Installation of Distributed Generation and Combined Heat and Power at Medway Plastics Corporation, Long Beach, CA

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ABSTRACT

This article describes the installation of three 375-kWe natural-gas-powered distributed generation units at Medway Plastics Corporation located in Long Beach, California. In addition to electric power, Medway has elected to utilize heat available in the engine jacket water to drive a 151-ton, single-effect, vapor absorption chiller, which Medway will use for cooling operations attendant to the injection molding process. As this article was being written, the units were scheduled to undergo exhaust gas emission testing to verify compliance with regulations set forth by South Coast Air Quality Management District.

MEDWAY PLASTICS CORPORATION

Medway Plastics Corporation (MPC) is a state-of-the-art injection molding plastics company located in Long Beach, California. MPC offers a diverse range of products including beverage containers, produce baskets, bread trays, audio speaker enclosures and office furniture.

MPC was incorporated in November, 1974. Today the corporation employs over 100 persons. Operations are carried out in five separate buildings, which include one administrative unit, three production units, and one research and development unit. Electrical utility service is provided by Southern California Edison (SCE). Gas service is provided by Long Beach Gas Company.

The founder of MPC began looking at cogeneration more than 15 years ago. He noted that utility costs were becoming an increasingly larger part of monthly operating expenses. So when electric deregulation opened in California, MPC was well prepared to consider alternatives for its electric supply. At present, MPC is under a Time of Use-8 contract with SCE, which includes the following rates: off peak of $0.09 per kWh; shoulder of $0.14/kWh; and peak of $0.27/kWh, with peak defined as 12 noon to 6 pm, from June 15 to October 15.

At present, the price of natural gas is ranging from $4 to $5 per million Btu. There is concern that these prices may escalate to $7. MPC is investigating long-term contracts to achieve some pricing stability.

DTE ENERGY TECHNOLOGIES, INC.

DTE Energy Technologies, located in Farmington Hills, MI is a wholly-owned subsidiary of DTE Energy Company. DTE Energy is also the parent of Detroit Edison, an electric utility serving the needs of electric customers in southeastern Michigan. It is also the parent of Michigan Consolidated Gas, a provider of natural gas throughout Michigan's Lower Peninsula.

DTE Energy Technologies (DTE Tech) was founded in 1998, with the specific purpose of entering into the distributed generation marketplace. The initial product offering was solely backup generation using natural gas powered internal combustion engines. Today the portfolio has grown to include a 7-kW proton exchange membrane fuel cell with on-board fuel reformer; 25- and 52-kW external combustion engines operating on the Stirling cycle; and natural-gas-powered internal combustion engine-generator systems ranging in size from 75 kW to 1000 kW. The packages are available in both lean-bum and stoichiometric configurations, except the 1000 kW, which is lean burn only. Lean bum offers higher electrical efficiency with relatively low emissions. The stoichiometric configuration provides the most economic path for exhaust gas clean-up to even the most stringent control regions.

MOVE TO DISTRIBUTED GENERATION

During the energy crisis of 2001, MPC rented portable generators, shed load, and worked odd shifts and weekends to balance productivity against rising power costs. With funds available through the SCE Self Incentive Program, MPC determined that an on-site power system was in their best long-term interest. It made the economics "work" for their profile of operating 24 hours per day, 7 days per week. Moreover, these tactics allowed them to operate in a consistent, non-disruptive manner even during peak power periods.

MPC was first contacted by another supplier in the spring of 2002, with a proposal for a single 1000-kW natural-gas-fired unit with cogeneration option. DTE Tech was also requested to submit a bid for a 1000-kW unit to allow MPC to compare performance and pricing. During the course of these initial discussions, DTE Tech was requested to submit a proposal for three 375-kW units, also with cogeneration option. MPC had identified that such an alternative would allow them to manage plant load even if one unit should be off line. MPC finally decided on the three smaller units with cogeneration, with the requirement that the aggregated thermal output be capable of driving a 151-refrigeration-ton, single-effect vapor-absorption chiller that MPC had purchased from Thermax, Limited, to off-load their electric chiller.

ENI 415 UNITS FOR MPC

The unit that MPC selected was DTE Tech's containerized ENI 415S, a stoichiometric unit with gross rating of 375 kW, with cogeneration providing jacket water heat recovery. Additional package details, as shown in Figure 1, include the following:

- 30-foot ISO container, equipped with acoustically-treated louvers for sound-deadening. Sound emission levels are specified at 70 dB (A) at 7 meters.
- Waukesha VGF24GSID natural gas-fired engineator, driving a Leroy Somer synchronous generator. Unit net electrical efficiency at 100% electric load is 30.7%, when unit is operating in 100% combined heat and power (CHP) mode (all water jacket energy is utilized by MPC).
- Three-way catalyst (catalyst supplied by Johnson Matthey, packaging provided by Silex, Inc.) for exhaust gas treatment to meet South Coast Air Quality Management District requirements.

