Desalination, 13 (1973) 91–94

Research Note

A DISTILLATE COLLECTION AND MEASUREMENT SYSTEM WITH A NON-CONTACT PHOTOELECTRIC LEVEL CONTROLLER

(Received March 21, 1973)

SUMMARY

A system for the uninterrupted collection of distillate and for the accurate measurement of its production rate, developed for a flash evaporation research apparatus, is described. The system incorporates a non-contact level controller which can also have other applications.

The uninterrupted collection of distillate and the accurate measurement of its production rate are important objectives in the design of most distillation units and are beset by difficulties for which a clear answer is not found in the available literature. This brief note describes a system which has been developed and successfully used for this purpose in a flash evaporation research apparatus (*1*) for the desalination of seawater. The non-contact level controller developed at this Laboratory can have many other applications related to level control and monitoring. It is simple, reliable, relatively inexpensive, and is free of the technical difficulties associated with the penetration of instruments and/or their electric leads through the walls of a vacuum/pressure enclosure, and with the immersion of such instruments in the hot liquid and vapor.

Gravity drive was used to provide continuous drainage of distillate from the condenser to the distillate collection vessel. The measurement of distillate flow rate is performed by determining with a stopwatch the time necessary to fill a calibrated volume in the collection vessel. This system provides a higher accuracy and lower pressure drop than, *e.g.*, in-line flowmeters. The volume and relative dimensions of the collection vessel were designed to yield the desired measurement accuracy which depends on the time response of the system, on the sensitivity in determining the position of the liquid-vapor interface, and on the accuracy of the volumetric calibration and of the stopwatch.

To provide continuous flow of distillate from the condenser to the collection vessel, the opening at the bottom of the condenser is streamlined, the properlysized interconnecting tubes have a continuous downgrade and terminate in an overflow cup (Fig. 1) which insures a submerged discharge and prevents vapor backup. The vapor spaces in the condenser and in the distillate collection vessels are interconnected in order to equalize the pressure. A glass tube level gauge on the condenser is monitored to verify adequate drainage of the distillate. Any vapor or gas bubbles discharged into the overflow cup escape there into the collection vessel vapor space. The bubble-free liquid (necessary for correct volumetric measurement) overflows into a transparent Lexan funnel and is discharged close to the bottom of the collection vessel. Essentially, the funnel is incorporated to insure that a clearly visible and quiescent vapor–liquid interface, which is necessary for the determination of the liquid volume, is maintained in the collection vessel.

To provide continuous flow and no vapor backup into the funnel, as well as to prevent the distillate pump from running dry, the funnel discharge and the

