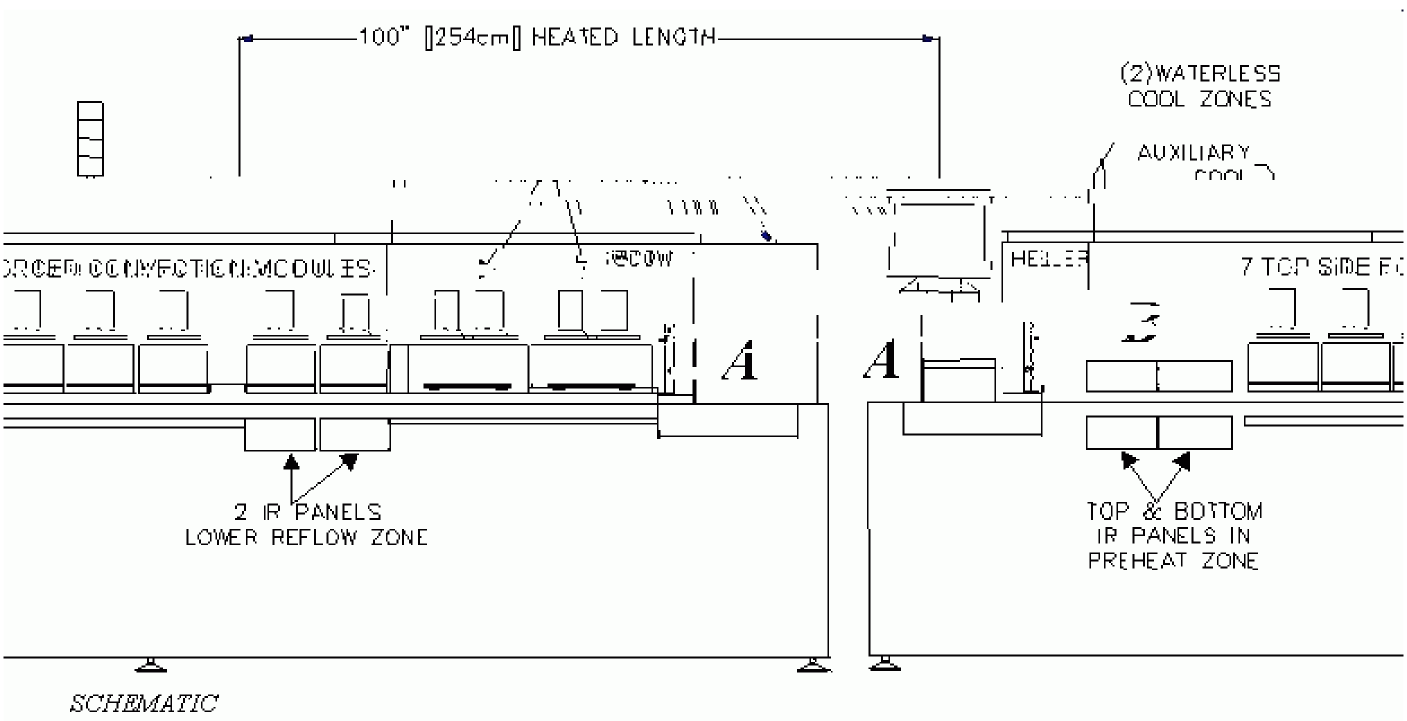
**White Paper: Ultra Low II**

*This paper describes the new, second generation Ultralow II, a low nitrogen consumption reflow oven to be introduced by Heller Industries, Inc. in 1999.*

The Ultralow II machine incorporates many technical innovations developed by Heller Industries to reduce the consumption of nitrogen gas in its solder reflow ovens. The cost of nitrogen gas can be a significant fraction of the total cost of operating a reflow oven. This is especially true in regions such as Asia, where liquid nitrogen is very expensive. The Ultralow design reduces nitrogen costs by 40-60% or over $10,000 per year without sacrificing the excellent thermal performance of traditional Heller forced convection ovens. The primary method for reducing nitrogen consumption is to reduce turbulence at the entrance and exit of the oven. This is accomplished with reduced tunnel opening area and with selective use of heating panels that heat without creating gas turbulence.




The following is a technical discussion of features incorporated into the new Ultralow II system.

