THEORY OF OPERATION

MULTISTAGE FLASH EVAPORATOR

ONCE-THROUGH SYSTEM

TECHNICAL BULLETIN

750-1007

WATER TECHNOLOGIES DIVISION

aqua-chem, Inc.

THEORY OF OPERATION

The Multi-Stage Flash Evaporator produces distilled water from feedwater by heating it until it is ready to flash. The flashed vapor is drawn to the cooler tube bundle surfaces where it is condensed and collected as distillate.

Flashing occurs when heated brine is turbulated in a chamber which is maintained at a lower vapor pressure than that of the entering heated brine. Heat is given up by the brine and a portion converted into vapor until the temperature of the brine reaches the saturation temperature corresponding to the chamber pressure. In other words, the heated brine is flashed off by a pressure reduction.

Entrained brine droplets are removed from the vapor by entrainment separators and the pure vapor condenses into distillate on the condenser tubes. The distillation process operates from a low vacuum in the first stage to a high vacuum in the last stage, with stage-to-stage pressure differential being the key to the repeated flashing.

Initial vacuum in the stages is created by the high-pressure steam-driven air ejector/condenser vacuum system.

The once-through system is designed to operate at temperatures up to 195°F. In order to achieve long run operation of the unit, it is necessary to retard the formation of scale on the heat transfer surfaces. This is accomplished through the chemical treatment systems described later.

PROCESS DESCRIPTION

Filtered raw feedwater is chemically treated for scale control purposes and pumped through the condenser tubes from the last stage to the first stage.

As the feedwater flows through the condenser tubes, it is progressively heated in each stage by flashing brine vapor condensing on the outer tube surfaces. The feedwater then passes through the tubes of the feedwater heater for final heating to the design terminal temperature.

The heated feedwater is directed to the shell side of the first stage for flashing. The brine flows successively from the first to the last stage, flashing in each stage, and is discharged from the last stage.

CONDENSATE FLOW

Low-pressure steam is used to heat the feedwater flowing through the tubes of the feedwater heater. When so specified, high-pressure steam turbines can be used to drive the feed and/or brine blowdown pumps, with the turbine exhaust steam also being used in the feedwater heater.

The low-pressure steam is piped into the shell side of the feedwater heater and, by transfer of its heat to the feedwater flow, condenses on the tube outer surfaces. Thus, the feedwater is heated to its design terminal temperature. Condensate formed by the condensing steam is piped to the condensate pump and is pumped to the condensate return system.

C41-5072 REV 8/75
Printed in U.S.A.

Telephone: (414) - 962-0100 Telex: 26679 Cable: AQUA TWX: 910-262-3421

aqua-chem, Inc.

WATER TECHNOLOGIES DIVISION
P.O. BOX 421
MILWAUKEE, WISCONSIN 53201 U.S.A.

