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An Evaluation of the Evaporative Performance of the Xinivane Round and Horizontal A-Massecuite Continuous Vacuum Pans

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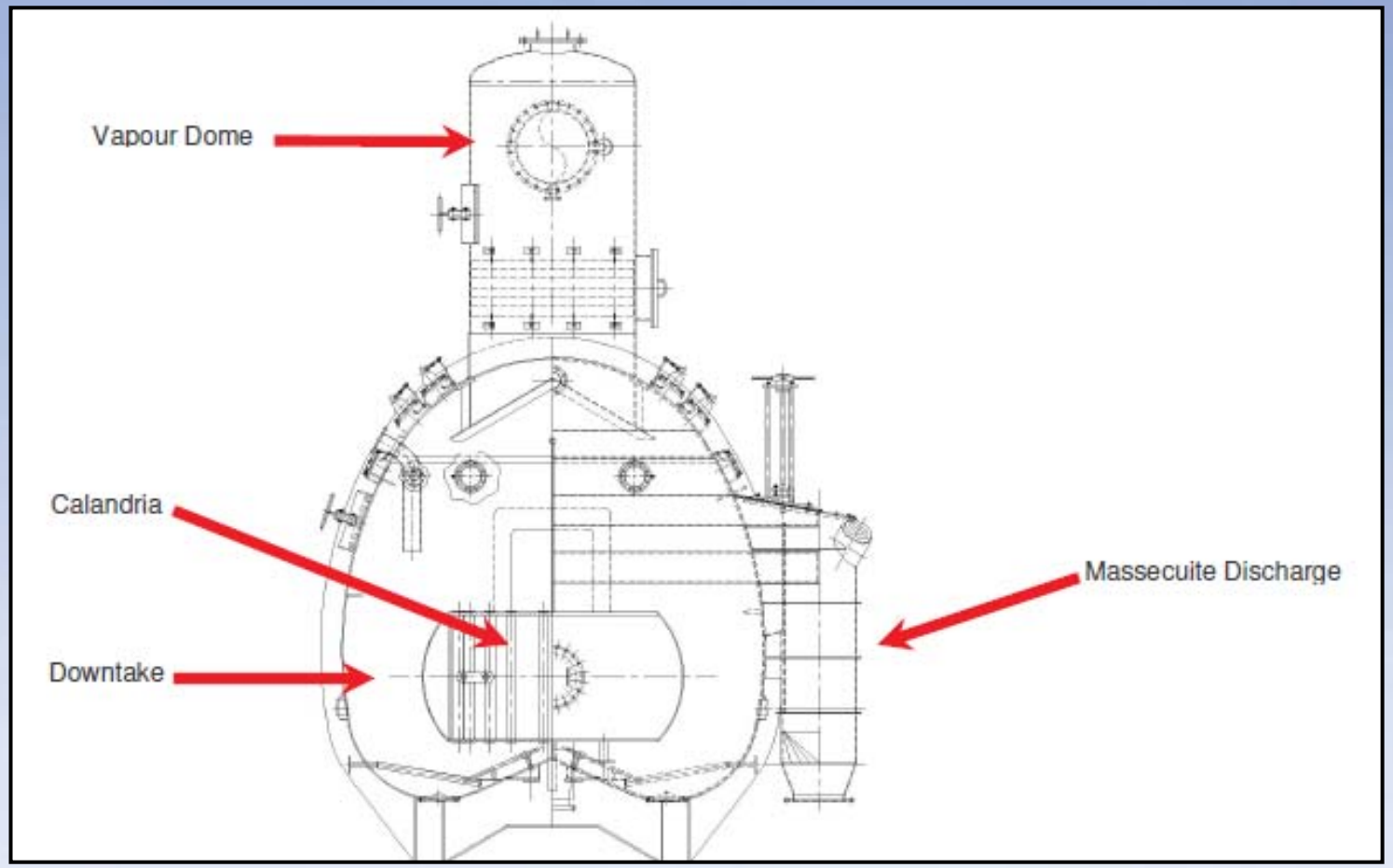
Introduction

- A new design of continuous vacuum pan (CVP) has been developed by Tongaat Hulett Sugar (THS).
- An A-CVP of this new design and has been installed at the Xinavane factory (XN) in Moçambique and operates in parallel with a CVP of the original THS design.
- This presentation gives the results of some evaporative performance evaluations carried out on the two CVPs during the course of a visit paid to XN in 2012.

