ThermOmegaTech®

THERMAL ACTUATOR TECHNOLOGY

A VERSATILE AND PRECISE SOLUTION TO AEROSPACE & DEFENSE THERMAL CONTROL CHALLENGES

In Aerospace & Defense applications, ineffective operation of critical temperature control systems can result in component degradation and system failure – ultimately leading to the loss of time, money, and in extreme circumstances, even lives.

Designers continuously look for ways to improve reliability and precision to keep their thermal management operating at peak performance. Thermostatic technology has become increasingly prevalent in these applications due to its ability to function without a power source, compact size, and low SWaP.

Thermostatic valves and actuators utilize paraffin wax phase-change technology to convert temperature change into a mechanical force to push/pull, open/close or move a load. The temperature at which this wax changes phase is so repeatable and reliable that to this day, the ASTM utilizes this wax to calibrate temperature instrumentation. The versatility of thermal actuator technology has led to its implementation in many unique projects used for Avionics, Space, and Defense applications.

ThermOmegaTech's thermostatic valves and actuators have been implemented into a variety of applications – including electronics cooling for high-performance aircraft and hydraulic oil cooling for ground-based military equipment - where accurate temperature control was critical to successful execution and is a trusted supplier for high-stakes designs.

Our thermal fluid control products combine a simplistic design and reliable performance, making them the ideal solution for particularly remote, unique, and extreme design challenges.

PRECISION

At ThermOmegaTech, each of our thermostatically actuated valves is powered by our proprietary Thermoloid® paraffin wax actuator, which is precisely blended to produce a controlled volume change and usable stroke in response to a narrow range of temperature variations. The actuators utilize paraffin wax blends with varying melting points ranging from 20°F to 270°F (-6.6°C to 132.2°C).

When the thermal wax actuator is in its "cold position," the Thermoloid® wax blend is solid, and the piston is retracted. Once the temperature increases to within the valve's pre-set active range, the wax changes into its liquid phase, undergoing thermal expansion and increasing volume. This expansion extends the piston, producing usable stroke and positioning the actuator into its "hot position."

The piston can then act upon a valve stem, lever, or any other mechanical device requiring this type of movement, establishing or curtailing flow as needed to maintain stable temperatures in a heating or cooling system.

The transition between the "cold" and "hot" positions is gradual, with the valve constantly modulating slightly more open or closed to accommodate ongoing temperature changes. This modulation enables a quicker response time when compared to a "snap" design, which is either fully open or fully closed.

Pressure changes also do not affect the actuator's ability to phase change, making them ideal for applications in hazardous environments.

ACCURACY

Thermal actuators convert changes in temperature into a mechanical motion which causes the wax to change its phase over a narrow and customizable temperature range, typically within 10°F to 15°F (-12.2°C to -9.4°C). At ThermOmegaTech, our thermostatic valves will be fully open 5°F to 8°F (-15°C to -13.3°C) above the thermal actuators' set-point in heating applications and fully closed 5°F to 8°F (-15°C to -13.3°C) below the set-point in cooling applications.

Our actuators monitor and respond to temperature variations for many fluids – water, air, oils, glycol, steam, and more, sensing ambient, surface, or fluid temperatures depending on the system's design. The wax's response is specific to the medium it is designed to sense and a repeatable action, even in extreme conditions.

In early 2020, a thermostatic valve installed in a water-sensing system was tested in an environmental chamber simulating extreme cold and moderate wind to see if exposure to external conditions could trigger a valve activation.

Figure 1. *GURU® DL 2.1 Low Temp Test Set Up*

Figure 2. *Environmental Chamber Settings*

After two hours and repeated tests, it was found that external conditions did not trigger a "nuisance" dump. The valve maintained sensing the intended water temperature inside the system.

Coolant Inlet Temp (°F)	Coolant Outlet Temp (°F)	Tenney Chamber Temp (°F)	Chamber Wind Velocity (MPH)	Coolant Flow Rate (GPM)	Result
55	55	-60	3	3	Closed
55	55	-60	3	0	Open

Table 1. *GURU® DL 2.1 Low Temp Test Results*

Maintaining temperatures within a narrow optimal range is a delicate balance for critical systems. Coolant can become viscous if fluid levels are too cool, damaging essential components over time and reducing thermal relief efficiency; too hot, the system will overheat, causing additional operation issues. Keeping the temperature of these systems maintained using the ThermOmegaTech thermal bypass valve (TBV) ensures optimal operation and extends component and system life.

When the fluid temperature is above the TBV valve's set-point, the valve automatically directs fluid to the heat exchanger. If it is below the set-point, the fluid is directed back through the system, ensuring the temperature is maintained in a narrow and pre-defined range.

Due to the non-compressible nature of the thermostatic wax, the valve's actuation motion produces a significant amount of force. This force can be used in various applications that require a considerable load to be moved with each activation or in high-pressure environments such as deep-sea or outer space. Force generated by an actuator varies depending on the actuator's overall size and design; however, ThermOmegaTech has seen specific actuator designs move up to 800 lbs. (362.9 kgs.) of weight.

