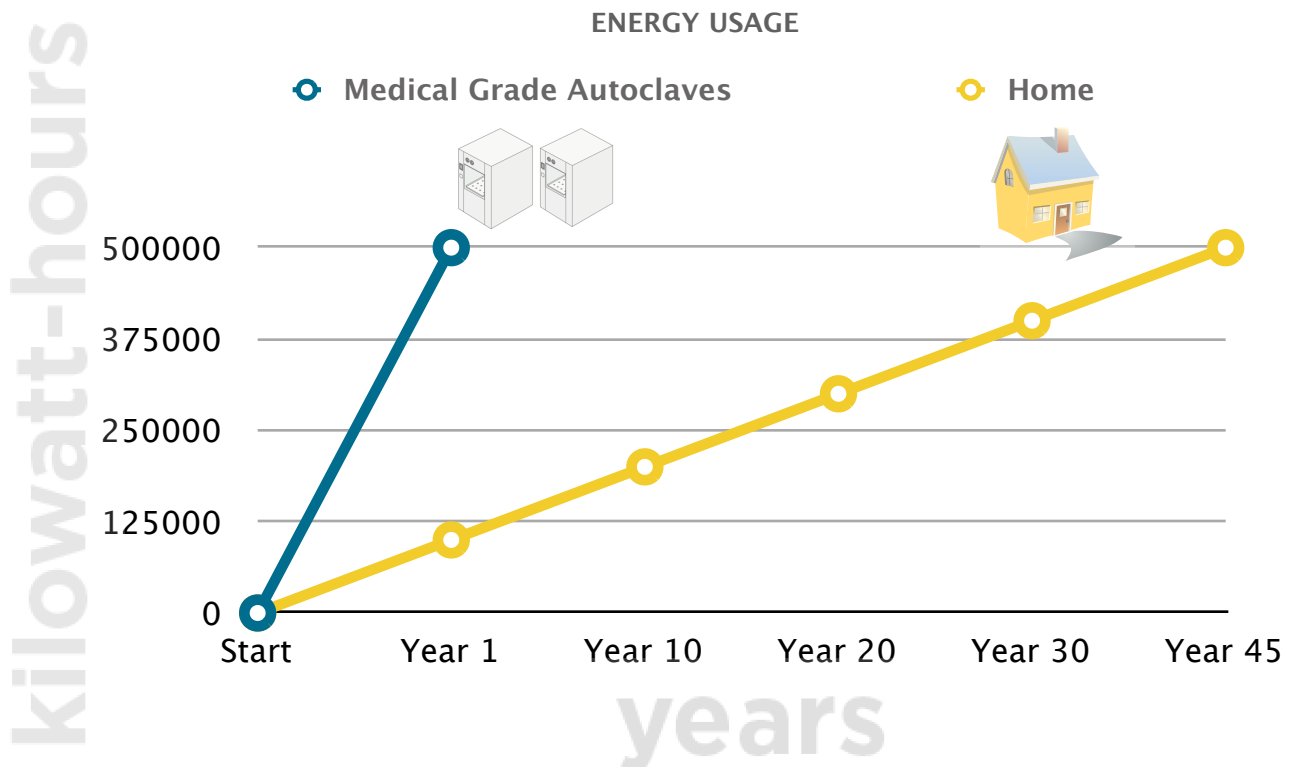




The Thermodynamic Realities Of Medical-Grade Autoclaves

As the cost of energy continues to rise and research budgets grow ever tighter, your lab's autoclave is an excellent place to create savings without compromising on usability or results.

In a 2011 audit, researchers with the British Higher Education for Environmental Performance Improvement (HEEPI) project's S-Lab initiative found that the University of Edinburgh's Cancer Research Centre's pair of large medical-grade autoclaves accounted for 41 percent of that facility's total annual energy usage. That's more than a half-million kWh (kilowatt-hours) used **solely** for steam sterilization of medical instruments, glassware, research materials, and biomedical waste. The average American home would take 45 years to consume that much energy. This extreme example serves as a reminder of how resource-intensive high-volume, high-throughput medical-grade autoclaves can be.