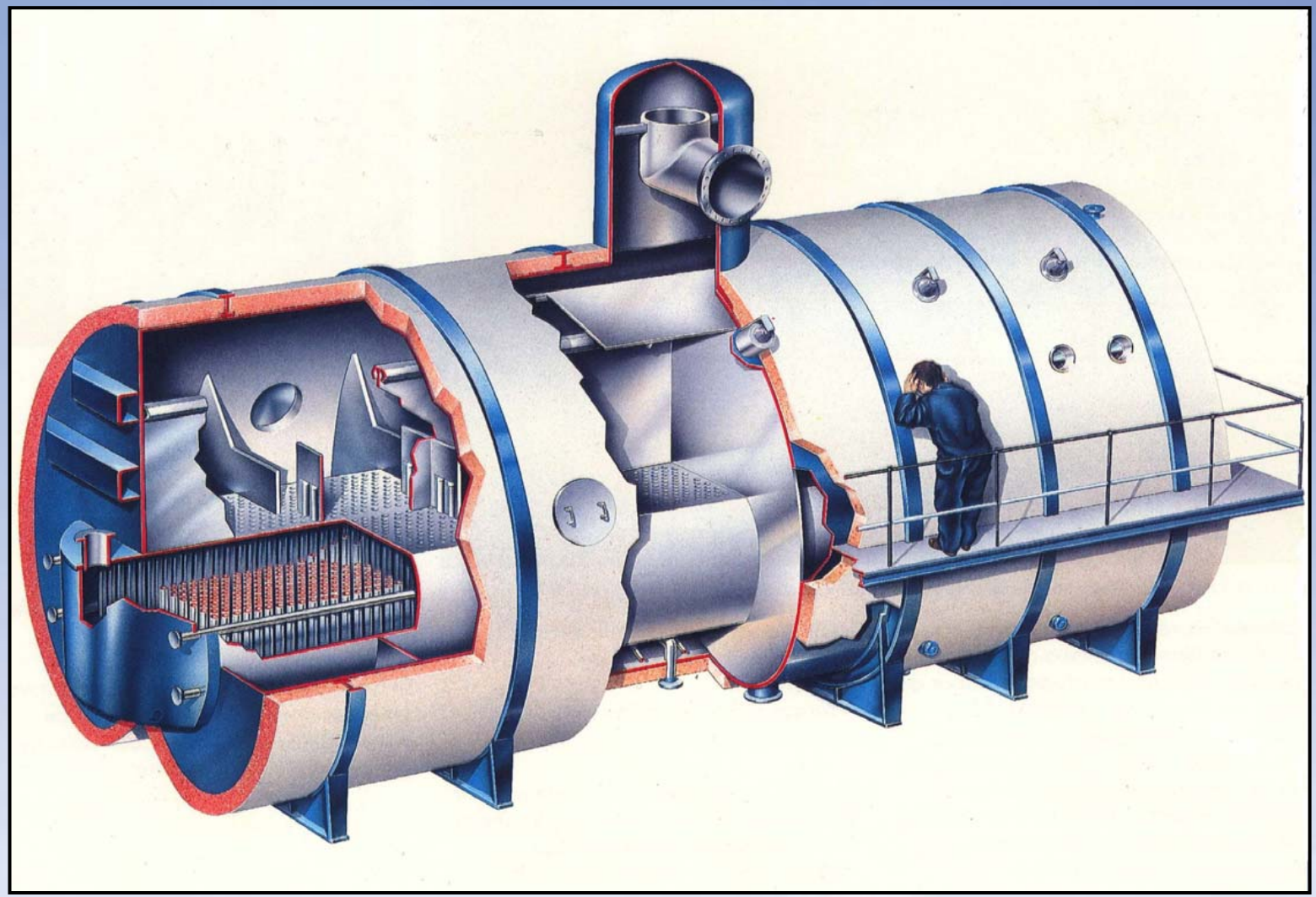
CVP Descriptions – Original THS Design

- The original THS design of CVP has been very successful and a large number have been installed in a multitude of countries around the world.
- This CVP's design features and operational performance has been the topic of many technical papers and presentations, which means the essential design features of this CVP are consequently well known to most sugar technologists:-



Original THS Design (Fletcher-Smith CVP Illustration)

- A successful technology agreement between THS and Fletcher Smith has added to the original THS design of CVP's worldwide distribution and familiarity.



XN CVP Specifications – Original THS Design

- *The original THS CVP design is called a horizontal CVP (H-CVP) at XN to distinguish it from the new CVP design.*
- The XN A-massecuite H-CVP is a 75 m^3 unit and was installed in 2004 as part of an expansion to take the factory to a 150 tch crushing capacity.
- The CVP has a nominal 750 m^2 heating surface with 1,365 mm long tubes having a standard 4” diameter.
- The CVP has a single calandria and 12 cells.

