continuous feedwater flow for constant drum water level control. Fail safe controls are built in for full exhaust bypass in the event of electrical or pneumatic loss.

The steam pressure controller maintains the operating steam pressure as it controls the modulating exhaust bypass assembly. This provides solid operating steam pressure under various operating steam load demands.

Engine Exhaust Application

- Capacity: 400kW – 7MW
- Entering gas temps: 600 – 1,600°F
- Heat sink types: Supplemental steam demand and/or primary steam source for steam heating or process steam.

QUALITY CONTROL

The ESG1 is manufactured, tested, and stamped in accordance with the requirements of Section I of the ASME Boiler and Pressure Vessel Code, and National Board. Boiler trim includes all safety controls and alarms to meet state and federal codes. Final assembly, electrical wiring, and factory adjustments are completed under a strict set of guide lines.

OPTIONAL COMPONENTS

Automatic Sootblower
Sootblowers are available either as a manual push button start or fully automatic with timed sequencing. Sootblowers are considered when firing with fuel oil and/or incomplete combustion. Sootblowers are also considered when manual cleanings are not feasible in order to maintain peak performance.

Continuous Blowdown with Intermittent Conductivity Sampling Assembly
Maximize boiler efficiency by periodically sampling surface blowdown water and controlling total dissolved solids. Maintaining optimal levels of concentrations will control the costs of water, energy, and chemicals. Assembly includes: motorized valve, probe, and piping assembly.

Hinged Access Door for full heating surface inspection
Hinged access doors are considered when firing with fuel oil and/or incomplete combustion requiring full access on a regular basis for manual cleaning. A hinged access door can be incorporated for 100% finned tube viewing and attention.

FEATURES

The ESG1 is an easy choice when compared to the "old technology" of a conventional firetube boiler:

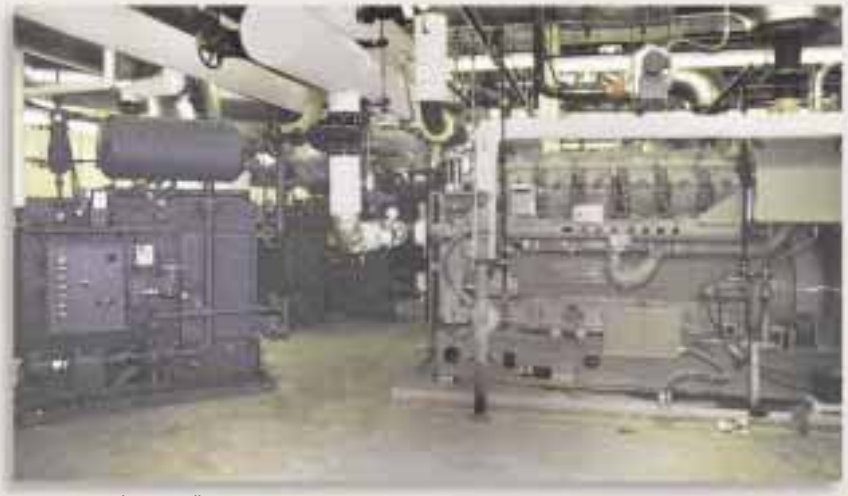
- Completely self-contained "package" design reduces engineering, installation and maintenance costs.
- Size requires only ½ the floor space and ½ the weight of conventional boilers, which reduces building size, structural support costs, and shipping costs.
- Ease of tube replacement requires no overhead cranes, special rigging, special crews, or extra roof height above the unit, while reducing down time.
- Many shapes and sizes are available to fit limited space and maintain performance requirements.
- Produces greater than 99% dry steam.
- Provides 100% turndown capability.
- 5–10 minute time from startup to full output.
- Integrated exhaust modulating bypass for safe automatic steam control.
- Explosion-proof heat transfer exchanger.
- Low friction loss for minimum static exhaust back pressure.
- High circulating flow to minimize scale buildup.
- No thermal expansion concerns with cold boiler feedwater.
- Performance aimed at the lowest pinch point in the industry, (final leaving exhaust temperature minus operating steam temperature) for maximum thermal efficiency.

MINIMUM CONNECTIONS

The ESG1 requires only the following connections for a cost effective installation:

- steam outlet
- exhaust flange inlet and outlet
- single main power
- single main blowdown
- feedwater inlet
- pneumatic control air
- cooling water inlet and outlet

Hospital, Renton, Washington
(4) Model ESG1-616B19CSS
Recovering Btu from (4) Jenbacher JMS-320, 900kW natural gas engines.
Reducing each 2,498 SCFM from 977°F to 392°F.
Delivering 1,863 pph steam @ 90 PSI operating (150 PSIG design).

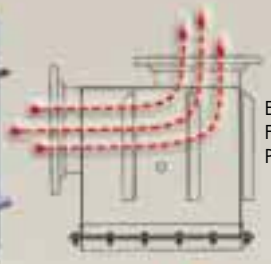


Hospital, Chicago, Illinois
(3) Model ESG1-616B18CSS.
Recovering Btu from (3) Waukesha 3516, 1,100kW natural gas engines.
Reducing each 2,392 SCFM from 1,135°F to 438°F.
Delivering 2,173 pph steam @130 PSI operating (150 PSIG design).

Water Purification Plant, Burlington, Ontario
Model ESG1-A12D18CSS
Recovering Btu from a Caterpillar 3516, 800kW natural gas engine. Reducing 2,382 SCFM from 770°F to 344°F.
Delivering 1,277 pph steam @130 PSI operating (150 PSIG design).

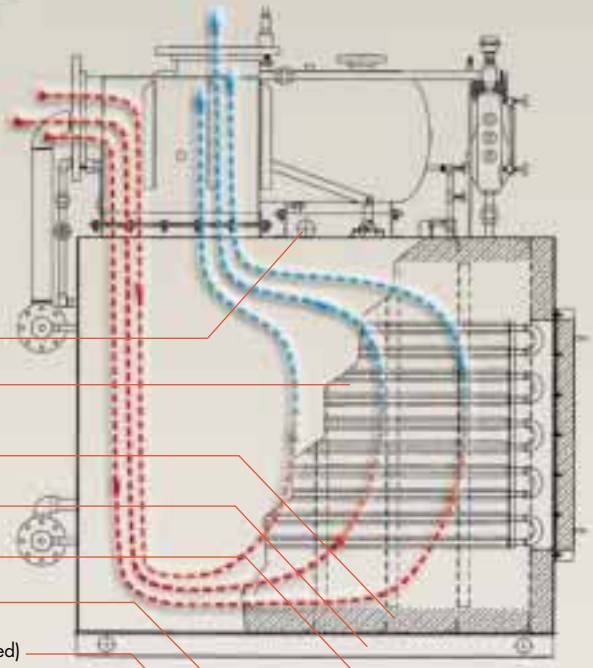
ESG1 SERIES
FOR: THE COMPLETE STEAM GENERATION PACKAGE

ASME & National Board stamped – Section 1

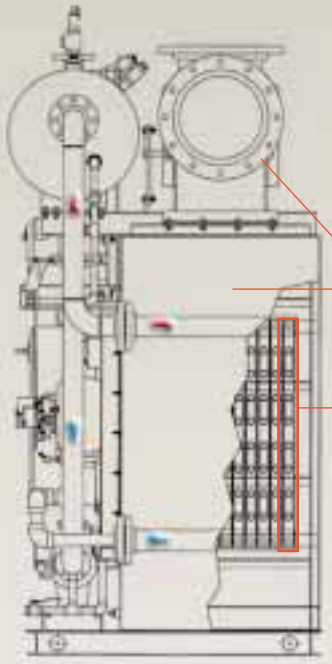


EXHAUST FLOW:
FULL BYPASS
POSITION

EXHAUST FLOW:
FULL OPERATING
POSITION

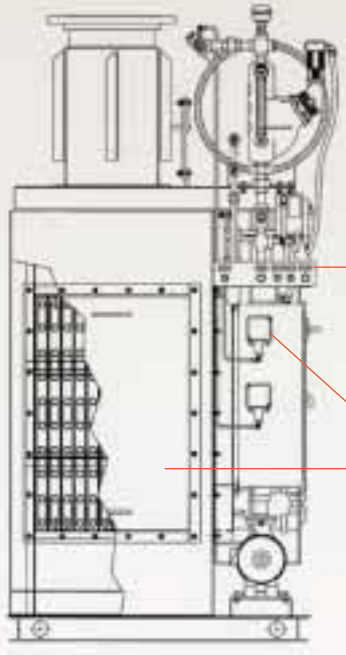


Back View

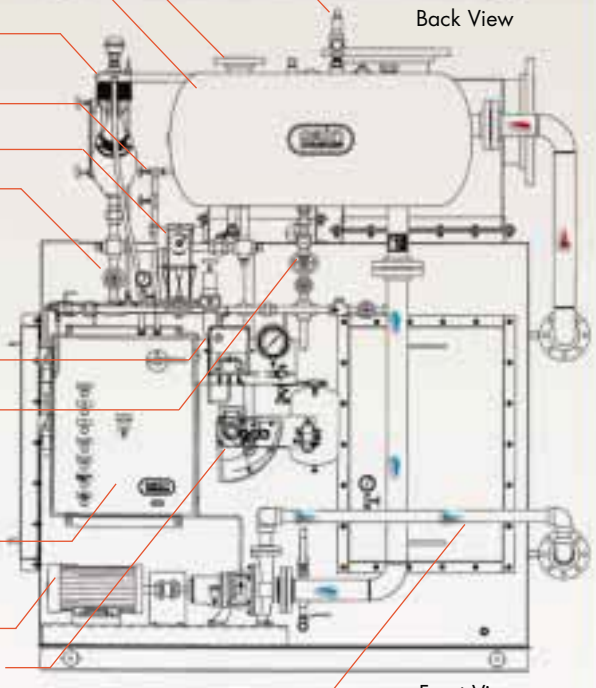


Header View

- Modulating exhaust bypass
- 10Ga. carbon steel exterior
- Lifting eye
- Finned tube heat transfer section (removable finned tube rack assy)
- High temperature insulation block
- Structural steel base
- ASME Steam safety valve
- Steam outlet flange
- Steam flash drum assembly (insulated)
- Water level controller with low & high water cutout
- Continuous surface blowdown
- Modulating feedwater valve
- Water level blowdown
- Localized piping connections:
  - Feedwater
  - blowdown manifold
  - 100psig control air
  - circulating pump cooling water
- Steam pressure controller
- Main blowdown valve assembly
- Excess steam pressure switch
- Tube removal access door
- NEMA 12 control panel: Fuse disconnect, Magnetic starter, Stepdown transformer, Alarm lights
- Circulating pump assembly
- Pneumatic modulating damper actuator
- Main inspection door



Door View



Front View

ESG1: SPECIFICATION

The following is a general specification, shown as a guide for design and construction.

1.0 General Design:

1.1 The ESG1 shall be a packaged forced circulation coil design, manufactured and tested in accordance with the requirements of Section 1, of the ASME Boiler and Pressure Vessel Code, and stamped at 150 PSIG (15 to 450 PSIG available) to the appropriate Section. The operating pressure shall be _____PSIG.

1.2 The ESG1 shall have the capacity to operate automatically as a supplemental or primary steam generator. It shall be designed to produce full steam output in approximately 10 minutes from a cold start and to operate fully automatic under fluctuating steam loads and/or exhaust volumes.

2.0 General Construction:

2.1 The design shall be made up of three basic sections mounted on a structural steel skid, pre-piped, wired for ease of installation, requiring no field assembly.

2.2 The sections shall include a finned tube heating surface, modulating full port exhaust bypass, and steam flash drum assembly, as standard components.

2.3 An integral circulating pump shall also serve to circulate water from the heat transfer section back to the steam flash drum assembly.

2.4 All water, air, and blowdown connections shall be localized within a common manifold assembly for ease of the piping installation.

2.5 Exhaust volume connections shall be located at the top of the ESG1 to serve ease of the exhaust piping installation.

3.0 Heat Exchanger Section:

3.1 Explosion-proof heating surface to be nickel brazed/welded fin to tube, for high heat transfer and corrosion protection (.109 wall thickness x .030 minimum fin thickness).

3.2 The finned tubing shall be designed in multiple sections for ease of replacement.

3.3 The heat exchanger section shall contain a main inspection door for tube removal and a main inspection access port for cleaning and/or inspection.

3.4 The reinforced enclosure shall contain 304 stainless steel baffles with 4" minimum thickness thermal insulation. The enclosure shall be designed to operate with exhaust temperatures entering @ 1,250°F maximum (1600°F design available) and shall have a gas tight seal with continuously welded 10ga. carbon steel exterior: Design Pressure (exhaust side): 10 inches water column, primed/painted with high temp. metallic paint.

4.0 Modulating Bypass Assembly:

4.1 The modulating bypass assembly shall be constructed of minimum .25" thickness plate steel (stainless steel available) and the exhaust connections shall be 150 lb. design SA105 exhaust flanges when applicable. The bypass assembly shall be bolted to the heat exchanger section for ease of maintenance. Insulation shall be provided by others as needed.

4.2 The bypass shall be controlled by a modulating pneumatic positioning actuator and steam pressure dial controller, for controlling the volume of waste heat exhaust as dependent on steam pressure.

4.3 The reinforced damper assembly shall be constructed of 304 stainless steel and designed for tight seal during the full bypass.

4.4 The 304 stainless steel damper shaft shall contain high temperature bearings and packing glands to seal exhaust leakage.

4.5 In the event of an air pressure or electrical failure to the ESG1, the modulating bypass assembly shall contain a alarm fail safe operating mode, whereby the damper assembly shall automatically move to the full exhaust bypass position.

5.0 Steam Flash Drum & Control Assembly:

5.1 The steam flash drum assembly shall contain internal baffles and dry pipes for 99% dry steam output, and 1" thick thermal insulation with minimum 16ga. carbon steel exterior and shall include the following:

5.1.1 The ANSI standard configured circulating pump and TEFC motor shall be incorporated to maintain high water flow turbulence for minimum fouling.

5.1.2 The blowdown valving shall include a main drum blowdown valving assembly including quick opening and shut off valves, continuous surface blowdown valve, and water level control blowdown valve all manifolded for a single blowdown connection.

5.1.3 Safety controls to include low/high water cutout, excess steam pressure cutout, low air pressure cutouts (for pneumatic exhaust bypass actuator).

5.1.4 The water level control system shall contain fully modulating boiler feedwater pump level control and valve assembly with boiler feedwater on/off auxiliary switch.

5.1.5 Water level control to contain red line water level sight glass with drain cock.

5.1.6 All required gauges for steam (4½" dial minimum), feedwater, pump cooling water, and air indication (2½" dial minimum) shall be provided.

5.1.7 (1) ASME and National Board stamped steam safety relief valve.

5.1.8 All necessary interconnecting piping linkages and valving shall be provided.

5.1.9 All inner connecting piping shall be insulated by others as required.

5.2 Control panel to be NEMA 12 construction to accept a single main power connection with main fuse disconnect and starter, fuse-protected stepdown transformer, power and run indicating lights, fill indicating light, low & high water alarm indicating lights, and low air & excess steam pressure lights.

Testing of all components, electrical controls, and hydrostatics as a system, is completed prior to shipment, insuring a smooth and efficient field startup.

Final inspection, under the strict guidelines of Cain Industries and ASME quality control standards, is conducted for each unit.

Complete packaged units are shipped for immediate installation upon arriving on site.

Field startup and operator training is realized quickly with factory trained personnel.

HEAT RECOVERY SILENCER RADIAL

The HRS Radial waste heat recovery silencer is a module configuration package with 176 standard models available. It packages standard features such as: full exhaust bypass, full heating surface access, factory insulation, hard shell exterior, stainless interior, 3" thickness factory insulation, and a variety of finned tube types and fin spacings to fit the proper application. The HRSR is designed to receive the total exhaust and liquid flow from a single source and control exit temperatures to the desired performance levels. During full operation, the radial design channels the exhaust flow through an hour glass expansion flow pattern which provides for significant dBA reduction.

The full port exhaust bypass is located at the top for convenient installation. Depending on space considerations, the unit may be installed in the horizontal position as shown below. The unique configuration of the single row design heating surface allows for reduced fouling potential. The full access to the core with optional hinged doors also allows for fast routine inspection and/or manual cleaning. Finned tube replacement requires no overhead cranes, special rigging, special crews, or extra roof height above the unit. Individual finned tube replacement if required, is fast and easy with minimum down time.

OPTIONAL EQUIPMENT:

- Liquid temperature indicating control assembly
- Hinged inspection doors for immediate access
- Timed automatic timed sootblowers
- Modulating damper actuator (pneumatic or electric)
- Compression fitted tube to header attachment requiring no welding for fin tube replacement

Fully packaged for micro-cogen applications through the large turbines

OEM Packager,
Model HRSR-1I2C26.5ALS
Recovering Btu from (1) 75 kW Micro Turbine Generator, natural gas engine.
Reducing each 500°F @ 1,198 SCFM to 213°F;
Raising 35 GPM hot water from 160°F to 181°F.

Engine Exhaust Application

- Capacity: 200kW – 6MW
- Entering gas temps: to 1,250°F
- Heat sink types: Engine jacket water, process water, boiler water, or ethylene glycol

Airport, Detroit, Michigan. (3) Model HRSR-472H28CSS
Recovering Btu from (3) Wärtsilä 345G, 5.7MW natural gas engines.
Reducing each 698°F @ 18,373 SCFM to 320°F.
Raising 175 GPM hot water from 250°F to 350°F.

FEATURES:

- Full exhaust gas bypass assembly
- Sound attenuation
- Stainless steel interior lining
- Internal heating surface expansion design
- No joint welds within the heating surface in contact with the exhaust gas stream
- 10ga. hard shell seal welded exterior
- Single row design for complete and full access
- Ease of tube replacement requiring no overhead cranes or special rigging.

Hospital, Ontario
(2) Model HRSR-336B28CSS
Recovering Btu from (2) Cummins Wärtsilä CW180, natural gas engines.
Reducing each 968°F @ 3,666 SCFM to 339°F.
Raising 175 GPM hot water from 195°F to 229°F.

(2) Mobile Trailers,
(2) Model HRSR-216826SSS
Recovering Btu from a diesel fueled N14 Cummins engine
Reducing each 865°F @ 1,188 SCFM to 465°F. Raising 70 GPM 50% Ethylene Glycol from 70°F to 90°F.

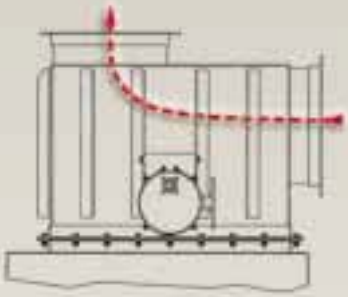
Premium footprint space is realized with rectangular variety

Gold & Silver Mine,
Eskay Creek, British Columbia.
(3) Model HRSR-316A26CSP
Recovering Btu from (3) Caterpillar 3512, 900kW diesel engines.
Reducing each 870°F @ 2,100 SCFM to 417°F.
Raising 265 GPM 50% ethylene glycol from 187°F to 197°F.

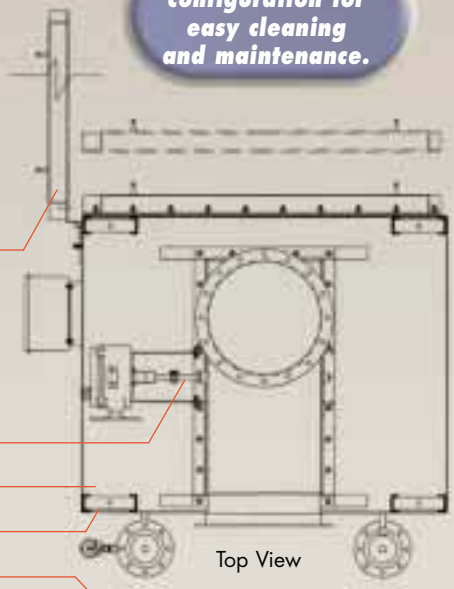
HRSR SERIES FOR: LARGE ENGINES & FULL FEATURE DESIGN

Single row tube configuration for easy cleaning and maintenance.

ASME & National Board stamped – Sec.VIII, Div.1



EXHAUST FLOW:
FULL BYPASS POSITION



Inspection door assembly, for finned tube inspection, clean out, or removal (optional hinged version)

Stainless steel damper shaft

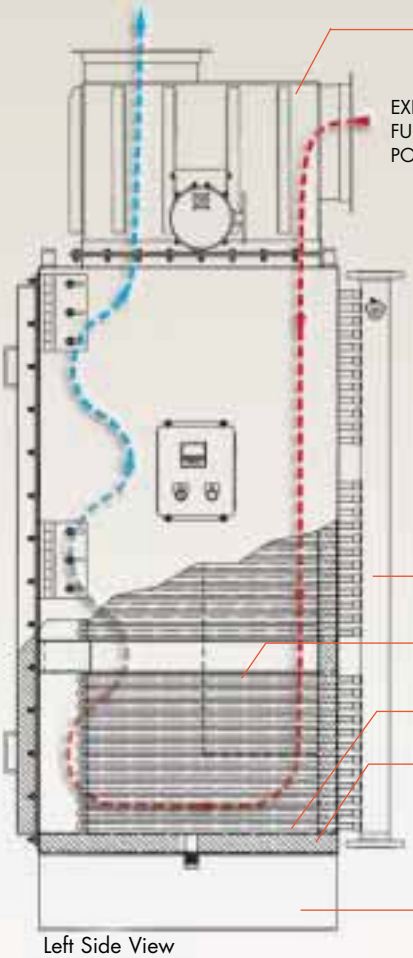
10ga thickness. exterior

Lifting lug

Top View

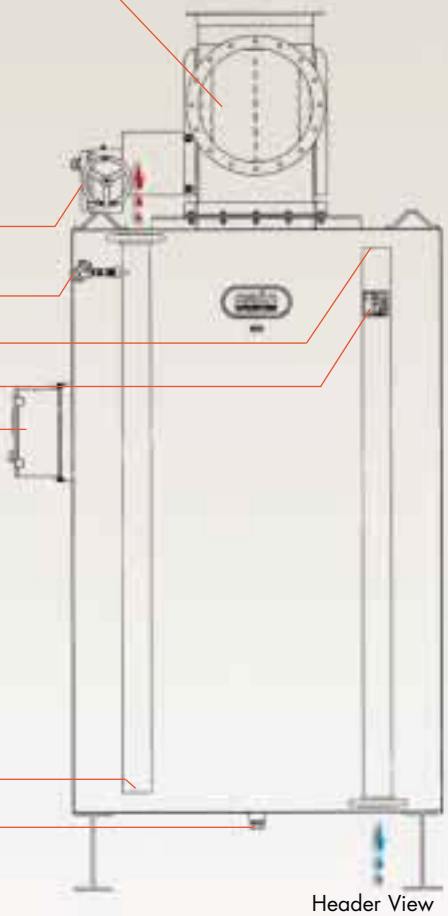
Stainless steel bypass damper

Exhaust bypass assembly



EXHAUST FLOW:
FULL OPERATING POSITION

Left Side View



Modulating actuator (optional pneumatic or electric)

Thermocouple

¾ NPT vent

ASME Stamp (optional)

Control panel (used with Automatic Sootlblower Assembly and/or Liquid Temperature Control - optional)

Header manifold (low liquid pressure drop)

Finned tube* assembly (single row design for complete access to heating surface)

Stainless steel interior

3" THKS. insulation

¾ NPT drain

1½ NPT cleanout

H-Beam support

Header View

*Available tube materials: carbon steel, TP316 stainless
Available fin type: carbon steel, TP304 stainless, aluminum
Methods of attachment: nickel brazed, welded, Al-Fuse

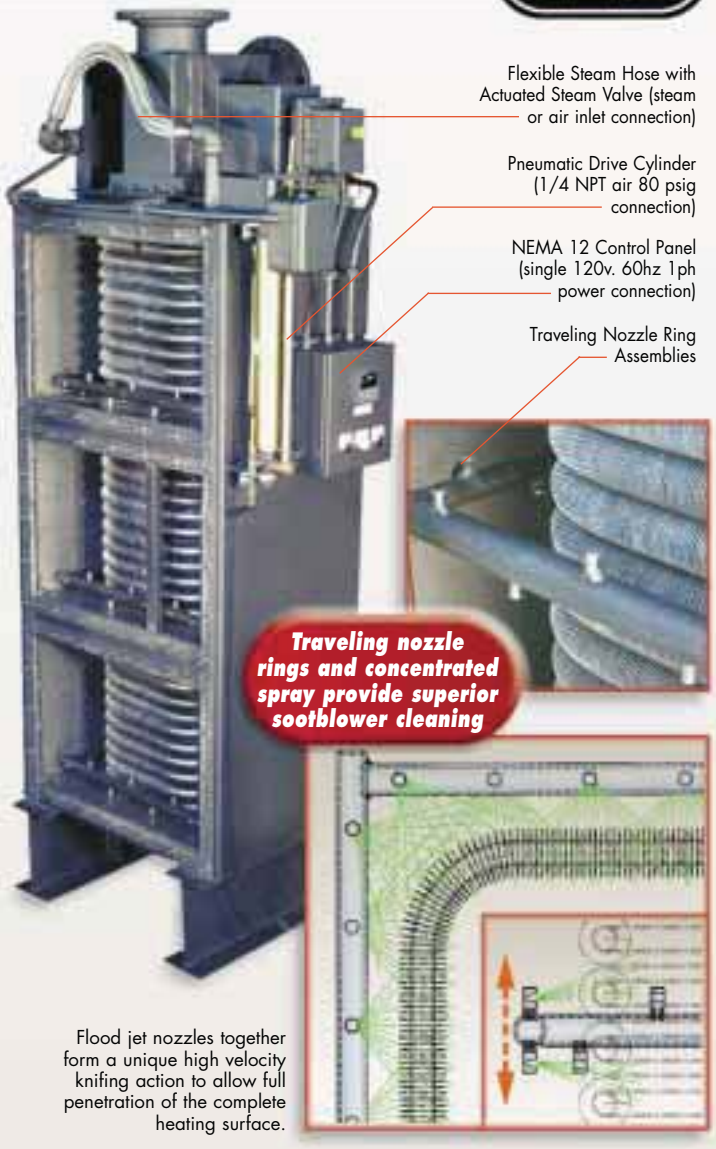
TIMED AUTOMATIC SOOTBLOWER (optional)

The exclusive Cain Industries Timed Automatic Sootblower design is applied to combustion sources where the sulphur content is high and/or combustion efficiency is poor. When a soot layer accumulates on the heating surface to a thickness of 1/8", fuel consumption is increased by 8.5%. The sootblower is also applied when it is not cost-effective to open inspection doors and clean the exchanger by other means. The sootblower system will continually keep the heating surface at a high performance level and eliminate the day-to-day operator expense and engine down time.

The blowdown sequence occurs while the engine is in full operation and is fully adjustable. The special flood-jet type nozzles achieve maximum cleaning velocity using steam or air as discharged through an electric control valve (included). Together they form a `continuous knife edge concentrated spray pattern' surrounding the heating surface. This `ring nozzle assembly' as attached to a manifolded flexible steel hose assembly, is powered up and down by a pneumatic drive cylinder. Dual timing relays allow complete control for 30 second cycle duration and intervals specific to each application. Final results are controlled double cleaning action, insuring that the maximum Btu recovery and anticipated savings are achieved.

LIQUID TEMPERATURE CONTROL (optional)

Operating Sequence: During a cold startup the exhaust bypass will be powered to the normal operating position. As the liquid temperature rises and approaches a preset point, the exhaust bypass damper will begin to move to the temperature control position. When the desired temperature is completely satisfied the damper actuator will move to the maximum open position, bypassing 99% of the exhaust flow (100% bypass cannot be attained due to some leakage and residual heat in contact with the fin tubing). Included is a 4-20 mA output controller, thermocouple, thermocouple weld and wire, and modulating bypass actuator installed, wired, and tested, for a single 120 volt, 1ph, 60hz power connection.



HRSR: SPECIFICATION

A general specification, shown as a guide for design & construction.

1.0 General Design:

1.1 Furnish and install a heat recovery silencer radial (HRSR) in the exhaust duct of the engine in accordance with the following specifications as designed and manufactured by Cain Industries, Inc.
1.2 The HRSR shall be a light weight design for easier installation, rectangular with counterflow heat transfer design.
1.3 The HRSR shall be designed to include as standard, an external Exhaust By-Pass Assembly to provide for: full emergency bypass, requiring no additional exhaust piping for controlling either: Turn Down Performance - Excessive flue gas back pressure due to fouling.
1.4 A manual bypass adjusting plate and arm assembly shall be provided to lock the damper assembly in a desired operating position (optional: modulating damper assembly).
1.5 The HRSR shall have removable, gas tight inspection doors, providing complete access to the entire heating surface for inspection, tube removal, and/or cleaning (optional hinged doors available).
1.6 The HRSR must be capable of being drained completely when mounted in the vertical or horizontal position.
1.7 Header manifolds for low liquid flow pressure drop shall be provided and shall have connections, screwed or flanged as specified. Liquid inlet and outlet pipe connections greater than 2" shall be flanged. The liquid header manifolds shall also contain 3/4" NPT connections for venting, draining, and/or safety relief valves as required.
1.8 The design of the vessel itself shall be such that no tube to tube, or tube to header joint welds shall be in contact with the exhaust stream so to minimize potential vessel failure.
1.9 The finned tubing shall be a single row design for ease of cleaning and inspection.

2.0 Construction:

2.1 Design Pressure (water side): 150 PSIG @650 F.; Test Pressure: 225 PSIG; Max. Flue Gas Inlet Temperature: 1250 F.; Design Pressure (exhaust side): 10 inches water column
2.2 Tube: outside diameter: 1.0"; wall thickness: .085"; material: SA178 GrA. ERW
2.3 Fins: 0.030" thks. carbon steel, nickel brazed/welded to the tube
2.4 Headers: thickness: Sch 80; material: SA53 GrB
2.5 3" thickness factory installed, high temperature insulation shall be contained within the exterior less the liquid headers and exhaust bypass assemblies.
2.6 Exterior surfaces shall be 10ga. carbon steel seam welded and the inner casing shall be 304 stainless steel.
2.7 Special codes (optional): design specifications of ASME Code: Section VIII Division I; `UM', `U', or `S' symbol; National Board registered; CRN and/or CSA.

U-TUBE RECOVERY 1

The UTR1 is applied primarily where confined area restrictions vs heat transfer requirements must be considered as a priority, secondarily to the features the HRSR. Its compact industrial design allows for maximum Btu recovery relative to the space allotted for installation. Finned tube spacings range from bare tube heating surface up through 8 fins per inch, depending on the fouling factor requirements. Standard fin to tube attachment using the nickel braze/weld fin-to-tube process allows no fin-to-tube separation to 2,000°F.

The UTR1 can be located above the engine or on the floor for convenient installation. With over 170 standard configurations to choose from, the UTR1 can be designed to meet the closest pinch point requirements when installation space is not an issue. Easy access allows for quick removal of finned tube rows or core assemblies without disturbing the exhaust gas connections, and allows for routine inspections and/or cleaning requirements.

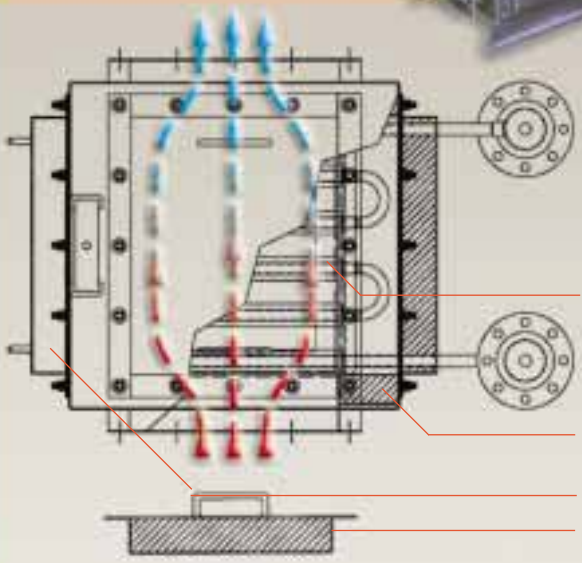
OPTIONAL EQUIPMENT:

- Inspection doors for easy access/cleaning
- Exterior exhaust gas bypass and actuator assemblies
- Exhaust piping to UTR1 transitions
- Rotating Sootblowers (automatic/manual)

MANUFACTURING PLANT, Mansfield, Ohio (3) Model UTR1-812B18SSP. Recovering Btu from (3) 7100 GSI Waukesha 1,150 kW natural gas engines; Reducing each 1,250°F @ 2,388 SCFM to 383°F; Raising 635 GPM engine jacket water from 235°F to 243.6°F

Engine Exhaust Application

- Capacity: 200kW – 10MW
- Entering gas temps: to 1,600°F
- Heat sink types: Process water, boiler feedwater, ethylene glycol, or thermal transfer fluids



Parallel piping flow arrangement for high liquid flow.

