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PROCESSING SYSTEMS **THAT KNOW NO BOUNDARIES**

Thermosyphon wort boiling – new plants and their impact on flavour stability

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San Francisco, California

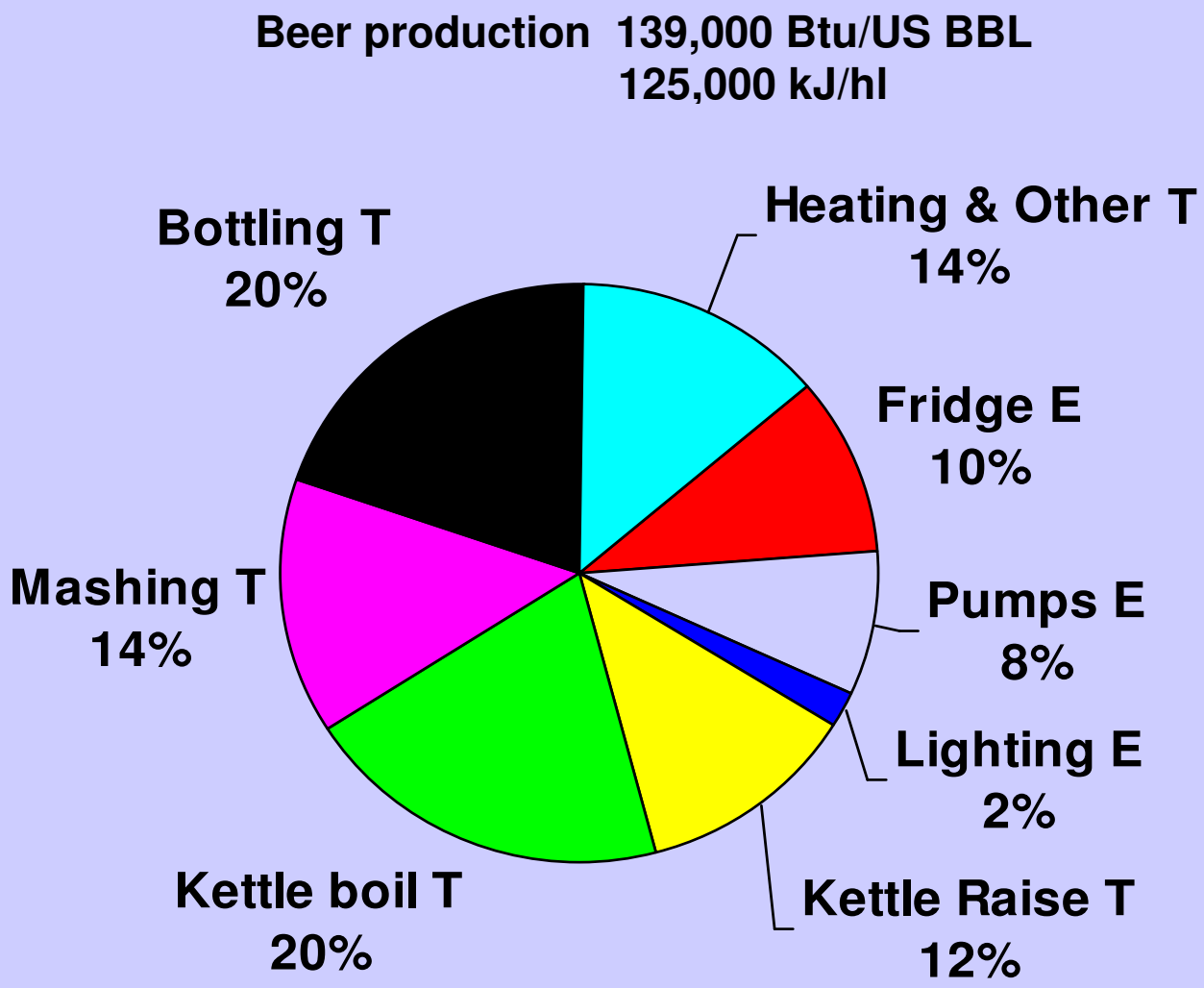
17th to 20th September 2006

The outputs of wort boiling

- The sterilisation of the wort
- The inactivation of the enzymes to ‘fix’ the sugar spectrum
- The extraction and isomerisation of hop alpha acids
- The formation of flavours and colour compounds
- The stripping of undesirable volatiles such as Di Methyl Sulphide
- The denaturation and coagulation of protein
- The formation of reducing agents
- The evaporation of water

whilst minimising the heat damage done to the wort

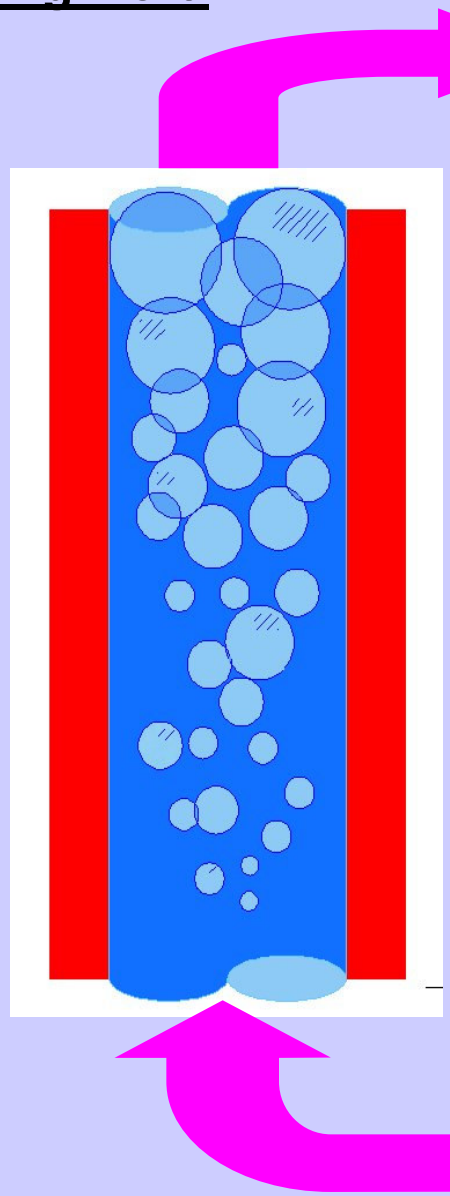
Energy consumption - environmental challenges



Nucleate boiling

Most commonly used mode for boiling wort.