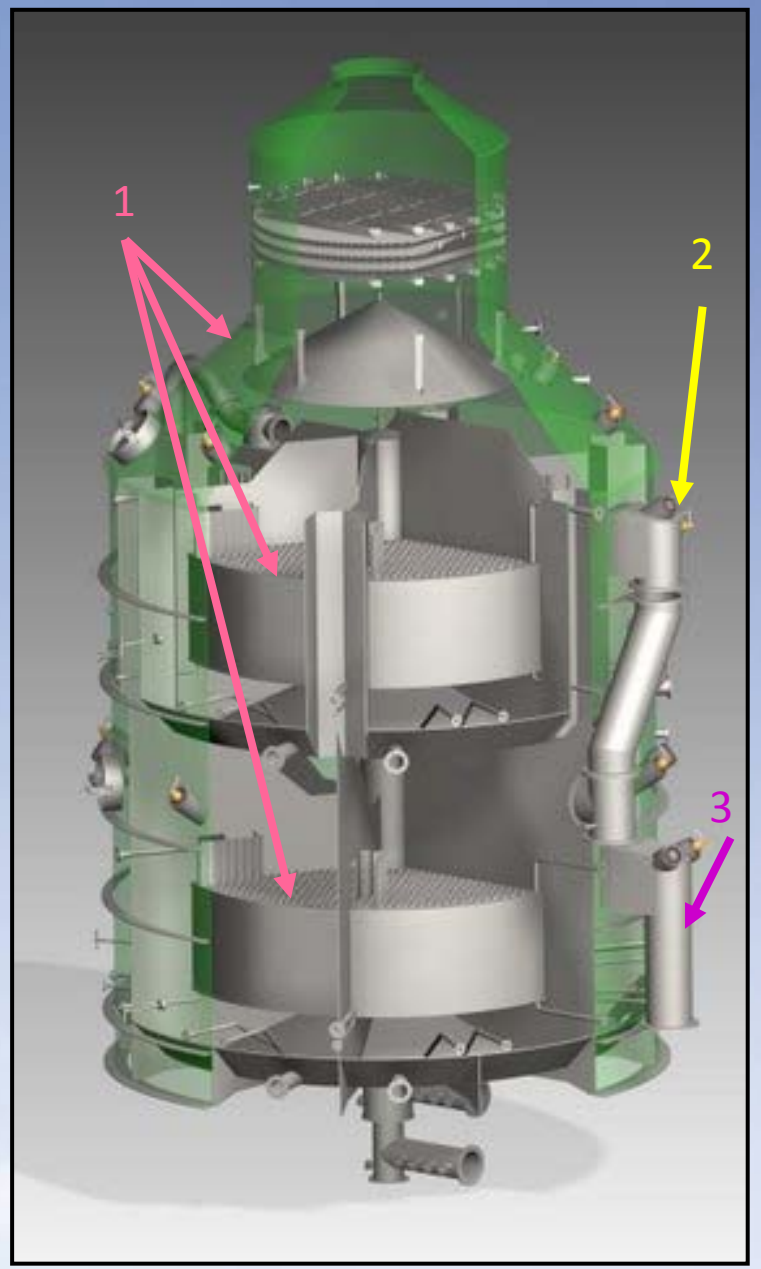
XN CVP Specifications – New Design

- *The new design of THS CVP is commonly referred to as the Round Pan design and so for purposes of this presentation will be called a Round CVP (R-CVP).*
- The XN A-massecuite R-CVP is a 120 m^3 unit and was installed in 2009 as part of an expansion to take the factory up to a 380 tch crushing capacity.
- The CVP has a nominal 1,200 m^2 heating surface with 1,350 mm long tubes having a standard 4” diameter.
- The CVP has two calandrias and 12 cells.

Round CVP Description and Illustration

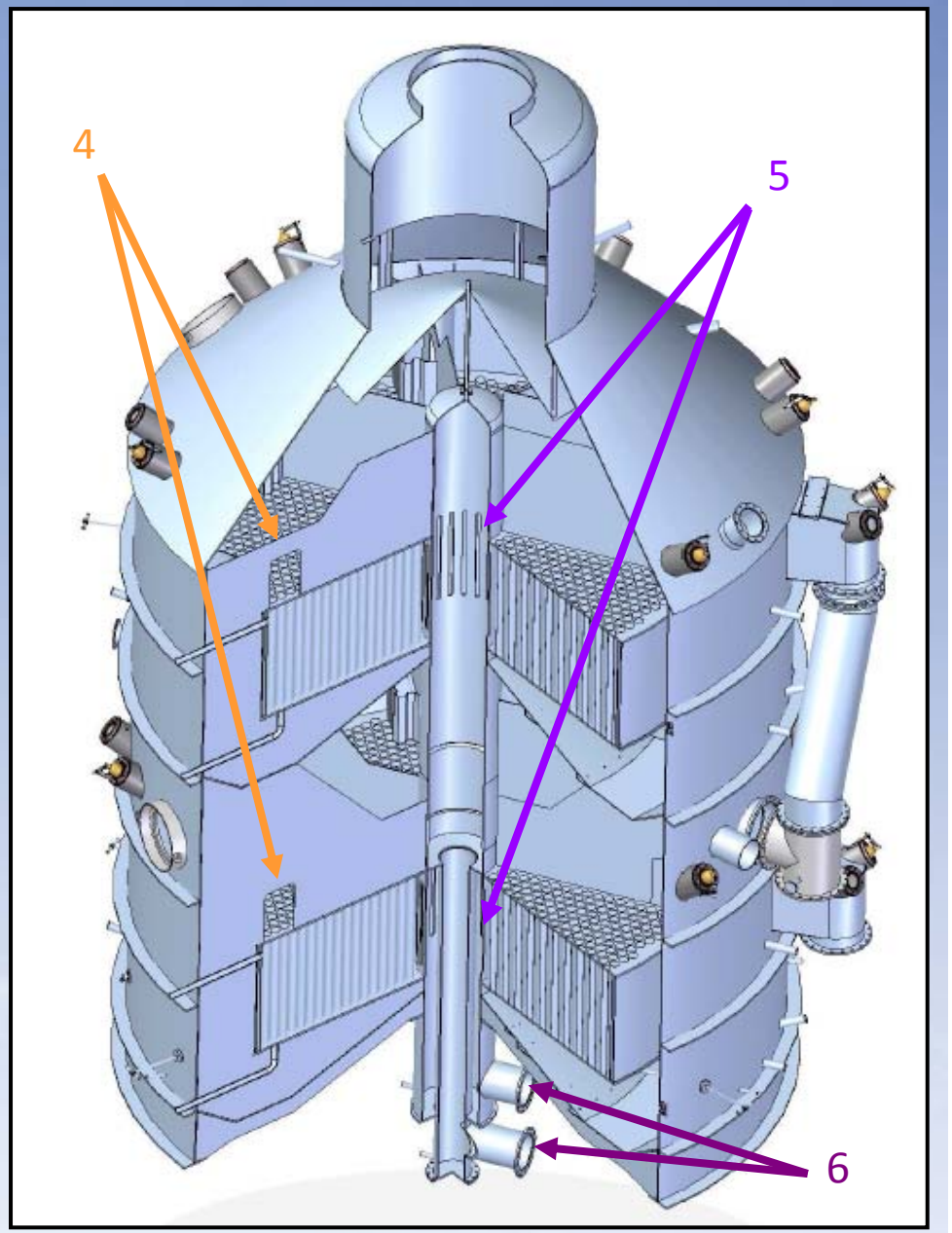
The main features of the R-CVP are;

