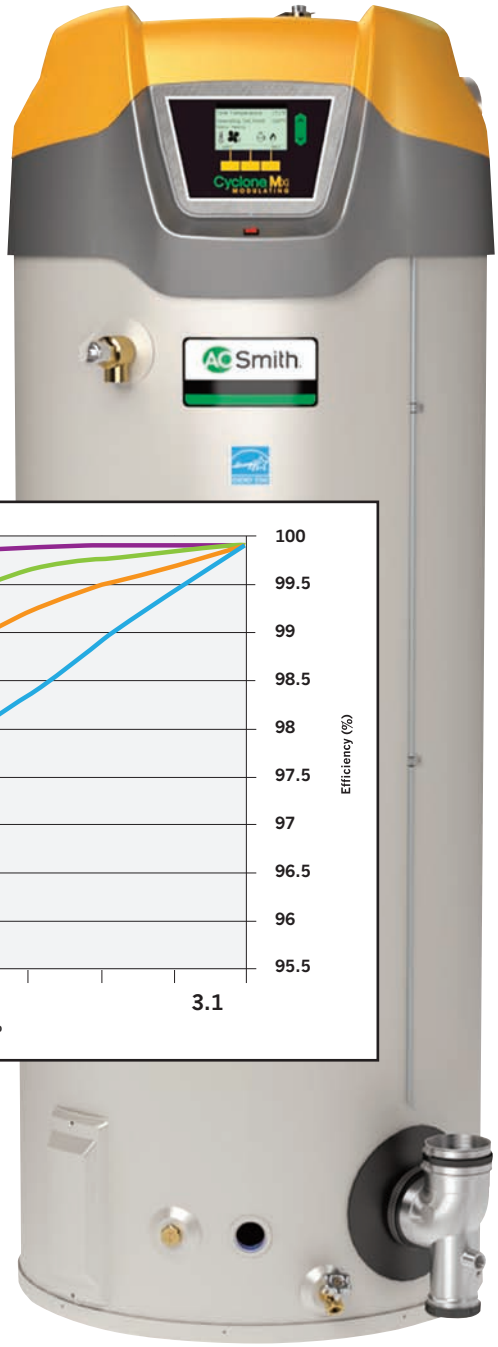
Cyclone® Mxi Modulating High Efficiency



Modulation Benefits with Cyclone Tank Type Water Heaters

Modulating combustion has become more prevalent with the market increase in condensing boiler and tankless water heater model offerings. These hydronic heating and on-demand products benefit from full modulation as they require precise temperature control to meet the space and water heating flow demands.

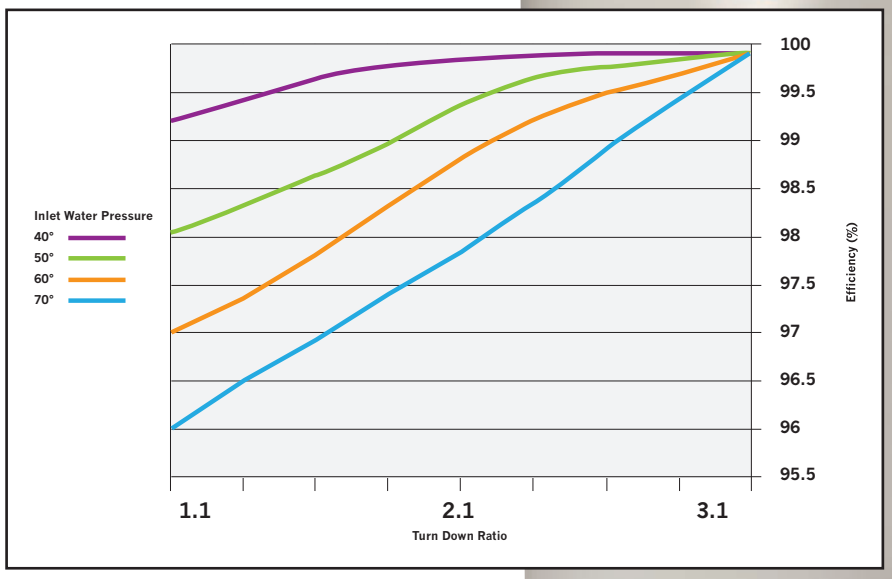


Figure 1

The modulation benefits with tankless and boiler products have been marketed for years and are more intuitive than tank type water heaters. However, tank type water heaters can realize significant benefits as well. With the Cyclone design there are two primary benefits related to modulating the firing rates.

One primary benefit is the efficiency gain achieved when the unit is operating in the modulating mode and firing at lower than full fire inputs. Modulating to these lower inputs increases the amount of time combustion gases are in contact with the helical coil heat exchanger resulting in higher thermal efficiencies. The efficiency gains can be significant (***see Figure 1***) and result in additional fuel saving that add up quickly. In addition, these higher efficiency rates reduce the exhaust vent temperatures and lower overall operating sound when the blower runs at reduced RPM's.

Another key benefit to modulation in the Cyclone design is the impact of the lower fire rates and reduced cycles on the longevity of the tank. Conventional on/off commercial tank type water heaters are fired at full input rate anytime a call for heat is initiated. Since tank type water heaters are sized to meet peak demand and dump load conditions there are many draw rate scenarios where full firing rates can result in shorter cycles. Short cycles can, over time, have a negative impact on the service life of the water heater.

Cyclone Mxi Turndown Rates

Unlike boilers and tankless designs that benefit from large turndown ratios (5:1, 10:1, 20:1, etc.) the Cyclone tank type water heater achieves top performance and benefits at lower ratios. Each model within the Cyclone family of products has been engineered to achieve the highest efficiency possible at the minimum firing rate. From the chart below you can see efficiencies of 99.9% are achieved at different inlet water temperatures. There are no additional benefits to firing the Mxi at lower rates and the turndown ratios listed below (***Figure 2***) detail the modulation range optimized by model.

Modulation Rates and Turndown Detail			
Model Size	Maximum Input	Minimum Input	Turndown
120	120,000	78,000	2:1 (1.54:1)
150	150,000	78,000	2:1 (1.92:1)
199	199,000	78,000	3:1 (2.55:1)
250	250,000	78,000	3:1 (3.21:1)
300	300,000	195,000	2:1 (1.54:1)
400	399,900	195,000	2:1 (2.05:1)
500	499,900	195,000	3:1 (2.56:1)

Figure 2

Cyclone Mxi Modulating Algorithm

The A. O. Smith developed control board utilizes a **PID (Proportional Integral Derivative)** algorithm to optimize the performance and hot water delivery. The calculations involving the PID parameters determine how much and when the unit modulates.

The **Proportional** band adjusts the input based on the tank temperature distance from the set point. The unit will operate at full fire anytime the tank is at a given number of degrees or more from the set point and operate at its minimum firing rate as it reaches set point.

The **Integral** band looks at the amount of time the water heater has been below the set point and how fast it is recovering at the current modulating firing rate. For example, a longer period of time below the set point would result in an increase in input and conversely a shorter period of time approaching the set point would result in a decrease in input. To avoid excess condensation accumulating in the heat exchanger any cycle of 8 continuous minutes will result in the control accelerating the unit to full fire for 45 seconds.

The **Derivative** parameter looks at the rate of change in the tank and works to anticipate and predict future demands. This logic helps anticipate when the unit will need to quickly ramp up to full fire to meet peak load demands. The feature helps prevent the water heater from lagging behind when full output is needed.

The control used in the Cyclone Mxi has been designed to optimize efficiency, performance and tank longevity. Unneeded complexity related to higher turndown ratios were avoided as they offer no real benefit in this particular tank type design.