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OCTOBER 2026

A study on the Impact of water temperature control parameters in steam sterilization on the ecological impact (water consumption) and vacuum performance in the fractionated pre-vacuum phase

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Hospital introduction

USDS

World Federation for Hospital Sterilisation Sciences

首都医科大学宣武医院
Xuanwu Hospital Capital Medical University

- Established in 1958 in Beijing,China.
- National Center for Neurological Disorders
- National Clinical Research Center for Geriatric Diseases
- Number of Beds: 1’643
- Number of ORs: 39
- Number of surgical operation per year: 50,000





Background

- Water temperature requirements for steam sterilizers

EN 285-2015

13.5 The sterilizer shall be designed to operate with water that is of potable quality and supplied at a temperature not exceeding 20℃

Sterilizer installation manual

Cold water <15℃

BUT

It is not a mandatory requirement for all regions

Background

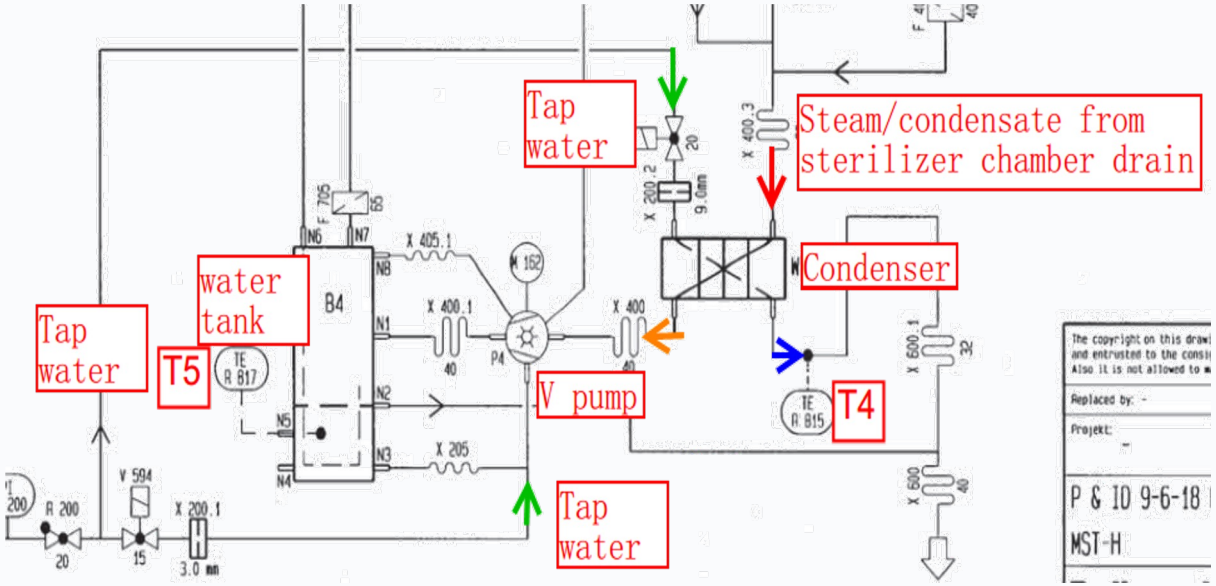
- Alarm logic of our steam sterilizer (Belimed MST-H 9-6-15, 15 STU capacity ,EN 285 complied)

T4: condenser temperature probe

- alarm when >80℃

T5: temperature probe of water tank (partly supplying the vacuum pump)