Series piping flow arrangement

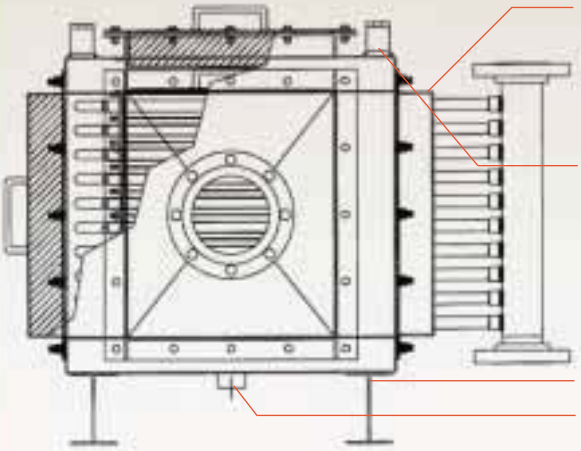
Fin tube Rack Assemblies (spaced for accessible cleaning)
-Tube materials: carbon steel, TP316 stainless
-Fin materials: carbon steel, TP304, aluminum
-Methods of finned tube attachment: nickel brazed, Al-Fuse, welded

Factory Insulation (optional): 2" - 6" thickness available

Inspection door, fin tube removal

Inspection door (optional), heating surface cleaning

UTR1 SERIES FOR: LARGE ENGINE & COMPACT DESIGN

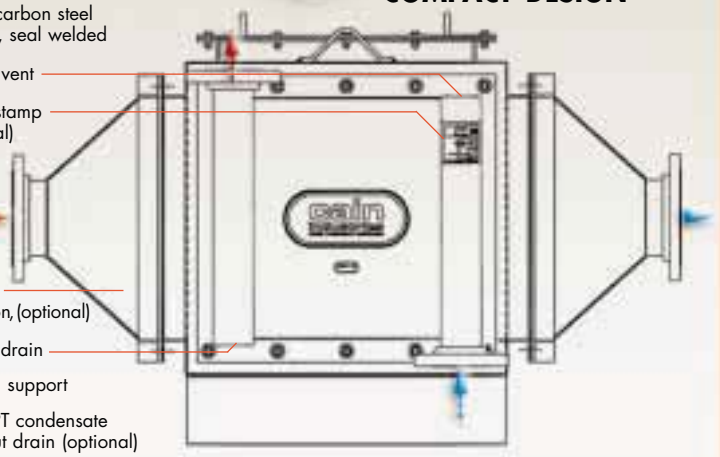


10ga. carbon steel exterior, seal welded

¾ NPT vent

ASME stamp (optional)

Lifting lug



Exhaust transition, (optional)

¾ NPT drain

H-Beam support

1½ NPT condensate cleanout drain (optional)

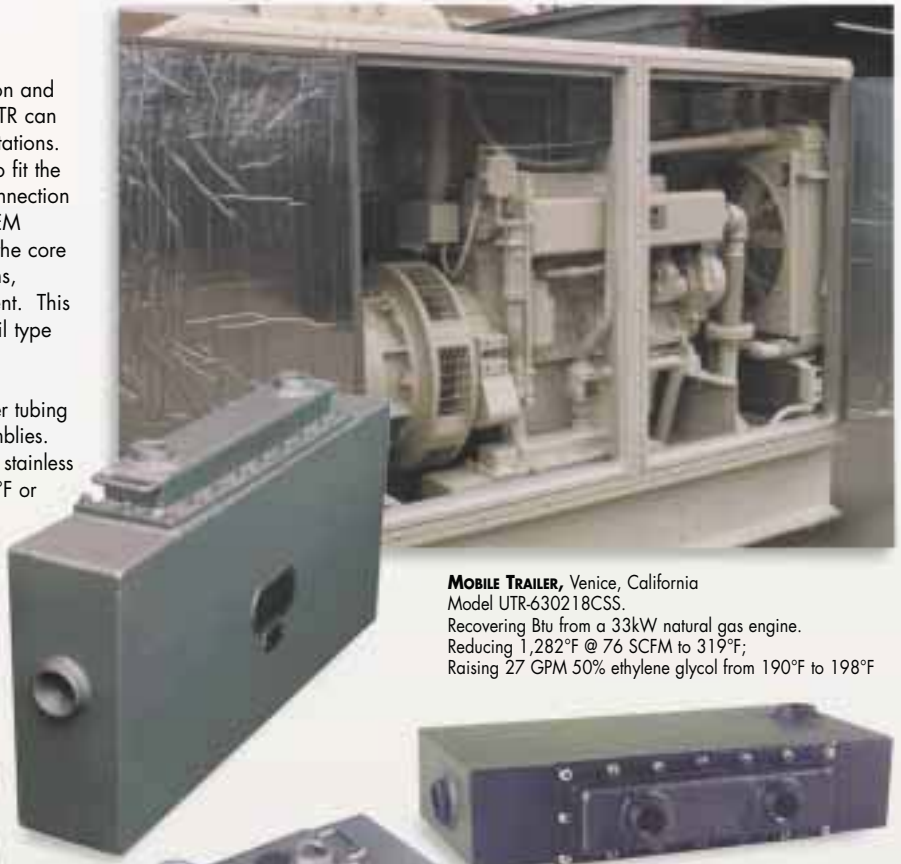
U-TUBE RECOVERY

The UTR is applied where both rectangular configuration and heat transfer surface vs. performance is critical. The UTR can be located within the engine to meet crucial space limitations. There are 44 standard models available for selection to fit the most compact of spaces. With flexible exhaust gas connection sizes and locations, the UTR can adapt easily to an OEM packager's design needs. The capability of removing the core assembly without disturbing the exhaust gas connections, makes cleaning and inspecting the finned tubing efficient. This is especially important when the combustion is a fuel oil type and could foul the heating surfaces.

The rugged heat transfer core is made from SA178 boiler tubing and .25" thickness high grade carbon steel heater assemblies. The heat transfer materials can also be constructed of all stainless steel when exhaust temperatures entering exceeds 1250°F or when liquid temperatures entering are below 120°F.

OPTIONAL EQUIPMENT:

- Exterior exhaust gas bypass and modulating actuator assemblies



MOBILE TRAILER, Venice, California
Model UTR-630218CSS.
Recovering Btu from a 33kW natural gas engine.
Reducing 1,282°F @ 76 SCFM to 319°F;
Raising 27 GPM 50% ethylene glycol from 190°F to 198°F

Engine Exhaust Application

- Capacity: 15 – 300 kW
- Entering gas temps: 400 to 1,600°F
- Heat sink types: Engine jacket water, ethylene glycol, process water, or boiler water

UTR SERIES FOR: SMALL ENGINE COMPACT DESIGN & HIGH LIQUID FLOW

Removable finned tube core assembly
(spaced for accessible cleaning)
-Tube materials: carbon steel, TP316 stainless
-Fin materials: carbon steel, TP304 stainless
-Methods of attachment: nickel brazed

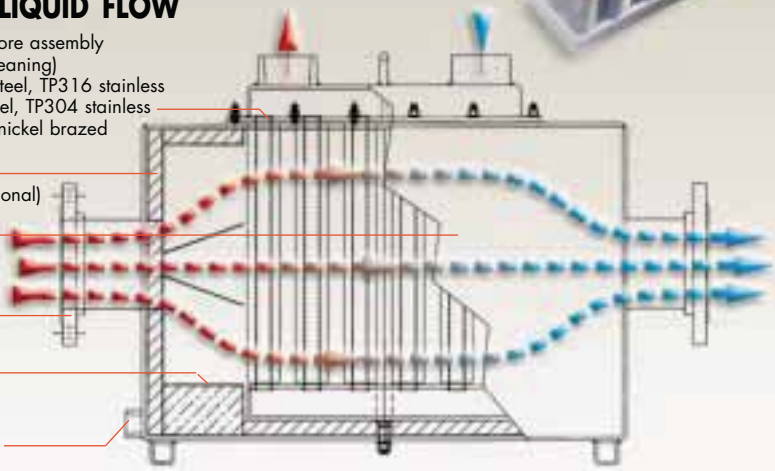
Factory insulation:
1,2, or 4" thickness (optional)

Carbon steel shell
.25" thickness

Exhaust connections:
flange, butt, or NPT

Stainless steel interior

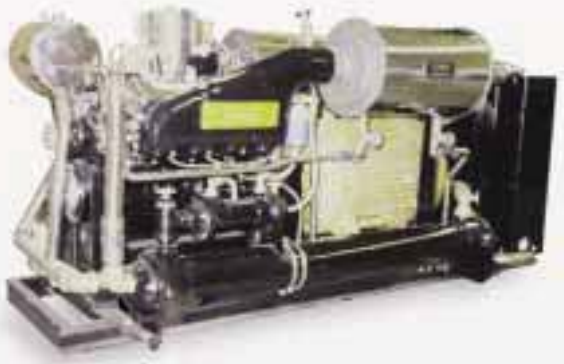
1" NPT condensate
cleanout drain (optional)



Removable core makes cleaning and maintenance easy

HEAT RECOVERY SILENCER AXIAL

Specifically designed for small engine sizes, the HRSA waste heat recovery silencers are compact cylindrical heat exchangers designed for either dual or single exhaust small engines. There are 65 standard models available to meet the specific design-performance criteria. In addition to lowered exhaust noise, the unique coil type configuration and optional circulating pump allows for a secondary circulating liquid flow system. 1" NPT interconnecting piping, to and from a main liquid flow loop, provides for simple and less costly special piping modification changes. The required heat transfer surface coupled with a small water flow diversion from the main flow, adequately recovers desired Btu/hr performance and controlled outlet exhaust temperatures as required. An optional internal or external stainless steel exhaust bypass can also allow tempering or full control of the exit temperature when required.

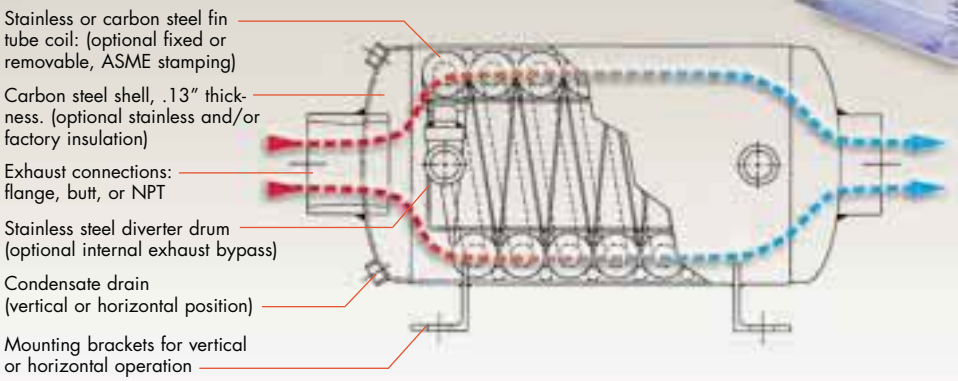


The HRSA waste heat recovery silencers shown with the smaller engines such as a 460 cu.in. V8 shown above or a smaller Caterpillar engine shown below.

Engine Exhaust Application

- Capacity: 15–150 kW
- Entering gas temps: 400–1,600°F
- Heat sink types: Engine jacket water, process water, boiler water, or ethylene glycol

HRSA SERIES FOR: COMPACT CYLINDRICAL DESIGN



The HRSA design utilizes full counter flow heat transfer for achieving very low outlet exhaust gas temperatures. All stainless steel construction for specific condensing applications is available. The HRSA can be mounted vertically or horizontally as required. The HRSA with its light weight construction and cylindrical configuration lowers the exhaust from 1000°F to 300°F with a 25 dBA reduction while operating with natural gas or diesel fuel oil.

EBULLIENT STEAM GENERATORS FROM ENGINE JACKET WATER

The Exhaust Cooling Steam Generator (ECSG) as designed to produce low pressure steam (15 PSIG and under) from engine jacket water via natural circulation. They are available in a variety of tank sizes for horizontal or vertical installations. Standard design includes: ASME stamped steam flash tank built in accordance with Sec.VIII Div.I; shipped as a packaged unit including continuous water level feed control with low water cutoff, auxiliary low water cutoff, excess steam pressure switch, gauge glass assembly, surface and main blowdown assembly, vent valve, steam safety valve, steam pressure gauge, wall or floor mount. Basic customer connections for ease of installation include: 150# steam outlet, 150# water outlet, 150# water/steam inlet, NPT Blowdown, & NPT Boiler feedwater. The unit shall be pre-piped and wired for a single 120v 1ph 60hz customer power connection.

BOILER FEEDWATER TANK ASSEMBLY

Cain Boiler feedwater systems are available in a variety of tank sizes, feedwater pump configurations, and optional water treatment assemblies. Packaged assemblies include: heavy wall tank as mounted on a 5' high rectangular tube structural steel stand with water level controls and low water cutout, gauge glass and thermometer, magnesium anode; (2) 2" NPT vents; 2" NPT condensate return; 1" NPT drain with shut off valve; Duplex or Triplex Boiler Feedwater Pump System; electrical control panel fully pre-wired with fused disconnect switches, magnetic starters, manual start-stop switches and indicating run lights for feedwater pumps and alarms; all interconnecting wiring from electrical control panel to each component, optional chemical feed system, and/or automatic water softening system; all interconnecting bypass piping, valves, gauges, fittings, etc. Primed, painted, and tested package is a complete, properly functioning assembly, ready for the customer's primary connections of water, condensate return, and electricity.

OUR UNIQUELY DESIGNED EXHAUST GAS BYPASS VALVES

Cain Industries offers total exhaust gas control with high temperature modulating bypass and shut off valves. The valve assemblies offer precise exhaust temperature control and/or the design capability for exhaust isolation. Sizes ranging from 4" to 40" diameter are available in carbon steel and stainless steel for all engine temperatures. All valves are available with either electric or pneumatic control actuation, and emergency fail safe features.

COMPONENTS FOR COMPLETE SYSTEMS:

Cain Industries' engineering team is available to propose the proper system components at competitive pricing. Upon review of your application, you can expect our proposal within 24 hours. It will include professionally engineered details showing equipment costs, savings analysis, computer generated economizer performance, CAD dimensional drawings, flow schematics, warranty, and a performance guarantee.

No matter how small the micro-turbine or how large the engine, Cain Industries has the heat transfer equipment, optional components, and years of experience to provide the best solution.

- Remote digital indicators and control packages
- Pre-piped skid mounted circulation pump system packages
- Boiler blowdown assemblies
- Valves: shut off, relief, vent, drain, check
- Steam stop and check valves
- Pressure or temperature control valves
- Bi-metallic or mercury thermometers
- Expansion joints
- Explosion hatch relief ports
- Tanks: storage or expansion
- Bypass damper actuators: pneumatic or electric, on/off or modulating, air or spring failsafe return

SAVINGS COMPARISON ANALYSIS

Four examples of typical combustion source types, and the results with a Cain Industries heat recovery system applied.

DATA without a Cain System		**PERFORMANCE with a Cain System**	
Combustion Source:	**Hot Water Boiler**	Model Selection	C700
Heat Sink	Return Water	Circulating Water Flow	20 gpm
Waste Exhaust Temp	510°F	Final Exhaust Temp.	250°F
Water Temp. Inlet	130°F	Water Temp. Outlet	186°F
Btu/hr Burner Input	6,437,000	Pressure Drop, Water	5.0 psig
Fuel Type	Natural Gas	Pressure Drop, Exhaust	0.10" WC
O_2 Content	10%	Btu/hr recovered	560,900
Excess Air	82%	Btu/hr saved	747,900
Combustion Efficiency	75%	Total Cost Installed	$12,400
Fuel Cost Per Therm	$.60	**Payback**	**5.5 mo.**
Annual Operating Hours	6,000	**Annual Return on Investment**	**217%**
		Annual Savings	**$26,880**

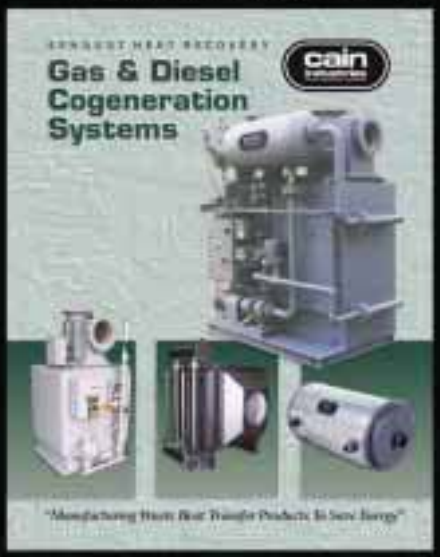
DATA without a Cain System		**PERFORMANCE with a Cain System**	
Combustion Source: 800 BHP	**Steam Boiler**	Model Selection	RTR-142H26ALS
Heat Sink	Boiler Feed Water	Boiler Feed Water Flow	55.2 gpm
Waste Exhaust Temp.	470°F	Final Exhaust Temp.	319°F
Water Temp. Inlet	210°F	Water Temp. Outlet	263.3°F
Btu/hr Burner Input	33,580,000	Pressure Drop, Water	2.0 psig
Fuel Type	Natural Gas	Pressure Drop, Exhaust	0.47" WC
O_2 Content	6%	Btu/hr recovered	1,417,000
Excess Air	36%	Btu/hr saved	1,776,000
Combustion Efficiency	78.9%	Total Cost Installed	$37,700
Fuel Cost Per Therm	$.60	**Payback**	**7.1 mo.**
Annual Operating Hours	6,000	**Annual Return on Investment**	**170%**
		Annual Savings	**$ 63,936**

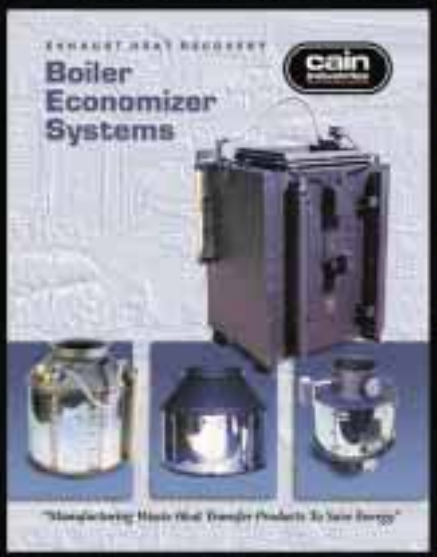
DATA without a Cain System		**PERFORMANCE with a Cain System**	
Combustion Source:	**1,250 kW Engine**	Model Selection	HRSR-336B28CSS
Heat Sink	50% Ethylene Glycol	Circulating Liquid Flow	175 gpm
Waste Exhaust Temp.	968°F	Final Exhaust Temp.	330°F
Water Temp. Inlet	195°F	Water Temp. Outlet	232°F
SCFM	3,667	Pressure Drop, Water	8.3 psig
Fuel Type	Natural Gas	Pressure Drop, Exhaust	1.75" WC
O_2 Content	N/A	Btu/hr recovered	2,863,000
Excess Air	N/A	Btu/hr saved	3,670,000
Combustion Efficiency (relative)	78%	Total Cost Installed	$ 57,960
Fuel Cost Per Therm	$.60	**Payback**	**5.3 mo.**
Annual Operating Hours	6,000	**Annual Return on Investment**	**228%**
		Annual Savings	**$ 132,120**

DATA without a Cain System		**PERFORMANCE with a Cain System**	
Combustion Source:	**1,700 kW Engine**	Model Selection	ESG1-620D18CSS
Heat Sink	Process Steam	Operating Steam Pressure	150 PSIG
Water Exhaust Temp.	783°F	Final Exhaust Temp	428°F
Water Temp. Inlet	N/A	Boiler Horsepower	68 BHP
SCFM	5,222	Equivalent Evaporation	2,339 pph
Fuel Type	Natural Gas	Pressure Drop, Exhaust	1.55" WC
O_2 Content	N/A	Btu/hr recovered	2,269,000
Excess Air	N/A	Btu/hr saved	2,908,000
Combustion Efficiency (relative)	78%	Total Cost Installed	$113,600
Fuel Cost Per Therm	$.60	**Payback**	**13.0 mo.**
Annual Operating Hours	6,000	**Annual Return on Investment**	**92%**
		Annual Savings	**$ 104,688**

Savings comparison data is based on a conservative fuel cost per therm (100,000 Btu), and approximate annual operating hours. Your results may vary. *Total Cost Installed* includes: Equipment, shipping, and complete installation. Contact Cain Industries for your FREE savings analysis proposal.

MARKET SPECIFIC PRODUCT LINES





Your Authorized Cain Representative

cain industries
heat recovery systems

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Germantown, WI 53022
262-251-0051
800-558-8690
sales@cainind.com
www.cainind.com

Printed in USA #90180

Quotation S12-0479

TRANSMITTAL COVER SHEET

Date: 9/28/2012

# of Pages: 9 (including cover sheet)

To:

Company: Electric Power Systems
Attn: Bob Whealy
Phone: (907) 646-5132
Fax:
Email: bwhealy@epsinc.com

INQUIRY:
- ☐ web
- ☒ e-mail
- ☐ phone
- ☐ fax
- ☐ other

From:

Submitted by: David Siedenburg
Subject: Electric Power Systems – Dutch Harbor Power Plant
Ref #: 56370

OUT:
- ☐ fax
- ☐ mail
- ☐ overnight
- ☒ e-mail
- ☐ file

Message:

As requested, please find your proposal attached for a different model for the new conditions. The Stack Corrosion Control Assembly (SCCA) has been added because of the customer's exhaust gas temperature concerns. Please see the "System Descriptions" section of the proposal.
Cain recommends that they use the exhaust gas bypass to control the exhaust gas temperature of the HRSR, and not attempt to control it by varying liquid flow rtes. We recommend this method in order to reduce the possibility of localized boiling, over heating of the liquid, and deposits on the inside of tubes that can be the result of too small of a liquid flow rate.
The quoted price is for (1) unit, F.O.B. Cain Industries.
Shipment is typically in approximately 10-12 weeks after submittal approval for 1 unit.
The terms of sale, Bulletin #25500 form part of this proposal. See this bulletin for payment terms.

12V32 Engine Exhaust Heat Recovery
Glycol/Water Loop Heater

Ref: 56370
Rep: 999
Rev: 0

Date: 9/26/2012
Page: 1

Engineered For:

Dehn Engineering Sales Co.
P.O. Box 68183
Seattle, WA 98168

Attn: David Siedenburg
Ph: (206) 243-3123
Fax: (206) 243-3124

Electric Power Systems
3305 Arctic Blvd., Suite 201
Anchorage, A 99503-4575

Attn: Bob Whealy
Ph: (907) 646-5132

End User:

Dutch Harbor Power Plant
nalaska, A

System Description:

Cain Industries is pleased to propose the following HRSR model exhaust heat recovery unit to recover exhaust heat from a diesel fired, Wartsila 12 32 engine. The recovered heat will be transferred to a 60/40 ethylene glycol/water loop .

The HRSR heat recovery unit features: a full port exhaust gas bypass individually removable, type 316 stainless steel tubes with 304 stainless steel fins a stainless steel interior shell 3 of factory insulation (less liquid header assemblies) a 10 gauge carbon steel exterior shell and a hinged full face access door(s) for inspecting and/or cleaning the finned tubes.

The finned tubes are compression fitted to the liquid headers. Tube replacement does not require welding.

The exhaust gas bypass is stainless steel with stainless steel flanges.

The heat exchanger section has 3 thickness factory insulation. The exhaust gas bypass will have 3 thickness blanket wrap insulation. The liquid headers are not insulated and field insulating is recommmended.

The iquid Temperature Control Assembly (TCA) automatically modulates the exhaust gas bypass to control the temperature of the heated glycol/water leaving the heat exchanger. A desired maximum temperature is entered on the digital indicating controller. The controller has a continuous temperature display, and ODB S communications which will allow remote monitoring of the process variable and control of the set point. The controller will be dual input and will switch to exhaust gas temperature control if the exhaust

12V32 Engine Exhaust Heat Recovery
Glycol/Water Loop Heater

Ref: 56370
Rep: 999
Rev: 0

Date: 9/26/2012

System Description: (cont)

gas temperature falls below a preset minimum temperature (355F). Either process variable, maximum liquid temperature out or minimum exhaust gas temperature out, can be set remotely. Contacts will be provided to remotely drive the exhaust gas bypass to the bypass position. The panel is approved.

The Cain Timed Automatic Sootblower has ring nozzle assemblies that travels the length of the heat exchanger while jetting steam or air at the finned tubes. The travelling action of the sootblower, along with the single row arrangement of the finned tubes, ensure coverage of the finned tubes by the steam/air jets.

The condensate drain connection will be piped from the center to the side of the unit. The access door will be divided into (2) doors in order to reduce the door swing clearance.

A blind flange to manually separate the exhaust gas bypass section from the heat exchanger section is included.

The annual operating hours and the cost per 100,000 Btu of diesel fuel were assumed. The exhaust pipe diameter was assumed.

12V32 Engine Exhaust Heat Recovery
Glycol/Water Loop Heater

Ref: 56370
Rep: 999
Rev: 0

Date: 9/26/2012
Page: 3

Quotation:

Qty	Part #	U/M	Description
1		EACH	HRSR-472J24SSS
			-INCLUDING:
			Full Port Exhaust Gas Bypass
			Sound Attenuation
			Stainless Inner Wall
			10ga. Carbon Steel Exterior
			Single Fintube Row Design
			3"Thickness Factory Insulation
			-SYSTEM COMPONENTS:
1	912055	EACH	HRSR Hinged Access Door Assy.
1	962020	EACH	ASME Stamp-SEC.VIII;DIV.I(`U')
1	971240	EACH	Timed Auto Stblwr.: HRSR-472H
112	912100	EACH	C.F.T.: Price x Tube Qty.
1	966040	EACH	Liq. Temp. Ctrl. Assy. Elec.
1	430602	EACH	1" NPT ASME Relief Val:150 PSI
2	467205	EACH	T-METER,5"Dial 200-1000'F
2	480190	EACH	3"Dial, bimetal 50-300 w/well

TOTAL PRICE (USD)	$247,277
ANNUAL RETURN ON INVESTMENT	235%
5 YEAR SAVINGS	$2,905,760
10 YEAR SAVINGS	$5,811,520
PAYBACK PERIOD, MONTHS	5.1

Terms of Sale:
* Estimated Shipping: 10-12 weeks after submittal approval
* Payment Terms: See Bul. #25500
* See Bulletin 25500 including 'Warranty and Performance Guarantee'.

17:25:jr

Representative

Jim Rozanski
Cain Industries

12V32 Engine Exhaust Heat Recovery
Glycol/Water Loop Heater

Ref: 56370
Rep: 999
Rev: 0

Date: 9/26/2012
Page: 4

Waste Heat Exhaust:
Primary Fuel Type: Diesel
Secondary Fuel Type:
Fuel Cost per 100,000 BTU (USD): $2.50

Heat Source: Wartsila 12V32 engine
Exhaust Flow: Horizontal/Vertical
Heat Sink: 50/50 propylene glycol/water loop

Model: HRSR-472J24SSS

Overall Configuration, inches	104x91
Overall Height, inches	322
Liquid Connection	8
Exhaust Connection	36" Dia.
Dry Weight, lbs.	29400
Wet Weight, lbs.	30190
Surface Area, Ft2	3,953
Design Pressure, PSIG	150
Hydrostatic Test Pressure, PSIG	225
@ Design Temperature, °F	550
Maximum Entering Temperature, °F	800

Performance:	**Load 1**	**Load 2**	**Load 3**
Load of Maximum Output, %	100%	75%	50%
Exhaust Entering Temp, °F	723°	626°	669°
Exhaust Flow Rate, SCFM	17900	15300	11100
Exhaust Leaving Temp, °F	375°	344°	331°
Pressure Drop " W.C. Max	1.54	1.10	0.65
Liquid Entering Temp, °F	250.0°	250.0°	250.0°
Liquid Flow Rate, GPM	351.0	221.0	185.0
Liquid Leaving Temp, °F	298.6°	302.6°	304.6°
Pressure Drop, PSIG	12.69	5.45	3.95
Heat Recovered, MBTU/Hr	7770	5287	4597

Savings:			
Heat Saved (x 100 MBTU/Hr)	77.697	52.866	45.970
Annual Hours of Operation	219	3504	657
ANNUAL SAVINGS (USD)	**$581,152**		

SUBMITTAL

DATE: 9/26/2012 REF#: **56370**
RE #: **0**
FOR: Dehn Engineering Sales Co.
c/o: Cain Industries, Inc.

ODE : HRSR-472 24SSS
HEAT SO RCE: Wartsila 12 32 engine

Bul. #10811

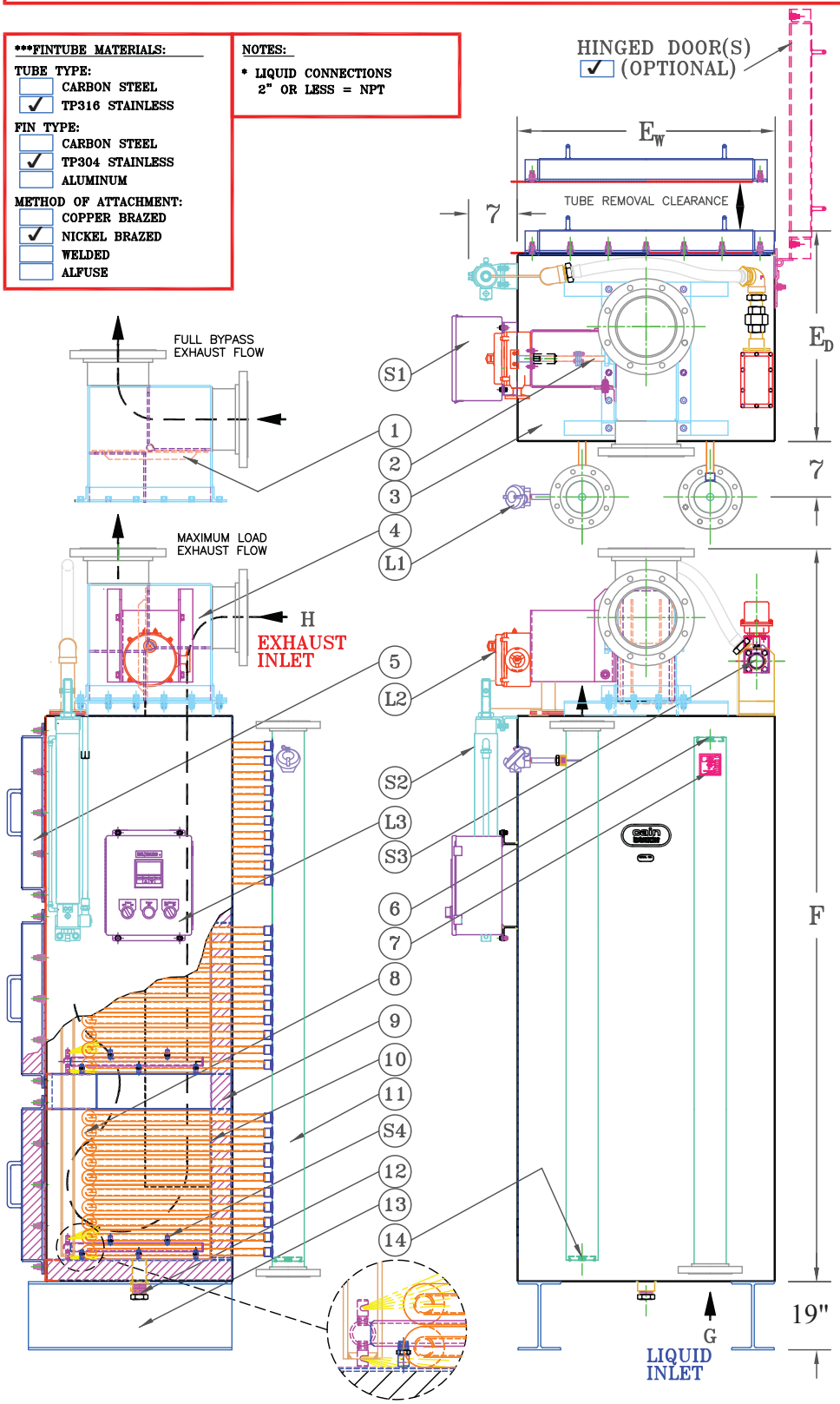
***FINTUBE MATERIALS:

TUBE TYPE:
- [ ] CARBON STEEL
- [x] TP316 STAINLESS

FIN TYPE:
- [ ] CARBON STEEL
- [x] TP304 STAINLESS
- [ ] ALUMINUM

METHOD OF ATTACHMENT:
- [ ] COPPER BRAZED
- [x] NICKEL BRAZED
- [ ] WELDED
- [ ] ALFUSE

NOTES:
* LIQUID CONNECTIONS 2" OR LESS = NPT



HRSR

PERFORMANCE AND DIMENSION DATA

A.	723	F
B.	375	F
C.	250	F
D.	299	F
E.	104x91	
F.	322	
.	8	CO .
H.	36 Dia.	CO .
	3,953	H.S.
	29400	# W T
	150	PSI
	800	TE P.

PARTS LIST
1. SS BYPASS DAMPER
2. SS DAMPER SHAFT
3. 10 & 7GA. THKS. EXTERIOR CORROSION PROTECTION LINED (10" W.C. EXHAUST SEAL MAX. DESIGN PRESSURE)
4. EXHAUST BYPASS ASSY.
5. INSPECTION DOOR ASSY.
6. 3/4 NPT VENT
7. ASME STAMP [x] (OPTIONAL)
8. FINNED TUBE ASSY.
9. 3" THKS. INSULATION
10. STAINLESS INTERIOR
11. HEADER MANIFOLD
12. 1 1/2 NPT CLEANOUT & CONDENSATE DRAIN
13. H-BEAM SUPPORT
14. 3/4 NPT DRAIN

[x] SOOTBLOWER (OPTIONAL)
S1. TIMER ASSY. LOCATION
S2. PNEUMATIC CYLINDER
S3. 1 1/2" NPT STBLR AIR OR STEAM CONN.
S4. SOOTBLOWER FLOOD JET NOZZLE ASSY.