Special entrance and exit tunnels are designed to minimize the opening and exit of the oven *(A)*. These openings adjust automatically for board width and can be enlarged vertically to allow for the passage of a Mole or KIC profiling device. The reason for the reduced opening size is as follows. Air, and therefore oxygen, are prevented from entering the reflow oven by a stream of nitrogen gas flowing out of the entrance and exit of the oven. For a given set of conditions within the oven, and over a reasonable range, the greater the velocity of gas exiting the oven, the lower the probability that air will be drawn into the oven against the current of escaping nitrogen. The velocity of the exiting nitrogen is governed by the simple relationship:

$$M=VxAxD$$

where M= mass flow, V= gas velocity, A= the area the gas flows through, and D =gas density.

Assume, for a given condition within the oven, that the temperature of the exit gas and, therefore its density are constant. In order to raise the gas velocity to a level sufficient to prevent oxygen flow upstream one can either decrease open area A or increase mass flow M. Since the goal is to minimize mass flow for a given concentration of oxygen inside the oven, the optimal course is to reduce open area. The prototype Ultralow II shown at Nepcon '99 has a standard clearance of .5" or 13mm above and below the edgehold pin and a maximum board width of 12.2"or 310mm *(PHOTO 1)*.

*PHOTO 1*

This clearance and maximum board width support a vast majority of commercial applications such as PC motherboards, peripherals and cell phones. Greater clearance and/or maximum width are readily available for special applications.

The edge hold conveyor rail has also been modified for the Ultralow II model to reduce the oven opening height and area *(PHOTO 2)*.

*PHOTO 2*

Instead of returning the edge hold chain along the rail, the chain is returned through the belly of the oven. This allows for a lower profile rail and a reduced opening area. In addition, the standard Ultralow II does not incorporate a mesh belt with the edgehold conveyor in order to reduce opening size. The mesh belt can be added back at customer request, but with an increase in gas consumption of approximately 20%. Similarly, a center board support can be fitted into the oven with some increase in gas consumption.

For a given gas mass flow and velocity exiting the openings of the oven, the lower the flow turbulence, the lower the probability of air and oxygen flowing upstream and into the oven. Forced convection heating modules create turbulence when the hot gas streams exiting the module impact the circuit board and are then sucked back up into the heater module. This turbulence tends to draw air into the oven if the heating zone is close to either the entrance or exit of the oven. The Ultralow II design utilizes a panel heater in the first preheat zone(s) in order to allow room for the turbulence caused by subsequent forced convection zones to dissipate as the gas flows out of the oven (PHOTO 3).