- alarm when >60℃



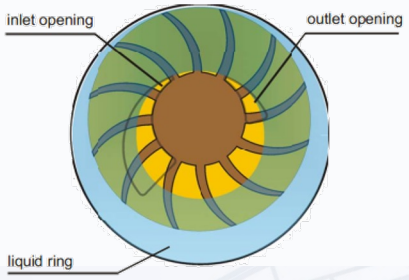
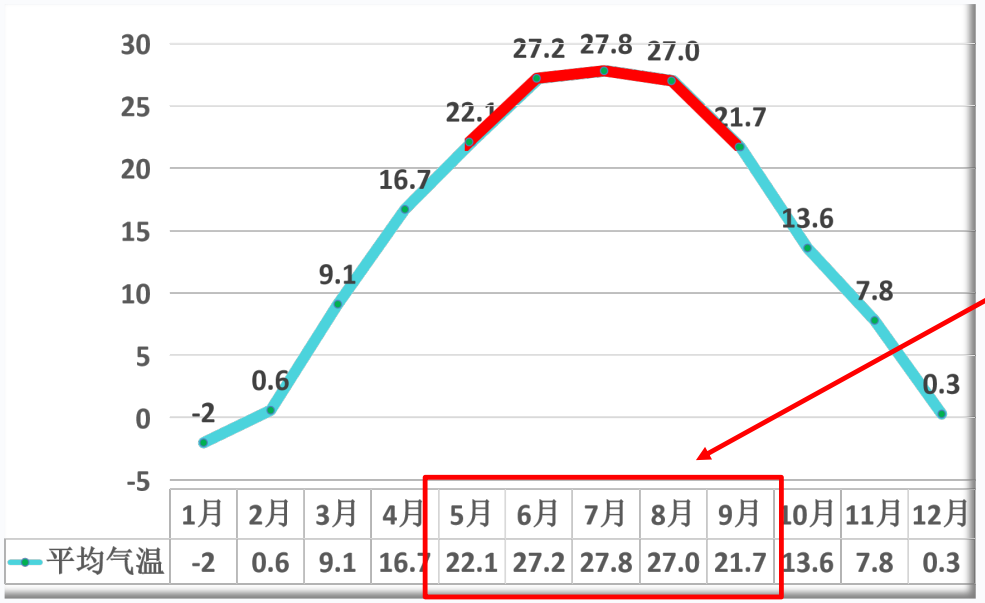


Figure 2.3 Working openings

Background

- Weather temperature vs alarms

Average temperature in 2024 in Beijing



Water-temperature alarms in 2024

Year/Month		Type of Alarm	Times of alarm
2024	5	T5 water tank over-temperature	2
	6	T5 water tank over-temperature	4
	7	T5 water tank over-temperature	5
	8	T5 water tank over-temperature	2
	9	T5 water tank over-temperature	3
	Total		**16**

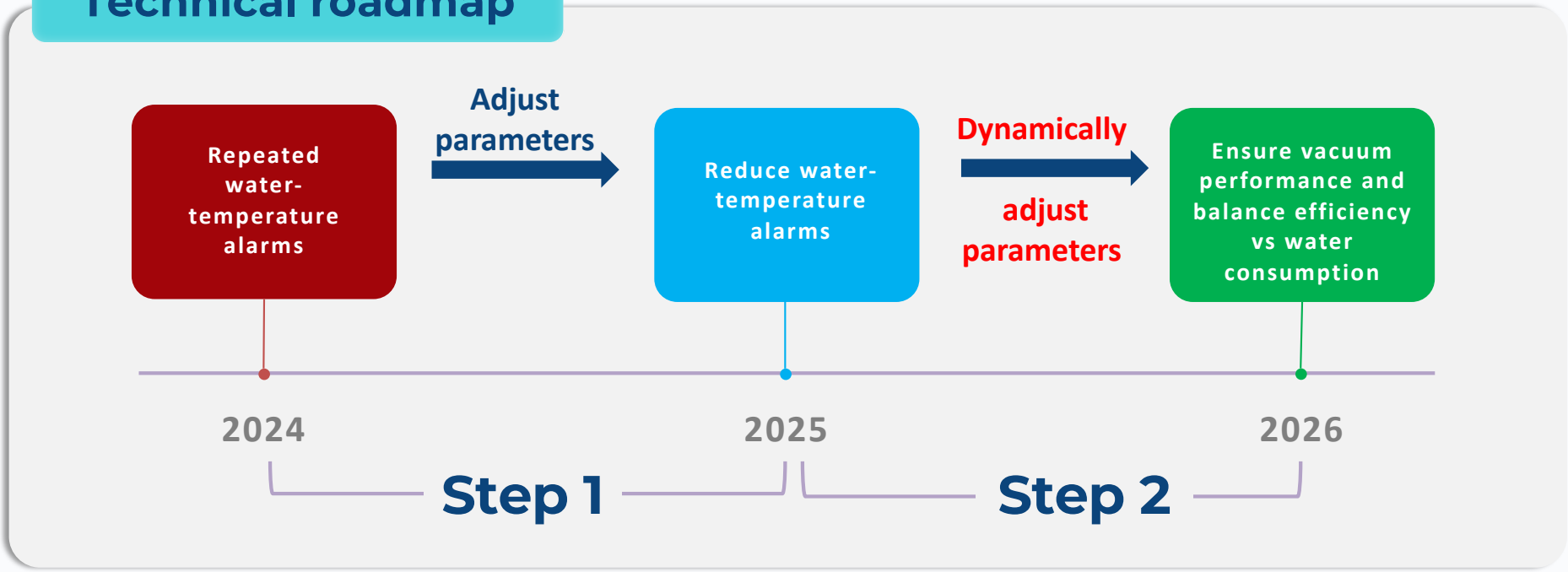
Water-temperature alarms were triggered mostly in Q2 and Q3

Aim

- Dynamically adjust water-temperature related process parameters according to the city water temperature in different seasons, to achieve the optimal balance between higher sterilizer operational efficiency and lower water consumption while ensuring sterilizer vacuum performance.