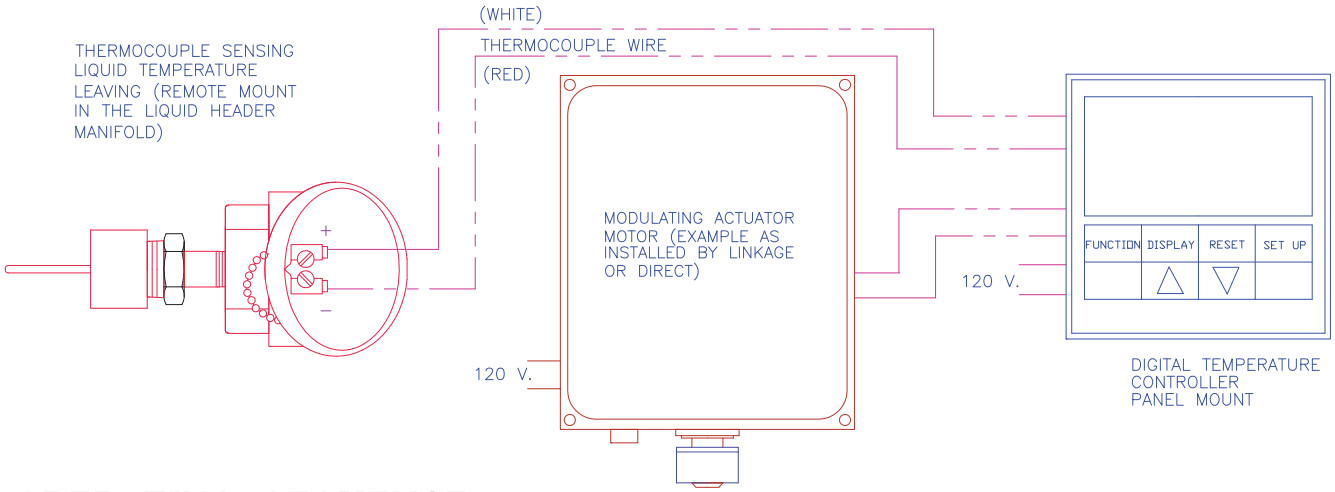
[x] LIQUID CONTROL (OPTIONAL)
L1. THERMOCOUPLE, LIQUID
L2. MODULATING ACTUATOR
L3. CONTROL PANEL ASSY. (USED WITH STBLR & LIQUID CONTROL)

CAIN INDUSTRIES Inc. PO Box 189 W194 N11826 McCormick Drive Germantown, WI 53022
Phone (262) 251-0051 (800) 558-8690 Fax (262) 251-0118 sales@cainind.com www.cainind.com

SUBMITTAL

LIQUID TEMPERATURE CONTROL ASSEMBLY

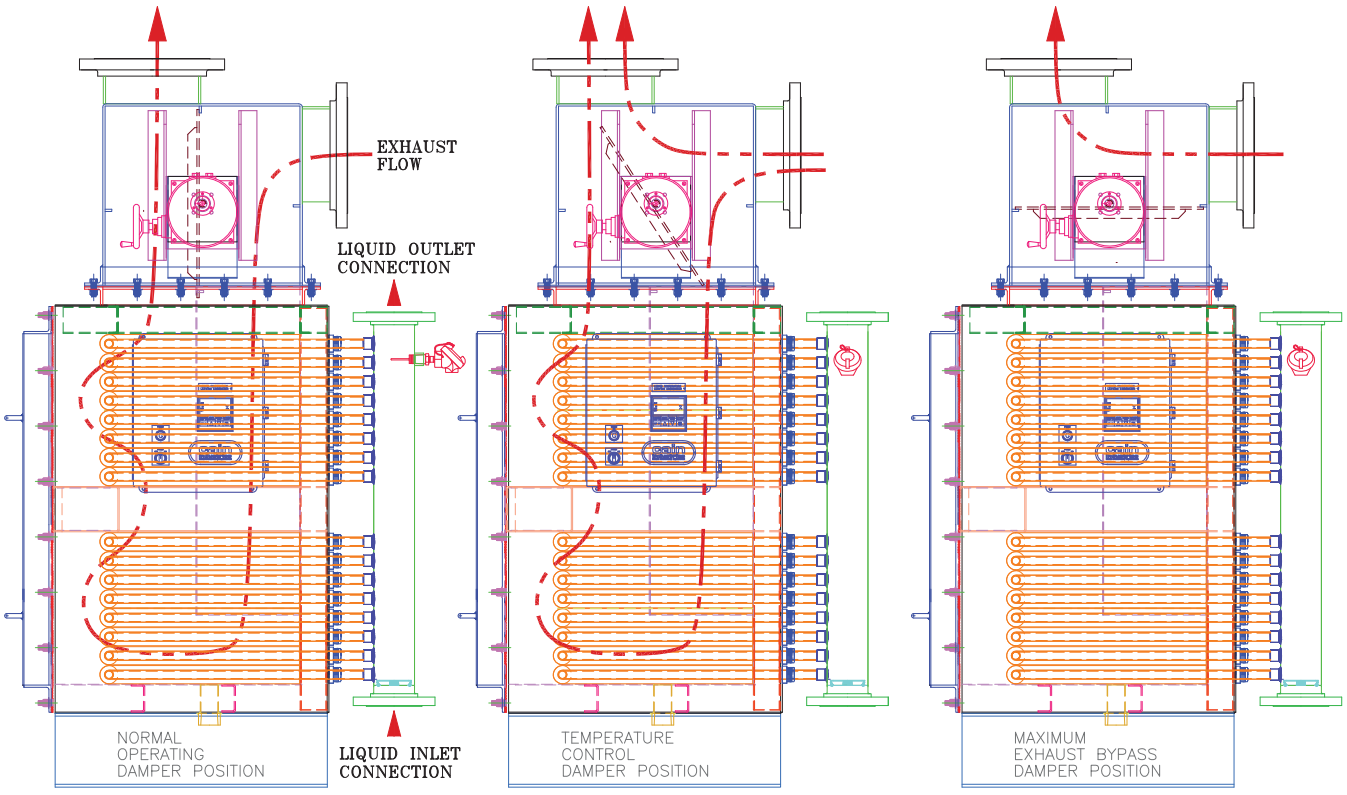
Bul. #11220



OPERATING SEQUENCE:

LIQUID TEMPERATURE CONTROL: (THERMOCOUPLE SENSING MAXIMUM LIQUID TEMPERATURE)
DURING A COLD STARTUP THE DAMPER WILL BE POWERED TO THE 'NORMAL OPERATING POSITON'. AS THE LIQUID TEMPERATURE RISES, APPROACHING A PRESET POINT, THE DAMPER WILL BEGIN TO MOVE TO THE 'TEMPERATURE CONTROL POSITION'. AS THE DESIRED TEMPERATURE IS SATISFIED THE DAMPER ACTUATOR WILL MOVE TO THE 'MAXIMUM OPEN POSITION, BYPASSING 99% EXHAUST AWAY FROM THE HEAT EXCHANGER. (PLEASE NOTE THAT 100% BYPASS CANNOT BE ATTAINED DUE TO CONVECTION LOSSES AND MINOR EXHAUST LEAKAGE THROUGH THE DAMPER BLADE ASSEMBLY).

NOTES:
1. THE WIRING CONNECTION DIAGRAM IS AN EXAMPLE INDICATING THE BASIC ELECTRICAL COMPONENT DESIGN REQUIREMENTS.
2. ACTUATOR TYPES AND/OR ADDED CONTROLS CAN CHANGE WITHIN THE SUBMITTAL DRAWING PROCESS.
3. A SPECIFIC WIRING SCHEMATIC IS SUPPLIED IN CUSTOMER APPROVAL SUBMITTAL DRAWINGS.



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Phone (262) 251-0051 (800) 558-8690 Fax (262) 251-0118 sales@cainind.com www.cainind.com

TERMS OF SALE

Bul. 25500

The terms of the attached Limited Warranty are included in these Terms of Sale and are incorporated by reference herein. The following “Terms of Sale” forms as a part of the Cain Industries equipment proposal as attached herein. All proposed pricing is quoted F.O.B. factory. All pricing is quoted in U.S. currency.

QUOTED DELIVERY TIME:
Delivery times quoted are appropriate for various product lines, and based on conditions at the time of quotation. Cain Industries, Inc. will, in good faith, attempt to deliver the equipment within the time quoted. In no case shall Cain Industries, Inc. be liable for incidental or consequential damages resulting from failure to meet requested or quoted delivery schedules. Quoted delivery time is based from the date of receipt of an approved written purchase order including written authorization to proceed with fabrication and the initial down payment if required, or from date of receipt of submittal drawings when required (less 10 working days).

OFFER EXPIRATION:
All offers expire 60 days from the quotation date unless otherwise stated and are subject to cancellation by Cain Industries, Inc. at any time prior to the formal acceptance of our offer to furnish equipment quoted.

SUBMITTAL DRAWINGS:
Submittal drawings are issued 5-10 working days from receipt of written purchase order, when required by either Cain Industries and/or the Buyer, and must be returned (marked “Approved for Production”, signed, and dated) in order to initiate production. Production cannot begin until the approved submittal drawings are returned.

SHIPMENT OF GOODS:
Unless otherwise specifically agreed, all shipments are made F.O.B. Factory via "best way" and shipped freight collect. Cain Industries, Inc. responsibility ceases upon acceptance by the carrier. SHOULD GOODS BECOME LOST OR DAMAGED IN SHIPMENT, THE PURCHASER OR RECIPIENT OF THE GOODS MUST IMMEDIATELY NOTIFY AND PLACE CLAIM WITH THE CARRIER, ADVISE CAIN INDUSTRIES, INC. OF ANY DAMAGE OR DISCREPANCY, AND OBTAIN AUTHORIZATION FOR RETURN OR REPLACEMENT. As a courtesy, Cain Industries, Inc. will assist in tracing and recovering lost goods and the collection of just claims, but cannot guarantee safe delivery. Loss or damage in shipment does not release the purchaser from payment of the total invoice.

PAYMENT-ESTABLISHED ACCOUNTS:
Payments for established accounts with a credit limit are due on or before the Net 30 days from date of invoice due date, and coinciding with shipment date and/or ‘ready for shipment date’.

EXPEDITING:
Expediting charges may be issued in order to improve delivery depending on the shorter delivery time required. Contact Cain Industries for pricing for the best possible delivery.

STORAGE:
When the equipment is ready for shipment, it will be shipped to the ‘ship to’ address noted on the Sales Order, unless other wise indicated. Should there be a request to hold the equipment beyond the ‘ready for shipment date’, Cain will store the equipment for up to 30 days at no cost providing storage space is available. Contact Cain Industries for storage costs when equipment is expected to be stored for more than 30 days. If storage space is unavailable, the buyer agrees to make provisions to receive the equipment when it becomes ready for shipment.

MINIMUM BILLING:
The minimum order is $100.00, plus shipping costs.

CREDIT LIMIT:
Accounts over credit limit will be on a "Cash with Order" basis until account is brought to below "Credit Limit" status. Special circumstances may occur where credit limits may be adjusted for companies with past credit history satisfactory to Cain Industries, Inc.

TAXES OR SURCHARGES:
Quoted prices do not include sales, use, excise, occupation, processing transportation or other similar taxes which Cain Industries, Inc. may be required to pay or collect with respect to any of the quoted materials. Such taxes which are or may be incurred shall be paid by the purchaser.

PAYMENT-NEW ACCOUNTS:
An initial purchase order received from a new account shall require a 50% down payment with the order, receipt of the completed credit application for immediate processing, and the balance due prior to shipment; or 30% with purchase order and receipt of the completed credit application (order will be held until credit limit has been established) in conjunction with credit limit and/or progress payment schedules. Allow a 3 week processing period to complete the credit check.

PAYMENT-ORDERS OUTSIDE THE UNITED STATES:
For purchase orders received wherein the the final installation and/or the Buyer is located outside the United States, payments shall be made according to the guide lines as set forth herein. It is recommended that a Letter of Credit be created and issued with the purchase order for immediate order processing. All costs associated with international payments such as but not limited to: proforma invoicing, letter of credit, agents of record processing, currency adjustments, tariffs and special taxes, etc. shall be the responsibility of the purchaser. All payments shall be made in U.S. currency and shall be paid in full prior to shipment outside the United States.

SERVICE CHARGE:
A 2% per month service charge will be assessed on all past due amounts.

PROGRESS PAYMENT SCHEDULES:
The following are payment schedules for orders exceeding credit limit:
- For purchase orders of $25,000 to $50,000:
  - -30% due with purchase order
  - -30% due at 45 days from receipt of approval drawings
  - -Balance due 30 days from shipment.
- Over $50,000 or required for the ESG product orders:
  - -15% due with purchase order
  - -15% due with submittal approval drawings
  - -30% due 45 days from receipt of approved submittal drawings
  - -30% due prior to shipment
  - -Balance due 30 days from shipment.

CANCELLATION AND CHANGES:
As many Cain Industries, Inc. products are manufactured and/or adjusted "to order", orders accepted and acknowledged by Cain Industries, Inc. are not subject to change or cancellation without prior consent of Cain Industries, Inc. Order quantity reductions or cancellations, if granted, will be subject to cancellation charges consistent with components "restockability versus made to order specifications" percent of production completion, etc.

EQUIPMENT STARTUP & SERVICE:
Pricing for equipment requiring startup or service: $1100 per day for installations located within the continental United States; $1300 per day for installations located in Canada; all other installation locations are quoted per application. Travel, lodging, and subsistence expenses are in addition. Startup can only be initiated upon receipt of completed Pre-Startup form. ESG & ESG1 boiler startups must be completed by authorized Cain personnel to allow the warranty to become effective, unless otherwise stated in a written agreement issued by Cain Industries to the Buyer.

RETURN OF GOODS FOR WARRANTY REPAIR, REPLACEMENT, OR CREDIT:
Authorization to return goods for any reason must be obtained from Cain Industries, Inc. prior to the return of the shipment being made. All items returned for repair, replacement or credit shall be returned freight prepaid. Freight collect shipments will not be accepted. A 30% "minimum" restocking charge will be made on all items returned for credit. Cancellation and/or restocking charges will apply to the balance of the order pending with a maximum of 90% as determined at the point of cancellation dependent on the work in process. Quantities shipped prior to the point of cancellation shall be issued an additional invoice for the difference in price breaks between the original quantity ordered and the total shipped up to the point of cancellation.

PROPRIETARY DATA:
All manufacturing drawings, specifications and technical material submitted by Cain Industries, Inc. are the property of Cain Industries, Inc. and are to be considered as confidential. Except for its original intent the submittal information supplied herein attached cannot be copied, transferred, or used in any way without the express written authorization from Cain Industries, Inc.

LIMITATION OF REMEDIES:
Cain’s liability is limited exclusively to its obligations under the attached **Limited Warranty**, the terms of which are incorporated by reference herein. Buyer agrees that in no event will Cain be liable for cost of processing, loss of profits, or any other consequential or incidental damages or cost of any kind resulting from the order and or use of its product, whether arising from breach of warranty, non-conformity to order specifications, delay in delivery or any other loss sustained by buyer.

Cain Industries, Inc. PO Box 189 Germantown, WI 53022 • USA • 262-251-0051 • 800-558-8690 • 262-251-0118 Fax • sales@cainind.com

LIMITED WARRANTY AND PERFORMANCE GUARANTEE

Bul. 25500

LIMITED WARRANTY AND PERFORMANCE GUARANTEE

Cain Industries, Inc. warrants all products manufactured to be free from defects in material or workmanship under normal use and conditions for a period of one year from the date of startup or 18 months from date of shipment from our factory whichever occurs first. Cain Industries liability under this warranty to the buyer shall be limited to Cain's decision to repair or replace, all its factory items deemed defective after inspection at the factory or in the field. When field service is deemed necessary in order to determine a warranty claim, the costs associated with travel, lodging, etc. shall be the responsibility of the buyer except under prior agreement for a field inspection. All warranty claim requests must be initiated with a Material Return Authorization (MRA) number for processing and tracking purposes. The MRA number shall be issued to the buyer upon Cain's receipt of a purchase order for replacement component(s) required immediately and prior to warranty claim approval and/or a field inspection. No agent or employee of Cain Industries, Inc. has any authority to make verbal representation or warranty of any goods manufactured and sold by Cain Industries, Inc. without written authorization signed by an executive officer of Cain Industries, Inc. Cain Industries, Inc. warrants the equipment designed and fabricated to perform in accordance with the specifications as stated in the proposal for the equipment, and while the equipment is in new and clean condition and properly operated within the specific design limits for that equipment. Should any piece of equipment designed by Cain Industries, Inc. not meet performance requirements when determined by standard test procedures, Cain will make corrections it deems necessary at its option under the limitations of this warranty. Any alterations or repair of Cain equipment by personnel other than those directly employed by Cain shall void this warranty unless otherwise stated under a specific written guideline issued by Cain Industries to the buyer. The ESG1 and ESG boiler startup must be completed by authorized Cain personnel to allow the warranty to take effect unless otherwise stated in a written agreement issued by Cain Industries to the buyer. This warranty does not cover damage resulting from misapplying Cain Industries products and/or improper installation. This warranty does not cover corrosion resulting from the effects of physical or chemical properties of water, steam or the liquids or gases used in the equipment. This warranty does not cover damage resulting from combustion source backfires or explosions which exceed Cain Industries product specific maximum design pressure and/or when explosion hatches are not properly installed where required. This warranty does not cover damage resulting from excessive vibration resulting from isolating vibration protection not properly installed where required. This warranty does not cover damage resulting from expansion due to expansion joints not properly installed where required. This warranty does not cover damage or lost performance due to combustion source related deficiency such as soot build up on the heating surface. Cain makes no other warranties of performance or product either expressed or implied which extends beyond the limits contained within this instrument. All acceptance tests shall be conducted at the buyer's expense. Any such tests shall be made when the equipment is new, clean, and before being placed into service, and shall be made within 120 days of delivery. Where field test are required, the following procedures are to be used. The exhaust gas and liquid inlet and outlet temperatures shall be recorded simultaneously and measured at a minimum distance of 6 pipe diameters from the equipment. Exhaust gas and liquid volumes shall be determined by actual measurement, if practical, or by calculations if necessary. All factors of O2, CO2, excess air, full input, altitude and the operating efficiency of the primary direct fired unit, shall be incorporated in the final determination and calculation of the volume of the exhaust gas. The expense incurred for such test shall be the responsibility of the buyer and a copy of the test procedures conducted, data accumulated, and calculations used to arrive at the final results shall be submitted to Cain Industries. All workmanship, material and performance requirements shall be deemed to have been met if a contrary report has not been furnished within 120 days of delivery. This "Limited Warranty and Performance Guarantee" forms as a part of the Cain Industries equipment proposal as attached herein.

IN NO EVENT SHALL SELLER BE LIABLE FOR CLAIMS (BASED UPON BREACH OF EXPRESS OR IMPLIED WARRANTY, NEGLIGENCE OR OTHERWISE) FOR ANY DAMAGES, WHETHER DIRECT, IMMEDIATE, INCIDENTAL, FORESEEABLE, CONSEQUENTIAL, OR SPECIAL.

Cain Industries, Inc. PO Box 189 Germantown, WI 53022 • 262-251-0051 • 800-558-8690 • 262-251-0118 Fax • sales@cainind.com

ElectraTherm Resume

Summer 2012

Highlights:

- Founded in 2005
- Approx. 50 Employees
- Patented & Patent-Pending Technology
- 19 Operational Machines
- Reno, Nevada

ElectraTherm Green Machines have been installed or have installations in process for pilot programs and commercial sites in 11 countries around the world.

Northern European Installation
...on stationary engine genset burning anaerobic digester gas. Diesel Engine Jacket Water as heat source works the same.

In 11 countries around the world
The locations pictured above are indicative of concentration of Green Machine installations.

On Internal Combustion Engine in EU:
65% of operational Series 4000s are on ICE

Three North American References

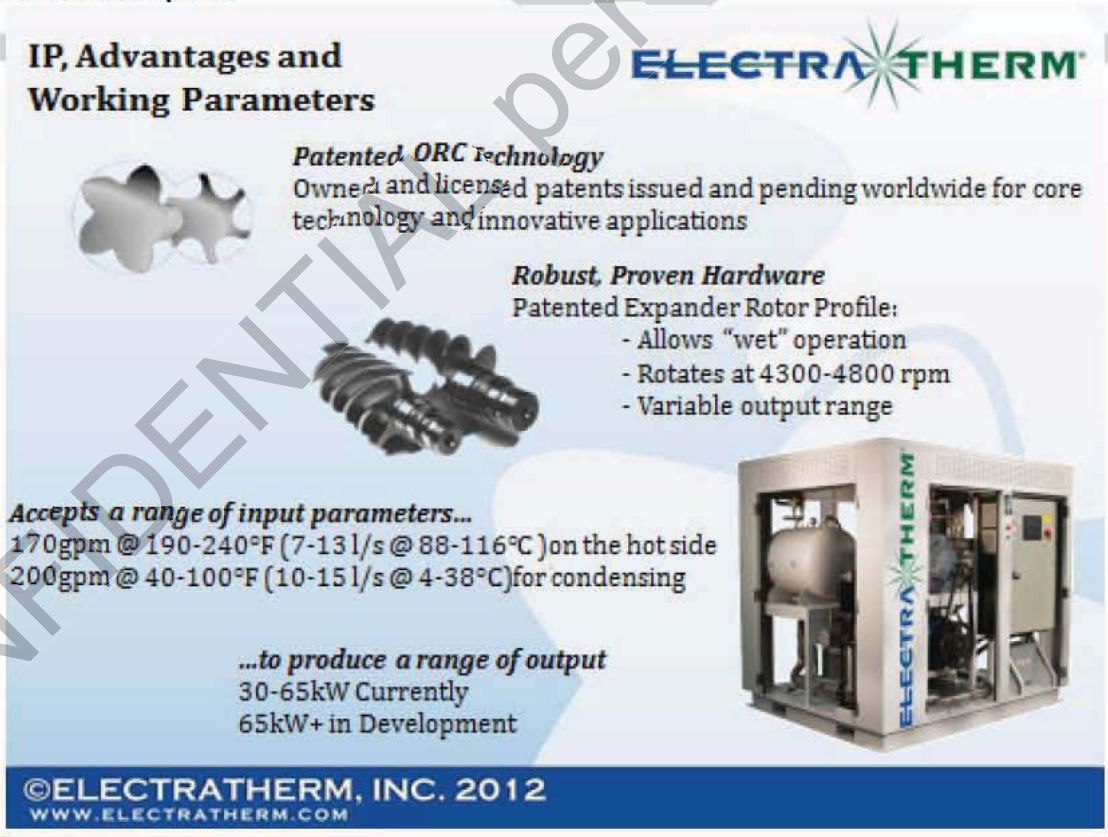
Publically available references: While many of ElectraTherm's customers prefer to keep run data and developments with the Green Machine private, the following references are available for your call or email. They include a PhD Professor, ElectraTherm's longest standing Distributor, and a representative of Canada's largest utility.

3 North American References			
Distributor/Customer	**Contact Name**	**Phone**	**Email**
University of Alaska Fairbanks	Dr. Chuen-Sen Lin	(907) 474-5126	clin@alaska.edu
Gulf Coast Green Energy	Loy Sneary	979.240.3512	loy.sneary@gmail.com
Hydro Quebec	Vasile Minea	813.539.1400 ext. 1	minea.vasile@lte.ireq.ca

Reliability

The ElectraTherm fleet now exceeds 43,000 run hours:

- **Comprised of long proven, off the shelf components**
- **Integrated with patented technology**
- **Commercial units running in the field following three years of Pilot Projects & Beta machines**
- **96%+ Fleet Uptime**



Two Reference Summaries:

Originally Prepared for the "Mass Save" Program Headquartered in Boston

1) Top section gives sampling of utilities around the world that authorized
   a. Interconnect with the Series 4000, and
   b. Identified its output as renewable energy, qualifying it for special tariffs or incentives
2) Lower section lists various grants that have purchased for pilot sites for the Green Machine

Sampling of Utility Interconnect & Renewable Qualification for ElectraTherm Series 4000

Permitted Utility Interconnect 13 Examples				
Site	**City**	**State**	**Utility**	**Description**
ElectraTherm	Reno	NV	NV Energy	50+ ElectraTherm Product (GM) tested & run w/ power exported kWe to NV Energy
SMU	Dallas	TX	Encore/Direct Energy	$0.02/kWe tariff - Green Energy power production paid by Direct Energy for GM power
ULa	Crowley	LA	Central LA Electrical Coop	CLECO purchased GM & approved Ula to run in CLECO funded Renewable Energy Center
UAF	Fairbanks	AK	University Local Grid	Alaska Center for Energy & Power, w/ funding from Tanana Chiefs, funded for phase 2
Denbury	Soso	MS	Dixie Electric Coop	no GPR, RPSEA put up 50/50 grant - money came from DOE, awarded October 2009
Shipyards	Houston	TX	Center Point Energy	Induction generator required no GPR, gave verbal permission for permit for installation
Hydro Quebec	Quebec	Canada	Hydro Quebec	Quebec's largest utility purchased & tested GM over 3 year period. Now preparing field test
Various	Northern	Germany	local	2 commercial sites running 24/7, 2 installing within 90 days: EEG incentives 2004, 2009, & 2012
Various	various	Czech Rep.	several local utilities	5 commercial sites running 24/7, 5 more in construction, 25cent green energy tariffs
Various	Northern	Italy	Enel	2 installations on Internal Combustion Engines JW. Installation on biomass boiler
KSP Solar Site	Kona	HI	Hawaiian Electric Light Co	2 Beta GMs ran 3 years (now retired) with this utility
FPPC		SC	Lynches River	kWe produced from biomass waste to fire boiler and feed to local utility
Geothermal	Oradea	Romania		new installation on geothermal resource
Grant FUNDIN(	**Program**	**Amount**	**Funding avenue**	**Site**
DoD	ESTCP	$400k	via Research Institute	undisclosed US Navy awarded early 2012
DOE	Geotherm	$986k	direct to ElectraTherm	Nevada www.reid.senate.gov/newsroom/pr_100915_geothermalgrants.cfm
DOE	RPSEA	$200k approx	ElectraTherm Distributor	Missouri awarded October 2009
ACEP			UAF Pilot	Univ. Alaska Fairbanks awarded 2010 for Phase 1 tests, approved 2012 for field tests at Tok
Dept. of Agr.	FPPC	$400k (?)	Farm Pilot Project Coord.	farm in South Carolina awarded started 2010 and ongoing

The Proof is in the Performance

Demonstration Period Terms:

In partnership with the City of Unalaska, in which the City ships and contracts the installation of the Series 4000 Green Machine, ElectraTherm will provide that Series 4000 at no charge until after 90 days of run time. At the conclusion of this demonstration (or "acceptance") period, if Unalaska wishes, ElectraTherm will remove the machine at no charge. If Unalaska instead chooses to keep it and complete the order of additional machines, then it will have proven the performance of the Series 4000 prior to purchase. An applicable Terms & Conditions document will be provided separately.

SCADA Interactive
Separate Power & Control Panels

McKINLEY SERVICE & EQUIPMENT INC.
43687 Kalifornsky Beach Road
Soldotna, Alaska 99669
(907) 262-2685 | FAX (907) 260-1984

October 4, 2012

Proposal/Quotes: #3232 #3233 #3234 #3235: ElectraTherm Series 4000 Green Machine - Water Condenser
Project: City of Unalaska: Dutch Harbor Power Plant
Heat: Engine Jacket Water - with closed loop fresh water condensing

City of Unalaska
Dutch Harbor Power Plant

Dear City of Unalaska,

Find in the following proposal McKinley Service & Equipment, Inc.'s (MSE) Quote and updated PEF Assessment for the first of 3 Series 4000 Green Machines for installation at Dutch Harbor in the City of Unalaska. In accepting this Quote, please affix your Purchase Order Number to the box and your signature to the space at the bottom left of the second page following this letter. Please email the signed Quote to me for review. Upon acceptance I will return a signed copy to you.

This Quote contains a number of special terms and conditions worthy of highlighting here:

- The shipping estimate includes shipping the first of three Series 4000 Green Machines and 700lbs. of refrigerant in a single 20ft. shipping container.
    - MSE is currently awaiting approval from Honeywell to ship the refrigerant in the same container as the Green Machine. If they cannot be shipped together there will be an addition shipping cost for the refrigerant.
- Acceptance Period shall follow 90 days of 'run time' as determined solely by MSE staff. Full payment shall then be immediately due and payable.
    - The offer of this "demonstration" is predicated on the End User Customer's purchase of the second and third machines per upcoming quote #3234 and #3235 should the Acceptance Period for the first machine be deemed successful.
    - Shipment of machine #1 from ElectraTherm's place of manufacture on or before December 31, 2012.
- We are including Quote #3234 and #3235 for Machines #2 and #3, should the City wish to employ the "demo" terms, with one possible exception:
    - The single shipment of 2 machines plus 1400lbs. of R245fa will likely require use of a single 40ft. shipping container, so the price of shipping machines 2 & 3 will likely be less than the per machine shipping costs in this Quote #3232.
- MSE is confirming the price of R245fa and these shipping arrangements with Honeywell, and is awaiting their comeback since EPS confirmed that ElectraTherm/McKinley is to supply refrigerant.
- The cost of the return of the cylinders to Honeywell shall be the responsibility of the City of Unalaska and is not included in this quote.
- City of Unalaska must supply internet access, (see Exhibit D), to comply with the warranty. Cellular or Satellite internet available at an additional cost.

Feel free to contact me directly with questions pertaining to the project and quote by email or by telephone at 907-262-2685.

Sincerely,

Matt McKinley - Business Manager
McKinley Service & Equipment, Inc.
matt@mckinleyservice.com

McKINLEY SERVICE & EQUIPMENT INC.
43687 Kalifornsky Beach Road
Soldotna, Alaska 99669
(907) 262-2685 | FAX (907) 260-1984

Table of Contents

McKinley Service & Equipment Inc.

43687 Kalifornsky Beach Rd
Soldotna, AK 99669

Quote

Date	Quote #
10/4/2012	3232

Name / Address
City of Unalaska Dutch Harbor Power Plant Unalaska, AK 99685

P.O. No.	Terms	FOB	Prepared By
	See Below		Matt McKinley

Description	Qty	Cost	Total
Series 4000, 50W,Water-Cooled, 60 Hz	1	185,000.00	185,000.00
Shipping: re-quoted 10 days prior to ship		8,590.42	8,590.42
TERMS: 90 DAY ACCEPTANCE PERIOD ~ FULL PAYMENT DUE AFTER 90 DAYS OF RUN TIME [Terms & Conditions Section 3(a)]			
RECEIPT OF PAYMENT WILL ACTIVATE QUOTE #3234 [Terms & Conditions Section 4(a)]			

See Terms & Conditions Attached

Subtotal	$193,590.42
Sales Tax (0.0%)	$0.00
Total	$193,590.42

Signature _____

McKinley Service & Equipment Inc.

43687 Kalifornsky Beach Rd
Soldotna, AK 99669

Quote

Date	Quote #
10/4/2012	3233

Name / Address
City of Unalaska Dutch Harbor Power Plant Unalaska, AK 99685

P.O. No.	Terms	FOB	Prepared By
	See Below		Matt McKinley

Description	Qty	Cost	Total
INSTALLATION FOR QUOTE #3232			
R245fa Refrigerant, sufficient for water condensed Green Machine (lbs)	700	19.75	13,825.00
Refrigerant Cylinder Deposits, refundable 100lbs Per	7	200.00	1,400.00
ORC System Start-Up & Commissioning		8,942.00	8,942.00
TERMS: DUE ON RECEIPT OF PRODUCT OR AT TIME OF SERVICES RENDERED: NET 30			

See Terms & Conditions Attached

Subtotal	$24,167.00
Sales Tax (0.0%)	$0.00
Total	$24,167.00

Signature _____

McKinley Service & Equipment Inc.
43687 Kalifornsky Beach Rd
Soldotna, AK 99669

Quote

Date	Quote #
10/4/2012	3234

Name / Address
City of Unalaska Dutch Harbor Power Plant Unalaska, AK 99685

P.O. No.	Terms	FOB	Prepared By
	See Below		Matt McKinley

Description	Qty	Cost	Total
Series 4000, 50W,Water-Cooled, 60 Hz	2	185,000.00	370,000.00
Shipping: re-quoted 10 days prior to ship		8,590.42	8,590.42
TERMS: AFTER SUCCESSFUL CONCLUSION OF THE ACCEPTANCE PERIOD WIRE 30% DEPOSIT WITH PURCHASE ORDER [Terms & Conditions Section 5(a)]			
WIRE ADDITIONAL 70% PRIOR TO SHIPMENT [Terms & Conditions Section 5(a)]			

See Terms & Conditions Attached

Subtotal	$378,590.42
Sales Tax (0.0%)	$0.00
Total	$378,590.42

Signature _____

McKinley Service & Equipment Inc.

43687 Kalifornsky Beach Rd
Soldotna, AK 99669

Quote

Date	Quote #
10/4/2012	3235

Name / Address
City of Unalaska Dutch Harbor Power Plant Unalaska, AK 99685

P.O. No.	Terms	FOB	Prepared By
	See Below		Matt McKinley

Description	Qty	Cost	Total
INSTALLATION FOR QUOTE #3234			
Refrigerant Cylinder Deposits, refundable 100lbs Per	14	200.00	2,800.00
R245fa Refrigerant, sufficient for water condensed Green Machine (lbs)	1,400	19.75	27,650.00
ORC System Start-Up & Commissioning		11,650.00	11,650.00
TERMS: DUE ON RECEIPT OF PRODUCT OR AT TIME OF SERVICES RENDERED: NET 30			

See Terms & Conditions Attached

Subtotal	$42,100.00
Sales Tax (0.0%)	$0.00
Total	$42,100.00

Signature _____

McKINLEY SERVICE & EQUIPMENT INC.
43687 Kalifornsky Beach Road
Soldotna, Alaska 99669
(907) 262-2685 | FAX (907) 260-1984

Terms & Conditions of MSE Quote 3232 3233 3234 3235 Water Condensed

1. CONTINGENCIES AND ACCEPTANCE

Acceptance of Quote 3232 and 3233: is conditional on the signing by both SE and City of nalaska of uote #3232 and #3233, and the Terms Conditions below.

Acceptance Period Payment Terms for Quote 3232 and 3233: offered in Section 3, below, are contingent on timely acceptance of the uote by City of nalaska such that Product ships prior to December 31, 2012.

Acceptance of Quote 3234 and 3235: is conditional on Section 4(a) of the Conclusion of the Acceptance Period, the signing by both SE and City of nalaska of uote #3234 and #3235, and the Terms Conditions below.

Payment Terms for Quote 3234 and 3235: offered in Section 5, below, are contingent on timely acceptance of the uote by City of nalaska.

