A SHEL LAB® White Paper

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Constant Temperature Lab Equipment and Thermoelectric Technology

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Thermoelectric Incubator solutions to reduce your lab's carbon footprint

Using new technology can improve your testing process while reducing your energy usage

Using Thermoelectric incubators can reduce your overall energy usage while providing excellent incubator performance.

Lab equipment and energy efficiency are often a contradiction in terms and technology. Thermoelectric Incubators from Shel Lab® bring energy saving to the forefront. When you consider reducing energy usage by 75% over traditional compressor based incubators, this product family is a wise choice in today's laboratory environment. The most common method of powering low temperature incubators has been with compressor-based refrigeration incubators.

Aligning with products that utilize new technology to reduce carbon footprint can help transform laboratories to highly efficient operations that excel in energy usage models. Thermoelectric devices offer several benefits beyond the widespread efforts to reduce energy usage by the product itself, but offer substantial savings to building load when it comes to HVAC costs.

Drawbacks of traditional compressor based incubators

For years, the various designs of low temperature incubators have been based on refrigeration compressor technology. These units are commonly in use for BOD and Drosophila test and research facilities. Many companies still use this same high energy use technology. In a review of the how these compressor-based units operate, most are designed for the compressor to run nearly all the time. As the incubator works to maintain a stable temperature near 20°C, the control of the unit requires both the refrigeration compressor and the heat system to work in concert, often with both running at the same time. Simply stated, in a compressor-based unit, the compressor runs constantly with the heater working to override the cooling provided by the compressor, creating energy inefficiency by design.

Problems of laboratory deployment of compressor based units

Often, the additional ambient heat from a compressor-based unit results in adding HVAC cooling to the lab.

When a laboratory configuration specifies one or more of the compressor-based units, additional issues and inefficiencies arise. From a pure energy and power formula standpoint, the energy required by the unit is actually converted or changed into another form. In this case, the electrical energy is converted and transformed into heat. The heat must be dissipated in some fashion. All refrigeration compressor based units dissipate this additional power consumption as heat that is exhausted into the room. This adds to thermal mass and heat loading that the HVAC cooling system must work to overcome. Often, this requires building maintenance to add additional cooling capacity to maintain the ambient conditions in the lab in acceptable and comfortable parameters. Quality lab results are dependent on the stable ambient conditions. Simply stated, the more compressor-based units that are installed in a confined lab space, the more difficult and costly it is to maintain this environment.

Another factor to consider when using compressor-based units is maintenance. While compressors have become more reliable over the years, the compressor is still a high pressure gas filled device. When a leak occurs, maintenance and repair are often costly and will require hiring a certified refrigeration technician. In the thermoelectric incubators, there is no refrigerant or compressor to deal with. The sum of mechanical parts is four reliable fans. Servicing the fans and/or the thermoelectric device requires no special certifications for service personnel.

Shel Lab Solution

The solid state heat pump acts as both the heater and the cooler!

Thermoelectric cooling/heating uses the Peltier effect to essentially create a cooler and a heater. You could say this is a thermoelectric heat pump, actually a solid state heat pump that can transfer heat from one end of the device to the other. If the electricity polarity is reversed, the heat transfer is also reversed. This allows the same device to act as both the heater and the cooler as needed. The sophisticated microprocessor controller senses minute changes in temperature from the desired setpoint to quickly adjust the power required to maintain a stable internal temperature. As the internal temperature nears the set point, the controller adjusts the power to only what is needed to maintain the required setpoint. With the advanced sensing and temperature detection systems, the Shel Lab unit creates a very stable temperature environment that detects and reacts to temperature change as small as 0.01°C. The controller responds and will apply the proportional amount of power needed for this small change.

Additional considerations and improvements are seen in the enclosure design. There are inherent differences in the functional design of the two technologies that result in capacity inefficiencies as well. By optimizing the interior space design, the thermoelectric incubator results in improved temperature uniformity and increased capacity that results in room for more BOD bottles. There are instances were one Shel Lab thermoelectric incubator replaced two compressor-based units based on effective interior space utilization.

Verification and Test Results

Meticulous testing and unit verification demonstrated the energy consumption and savings to be real and applicable in most all laboratory conditions and environments. Testing at Shel Lab for both 6 and 20 cubic foot units demonstrated the difference between the thermoelectric and compressor-based equivalents. Extensive testing, including ambient conditions, have detailed the operational parameters, energy usage, and capacity loading.