Method & Results

Technical roadmap



Method & Results

➢ **Step 1** – Method:

	Default setting	Adjustment Jan–Dec 2025	Expected impact (+)	Expected impact (-)
Control logic of water tank refilling (T5)	Refill cooling water when T5 ≥40℃	≥35℃	1 Lower vacuum pump operating temperature 2 Deeper vacuum 3 Less T5 alarm	Water consumption increases
	Refill cooling water At vacuum step and T5 ≥21℃	As default		
Control logic of condenser cooling (T4)	Fill cooling water When $P_{chamber}$ >500 mbar and T4 ≥50℃	≥45℃	1 Lower condenser operating temperature 2 Higher cooling efficiency of steam condensate. 3 Less T4 alarm	Water consumption increases
	Fill cooling water When $P_{chamber}$ < 500 mbar and T4 ≥ 35℃	≥30℃		

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Method & Results

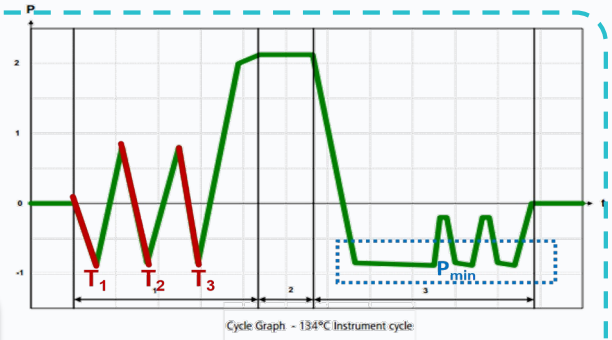
➢ **Step 1** – Study objects:

1. Status of water temperature alarm
2. Water temperature vs water consumption
3. Water temperature vs vacuum performance

* Process data were obtained via Belimed IC8535 system

Water consumption indicators

- Daily water temp (Avg) $= \frac{T_{8AM} + T_{12MN} + T_{8PM}}{3}$
- Daily water consumption (tons) per sterilizer, V: V = V2 – V1
- V1: water meter reading at sterilizer start-up
- V2: water meter reading at sterilizer shutdown
- Avg. water per cycle (tons) = daily consumption / daily cycles



Vacuum performance indicators

*Evacuation time of a single evacuation in pre-vacuum phase, Tn (n= 1,2,3)

Total evacuation time in pre-vacuum phase,

- T_{total}: $T_{total} = T_1 + T_2 + T_3$
- **P_{min}**: ultimate vacuum depth in the drying phase

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Method & Results

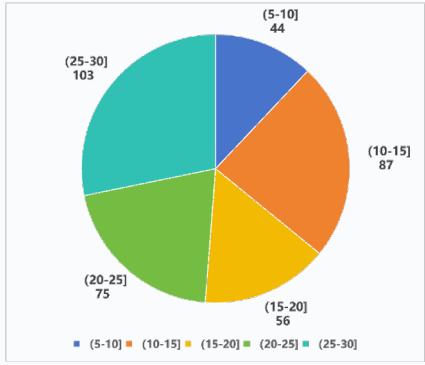
➢ **Step 1** – Results 1:

- After parameter adjustment, alarms triggered in 2025 (4 cases) were 75% lower than in 2024 (16 cases)

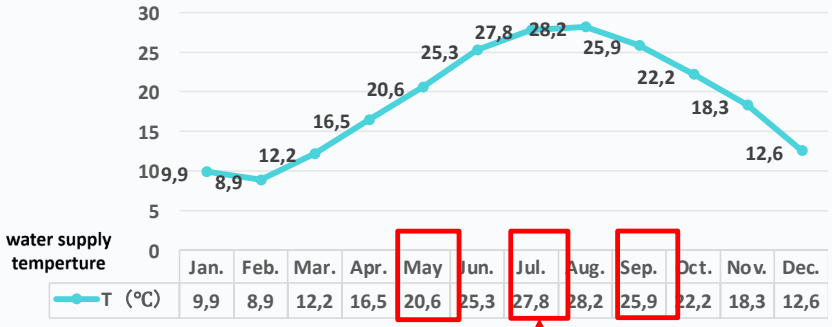
Water-temperature alarms in 2025

Year/Month		Type of Alarm	Times of alarm
2025	5	T5 over-temperature	1
	7	T5 over-temperature	2
	9	T4 over-temperature	1
	Total		**4**