2. PURCHASE OF PRODUCTS BY CITY OF UNALAS A

(a) Ship Date. SE will use commercially reasonable efforts to ship Product (reen achine 4000 and ancillary items) in a timely manner per the Purchase Order. Targeted ship date shall be determined following SE and City of nalaska's acceptance of quote. SE will not be liable for any delay in delivery, regardless of cause.

(b) Shipping. All shipments will be made FCA (per Incoterms 2010) from ElectraTherm's facility or place of manufacture to City of nalaska's address as set forth in page two (2) of this uote or other such address as City of nalaska specifies in writing prior to shipment. Delivery will be deemed complete and risk of loss or damage, as well as title, to the Products will pass to City of nalaksa upon delivery to the carrier. ElectraTherm will select the carrier and arrange shipping unless otherwise mutually agreed to by all parties. City of nalaska will advance pay all costs of transportation, any insurance requested by City of nalaska, export and import fees, customs brokerage expenses and similar charges. City of nalaska, at its expense, will make and negotiate any claims against any carrier, insurer, customs broker, freight forwarder or customs collector.

Shipping Charges. ElectraTherm will update the shipping quote within 10 days before shipment. Shipping charges are due and payable prior to shipment.

(c) Taxes. In addition to any payments due to SE under this Agreement, City of nalaska will pay, indemnify and hold SE harmless from any sales, use, excise, import or export, value added or similar tax, not based on SE's net income (collectively the "Taxes") and any penalties or interest associated with any of the Taxes, imposed by any governmental authority with respect to either

or both of any payment to be made by City of nalaska to SE under this Agreement or any Products to be delivered by SE under this Agreement.

3. PAYMENT TERMS: 90 DAY RUNTIME ACCEPTANCE PERIOD AS STATED IN QUOTE 3232 AND 3233

(a) The Acceptance Period will begin upon successful installation, interconnection and start-up of the Product at the Dutch Harbor Power Plant and will operate until the later of ninety (90) days from the date of start-up or one hundred and fifty (150) days from date of arrival of the Product at the City of nalaska, unless extended or terminated by mutual consent of the Parties in writing.

4. CONCLUSION OF ACCEPTANCE PERIOD:

Within three business days of the conclusion of the Acceptance Period, City of nalaska will either:

(a) Complete the purchase of Product as described in the uote with payment in full, and wire 30 deposit with Purchase Order for purchase of two (2) additional Product's and ancillary items as described in uote #3234 and #3235.

(b) Request removal of the Product. If City of nalaska requests removal of Product in lieu of purchase, City of nalaska, at its sole expense, will disconnect and make the Product available in good condition for removal by SE. SE will not be responsible for the removal or replacement of any site-improvements or connection appurtenances installed at the Dutch Harbor Power Plant.

5. PAYMENT TERMS: FOR MACHINE 2 AND 3 AS STATED IN QUOTE 3234 AND 3235

(a) City of nalaska will wire 30 with Purchase Order, and wire 70 prior to shipment, (as mandated by manufacturer.) If ten (10) days after the scheduled ship date, City of nalaska has not delivered to SE payment totaling 100 of the Purchase Order amount, SE may cancel the order, charge City of nalaska the 20 cancellation fee, and return Product to SE's inventory for sale. Custom third party accessories, such as and including air-cooled-condensers, require deposit of 100 with Purchase Orders.

6. GENERAL: THE PARTIES AC NOWLEDGE THAT:

(a) During the Acceptance Period, value created by the Product, including but not limited to energy production, utility incentives, or any other benefit derived from operation, will belong to, or be the property of, City of nalaska or its assigns.

(b) Performance data generated during the Acceptance Period will remain the confidential property of SE until, by mutual consent in writing, the Parties agree to make data available to the public. Thereafter, SE and/or ElectraTherm will have the right to video and photograph the Product in operation, interview site personnel regarding Product performance, and attend events and tours related to installation of the Product hosted at the Dutch Harbor Power Plant.

(c) Employees, representatives and vendors of the Parties will have access to the installation site. After mutual consent per Section 6(b) above, media representatives, customers and other associates of the Parties will have access to the installation site.

(d) Should SE or City of nalaska fail to install the Product within 150 days of arrival at Dutch Harbor from SE's place of manufacture, SE shall have the right to take possession of the Product.

7. OTHER PROVISIONS OR OBLIGATIONS OF MSE

(a) SE shall retain ownership of the Product during the Acceptance Period

(b) SE will at its sole expense:

Train engineers operators at the Dutch Harbor Power Plant on the use and commissioning of the Product at the installation site and/or at SE's Soldotna facility and/or ElectraTherm's place of manufacture

Remotely monitor machine performance

Should City of nalaska request removal of Product in lieu of purchase, City of nalaska shall inform SE within 3 business days and shall disconnect and make the Product available for removal by SE within 10 business days. SE shall remove Product but shall not be responsible for the removal or replacement of any site-improvements or connection appurtenances installed by at the Dutch Harbor Power Plant. SE will be responsible for shipping charges.

(c) Fees quoted by SE regarding Start-up and Commissioning are limited to the following:

Travel: One (1) trip per fee.

abor: ot to exceed 40 hours per Technician.
Hours exceeding 40 will be billed at an additional fee of 117 / hour straight time and 155.00 / hour overtime, plus hours for travel and expenses, if required.

8. MSE SCOPE OF SUPPLY (THROUGH THE MANUFACTURER)

(a) <u>Specifications & Documents:</u>

PEF Assessment: Dependent on Electrical Power Systems, Inc. (EPS) provided heats, flows, ambient and condensing conditions, and other project specifications ElectraTherm provides a non-binding, estimate of gross and net power output, heat balance, and single line drawings in the Project Evaluation Assessment supplied herein as <u>Exhibit A</u>.

Installation Drawings: ElectraTherm equipment dimensions hot-in and condenser interface supplied herein <u>Exhibit B</u> of this quote. All drawings are subject to change without notice and Buyer should request updated installation guidance and drawings from ElectraTherm's Service Team prior to initiating installation.

ORC Primer: A 33 page basic description of the workings of the ElectraTherm reen achine.

Installation & Connection Guide: in depth review of items outlined in this Section 8, including but not limited to materials and processes pertinent to successful installation of the reen achine.

Operations Manual

Spare Parts Lists

Maintenance Schedules

(b) Equipment: Series 4000 Green Machine 50kW (ORC), assembled

ood Title

ajor components inside the cabinet, or within the exterior dimensions as described in the Installation drawings, include:

Evaporator
Pre-heater
Condenser
Induction generator, 50kw
Power factor correction capacitors
Working fluid pump
Working fluid reservoir
Twin-screw expander
Internal to the cabinet enclosure: piping, joints, valves, and fittings
required for the successful factory test and operation of the orc.
2 integrated control panels with H I touchscreen
Cabinet enclosure, ema 3r rating
Software available for license by end-user customer
Interface access as described in the installation drawings

(c) Factory Test and Inspection: at ElectraTherms's place of manufacture.

(d) Loading of Equipment at place of manufacture to Common Carrier

(e) Exclusions: SE's scope of supply does OT include the following:

Site engineering or design

Site preparation or installation, including but not limited to:

Soil preparations, concrete pads, other footings, foundations or equipment stands

Piping, fittings, pumps, valves (etc.) or electrical wiring, cables or components external to the reen achine, albeit required to interface with site inflow or output of heat or electrical power.

Heat exchange devices outside the dimensions of the reen achine

rid Protection Relay and Interconnection as required

Installation abor

Permits icenses

POE oil

Charging of Equipment with Working Fluid

Equipment or hardware to deliver condensing water flows to the reen achine

Insulation, isolation or anti-freeze protection

Hot Water Bypass

Internet Connection required for remote monitoring of equipment performance.

Shipment or delivery from dock, unloading at installation site, and any related storage

Return shipment of R245fa cylinders to Honeywell.

Import fees, taxes, customs, duty or storage charges

9. REPLACED PARTS:

(a) Parts or Components of the reen achine replaced under warranty are the property of ElectraTherm

10. CERTIFIED HANDLERS:

(a) c inley shall inform end-user customer that working fluid contains R245fa, a fluorinated greenhouse gas which is controlled by local and regional regulations. Handlers of the working fluid must be trained and certified in containment, recovery, and transfer of such materials.

11. CITY OF UNALAS A SCOPE OF SUPPLY

(a) Temperatures & Flows for expanding and condensing as minimally described in the applicable Project Evaluation Form integrated herein as Exhibit A.

(b) Services and Equipment Excluded from ElectraTherm s Scope of Supply or otherwise not provided by seller, but required for successful installation and operation of the ElectraTherm reen achine. (See Section 1.d above)

(c) Internet Connection and Specifications:

Completely independent of onsite existing network, P , firewalls, etc.

Programmable Specifications: for preparation of the reen achine router prior to shipping. (See specs. in Exhibit D below)

Tested as part of site installation, prior to scheduling site commissioning and start-up.

12. SOFTWARE LICENSE AGREEMENT

(a) City of nalaska agrees to the End ser Software icense attached hereto as Exhibit C.

13. REMOTE MONITORING

(a) City of nalaska agrees to comply with remote monitoring requirements per Exhibit D, attached hereto.

14. INTELLECTUAL PROPERTY

(a) City of nalaska acknowledges and agrees that the Products and Components are proprietary to ElectraTherm and that ElectraTherm (or its suppliers) retain exclusive ownership of all Intellectual Property Rights embodied in the Products and Components.

(b) City of nalaska will not develop, manufacture, distribute, market, lease or sell a) any heat or pressure generators or twin screw expanders using, referencing, derived from, or covered by ElectraTherm's Intellectual Property Rights or Confidential Information and will not enable any third party to do (or enter into a Third Party Agreement with a third party that is doing) any of the foregoing, and, or b) any heat electricity generators operating on heat flows under one hundred twenty degrees Celsius.

(c) City of nalaska is not granted any rights or license to any Intellectual Property Rights with respect to any Product or any Component thereof.

15. SUPPORT WARRANTY LIMITATION OF LIABILITY

(a) Technical Support. SE will provide standard initial technical assistance to trained City of nalaska engineers as may be reasonably necessary for City of nalaska to use the Products, including, without limitation, reasonable telephone, fax and e-mail support during SE's normal business hours.

(b) Training. City of nalaska agrees to have at least two engineers in attendance at the commissioning and start up at City of nalaska's installation for training in use of the Product.

(c) Consulting Support. At City of nalaska's request and at the discretion of SE, SE may provide support and consulting services on a time and material basis pursuant to a separate written agreement entered into between the parties.

(d) Warranty. SE warrants that (a) for one (1) year from the date of commissioning, or for 1 year from one hundred and fifty (150) days from date of shipment of Product from the factory, whichever comes first, Products sold hereunder will function in accordance with standard specifications for the Products, and (b) SE is passing good title in Products sold to City of nalaska. This warranty is extended only to City of nalaska by the Seller. The warranties set forth in this Section will not apply to: (a) any "Third Party Product", whether or not such "Third Party Product" is provided by SE (b) any Products that have been modified, repaired or altered, except by SE or its authorized representative (c) any Products which have not been properly installed or maintained in accordance with any handling or operating instructions supplied by SE or (d) any Products that have been subjected to physical or electrical stress, misuse, abuse, negligence or accidents. In no case will SE be responsible to replace refrigerant. This warranty does not cover corrosion resulting from the effects of physical or chemical properties of water, steam or the liquids or gases used in or in proximity of the equipment.

(e) Access to Equipment: SE and City of nalaska shall provide access to equipment to SE and ElectraTherm's representatives for inspections and warranty work.

(f) Preservation of Warranty: Removing serial numbers, patent markings, paints, seals or other devices will result in loss of warranty as described in this section. Attempts to make, modify, translate, reproduce, reverse engineer, disassemble, assemble, prepare derivative works, or otherwise use any Products or Components, equipment or other materials provided by SE in whole or in part, without the express prior written consent of SE, will result in loss of warranty.

(g) Estimated Product Output: City of nalaska acknowledges that temperatures and flows of heat and condensing cycles, as well as ambient conditions and other variables, at installation sites may vary and will affect power output from Product. Therefore, the amount of power produced by Product will not, in itself, be cause for a warranty claim.

(h) Extended Warranty: At City of nalaska's request and at the discretion of SE, City of nalaska may purchase extended warranty pursuant to a separate written agreement.

(i) Warranty Service. If Products qualifying for warranty service require SE personnel to travel to installation site to effect warranty service, SE will pay for such travel and expense, and parts and labor, unless the "warranty" work is found to not be a true warranty issue. If the "warranty" work is found to be caused by misuse, abuse, faulty repair, alteration etc. City of nalaska will compensate SE for such travel and other expenses plus work performed on-site based on SE's standard rates at the time of service. City of nalaska's exclusive remedy and SE's total liability for breach of any warranty under this Agreement and any and all losses and damages arising out of any cause related to the Products will be the repair, replacement or refund of such Product.

(J) DISCLAIMER. E CEPT AS SET FORTH HEREI , SE DISC AI S A WARRA TIES, WHETHER E PRESS, I P IED OR STAT TOR , I C DI , WITHO T I ITATIO , THE I P IED WARRA TIES OF ERCHA TABI IT , FIT ESS FOR A PARTIC AR P RPOSE A D O I FRI E E T, A D A WARRA TIES THAT A ARISE FRO CO RSE OF DEA I , CO RSE OF PERFOR A CE OR SA E OF TRADE. SE EITHER ASS ES, OR A THORI ES A OTHER PERSO TO ASS E FOR IT, A OTHER IABI IT I CO ECTIO WITH THE PROD CTS, I C DI , WITHO T I ITATIO , IABI IT ARISI O T OF THE DE I ER OR SE OF THE PROD CTS.

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16. INDEMNIFICATION.

(a) City of nalaska will defend (at SE's request) and pay all damages, costs, liabilities, expenses (including reasonable attorneys' fees) awarded and reasonable settlement amounts due in connection with, any suit, claim or action by any third party against SE as a result of installation or other support of the Products other than by SE or its authorized service agent.

17. MISCELLANEOUS TERMS

(a) Governing Law. This Agreement will be governed by and construed in accordance with the laws of the State of Alaska, .S.A., without reference to its conflicts of law provisions. The parties agree that all matters concerning this Agreement will be determined by the federal or state courts of the State of Alaska., and consent to jurisdiction of such courts and service of process by mail or other means of hard copy delivery, such as fax, is hereby granted by the parties

(b) Severability & Waiver. If any term, provision, covenant or condition of this uote is held by a court or arbitral panel of competent jurisdiction to be invalid, void or unenforceable, then such term, provision, covenant or condition will be enforced to the maximum extent possible so as to effect the intent of the parties, or in the event that is not feasible, such term, provision, covenant or condition will be deemed severable from this uote and the remainder of the provisions hereof will remain in full force and effect and will in no way be affected, impaired or invalidated. The failure of either party to exercise any right or interest it is granted herein, or to require the performance by the other party hereto of any provision of this Agreement, or the waiver by either party of any breach of this uote, will not prevent a subsequent exercise or enforcement of such provisions or be deemed a waiver of any subsequent breach of the same or any other provision of this Agreement

(c) Force Majeure. SE will be not be liable under these terms because of any failure or delay in the performance of its obligations (except for payment of money) on account of strikes, shortages, riots, fire, flood, storm, earthquake, acts of od, hostilities or any other cause beyond its reasonable control.

EXHIBIT A

Unalaska Power Plant 1st ORC

EPS Inc.

Heat Source: Engine Jacket Water (JW)

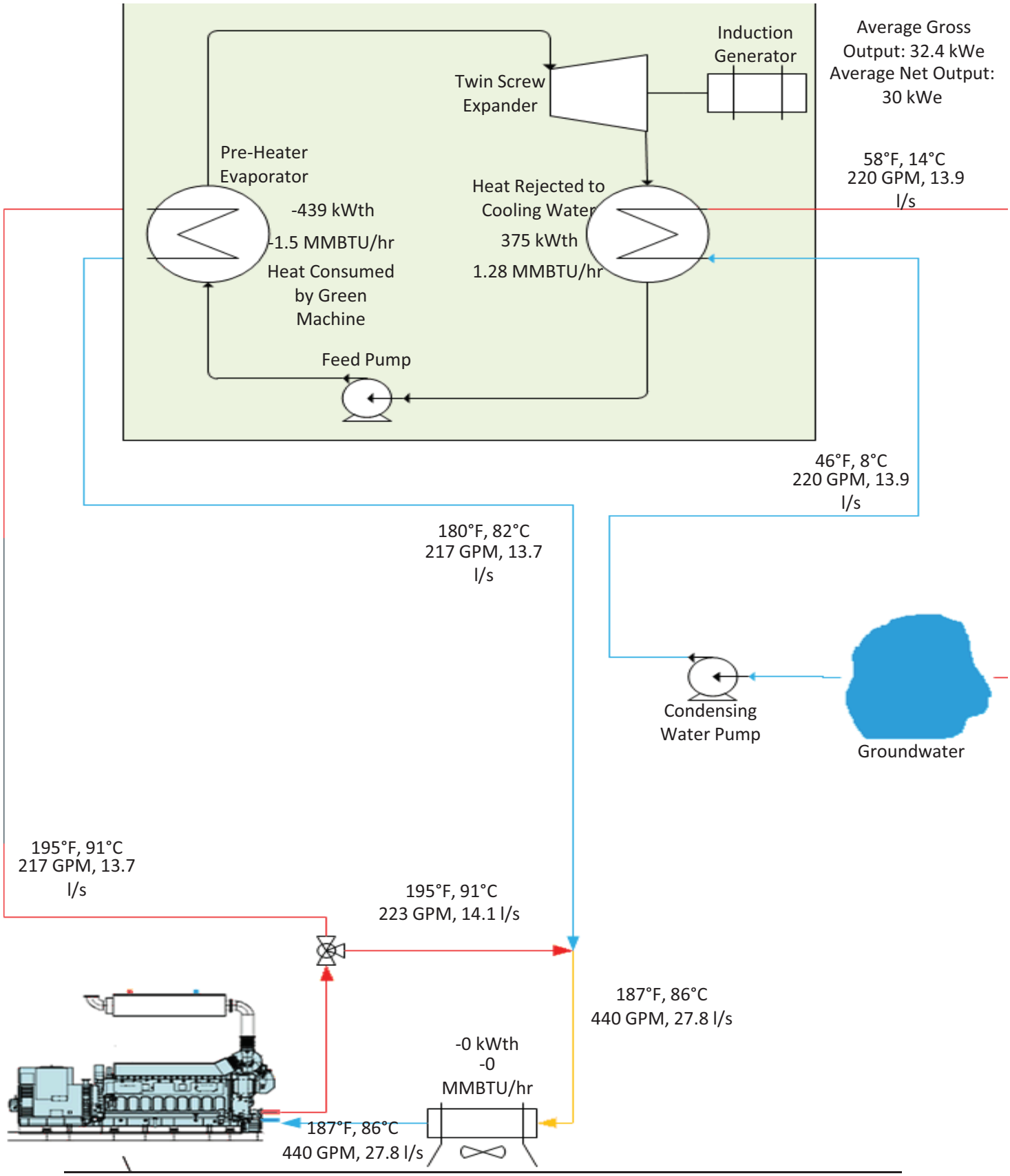
Condensing Solution: Fresh Water Close Loop System

Project Evaluation

9/21/2012

The project assessment program contains default input values intended for internal system use. Input values will vary depending on technology, geographic location, and site dependent variables e.g.: water temperature and flow. The following reports serve as a guide only. Due to volatility of incentive policies/availability, electric prices and technology some of projected values may be out of date or inaccurate. Before submitting for a report, review data and verify that they are correct for your analysis.

One Line Heat Balance Diagram



Project Input	
Project Name:	Unalaska Power Plant 1st ORC
Project Company:	EPS Inc.
Heating Source:	Engine Jacket Water (JW)
Cooling Source:	Process Water
Annual Runtime:	8322 Hours
Project Service Lifetime:	20 Years
Pump Parasitic Load:	0 kW
Price per kWh:	0.42 U.S.D.
Hot Water Temperature:	195°F
Hot Water Flow:	217 GPM
Avg. Ambient Temperature:	46°F
Approach Temperature:	0°F
Available Thermal Power:	1.5 MMBTU/hr
Green Machine Size:	51-65 kWe
Green Machine Generator Frequency:	60 Hz

Electrical Output*	
Average GM Gross Power Output:	32.4 kWe
Average Total Net Power Output:	30 kWe
Avg. Total Internal & External Parasitic Load:	2.4 kWe
Average GM Internal Parasitic Load:	2.4 kWe
Average External to GM Fan Parasitic Load:	0 kWe
Average External to GM Pump Parasitic Load:	0 kWe
Annual Gross Energy Output:	269 MWh
Annual Net Energy Output:	249 MWh

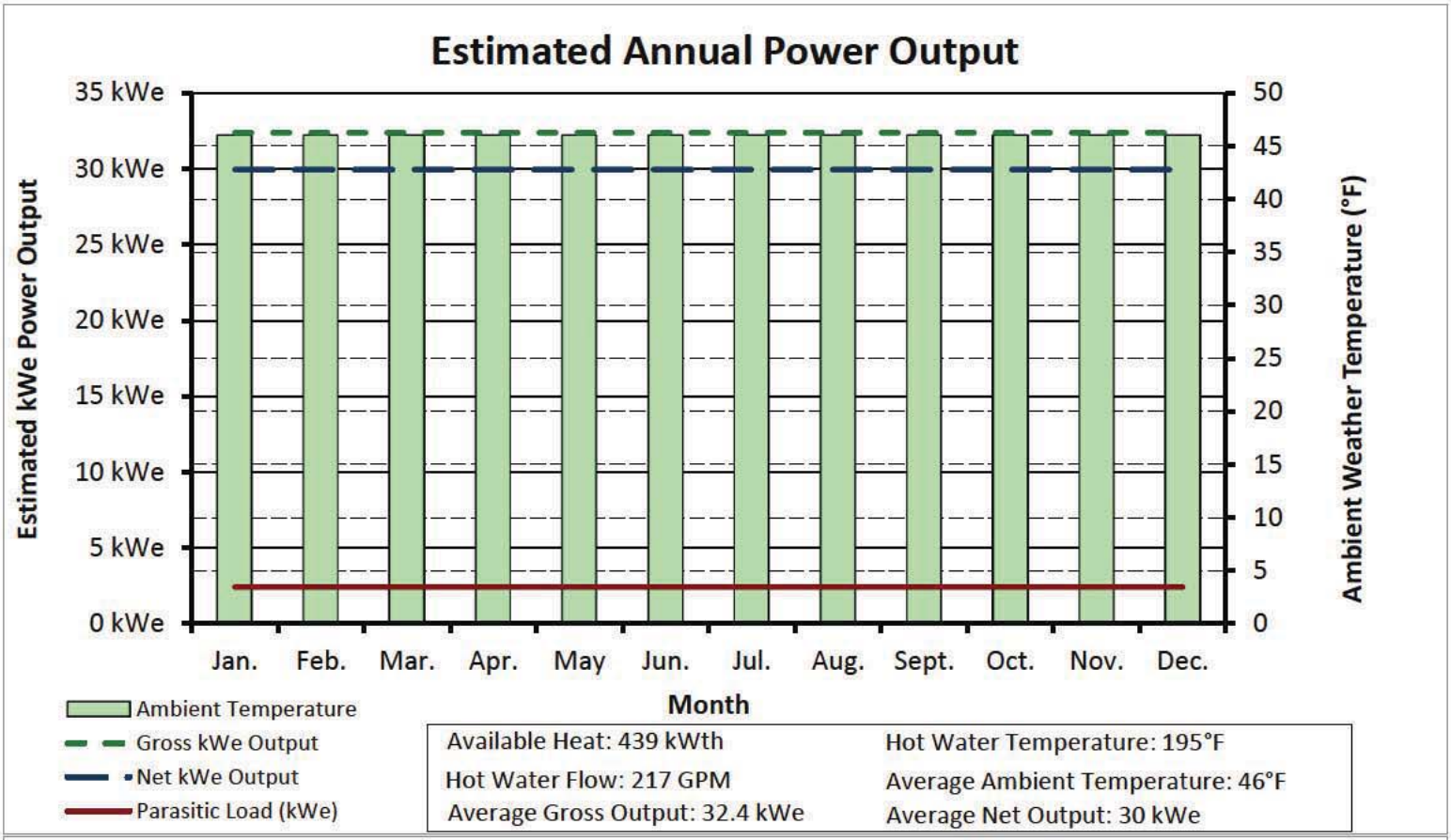
Thermal Balance*	
Average Heat Consumed:	1.5 MMBTU/hr
Maximum Heat Consumed:	1.5 MMBTU/hr
Average Heat Rejected:	1.28 MMBTU/hr
Maximum Heat Rejected:	1.28 MMBTU/hr
Hot Water Inlet Temperature:	195°F
Hot Water Outlet Temperature:	180°F

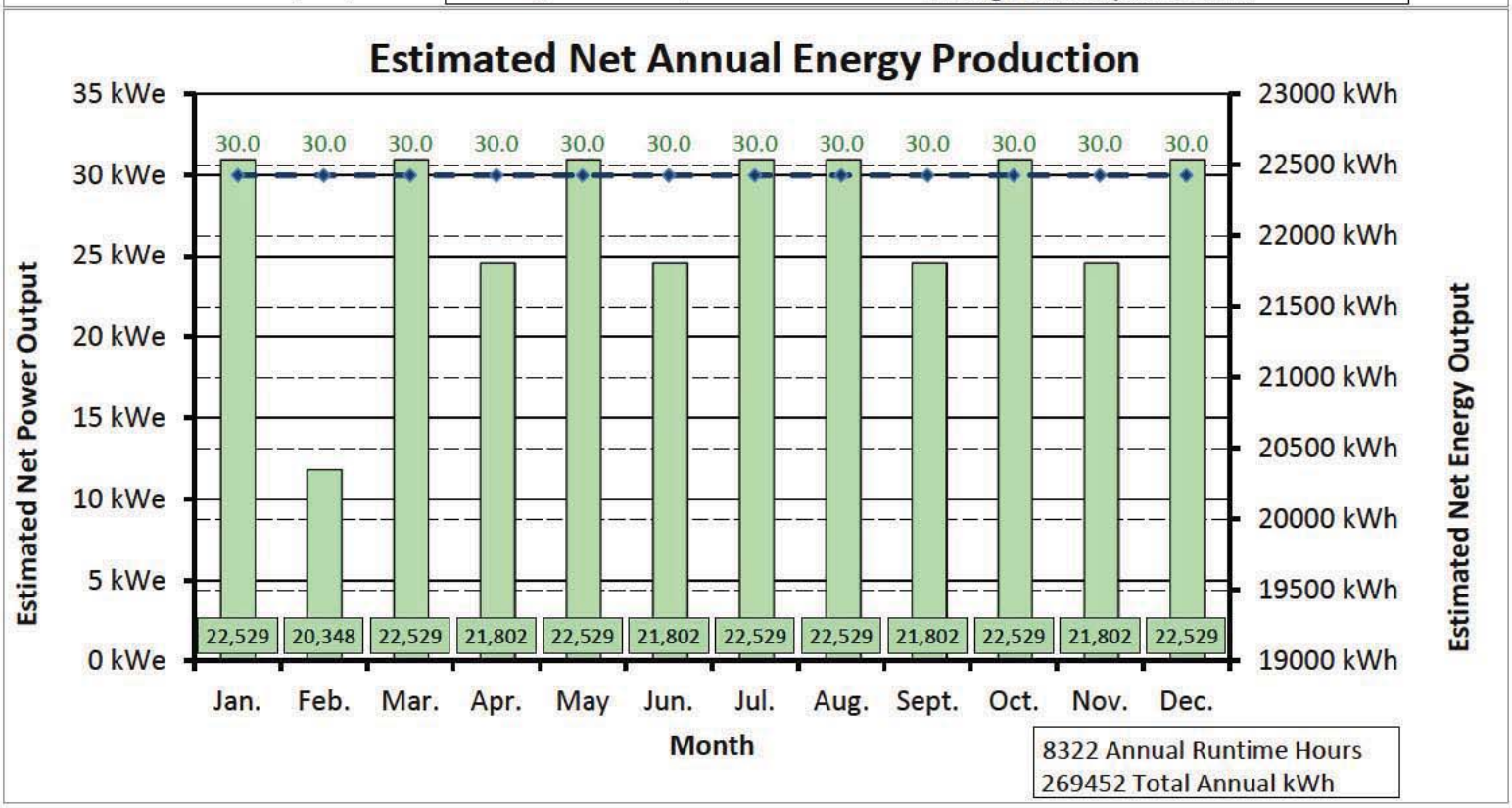
Hot Water Temperature Comparison		
Temperature	**Gross Power**	**Net Power**
195°F	***32.4 kWe***	***30 kWe***
200°F	33 kWe	30.5 kWe
220°F	35.6 kWe	32.6 kWe
240°F	36.6 kWe	33 kWe

*consumed heat, rejected heat, and electrical output values are based on measured ElectraTherm test data. Small errors in measuring temperature and flow due to instrumentation tolerances can induce a noticeable error in thermal measurement. This document is a guideline only, and the thermal error on heat rejected and heat consumed can be up to +/- 80kW

Engineer's Notes

1. Project requires condensing water flow of 220 GPM.
2. Green Machine electrical output is limited by available thermal energy.
3. 30% glycol/water mix is assumed in the hot water flow.
4. This represents the 1st ORC utilizing heat from the 1st Wartsilia engine which also supports building heat.
5. There is potential for up 2 kW loss due to approach on salt water/fresh water heat exchanger.





ANALYSIS RESULTS FROM GREEN MACHINE (GM) PERFORMANCE TEST:

Table-1: Measured performance results for HW Temp= 155°F, 195°F and 215°F; HW flow rate = 120gpm, 160 and 250gpm; CW Temp 50°F and CW flow rate = 160gpm

Case #	Hot water flow rate - Average (GPM)	Hot water Supply Temp - Average (F)	Cold water flow rate - Average (GPM)	Cold water supply Temp - Average (F)	GM Net Power - Average (kW)	GM Pump Power - Average (kW)	Hot water pump power - Average (kW)
	HW Temp= 155°F						
1	120.592	157.934	157.326	52.635	14.554	0.914	1.005
2	159.151	158.195	158.502	52.275	15.730	0.962	1.781
3	251.794	158.933	156.831	52.116	17.865	1.068	5.812
	HW Temp= 195°F						
4	119.831	195.716	157.997	51.881	31.164	1.907	1.010
5	157.969	195.853	158.123	52.174	34.121	2.268	1.779
6	251.334	196.274	159.515	52.100	36.808	2.549	5.732
	HW Temp= 215°F						
7	123.395	214.637	163.370	51.726	41.551	2.910	1.028
8	162.437	214.151	164.837	51.600	44.529	3.326	1.840
9	252.859	214.451	163.707	51.793	47.727	3.622	5.794

Table-2: Induced performance results from measured readings of above Table-1

Case #	Heat supplied by hot water (kW)	Heat rejected to cold water (kW)	Cold water pump Power (kW)	GM Gross Power (NO pumps) (kW)	GM net efficiency (GM pump) (%)	GM gross efficiency (NO pumps) (%)
	HW Temp= 155°F					
1	261.905	239.079	1.799	15.468	5.557	5.906
2	277.285	249.353	1.799	16.691	5.673	6.020
3	305.947	266.759	1.799	18.932	5.839	6.188
	HW Temp= 195°F					
4	427.198	391.780	1.799	33.072	7.295	7.741
5	470.236	420.927	1.799	36.389	7.256	7.738
6	515.273	456.774	1.799	39.357	7.143	7.638
	HW Temp= 215°F					
7	554.907	494.425	1.799	44.461	7.488	8.012
8	600.039	536.355	1.799	47.855	7.421	7.975
9	641.869	563.160	1.799	51.349	7.436	8.000

Table-3: Payback period and gallons of diesel fuel saved per year for different GM net power outputs.