- A circular (round) construction, with two floating calandrias stacked one above the other. (1)
- Each calandria section has six cells with down-takes located at the vessel periphery.
- Seed massecuite is pumped into cell 1 located in the top section.
- An overflow weir in cell 6 delivers massecuite to cell 7 in the bottom section (2).
- Product massecuite leaves cell 12 via an overflow weir into the discharge pipe (3).



Round CVP Description and Illustration

- Massecuite passes from one compartment to the other in a similar manner to the H-CVP (4).
- Steam enters each calandria through a central steam pipe running vertically through the centre of the pan(5).
- Each calandria has its own separate steam supply and control valve(6).
- The R-CVP has a common interconnected vapour space and a single condenser.



CVP Evaporation Rate Evaluations

- The principal objective of pan design is to obtain good evaporation and circulation rates.
- Since it is not possible to measure massecuite circulation in a pan directly it is commonly inferred from the rate of evaporation.
- It can therefore be assumed that a pan that has a good evaporative performance should have both a good capacity and good circulation.
- Common practice is to infer the rate of evaporation from the flow of pan condensate.

Batch Pan Evaporation Rate Comparisons

- Comparing evaporation rates requires them to be calculated on a per unit area of heating surface basis.
- This is most commonly referred to as a specific evaporation rate (SEV) and reported in units of kg/(h.m^2).
- The following table gives an idea of range of batch pan SEVs;

	SEV in kg(h.m^2)	
	Start of boiling	End of boiling
Grain / Seed	61.0	8.2
A-massecuite	38.0	22.0
B-massecuite	25.0	6.2
C-massecuite	18.0	3.5

Source: Rein PW (2007). Cane Sugar Engineering. Verlag Bartens, Berlin

CVP Evaporation Rate Comparisons

- Rein (SASTA, 1986) has reported the following design SEVs were used for the CVPs at the THS's Felixton factory;
  - A-massecuite : 22 kg/(h.m^2)
  - B-massecuite : 10 kg/(h.m^2)
  - C-massecuite : 7.5 kg/(h.m^2)
- For further refinement of evaporation rate comparisons the temperature difference between the heating steam and massecuite needs to be considered (ΔT).
- Rein and Msimanga (ISSCT, 1999) have reported the following correlation for THS H-CVPs boiling A-massecuite.
  - A-massecuite SEV = 0.28 * ΔT + 11.3 ……..(Eqn 1)

Grade of Vapour Supply	V1	V3
Calandria steam pressure (kPa abs)	151	82
Steam to Massec ΔT (°C)	47.5	30
A-massec. H-CVP SEV - kg/(h.m^2)	24.6	19.7