Water temperature range in 2025



Sterilizer supply water temperature in 2025



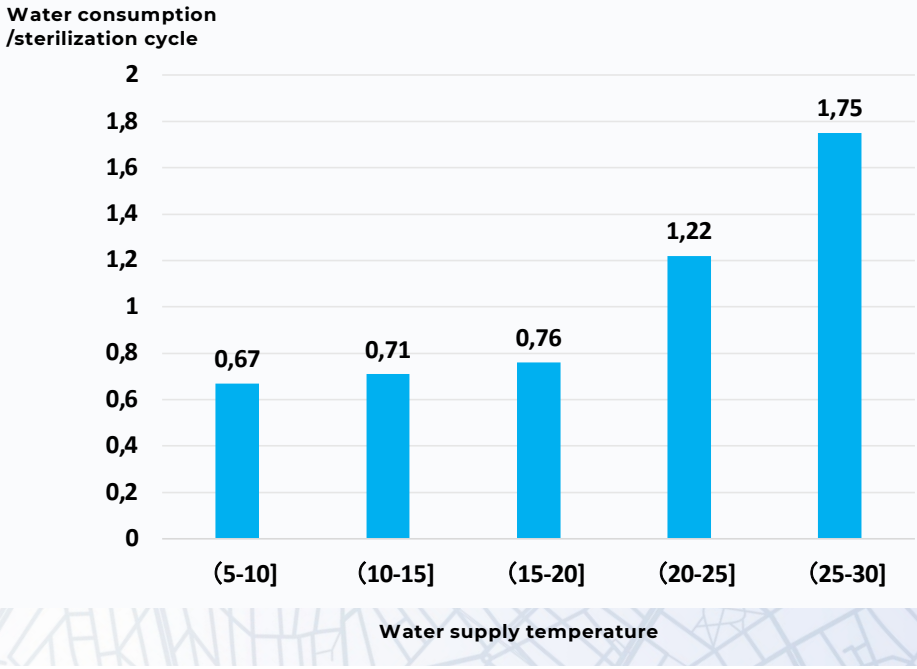
Method & Results

➢ **Step 1** – Results 2:

- Average water consumption per sterilization cycle (134℃, 5 min) varies --- the lower the cooling water temperature, the less water is consumed per cycle.

Water consumption per cycle vs water temperature

Temp. range (℃)	Total water consumption (tons)	Sterilization cycles	Water consumption per sterilization cycle (tons)
(5-10]	437.1	650	0.67
(10-15]	1014.1	1418	0.71
(15-20]	712.8	935	0.76
(20-25]	1387.8	1134	1.22
(25-30]	2870.5	1637	1.75
Total	5500	5810	0.94



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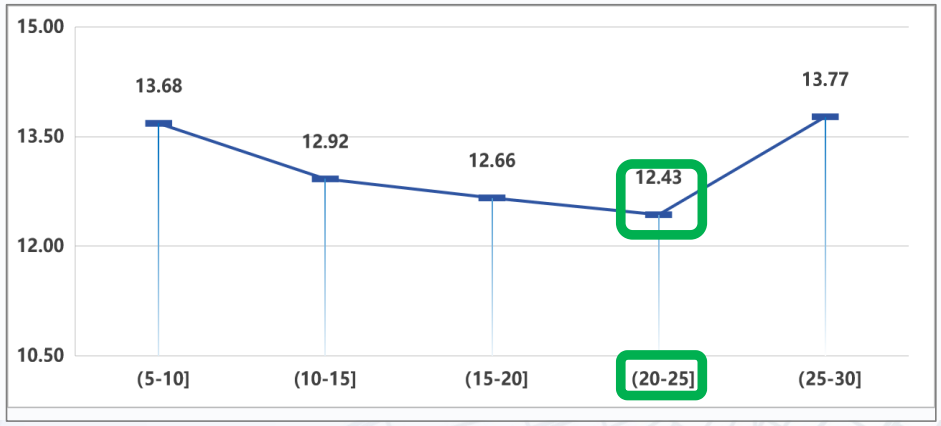
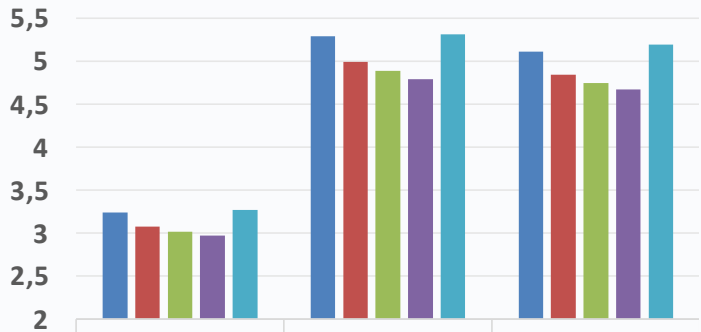
➢ **Step 1** – Results 3:

- Vacuum performance at different water temperatures --- Sterilization program 134℃,5 min (5,810 batches in total).