Internal heater or
External thermosyphon



two phase flow (liquid & vapour)

The difference in density between single phase & two phase is the driving force for the thermosypon

single phase flow (liquid)

Vapour bubbles beneficial

1) protein denaturation & coagulation

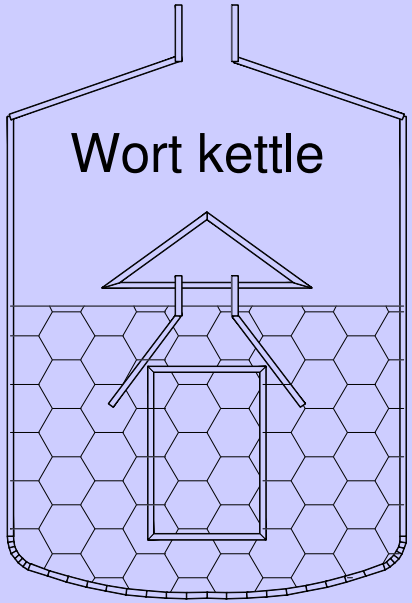
2) volatile stripping

3) hop acid isomerisation

intensity of boil

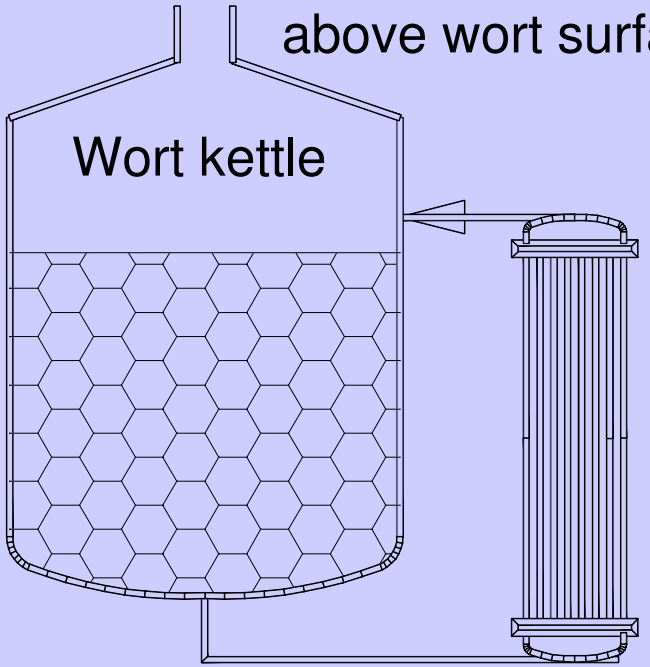
The more steam vapour bubbles formed per unit volume of wort the more intense the boil

Wort heater surface area



Typical internal heater
heater surface area
0.73ft ^{2}/ US Brl
0.08 M ^{2}/ HL

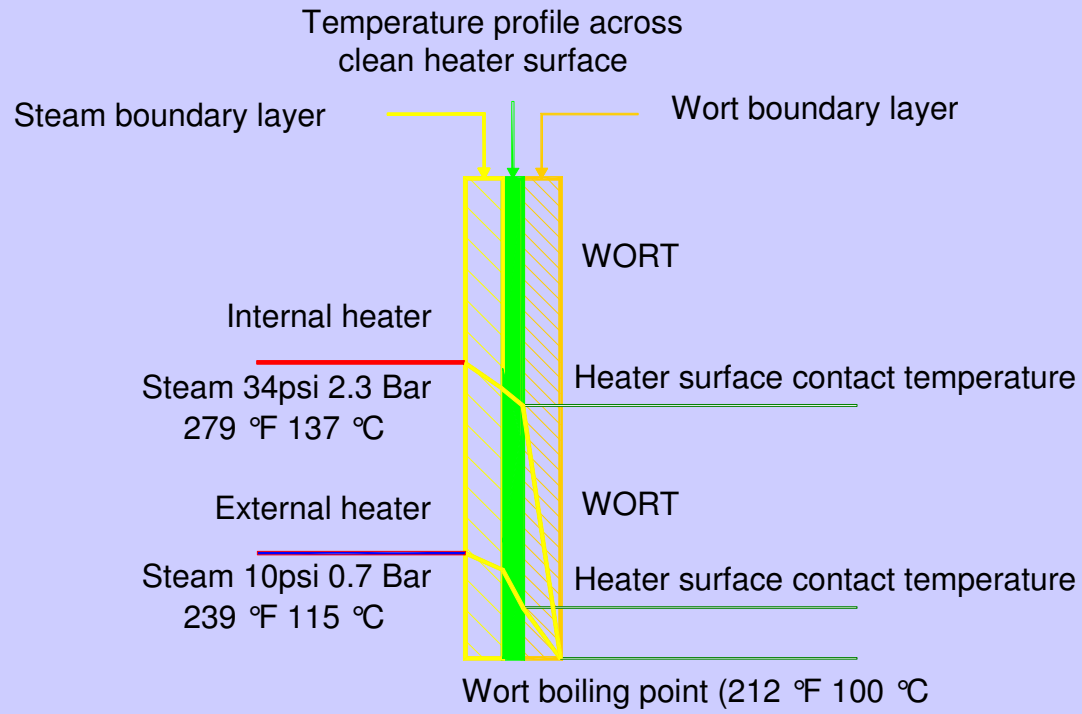
Open tangential return
above wort surface



