

## Time-of-Fall

Reprint 140

### Time of Fall Tells It All

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Producing good solder joints on today's complex PC boards requires the precise control of solder flux density, the most critical parameter in wave soldering. Unfortunately, it is difficult to maintain the flux at a specified density with the majority of measuring devices available.

Flux density is measured and/or controlled with any of these instruments: hand-held hydrometers, density meters, density controllers, flow-measurement devices, and automatic viscosity controllers. Of these, the automatic viscosity controller, a newcomer to wave soldering, is the only one capable of consistently accurate measurements. The viscosity control system will maintain specific gravity to within  $\pm 0.005$  gm/ml.

The automatic viscosity controller gets high scores for performance in controlling flux density because the operator never needs to intervene and, of course, viscosity measurements are not affected by temperature changes. In addition, there are further labor and material savings. Electronics manufacturers using the viscometer report that it reduces labor-intensive touch-up time by as much as 60%, lessens the probability of premature field failure of board components resulting from touch-up, and cuts the cost of both flux and board cleaning solvents.

Adapting viscosity controllers to wave soldering was inevitable for a number of reasons. First, the viscosity and specific gravity of a typical solder flux both vary in direct relation to its solids

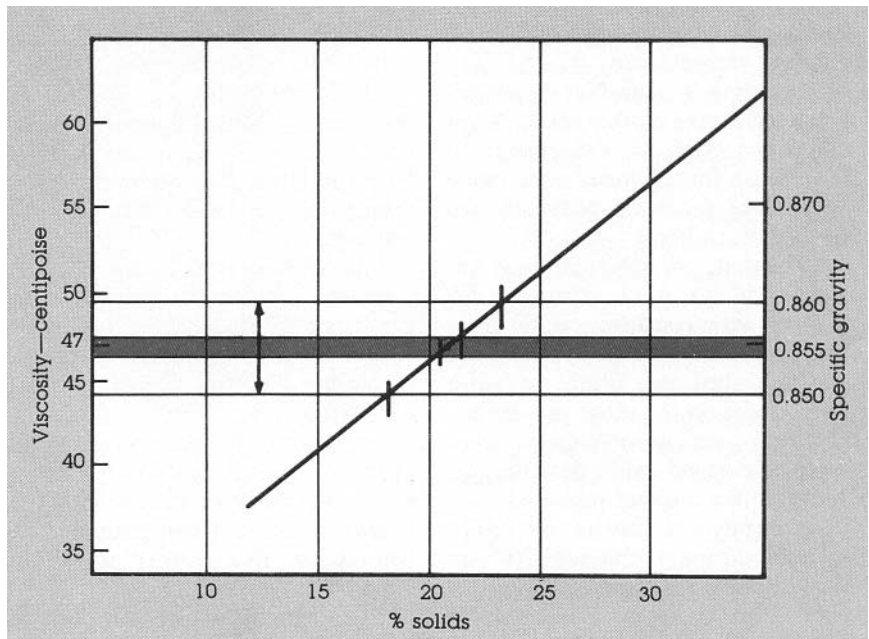


Figure 1: This graph shows why viscosity gives a more precise measurement than specific gravity of the percent of solids in a flux. The wide band represents a change in specific gravity of  $\pm 0.005$ , which is the normal variation detectable with a hydrometer. The shaded portion within the band represents a change in specific gravity of  $\pm 0.002$ , a measure that is easily obtained with automatic viscosity control.

content. Second, a significant change in viscosity corresponds to a small change in specific gravity. Third, significant changes in viscosity are easily measured, while small changes in specific gravity are not. Thus automatic viscosity control by its very nature can maintain the solids content of the flux within  $\pm 0.5\%$ , whereas specific gravity control by means of a hydrometer can maintain the solids content only within  $\pm 2.5\%$  (Fig. 1). A big advantage here is that once the specific gravity has been established for a particular board type, it can be precisely duplicated when the board is run again.

The viscosity-control system was developed for use in a wide variety of solvent control applications. The system consists of a measuring element immersed in a small tank of solder flux, a microprocessor-based controller and receiver, a solvent-control valve and a flux-circulating pump. If there is enough space, the measuring element can be submerged in the flux pot on the soldering machine.

In addition to control and display functions, the receiver contains a diagnostic program that checks relay operations and verifies the values of operating parameters used by the microprocessor. The equipment can

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be retrofitted to automated wave soldering machines.

The system is easy to operate. Prior to start-up, the operator turns on the flux-circulating pump, starts the measuring element cycling and, using a Shell Cup and Viscosity/Specific Gravity conversion chart furnished by the equipment supplier (Fig. 2), adjusts the flux to the required specific gravity by adding flux or solvent manually to the flux pot via a pushbutton switch on the controller.

Meanwhile, the piston in the measuring element is raised mechanically a fixed distance twice a minute to permit flux to flow into the piston chamber.

The piston is then allowed to fall by gravity, forcing the flux out of the chamber. The time required for the piston to fall is proportional to the viscosity of the flux (and hence proportional to the fluid's solids content), and the time-of-fall signal is transmitted to the controller, which displays the time of fall in seconds. Since the measuring element of the viscometer can be synchronized to provide displays in different units of measure, the controller is available with direct readouts in Shell-Cup seconds or in specific gravity.

After the flux has reached the specified viscosity, the operator notes the reading and dials it into the controller as the set point, via thumb-wheel-switches. From here on, the flux density is monitored and controlled by the viscometer. When the viscosity exceeds the set point, the controller calls for solvent addition via the control valve.

During solvent addition, an indicating light on the controller is lit to show that a viscosity correction is being made. Viscosity measurements are suspended during solvent addition, then made once each minute until the flux reaches a state of equilibrium. When the set point is changed by dialing in a new number, the controller automatically adjusts the viscosity to the new setting by either adding or withholding solvent until the viscosity reaches the set-point value.

Depending on the options selected, the controller will provide high/low viscosity alarms, a 4-20 mA output signal (which is proportional to viscosity), hard-copy viscosity data and computer interface capability.

A significant benefit of this mode of operation is that the operator can spot check system performance by simply taking a Shell Cup reading. Since the Shell Cup is easier to use than a hydrometer, the result is greater accuracy and ready operator acceptance of both the system and procedure.

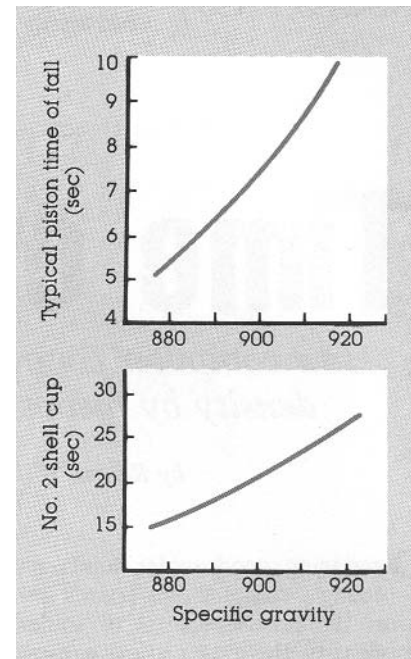


Figure 2: The equivalent specific gravity is found from the viscosity obtained from a Shell Cup or time-of-fall reading.