# INSTRUCTIONS FOR THE CARE AND OPERATION OF DISTILLING PLANTS

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VARIOUS

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# INSTRUCTIONS

FOR THE

# CARE AND OPERATION OF DISTILLING PLANTS.

NAVY DEPARTMENT,
BUREAU OF ENGINEERING, *December 29, 1920.*

These instructions have been compiled for the information and guidance of the naval service. They apply to all types of distilling plants. Commanding officers are requested to address to the Bureau of Engineering requests and recommendations to improve these instructions, including especially any precautions deemed necessary under special conditions and not herein provided for.

R. S. GRIFFIN,
*Engineer in Chief, U. S. Navy.*

NAVY DEPARTMENT,
*Washington, D. C., December 29, 1920.*

The "Instructions for the Care and Operation of Distilling Plants" are approved for issue to all officers for their information and guidance. The instructions and recommendations contained therein will be followed on all vessels.

JOSEPHUS DANIELS,
*Secretary of the Navy.*

## INTRODUCTION.

1. These instructions and suggestions are written primarily for officers doing engineering duty. The instructions apply in general to all types of evaporators except where special note is made. Detailed instructions for the operation of the plant on a given ship will be prepared and posted by the engineer officer.

The purpose of a distilling plant on board ship is to produce the required quantity of fresh water with a minimum expenditure of steam. This should be accomplished without unnecessary complications of apparatus and with minimum care and labor on the part of the attendants.

2. Distilling plants on naval vessels are classed as (*a*) high-pressure type and (*b*) low-pressure type.

(*a*) The high-pressure type is designed to operate primarily using steam from auxiliary steam line, and may be piped up to operate in single effect, double effect, or multiple effect (triple or more). Also piping, for operating on steam drawn from the auxiliary exhaust, is generally installed. When auxiliary exhaust is used it is usual on the larger vessels to provide an air pump to produce a vacuum of 20 inches or better on the distillers

with corresponding low pressure on shell of evaporator, in order to produce a sufficient amount of water. The high-pressure type is in general use with few exceptions.

(*b*) The low-pressure type is designed and rated to operate on steam drawn from the auxiliary exhaust and is always piped up to operate in double or multiple effect. This style—Lillie type—is installed on the *Dixie*, *Salem*, *Tennessee*, and *California*.

The following is a list of distilling plants installed on later battleships and destroyers:

| Vessel. | Number installed. | Type. | Heating surface, each. | Rated total capacity. | Remarks. |
|---|---|---|---|---|---|
| | | | *Sq. ft.* | *Gallons.* | |
| Delaware and North Dakota. | 4 | Bureau horizontal | 312.00 | 25,000 | Double effect. |
| Florida and Utah | 4 | Model bureau horizontal. | 312.00 | 25,000 | Do. |
| Wyoming | 4 | do | 312.00 | 25,000 | Do. |
| Arkansas | 4 | do | 312.00 | 25,000 | Do. |
| New York | 4 | do | 194.00 | 28,000 | Do. |
| Texas | 4 | Griscom-Russell vertical. | 93.60 | 28,000 | Do. |
| Nevada | 4 | Griscom-Russell horizontal. | 221.40 | 25,000 | Do. |
| | 2 | Row & Davis | 75.30 | 12,500 | Do. |
| Oklahoma | 4 | Schutte-Koerting vertical. | 117.78 | 25,000 | Do. |
| Pennsylvania | 4 | do | 146.47 | 35,000 | Do. |
| Arizona | 4 | Bureau horizontal | 254.00 | 25,000 | Do. |
| New Mexico | 5 | Schutte-Koerting vertical. | 113.00 | 40,200 | Do. |
| Mississippi and Idaho. | 4 | Griscom-Russell vertical. | 130.00 | 30,000 | Do. |
| Tennessee and California. | 6 | Lillie horizontal | 150.00 | 37,500 | Multiple effect. |
| Colorado and Washington. | 5 | Schutte-Koerting vertical. | 114.50 | 37,500 | Double effect. |
| Maryland and West Virginia. | 6 | Griscom-Russell vertical. | 74.48 | 37,500 | Do. |
| **DESTROYERS.** | | | | | |
| 22, 25, 32, 37 | 2 | Newport News | 75.00 | 3,000 | Single effect. |
| 26 to 29, 34, 45 | 2 | Williamson | 75.00 | 3,000 | Do. |
| 30, 31, 36 | 2 | Cramp | 75.00 | 3,000 | Do. |
| 38 to 40 | 2 | Reilly | 61.50 | 3,000 | Do. |
| 41, 42 | 2 | Bath | 75.00 | 3,000 | Do. |
| 43, 44, 54 | 2 | do | 100.00 | 3,750 | Do. |
| 45, 52 | 2 | Schutte-Koerting | 81.79 | 2,750 | Double effect. |
| 46 to 53, 55, 56 | 2 | Reilly | 61.80 | 3,700 | Do. |
| 57, 63, 64, 67, 68 | 2 | No. 14, Reilly | 86.10 | 5,400 | Do. |
| 58, 59 | 2 | Schutte-Koerting | 55.15 | 5,400 | Do. |
| 60, 65, 66, 74 | 2 | Bath | 110.00 | 5,400 | Do. |
| 69, 70 | 2 | Schutte-Koerting | 50.75 | 6,000 | Do. |
| 71, 72, 73 | 2 | Navy Schutte-Koerting. | 32.75 | 5,400 | Do. |
| 75 to 134, 142 to 160 | 2 | No. 16, Reilly | 42.66 | 7,500 | Do. |
| 135 to 141, 336 to 341 | 3 | Bureau standard | 50.75 | 9,000 | Do. |
| 161 to 335, 342 to 344 | 2 | No. 24, Reilly | 63.84 | 10,500 | Do. |
| 345 to 347 | 2 | U tube, Bath type | 110.00 | 10,000 | |