- 55-gallon oil reservoir feeds the 28 gallon capacity crankcase on an as-required basis.
- Dual-core radiator provided by Young Touchstone. One core is rated for jacket water heat rejection of 1.117 million Btu/hr, and the second is rated for 300,000 Btu/hr (rejection of heat from the oil and intercooler circuits). A single fan draws ambient air through the louvers in the walls of the enclosure to be blown over the cores. The fan is controlled by a variable frequency drive (VFD) which raises or lowers fan speed to provide control of both engine jacket water and intercooler water return temperatures.
- Plate-and-frame heat exchanger provided by Young Touchstone transfers the 1.2 million Btu/hr of jacket water energy to MPC chiller hot water loop. An integral three-way bypass valve provides control of energy flow to the plate-and-frame unit.
- Electrical interface panel provided by ASCO. The integral generator breaker is rated at 800 amps at 480 V AC. The ASCO panel also includes a Woodward EGCP-2 engine controller, a GE Fanuc 90-30 PLC, a QuickPanel Jr. HMI display, and a Basler synchronizing relay.
- 24 VDC battery pack rated at 1000 cold-cranking amps and 1200 cranking amps, or approximately 150 ampere-hours. An on-board charger provides recharging when battery voltage drops below the normal level.
- A single cooling fan, rated at 5,000 ft^3/min, maintains interior cabin temperature.

Figure 1 shows the arrangement of the various components in the package. The dual core radiator is partitioned from the engine via a floor-to-ceiling wall. The engine, oil reservoir, catalytic converter, and plate and-frame heat exchanger are contained in the middle of the enclosure. A second floor-to-ceiling wall separates the ASCO panel from the engine compartment. Natural gas supply and hot water supply and return piping connections are made through the exterior wall of the engine compartment. The single cooling fan is located in the engine compartment, discharging its heated exhaust into the radiator compartment.

Figure 2 shows an end view of the package. The engine/generator is positioned mid-span, as is the radiator. The three-way catalyst is suspended to the left of the engine, facilitating the connection of the unit to the engine exhaust pipe.

Figure 3 shows the hot water circuit for the ENI package. Jacket water is circulated by a gear-driven pump internal to the engine. The water loops through the engine until the internal thermostat reaches 210°F, at which point water then flows through a 3-way valve to the plate and frame heat exchanger. Outlet temperature (T3) from the plate and frame exchanger is monitored to control the position of the proportioning valve to bypass hot water around the plate and frame, as thermal demand varies. Water then continues to the radiator. The radiator is used to transfer any heat not required in the Medway processes to the atmosphere. The quantity of heat to be transferred is controlled by a variable frequency drive-powered fan and a thermal mixing valve to provide 195°F water return to the engine (Tl).

Note also that intercooler heat rejection is cooled in this same radiator, passing through a separate radiator core. The return temperature (T4) is controlled by the VFD to a constant temperature of 130°F.

Use of the VFD to operate the fan provides dual benefits when Medway is consuming all of the energy produced by the engine. First, it reduces the parasitic losses, because the fan operates only to remove the intercooler heat load. Second, the noise emissions are reduced because of the lower operating speed of the fan.

MEDWAY VAPOR ABSORPTION CHILLER SYSTEM

Figure 4 shows the three ENI units arranged with Medway's 151-ton(R) lithium bromide vapor absorption chiller, the chiller pump skid (hot water), and the chilled water pump skid system. The chiller has a coefficient of performance (COP) of 71% at 100% power, hence requires approximately 2.55 million Btu/hr of heat input from the units. Recall that each unit has a jacket water capacity of 1.117 million Btu/hr; hence full thermal requirements for the chiller are satisfied when the engines are at 76% power.

The chiller system includes dual hot water pumps, which are manually changed over as required. Total flow from the chiller pump flows first through a three-way bypass valve which proportions the flow through the chiller and the three units. The valve bypasses the chiller and loops through the engines as long as the return temperature from the