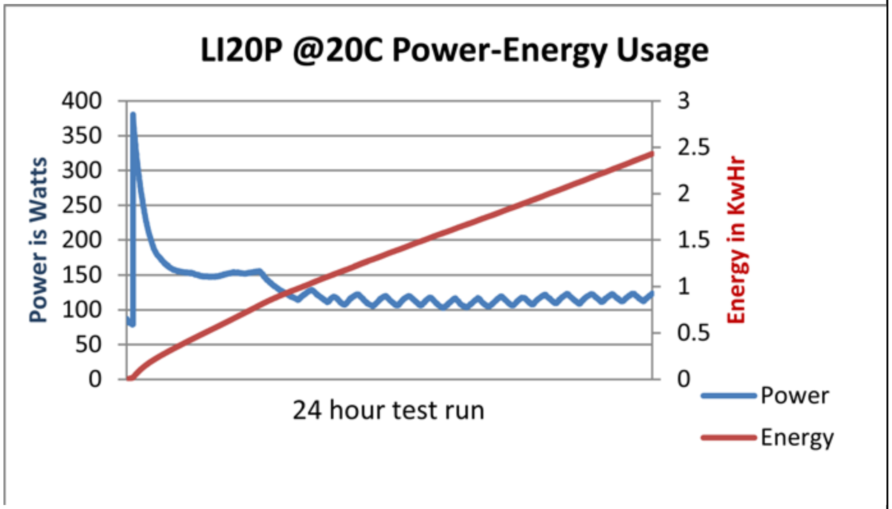
- *20 Cubic Foot Incubator Test*

The incubators used in the study were a VWR model 2020 and a Shel Lab model LI20P. The units were setup in a side by side setting in the test lab at Sheldon Manufacturing. Test lab ambient conditions were identical at 23°C. The units were allowed to stabilize at room temperature. The units were connected to a National Instruments CompactRIO data acquisition system. The test comprised recording the energy used by both incubators from initial startup at ambient temperature cooling to 20°C with continuous recording for a full 24hour period. The results show substantial differences in the total energy consumption as depicted in Figures 1 and 2.

The smart controller throttles back the power to the minimum needed.

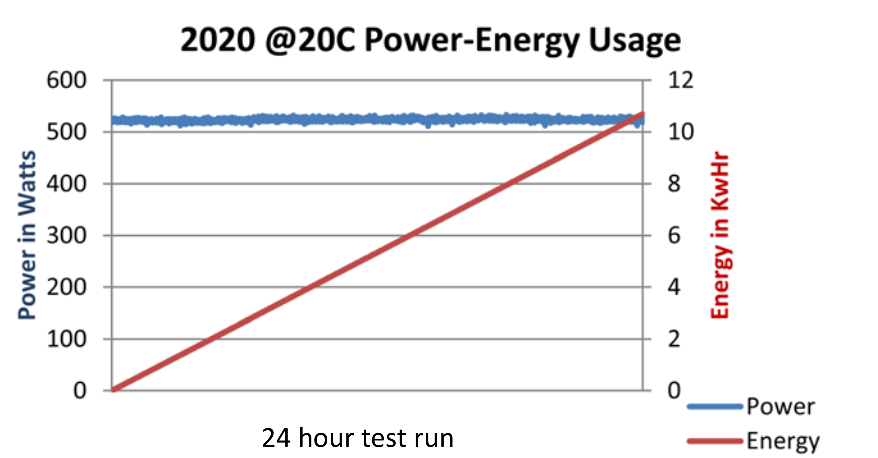
The thermoelectric incubator (figure 1) shows the initial power adjusting to full power to bring the unit to the setpoint of 20°C. In the graph, the blue line indicates the actual power used as a function of time. The red line indicates the cumulative energy used (just like the electricity meter on your house) over the 24 hr period. As the unit approaches set point, the smart controller works to throttle back the power to the thermoelectric device. At set point, the controller applies only enough the power to maintain the 20°C set point. You can see the unit only draws 110-120 Watts, essentially, the same power as one 100 Watt light bulb.

Figure 1: Thermoelectric Incubator Power Usage
Shel Lab Model LI20P



The compressor-based incubator (figure 2) goes to full power almost immediately and shows no appreciable reduction in power (again, the blue line is the actual power usage and red line is cumulative energy used). Even after the unit has achieved set point, the incubator still requires the compressor to run drawing considerable power. This high power usage is a function of the compressor. It is required to continuously operate.