Evaporation Rate Assessment

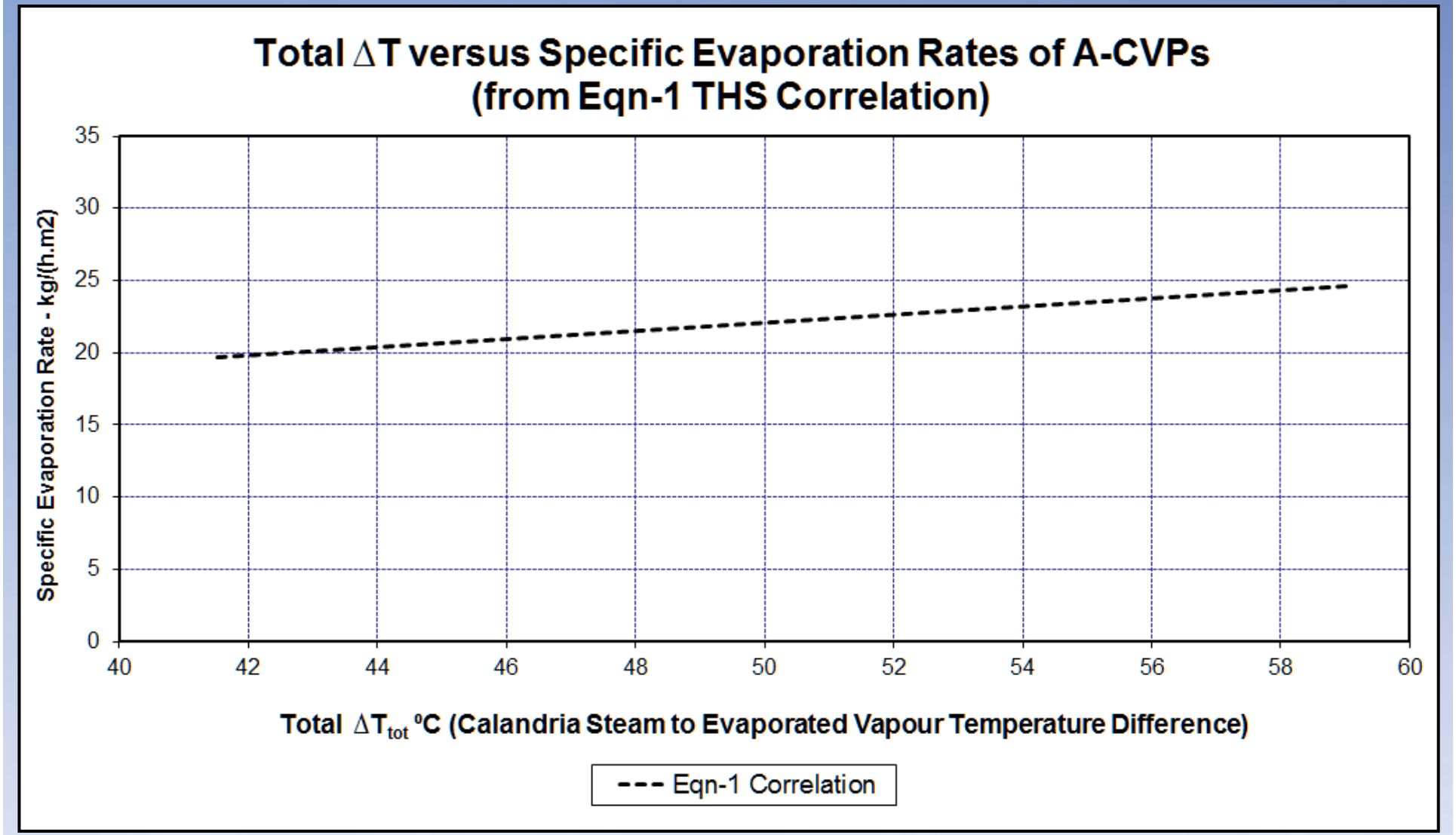
- Determining massecuite temperature in a factory is often difficult giving problems with “Steam – Massecuite ΔT” calculations.
- Modern pressure transmitters give easy & more reliable measurement - these values can in turn easily be converted to the equivalent “saturation” temperatures to give a “Steam to Vapour ΔT” value.
- “Steam to Vapour ΔT “ values do not account for several effects the most significant of which, in pan boiling, is the boiling point elevation.
- Despite these limitations “Steam to Vapour ΔT” (ΔT_{tot}) values can be usefully used for evaporation rate comparison and the simplicity of collecting and calculating results makes it a practical parameter to use.

A-CVP Eqn 1 - SEV ΔT and ΔT_{tot} Evaluation

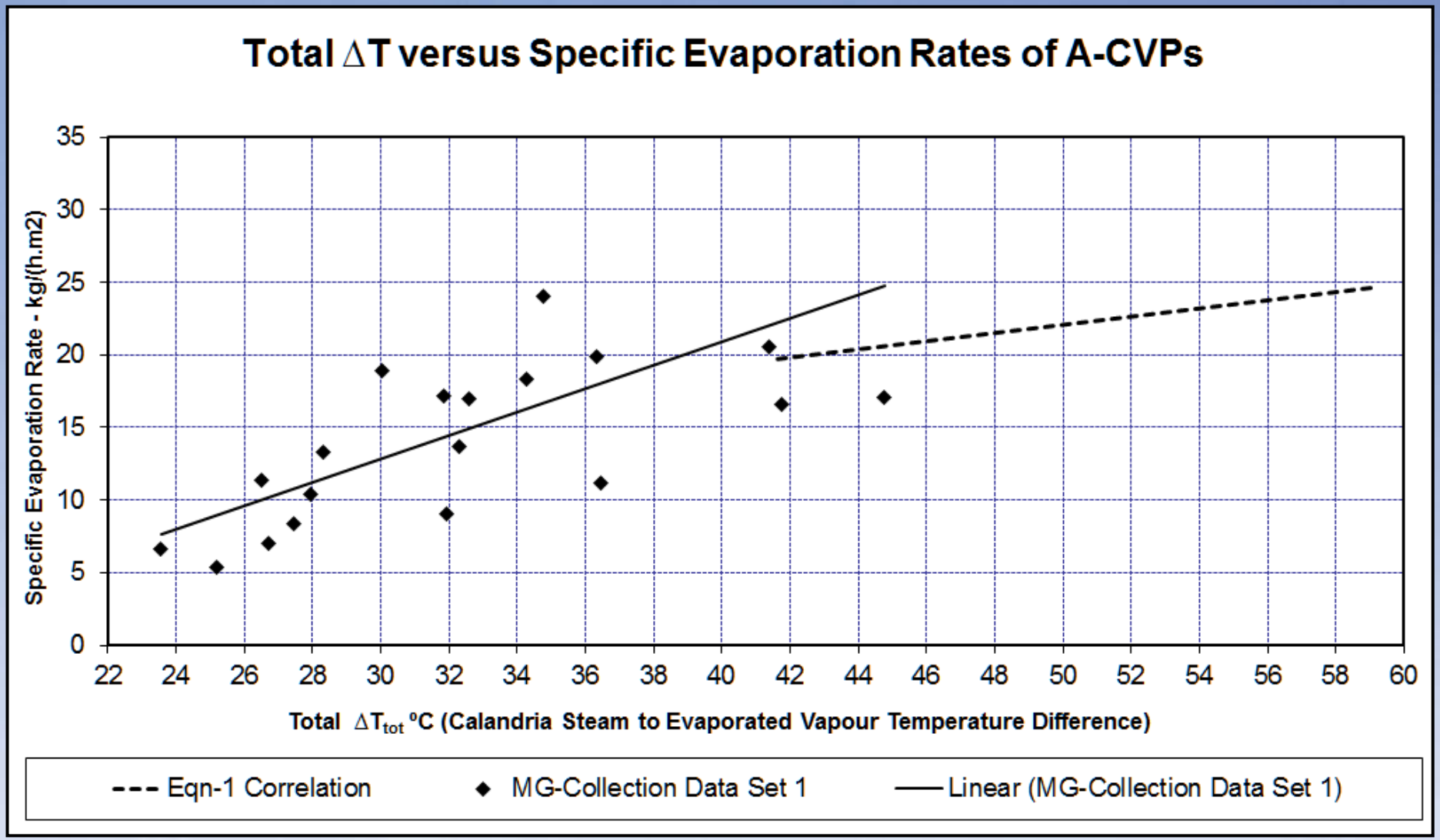
The Eqn-1 correlation can be converted to a "Steam – Vapour ΔT" (ΔT_{tot}) value by assuming a typical Boiling Point Elevation value for an A-massecuite.