Total evacuation time in pre-vacuum phase vs cooling water temperature



Evacuation time of each single evacuation in pre-vacuum phase vs cooling water temperature



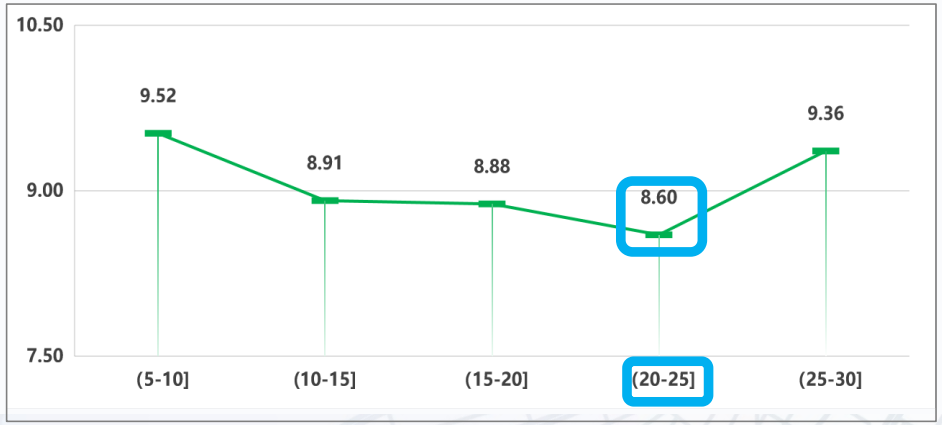
	T1	T2	T3
(5-10]	3,24	5,29	5,11
(10-15]	3,08	4,99	4,84
(15-20]	3,02	4,89	4,75
(20-25]	2,97	4,79	4,67
(25-30]	3,27	5,31	5,19

Method & Results

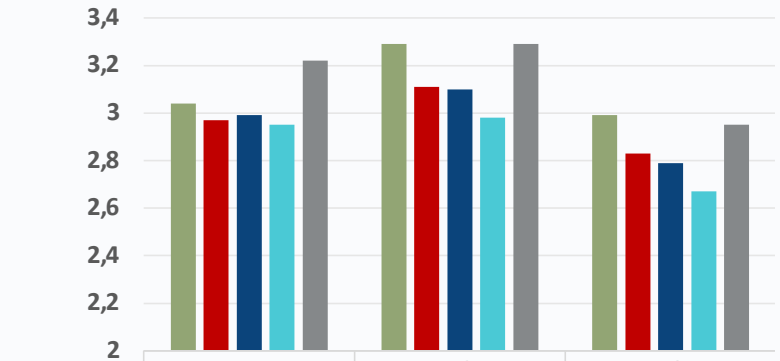
➢ **Step 1** – Results 3:

- Vacuum system performance at different temperature --- B-D cycle (895 batches in total).