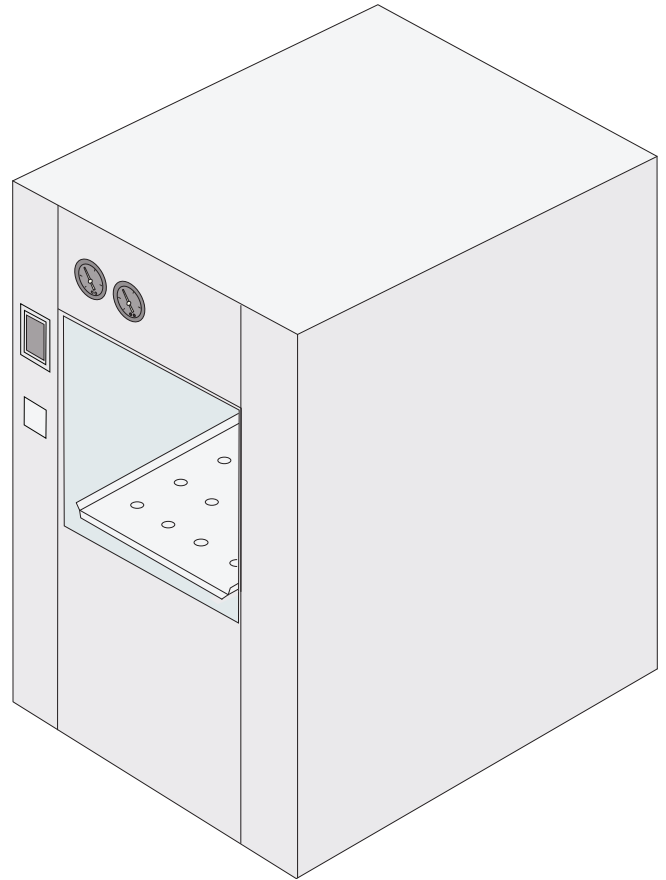


HOSPITAL STERILIZERS IN THE RESEARCH LAB?

In a separate report S-Lab researchers placed autoclaves high on their “Priority List for Sustainable Procurement of Laboratory Equipment,” citing traditional medical-grade autoclaves’ high energy and water consumption. According to their findings, “higher education needs to pay greater attention to sustainability issues when purchasing equipment. This is especially true of energy, where there is already potential for considerable whole life cost savings by choosing more energy efficient models.”

Take a moment to look at your laboratory sterilizer. It's almost certainly warm right now, even if you haven't run a cycle yet today. There's likely a steam generator chugging along next to it, which probably has a full head of steam, even if you aren't planning to run a cycle any time soon. Open the door to your autoclave, and odds are you'll be looking at a rectangular stainless steel box, encapsulated by a hot steam jacket.

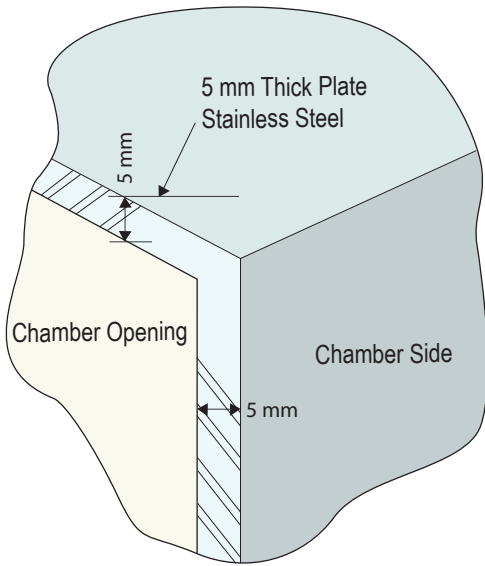
Unless you're in a hospital, this perpetually hot box is almost perfectly ill-suited to your facility.