GM Net power output (kW)	Payback (0% interest on capital) (years)	Payback (10% interest on capital) (years)	Gallons of fuel saved per year
16.1262	4.2	5.66	9814.46
23.8708	2.76	3.37	14527.86
34.871	1.86	2.15	21222.62
45.5752	1.41	1.55	27737.23
47.4806	1.35	1.49	28896.87

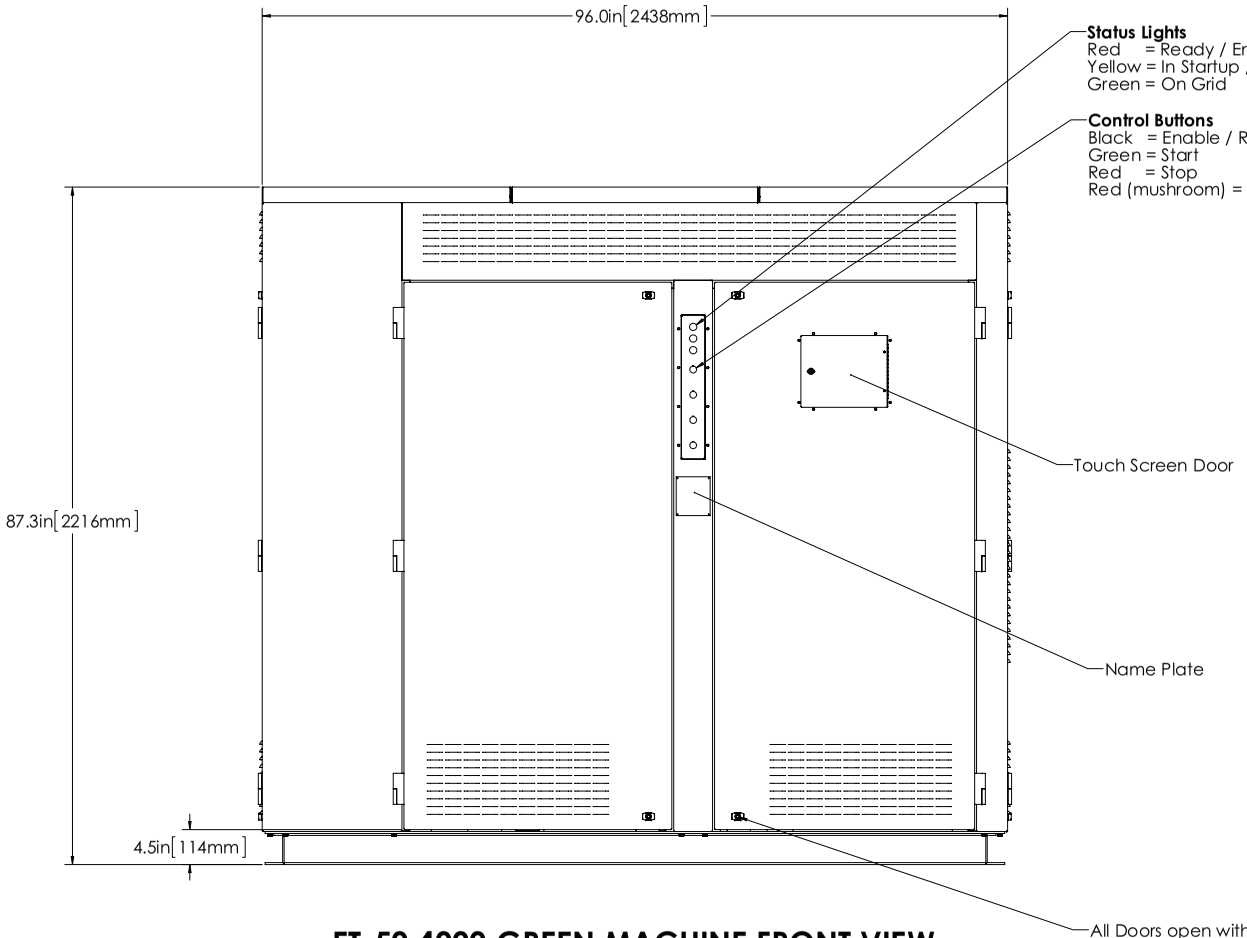
Notes:

1. There are three pumps in the system, they are working fluid pump (GM pump), hot water pump and cold water pump.
2. Green Machine (GM) net power is the power generated by green machine **without** considering any pump power consumed.
3. GM gross power is the sum of GM net power and GM pump power.
4. GM net efficiency = (GM net power output/ Heat supplied by hot water)
5. GM gross efficiency = (GM gross power output/ Heat supplied by hot water)

EXHIBIT B

Drawing #	Drawing Title	# pages
ETS-90028	Detail, Interface, WATER Cooled	4

REVISIONS				
REV.	ECN	DESCRIPTION	DATE	APPROVED
A	100283	PRODUCTION RELEASE	27 JUL 12	TEB



ET-50 4000 GREEN MACHINE FRONT VIEW

ET-50 4000 GREEN MACHINE OVERALL

Height = 7'3.3" [2216 mm]
Length = 6'6" [1981 mm]
Width = 8' [2438 mm]
Weight = 7245 Lbs [3290 kg]

DXF50-W5-004 A

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES [MM]
TOLERANCES:
FRACTIONAL ± 1/16'
ANGULAR: MACH ± .5° BEND ± 1°
2 PLACE DECIMAL ± .10 [2.5]
3 PLACE DECIMAL ± .030 [0.80]
INTERPRET GEOMETRIC TOLERANCING PER: ANSI Y14.5M-1998
MATERIAL: N/A
FINISH: N/A
NEXT ASSY | USED ON
APPLICATION

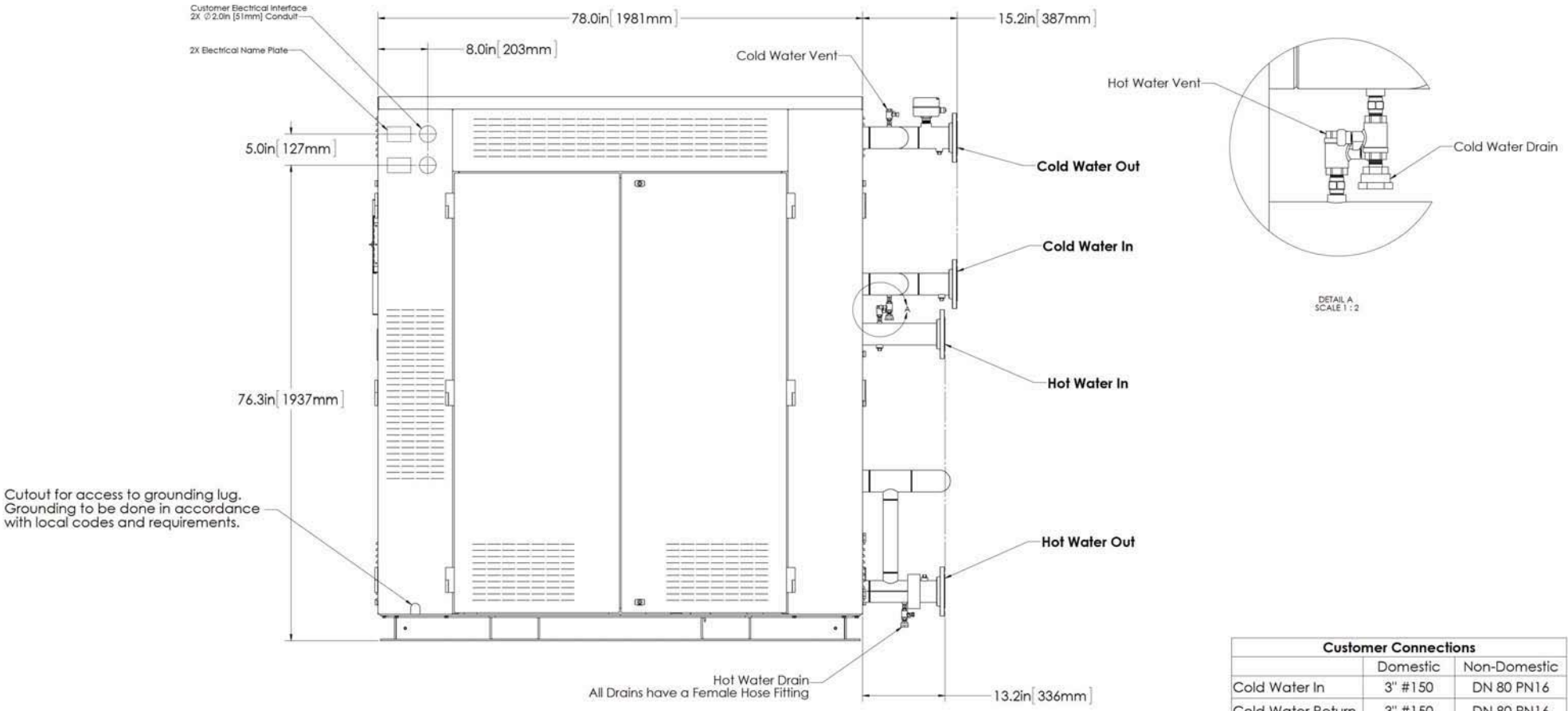
	NAME	DATE
DRAWN	DPH	10 JUL 12
CHECKED	GJM	27 JUL 12
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

ELECTRATHERM
4750 TURBO CIRCLE RENO, NV 89502 (775) 398-4680

TITLE: Detail, Interface, Water Cooled

SIZE	DWG. NO.	REV
D	ETS-90028	A

SCALE: N/A | WT: N/A | SHEET 1 OF 4



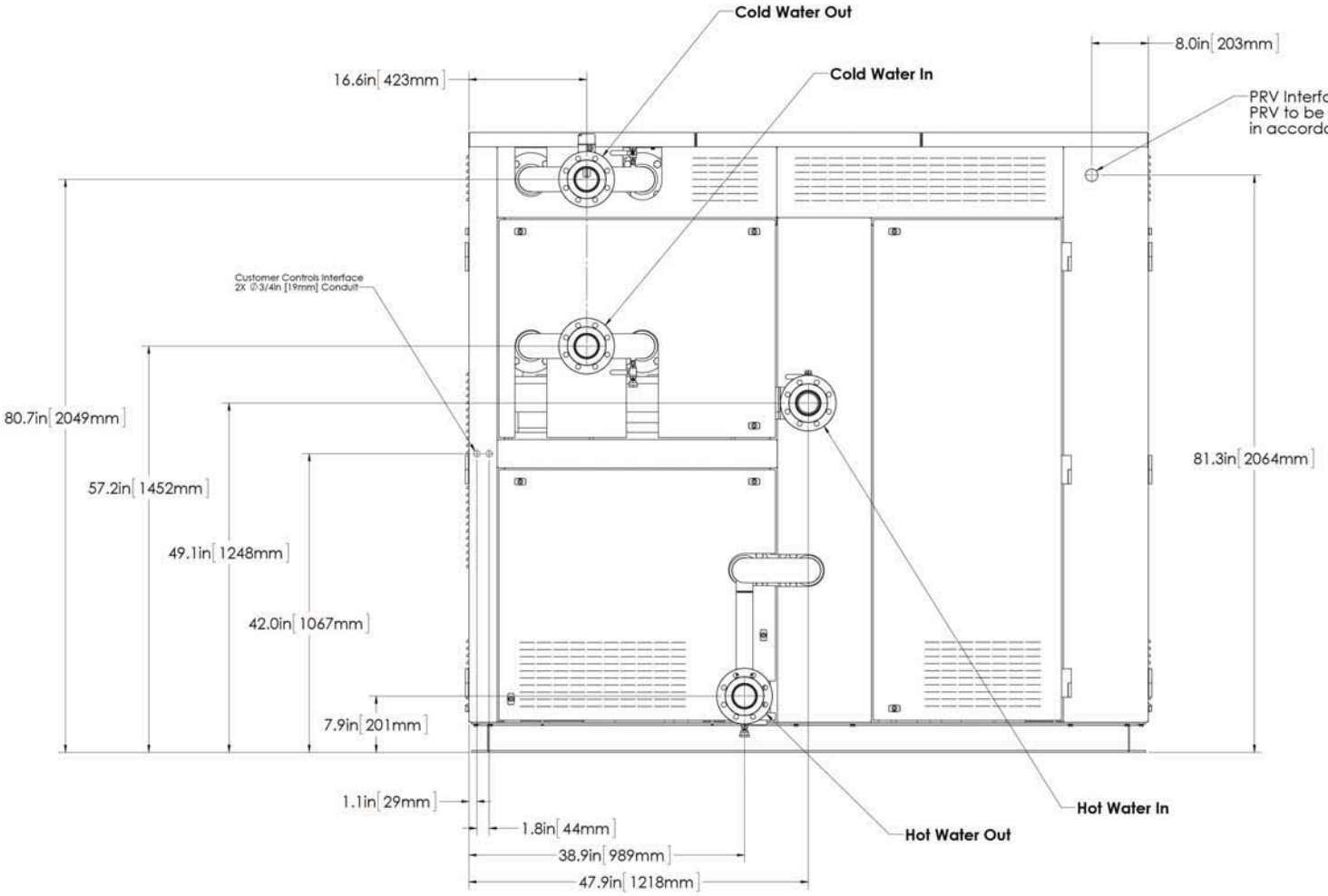
Customer Connections		
	Domestic	Non-Domestic
Cold Water In	3" #150	DN 80 PN16
Cold Water Return	3" #150	DN 80 PN16
Hot Water In	3" #150	DN 80 PN16
Hot Water Return	3" #150	DN 80 PN16

All external manifolds for customer connections are removed and ship inside the enclosure

ET-50 4000 GREEN MACHINE SIDE VIEW

D4X50-W5-004 A

ELECTRA THERM			SIZE	DWG. NO.	REV
			D	ETS-90028	A
DRAWN	DFH	10 JUL 12			
CHECKED	GJM	27 JUL 12	SCALE: 1:8		SHEET 2 OF 4



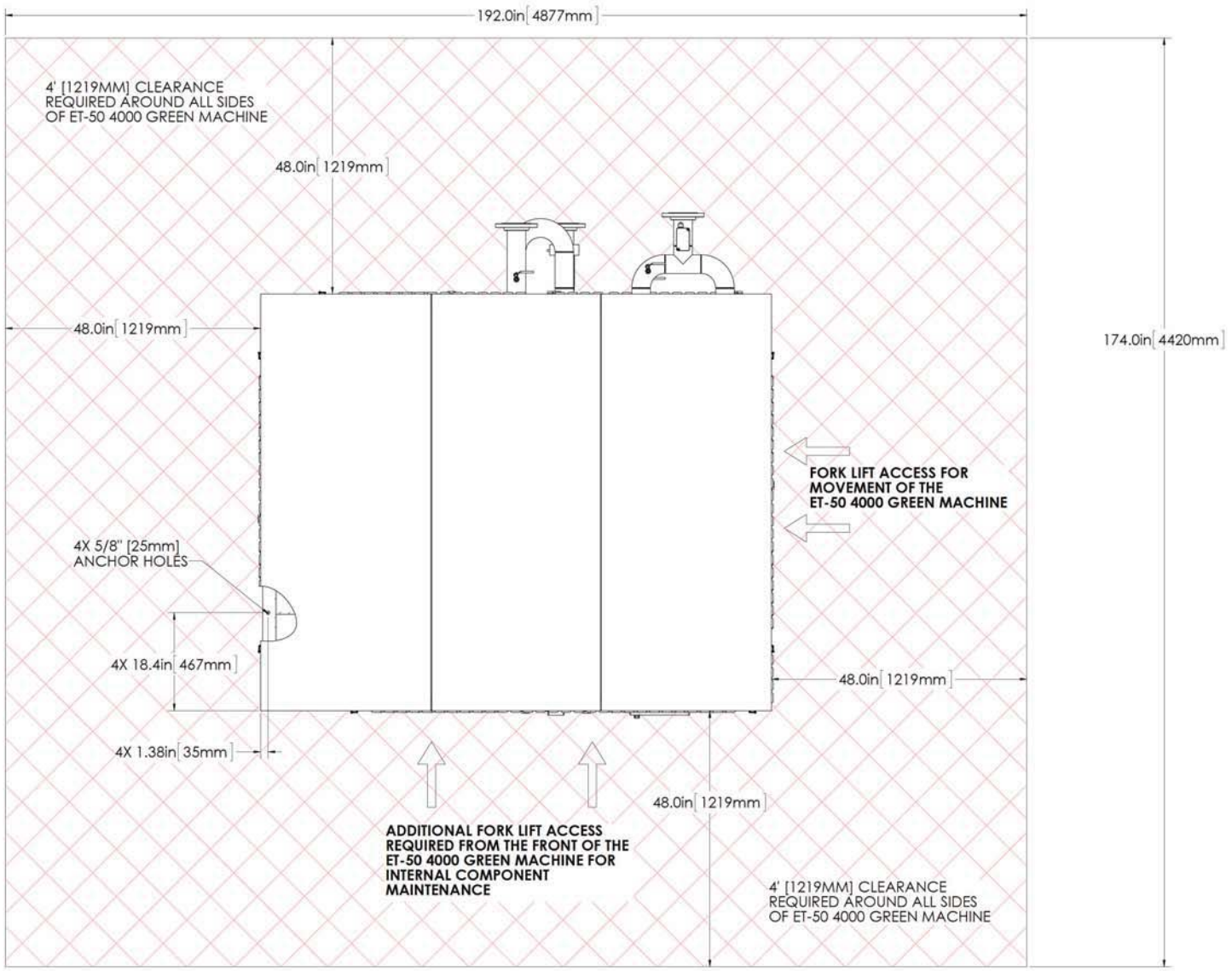
Customer Connections		
	Domestic	Non-Domestic
Cold Water In	3" #150	DN 80 PN16
Cold Water Return	3" #150	DN 80 PN16
Hot Water In	3" #150	DN 80 PN16
Hot Water Return	3" #150	DN 80 PN16

All external manifolds for customer connections are removed and ship inside the enclosure

ET-50 4000 GREEN MACHINE REAR VIEW

D4X50-WS-004 A

ELECTRATHERM	SIZE	DWG. NO.	REV
DRAWN DFH 10.JUL.12	D	ETS-90028	A
CHECKED GJM 27.JUL.12	SCALE: 1:8		SHEET 3 OF 4



ET-50 4000 GREEN MACHINE TOP VIEW

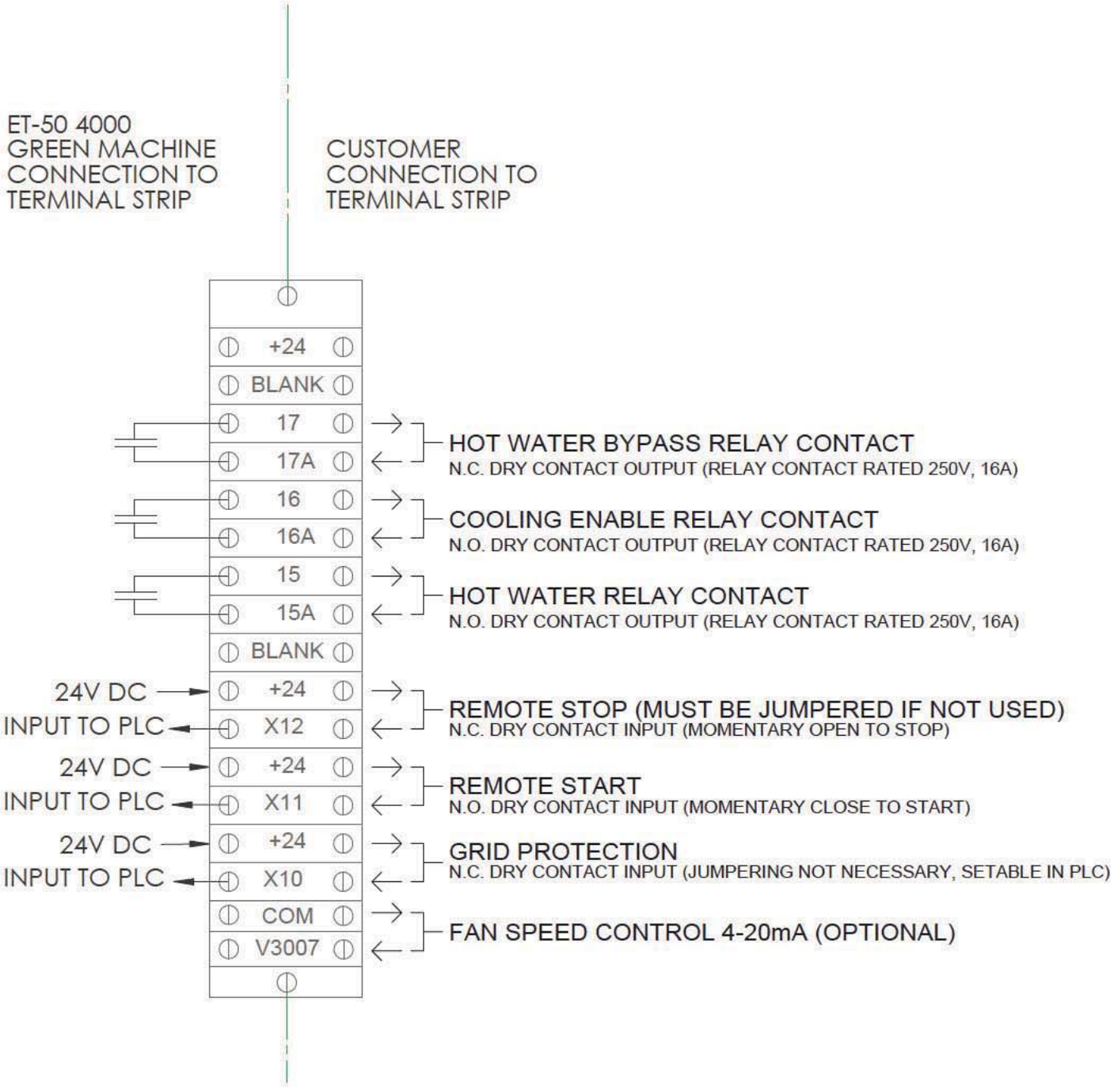
ELECTRATHERM			SIZE	DWG. NO.	REV
			D	ET-90028	A
DRAWN	DFH	10 JUL 12			
CHECKED	GJM	27 JUL 12	SCALE: 1:10		SHEET 4 OF 4

D4XS0-WS-004 A

Drawing #	Drawing Title	# pages
ETS-90027	Diagram, Trmnl Strip, Interface, ET-50-4000	1

REVISIONS				
REV.	ECN	DESCRIPTION	DATE	APPROVED
A	100201	PRODUCTION RELEASE	09 MAY 12	TEB

CUSTOMER INTERFACE TERMINAL STRIP



NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES[MM]
TOLERANCES:
FRACTIONAL± 1/16"
ANGULAR: MACH± .5° BEND ±1°
2 PLACE DECIMAL± .10[2.5]
3 PLACE DECIMAL± .030[0.80]

MATERIAL N/A

FINISH N/A

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	TEB	11 APR 12
CHECKED	GJM	09 MAY 12
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

ELECTRATHERM
4750 TURBO CIRCLE RENO, NV 89502 (775) 398-4680

Diagram, Trmnl Strip, Interface, ET-50 4000

SIZE	DWG. NO.	REV.
A	ETS-90027	A

SCALE:N/A | WEIGHT: N/A | SHEET 1 OF 1

EXHIBIT C

(END-USER SOFTWARE LICENSE)

END USER LICENSE AGREEMENT

This End User License Agreement ("Agreement") is entered into and effective as of _____, 201_ ("Effective Date") by and between ElectraTherm, Inc. ("ElectraTherm") and the customer identified below ("You") using the ElectraTherm heat and pressure generator ("Product") and the controls software (including firmware) included in such Product ("Software"). This Agreement contains the terms and conditions that apply to any and all software and related documentation provided with the Product or later provided or installed by ElectraTherm or the dealer who sold you this Product. You are required to execute this Agreement prior to your use of the Product. By signing below, you agree to the terms and conditions of this Agreement.

IF YOU DO NOT AGREE WITH ALL THE TERMS OF THIS AGREEMENT, YOU MAY NOT USE THE SOFTWARE AND SHOULD RETURN THE PRODUCT AND THE SOFTWARE TO THE DEALER WHO SOLD YOU THE HARDWARE. IN SUCH EVENT, PLEASE CONTACT YOUR DEALER IMMEDIATELY.

1. Software License

Subject to and conditioned on the terms and conditions of this Agreement, ElectraTherm hereby grants you a limited, non-exclusive, non-transferable license (without the right to sublicense) during the term of this Agreement:

- to use the user guides and manuals for installation and use of the Product and Software ElectraTherm makes available to you ("Documentation") to support your authorized use of the Product and Software; and
- to use the Software solely for your own business operations solely on the designated Product in accordance with any limitations specified or referenced in this Agreement and the applicable Documentation.
- You may not:
- copy or use the Software or Documentation, except to make one copy of the Documentation for backup purposes;
- remove or modify any markings or any notice of ElectraTherm's proprietary rights from the Software, Documentation, or Product;
- relicense, sublicense, rent, lease, act as a service bureau or provide subscription services or third party training for the Software;

- permit any third party to, disassemble, decompile, or otherwise attempt to derive the source code of any Software, except to the extent expressly permitted by applicable law, and then only after you have notified ElectraTherm in writing of your intended activities; and

- use the Software or Documentation except as expressly permitted.

2. Ownership. ELECTRATHERM WILL RETAIN ALL RIGHT, TITLE, AND INTEREST IN AND TO THE SOFTWARE DOCUMENTATION AND THE PATENT, COPYRIGHT, TRADEMARK, TRADE SECRET, AND ANY OTHER INTELLECTUAL PROPERTY RIGHTS IN THE SOFTWARE, DOCUMENTATION, AND ANY DERIVATIVE WORKS THEREOF, SUBJECT ONLY TO THE LIMITED LICENSES SET FORTH IN THIS AGREEMENT. YOU DO NOT ACQUIRE ANY OWNERSHIP INTEREST OR OTHER RIGHTS, EXPRESS OR IMPLIED EXCEPT THOSE EXPRESSLY SET FORTH IN THIS AGREEMENT.

3. No Support. Contact your dealer if you require support. ElectraTherm has no obligation to provide support, maintenance, upgrades, modifications or new releases under this Agreement.

4. Upgrades; Recall. ElectraTherm may issue upgraded versions of the Software from time to time, including upgrades, updates, bug fixes or modified versions, and may upgrade the Software. ElectraTherm may provide such upgrades to you but is under no obligation to do so. You agree to install and use the most updated version of the Software made available to you by or for ElectraTherm. To the extent ElectraTherm reasonably believes your version of the Software poses a threat to health, safety or security (and as required or permitted by applicable law), ElectraTherm may provide an automatic or remote electronic upgrade or recall the Software. You will comply with all reasonable directions regarding such upgrade or recall. For upgrade or recall of the Software which requires onsite access by ElectraTherm or its representatives, as determined by ElectraTherm at its sole discretion, you will enable onsite access to ElectraTherm Product during normal business hours. Where practicable, ElectraTherm will provide three (3) days notice of any automatic, remote, or onsite upgrade or recall. You consent to such upgrading and recall and agree that this Agreement (as amended from time to time) will govern all upgraded versions of the Software.

5. Disclaimers; Exclusive Remedies

Disclaimer. ELECTRATHERM PROVIDES NO WARRANTIES DIRECTLY TO END USERS. TO THE EXTENT PERMITTED BY LAW, ELECTRATHERM DISCLAIMS ALL WARRANTIES WITH RESPECT TO THE SOFTWARE, WHETHER EXPRESS, IMPLIED OR STATUTORY, INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, SATISFACTORY QUALITY, AND NONINFRINGEMENT, AND ALL WARRANTIES THAT MAY ARISE FROM COURSE OF DEALING, COURSE OF PERFORMANCE OR USAGE OF TRADE. ELECTRATHERM NEITHER ASSUMES, NOT AUTHORIZES ANY OTHER PERSON TO ASSUME FOR IT, ANY OTHER LIABILITY IN

CONNECTION WITH THE PRODUCTS, INCLUDING, WITHOUT LIMITATION, LIABILITY ARISING OUT OF THE DELIVERY OR USE OF THE PRODUCTS

ElectraTherm does not warrant that the Software will operate in combination with hardware, software, systems, or data not provided by ElectraTherm or that the operation of the Software will be uninterrupted or error-free. ElectraTherm will have no obligation for breach of warranty caused by abuse, misuse, alteration, neglect, accidental damage of and/or unauthorized repair, modification, or installation of the Software.

6. Termination. This agreement is effective until terminated. ElectraTherm may terminate this agreement at any time upon your breach of any of the provisions hereof. Upon termination, you will cease all use of the Software and Documentation and return any copies to ElectraTherm. Except for the license granted herein and as expressly provided herein, the terms of this agreement shall survive termination.

7. Disabling of Software. Should you remain in material breach of any provision of this Agreement or any other agreement with ElectraTherm after thirty (30) days notice to cure by ElectraTherm, ElectraTherm, at its option and to the extent permissible under applicable law, may remotely disable the Software (and you consent to such disabling) in addition to its other available remedies.

8. Limitation of Liability. IN NO EVENT WILL ELECTRATHERM BE LIABLE FOR ANY INDIRECT, INCIDENTAL, SPECIAL, CONSEQUENTIAL, OR PUNITIVE DAMAGES; OR DAMAGES FOR LOSS OF PROFITS, REVENUE, BUSINESS, SAVINGS, DATA, USE, OR COST OF SUBSTITUTE PROCUREMENT, INCURRED BY YOU OR ANY THIRD PARTY, WHETHER IN AN ACTION IN CONTRACT OR TORT, EVEN IF ELECTRATHERM HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES OR IF SUCH DAMAGES ARE FORESEEABLE. NOTWITHSTANDING ANY OTHER PROVISION OF THIS AGREEMENT, AND TO THE MAXIMUM EXTENT PERMITTED BY LAW, EXCEPT WITH RESPECT TO LIABILITY FOR PERSONAL INJURY CAUSED BY A PRODUCT DEFECT FOR WHICH ELECTRATHERM IS RESPONSIBLE UNDER APPLICABLE LAW, ELECTRATHERM'S AGGREGATE LIABILITY TO YOU OR ANY THIRD PARTY FOR ALL CLAIMS RELATING TO THIS AGREEMENT AND ITS SUBJECT MATTER, WHETHER FOR BREACH, NEGLIGENCE, INFRINGEMENT, IN TORT OR OTHERWISE, SHALL NOT EXCEED $100.

9. Miscellaneous. This agreement constitutes the complete agreement between the parties and supersedes all prior or contemporaneous agreements or representations, written or oral, concerning the subject matter of this agreement. If any term of this agreement is found to be invalid or unenforceable, the remaining provisions will remain effective. This agreement may not be modified or amended except in writing signed by a duly authorized representative of each party; no other act, document, usage, or custom will be deemed to amend or modify this agreement. You may not assign this agreement or your obligations or rights hereunder without the prior written consent of ElectraTherm. Any purported assignment,

transfer, or delegation by you will be null and void. Subject to the foregoing, this agreement will be binding upon and will inure to the benefit of the parties and their respective successors and assigns. You will comply fully with all relevant export laws and regulations of the United States, including without limitation the U.S. Export administration regulations. All disputes, claims or controversies will be settled by binding arbitration administered by the American Arbitration Association in accordance with its International Arbitration Rules and conducted in English by one neutral arbitrator appointed in accordance with such rules. The arbitration will take place in San Francisco, CA, U.S.A. The award rendered by the arbitrator will be final, binding and, except as permitted by applicable law, non-appealable. Judgment upon such award may be entered by any court of competent jurisdiction. You will notify ElectraTherm promptly of any unauthorized use of the Software. Notwithstanding the foregoing, the parties acknowledge that any misuse of ElectraTherm's confidential information or intellectual property rights will entitle ElectraTherm to appropriate equitable or injunctive relief in any court of competent jurisdiction in addition to whatever remedies it might have at law or otherwise. This agreement is governed by the laws of California, without reference to its conflict of law provisions. To the extent that a dispute arises and arbitration as set forth above is not applicable, the parties agree that all matters concerning this Agreement will determined by the federal or state courts of the State of California, U.S.A., and consent to jurisdiction of such courts and service of process by mail or other means of hard copy delivery, such as fax, is hereby granted by the parties. This Agreement will not be governed by the United Nations Convention on Contracts for the International Sale of Goods, the application of which is hereby expressly excluded.

By signing below, I acknowledge my consent to the terms and conditions of this Agreement.

CUSTOMER

By:

Name:

Exhibit D

Internet Connection & Green Machine Monitoring

Virtually all operational questions can be answered by ElectraTherm service personnel through data provided by an Internet connection that links ElectraTherm to an installed Green Machine. Therefore, Internet connection is a required part of installation and will save time and money for operators.

The Internet connection must be:

1. completely independent of onsite existing network, VPN, firewalls, etc.
2. programmed into the Green Machine router prior to shipping. (See specs. below)
3. tested as part of site installation, prior to scheduling site commissioning and start-up.

Please provide all of the following Internet connection information as soon as possible so your installation can proceed on schedule. Please select one of the following two options:

1) Dedicated Wired Broadband Internet Connection, Static IP Address (PREFERRED)

- ElectraTherm supplies and provisions VPN Router to be shipped with the Green Machine
- End-User provides connection and modem. (DSL or equivalent preferred.)
- DSL Modem set to operate in Bridge Mode (router if present, disabled.)
- **End-User provides ElectraTherm with the following provisioning information no later than 2 weeks prior to Green Machine ship date:**
    - WAN Static IP Address
    - WAN Subnet Mask
    - WAN Gateway Address
    - Primary DNS Address
    - Secondary DNS Address

Or:

2) Wireless 3G Cellular Connection, Static IP Address

- ElectraTherm provides all equipment and invoices End-User for usage charges
- **End-User provides ElectraTherm with the following provisioning information no later than 3 weeks prior to Green Machine ship date:**

    _____

    - GPS coordinates of installation site
        - end-user provides adequate signal strength and minimum a 1GB per month
        - Static IP address and SIM card
    - photos and description of enclosing structure

*****Please direct required information or questions regarding Internet connectivity to:**
Fred Williams, Systems Manager, ElectraTherm at fwilliams@electratherm.com.

Dutch Harbor Power Plant Waste Heat to Energy

Electric Power Systems, Inc

Engine Jacket Water (JW)

Groundwater

Project Evaluation

8/20/2012

The project assessment program contains default input values intended for internal system use. Input values will vary depending on technology, geographic location, and site dependent variables e.g.: water temperature and flow. The following reports serve as a guide only. Due to volatility of incentive policies/availability, electric prices and technology some of projected values may be out of date or inaccurate. Before submitting for a report, review data and verify that they are correct for your analysis.