Typical British External
Thermosyphon
1.83ft ^{2}/ US Brl
0.2 M ^{2}/ HL

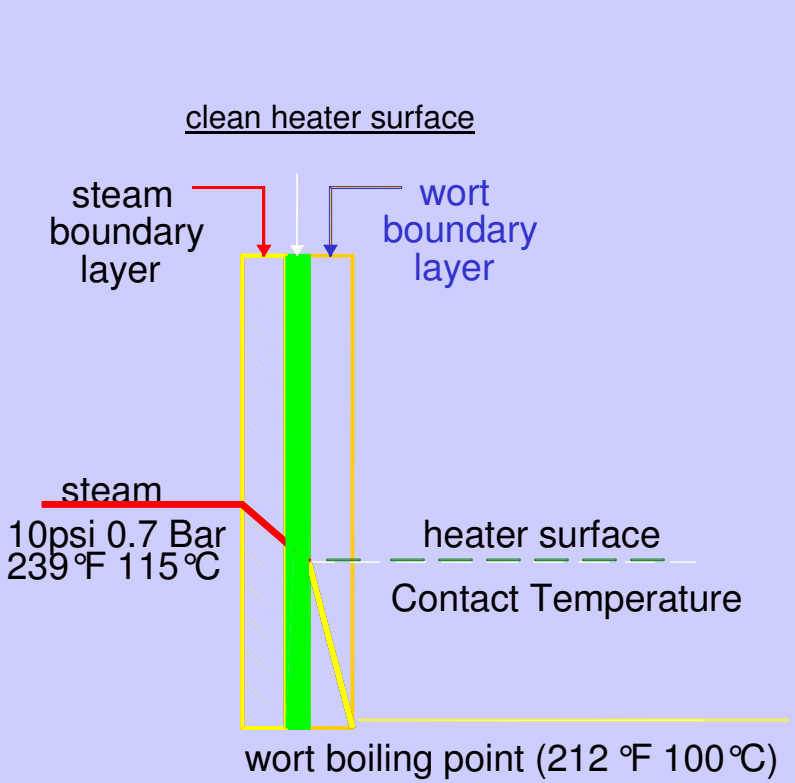
Wort heater surface area

	SURFACE AREA	
	ft^2 / US BBL	M^2 / hl
TYPICAL INTERNAL HEATER	0.73	0.08
BRITISH EXTERNAL THERMOSYPHON	1.83	0.20

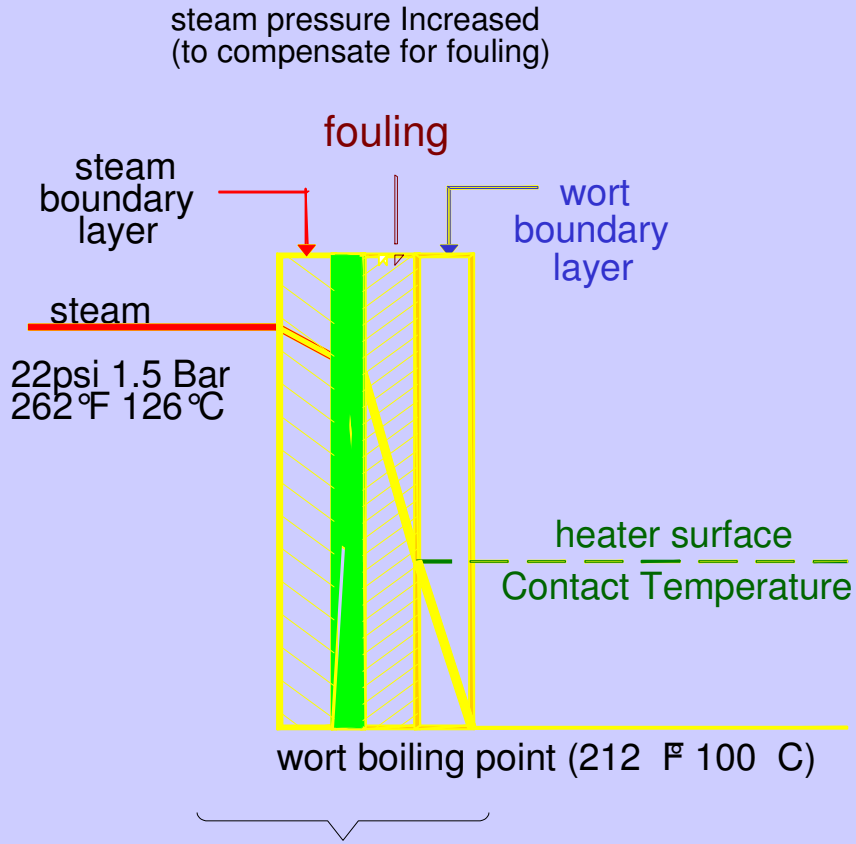


Higher surface area lowers heater surface temperature in contact with wort.
This lower Delta T is considered beneficial for foam, flavour & flavour stability

Heater surface fouling - evaporation consistency



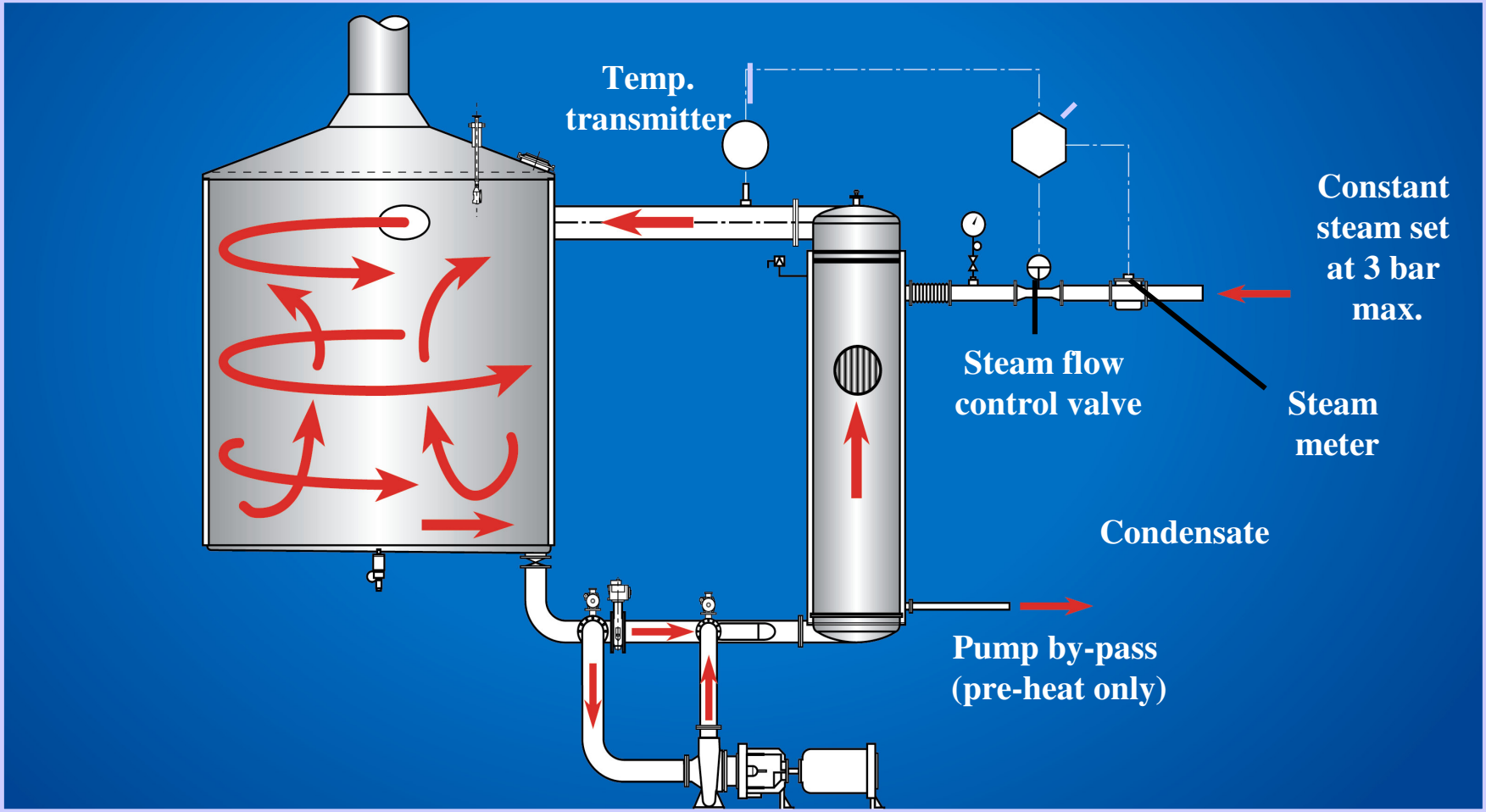
μ = 1.57
clean heater surface
evaporation rate
7 % Hr



μ = 0.85
steam pressure increased
evaporation rate
7 % Hr

Steam control - evaporation consistency

The weight of water evaporated is directly related to the mass of steam condensed in the wort heater.

