



1. Boiling Point Elevation (BPE)

Definition:

Boiling Point Elevation (BPE) is the increase in the boiling temperature of a solution compared to that of the pure solvent due to the presence of dissolved solids or solutes.

Causes of Boiling Point Elevation:

- When solutes dissolve in a solvent (e.g., salts, sugars in water), they disrupt the solvent's ability to vaporize, requiring a higher temperature to reach the boiling point.
- BPE depends on the nature of the solute, its concentration, and the solution's colligative properties.

Effect on Evaporator Performance:

- As BPE increases, the temperature difference between the heating steam and the boiling liquid decreases.
- This reduces the overall heat transfer rate, impacting the efficiency of the evaporator.
- Engineers must consider BPE when designing evaporators to ensure proper heat transfer calculations.

2. Capacity of an Evaporator

Definition:

Capacity of an evaporator refers to the amount of vapor produced per unit time, usually measured in **kg/hr**.

Factors Affecting Capacity:

Heat Transfer Rate (Q):

$$Q = U \times A \times \Delta T$$

U = Overall heat transfer coefficient ($\text{W/m}^2 \cdot \text{K}$)

A = Heat transfer surface area (m^2)

ΔT = Temperature difference between heating steam and boiling liquid



Boiling Point Elevation:

Higher BPE reduces ΔT , lowering capacity.

Feed Conditions:

Preheated feed increases capacity.

Cold feed reduces efficiency.

Evaporator Type:

Forced circulation and falling film evaporators handle high BPE solutions better than natural circulation evaporators.

Steam Pressure and Temperature:

Higher steam pressure increases heat transfer but may require higher equipment design standards.

3. Economy of an Evaporator

Definition:

The economy of an evaporator is the ratio of **the mass of vapor produced to the mass of steam used**.

Economy = Mass of Vapor Evaporated / Mass of Steam Used

Types of Economy

Single-Effect Evaporators:

Economy is close to **1.0**, meaning 1 kg of steam evaporates about 1 kg of water.

Less efficient due to steam wastage.

Multiple-Effect Evaporators:

- Economy improves significantly by using vapor from one effect as the heating medium for the next.
- Example:



- A **Triple-Effect Evaporator** can have an economy of **2.0 to 2.5**, meaning 1 kg of steam evaporates **2 to 2.5** kg of water.

Factors Affecting Economy:

- **Number of Effects:** More effects increase economy but raise capital costs.
- **Steam Utilization:** Effective vapor reuse enhances efficiency.
- **Heat Losses:** Minimizing losses through insulation improves economy.
- **Feed Preheating:** Using waste heat to preheat feed enhances performance.