In the naval service the following ratings for evaporators are standard:

| Type. | Gallons per 24 hours per square foot heating surface. | Remarks. |
|---|---|---|
| Standard Navy horizontal | 25 | Single effect. |
| Schutte-Koerting vertical "U" tube | 60 | Double effect. |
| Griscom-Russell vertical "U" tube | 60 | Do. |
| Row & Davis vertical coiled tube | 60 | Do. |
| Bureau vertical U tube | 60 | Do. |

These are the standards considered by the bureau as the limit for satisfactory all-round operation, but on some vessels where weight is of paramount importance this rating is exceeded for the Griscom-Russell type. It is advisable to operate the evaporators at this standard rate if the quantity needed does not exceed the capacity at this rate.

## OPERATION.

3. **General.**—The following notes on operation, intelligently applied, should be helpful to all concerned with the operation of evaporators. Where a positive direction is given the procedure must not be diverged from unless the plant is in such condition that these instructions can not be carried out. Plants piped up to operate in double or multiple effect should be operated in this manner rather than as single-effect evaporators because of the enormous increase in efficiency obtained. If auxiliary exhaust connections to coil are provided, this method of operation should be used whenever possible. If the necessary quantity can not be made when operating on auxiliary exhaust, it may still be possible to operate in this manner when in port or, say, two weeks out of four, operating the remainder of the time in double effect on live steam, or operating part of the plant on auxiliary exhaust and part on live steam. It is more economical to operate in single effect on auxiliary exhaust than double effect on live steam. Attention is called to the fact that the normal working pressure of auxiliary exhaust on vessels having turbine auxiliaries exhausting into this line is 10 pounds gauge, with an allowable maximum pressure of 15 pounds gauge. On vessels having no turbine-driven auxiliaries, and where the personnel is experienced, it is permissible to boost the auxiliary exhaust to 25 pounds gauge, if necessary, in order to produce the required amount of water when evaporators are operating on auxiliary exhaust.