Figure 2: Compressor-based Incubator Power Usage
VWR Model # 2020

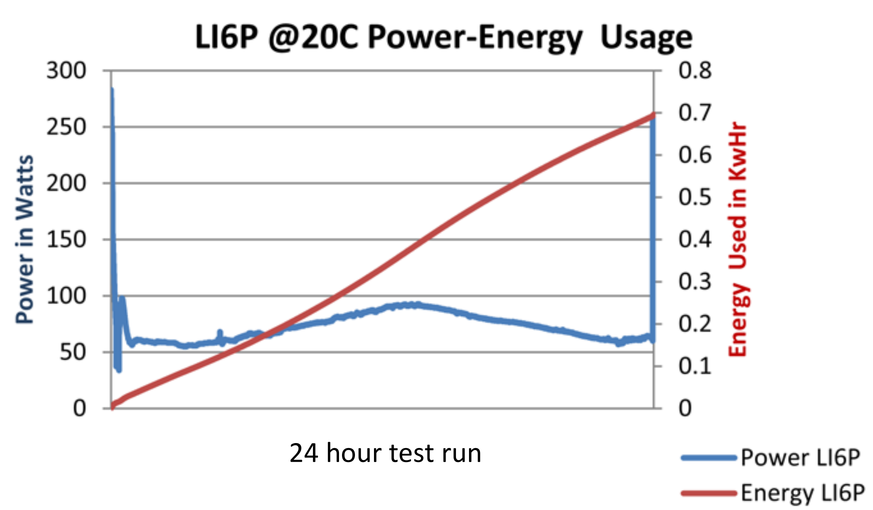


- *6 Cubic Foot Incubator Test*

The incubators used in the study were a VWR model 2005 and a Shel Lab model LI6P. These units are slightly different in capacity as the VWR unit is a 2.4 CuFt capacity while the Shel Lab unit has a 6 CuFt capacity. For the purpose of this the test, the advantage should go to the VWR 2005 as the capacity is half that of the Shel Lab LI6P. The test setup was the same as the large incubators in a side by side setting in the test lab at Sheldon Manufacturing. Test lab ambient conditions were identical at 24°C. The units were allowed to stabilize at room temperature. The units were connected to a National Instruments CompactRIO data acquisition system.

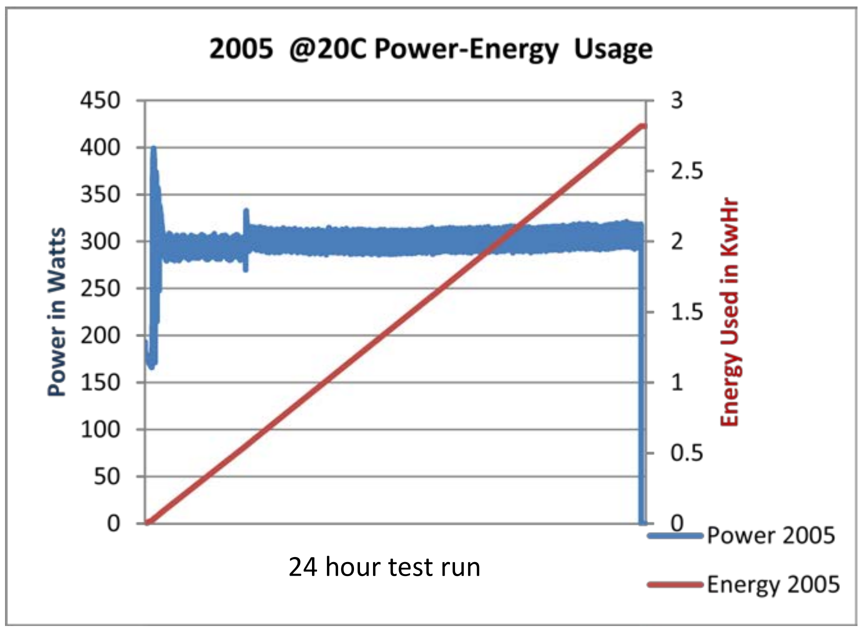
The test results mirrored the large incubators. The operational characteristics are essentially the same as the thermoelectric units and the compressor-based units follow the same electrical design techniques. The smart controller of the thermoelectric incubator again adjusts power to be only what is the needed.

Figure 3: Thermoelectric Small Incubator Power Usage
Shel Lab Model LI6P



The compressor-based incubator shows the same power usage model as the large unit. The power needed settles into a steady state 300 Watts. This remains relatively consistent throughout the test period.

Figure 4: Compressor-based Small Incubator Power Usage
VWR Model 2005



Even with the larger capacity of the 6 CuFt incubator versus the 2.4 CuFt incubator, the energy footprint is substantially less. Again, in this application, the thermoelectric incubator proves to be the more efficient unit.

- *Energy Usage Summary*

The cost of energy varies greatly state by state and even country by country. Whatever your local cost base is, the reduced energy usage still amounts to quantifiable savings in a monetary sense as well as a major reduction in carbon footprint. Table 1 shows details the power usage by unit model for daily and annual usage and the percentage savings that can be obtained when the thermoelectric incubators are deployed.

Table 1: Energy Usage Comparison Summary

Unit	Daily Usage in KwHr	Annual Usage in KwHr	Energy Reduction
LI20P	2.41	879.6	77.24%
2020	10.59	3865.4	NA
LI6P	0.65	237.3	75.38%
2005	2.64	963.6	NA

The benefits of using a Shel Lab thermoelectric incubator

Shel Lab has long been sensitive to efforts to reduce waste, save energy and in general, be eco-friendly. Taking this belief forward into product design that substantially reduces the energy consumption for long-run products is a natural extension of this company value.

1. Substantial reduction in energy usage; 77% less power in the 20 CuFt incubator and 75% less power in the 6 CuFt incubator.
2. Direct reduction in the impact on the building HVAC energy footprint/load by dissipating less heat in the laboratory.
3. Reduced maintenance as many moving parts and high pressure parts have been designed out. This equates to a lowered total cost of ownership.
4. Improved space utilization with the improved interior design yields more BOD bottle capacity.
5. Ability to add affordable battery back-up for continued operation when a power outage occurs. The low overall power requirement means a 2200VA UPS would provide in excess of eight hours of runtime should the main power fail.