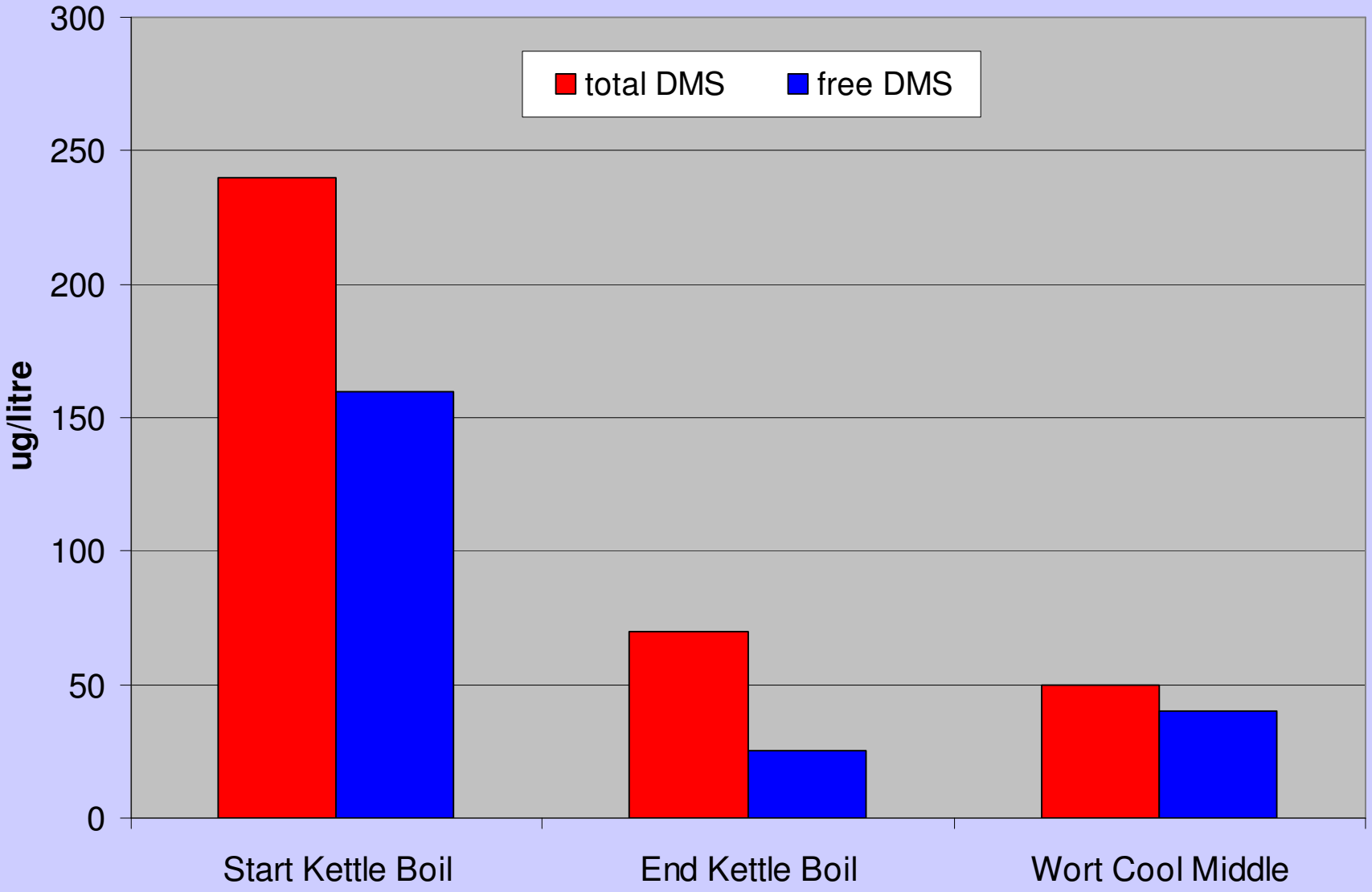


Fouling of the heater surface slows heat transfer which reduces the steam mass condensed and therefore evaporation. The flow control valve automatically opens sufficiently to raise the steam temperature (pressure) to restore the target rate of steam condensation.

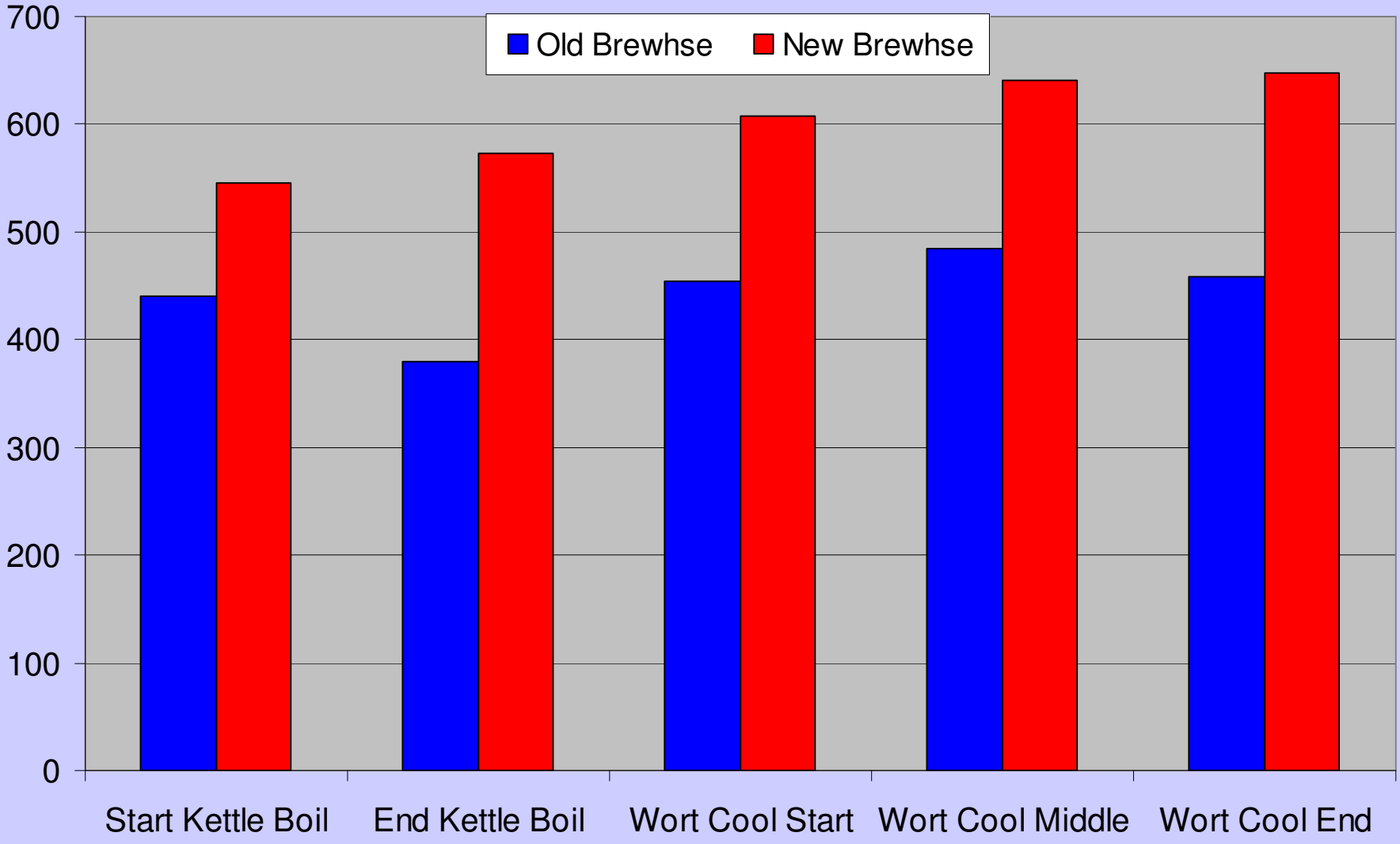
Breweries surveyed

Brewery	Geographical location	Brewlength (hl)	Evaporation rate (%vol per hr)	Length of boil (minutes)	Heater surface area per unit volume (m2/hl)
A	Australasia	830	6.5	70	0.22
B	North America	1215	4.67	90	0.24
C	North America	1215	4.67	90	0.24
D	Great Britain	570	6.5	45	0.22

