Bingham

F.M.C. (AUSTRALIA) LTD.
D.W. BINGHAM DIVISION.

Food Processing Machinery & Supplies

REGISTERED OFFICE
224-238 NORMANBY ROAD SOUTH MELBOURNE S.C.5
VICTORIA AUSTRALIA

INSTRUCTIONS
FOR BLAW-KNOX
FALLING FILM EVAPORATORS

"Serving the Food Industry"

OPERATION

BASIC PRINCIPLES OF FALLING-FILM EVAPORATORS

WHAT IS FALLING FILM? A falling film evaporator requires no level of liquid. The in-feed enters the top of the steamchest and is evenly distributed to the tubes, then flows down and is immediately removed. The only actual time that the fluid is exposed to the process heat is the interval required for the film of product to flow down the tube wall, which is, understandably, only a matter of seconds.

In a conventional milk evaporator, liquid is drawn into the bottom of the steamchest and vapour separator until it reaches a static level in the tubes at sufficient height to permit circulation. This amount of liquid must be maintained at all times to insure that the tubes are wetted, otherwise the product will scorch. Several hundred gallons must be kept in the machine and subjected to a prolonged heat treatment which may be detrimental to its physical properties.

Also, since the Falling Film Evaporator is not dependent on large temperature differentials to maintain circulation, it is possible to use triple effect operation in combination with thermal recompression to realise very economical operation.

The operation of a falling film machine is automatic. The product is fed at an even, metered flow and once the operation has begun, there is nothing to alter the evaporation rate. This feature pays off in uniform product concentration and ease of operation not usually found in contemporary evaporators.

RECOMPRESSION BOOSTER

A unit similar to a steam operated single stage air ejectors, which is known as a booster, is used in conjunction with a source of high pressure steam to supply the motive heat to the first effect. Then, rather than passing all of the vapour produced in the first effect through, the piping to the second effect steamchest, part of this vapour is drawn into the suction connection of the booster due to being entrained by the flow of steam from the steam nozzle through the venturi throat of the booster diffuser.

BOOSTER DESIGNED FOR SPECIFIC CONDITIONS

In designing a recompression evaporator, a booster is used that will require a fixed amount of steam at a given pressure. The design of the booster is then such that a predetermined amount of vapour at some set temperature may be drawn into the suction connection. This vapour, when mixed with the steam, has its temperature raised to level which is in accordance with the needs of the individual evaporator application.

Recompression boosters can be designed to raise the temperature of vapour over a widely varying range. In general, the higher the temperature to which a vapour at any given vacuum is boosted, the greater will be the ratio of steam as to vapour entrained. Since this ratio of steam to vapour determines the operating economy of the evaporator, the booster is normally held to a minimum to provide the least possible usage of steam.

Another factor to be considered is that, using a low differential, a large amount of heating surface is required, to transfer the heat from the vapour to the milk. If a higher degree of temperature boost is used, then the heating surface required will be much less.

The temperature ratios used by Blaw Knox permit use of a moderate amount of heating surface and still provide steam economy considerably better than that attained in standard evaporator operation.

PREHEATING OF MILK

When the evaporator was purchased, there was undoubtedly some auxiliary equipment included. Various milk holding tanks and milk preheaters are required for successful evaporator operation.

PREHEAT MILK TO DESIGN FEED TEMPERATURE

Before the milk is drawn into the evaporator to be concentrated, it is essential that this milk be preheated to a temperature at or above design feed temperature. If this is not done, the liquid will not be distributed properly in the tubes and the machine will not operate.

The temperature of the preheat is largely determined by the type of product to be produced. If the milk is to be concentrated for drying, the preheat may vary from 165° or less for low heat powder to 210° for high heat powder.

This preheating may be accomplished by use of a steam preheater alone or, to affect a greater operating economy, one or more vapour preheaters may be used to partially raise the temperature of the milk. Use of these vapour preheaters will, of course, mean that a much smaller quantity of steam must be used in the final preheating. In some cases, a two section plate heater is used, using evaporator condensate in the first section and steam or hot water in the second stage.

TESTING

After the installation is completed, the evaporator should be filled with water and all pipe connections and joints checked for leaks. Any leaks should be taken care of and made tight before proceeding any further with the test. If there are leaks under a water test, the equipment will leak under vacuum. For good economy and proper operation of the equipment, it must be tight before starting operation.

1. Close feed and discharge valves, open milk valves between effects. Open vent valves, make sure steam valve is closed. Close all drain cocks on pumps and drain valves in condensate lines and water lines. Close the valve in the discharge line from the condensate and tailpipe pumps. Water may then be added.