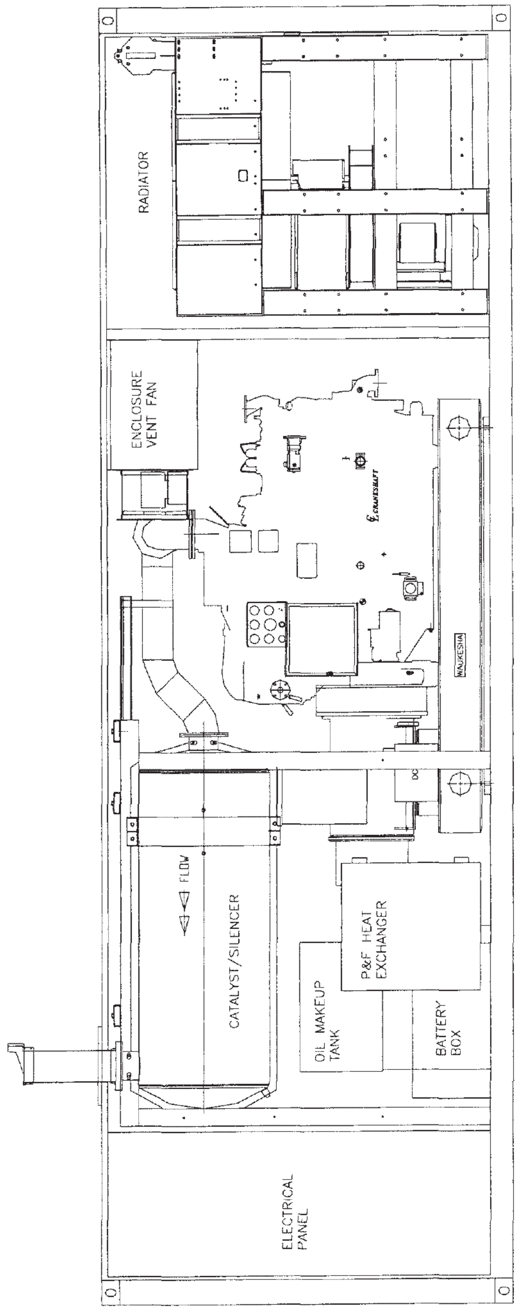

Figure 1. ENI15S Container side view—Medway Plastics

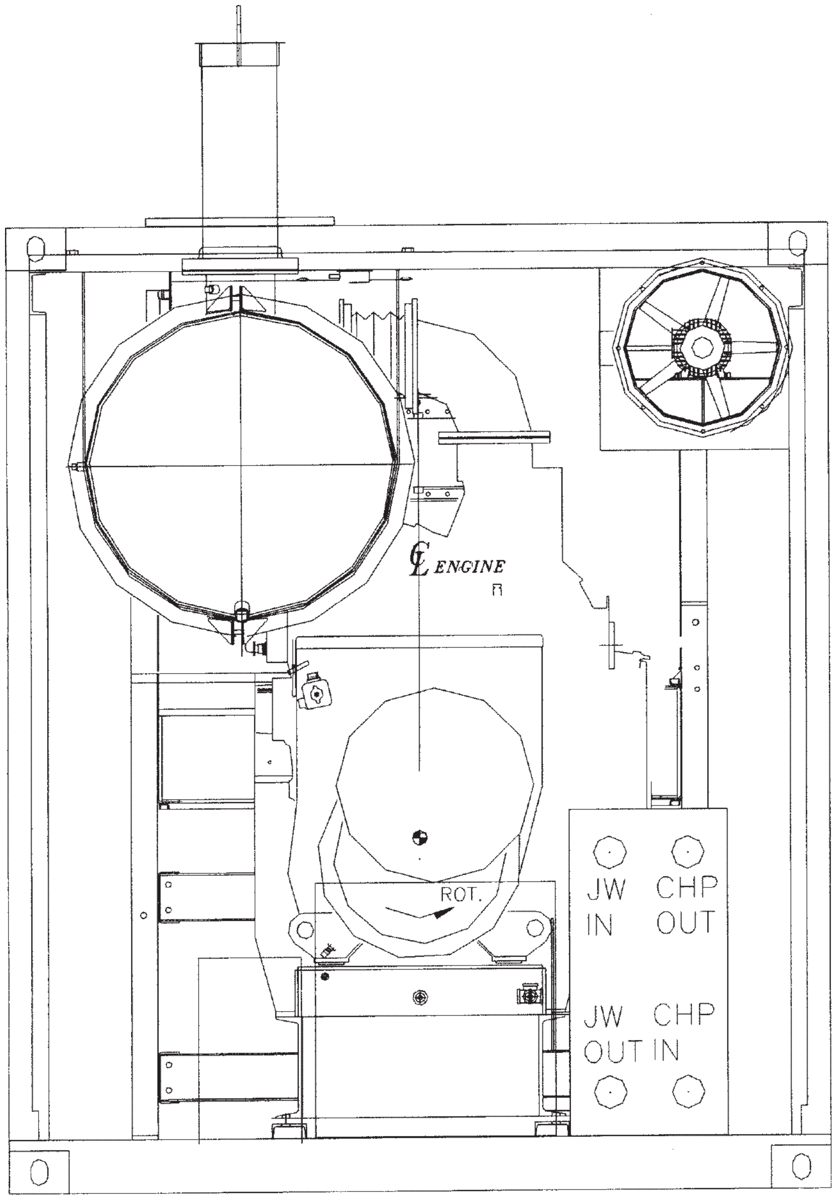

Figure 2. ENK415S Container end view—Medway Plastics

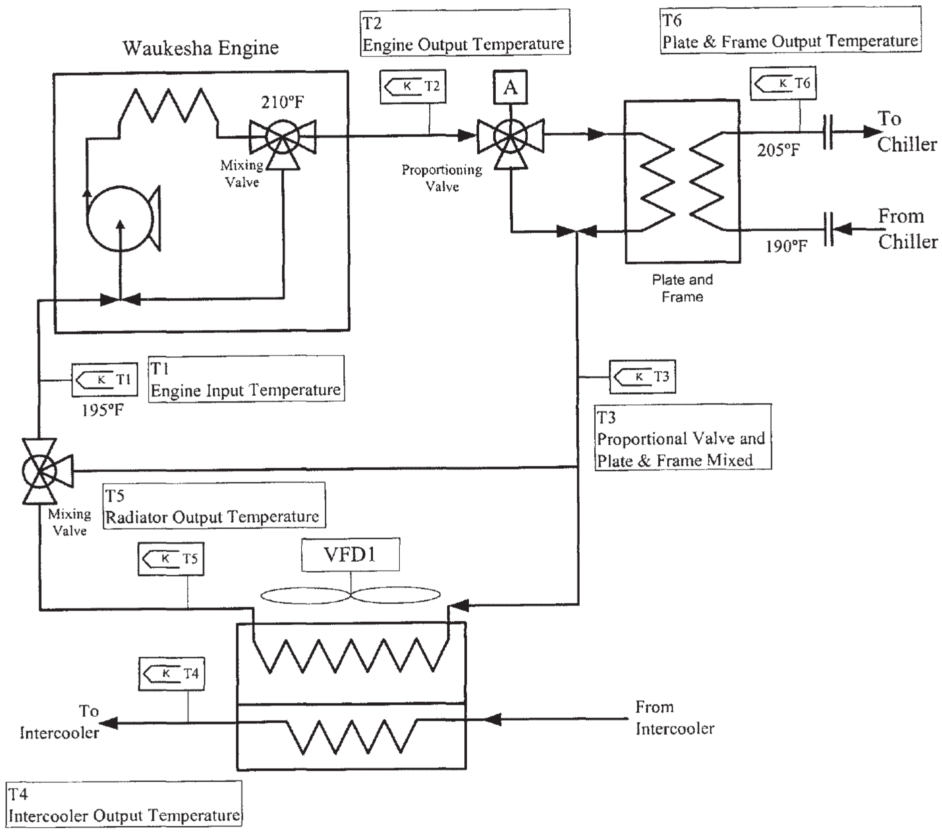

Figure 3. ENI415S Hot water circuit—Medway Plastics

engines is less than 170°F. The hot water exiting the common header passes through an air/water separator before returning to the inlet of the hot water pumps.

When hot water exiting the engine plate and frame heat exchangers exceeds the 170°F set point, the proportioning valve routes the hot water into the high pressure section of the chiller, which in turn initiates the production of chilled water in the low pressure section. The chilled water pumps are then activated, and chilled water at 44°F is pumped into the cold water reservoir of the chilled water tank. Chilled water is then pumped out of this tank by separate pumps, as the Medway processes call for chilled water.

Water returning from the processes is pumped back to the hot water reservoir of the chilled water Tank at 54°F, where it is pumped