DISTILLATE FLOW

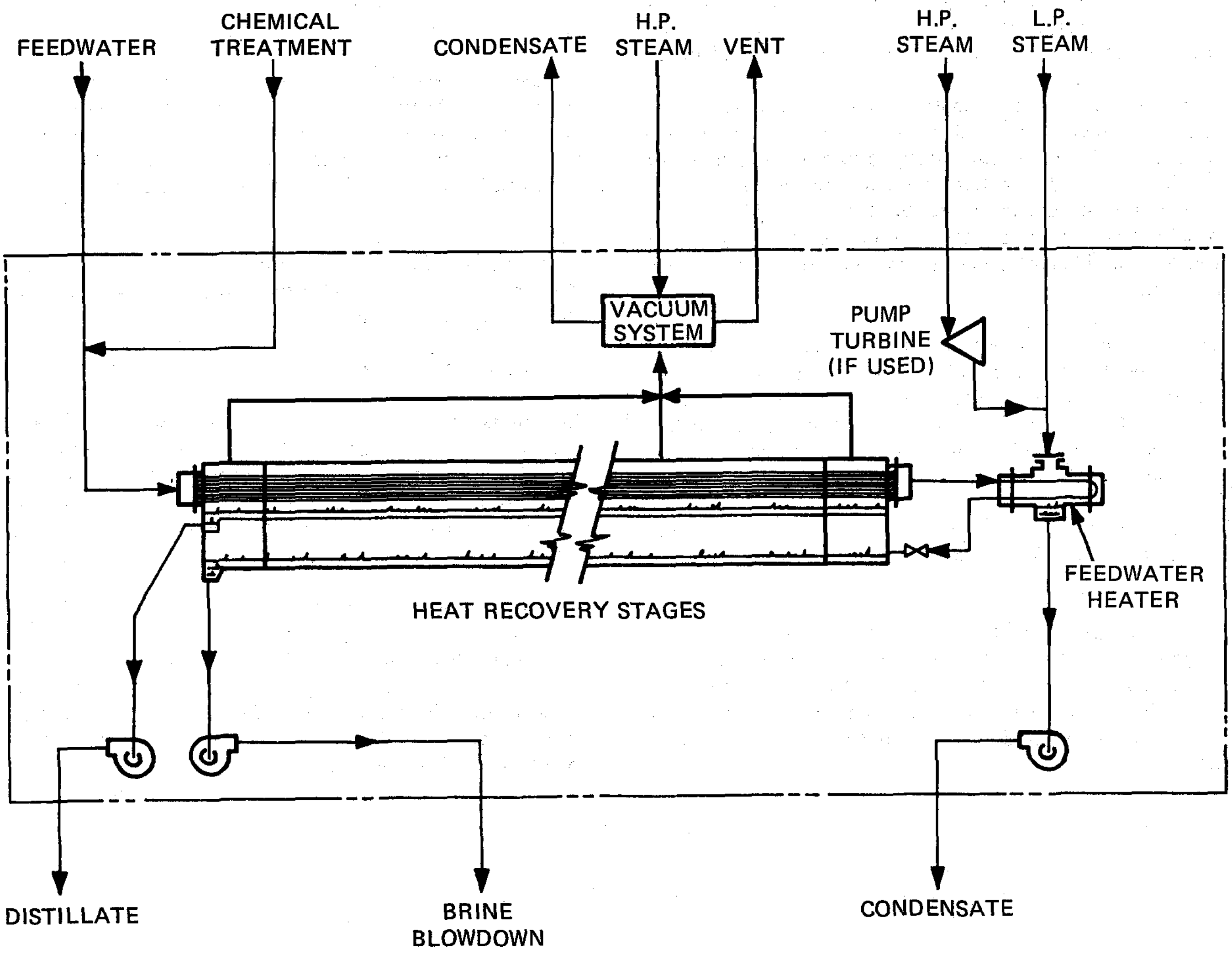
Distillate is formed on the stage condenser tubes by condensing of the flashed brine vapor. The distillate collects in a distillate trough which is common to all the stages and flows from the first stage to the last stage. From there it is pumped into the distillate storage system.

VACUUM SYSTEM

Venting of the evaporator is essential to the operation of the distilling plant. High-pressure steam is used to drive air ejectors to create the initial vacuum in the evaporator. Once the plant is in normal operation, the vacuum is maintained by the condensing action in each stage, supported by the air ejectors. The air ejectors also evacuate noncondensibles from the evaporator. The spent high-pressure steam and the noncondensibles are discharged from the air ejectors into condensers where the steam is condensed and the non-condensibles are vented to atmosphere.

CHEMICAL TREATMENT SYSTEMS

A measured amount of AC-1* feedwater treatment compound is continuously injected into the feedwater flow to retard the formation of hard scale in the stage and feedwater heater condenser tubes. AC-3* antifoam compound also can be introduced into the feedwater when needed. Post distillate treatment can be employed to reduce corrosion of the product water storage and distribution systems.



FLOW DIAGRAM
MULTISTAGE FLASH EVAPORATOR
(ONCE-THROUGH SYSTEM)

*AC-1 and AC-3 are treatment chemicals especially compounded for use with Aqua-Chem distillation plants.

THEORY OF OPERATION MULTI-EFFECT SPRAY-FILM EVAPORATOR

TECHNICAL BULLETIN

750-1037

WATER TECHNOLOGIES DIVISION

aqua-chem, Inc.

THEORY OF OPERATION

The Multi-Effect Spray-Film evaporator produces distilled water by boiling fresh water vapor from feedwater. The vapor produced is drawn to the inside of cooler evaporator tube bundle surfaces where it is condensed and collected as distillate.