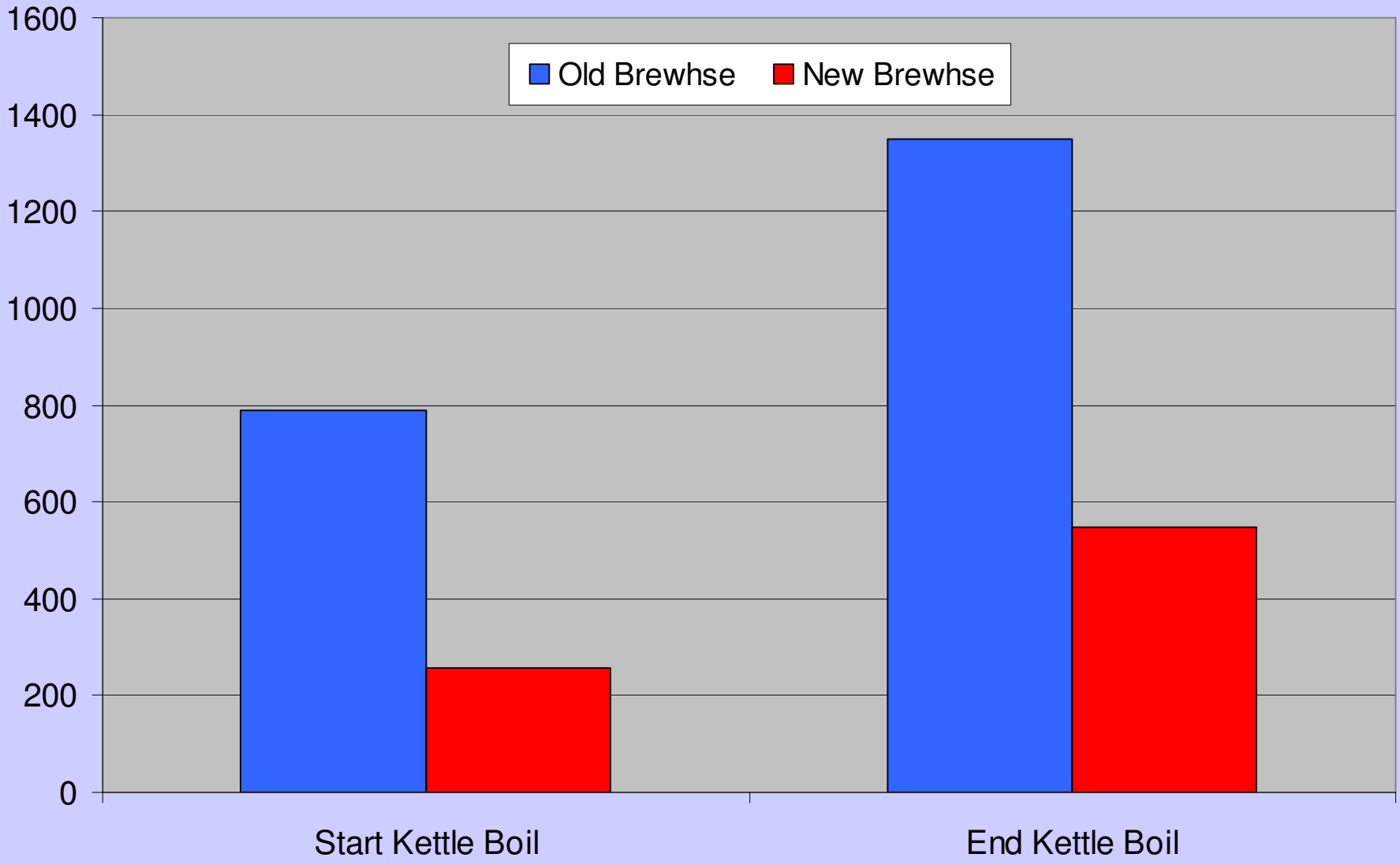
Brewery A – DMS reduction during the boil



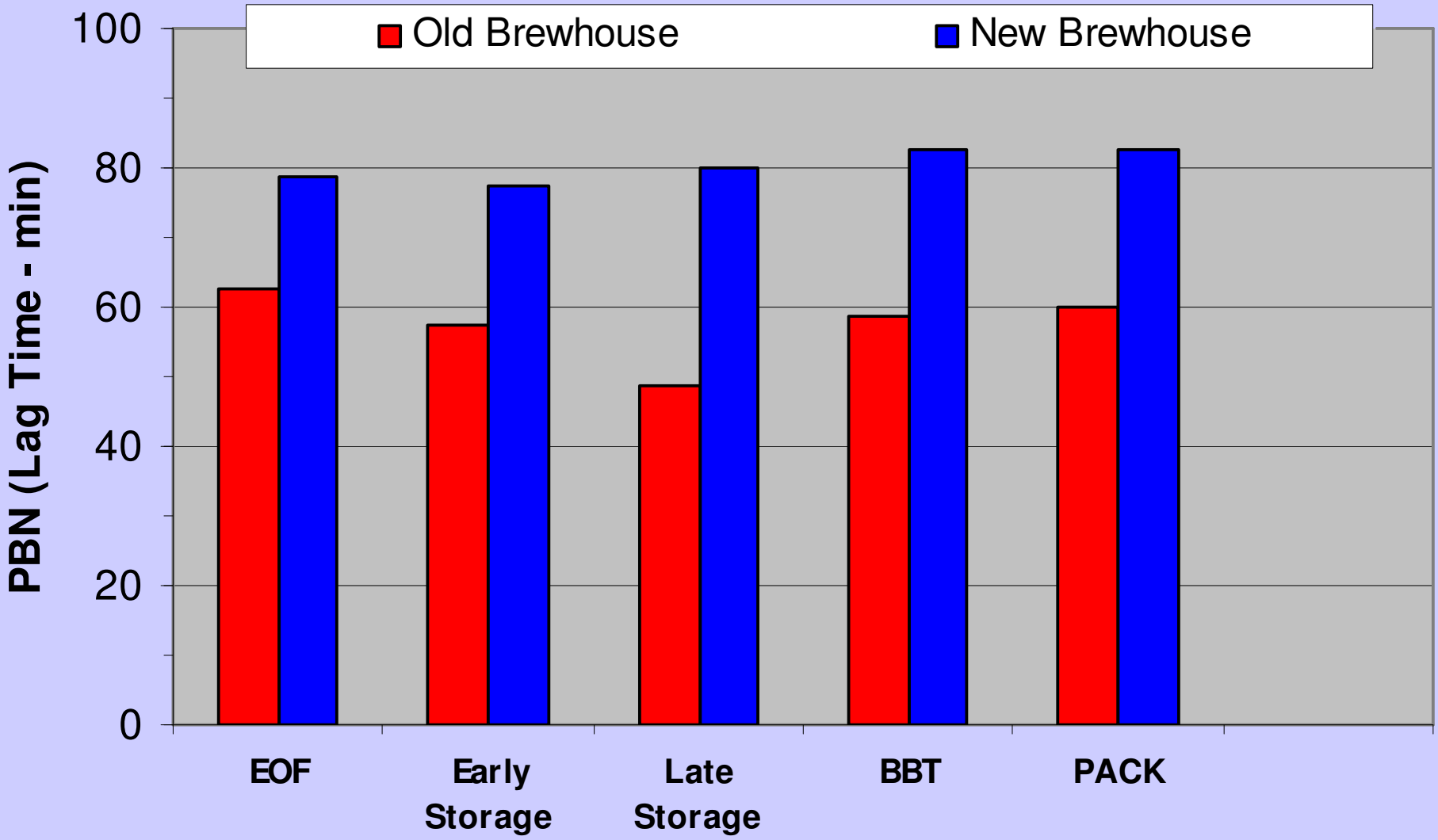
Brewery A – Increase in Anti Radical Potential - DPPH