   NOTE All manholes and cleanout doors should be fastened with clamps during water test.

2. Any leaks should be properly taken care of before proceeding further, then drain evaporator.

3. The pressure reducing valve for the air ejectors and recompression boosters should be adjusted for a few pounds above their operating pressures. The back pressure relief valve located at the booster inlet vapour pipe should be checked to open at 15 PSI maximum pressure.

4. All pumps should be flushed out to make sure all foreign material which could cause damage to pump is removed. Pumps should be tried for correct rotation.

5. Following the procedure under "Operation Start Up" the evaporator should be tested using water. If the evaporator fails to operate correctly, turn to section "When Evaporator Fails to Operate Correctly" for cause.

6. Shut down and clean the evaporator as described in section "Operation, Shutdown" and "Operation Cleaning".

..*.*.*.*.*.*.*.*

OPERATIONAL DATA

Operation - START-UP AND SHUT-DOWN

SKIM MILK LOW TEMPERATURE OPERATION - **Refer to Diagram 208 ue at the end of this instruction book.**

1. Close up the machine. Be absolutely sure that all connections that have been opened are closed and all gaskets are serviceable and are air tight, check pumps carefully as one small leak can ruin the entire operation. Also be certain that there is no possibility of foam being drawn in with the feed liquid. It is absolutely vital that no air enter the machine. If air in any small quantity should be present, the liquid will burn onto the tubes and necessitate a shut down and complete cleaning of this machine. See that micro valve MV1 is fully closed and three way valve V3 positioned to discharge onto Raw Milk Feed Tank.

2. Turn on water to all pump seals. Start all condensate pumps and water to cooling tower pump, now start water to condenser pump and open tailpipe water valve, turns and air ejector inter-condenser water valve turns. See that 100 gallon feed tank is filled with water.

3. Now, turn on the steam to the air ejector and the hogging jet, valves between air ejectors and condenser to be opened. When vacuum has built up to 26", close gate valve between the hogging jet and condenser and turn off the steam to the hogging jet. The steam to the air ejectors must be at or slightly above the design pressure.

4. Start vapour heater pump M1, plate heater milk pump M2 and steam heater milk pump M3, allow liquid (water) to circulate around by-pass of preheater. Turn on steam at valve S1 to preheater and set control instrument to maintain minimum temperature 165°F. *

   Open micro valve MV1 turns and admit liquid to the evaporator.

   Start first effect milk pump M4 and open micro valve MV2 turns.

Start second effect milk pump M5 and open micro valve MV3 turns.

Start third primary effect milk pump M6 and open micro valve MV4 turns.

Start 3rd finishing effect milk pump M7 and open discharge micro valve MV5 turns.

When liquid is being discharged from third finishing effect milk pump M7 the steam may then be turned on to the recompression booster, at valves S2 or S3. For skim milk the large booster is used with steam supplied at S2, and V7 fully open and V8 tightly closed. For whole milk the small booster is used with steam supplied at S3 and V8 fully open and V7 tightly closed.

When evaporator is operating on all effects (this will take several minutes) consult flow sheet at back of instruction manual for design temperatures and conditions. The effect temperatures on water should show 5^{o} - 10^{o} lower than when operating on milk.

With evaporator operating on all effects, adjust micro valve MV2 to be open turns and micro valve MV3 to be open turns and micro valve MV4 to be open turns to maintain the minimum level of liquid in the discharge cone at the bottom of the separators. The Evaporator is now ready to receive milk.

5. Replace the flow water with milk, making sure that no air or foam is admitted into unit. Continue operation until all water has been discharged from evaporator and run to the drain.

The evaporator is equipped with a continuous reading refractometer to enable easy determination of discharge solids when starting up, readings should be taken every few minutes and setting of micro valve MV1 adjusted to give desired discharge density.

6. When the machine is discharging product at the desired solids concentration, 3 way valve V6 should be adjusted to discharge to concentrate tank, the machine will run with very little attention until the termination of the run if steam pressure is held constant and there is no deviation or interruption to the feed to the machine.

Feed to the machine is regulated of course by the setting of micro valve MV1 in the feed line, and small adjustments to this valve, to either raise or lower the discharge concentration, will effect discharge solids by several per - cent, so be sure to allow adequate time for any adjustment to take effect.

7. SHUT DOWN OPERATION

When the feed supply is nearly exhausted and the evaporator is to be shut down run water into the feed tank and continue operation until the solids of the discharge concentrate become diluted, then divert discharge from evaporator to drain and continue to run water until evaporator has been adequately rinsed free of milk. The evaporator is now ready for cleaning operation.