Total evacuation time in pre-vacuum phase vs cooling water temperature



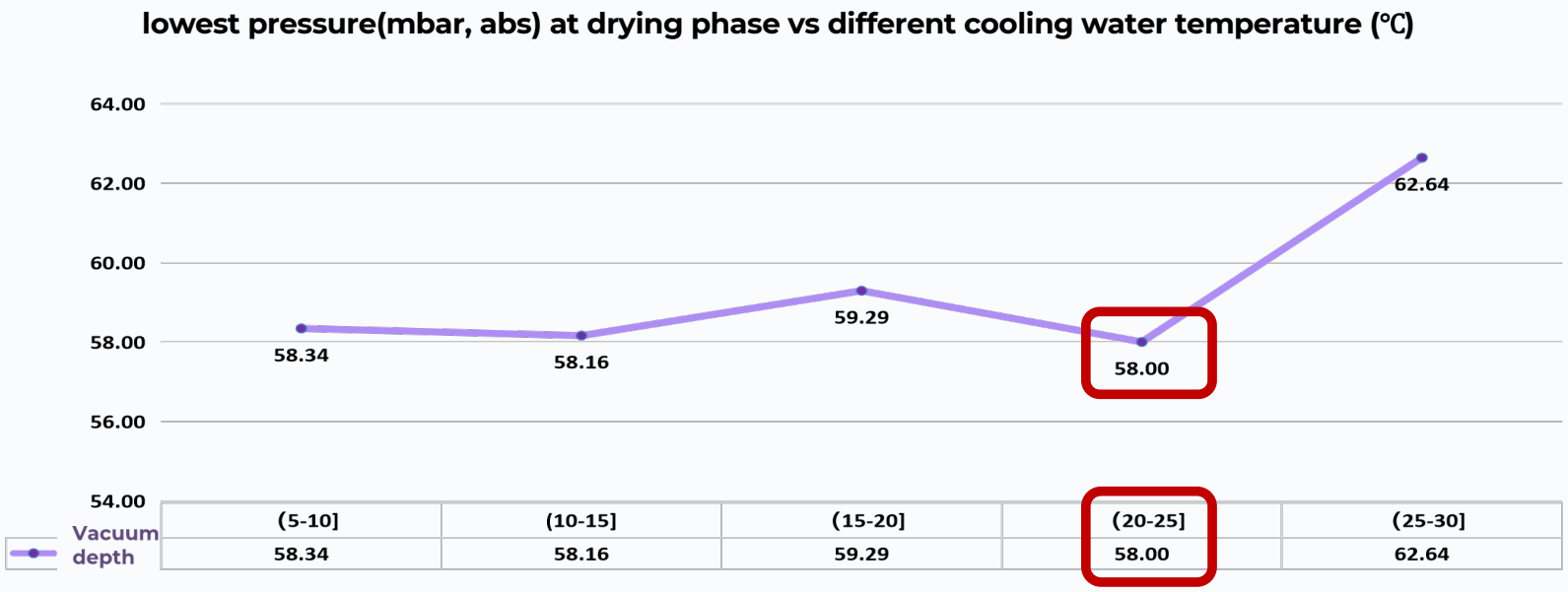
Evacuation time of each single evacuation in pre-vacuum phase vs cooling water temperature



	T1	T2	T3
(5-10]	3,04	3,29	2,99
(10-15]	2,97	3,11	2,83
(15-20]	2,99	3,1	2,79
(20-25]	2,95	2,98	2,67
(25-30]	3,22	3,29	2,95

Method & Results

- **Step 1** – Results 3:
  - B-D cycle---Vacuum system performance at different water temperature ranges.



Discussion

➢ **Step 1** – Discussion:

1. Water-temperature alarms:

- The results of step 1 showed optimizing water-temperature related control parameters in line with the local supply water temperature can significantly reduce this type of alarm (↓ by 75%). With this outcome the goal of step 1 was achieved.

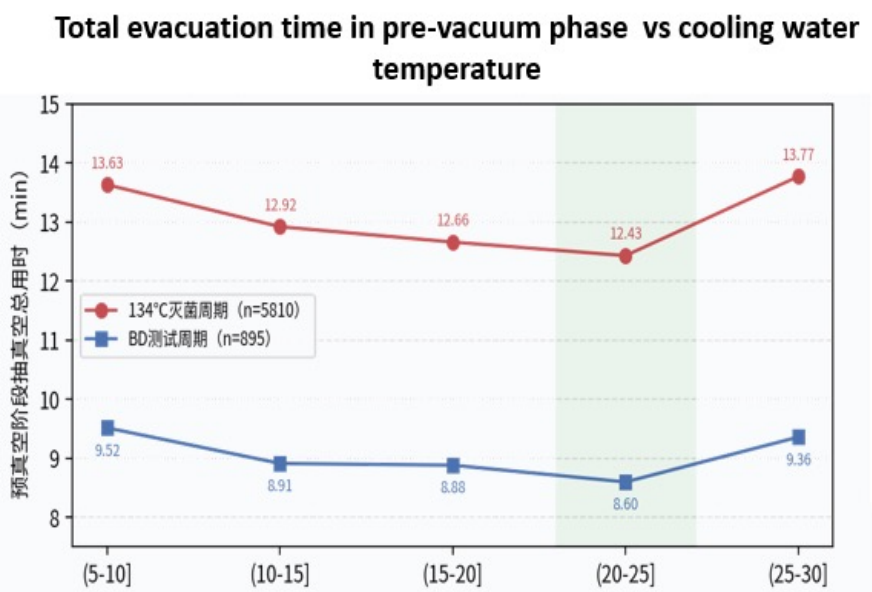
2. Relationship between water temperature and sterilizer water consumption:

- The results confirm a clear relationship between water temperature and water consumption. A second-step study was therefore initiated, in order to further reduce water-temperature alarms while achieving water savings by optimizing the sterilizer's water temperature control parameters.

Discussion

➢ **Step 1** – Discussion:

3. Correlation between water temperature and vacuum performance:



3.1 Water temperature affects sterilizer vacuum performance mainly on evacuation time in the pre-vacuum phase. Its effect on the minimum pressure reached in the drying phase is not significant.