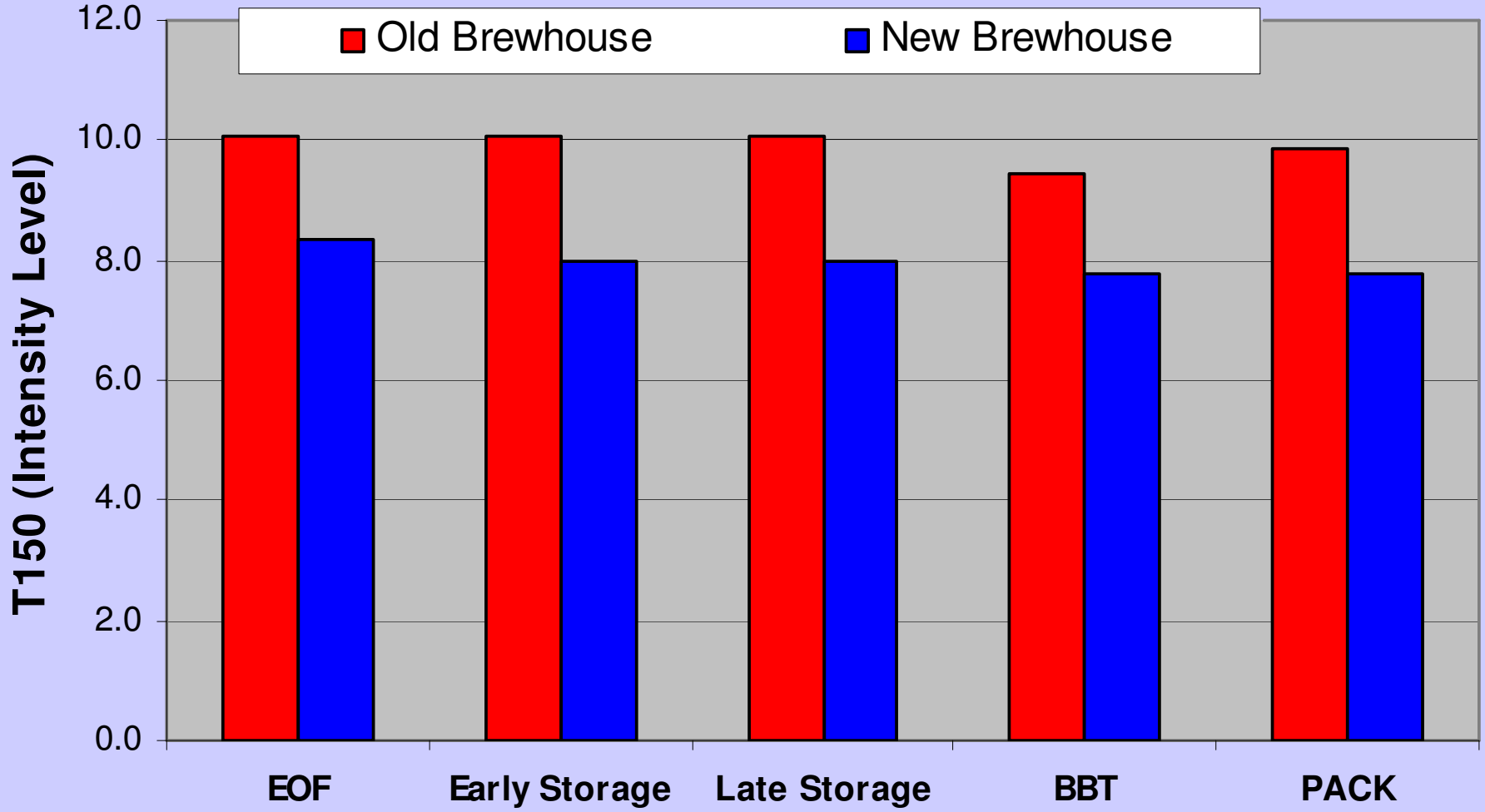
Brewery A – Reduction in Furfural levels