Grade of Vapour Supply	V1	V3
Calandria steam pressure (kPa abs)	151	82
Steam to Massec ΔT (°C)	47.5	30
Boiling Point Elevation (°C)	11.5	11.5
Steam to Vapour ΔT (°C)	59.0	41.5
A-massec. H-CVP SEV - kg/(h.m^2)	24.6	19.7

A-CVP Eqn 1 - SEV vs ΔT_{tot} Illustration



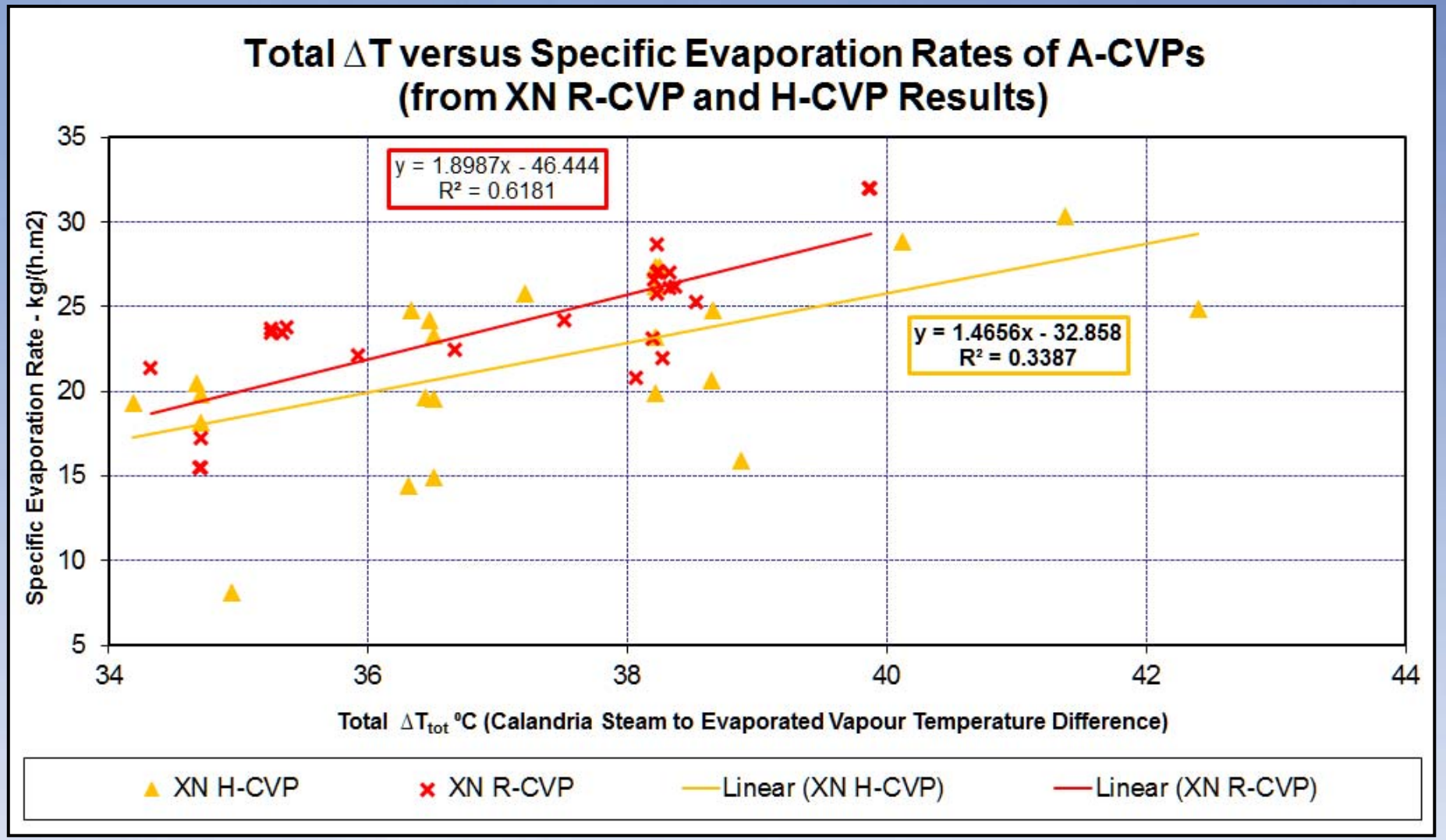
MG Collection of A-CVP SEV vs ΔT_{tot} Values