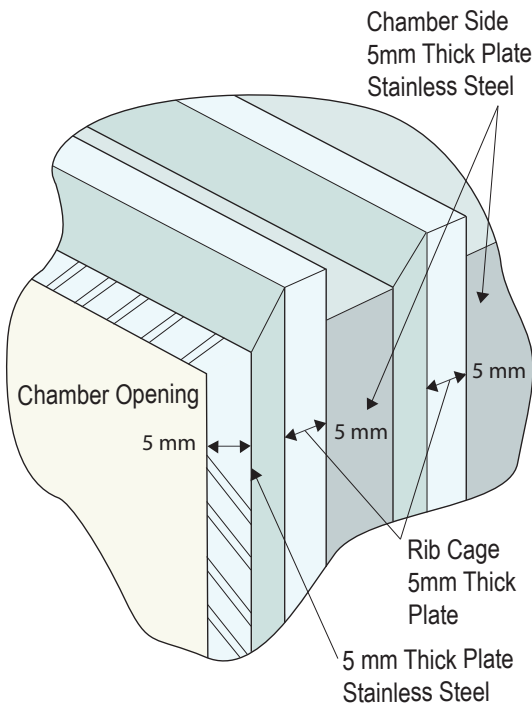
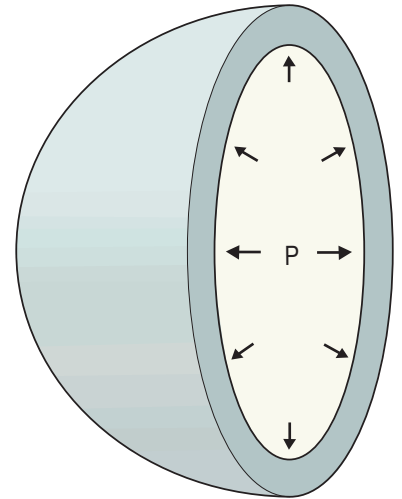
RECTANGULAR PRESSURE VESSELS

The most common autoclave seen in laboratories today is a rectangular medical-grade steam sterilizer. These sterilizers have rectangular pressure vessels because they were designed for the high-volume, high-throughput demands of modern hospital operations, where loads tend to consist of trays of medical instruments, or medical waste bags packed into reusable rectangular loading cassettes. As demand for steam sterilization rose in other industries, manufacturers serving the medical market simply scaled down their existing designs to fit within the tighter confines of research facilities.

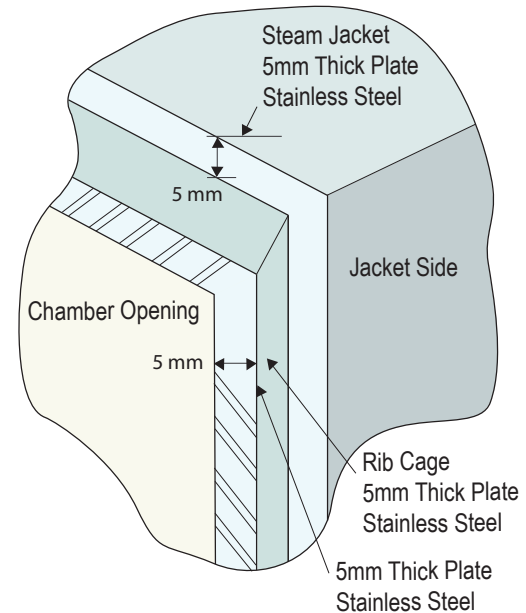
RECTANGULAR PRESSURE VESSELS



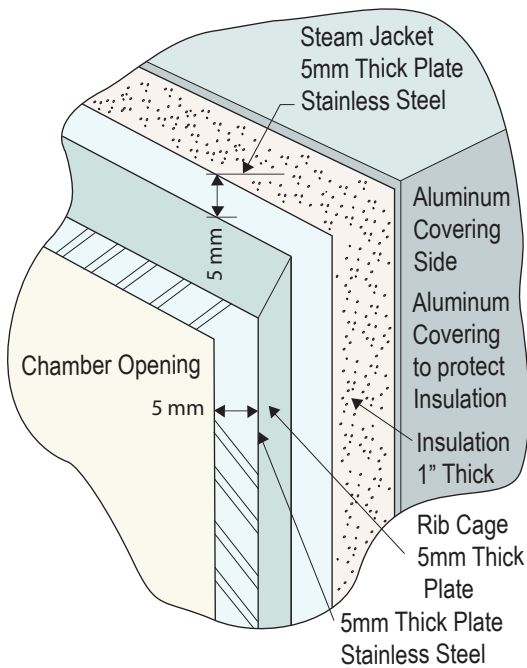
But a rectangular pressure vessel is not a natural fit for steam sterilization. For starters, boxes make poor thermal vessels. This is compounded by the fact that a pressure vessel, by its very nature, wants to be round. During the average sterilization cycle, tremendous forces strain every joint, corner, and seam of the pressure vessel, as the steam works to turn that box into a sphere. In order to resist these forces, a rectangular pressure vessel must be made of a substantial gauge of stainless steel, and then reinforced with an equally impressive rib cage.