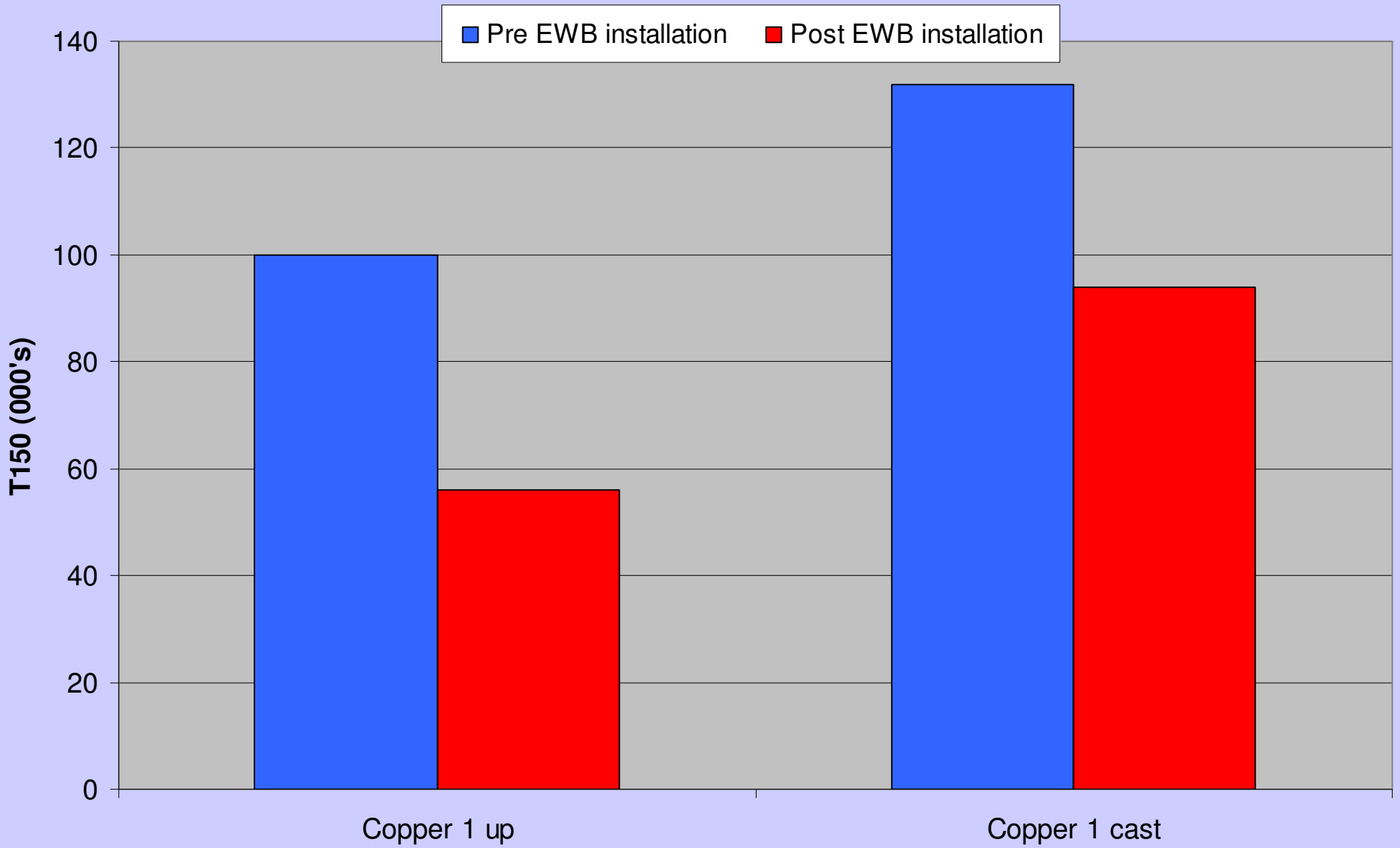
Brewery A - ESR Lag Time



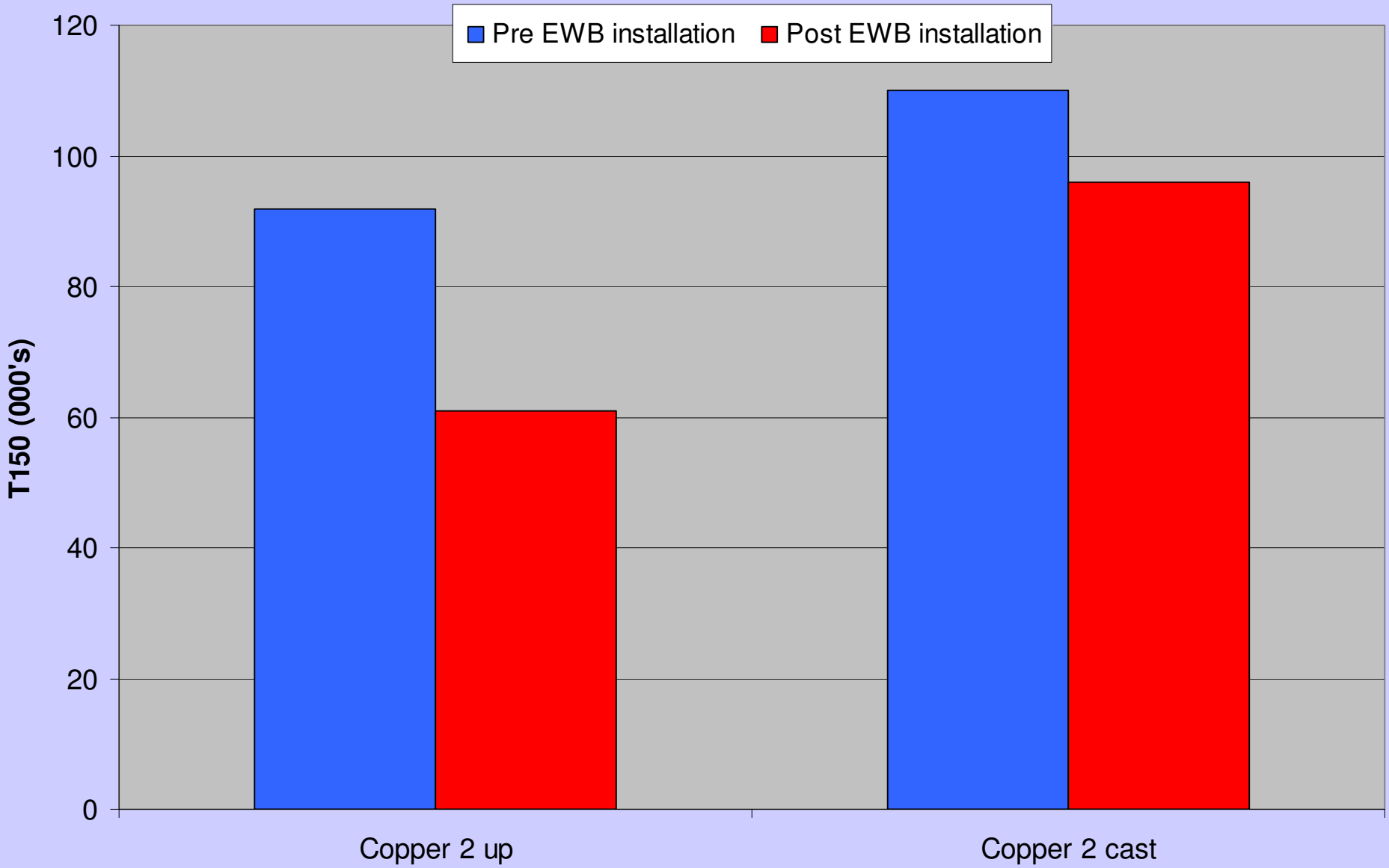
Brewery A - ESR T150



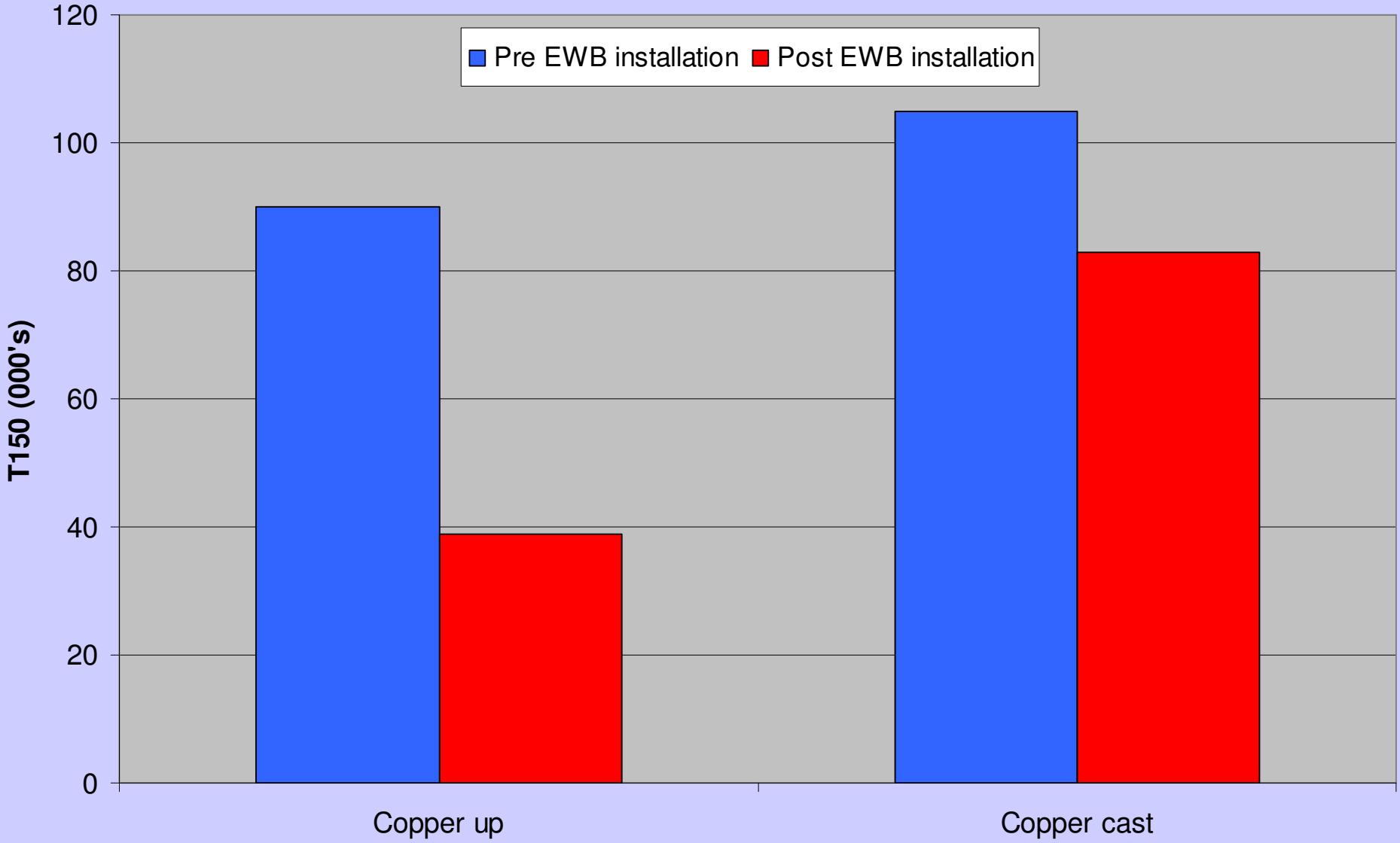