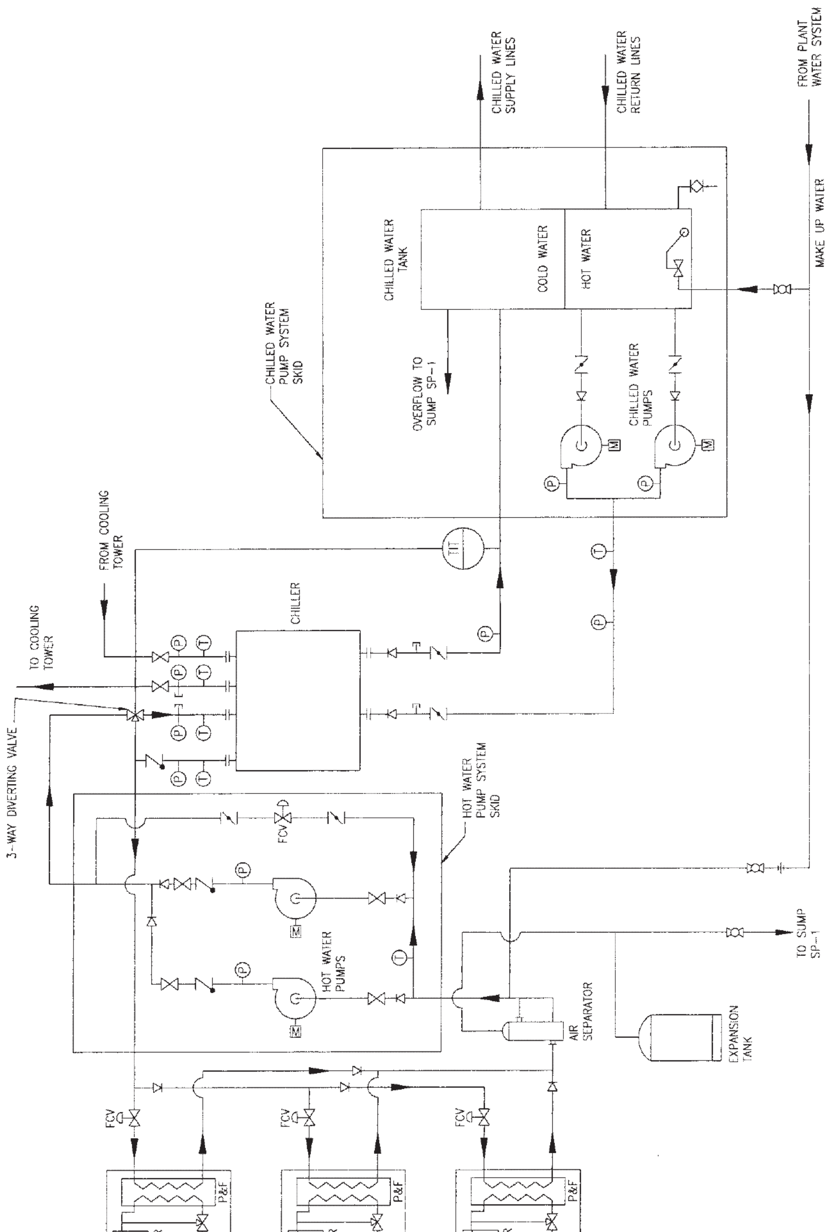

Figure 4. Vapor absorption chiller water circuit—Medway Plastics

back to the chiller for cooling.

The chiller also requires the installation of an evaporative cooling tower for proper operation. Within the chiller, there are two boiling processes, one in the high pressure section and one in the low pressure section, which require a cooling coil to achieve condensation of the water within the lithium bromide mixture. This is done most effectively with a tower. The capacity required for the Medway 151-ton chiller is approximately 4.36 million Btu/hr at full load operation. Figure 4 only depicts flow to and from the tower.

PROJECT STATUS

When this article was submitted, the project was not complete. The target date for live operation is Wednesday, 12 March 2003.

Figure 5 shows Unit No 3 installed on its concrete slab. The double doors on the left side allow access into the radiator section of the enclosure. The louvered inlet on the left side of the enclosure allows ambient air to enter the radiator to provide cooling for jacket water and intercooler water. Louvers in the left door located midspan allow air flow into the engine compartment. The louver on the lower right allows additional cooling air into the engine enclosure, while the louver on the far right provides cooling air to the switchgear section.

Figure 6 shows Unit No 1 installed. Radiator doors are now on the right end of the figure. The trapezoidal extension toward the upper left provides sound attenuation for air entering the engine compartment through a louver. The louver at the lower left provides more cooling air for the engine compartment. The rectangular box at the far left end in a NEMA cabinet through which power cables from the generator are connected to the Medway bus. The 2-inch pipe overhead provides gas supply to each of the three engines.

The l51-ton Thermax vapor absorption chiller is shown in Figure 7. Hot water from the engines enters the generator section through the lower pipe on the right hand side. The upper pipe serves as the return to the plate-and-frame heat exchangers for reheating.

Cooling water from the closed loop evaporative cooling tower enters the generator section through the upper pipe, where it condenses water leaving the generator, then passes to the absorber section (lower