It is most desirable to operate the evaporators at a steady daily output and not to force clean evaporators at a high rate and allow dirty evaporators to run at a low rate. Steady and controlled capacity can easily be obtained by use of an orifice or nozzle in the steam-supply line and by this method only, unless the steam pressure in the first-effect coils is constantly adjusted by experienced operators to correspond with output. This method of operation is fully described in the last pages of this

pamphlet, and engineer officers are advised to give it a trial. All necessary fittings can easily be made and installed by the ship's force. Attention is called to the fact that when operating with orifice, the coil pressure will tend to rise to a point above relief valve setting if for any reason the rate of condensation of coil steam is checked, either by water getting low in the shell or by drainage becoming stopped. When using orifice, the coil relief valve must be in particularly good working order. When operating double effect on live steam, if possible, run at rated capacity steadily, i. e., 25 gallons per square foot heating surface for horizontal shell and 60 gallons per square foot for vertical shell type. Other things being equal, the most economical method of operating is to endeavor to maintain a steady daily output which will meet the required average daily consumption. The expenditure from ship's tanks, while it does vary from day to day, is fairly steady for weekly consumption. The make-up feed will be greater at sea than in port, and at sea will vary directly as the speed. The amount of cruising to be done for the week is usually known in advance, and one can, knowing this and the average weekly ship's tanks expenditure, determine on a daily capacity for the week which will take care of this expenditure. The ship's tank capacity is usually about two or three days' expenditure. A good rule is to endeavor to prevent the amount on hand in ship's tank falling below 50 per cent of capacity and reserve feed tanks 25 per cent, and to have the reserve feed tanks as nearly full as possible before getting under way. The amount of water in reserve feed tanks should never fall below 25 per cent of capacity. If a long stay in port is contemplated the daily capacity necessary will be low, and the filling up of the reserve feed tanks, if low on anchoring, should be spread out over a reasonable period. This must, however, be guided by the military requirements of the service and sufficient reserve feed always maintained for any possible emergencies.

If the number of men available permits, it is desirable to operate for full 24 hours. Particularly when the ship has coal-burning boilers, it is advisable to run the evaporators when getting under way and on coming to anchor. This assists the handling of the steam when warming up or disconnecting boilers.

When anchored in a river or harbor where on ebb tide the water is materially fresher than on flood and full 24-hour operation is not required, run evaporators only on ebb tide in order to reduce scaling up and decrease the rate of increase in salinity. This will prove to be most economical, except where the harbor water is impure, when it will be necessary to run on flood tide only.

4. **Starting.**—To start up a plant with evaporators empty and all pumps secured, proceed as follows:

(*a*) Start feed pump, distilling condenser circulating pump, fresh-water pump slow speed, and, if fitted, distilling condenser air pump.

(*b*) Fill shells of evaporators up to two-thirds working level.

(*c*) All vapor valves to be used should be wide open and kept there. It is not necessary or desirable to build up a shell pressure before opening shell vapor valves, the only exception being as noted under 6 (*c*).

(*d*) Crack steam root valve, warming up lines by passing steam into coil. Gradually open steam valve wide after line is warmed up. If using orifice in steam line, maintenance of proper pressure is now automatic while water is in the shell. If using reducing valve, control coil pressure

to proper amount with evaporator throttle by hand, keeping reducer set at maximum pressure likely to be used (relief valve setting). If using auxiliary exhaust, open valve wide.

(*e*) Regulate coil drain valve so that a water seal will be maintained in seal glass.

(*f*) Gradually raise water level in shell to the maximum that can safely be carried at the rate of evaporation desired without danger of priming.

(*g*) See that all entrained air is blown out of evaporator coils, traps, highest point of feed line, distillers, and feed heaters (when operating with gauge pressure on shell) and leave air cocks cracked so that air will be blown off as it accumulates, this being desirable even at the sacrifice of a little steam which is lost.

(*h*) When in full operation, adjust speed of distilling condenser circulating pump so that fresh-water discharge from distilling condensers will be about 100° F. Care must be exercised not to put excessive pressure on distilling condensers either by using fire main pressure or by choking down too much on overboard discharge when feeding the shells with pressure on overboard discharge from distilling condensers. Distilling condensers have been ruined through neglect of this point.

(*i*) If fitted, and when using continuous blow down, start brine pump or adjust continuous blow valve so as to maintain correct density in shell.

(*j*) When using intermittent, complete, or partial blow, in starting up after blowing down, all of the above points that are applicable should be given attention. (*c*) is modified, when using complete blow down, in that the vapor valves are opened slowly as soon as the bottom blow is closed. (*d*) is modified by turning steam on coils quickly when cracking off scale.