Project Input	
Project Name:	Dutch Harbor Power Plant Waste Heat to Energy
Project Company:	Electric Power Systems, Inc
Heating Source:	Engine Jacket Water (JW)
Cooling Source:	Groundwater
Annual Runtime:	8000 Hours
Project Service Lifetime:	20 Years
Pump Parasitic Load:	0 kW
Price per kWh:	0.42 U.S.D.
Hot Water Temperature:	200°F
Hot Water Flow:	217 GPM
Avg. Ambient Temperature:	45°F
Approach Temperature:	0°F
Available Thermal Power:	3.08 MMBTU/hr
Green Machine Size:	30-50 kWe
Green Machine Generator Frequency:	60 Hz

Electrical Output*	
Average GM Gross Power Output:	45.3 kWe
Average Total Net Power Output:	42.3 kWe
Avg. Total Internal & External Parasitic Load:	3 kWe
Average GM Internal Parasitic Load:	3 kWe
Average External to GM Fan Parasitic Load:	0 kWe
Average External to GM Pump Parasitic Load:	0 kWe
Annual Gross Energy Output:	362 MWh
Annual Net Energy Output:	338 MWh

Thermal Balance*	
Average Heat Consumed:	2.08 MMBTU/hr
Maximum Heat Consumed:	2.08 MMBTU/hr
Average Heat Rejected:	1.78 MMBTU/hr
Maximum Heat Rejected:	1.78 MMBTU/hr
Hot Water Inlet Temperature:	200°F
Hot Water Outlet Temperature:	179°F

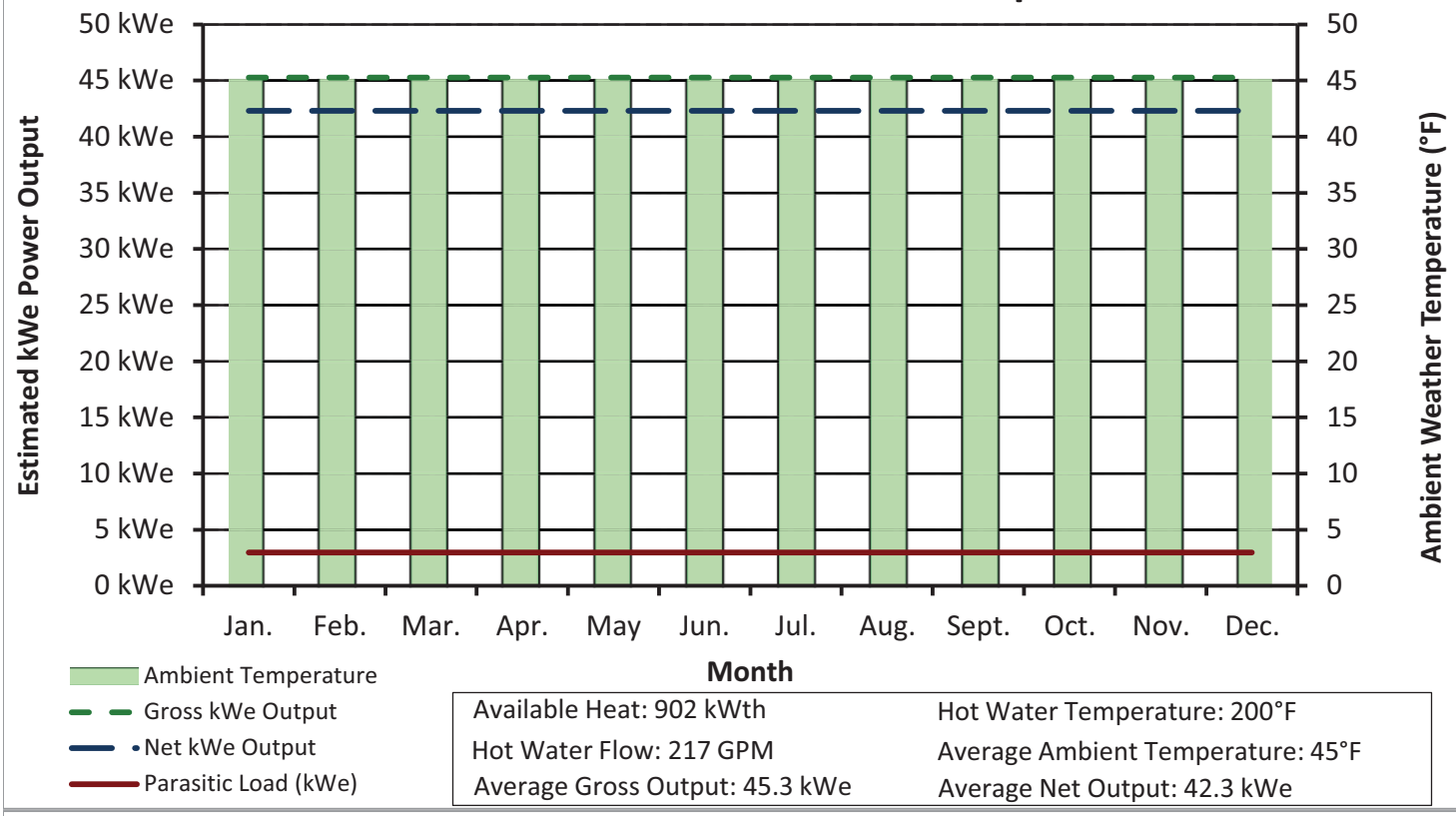
Hot Water Temperature Comparison		
Temperature	**Gross Power**	**Net Power**
200°F	45.3 kWe	42.3 kWe
200°F	***45.3 kWe***	***42.3 kWe***
220°F	47.1 kWe	43.3 kWe
240°F	47 kWe	42.4 kWe

*consumed heat, rejected heat, and electrical output values are based on measured ElectraTherm test data. Small errors in measuring temperature and flow due to instrumentation tolerances can induce a noticeable error in thermal measurement. This document is a guideline only, and the thermal error on heat rejected and heat consumed can be up to +/- 80kW

Engineer's Notes

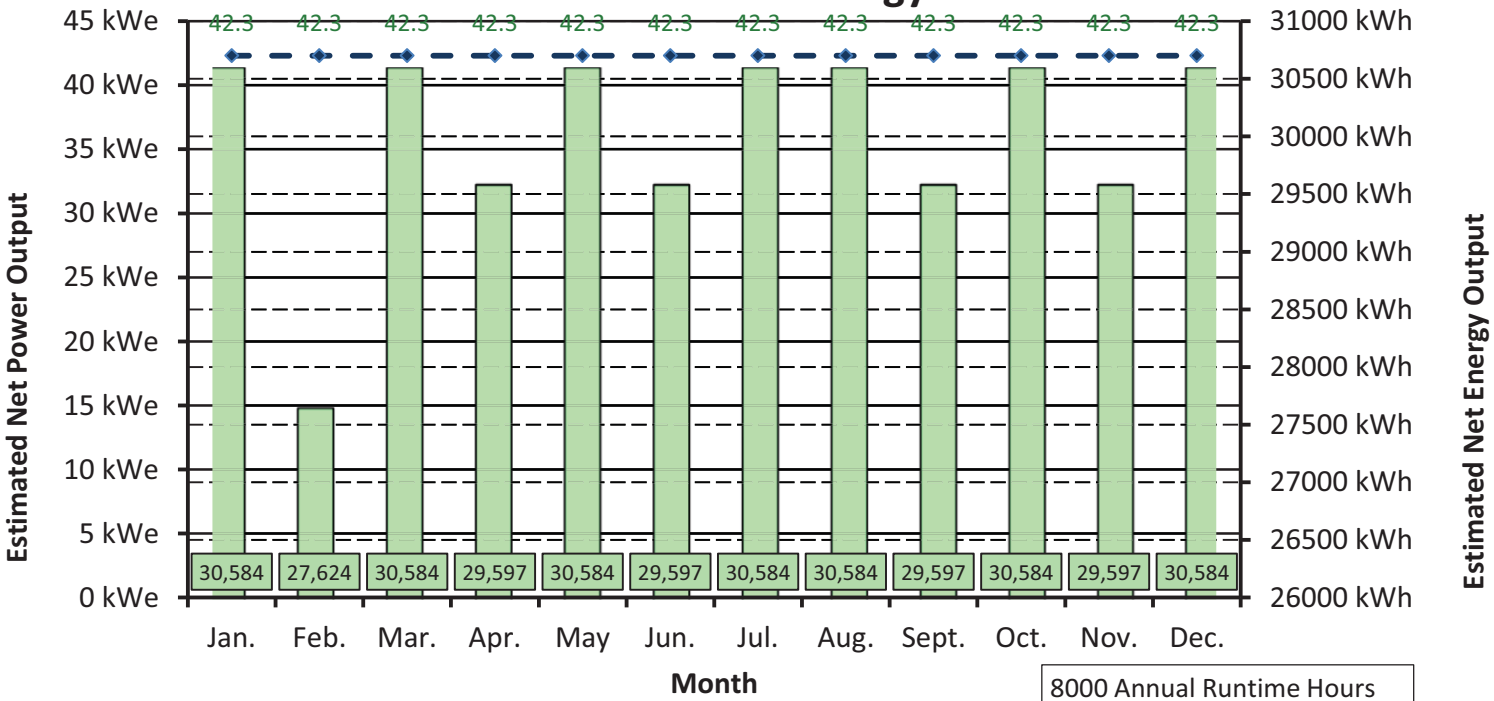
1. A 30-50 kWe Green Machine will be suitable for this project.
2. 30% water/glycol mix assumed in this evaluation.
3. Green Machine electrical output limted by hot water inlet temperature.
4. It should be noted that there is additional kW of heat available in the exhaust gas flow. There is the potential for increased power output by utilizing an exhaust gas to liquid heat exchanger. This would increase the incoming hot water stream to the Green Machine, as well as increase the total amount of thermal power available.
5. ElectraTherm does not provide exhaust gas heat exchangers; however, we can help you contact an exhaust gas heat exchanger manufacturer for this project.
6. Estimated temperatures, heats, and flows used in analysis are based on information available in the PEF. Re-evaluation of the project will be necessary if heat inputs/assumed inputs differs from actual.
7. Zero external parasitic loads were taken into account for this evaluation. Parasitic loads include additional kWe use from condensing water pumps, hot water pumps, etc.

Estimated Annual Power Output



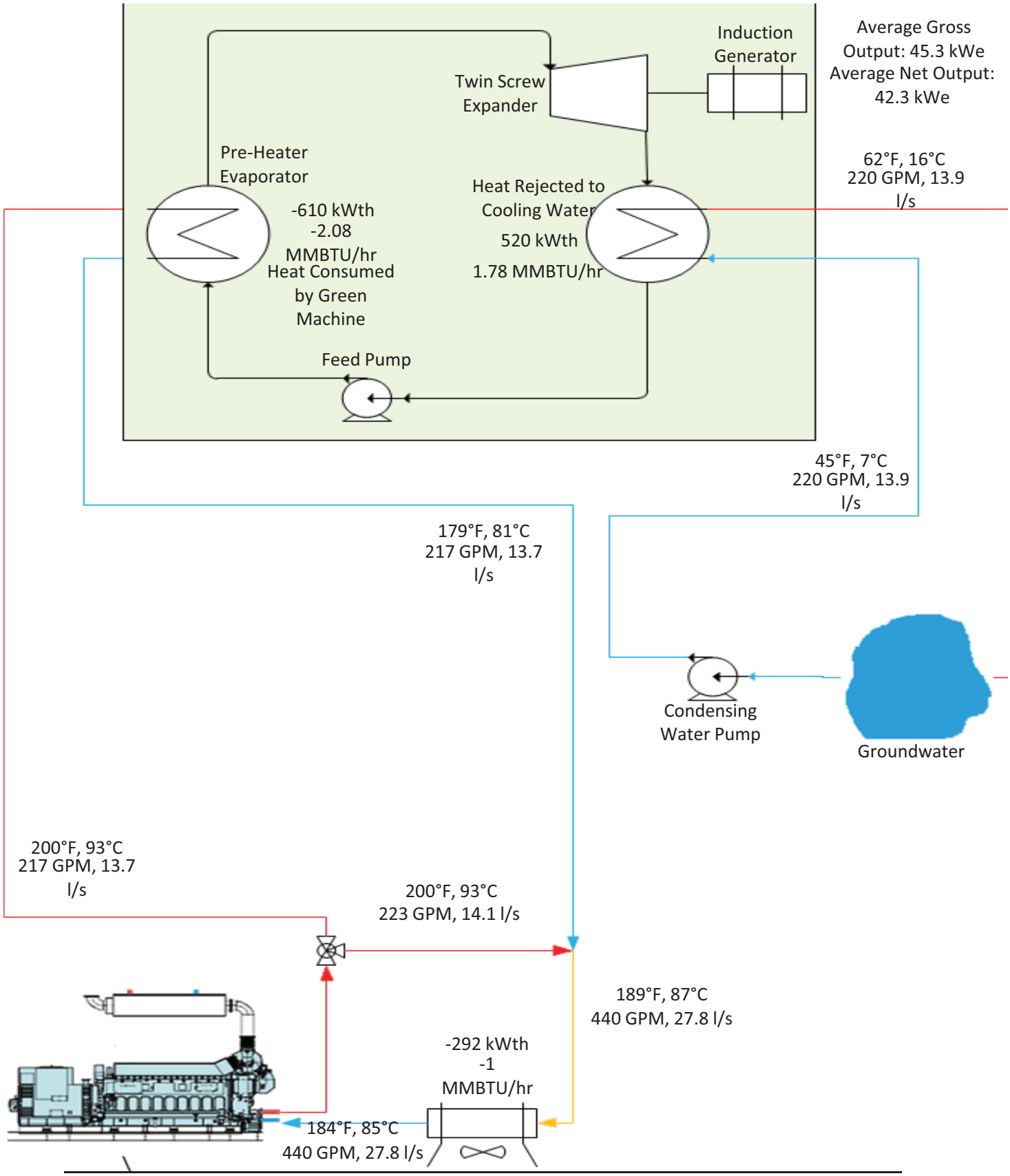
Available Heat: 902 kWth	Hot Water Temperature: 200°F
Hot Water Flow: 217 GPM	Average Ambient Temperature: 45°F
Average Gross Output: 45.3 kWe	Average Net Output: 42.3 kWe

Estimated Net Annual Energy Production



8000 Annual Runtime Hours
362268 Total Annual kWh

One Line Heat Balance Diagram



Andrew Durham

From: ElectraTherm <sales@electratherm.com>
Sent: Thursday, August 16, 2012 5:04 PM
To: 398-4676 Sales
Subject: [electratherm.com] Project Evaluation Form

ElectraTherm Project Evaluation Form

The following Project Evaluation Form was submitted on 8/16/2012

Units: standard

Other Contact Info	
Customer Type:	Other (Consulting Engineer)
Company:	Electric Power Systems, Inc
Contact:	Robert Whealy
Address:	3305 Arctic Blvd. Suite 201
City:	Anchorage
State / Province:	Alaska
Zip:	99503
Country:	United States
Phone:	907-646-5132
Email:	bwhealy@epsinc.com
Project Details	
Project Name:	Dutch Harbor Power Plant Waste Heat to Energy
Project Description:	Convert diesel engine jacket cooling water heat to electricity.
Justification:	green, costs, roi
Hours Of Available Heat & Condensing Flow:	8000 HRS PER YEAR
End User Electrical Cost:	$0.42 (US) per average kWh
Project Location	
City:	City of Unalaska
State / Province:	Alaska
Country:	USA
Heat Sources: liquid	
Liquid Heat Details	
Temp:	200 F
Flow:	440 GPM
Type:	glycol (30%, Ethylene Glycol)
Source:	engine

	Average Engine Load: 70
Rate:	3080000 (BTU/hr)
Other Heat Source Users:	No
Cooling Source: water	
Temp:	45 F
Flow:	1000 GPM
Source:	other (Sea Water)
Type:	Ocean sea water
Status:	existing
Other Cooling Source Users:	No
Verified:	Robert W. Whealy, P.E.
Notes:	

GE Energy

Turning heat into power

Discover a way to get more from your reciprocating engine with the Clean Cycle generator

a product of
ecomagination

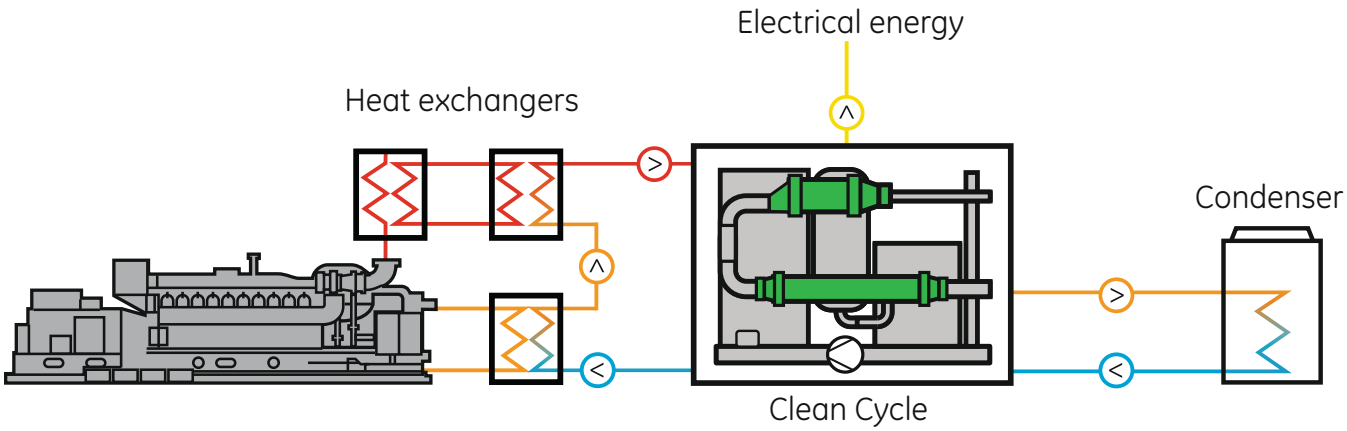
GE imagination at work

Turn your reciprocating engine heat into additional power

Heat is a by-product of reciprocating engine operation, but it is often released into the atmosphere and not fully utilized. GE can change that: the Clean Cycle[1] power generator from GE's Heat Recovery Solutions division captures energy in the form of heat and converts it into usable energy in the form of electricity.

making a simple concept more versatile

The Organic Rankine Cycle (ORC) has been used for decades in large power generation applications throughout the world. GE's Clean Cycle module integrates innovative technologies enabling small-scale heat to power applications.



Heat is captured from the engine exhaust and water jacket in heat exchangers.

Organic fluid in the ORC is pumped through the heat exchangers, exposing it to the heat source.

The heat converts the fluid into a super heated vapor, which is expanded across a turbine, causing it to spin.

The turbine is integrated into a power module, which creates electricity that can be sold to the grid or used onsite.

After passing through the Integrated Power Module, the vapor is cooled back to a liquid, and the cycle repeats.

[1] Trademark of General Electric Company

Advanced technology for efficient and reliable power generation

- The Integrated Power Module is a hermetically sealed 125kW high-speed generator and turbine in a single package. It has no external rotating seals and no gearbox.

- Magnetic bearing technology within the Integrated Power Module results in a non-contact, cleaner (no oil required), more efficient (minimized losses) and low-maintenance solution.

- Sophisticated power electronics automatically match the voltage and frequency of the electrical grid, enabling the Clean Cycle to connect directly to it.

Key technical data

Thermal input	980 kW (3.4 MBtu/hr.)
Evaporation Temperature	121˚C+ (250˚F+)
Electrical output	~125 kW gross
Frequency	50/60 Hz
Working Fluid	R245fa (Non-Ozone depleting)

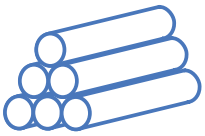
Installed dimensions

Mass	2,900 kg (6,400 lbs.)
Dimensions	200 x 285 x 117cm (78.7 x 112.2 x 46 inch)

Many industries can benefit from GE's Clean Cycle technology

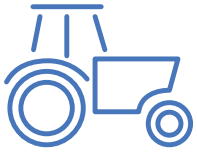
waste treatment

Landfills and wastewater treatment plants present opportunities to convert captured gas into electricity via an engine.



lumber, milling & timber

Wood, refuse, and other waste can be converted into a syngas - a low-emission fuel source for engines.



agriculture, greenhouse & food

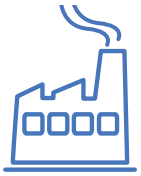
Biogas, created by digesting food and agriculture waste, and biodiesel can be used in engines. Natural gas is also used to fuel engines in greenhouse applications.

metals, mining & chemicals

Captured methane from mines, steel gas, and special gases from the chemicals industry are all harmful if released into the atmosphere. Instead, they can serve as a fuel source for engines.

oil & petroleum

Engines that compress natural gas produce heat, but often do not have a use for it nearby. Engines using associated petroleum gas to generate electricity often face a similar situation.



independent power producers

Natural gas and diesel engines, as well as engine compressors, all generate heat, and can be found in nearly every corner of the world.

Advantages of the technology

increased power output

- The solution generates up to 125kW of electricity (gross).
- No incremental fuel is required. The technology runs entirely on reciprocating engine heat.
- A complete installation typically is 5 % more efficient than a reciprocating engine alone, and creates up to 10 % more power.

reliable and consistent performance

- The technology automatically tracks the engine heat, so it runs even on engines that have varying output levels.
- Power electronics seamlessly integrate with the electrical grid, making it simpler to sell the power or offset local power costs.
- Clean Cycle units require minimal maintenance.

proven results for a range of installations

- The Clean Cycle solution is suitable for new and retrofit reciprocating engines.
- Installations are scalable: Multiple units can be installed on a single reciprocating engine, and one unit can be installed on multiple engines.
- Installations may qualify for additional incentives, depending on location and fuel used in the reciprocating engine.

Our competence

The Clean Cycle system has received GE's ecomagination qualification for its ability to provide customers with cost-saving and environmental benefits, such as the generation of about 1 million kWh of electricity and the avoidance of 350 metric tons of CO_2 per year in combination with a reciprocating engine[1]. That equates to the annual electricity consumption of 240 European households and the annual CO_2 emissions of almost 200 cars on European roads. Ecomagination is GE's corporate-wide initiative (www.ecomagination.ge.com) to use and develop new technologies that help customers meet pressing environmental challenges.

[1] Based on 8,000 annual operating hours from heat supplied by a reciprocating engine.

GE Energy

GE's Heat Recovery Solutions division manufactures the Clean Cycle generator, a revolutionary heat to power generator suited for reciprocating engines, biomass boilers and microturbines. The Clean Cycle module generates electricity from heat without creating additional emissions or requiring incremental fuel. This advanced technology has been designed, manufactured, and deployed globally by an experienced and dynamic team with offices in the United States and across Europe.

Are you interested in this advanced waste heat to power technology? For more information on GE's Clean Cycle solution, visit **geheatrecovery.com** or contact your GE sales team.

Heat Recovery Solutions
2901 S.E. Monroe Street
Stuart, Florida 34997, USA
T: +1-772-219-9449

United Kingdom
T: +44 1666 822 482

info.heatrecovery@ge.com
www.geheatrecovery.com

GE imagination at work

GE Energy
Gas Engines

Heat Recovery Solutions

Clean Cycle™ 125 kW

Stop wasting heat.
The Clean Cycle™ system from GE's Heat Recovery Solutions division captures wasted heat and turns it into electricity that you can use or sell back to the grid.

For the first time, small-scale installations can benefit from proven Organic Rankine Cycle to recapture lost energy and turn it into money. The Clean Cycle™ from GE's Heat Recovery Solutions division captures heat from a wide range of systems including various engine types and biomass boilers. Typical payback periods for applications like these range from 18 to 36 months.

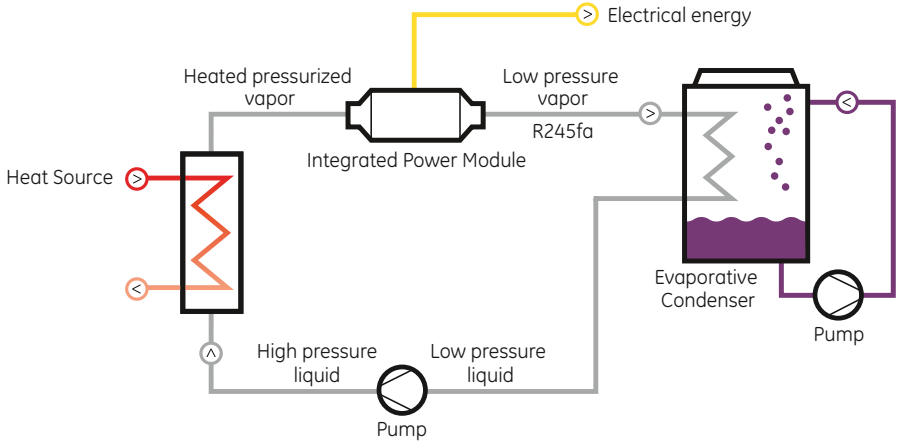
Optimized Rankine Technology

The Clean Cycle™ 125 kW integrates proven technologies into a highly efficient system design. Key innovations include:

- Integrated power module, a high-speed turbine expander (26,500 rpm) plus high-efficiency alternator in one sealed unit. Only one moving part. No external seals. No gearbox.
- Super-efficient magnetic bearings with self-centering. No metal-on-metal. No oil systems.
- Sophisticated power electronics to turn the high-frequency output into utility-grade power. Power factor is 1, so no expensive capacitors.

The benefits

- Cleaner energy with no fuel needed
- No additional emissions
- High-speed, high-efficiency power module
- Simple synchronization with utility
- Small-footprint packaged unit: ready to integrate
- High reliability, very low maintenance and ownership costs
- Modular and scalable design
- Fast payback



a product of
ecomagination

GE imagination at work

GE Energy
Gas Engines

Component Design

Alternator	High speed, permanent magnet
Turbine	Single stage radial expander turbine
Bearings	Magnetic frictionless
Design Standards	Yes
Piping	ASME B31.1
Heat Exchangers	ASME VIII/PED
Electrical Enclosures	NEMA1/IP23

System

Refrigerant	R245fa (Non-ozone depleting)
Controls	PLC based
Remote Monitoring	Web based gateway
Operation	Designed for local and remote control
Packaged Solutions	Available

Clean Cycle™ 125 Performance Parameters

Electrical Output Gross	125 kW

Waste Heat Conditions

Evaporation Temp	250°F	121°C
Input Energy	3,340,000 BTU/hr	980 kW

Condensing in ISO Ambient: 59°F (15°C) 60% RH

Temp	70°F	21°C
Condensing Load	2,800,000 BTU/hr	821 kW

Pressurized Hot Water to Power

Electrical Output Gross	125 kW

Waste Heat Conditions

Inlet Temp	290°F	143°C
Outlet Temp	260°F	127°C
Flow Rate	119,555 lbm/hr	54,343 kg/hr

Condensing temperature of 70°F (21°C) and heat exchanger 95% efficient.

Saturated Steam to Power

Electrical Output Gross		125 kW
Temperature	255°F	124°C
Pressure	32 psia	220.6 kPa
Flow	3,692 lbm/hr	1,678 kg/hr

1. Waste heat operating conditions: no superheat in steam included.
Condensing temperature of 70°F (21°C) and heat exchanger 95% efficient.

Hot Gases to Power

Electrical Output Gross	125 kW

Inlet Temp		Flow Rate	
°F	**°C**	**lbm/hr**	**kg/hr**
400	204	150,000	68,182
500	260	75,000	34,091
600	316	49,500	22,500
700	371	36,900	16,773
800	427	29,250	13,295
900	482	24,250	11,023

1. Waste heat conditions – Exhaust gas temperature reduced to 300°F (149°C) with condensing temperature of 70°F (21° C)
2. Assumed exhaust gas Cp = 0.25 Btu/lbm - °F (1.05 kJ/kg - °C)
3. Heat exchanger 95% efficient

The technological strength of GE's Heat Recovery Solutions division lies in the generation of power from waste heat within the low power range. The innovative Clean Cycle™ 125 kW generator that produces emission-free power from waste heat emitted by various engine types and biomass boilers was developed under the guidance of an experienced and dynamic management team.

GE imagination at work

Talk to us.

Heat Recovery Solutions
2901 S.E. Monroe Street
Stuart, Florida 34997, USA
T: +1-772-219-9449

United Kingdom
T: +44 1666 822 482

Jenbacher gas engines
Achenseestrasse 1-3
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T: +43 5244 600-0

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www.geheatrecovery.com

GEA18410 A

Heat to power generation

An overview of the Clean Cycle generator for diesel applications

a product of ecomagination

imagination at work

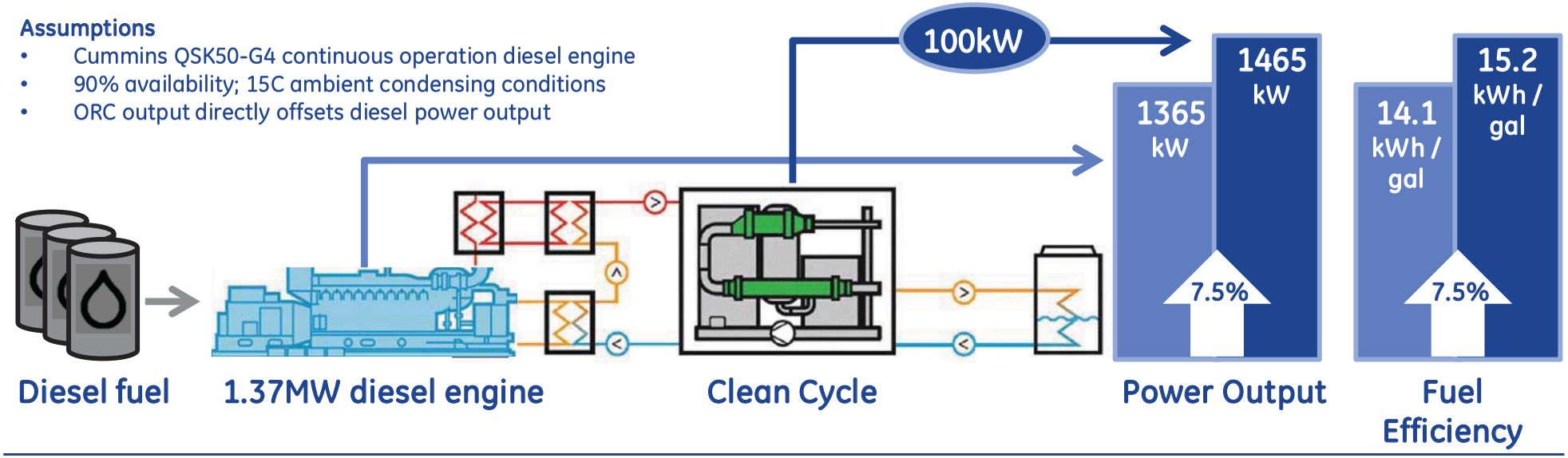
Clean Cycle heat to power generator

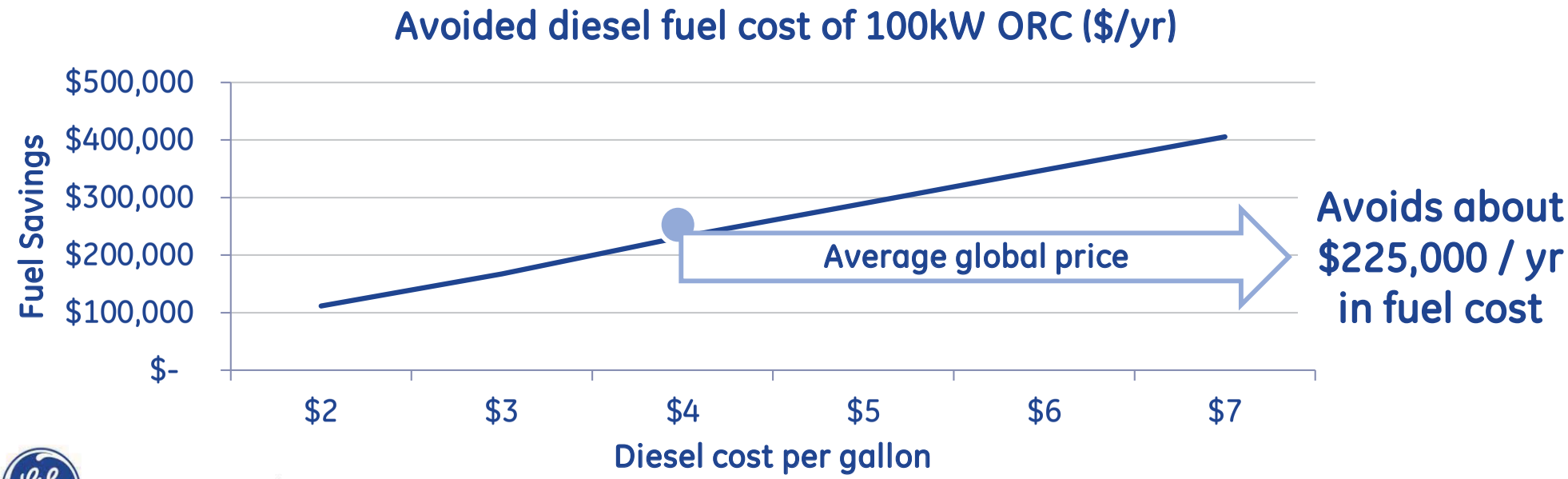
Benefits

- One unit **generates up to 125kW** of electricity from a heat source
- Heat is the only input; **no additional fuel** required **or emissions** generated
- **Low maintenance:** magnetic bearing generator, no lubricants, no overhauls
- Called an ORC because it utilizes the **"Organic Rankine Cycle"** to generate power from heat

Quantifying 100kW avoided diesel gen

Assumptions
- Cummins QSK50-G4 continuous operation diesel engine
- 90% availability; 15C ambient condensing conditions
- ORC output directly offsets diesel power output





imagination at work

The Clean Cycle advantage

Proven fleet in operation

- Accumulated over 120,000 operating hours
- Produced ~10.8GWh of electricity, enough for 1,300 US homes
- Market leader for <500kW in-field units

Simple installation and operation

- Modular & turnkey systems enable consistency across applications
- Power electronics match the voltage and frequency of the electrical grid, making selling or using electricity easy
- The ORC follows the heat source, so it runs continuously on an engine or heat source with fluctuating heat output

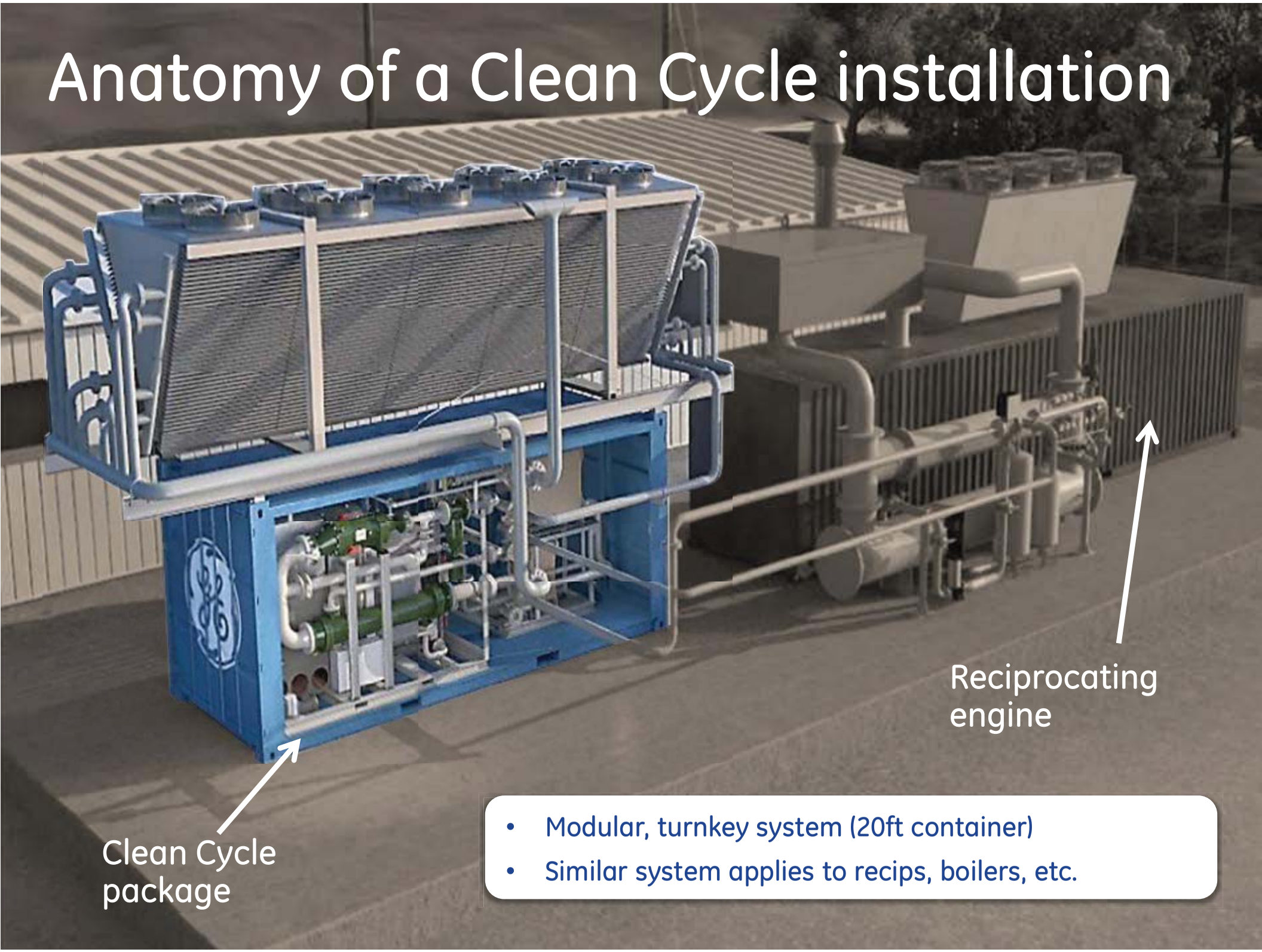
Low maintenance and reliable

- Turbine generator floats on non-contact magnetic bearings within the Integrated Power Module (IPM)
- No gearbox, no external seals, no lubrication required to operate
- No major overhauls, no added fuel, no added emissions

Integrated Power Module

imagination at work

Anatomy of a Clean Cycle installation



- Modular, turnkey system (20ft container)
- Similar system applies to recips, boilers, etc.