3.2 According to the study data in 2025, the vacuum system had its best performance when water temperature ranged 20–25°C . However the difference from other two ranges , 10–15°C and 15–20°C, is not significant.

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Method & Results

➢ **Step 2** – Method:

	Jan–Mar 2025 (pre-intervention)	Jan–Mar 2026 (post-intervention)	Expected impact (+)	Expected impact (-)
Control logic of water tank refilling (T5)	Refill cooling water when T5 ≥35℃	≥50℃	Water consumption decreases	1 Higer Vacuum pump operating temperature 2 Poorer vacuum performance 3 More T5 alarm
	Refill cooling water At vacuum step and T5 ≥21℃	≥30℃		
Control logic of condenser cooling (T4)	Fill cooling water When $P_{chamber}$ >500 mbar and T4 ≥45℃	≥60℃	Water consumption decreases	1 Higher condenser operating temperature 2 Poorer cooling effect 3 More T4 alarm
	Fill cooling water When $P_{chamber}$ < 500 mbar and T4 ≥ 30℃	≥35℃		

Method & Results

➢ **Step 2** – Results:

- sterilizer water consumption fell dramatically — as expected.



Save 623.9 tons of water in Q1.2026

Water consumption pre & post intervention

Time	Cycles	Total water consumption (tons)	Water consumption /cycle (tons)
Pre-intervention	1425	1004.5	1004.5/1425=0.70
Post-intervention	1187	380.6	380.6/1187=0.32
Variation		62.1%(-)	57.1%(-)

*:water pricing for hospital in Beijing: CNY 9.5/ton

Water consumption by water temperature

Temperature range	Item	Pre-intervention	Post-intervention	variation
(5-10]	Total water use (tons)	437.1	215.9	50.6%(-)
	Water/cycle (tons)	0.67	0.46	31.3%(-)
(10-15]	Total water use (tons)	567.4	117.7	79.2%(-)
	Water/cycle (tons)	0.73	0.27	63.0%(-)
(15-20]	Total water use (tons)	/	46.9	/
	Water/cycle (tons)	/	0.29	/

Discussion

➢ **Step 2** – Discussion:

1. Water temperature vs water consumption:

- Step 1 study found that water consumption decreases as water temperature falls, leading to the hypothesis that the current water-temperature control parameters may trigger refilling cooling water too early in cold seasons, increasing water consumption.
- In Step 2 study, set higher thresholds of refilling cool water during the cold season (Jan–Mar, water temperature 5–15℃) to save water.
- In step 2 study it is also confirmed that water consumption can be regulated by sterilizer parameters rather than being driven directly by city water temperature itself.

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➢ **Step 2** – Results :

- Sterilization cycles (134°C, 5 min): Variations in vacuum performance before vs after intervention at different water temperatures (5,810 batches).

Vacuum performance, pre- vs post-intervention

	Pre-intervention	Post-intervention	Variation
T1 (min)	3.26	3.37	3.37% ↑
T2 (min)	5.26	5.22	0.76% ↓
T3 (min)	5.08	5.09	0.19% ↑
T total (min)	13.60	13.67	0.51% ↑
Post-drying Pmin (mbar)	60.67	69.03	13.78% ↑

Vacuum performance by temperature range, pre vs post

	(5-10]			(10-15]			(15-20]	
	Pre-intervention	Post-intervention	Variation	Pre-intervention	Post-intervention	Variation	Pre-intervention	Post-intervention
T1 (min)	3.23	3.31	2.48% ↑	3.27	3.39	3.67% ↑	/	3.56
T2 (min)	5.29	5	5.48% ↓	5.23	5.39	3.06% ↑	/	5.41
T3 (min)	5.1	4.9	3.92% ↓	5.05	5.25	3.96% ↑	/	5.2
T total (min)	13.63	13.21	3.08% ↓	13.57	14	3.17% ↑	/	14.18
Post-drying Pmin (mbar)	59.92	67.34	12.38% ↑	61.35	71.06	15.83% ↑	/	71.86

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➢ **Step 2** – Results :

- B-D cycles: Variation in vacuum performance before vs after intervention at different water temperature (1,208 batches).