5. **Feeding.**—Once the evaporators are in operation, the feeding must be maintained at a steady rate. The rate is dependent on the capacity at which the evaporator is being operated. Sudden raising of the water level or a too high level will cause priming. The level of the water in the shell must be the highest that can be held and still prevent the carrying over of water particles into the distilling condensers with the fresh-water vapor. It is most uneconomical to attempt to dry the vapor by heating it with uncovered coil surface. Exposed parts of coils scale up quickly and are a direct loss of working heating surface. The water level depends on the capacity at which operating, maximum brine density, the carefulness of installation of baffles and skill of personnel. The level is higher the less the capacity (within limits) and brine density, and the greater the skill of personnel and carefulness of installation of baffles.

Due to the turbulence of the surface of the water in the shell, the real water level is always a little higher than that shown by the gauge glass, usually 3 inches in horizontal shells to 6 inches in vertical shells (at full capacity).

The internal feed pipe should have holes drilled in it (total area equal twice the area of pipe) so as to distribute the feed equally to all parts of the bottom of the shell and the holes should be arranged to direct the feed downward or horizontally toward center of shell but not upward.

Some makes of evaporators are fitted with automatic feed regulators to maintain a constant water level.

The suction for feed pump should always be taken from the distilling condenser overboard discharge pipe.

On modern installations, except in small auxiliary vessels, feed-water heaters are usually installed for heating the feed first with the vapor and next with drain from the first effect coils.

With evaporators which maintain a vacuum on shell the feed pump may be shut down and by-passed after the plant is started.

6. **Blowing or Brining.**—Sea water contains about $\frac{1}{32}$ part by weight solid matter. As the sea water is distilled in the evaporator, the solid remains and further increases the proportionate part in the new water pumped in to replace that distilled. It is common to speak of the water in shell (the brine) being of $\frac{1}{16}$ or $\frac{3}{16}$, etc., salinity, meaning that $\frac{1}{16}$ or $\frac{3}{16}$, etc., part is solid matter. The salinity may be ascertained by use of a salinometer (described later). The maximum salinity allowable is $\frac{6}{32}$, and this *must not be exceeded* no matter what system of brining is used. The shell salinity may be reduced to as low a maximum as $\frac{4}{32}$ when urgent need for increased output is necessary at a sacrifice of efficiency. High shell salinities will (*a*) reduce capacity (with constant coil pressure) and vice versa if salinity be lowered, capacity will be increased; (*b*) cause rapid scaling up of coils; (*c*) increase tendency to prime; and (*d*) cause rapid corrosion of interior parts due to liberation of acid. Therefore, it is necessary to blow or pump out some or all of the water either at intervals or continuously. An additional reason for blowing is to rid the shell of some of the accumulation of cracked-off scale.

There are three methods of blowing:

(*a*) Intermittent complete blow down.
(*b*) Intermittent partial blow.
(*c*) Continuous blow.

(*a*) To carry out intermittent complete blow down, proceed as follows, the evaporator being in operation:

Close vapor valve and raise shell pressure to about 25 pounds gauge. If using in the coil vapor from another evaporator or auxiliary exhaust, close this supply and admit live steam to coil.

Open bottom blow wide—open quickly.

Immediately thereafter close steam to coil.

Allow brine to blow out until shell pressure reaches about 5 pounds gauge, then close bottom blow quickly.

Then start up as outlined in paragraph 4 above, being careful to have low water level at start except when cracking scale as indicated below.

No matter what method of blowing is used, *at least twice in 24 hours* operation, crack scale off coils by following operation: Fill shell quickly up to *level* of top of coils and turn steam on coils rapidly (about 40 pounds pressure). This will expand the tubes suddenly (due to rapid heating) and crack off the majority of the scale. It is more successful with coiled tube types than with straight tube types. Then, in about five minutes, reduce steam pressure and operate as before. (Until water level is reduced to the proper point by evaporation be very careful not to prime.) It is best to by-pass the feed heater while filling the shell in order to have cool water.

When using this method, the blow should be given when the salinity of the brine reaches $\frac{6}{32}$. The interval between blows depends on the rate at which operating. It can only be found by taking the salinity