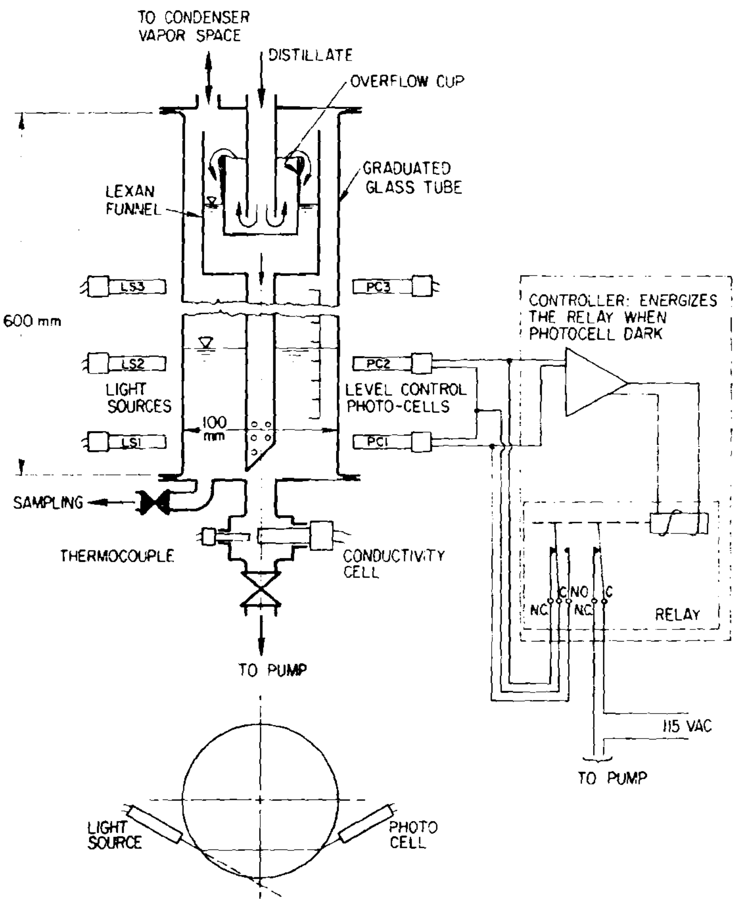

Fig. 1. Distillate collection system: Scaled drawing and controller schematic.

collection vessel outlet are kept submerged by means of an automatic photoelectric level controller designed for this purpose.* The principle of operation is based on the difference in refractive index of light for water and vapor. The light source is positioned on one side of the glass collection vessel and the photocell on the other side, in the path of the light beam refracted through the water. When the water level recedes below this path, light does not strike the photocell. This optical arrangement was chosen to insure dependable operation regardless of varying degrees of fogging and droplet adhesion on the glass tube surfaces. The controller keeps the water level between the bottom cells, PC1 and PC2, by starting the distillate pump when the level reaches the upper cell and by stopping it when it reaches the lower one. When the liquid reaches the level of the third (top) cell, a larger bypass solenoid valve opens and dumps the distillate rapidly (circuit not shown).

The cycle of the level controller can be described as follows:

Phase 1: Water level below PC1: All photocells dark, relay energized, only PC2 controlling (PC1 shorted out), pump off;

Phase 2: Water level between PC1 and PC2: Since PC2 is controlling, no change occurs from previous condition until water level reaches PC2;

Phase 3: Water level at PC2 or higher: PC2 receives light, the relay is de-energized, thus transferring control to PC1 (which at this time also receives light) and starting the pump to drain the vessel (Fig. 1 shows the system in this phase);

Phase 4: Water level recedes below PC2: Since PC1 is still controlling and receiving light, no change occurs. The water level continues to fall until Phase 1 is reinitiated.

To avoid erratic control due to spurious interruption of a lightbeam, the controller logic module selected energizes only if the "dark" condition is maintained for a certain adjustable period of time (selected to be 2–3 seconds in this case).

During the actual volumetric measurement, the controller action on the pump is overriden by a microswitch which turns the pump off when the collection vessel discharge valve is closed.

The distillate temperature and electric conductivity are measured continuously at the bottom of the collection vessel, by means of a thermocouple and conductivity cell, respectively. The conductivity cell is also connected to an adjustable high-conductivity alarm to insure prompt detection of excessive carry-over of brine into the distillate.** Withdrawal of distillate samples from the vessel is by means of the sampling valve at its bottom.

* The components used are: Logic Module TR5 with ON-delay, on TRB chassis with DPDT relay; Photocell Receivers Model TPC-2L and light sources model TLS-3, all from Micro Switch-Farmer Electric Co., Natick, Massachusetts 01760.

** The electric conductivity measurement and alarm system consists of a model RE-R4-HI Solu-Bridge Controller (with alarm on rise) and an epoxy screw-in type conductivity cell, all from Beckman Instruments, Inc. (Industrial Instruments), Cedar Grove, N.J. 07009.

N. LIOR, J. LEIBOVITZ AND A. D. K. LAIRD
Sea Water Conversion Laboratory,
University of California, Berkeley, Calif. (U.S.A.)

REFERENCES

1. N. Lior, Heat Transfer with Flash Evaporation in a Stream with a Free Surface, *Ph.D. Dissertation*, University of California, Berkeley, 1973.