For more information

John Lerch
Global Marketing Manager
GE Energy, Heat Recovery Solutions
john.lerch@ge.com

www.geheatrecovery.com

imagination at work

How the Clean Cycle works

Clean Cycle™ technology is based on the Organic Rankine Cycle (ORC), which utilizes an organic working fluid with a lower boiling point than water to generate electrical power from heat

- **The cycle is closed loop – there is no combustion and no emissions**

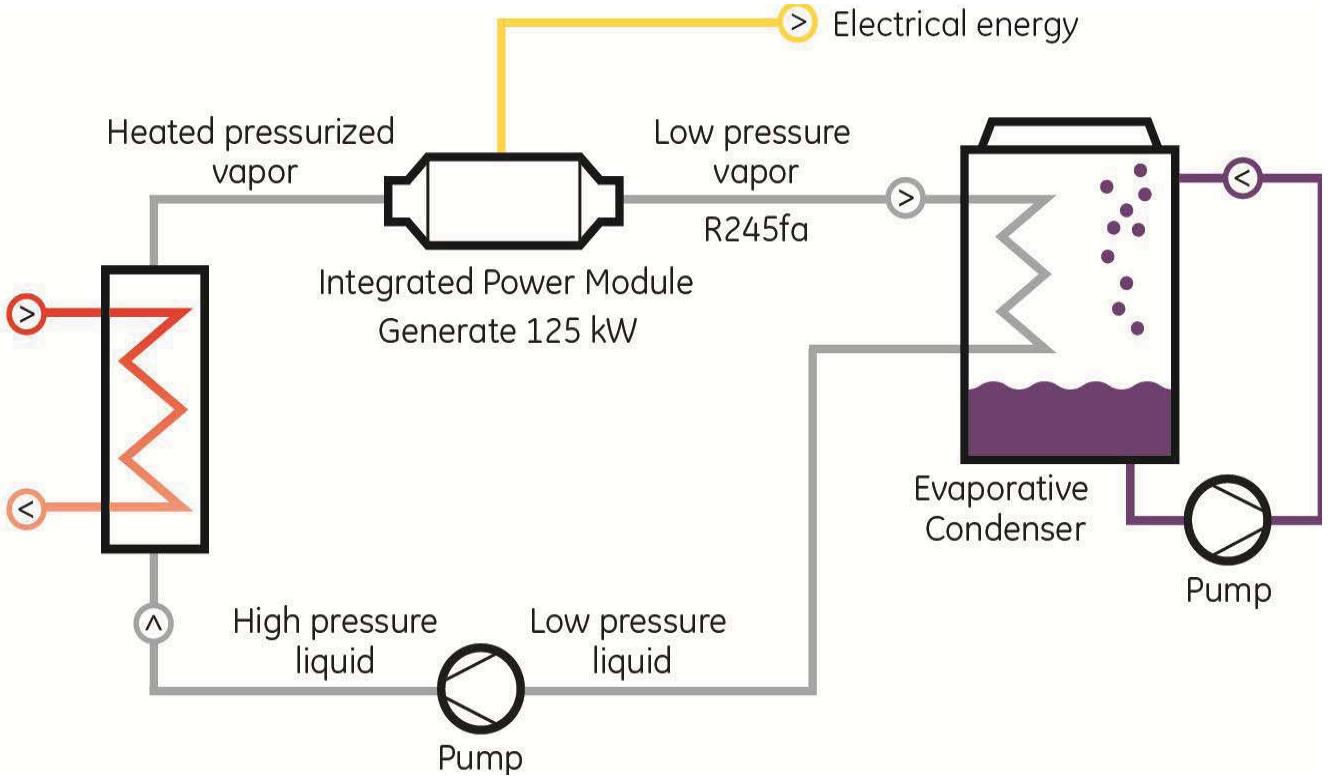
Heat Source

Recip Engines

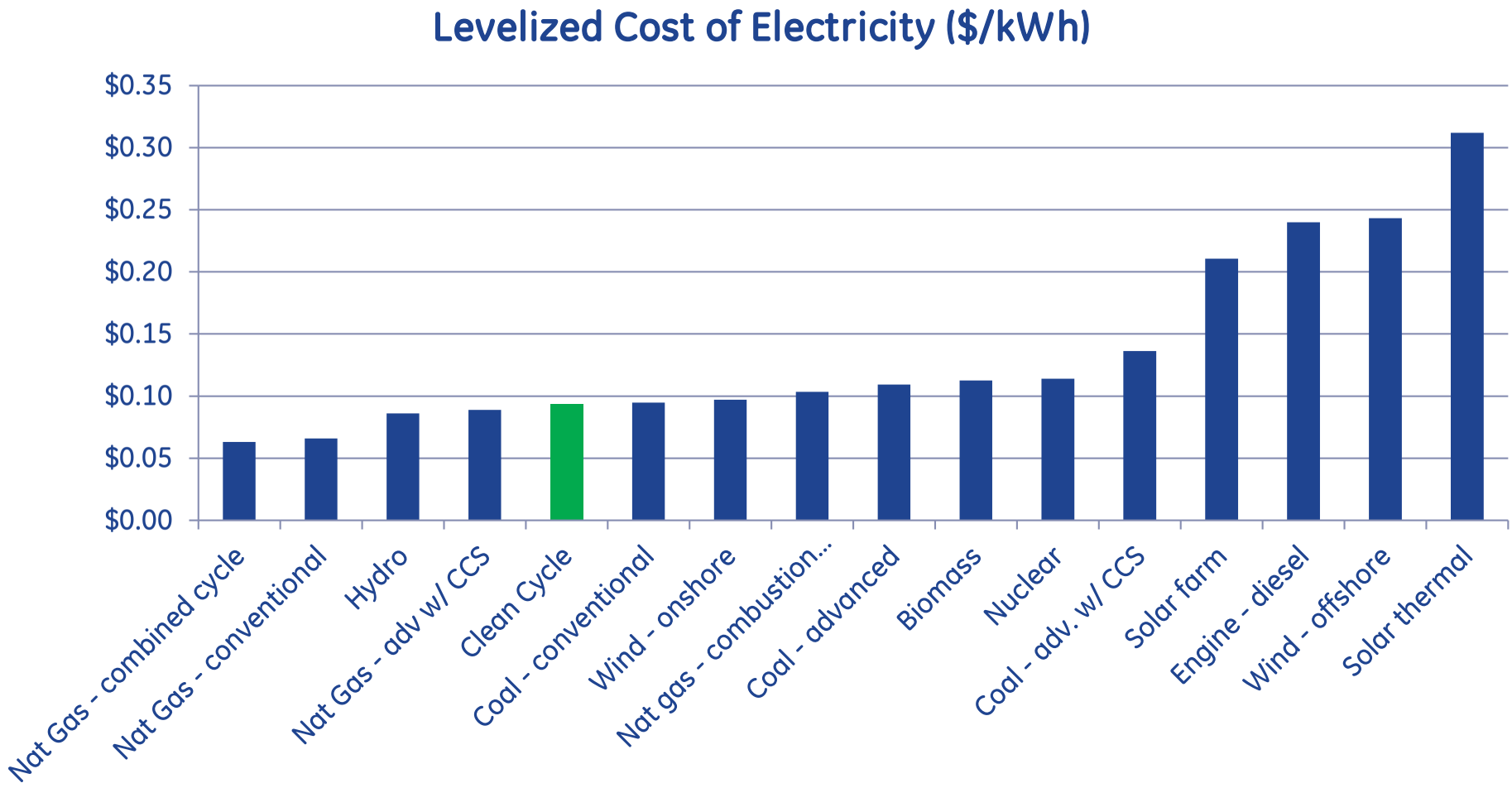
Turbines

Biomass Boilers

Other / Industry



Economic electricity production



No fuel, no emissions, low OpEx

Clean Cycle information compiled internally based on 90% availability at 100kW net output, 15 year product life and 15% discount rate

All other data from Energy Information Administration 2011 Annual Outlook

A Fire-Tube Design with Maxim Quality and Durability

APPLICATIONS:

The MBT is a fire tube type heat recovering unit that can be supplied in various configurations. It is used primarily on large reciprocating engines and those that use heavy fuel.

CODE COMPLIANCE

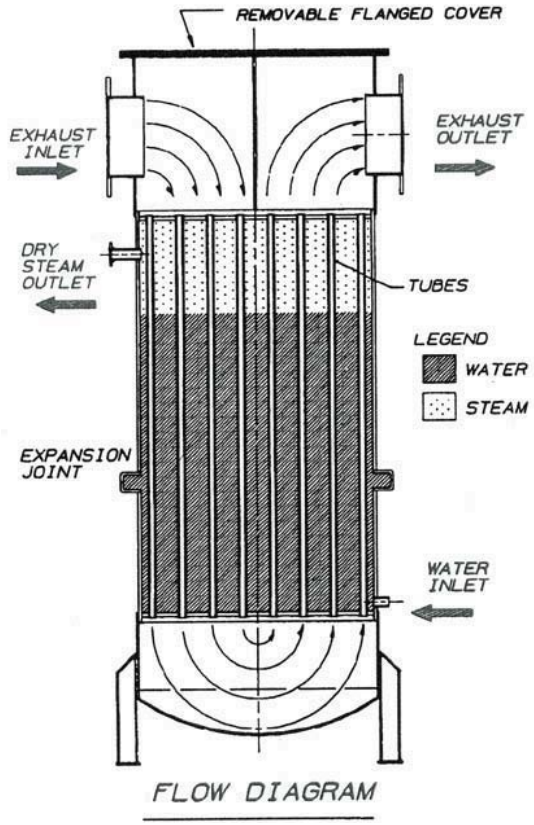
The Maxim MBT heat recovery unit is designed and fabricated in compliance with Section VIII or Section I, Division I, ASME Code.

Size Range: Exhaust connections from 14" through 36" in diameter

Features

- Hot water or steam generation
- Horizontal or vertical configuration
- Certified quality standards, ASME Section VIII (Std.), ASME Section I, U.S. Coast Guard, American Bureau Ships, ASME Sect. IV, and other options available
- Single or two pass arrangements
- Various exhaust connection locations
- Various pressure ratings available
- Critical grade noise attenuation

Construction: All sizes incorporate provisions for the difference in expansion of the tubes and shell. Pressure containing shell and tubesheet shall be constructed of SA-516 gr. 70 carbon steel. Tubes shall be SA-178A carbon steel and strength welded in the tube sheets. The unit shall be provided with properly sized fluid connections and include safety valve(s) per ASME code requirements.



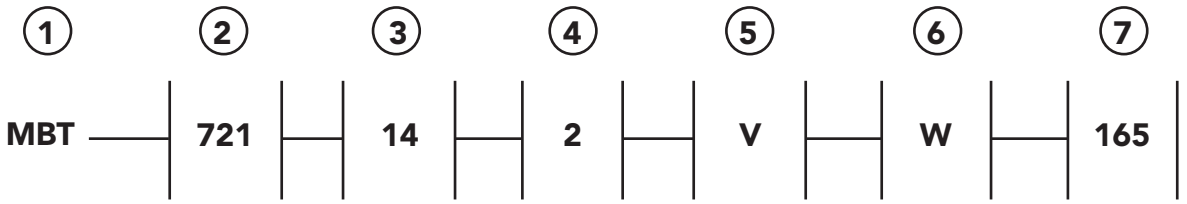
FLOW DIAGRAM

OPERATION

Flow Diagram

Exhaust gas enters the unit and passes through the tubes where heat is transferred to the water. Configurations available for generating steam or hot water (steam unit shown).

Optional internal diverter available on two pass units. Consult Maxim Silencers, Inc. for application specification.



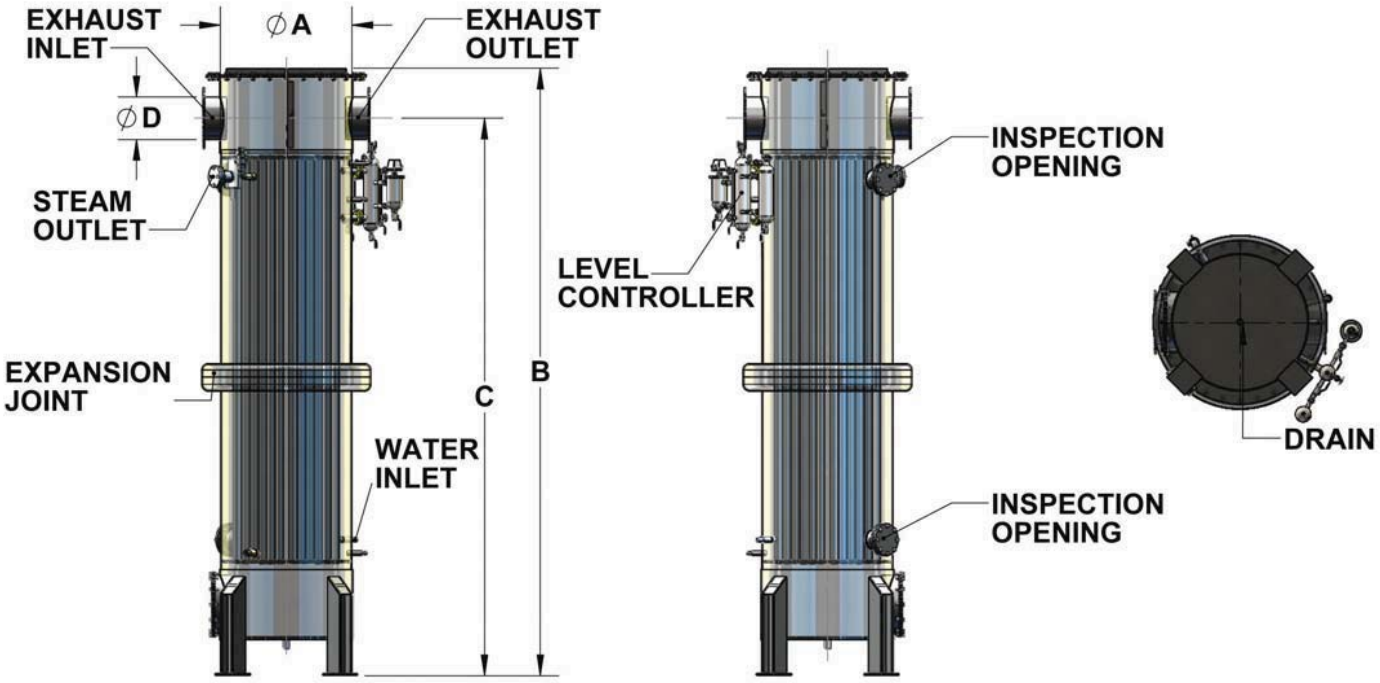
1. Model designation
2. Nominal heat transfer area (sq. ft.)
3. Nominal exhaust inlet/outlet diameter (in.)
4. Two gas side passes
5. Horizontal orientation (H)
   Vertical orientation (V)
6. Water heater (W)
   Steam generator (S)
7. Design pressure 165 psi

EXAMPLE:

MBT-721-14-2-V-W-165D*

A unit for a nominal 721 sq. ft. heating surface - 14" inlet and outlet exhaust connections - two pass unit - vertical orientation - hot water service - 165 psig - with a diverter valve (internal or external).

*Add "D" if diverter valve is required

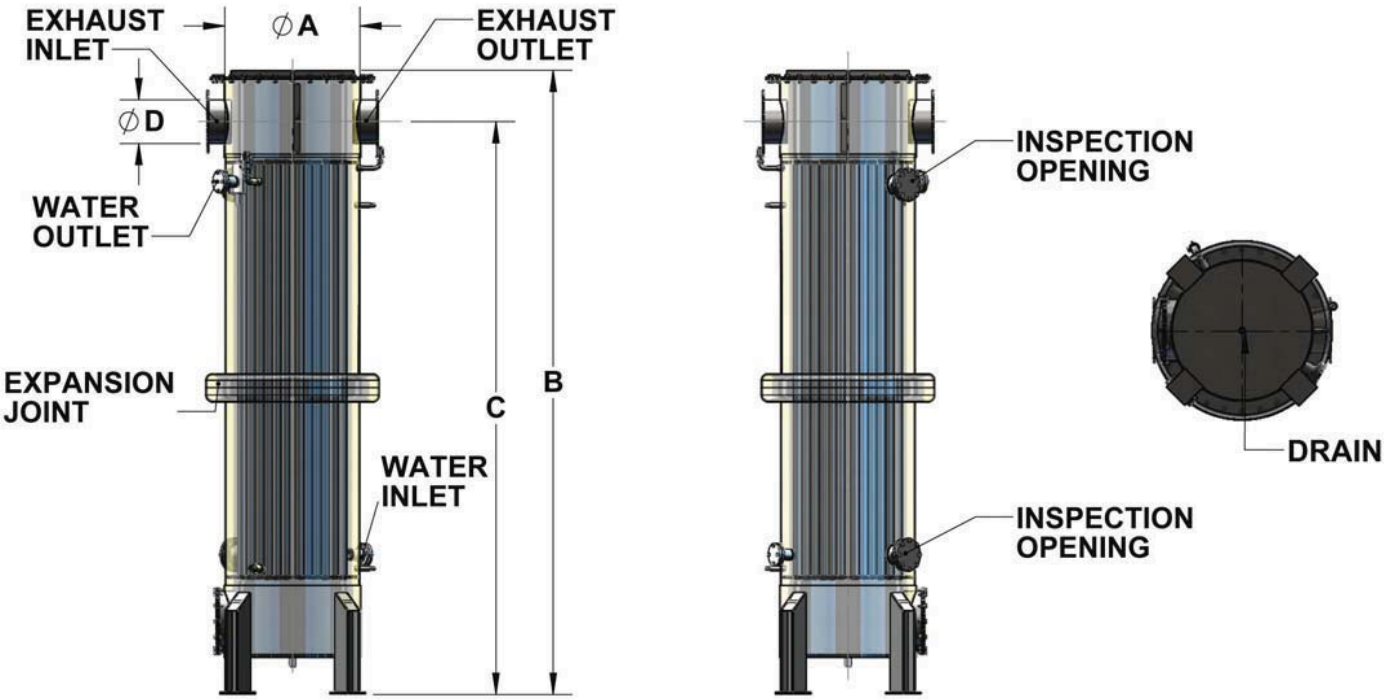


MBT MODEL NUMBER	A (IN)	B (IN)	C (IN)	D (IN)	WATER INLET NPT	STEAM OUTLET 150# ANSI	* WEIGHT (LBS) DRY	* WEIGHT (LBS) WET
721–14	45	213	192	14	1	3	11500	15800
831–16	48.5	219	196	16	1	3	12900	17900
1027–18	52	226	200	18	1	3	15100	20700
1198–20	57	233	200	20	1	4	17800	24600
1382–22	60	239	204	22	1.5	4	19400	26800
1675–24	65	245	210	24	1.5	4	22600	31100
2054–26	72	252	218	26	1.5	4	27400	37900
2348–28	76	260	230	28	1.5	4	31100	42600
2641–30	80	266	236	30	1.5	4	34400	46900
3042–32	85	272	240	32	1.5	6	38600	52600
3534–34	92	280	246	34	1.5	6	43900	60400
3962–36	98	288	252	36	1.5	6	48700	67700

NOTES:

- Constructed and stamped for 165 psi service
- Furnished with internal steam separator and level controller
- Tubes strength welded to tubesheets
- Exterior paint - one coat of high temperature black
- Expansion joint designed for wet start-up from ambient
- Special configurations allow cold,dry start-up
- Trunnions and tailing lugs for lifting are standard with units
- Dimensions and locations of level controller and connections may be subject to change (certified drawings will be issued after order)
- Ship loose controls consist of: liquid level controller, low/high level alarms, low water cutoff, gauge glass, pressure gauge, safety valve, modulating feed valve, automatic air vent and bottom and surface blowdown valves
- Vertical or horizontal configurations available
- Optional factory installed insulation is available

*Weights shown above do not include insulation



MBT MODEL NUMBER	A (IN)	B (IN)	C (IN)	D (IN)	WATER INLET NPT	STEAM OUTLET 150# ANSI	* WEIGHT (LBS) DRY	* WEIGHT (LBS) WET
721–14	45	201	180	14	4	4	10700	15000
831–16	48.5	207	184	16	4	4	12000	17000
1027–18	52	214	188	18	4	4	14000	19600
1198–20	57	221	188	20	6	6	16500	23300
1382–22	60	227	192	22	6	6	18000	25400
1675–24	65	233	198	24	6	6	21000	29500
2054–26	72	240	206	26	6	6	25500	36000
2348–28	76	248	218	28	6	6	29000	40500
2641–30	80	254	224	30	6	6	32000	44500
3042–32	85	260	228	32	8	8	36000	50000
3534–34	92	268	234	34	8	8	41000	57500
3962–36	98	276	240	36	8	8	45500	64500

NOTES:

- Constructed and stamped for 165 psi service
- Tubes strength welded to tubesheets
- Exterior paint - one coat of high temperature black
- Expansion joint designed for wet start-up from ambient
- Special configurations allow cold,dry start-up
- Trunnions and tailing lugs for lifting are standard with units
- Dimensions and locations of connections may be subject to change (certified drawings will be submitted after order)
- Ship loose controls consist of: safety relief valve, air vent valve
- Vertical or horizontal configurations available
- Optional factory installed insulation is available

* Weights shown above are without insulation

MBT PERFORMANCE PROGRAM DATE 10-05-2012

REF. NO. DUTCH HARBOR CAT C280-16 100% LOAD

COMBUSTION AIR AND FUEL DATA

AMBIENT TEMP.	40.5 F
AMBIENT PRESS.	14.700 PSIA
RELATIVE HUMIDITY	50. PCT.
TYPE FUEL	DIESEL FUEL
EXCESS AIR	100. PCT.

MAXIM MODEL MBT 3094.- 32. - 2PVW - 100 VERTICAL
EXH. GAS CONN. 32. IN.
LIQUID CONN. 6.0 IN.
SHELL I.D. 84.00 IN.
WORK. PRESS. 60. PSIG
DESIGN PRESS. 100. PSIG

DESIGN DATA

NO. PASSES	2.
TUBES/PASS	249.
TUBE SIZE	2.50 IN. O.D. X .120 WALL
TUBE PITCH	3.375 IN.
TUBE LENGTH	126. IN.
NO. BAFFLES	2.

OPERATING DATA

	TUBE SIDE	SHELL SIDE
TYPE FLUID	COMBUSTION PRODUCT	50/50 PPG-WATER DOWFROST HD
FLOW RATE	67078. LB/HR	131250. LB/HR (271 GPM)
INLET TEMP.	687. F	250. F
OUTLET TEMP.	338. F	300. F
PRESS. DROP		
WET	3.35 IN WC	.2 PSI
FLUID PROPERTIES		
SP. WT.	.0409 LB/CU FT	60.38 LB/CU FT
SP. HEAT	.2623 BTU/LB/F	.9350 BTU/LB/F
TH. COND.	.0229 BTU/HR/FT/F	.2135 BTU/HR/FT/F
VISCOSITY	.0652 LB/FT/HR	1.2216 LB/FT/HR
FOUL FACTOR	.005	.001

HEAT RECOVERY 6135938. BTU/HR

MBT PERFORMANCE PROGRAM DATE 10-05-2012

REF. NO. DUTCV HARBOR CAT C280-16 75% LOAD

COMBUSTION AIR AND FUEL DATA

AMBIENT TEMP.	40.5 F
AMBIENT PRESS.	14.700 PSIA
RELATIVE HUMIDITY	50. PCT.
TYPE FUEL	DIESEL FUEL
EXCESS AIR	100. PCT.

MAXIM MODEL MBT 3094.- 32. - 2PVW - 100 VERTICAL

EXH. GAS CONN.	32. IN.
LIQUID CONN.	6.0 IN.
SHELL I.D.	84.00 IN.
WORK. PRESS.	60. PSIG
DESIGN PRESS.	100. PSIG

DESIGN DATA

NO. PASSES	2.
TUBES/PASS	249.
TUBE SIZE	2.50 IN. O.D. X .120 WALL
TUBE PITCH	3.375 IN.
TUBE LENGTH	126. IN.
NO. BAFFLES	2.

OPERATING DATA

	TUBE SIDE	SHELL SIDE
TYPE FLUID	COMBUSTION PRODUCT	50/50 PPG-WATER DOWFROST HD
FLOW RATE	50673. LB/HR	123175. LB/HR (254.4 GPM)
INLET TEMP.	769. F	250. F
OUTLET TEMP.	338. F	300. F
PRESS. DROP		
WET	2.01 IN WC	.2 PSI
FLUID PROPERTIES		
SP. WT.	.0390 LB/CU FT	60.38 LB/CU FT
SP. HEAT	.2637 BTU/LB/F	.9350 BTU/LB/F
TH. COND.	.0237 BTU/HR/FT/F	.2135 BTU/HR/FT/F
VISCOSITY	.0672 LB/FT/HR	1.2216 LB/FT/HR
FOUL FACTOR	.005	.001

HEAT RECOVERY 5758431. BTU/HR

MBT PERFORMANCE PROGRAM DATE 10-05-2012

REF. NO. DUTCH HARBOR C280-16 50% LOAD

COMBUSTION AIR AND FUEL DATA

AMBIENT TEMP.	40.5 F
AMBIENT PRESS.	14.700 PSIA
RELATIVE HUMIDITY	50. PCT.
TYPE FUEL	DIESEL FUEL
EXCESS AIR	100. PCT.

MAXIM MODEL MBT 3094.- 32. - 2PVW - 100 VERTICAL
EXH. GAS CONN. 32. IN.
LIQUID CONN. 6.0 IN.
SHELL I.D. 84.00 IN.
WORK. PRESS. 60. PSIG
DESIGN PRESS. 100. PSIG

DESIGN DATA

NO. PASSES	2.
TUBES/PASS	249.
TUBE SIZE	2.50 IN. O.D. X .120 WALL
TUBE PITCH	3.375 IN.
TUBE LENGTH	126. IN.
NO. BAFFLES	2.

OPERATING DATA

	TUBE SIDE	SHELL SIDE
TYPE FLUID	COMBUSTION PRODUCT	50/50 PPG-WATER DOWFROST HD
FLOW RATE	33314. LB/HR	97500. LB/HR (201.4 GPM)
INLET TEMP.	839. F	250. F
OUTLET TEMP.	322. F	300. F
PRESS. DROP		
WET	.91 IN WC	.2 PSI
FLUID PROPERTIES		
SP. WT.	.0377 LB/CU FT	60.38 LB/CU FT
SP. HEAT	.2648 BTU/LB/F	.9350 BTU/LB/F
TH. COND.	.0243 BTU/HR/FT/F	.2135 BTU/HR/FT/F
VISCOSITY	.0686 LB/FT/HR	1.2216 LB/FT/HR
FOUL FACTOR	.005	.001

HEAT RECOVERY 4558125. BTU/HR

MBT PERFORMANCE PROGRAM DATE 10-05-2013

REF. NO. DUTCH HARBOR WARTSILA 12V32 100% LOAD

COMBUSTION AIR AND FUEL DATA

AMBIENT TEMP.	40.5 F
AMBIENT PRESS.	14.700 PSIA
RELATIVE HUMIDITY	50. PCT.
TYPE FUEL	DIESEL FUEL
EXCESS AIR	100. PCT.

MAXIM MODEL MBT 3962.- 36. - 2PVW - 100 VERTICAL

EXH. GAS CONN.	36. IN.
LIQUID CONN.	6.0 IN.
SHELL I.D.	97.00 IN.
WORK. PRESS.	60. PSIG
DESIGN PRESS.	100. PSIG

DESIGN DATA

NO. PASSES	2.
TUBES/PASS	324.
TUBE SIZE	2.50 IN. O.D. X .120 WALL
TUBE PITCH	3.375 IN.
TUBE LENGTH	124. IN.
NO. BAFFLES	2.

OPERATING DATA

	TUBE SIDE	SHELL SIDE
TYPE FLUID	COMBUSTION PRODUCT	50/50 PPG-WATER
FLOW RATE	80715. LB/HR	172500. LB/HR (356.3 GPM)
INLET TEMP.	723. F	250. F
OUTLET TEMP.	343. F	300. F
PRESS. DROP		
WET	2.96 IN WC	.3 PSI
FLUID PROPERTIES		
SP. WT.	.0400 LB/CU FT	60.38 LB/CU FT
SP. HEAT	.2630 BTU/LB/F	.9350 BTU/LB/F
TH. COND.	.0233 BTU/HR/FT/F	.2135 BTU/HR/FT/F
VISCOSITY	.0662 LB/FT/HR	1.2216 LB/FT/HR
FOUL FACTOR	.005	.001

HEAT RECOVERY 8064375. BTU/HR

MBT PERFORMANCE PROGRAM DATE 10-05-2013

REF. NO. DUTCH HARBOR WARTSILA 12V32 75& LOAD

COMBUSTION AIR AND FUEL DATA

AMBIENT TEMP.	80. F
AMBIENT PRESS.	14.700 PSIA
RELATIVE HUMIDITY	50. PCT.
TYPE FUEL	DIESEL FUEL
EXCESS AIR	100. PCT.

MAXIM MODEL MBT 3962.- 36. - 2PVW - 100 VERTICAL

EXH. GAS CONN.	36. IN.
LIQUID CONN.	6.0 IN.
SHELL I.D.	97.00 IN.
WORK. PRESS.	60. PSIG
DESIGN PRESS.	100. PSIG

DESIGN DATA

NO. PASSES	2.
TUBES/PASS	324.
TUBE SIZE	2.50 IN. O.D. X .120 WALL
TUBE PITCH	3.375 IN.
TUBE LENGTH	124. IN.
NO. BAFFLES	2.

OPERATING DATA

	TUBE SIDE	SHELL SIDE
TYPE FLUID	COMBUSTION PRODUCT	50/50 PPG-WATER
FLOW RATE	69049. LB/HR	118000. LB/HR (243.7)
INLET TEMP.	629. F	250. F
OUTLET TEMP.	322. F	300. F
PRESS. DROP		
WET	2.08 IN WC	.3 PSI
FLUID PROPERTIES		
SP. WT.	.0427 LB/CU FT	60.38 LB/CU FT
SP. HEAT	.2610 BTU/LB/F	.9350 BTU/LB/F
TH. COND.	.0221 BTU/HR/FT/F	.2135 BTU/HR/FT/F
VISCOSITY	.0633 LB/FT/HR	1.2216 LB/FT/HR
FOUL FACTOR	.005	.001

HEAT RECOVERY 5516500. BTU/HR

MBT PERFORMANCE PROGRAM DATE 10-05-2013

REF. NO. DUTCH HARBOR WARTSILA 12V32 50% LOAD

COMBUSTION AIR AND FUEL DATA

AMBIENT TEMP.	80. F
AMBIENT PRESS.	14.700 PSIA
RELATIVE HUMIDITY	50. PCT.
TYPE FUEL	DIESEL FUEL
EXCESS AIR	100. PCT.