8. HIGH TEMPERATURE OPERATION SKIM MILK

The start-up and shut down procedures are basically the same as for low temperature operation. The temperature controller on the Instrument Panel should be adjusted to 190 °F, the through put of milk through the evaporator will increase slightly.

9. WHOLE MILK OPERATION

When the Blaw Knox Falling Film Evaporator is required to process both whole milk and skim milk in a balanced operation with a Spray Dryer, it would have been originally equipped with two separate steam boosters, the larger one is used for the skim milk operation and the small one for the whole milk duty. Care should be taken to ensure the booster not used is completely isolated by the appropriate valve V7 or V8. This is because the higher solid content of the whole milk, which would then require a reduction in through put to balance the Spray Dryer capacity.

Start-up and shut down procedures are the same as for skim milk, however, milk pump micro valve settings will be different and these will be determined at the initial start-up of the equipment. Valve settings should be MV1 turns, MV2 turns, MV3 turns, MV4 turns, MV5 turns. Cleaning procedures will be as described for skim milk and again the strength of the cleaning solution will depend on the degree of fouling of the tubes.

OPERATION CLEANING

Faulty cleaning of evaporators and preheaters has probably damaged more equipment manufacturer's reputations than any other single thing.

Cleanliness determines the efficiency of the evaporator or preheater operation, but in all too many instances, the operator of a plant falsely believes that the use of cleaning compounds be restricted in order to conserve money. Upon investigation, it will be revealed that cleaning compounds are inevitably the cheapest item in a dairy plant. If the proper amount of cleaning compound is not used, the equipment is not clean. If the equipment is not clean , a loss of heat transfer results, in a lower processing capacity. Also, unclean equipment is the index to bacteria growth in the product which results in a rejection of the product by the purchaser.

? MANUFAC. EXCLUS.

The fundamentals of cleaning evaporating and heating equipment are simply: -

1. Time
2. Temperature
3. Concentration of the cleaning solution

To aid the above fundamentals we recommend to first adequately rinse the equipment with water. This is done by finishing off the operation on water as described in Section 7 of "Start-Up and Shut-Down Operation".

Caustic soda is the main substance of cleaning and the concentration should be $1\frac{1}{2}\%$ to 5% of the solution. The actual amount will be determined by how badly fouled the heat exchange surfaces are.

93°C

It is a known fact that the cleaning properties of caustic soda are poor at temperatures below 180°F. The preheat of the caustic and the temperature inside the machine, should be maintained at this minimum figure.

The time allowed for cleaning is such that complete cleaning is attained. This point again is contingent upon the degree of fouling of the equipment.

Blaw Knox does not assume the responsibility of recommending cleaning procedures or the various trade name chemicals available. This responsibility would properly rest with those people who sell the cleaning compounds.

The falling film evaporator is generally best cleaned by the circulation principle or in effect the continuation of the normal process of operation taking into account the facts established earlier in this section of operation cleaning and as follows:-

1. When the evaporator is adequately rinsed with water, the discharge may then be returned to the feed tank and recirculated.

2. A caustic solution is then added to the feed tank of sufficient concentration to ensure adequate cleaning. It will be found necessary to continue to add water equal to the rate of evaporation to maintain a constant level in the feed tank.

3. Set preheater control instrument at 180°F and slightly open vacuum break at first effect separator and admit sufficient air to drop and maintain condenser vacuum at 18". This in turn will raise the temperature in the first effect separator to approximately 190°F at which the caustic solution will have most effect.

4. Continue the operation under these conditions for approximately one hour. This time of course will vary as to the degree of fouling of the tubes.

5. Close vacuum break and allow evaporator to attain normal vacuum conditions, divert discharge from feed tank to drain and add additional water to feed tank to maintain level.

6. When all caustic solution has been discharged from evaporator and caustic free water is being discharged, recirculate discharge back to feed tank.

7. Add to feed tank a solution of inorganic acid and set preheater control to 160°F maximum, or as recommended by suppliers to remove the "Milk Stone" as this substance will not come out with caustic.

8. Allow this acid solution to recirculate for approximately 15 minutes then follow with water until all acid has been discharged from evaporator.

9. Shut off steam valve S2, S3 and S1 to recompression boosters and preheater. Shut off steam valves S4 and S5 to ejectors and open vacuum breaks at separators,

Switch off all milk pumps.

Turn off cooling tower, tailpipe and condensate pumps.

Turn off seal water to all pumps.

Turn off water valve to condenser and intercondenser.