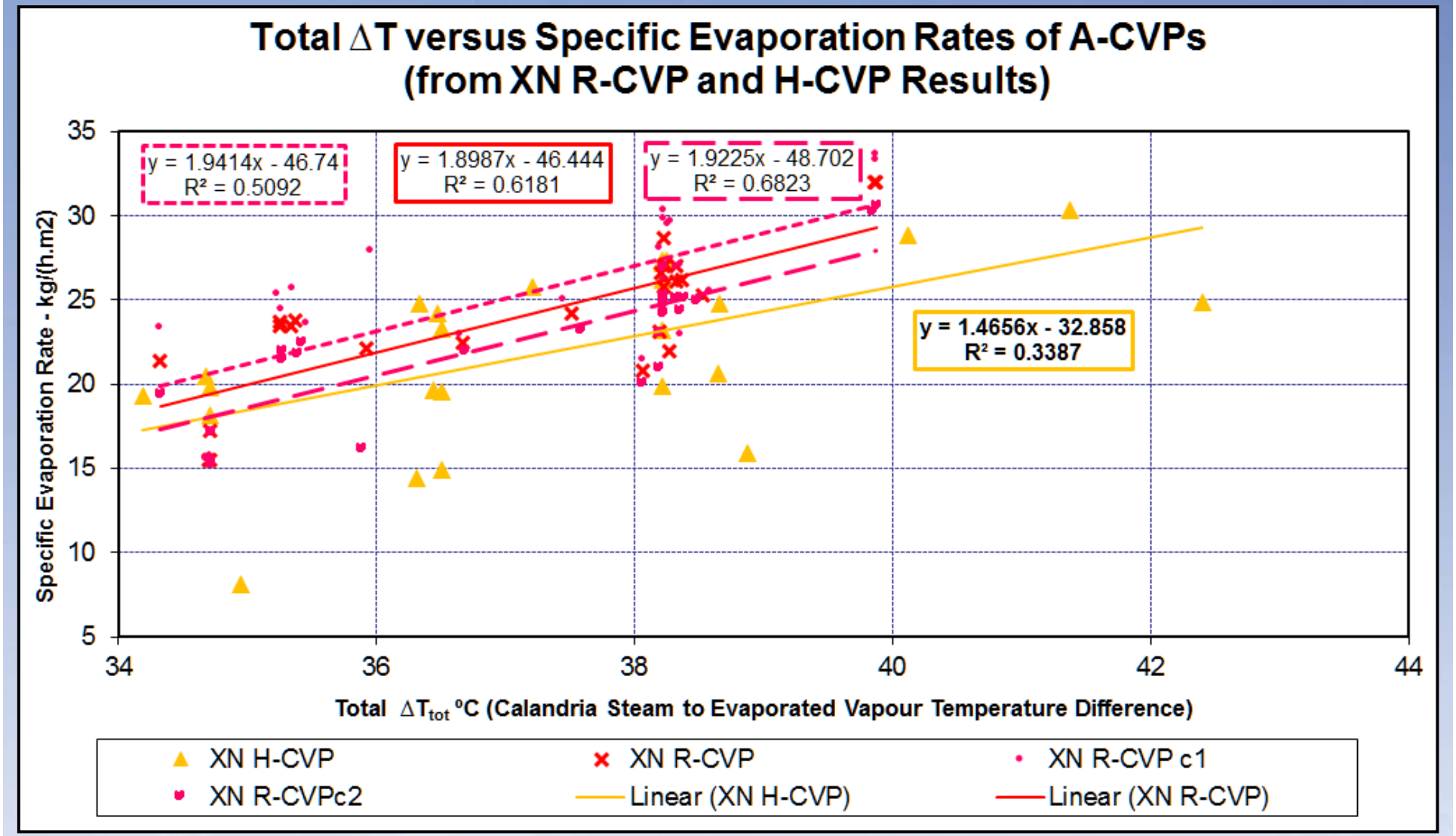
XN SEV and ΔT_{tot} Evaluation

- Condensate flow measurements were used for assessing the XN CVP evaporation rates and converted appropriately from volumetric to mass flows.
- The ΔT_{tot} values were calculated from the CVP calandria and vapour space pressures.
- The condensate flows meters and pressure gauges were all checked and assessed before the assessments were started.
- XN has a powerful “Plant information Management System” called Exaquantum which was used to download the relevant data point values at 30 second intervals during the 24 hours of the evaluation test.
- During the test period no jigger steam or movement water was used in either CVP and the CVPs had been recently cleaned.
- The downloaded Exaquantum data from the tests was averaged and sorted into a series of 1 hour periods.
- These 1 hour averages were selected only for periods where both CVP calandria and vapour space pressures were steady, at normal operating levels and no set-point changes had been made.