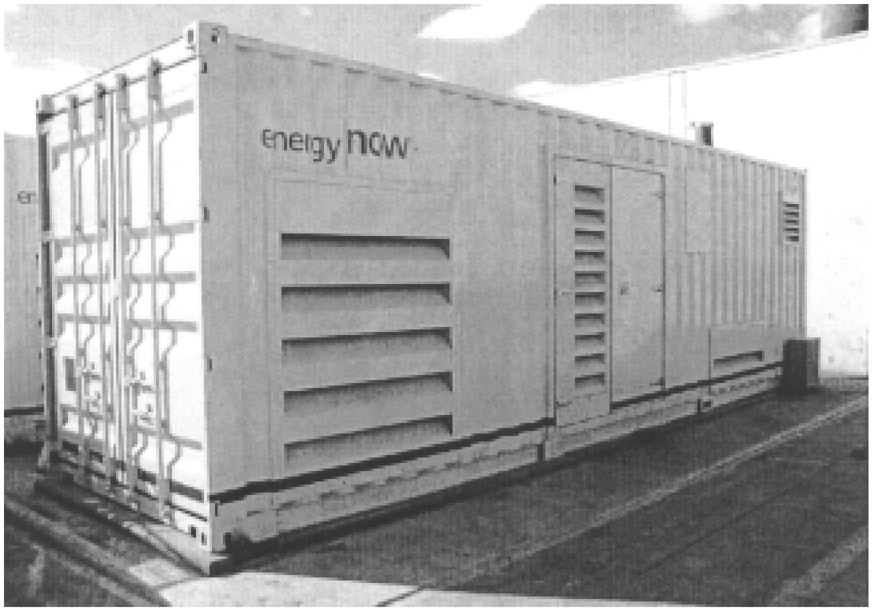

Figure 5. ENI415S Unit #3 Medway Plastics

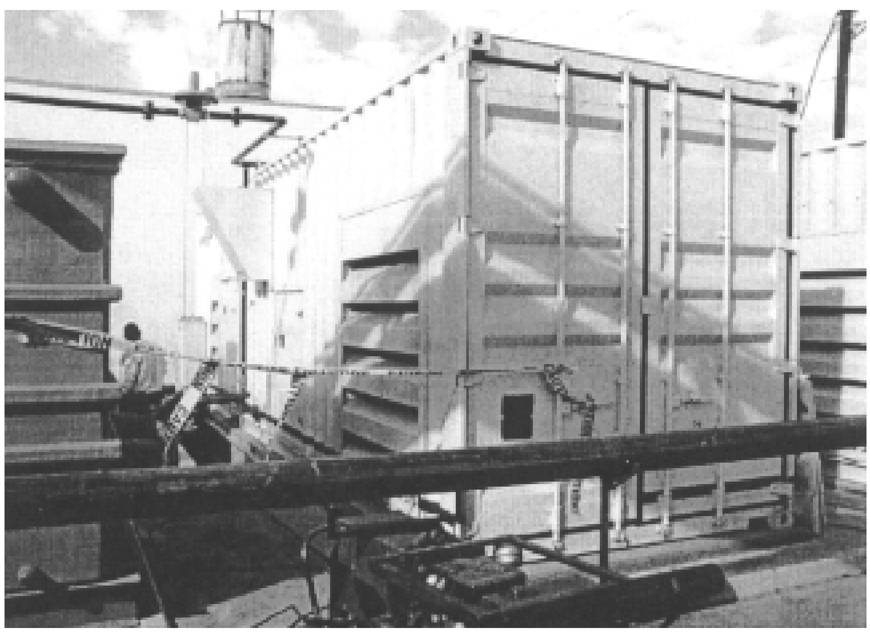

Figure 6. ENI415S Unit #1 Medway Plastics

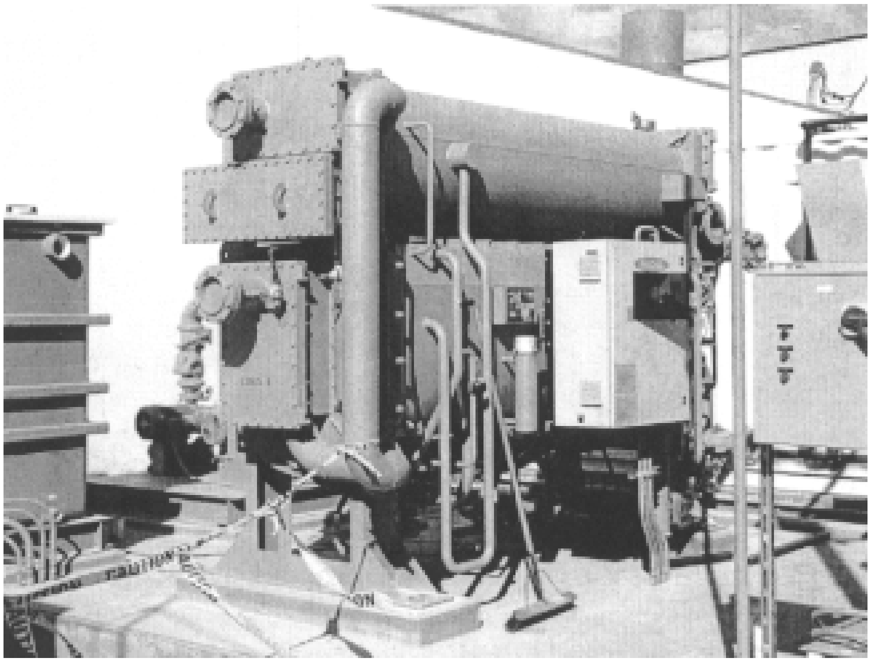

Figure 7. Thermax 150-ton chiller Medway Plastics

vessel), where low pressure condensation takes place, then exiting the vessel through the lower flange to return to the tower. Chilled water connections are located on the back side of the unit.