..*.*.*.*.*.*.*.*

CAUTION:

Never use cold water on hot stainless steel as the rapid contraction of the metal will often result in a hard-to-find and hard-to-mend crack. This is particularly true on tubular preheaters and evaporators.

With a little thought about the cleaning procedure, a permanent cleaning arrangement can be set up so that to change from milk processing to cleaning, the simple turning off valves is all that is necessary.

We have talked about cleaning the product side of the evaporate and preheater. The other side, the steam side, is just as important.

On countless occasions, it has been found that slowly reducing capacities in a preheater or evaporator is directly traceable to an accumulation of boiler scale and rust on the steam side of the heat exchange surface. The deposits occur only because of the high mineral content of the steam produced by the boiler. Ordinarily, proper boiler water treatment holds this condition at a low level, but many dairy plants have poorly run boiler facilities and often do not know the condition of the steam produced.

When a condition of scale and rust is evident, it will require extensive cleaning of the surfaces with special chemicals to remove the deposit.

..*.*.*.*.*.*.

WHEN EVAPORATOR FAILS TO OPERATE CORRECTLY

Vacuum Fails to Build up in Evaporator

1. Steam pressure to ejector too low. Pressure at gauge must not be less than shown on name plate.

(a) Steam supply valves to ejectors not fully open.
(b) Screens in strainer in steam line to ejector may be plugged.
(c) Boiler pressure too low or valve in steam line partly closed.

2. Wet steam supply to ejectors.

3. Restriction in exhaust line from second stage ejector, or single stage ejector.

4. Valves in lines to condenser may be closed.

5. Too much water to ejector intercondenser, condenser flooding. Water valve open too wide. Not enough water to ejector intercondenser to condense steam from first stage ejector.

6. Steam nozzle of ejector plugged.

7. Manhole covers on separator not properly sealed, check gaskets.

8. Steamchest covers not clamped tight, check gaskets.

9. Covers on vapour pipes not tightly closed.

10. Leaks in sanitary piping.

11. Liquor inlet valve not fully closed or does not seat properly.

12. Liquor discharge valve not fully closed or does not seat properly.

13. Packing glands on condensate and tailpipe pumps not tight. Valve for water seal not opened.

14. Leaking check valve on discharge side of condensate pump.

15. Not enough water in sump for seal on barometric type condenser.

16. Leaking check valve on tailpipe pump discharge.

17. Leaks on observation glasses.

No Vacuum in First or Second Effect Separator

1. Vent valve closed. Should be approximately ½ to ¾ of a turn open.

2. Feed valve open or leaking. Should be closed and tight.

3. Manhole cover, steamchest covers and cover on vapour pipe not tight, check for faulty gaskets.

4. Check valve on second or third effect condensate pump leaking.

5. Vacuum break valve not tight.

6. Light glass and observation glasses not tight.

7. Sanitary piping leaking.

8. Leak in seal of second effect condensate pump, sealing water not turned on.

9. Leak in stuffing box of vent valve.

No Vacuum in First Effect Steamchest

1. Vent valve must be open approximately ½ turn.

2. Main steam valve open or seat leaking.

3. Leak in seal of condensate pump or sealing water not turned on.

4. Leak in seal of stuffing box of vent valve.

5. Leaking check valve in condensate pump discharge.

6. Safety relief valve not seating properly.

Vacuum Builds up too Slowly

1. Air leakage.

(a) Fluid lines not tight.
(b) Manhole covers on separator not properly seated.
(c) Steamchest covers not properly seated.
(d 'over on vapour pipe not properly seated.

2. Wet steam to ejectors.

3. Steam pressure to ejector too low.

(a) Steam supply valves not fully open.
(b) Screen of strainer in steam line to ejector partly plugged.
(c) Boiler pressure too low or valve in steam line partly closed.

4. If this is gradual over a period of time, it may be due to nozzle wear or lime build up in the venturi of the ejector.

If it is necessary to keep increasing steam pressure to ejectors, it is a sign the ejectors may need replacement parts.

The ejectors should be closely inspected for wear at this time.