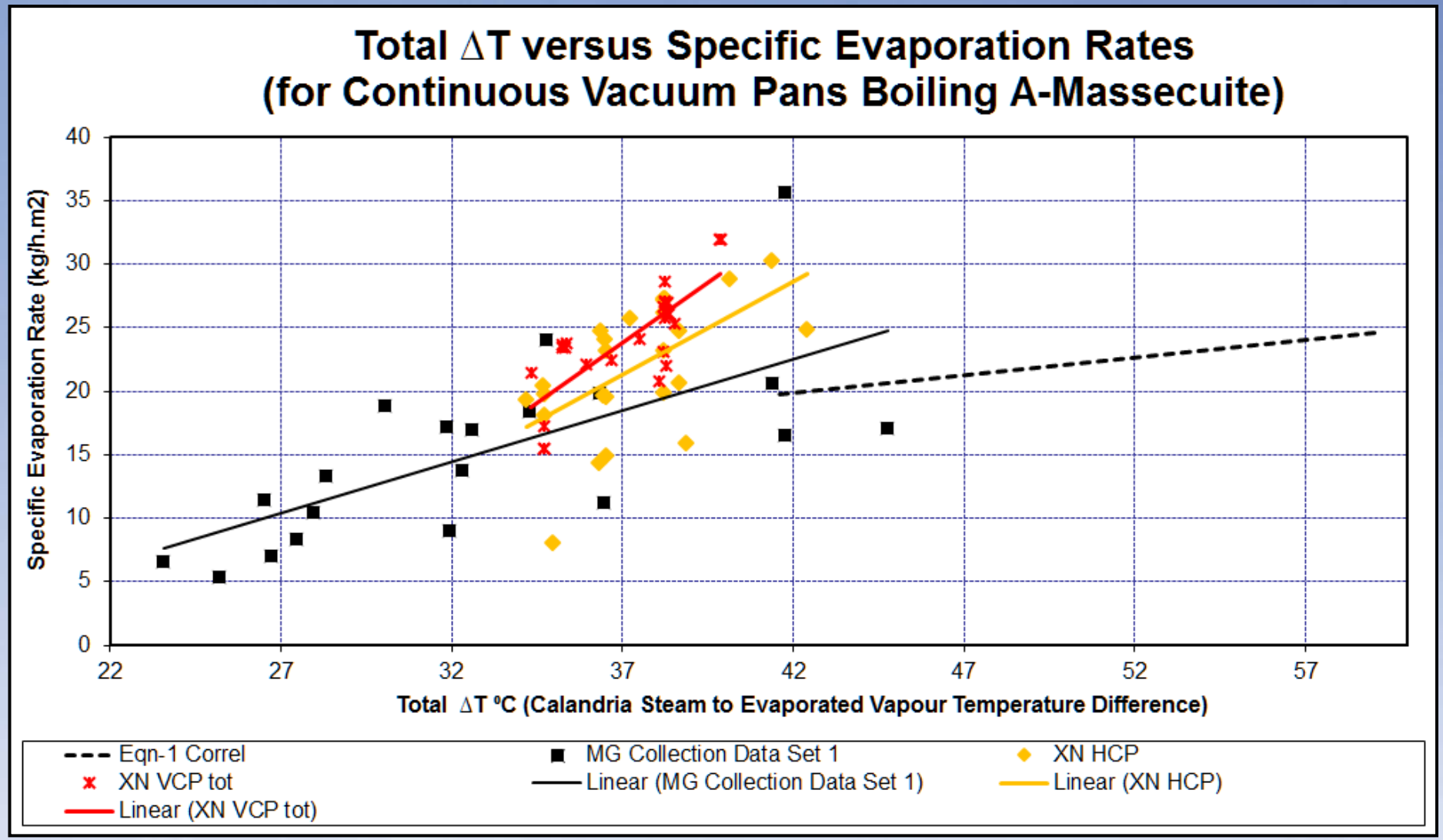
XN A-Massecuite CVP SEVs vs ΔT_{tot}



XN A-Massecuite CVP SEVs vs ΔT_{tot}



XN A-Massecuite CVP SEVs vs ΔT_{tot}



Conclusions

This evaluation of the evaporative performance of the XN A-CVPs has shown that;

- The R-CVP calandria no. 1 results gave the best evaporative performance.
- The R-CVP total pan produced the 2nd best results.
- The R-CVP calandria no. 2 produced the 3rd best results.
- The H-CVP produced the 4th best results.
- Massecuite quality (i.t.o. brix, purity, viscosity etc.) also significantly influences SEVs – so no firm conclusions can be drawn between these XN results and the Eqn-1 correlation of Rein and Msimanga or the “MG Collection Data Set 1”

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Acknowledgements

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