

Appendix 1: Quintuple vessels configuration and Evaporator control philosophy.

In operation, the quintuple consists of a single evaporation line with two new Kestner vessels as first effect, one Kestner as second effect (in phase 3, one more Kestner will be installed for second effect) three Robert evaporators as third effect and two tails of fourth and fifth effect made up of three and four different Robert vessels. Juice/syrup will flow in series while steam and vapour will be connected in parallel to vessels of the same effect. Kestner 1C will either be used as first effect or second effect if not stopped for cleaning. Only one of the four Kestner can be stopped for cleaning at any one time.

Robert evaporators 3A, 3B and 3C will always be used as third effect, any two will be in operation while the third will be stopped for cleaning.

The two fourth and fifth effects tails will consist of Robert evaporators 4.1, 5.1A and 5.1B from the DL set and Robert evaporators 4.2, 5.2A, 5.2B and 5.2C from the JBH set. One set will be in operation while the other will be stopped for cleaning

When starting and stopping for cleaning, juice, vapour and condensate isolation and by-pass valves are opened or closed in the right sequences & delays to fill the vessels and bring it on range without disturbing the evaporator vapour equilibrium, syrup brix and flow rate. These are automated. However, some operations such as locking of isolation valves closed, venting and draining vessels are done manually *in-situ* to prevent accidents.

Control philosophy

Steam pressure in the first effect shall be controlled to keep constant V1 (or V2 control option) by adjusting flow of exhaust steam to the evaporator. Level of evaporator vessels are maintained by controlling the juice/syrup discharge valves.

Brix from the fourth effect will be controlled by adjusting flow of V3 to the fourth effect. Syrup extraction from the fifth effect will be controlled by brix syrup from the fifth effect outlet. High and low level inside last vessel will be used to override brix measurement to control syrup extraction.

The vacuum on the fifth effect will be controlled by throttling the flow of injection cooling water to the condenser. However, the maximum valve opening shall be limited by condenser tail pipe temperature (five degrees) to avoid flooding the condenser.

As a safety measure to prevent high brix syrup, the vapour space pressure of the fifth effect shall be increased to keep brix to below 69. A maximum shall be set (say 30 kPa) to ensure that a minimum vapour pressure is maintained to keep a pressure gradient across the evaporator set.

Condensate accept/reject

Online conductivity meters are installed on condensate pots 1A, 1B, 1C and 2A to determine whether condensate is pure enough to be sent to the boiler feed water tank.

Maximum conductivity levels to reject condensate and duration of condensate reject at start-up can be set in the SCADA.