Figure 8 shows the hot water pump skid for the chiller. As noted earlier, only one of the two pumps is in service at any time, and changeover from one to the other is done manually. Output flow from the pump passes to a three-way valve, where the water is routed either to the chiller, or bypassed back to the plate-and-frame heat exchangers, dependent on inlet temperature.

Figure 9 shows the evaporative cooling tower, which provides the cooling required by the absorption chiller. Condensing water returning from the chiller is routed through tube bundles, over which moist air is passed, extracting energy from the condenser water.

Figure 10 shows the trestle being installed over a service drive adjacent to one of the Medway production facilities. The trestle provides natural gas to the ENI 415 S units, as well as routing electric power and chilled water for use in Medway production operations.

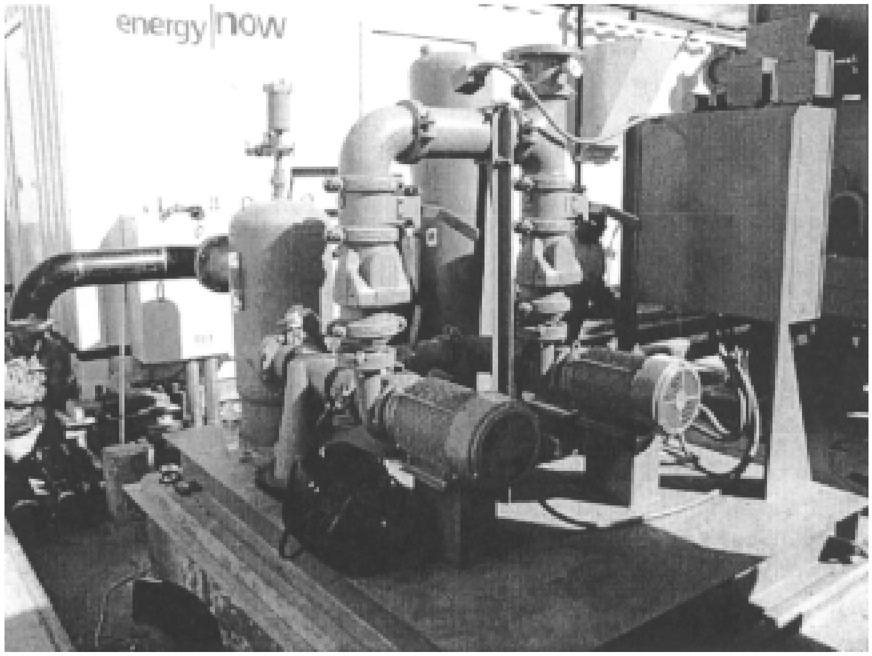

Figure 8. Chiller hot water pump skid Medway Plastics

Figure 11 shows the new transformer installed for this project. This single transformer replaces five units formerly used in servicing Medway. The transformer is Y, 12,000V/480V, rated at 1500 kVA.

CLOSURE

Medway Plastics Corporation has proven itself as an innovative supplier of plastic products. They have also demonstrated keen business sense with the installation of a distributed generation system to ensure continued delivery of electric power for their operations. They serve well as a role model for other industrial and commercial business enterprises who are facing similar problems.

ABOUT THE AUTHOR

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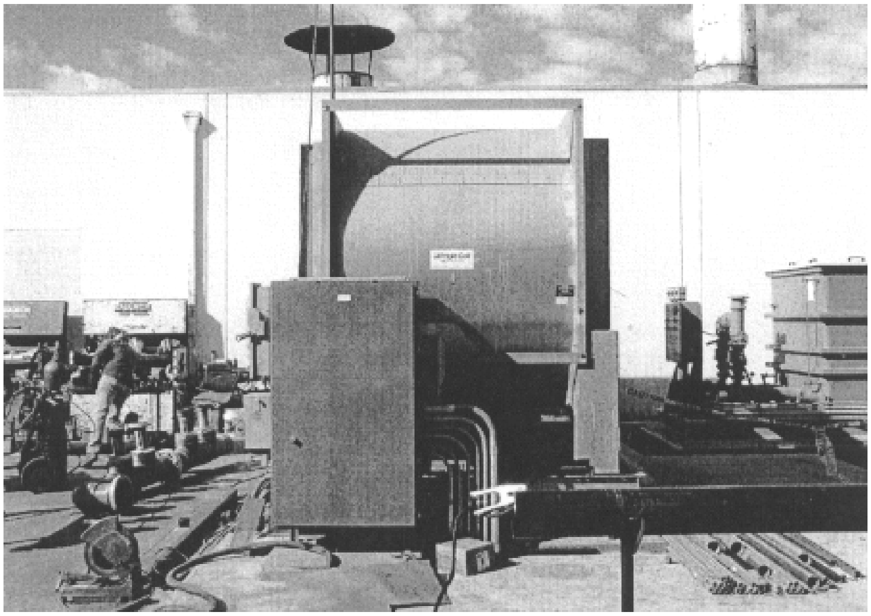