Foaming in First and Second Effect Separator

1. Air leaks in feed inlet piping.

2. Too sudden rise in steam pressure. This may be due to faulty regulator operation.

3. Air mixed into product in hot well or feed tank.

4. High acid product.

5. Insufficient steam to steamchest to keep foam down.

6. Leak in steamchest cover.

7. Leak in manhole cover.

8. Leak in liquor piping between separator and feed pump.

Foaming in Third Effect Separator

1. Air leaks in line to discharge pump or in pump itself.

2. Air leaks in sanitary piping from second effect to third effect.

3. Leak in steamchest cover.

4. Leak in manhole cover.

5. High acid product.

6. Fluctuating vacuum.

Loss of Vacuum When Steam is Turned On

1. Insufficient condenser water.

2. Too much steam for condenser capacity.

3. Vacuum not up to operating vacuum in entire machine before turning on steam.

Evaporator Slows Down or Stops

1. Insufficient steam to first effect steamchest.

2. Milk feed to evaporator too cold..

3. Vacuum dropped (see sudden loss of vacuum).

4. Condensate build up in steamchest caused by pump failure to remove condensate.

5. Dirty tubes.

6. Vent valves may be closed or not open enough.

7. Feed pump stopped.

Sudden Loss of Vacuum

1. Insufficient cooling water to condenser or intercondenser.

2. Air drawn in from source of condenser water supply.

3. Steam pressure to ejectors dropped below design operating pressure indicated on name plate.

4. Wet steam to ejectors.

5. Feed tank empty allowing evaporator to draw air.

6. Sudden leak in sanitary piping or pumps.

Vacuum Fluctuates

1. Wet steam to ejectors.

2. Too much cooling water to intercondenser, valve open too wide.

3. Improper installation of condenser tailpipe.

4. Improper installation of ejector intercondenser tailpipe.

5. Fluctuating steam supply.

6. Fluctuating water supply.

7. Fluctuation of milk supply.

Water in Tailpipe Surges

1. No seal water to tailpipe pump.

2. Tailpipe pump packing leaks.

3. Leaking check valve in tailpipe pump discharge.

4. Pump speed not constant.

5. Condenser water flow too great.

6. Condenser water flow too low.

7. Vent line from pump not correctly attached, pump loses priming.

8. Vacuum fluctuating caused by ejector or condenser troubles.

Water Run-Back from Condenser to Third Effect Separator

1. Too much condenser water.

2. Tailpipe pump speed below normal.

3. Free discharge from tailpipe pump impaired.

4. Air leak in tailpipe pump suction.

5. Tailpipe pump fails.

Evaporator Operates at Low Capacity

1. Low steam pressure to evaporator.

2. Insufficient preheat of milk.

3. First effect of recompression type operating below design temperatures so booster does not handle full vapour pick-up. Boosters are designed and factory tested to handle the exact designed load of steam and vapour. This being the case, if operation is exactly at design preheat and first effect temperature and booster steam pressure, the evaporative capacity of the machine will be exactly as it has been designed. Under these conditions there is no possibility of an under production on a properly designed machine.

4. Insufficient water to condenser.

5. Fouled tubes, either inside or outside of tubes.

Raising or Lowering the Capacity of the Evaporator

To increase capacity, the milk may be preheated to a higher temperature and/or the steam pressure to the booster may be increased above the design pressure. This will of course cause the first effect temperature to rise to a higher level. To decrease capacity throttle the steam pressure to the evaporator below the design conditions. On recompression type machines the recompression boosters will continue to operate quite well when throttled to 85% of the design pressure. When running below design capacity it is normal for the first effect temperature to run lower.

SKIMMED CONDENSED MILK

BAUME	110°F. Solids%	120°F Solids%	130°F. Solids%
8	17.55	18.04	18.50
8.5	18.50	18.98	19.44
9	19.45	19.92	20.38
9.5	20.39	20.87	21.34
10	21.34	21.82	22.30
10.5	22.29	22.77	23.25
11	23.26	23.73	24.19
11.5	24.19	24.67	25.15
12	25.14	25.62	26.10
12.5	26.09	26.57	27.04
13	27.03	27.53	27.97
13.5	27.98	28.47	28.94
14	28.93	29.41	29.90
14.5	29.88	30.35	30.84
15	30.83	31.30	31.78
15.5	31.78	32.24	32.73
16	32.77	33.19	33.68
16.5	33.68	34.14	34.62
17	34.62	35.09	35.57
17.5	35.57	36.05	36.52
18	36.52	37.00	37.47
18.5	37.47	37.95	38.42
19	38.42	38.90	39.37
19.5	39.37	39.90	40.32
20	40.32	40.79	41.27
20.5	41.27	41.73	42.21
21	42.21	42.69	43.16
21.5	43.16	43.64	44.11
22	44.11	44.58	45.05
22.5	45.06	45.53	46.01
23	46.01	46.48	46.96
23.5	46.96	47.43	47.90
24	47.91	48.38	48.85
24.5	48.85	49.33	49.80
25	49.80	50.28	50.75