The amount of energy required to bring all that steel up to 121°C – the vessel and the rib cage – and hold it there, for any period of time, is enormous. To complicate matters further, in order to provide the high-throughput hospital operations demand, an additional steel box encases the rib cage. By keeping this so-called “steam jacket” hot between cycles, operators can bring the pressure chamber up to sterilizing temperature more quickly.



RECTANGULAR PRESSURE VESSELS



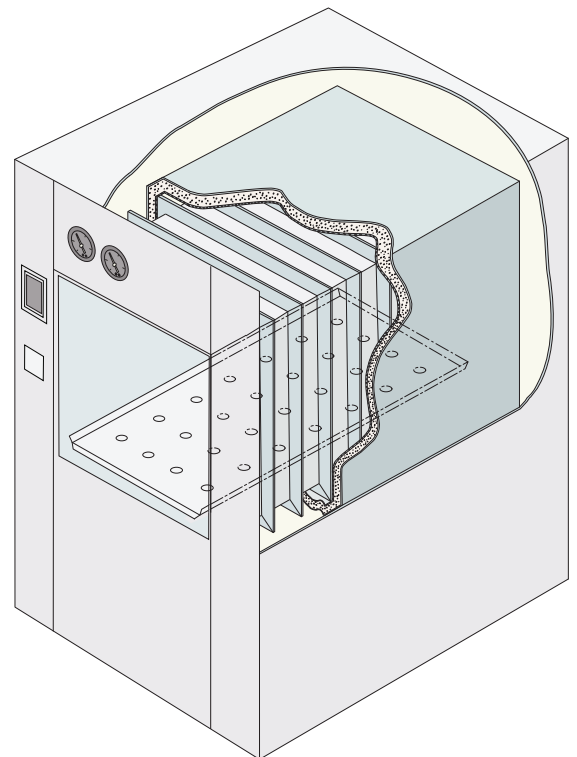
But putting a second cube around the first cube does nothing to address the challenge of keeping such an incredible mass at 121°C. Most manufacturers address this issue by wrapping their double-walled steam box with an insulating blanket.

“Laboratories consume large quantities of energy--often 3 to 4 times more than offices on a square meter basis. . . . While each lab will be different, a general rule of thumb is anything that is heating or cooling, is on 24/7, or has a 3-phase power supply, is likely to be a significant energy consumer.”

While adding insulation does make it easier to reach and maintain sterilization temperature, it also makes this insulated, double-walled steel box difficult to cool. In the high-throughput hospital setting--where there are always more loads to sterilize than there are hours in the day--the solution is to flood the steam jacket with cold water at the end of each cycle.

But flooding a 121°C steel box with cold water creates a series of thermodynamic shocks throughout the pressure vessel--a fact attested by the knocks, clangs, and bangs familiar to anyone who's operated a medical-grade sterilizer.

The end result is a high-volume, high-throughput steam autoclave capable of running cycles back-to-back all day and all night with a minimum of down-time. It's an excellent fit for hospitals, but the design is a recipe for consumption: Even when idle, a rectangular-vessel medical-grade sterilizer constantly consumes countless gallons of fresh water and kilowatt-hours of power.



INDEPENDENT STEAM GENERATORS: THE LITTLE BLACK BOX

Since small rectangular-vessel autoclaves are just scaled-down versions of larger medical-grade units (like those used at the University of Edinburgh), they typically rely on independent generators to provide their steam. These generators are quite an asset in medical facilities, where time is precious, and a reliable central steam supply is not readily available.