The Multi-Effect Spray-Film evaporator employs two or more evaporator effects, each operating at a successively lower temperature and pressure. The first effect (highest temperature) is heated by low-pressure steam or hot water on the inside of the effect evaporator tube bundle. Vapor is generated from the feedwater sprayed on the outside of this tube bundle and is directed to the second (lower temperature) effect where it condenses inside its evaporator tube bundle, producing additional vapor. This process is repeated several times, multiplying the effectiveness of the original low-pressure steam in the first effect, thereby giving the process its name.

The Spray-Film principle refers to the method employed to efficiently distribute the fluid to be evaporated over the outside surfaces of the evaporator tube bundle. In each effect there are several spray nozzles which distribute the effect feed over the evaporator tube bundle in a rain of fine droplets. The high velocity of the droplets as they leave the spray nozzles and fall on the evaporator tube bundle assures even brine distribution in a thin liquid film creating a high heat transfer rate. As vapor is generated outside the evaporator tube bundle, it flows downward with the liquid feed. This downflow action pulls the feed liquid through the evaporator tube bundle at high velocity, thereby maintaining a high heat transfer rate.

PROCESS DESCRIPTION

Feedwater is pumped into the final condenser of the plant and serves as a coolant to condense the vapor produced in the last effect. The major portion is returned to the source. A portion of the feedwater is withdrawm as make-up water and is passed through the last effect preheater where it is warmed. It is then treated with a scale-inhibiting chemical, is sprayed over a packed-bed deaerator in a special section of the last effect, and is fed to the make-up pump. This stream maintains the material balance in the plant. The make-up water passes through a series of tubular preheaters, where it is warmed by condensing the generated vapor from each effect. After leaving each effect preheater, a portion of the make-up water is withdrawn and sprayed over the evaporator tube bundle in that effect.

A fraction of the make-up water entering the first effect is vaporized as it is sprayed over the evaporator tube bundle in which the low-pressure heating steam is condensed. The vapor produced passes through an entrainment separator and is drawn to the second-effect evaporator tube bundle where it serves as the heat source for vaporizing the feed water spray entering that effect. Some of the vapor from the first effect passes through the second-effect evaporator tube bundle to the second-effect preheater where it condenses and heats the make-up water.

The portion of the make-up water not vaporized in the first effect passes to the second effect through a loop seal. As it enters the second effect, a fraction flashes due to the lower pressure and temperature, producing more vapor.

The vapor and liquid flows described above are repeated in each effect of the plant. The blowdown is pumped from the system out of the last effect. The vapor produced in the last effect is condensed in the final condenser.

CONDENSATE FLOW

Low-pressure steam enters the evaporator tube bundle of the first effect, gives up its heat by condensing inside the evaporator tube bundle and preheater, and is pumped to the condensate return system. When steam is not available, hot water heaters or engine jacket water heating sources can be employed.

Telephone: (414) - 962-0100 Telex: 26679 Cable: AQUA TWX: 910-262-3421

aqua-chem, Inc.

WATER TECHNOLOGIES DIVISION
P.O. BOX 421
MILWAUKEE, WISCONSIN 53201 U.S.A.