B-D cycle vacuum performance, pre vs post intervention

	Pre-intervention	Post-intervention	Variation
T1 (min)	3.03	3.26	7.59% ↑
T2 (min)	3.29	3.15	4.25% ↓
T3 (min)	2.94	2.93	0.34% ↑
T total (min)	9.33	9.72	4.18% ↑
Post-drying Pmin (mbar)	59.13	66.27	12.07% ↑

B-D cycle vacuum performance by temperature range, pre vs post intervention

	(5-10]			(10-15]			(15-20]	
	Pre-intervention	Post-intervention	variation	Pre-intervention	Post-intervention	variation	Pre-intervention	Post-intervention
T1 (min)	3.04	3.47	14.14% ↑	3.03	3.76	24.09% ↑	/	3.74
T2 (min)	3.28	3.03	7.62% ↓	3.3	3.29	0.30% ↓	/	3.2
T3 (min)	2.99	2.78	7.02% ↓	2.99	3.05	2.0% ↑	/	3.1
T total (min)	9.32	9.29	0.32% ↓	9.33	10.12	8.47% ↑	/	10.04
Post-drying Pmin (mbar)	58.33	64.84	11.16% ↑	59.83	67.56	12.92% ↑	/	67.47

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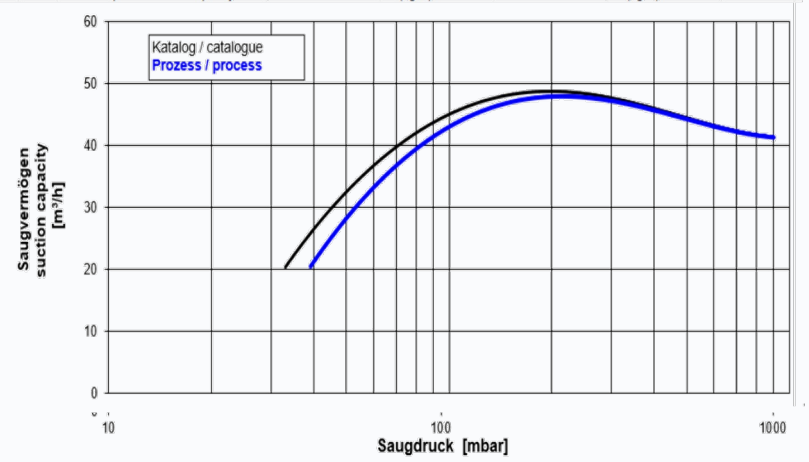
Discussion

➢ **Step 2** –Discussion：

2. Water temperature vs vacuum performance (Jan–Mar, 10–15℃)

Kühlflüssigkeit / cooling liquid		
Bezeichnung / name	Wasser	Wasser
Temperatur / temperature	20.0 °C	15 °C
Dampfdruck / vapour pressure	23.3 mbar	17.0 mbar
Dichte / density	998 kg/m³	998 kg/m³
Viskosität / viscosity	101 10^{-5} Ns/m²	101 10^{-5} Ns/m²
Wärmekapazität / heat capacity	4.18 kJ/(kg K)	4.18 kJ/(kg K)



	Pmin(mbar) Pre-intervention	Pmin(mbar) Post-intervention	variation in Pmin
B-D	59.13	66.27	12.07% ↑
Sterilization program (134C,5min)	60.67	69.03	13.77% ↑

1 Evacuation times of the sterilization and B-D cycles showed no significant variation by the intervention.

2 By intervention, the ultimate post vacuum pressure of both B-D cycle and sterilization program rose by 6 mbar (12%) and by 9 mbar (13%) respectively, a slight performance decline. But still lower than the max pressure limit of post vacuum phase, that is 100 mbar.

3 However, CSSD needs to pay closer attention to variations in the physical parameters of sterilization batch report when making release decisions.

Conclusion

1. In regions without temperature requirements on water supplied to sterilizers,attention should be paid to the risk of frequent sterilization failures caused by excessively high water temperature.
2. In regions with temperature requirements on water supplied to sterilizer,CSSDs should accurately understand water-temperature related parameters in the sterilization programs of their sterilizers.
3. These two-step experiments conducted so far in this study demonstrate that control parameters of refilling water to sterilizer can be dynamically adjusted based on cool water temperature to effectively save water while keeping vacuum performance within its specifications,thus achieving the goal of significant reduction of ressource consumption and therefore of a more „green“ operation.
4. **The next step will study strategy of dynamic adjustment when supply water temperature is high. The goals are to avoid sterilization alarms, maintain sterilizer efficiency, and reduce operating costs of unexpected repairs and re-sterilization due to aborted cycles.**

Conclusion

Generalizability

- In theory, all hospitals can implement similar dynamic optimization approach based on their CSSD‘s supply water temperature variations and sterilizer control parameters.

Sustainability

- This approach can be an important step towards achieving the optimal balance among three goals: sterilization reliability, sterilizer operational efficiency, and sustainable green development of the CSSD.

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- **WFHSS** for once again recognizing our team's research. We will strive for a 3rd opportunity to share our improvements with peers worldwide at future WFHSS!