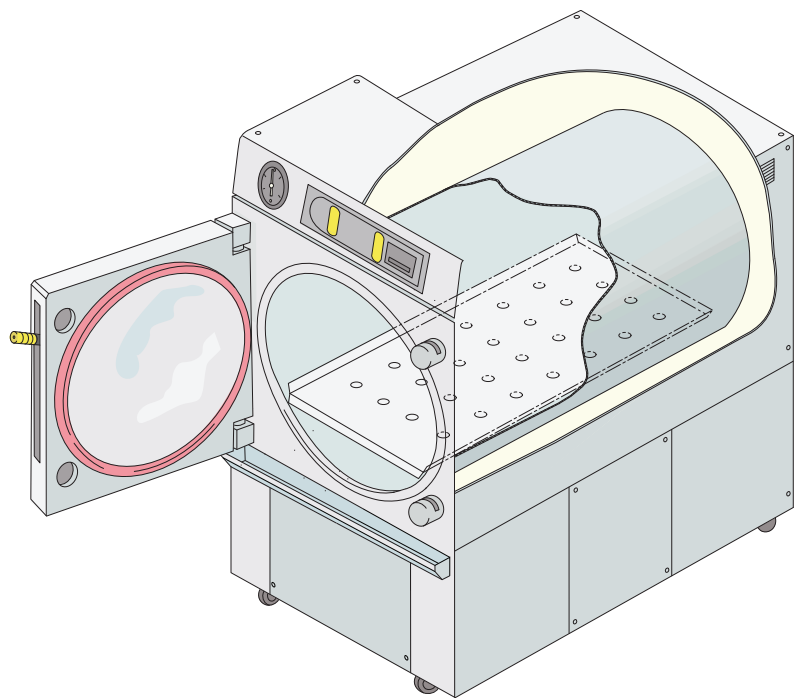
Independent generators can pump out steam at a moment's notice, and keep it coming all day long. But constantly generating steam only makes sense if you're constantly running loads. This is rarely the case in a research facility. The obvious solution for a research lab would be to power down their steam generator each evening. Unfortunately, that's not possible with most units. To prevent damaging the system, manufacturers recommend their generators *only* power down completely for service or maintenance.

Inevitably, these independent steam generators become a lab's inconvenient little black box: Racking up the kilowatt-hours and flushing water down the drain all day and night, regardless of how often they're needed.

RESEARCH-GRADE AUTOCLAVES FOR RESEARCH LABS

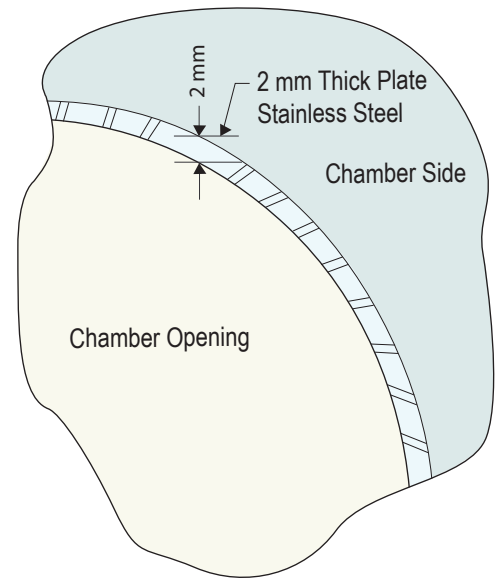
Research labs are not hospitals. High-volume, high-throughput, round-the-clock operations are the exception, not the rule. In most cases, research facilities are running fewer than five sterilization cycles per day.

Cylindrical research-grade autoclaves were designed specifically for research lab use. Due to the more natural shape of a cylindrical pressure vessel, they require neither a reinforcing rib cage nor steam jacket, and have far less mass to heat and to cool. They rely on integrated in-chamber steam generators, which require fewer moving parts, waste little heat, and are designed to be completely powered down when not in use, consuming zero energy. To wit, the steam generators built into cylindrical research-grade autoclaves are rated to draw half the power of the generators bolted on to medical-grade sterilizers.