DISTILLATE FLOW

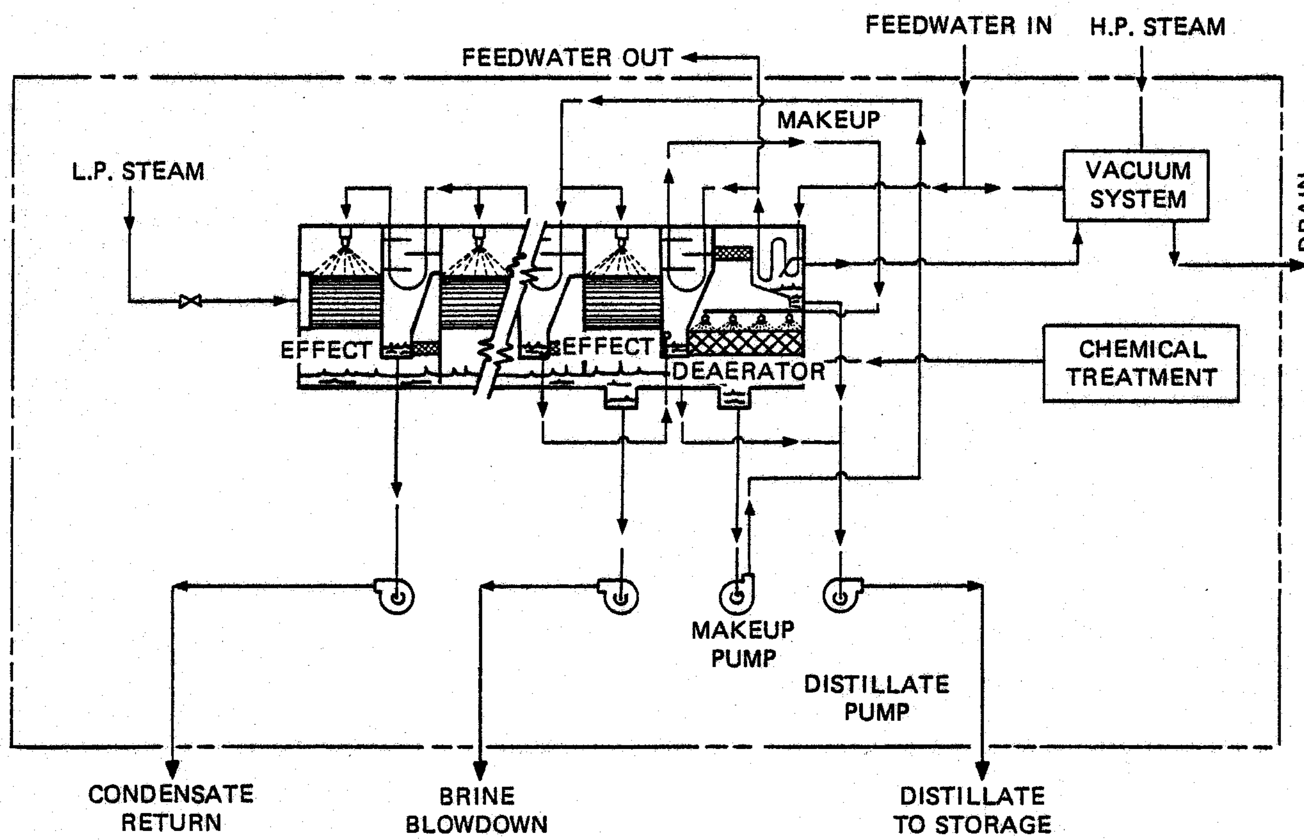
Distillate is formed in the evaporator tube bundles and preheaters by condensation of the vapor. The distillate collects in a distillate trough in each effect and flows from the first effect to the last effect. From there it is pumped into the distillate storage system.

VACUUM SYSTEM

Venting of the evaporator is essential to the operation of the distilling plant. Air and other noncondensible gases in the system are vented from effect to effect, and are collected and removed from the system by means of a high-pressure steam-jet air ejector system. The exhaust steam and gas mixture from the air ejector system is condensed in a special section of the first-effect evaporator tube bundle, or in a water-cooled barometric-type condenser. When steam is not available, mechanical vacuum pumps can be employed.

CHEMICAL TREATMENT SYSTEM

For systems with a maximum seawater temperature of 195°F, a measured amount of AC-1* feed treatment compound is continuously injected into the make-up flow to retard formation of scale on the evaporator tube bundle. For plants above 195°F, sulphuric acid is used to retard scale formation. An antifoam compound also can be injected into the make-up when needed. Provisions also can be made to add sodium sulphite to scavenge oxygen from the brine flow. Distillate post treatment can be employed to reduce corrosion of the product water storage and distribution systems.



FLOW DIAGRAM
MULTI-EFFECT SPRAY-FILM EVAPORATOR

*AC-1 is a treatment chemical especially compounded for use with Aqua-Chem distillation plants

C19-6117

aqua-chem, Inc.
WATER TECHNOLOGIES DIVISION
P.O. BOX 421
MILWAUKEE, WISCONSIN 53201 U.S.A.