Brewery B - ESR T150's



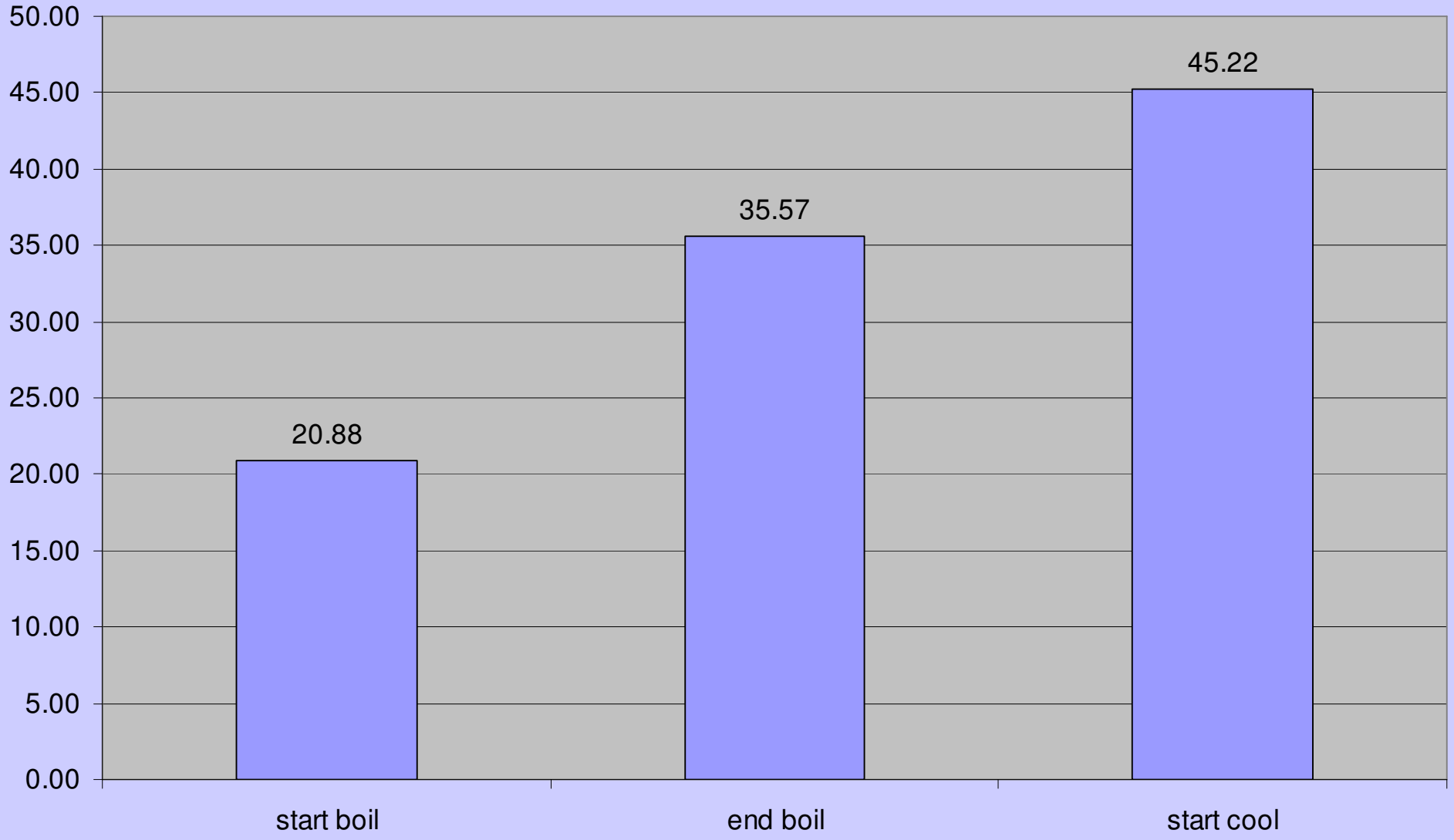
Brewery B - ESR T150's



Brewery C - ESR T150's



Brewery D – TBA values



Brewery D – Reduction of DMS