CYLINDRICAL PRESSURE VESSELS

The key to the efficient design of the research-grade autoclave is its cylindrical pressure vessel. All else being equal, there is a linear relationship between weight and energy consumption: More steel in the pressure vessel means more energy must be consumed to achieve the same results in the same period of time. The major factor in determining how much steel is going into that pressure vessel is its shape and, as a rule, a rectangular vessel contains more than twice as much steel as a functionally similar cylindrical vessel.



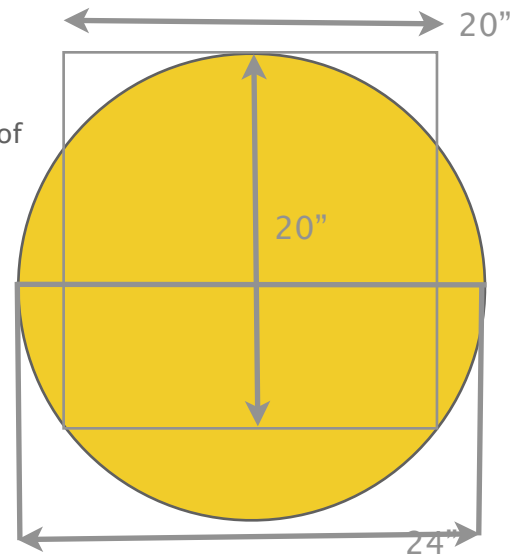
While a cylindrical sterilizer does require 30 percent more volume to provide the same working space as a similar rectangular model, the cylindrical shape of the research-grade unit's pressure vessel makes for a far simpler autoclave overall. Cylindrical chambers easily manage intense pressure, and thus can be manufactured from lighter gauge steel--roughly one-third as thick--with no reinforcing rib cage. Since there's less steel to heat and cool, no insulation or temperature-regulating steam jacket is necessary.

	Chamber Volume	Chamber Dimensions	Ideal Applications
Medical-Grade	250L	20"W x 20"H x 38"D	Trays of Medical Instruments Reusable Rectangular Loading Cassettes
Research-Grade	320L	24"W x 20"H x 40"D	Large Numbers of Small Items Dense Loads Requiring Enhanced Steam Circulation

CYLINDRICAL PRESSURE VESSELS

The additional volume and curved inner wall of the cylindrical vessel results in better steam circulation throughout the chamber. Instead of flooding an insulated steam jacket with cold water at the end of the cycle, research-grade autoclaves can use low maintenance fans to blow cold air directly over the chamber. This silent process speaks volumes to the longevity of light-weight cylindrical pressure vessels, which are not subjected to the dramatic thermodynamic forces that make steam-jacketed autoclaves knock and clatter.

Because of their design, rectangular autoclaves will invariably be heavier and use at least twice as much energy as their cylindrical peers. While this trade-off may be worthwhile in a hospital setting, it can prove tremendously wasteful in the lab.



It's as simple and irrefutable as any law of physics: A lighter chamber is more efficient, heats faster, and consumes far less energy in the process. For similar sterilizing cycles with similarly sized chambers, a cylindrical research-grade autoclave will always outperform its rectangular medical-grade counterpart.

Medical vs. Research Grade Steam Sterilizers	
Medical-Grade	Research-Grade
Rectangular vessel	Cylindrical vessel
Heavy rib-reinforced insulated steam jacket	Single wall construction
“High-throughput” – designed for 24/7 hospital use, over a dozen cycles per day	“Light duty” – less than five cycles per day
24/7 Independent steam generator	On-demand in-chamber steam generator
Constant maintenance expense	Maintenance only relative to usage
250 liter working capacity	320 liter volume, 250 liter effective capacity

SOURCES

S-Lab (Safe, Successful and Sustainable Laboratories) initiative of HEEPI (Higher Education for Environmental Performance Improvement). [Saving Money Through Sustainable Procurement of Laboratory Equipment](#). March 25, 2011. Lisa Hopkinson and Peter James.

S-Lab (Safe, Successful and Sustainable Laboratories) initiative of HEEPI (Higher Education for Environmental Performance Improvement). [Energy Consumption of University Laboratories: Detailed Results from S-Lab Audits](#). July, 2011. Lisa Hopkinson, Peter James, Nigel Lenegan, Tom McGrath, and Malcolm Tait.