Figure 9. Evaporative cooling tower for chiller Medway Plastics

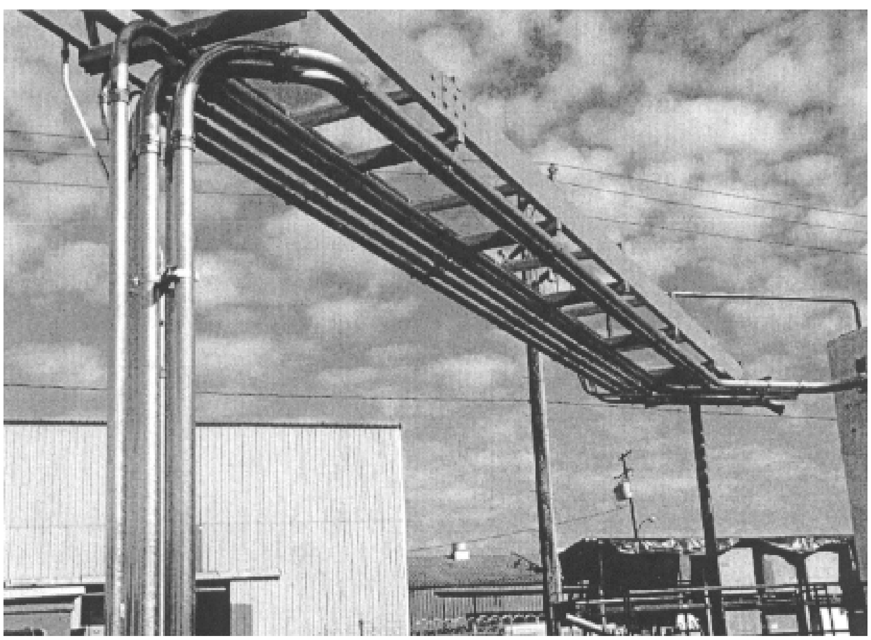

Figure 10. Service trestle Medway Plastics

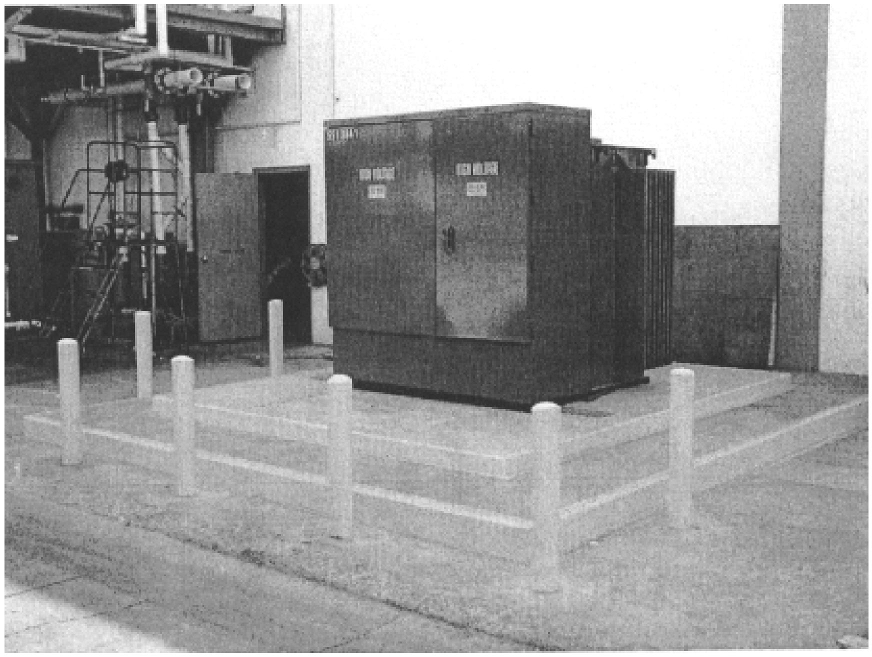

Figure 11. New transformer Medway Plastics