MAXIM MODEL MBT 3962.- 36. - 2PVW - 100 VERTICAL

EXH. GAS CONN.	36. IN.
LIQUID CONN.	6.0 IN.
SHELL I.D.	97.00 IN.
WORK. PRESS.	60. PSIG
DESIGN PRESS.	100. PSIG

DESIGN DATA

NO. PASSES	2.
TUBES/PASS	324.
TUBE SIZE	2.50 IN. O.D. X .120 WALL
TUBE PITCH	3.375 IN.
TUBE LENGTH	124. IN.
NO. BAFFLES	2.

OPERATING DATA

	TUBE SIDE	SHELL SIDE
TYPE FLUID	COMBUSTION PRODUCT	50/50 ETG-WATER
FLOW RATE	50001. LB/HR	97500. LB/HR (201.4 GPM)
INLET TEMP.	669. F	250. F
OUTLET TEMP.	320. F	300. F
PRESS. DROP		
WET	1.13 IN WC	.3 PSI
FLUID PROPERTIES		
SP. WT.	.0419 LB/CU FT	60.38 LB/CU FT
SP. HEAT	.2615 BTU/LB/F	.9350 BTU/LB/F
TH. COND.	.0224 BTU/HR/FT/F	.2135 BTU/HR/FT/F
VISCOSITY	.0641 LB/FT/HR	1.2216 LB/FT/HR
FOUL FACTOR	.005	.001

HEAT RECOVERY 4558125. BTU/HR

HEAT RECOVERY SILENCERS FOR RECIPROCATING ENGINES WVS/WHS

Silencing + Energy Conservation

APPLICATIONS:

- Power plants
- Water purification plants
- Sewage treatment plants

CODE COMPLIANCE

All Maxim heat recovery equipment is designed and fabricated in compliance with Section VIII, Division I, ASME Code.

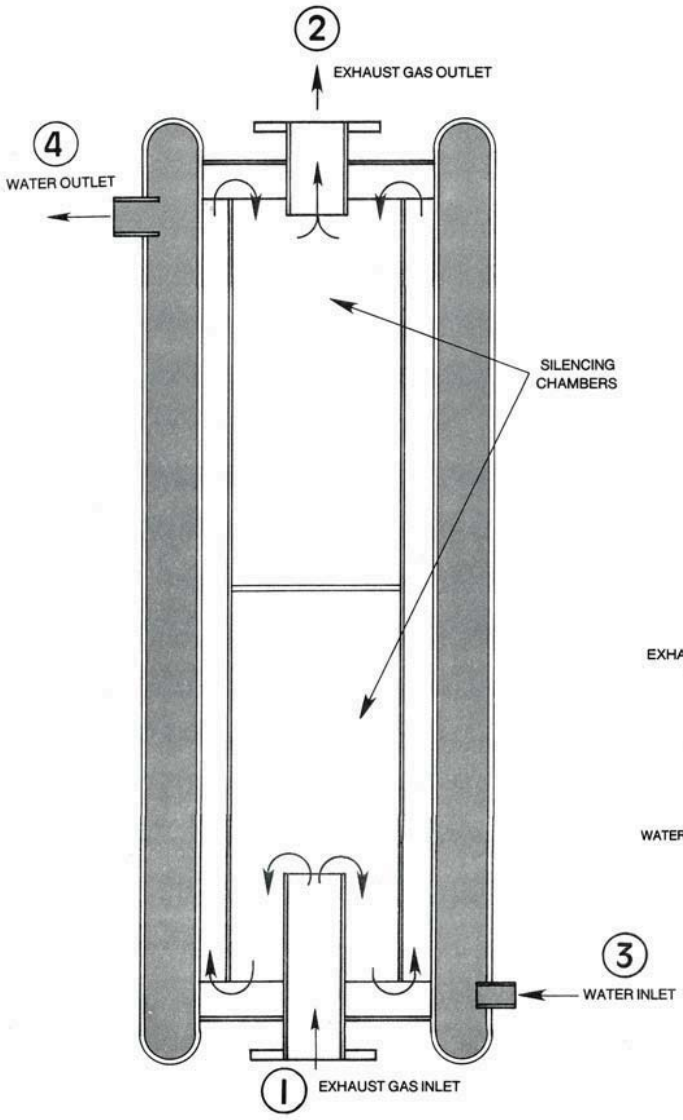
Size Range: Exhaust connections from 3" through 30" in diameter

Construction: The unique, tubeless construction of the WVS/WHS gives extraordinary service life with a minimum of attention. The annular jacket type heat exchanger eliminates problems with tube sheet joints and differential expansion among tubes associated with conventional tube type construction. Large volume attenuation chambers enclosed by a double wall of heavy steel plate assure highly effective silencing of engine exhaust noise. The standard WVS/WHS is designed for a maximum working pressure of 50 psig but is available at higher pressure ratings.

The Maxim models WVS (vertical) and WHS (horizontal) units are efficient heat recovery silencers that combine effective exhaust silencing with the conservation of exhaust heat to produce hot water.

Features

- Longitudinal fins are continuously welded to the inner wall of the water jacket to increase the heat transfer efficiency of the unit and permit design flexibility as to recovery rate and material selection
- Removable cover plates on each end of the unit allow access to the gas flow passages and heat transfer surfaces
- The WVS/WHS can be supplied with the standard bottom inlet, top outlet connections or a variety of optional inlet and outlet configurations
- Factory applied insulation is offered as an option
- Unique design and rugged construction make these units the choice for applications requiring maximum equipment life and minimum maintenance
- Increased corrosion resistance may be achieved economically with low alloy weathering steel used in non-pressurized parts exposed to the exhaust gases (this feature is especially beneficial in sewage treatment plant applications)

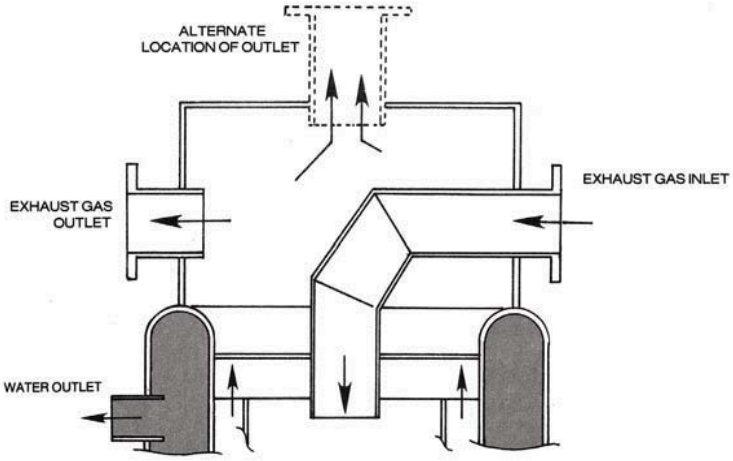


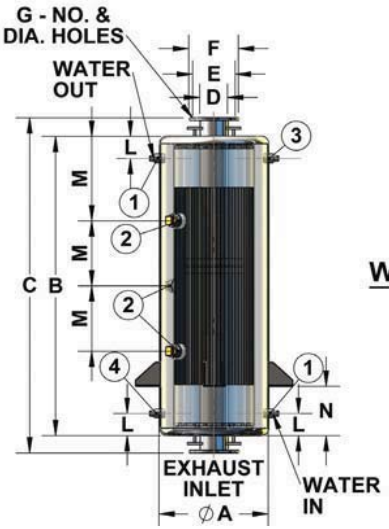
OPERATION

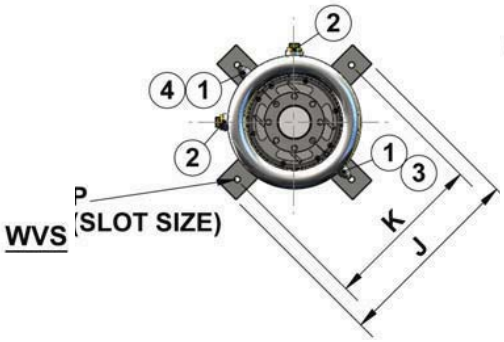
Flow Diagram

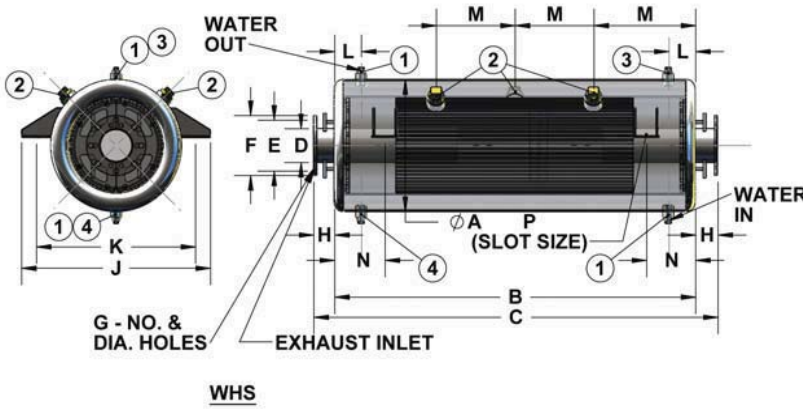
Exhaust gas enters the heat recovery silencer through connection (1), makes two reversals, then flows through a longitudinally finned annular passageway where heat is transferred to the water in the surrounding jacket. The gas exits from the exhaust connection (2).

Water enters the annular jacket through connection (3) and absorbs heat from the exhaust gas. The heated water exits from connection (4).







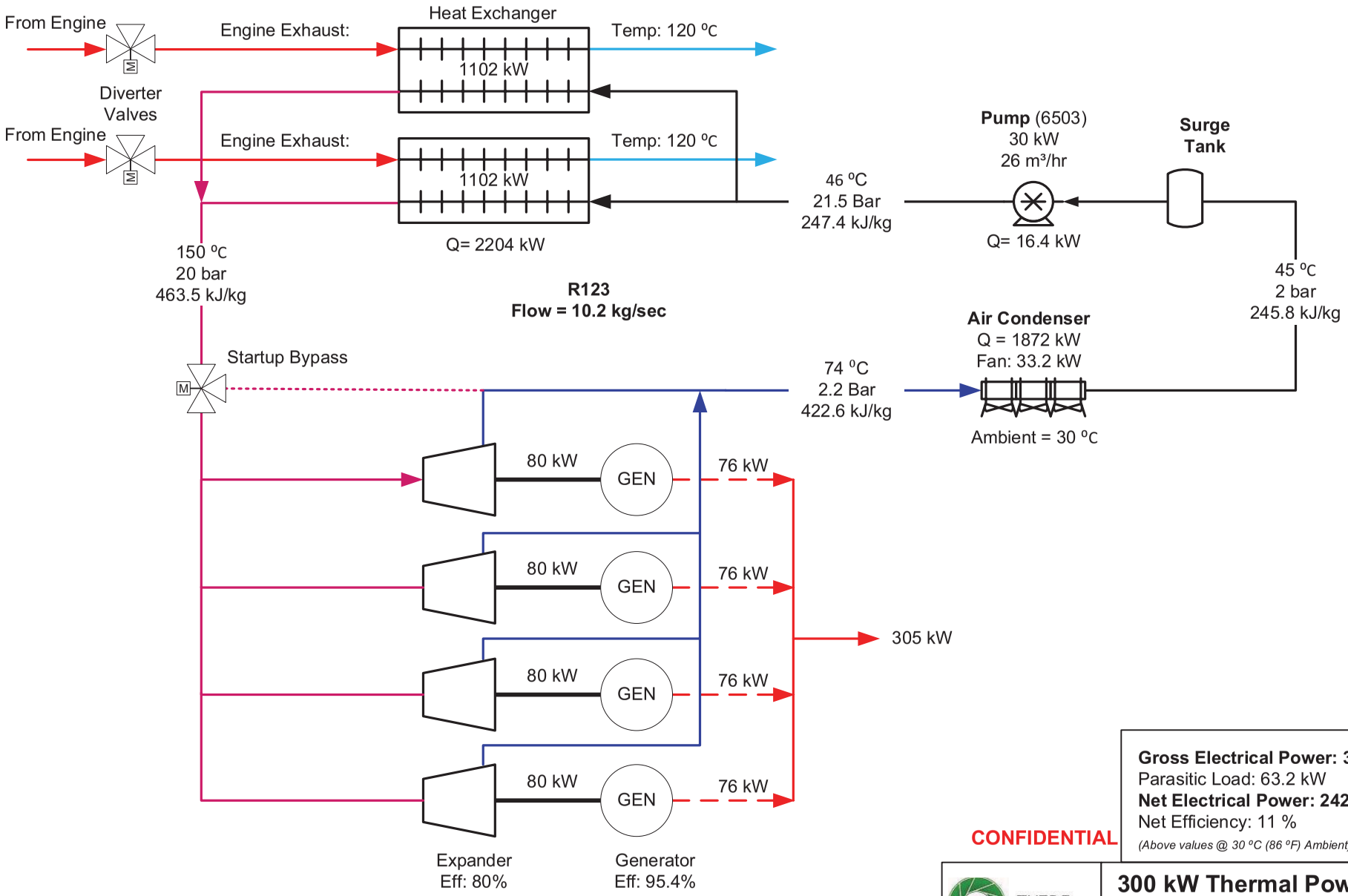


①= Water connection
②= Wash out connection
③= Relief valve connection
④= Drain connection

MODEL SIZE	DIMENSIONS IN INCHES														WEIGHTS - LBS					
	A	B	C	D	E	F	G	H	J	K	L	M	N	P	DRY	WET	①	②	③	④
25-3	18	48 7/8	51 7/8	3	6	7 1/2	(4) 3/4	1 1/2	30	28	4 1/4	12 1/4	9 3/4	3/4 - 1	650	790	1 1/2	2	1	1
35-4	22	52 7/8	55 7/8	4	7 1/2	9	(8) 3/4	1 1/2	34	32	4 1/4	13 1/4	10 1/2	3/4 - 1	860	1050	1 1/2	2	1	1
75-5	27 1/8	65 1/2	69	5	8 1/2	10	(8) 7/8	1 3/4	39 1/8	37	4 1/2	16 1/2	13	7/8 - 1 1/4	1360	1750	2	2	1	1
130-6	31 1/8	77 1/2	81	6	9 1/2	11	(8) 7/8	1 3/4	43 1/8	40 3/4	4 1/2	19 1/2	15 1/2	7/8 - 1 1/4	1850	2410	2	2	1	1
240-8	35 1/4	87 1/2	91	8	11 3/4	13 1/2	(8) 7/8	1 3/4	47 1/8	44 3/4	5 1/4	22 1/4	17	7/8 - 1 1/4	3160	3920	3	2	1 1/2	1 1/2
380-10	41 1/4	101 1/2	105	10	14 1/4	16	(12) 1	1 3/4	57 1/4	54 3/4	5 1/4	25 1/4	20 1/4	1 - 1 1/2	4750	5790	4	2	1 1/2	1 1/2
585-12	46 1/4	114	119	12	17	19	(12) 1	2 1/2	62 1/4	60	5 1/2	28 1/2	22 3/4	1 -1 1/2	6400	7900	4	2	1 1/2	1 1/2
885-14	52 1/2	126	131	14	18 3/4	21	(12) 1 1/8	2 1/2	72 1/2	70	6 1/4	31 1/2	25 1/4	1 1/8 - 1 3/4	9530	11320	6	2	1 1/2	1 1/2
1070-16	56 5/8	138	143	16	21 1/4	23 1/2	(16) 1 1/8	2 1/2	76 5/8	74	6 1/4	34 1/2	27 1/2	1 1/8 - 1 3/4	11840	14100	6	2	2	2
1500-18	60 5/8	154	159	18	22 3/4	25	(16) 1 1/4	2 1/2	80 5/8	78 1/4	6 1/4	39 1/2	30 3/4	1 1/4 - 2	15680	18460	6	2	2	2
2040-20	65 5/8	170 1/2	178	20	25	27 1/2	(20) 1 1/4	3 3/4	85 5/8	83	7 1/2	42 1/2	34 1/4	1 1/4 - 2	20810	24540	8	2	2	2
2900-22	71 3/4	186 1/2	193	22	27 1/4	29 1/2	(20) 1 3/8	3 3/4	95 3/4	93	7 1/2	46 1/2	37 1/4	1 3/8 - 2 1/4	27979	35509	8	2	2	2
3365-24	77 7/8	202 1/2	210	24	29 1/2	32	(20) 1 3/8	3 3/4	101 7/8	99	7 1/2	50 1/2	40 1/2	1 3/8 - 2 1/4	31175	36535	8	2	3	2
4230-26	86	219 1/2	227	26	31 3/4	34 1/4	(24) 1 3/8	3 3/4	110	107	9 1/2	55	44	1 3/8 - 2 1/4	43974	52044	8	2	3	2
4920-28	92 1/8	235 1/2	243	28	34	36 1/2	(28) 1 3/8	3 3/4	116 1/8	113	9 1/2	63	47	1 3/8 - 2 1/4	47776	57106	10	2	3	2
5550-30	98 1/4	251 1/2	259	30	36	38 3/4	(28) 1 5/8	3 3/4	122 1/4	119	9 1/2	69	50 1/2	1 3/8 - 2 1/4	54865	65565	10	2	3	2

NOTES:

- All bolt holes straddle C.L. (exhaust flanges are identical)
- Horizontal & vertical mounting arrangements shown may be varied to suit customer requirements
- Exhaust piping must be supported independently of silencer with expansion joints as required
- Unit must be insulated with minimum of 2" insulation for maximum efficiency
- Responsibility of installation is assumed by purchaser
- Dimensions not guaranteed unless certified
- Units designed for hot water service, ASME VIII, Division I, max pressure 50 psig @ 500 °F
- End plates removable to provide access for cleaning
- For either configuration the water flow should be from bottom to top
- Connection sizes subject to change to suit application



Gross Electrical Power: 305.3 kW
Parasitic Load: 63.2 kW
Net Electrical Power: 242.1 kW
Net Efficiency: 11 %
(Above values @ 30 °C (86 °F) Ambient)

CONFIDENTIAL

TURBO THERMAL

300 kW Thermal Power Pac

2 – Cat 3520C

1/30/12		R123		0
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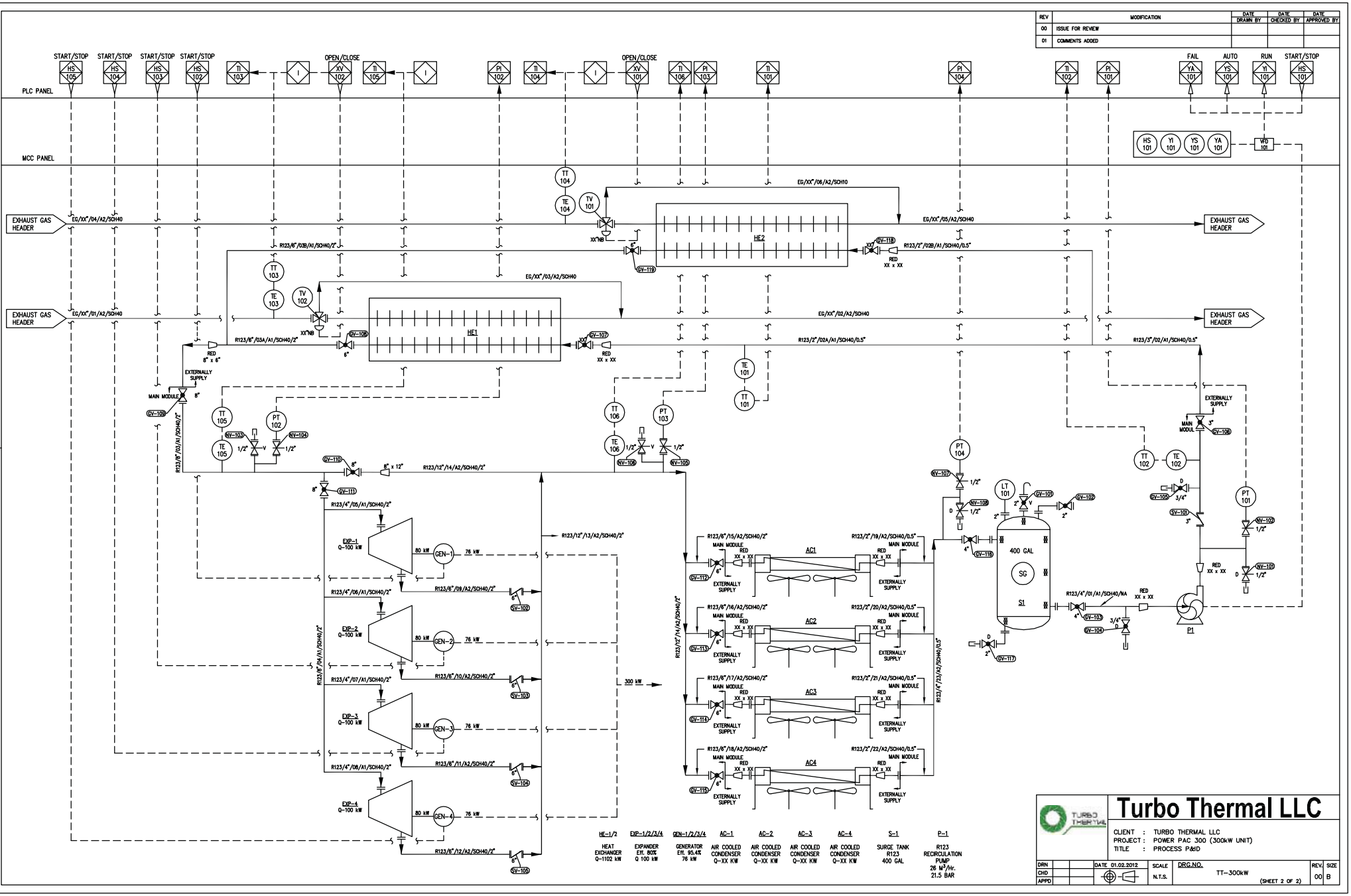
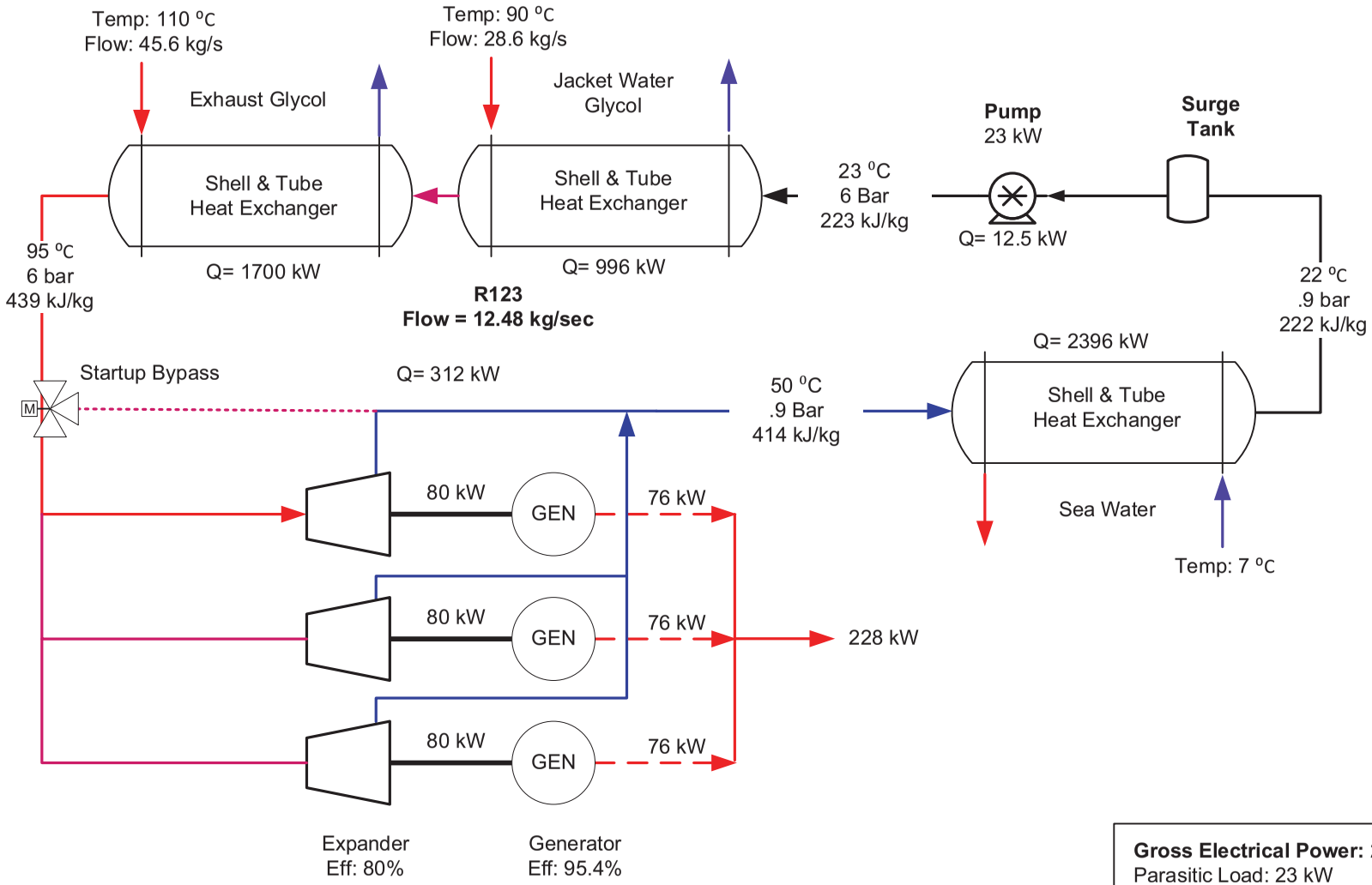

REV | MODIFICATION | DATE DRAWN BY | DATE CHECKED BY | DATE APPROVED BY
00 | ISSUE FOR REVIEW
01 | COMMENTS ADDED
START/STOP HS 105
START/STOP HS 104
START/STOP HS 103
START/STOP HS 102
TI 103
OPEN/CLOSE XV 102
TI 105
PI 102
TI 104
OPEN/CLOSE XV 101
TI 106
PI 103
TI 101
PI 104
TI 102
PI 101
FAIL YA 101
AUTO YS 101
RUN YI 101
START/STOP HS 101
WD 101
PLC PANEL
MCC PANEL
EXHAUST GAS HEADER
EG/XX"/04/A2/SCH40
EG/XX"/01/A2/SCH40
EG/XX"/05/A2/SCH40
EG/XX"/02/A2/SCH40
EG/XX"/03/A2/SCH40
EG/XX"/06/A2/SCH10
HE1
HE2
TT 104
TE 104
TV 101
TT 103
TE 103
TV 102
TT 105
TE 105
PT 102
TT 106
TE 106
PT 103
TE 101
TT 101
PT 104
LT 101
TT 102
TE 102
PT 101
MAIN MODULE
EXTERNALLY SUPPLY
RED
R123/6"/03A/A1/SCH40/2"
R123/6"/03B/A1/SCH40/2"
R123/2"/02A/A1/SCH40/0.5"
R123/2"/02B/A1/SCH40/0.5"
R123/3"/02/A1/SCH40/0.5"
R123/8"/04/A1/SCH40/2"
R123/12"/14/A2/SCH40/2"
R123/12"/13/A2/SCH40/2"
R123/12"/1A/A2/SCH40/2"
R123/4"/23/A2/SCH40/0.5"
EXP-1 Q-100 kW
EXP-2 Q-100 kW
EXP-3 Q-100 kW
EXP-4 Q-100 kW
GEN-1
GEN-2
GEN-3
GEN-4
80 kW
76 kW
300 kW
R123/4"/05/A1/SCH40/2"
R123/4"/06/A1/SCH40/2"
R123/4"/07/A1/SCH40/2"
R123/4"/08/A1/SCH40/2"
R123/6"/09/A2/SCH40/2"
R123/6"/10/A2/SCH40/2"
R123/6"/11/A2/SCH40/2"
R123/6"/12/A2/SCH40/2"
SV-102
SV-103
SV-104
SV-105
AC1
AC2
AC3
AC4
R123/6"/15/A2/SCH40/2"
R123/6"/16/A2/SCH40/2"
R123/6"/17/A2/SCH40/2"
R123/6"/18/A2/SCH40/2"
R123/2"/19/A2/SCH40/0.5"
R123/2"/20/A2/SCH40/0.5"
R123/2"/21/A2/SCH40/0.5"
R123/2"/22/A2/SCH40/0.5"
400 GAL
SG
S1
R123/4"/01/A1/SCH40/NA
P1
HE-1/2 HEAT EXCHANGER Q-1102 kW
EXP-1/2/3/4 EXPANDER Eff. 80% Q 100 kW
GEN-1/2/3/4 GENERATOR Eff. 95.4% 76 kW
AC-1 AIR COOLED CONDENSER Q-XX KW
AC-2 AIR COOLED CONDENSER Q-XX KW
AC-3 AIR COOLED CONDENSER Q-XX KW
AC-4 AIR COOLED CONDENSER Q-XX KW
S-1 SURGE TANK R123 400 GAL
P-1 R123 RECIRCULATION PUMP 26 M3/Hr. 21.5 BAR
Turbo Thermal LLC
CLIENT : TURBO THERMAL LLC
PROJECT : POWER PAC 300 (300kW UNIT)
TITLE : PROCESS P&ID
DRN
CHD
APPD
DATE 01.02.2012
SCALE N.T.S.
DRG.NO. TT-300kW (SHEET 2 OF 2)
REV. 00
SIZE B



Gross Electrical Power: 228 kW
Parasitic Load: 23 kW
Net Electrical Power: 205 kW
Net Efficiency: 7.6 %

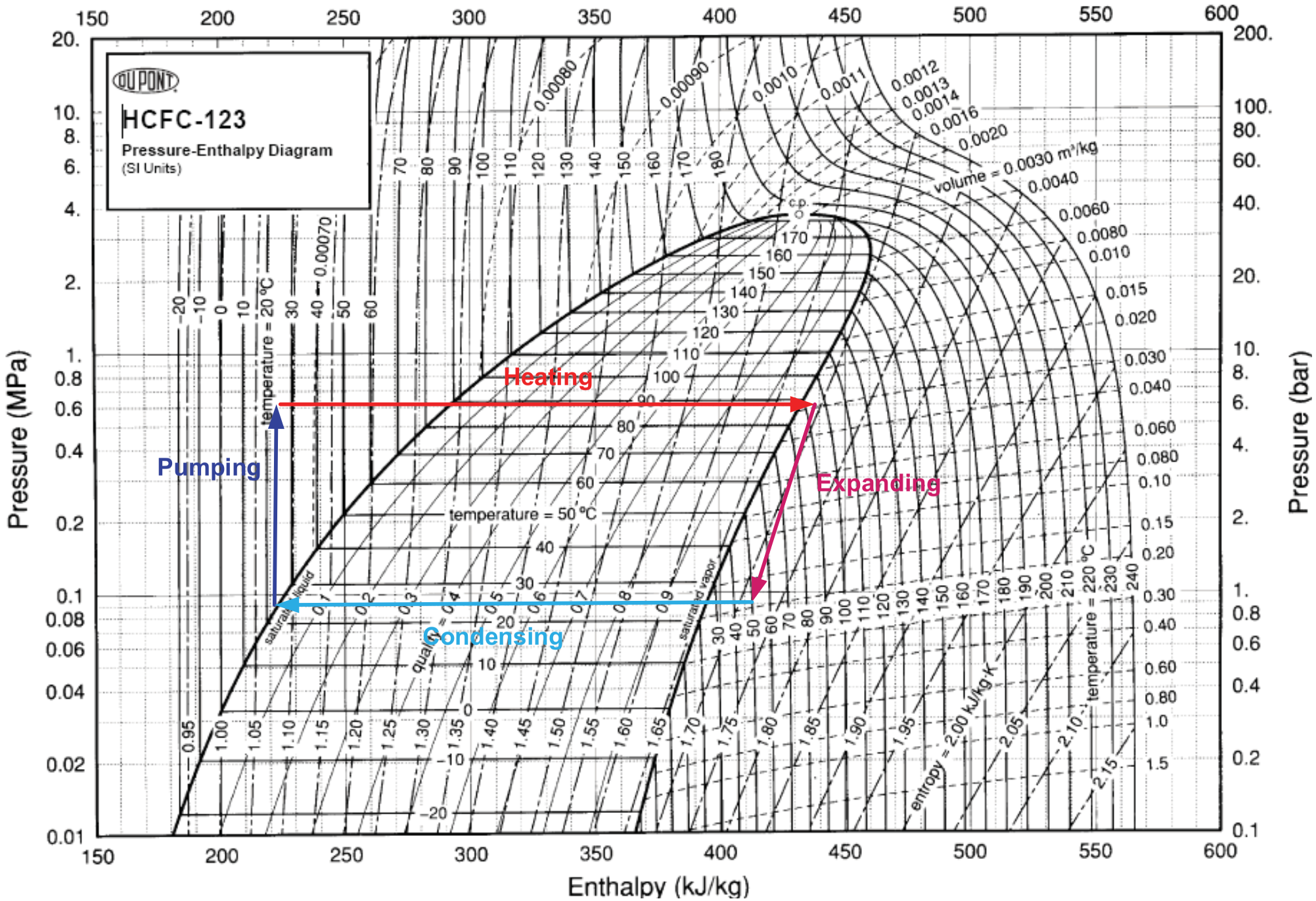
CONFIDENTIAL

TURBO THERMAL

Dutch Harbor Project

Wartsila Engine ORC

9/7/12 | R123 | 0


DUPONT
HCFC-123
Pressure-Enthalpy Diagram
(SI Units)
Heating
Pumping
Expanding
Condensing
Pressure (MPa)
Pressure (bar)
Enthalpy (kJ/kg)
temperature = 20 °C
temperature = 50 °C
temperature = 220 °C
volume = 0.0030 m³/kg
entropy = 2.00 kJ/kg·K
quality = 0
quality = 1
saturated liquid
saturated vapor
c.p.