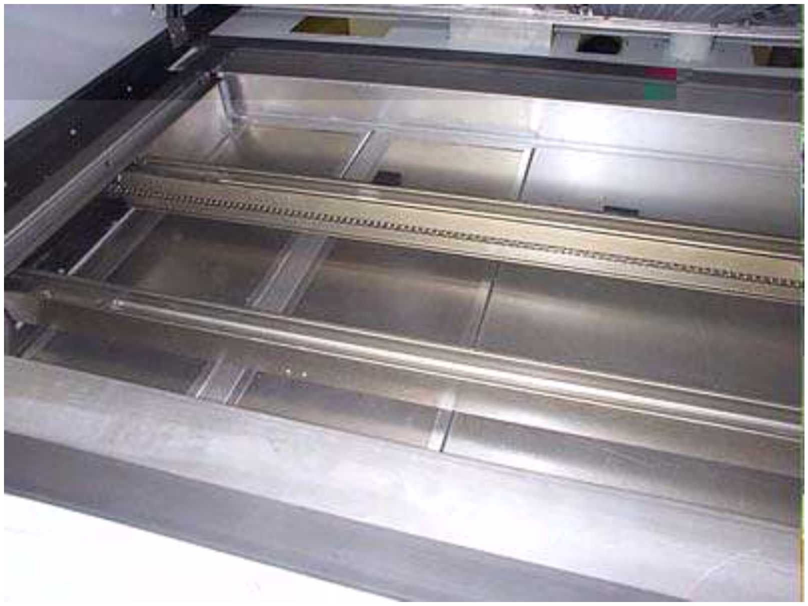
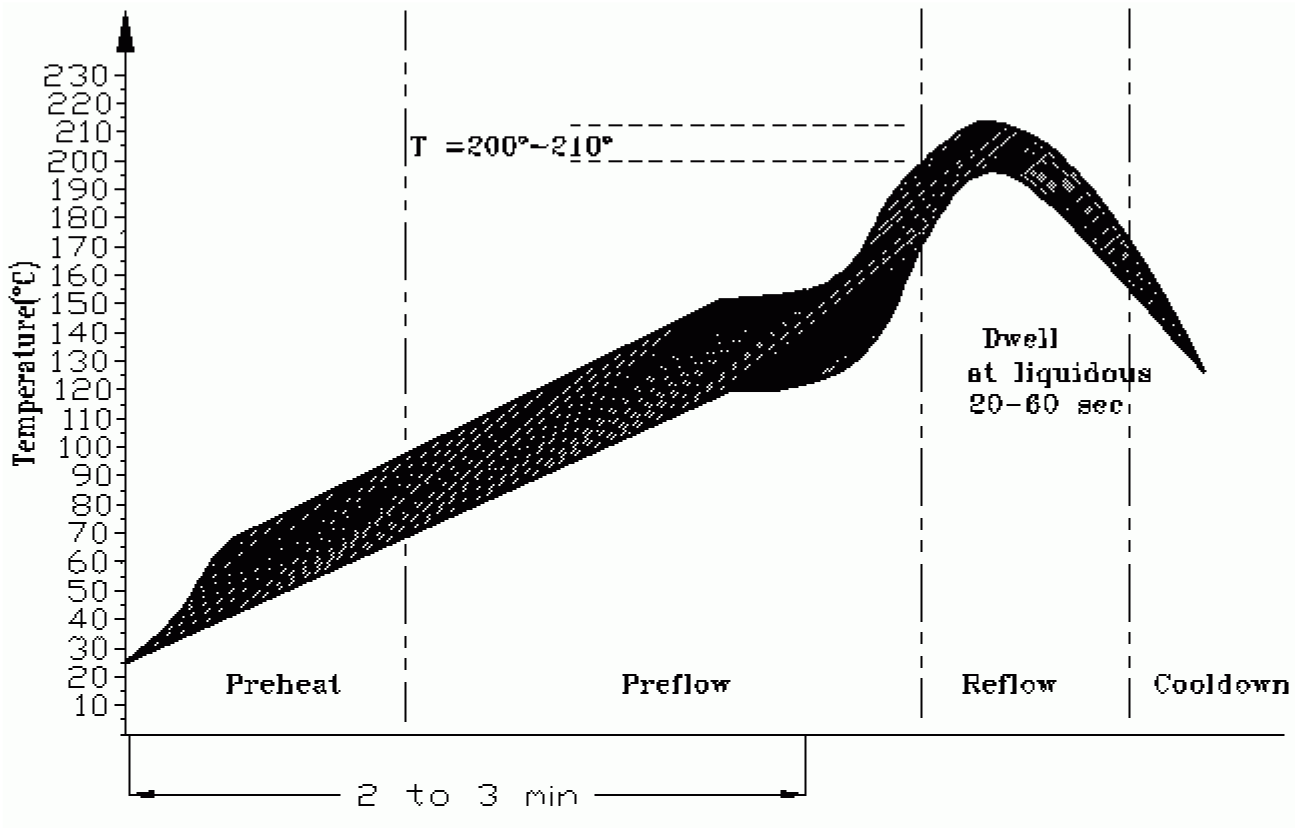


*PHOTO 3*

The exiting gas flow is more laminar, with fewer vortices that can transport oxygen from the outside into the oven.

A concern might be that a panel heater in preheat would not heat the circuit board as uniformly as a forced convection zone. This is not a practical problem because any excess temperature difference between large and small components generated in preheat will be eliminated after the board has passed through subsequent forced convection zones in ramp-up and reflow. In addition, most customers now run "Tent" profiles that require a very gentle ramp in preheat *(GRAPH 1)*.




*GRAPH I*

Since there is relatively little heating in preheat, only modest temperature differences will be generated regardless of heat source.

Slowing the gas flow within each heating module also reduces gas turbulence. The tradeoff of lower gas speed is reduced heat transfer rates to the circuit board. Manual or computer controlled blower flow control is an available option for the Ultralow II and is helpful in applications where thermal demands are modest and full blower speed is unnecessary. Circuit boards with low, uniform thermal mass such as cell phones and pcmcia cards can be run with very low thermal gradients at reduced blower speeds. PC mother boards with large BGA devices can also be run successfully with reduced blower speeds in ramp-up and cooling modules and full blower speed in reflow modules.

A final feature designed to reduce nitrogen consumption is the elimination of bottom side forced convection modules in ramp up and the substitution of panel heaters for bottom side forced convection modules in reflow. Most circuit boards with moderate thermal mass such as cell phones, PC mother boards and peripherals can be profiled successfully without bottom side forced convection. High thermal mass boards such as back planes and mainframe motherboards would benefit from bottom side forced convection modules. These modules are an available option for the Ultralow II model and would cause a modest increase in gas consumption.

The Heller Ultralow II inert atmosphere reflow oven delivers unsurpassed nitrogen economy without sacrificing excellent heat transfer characteristics. Please consult Heller applications