LONG-LASTING

Considerations must be made for prolonged service life for equipment sent into the upper atmosphere and beyond the stars. Most of these systems are intended to stay in the atmosphere for extended periods, such as satellites, the International Space Station, or the Mars Rover; therefore, they must be designed with a long service life in mind.

Thermostatic valves on long-range space vehicles should include high-quality parts with extensive cycle tests to withstand many modulations and constant operation over years or even decades.

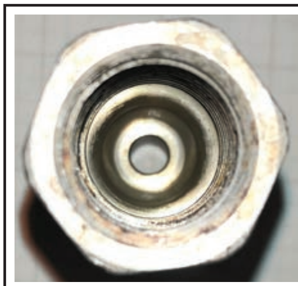
ThermOmegaTech has been conducting an ongoing test since January 2013 at our headquarters in Warminster, PA, to determine the possible effects of corrosive conditions on their thermostatic valve's operations. The test monitors a valve installed in hard water, with a total hardness reported as 229 mg/L and verified by a third-party testing laboratory.

Below is a typical description of hardness level as defined by the U.S. Department of Interior and Water Quality Association and conforms to widely accepted guidelines on water hardness:

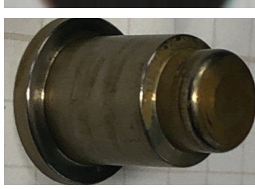
Classification	***mg/L***	***gpg***
Soft	0 - 17	0 – 1
Slightly Hard	17 - 60	1 – 3.5
Moderately Hard	60 - 120	3.5 – 7.0
Hard	120 - 180	7.0 – 10.5
Very Hard	> 180	> 10.5
The hardness concentrations shown above are in terms of mg/L or gpg as $CaCO_3$		

The last inspection was in March of 2022. There were no visible signs of mineral deposits, wear, or fatigue in the installation. The valve continued to cycle normally after an estimated 173,600 modulations.

The following photographs show a sample of a CircuitSolver® removed from the last inspection.




CircuitSolver® from the in-house test after over 9 years of installation. Unit disassembled and photographed. The two pictures on the left show CircuitSolver® as it was removed from the set-up. The pictures below show the components disassembled from the CircuitSolver®.


These thermostatic valves have a high thrust design to force out any mineral buildup in their path as they modulate, allowing them to withstand harsh conditions for a long time.

In addition, for eventual human-crewed long-haul space voyages, vital components should be designed to be easily swapped out with a spare, without having to dissect and disassemble the entire system in which it resides.

Since thermostatic valves are entirely self-powered – the “wax motor” at the heart of each valve uses temperature variations to do the heavy lifting for thermal regulation. There is no need for an external transducer power source, and the valve will continue to operate as designed during a temporary or extended power outage.

The simplicity of these valves allows for a lightweight and compact design with minimal external components that could break and need to be replaced – a significant challenge in extreme conditions such as space. Since power is not required, thermostatic valves also make ideal solutions for applications in explosion-proof environments, such as purposefully oxygen-rich environments.

While not all thermostatic valves feature an easily replaceable actuator, valves with a cartridge-style design can easily be switched out with an on-hand spare, minimizing maintenance difficulties.

Precise, compact, and reliable thermostatic valves are the preferred temperature control solution trusted in delicate Aerospace & Defense applications.

CUSTOMIZABLE

Thermostatic wax actuator technology is incredibly flexible. Its parameters are able to be molded to fit unique temperature control projects and individual visions. ThermOmegaTech’s thermostatic actuators have been used in applications with operating temperatures from 20°F to 270°F (-6.6°C to 132.2°C). However, temperature ranges can be extended for unique applications by creating a custom blend wax.

Wax actuator blends can also be modified to produce different force ratios with a recorded lift of up to 800 lbs. (362.9 kgs.) of weight in low-cycle count scenarios.

Cartridges or actuators can also be modified to integrate into custom valve bodies or a pre-existing/custom manifold. Accommodations can be made to size, spring strength, weight ratios, temperature ranges, and more to satisfy projects’ needs.

A few applications where ThermOmegaTech’s temperature actuated valve technology has been implemented into custom designs include thermal bypass control in fuel or oil cooler assemblies for military planes, thermostatic control for heat exchangers in army tanks, airflow control on unmanned aerial vehicles (UAV), temperature control in navy radar systems, and linear heater actuator release of buoys.

IN SUMMARY

For Aerospace & Defense applications where mission-critical systems rely on delicate and precise thermal control, thermostatic actuator technology ensures optimal operation.

With precise temperature monitoring capabilities and a modulating response to gradual thermal variations, thermostatically controlled valves eliminate large swings in temperature while facilitating an inclusive design that minimizes the risk of component failure and nullifies the risks if electricity is lost.

For a long-lasting and reliable thermal control solution that can be molded to fit into just about any temperature regulation system, thermostatic technology will take you far.