AM-04.34 — Cavitation: when liquid begins forming bubbles where the pump needs liquid

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Course compass

Guiding question: Why can a pump malfunction even when the tank still contains plenty of liquid?

Markers: MEASURED · CONVENTION · CALCULATED · TEACHING ASSUMPTION · APPROXIMATION

• define cavitation

• understand pump inlet

• reason in margin

• connect temperature and pressure

Essential answer

Cavitation: when liquid begins forming bubbles where the pump needs liquid. The question to solve is: Why can a pump malfunction even when the tank still contains plenty of liquid? Markers: MEASURED · CONVENTION · CALCULATED · TEACHING ASSUMPTION · APPROXIMATION define cavitation understand pump inlet reason in margin connect temperature and pressure? The pump must receive and accelerate fluid. Tank pressure, line losses, vehicle acceleration, and temperature all affect inlet state. The rest of the course turns that idea into an auditable line of reasoning: explicit units, stated assumptions, reproducible calculations, order-of-magnitude checks and interpretation limits. A result is useful only when the reader can explain what it measures, where every input came from and which engineering decision it can support.

Starting synthesis: derivations, examples, limitations and sources are developed in the course body.

Key terms before you start

mass flow rate · cavitation · unit · assumption · approximation

1 — Liquid can vaporize locally

If local pressure falls sufficiently relative to the fluid’s thermodynamic state, some liquid can form vapor.

In a pump, vapor pockets may appear and later collapse in higher-pressure regions.

2 — Why pump inlet is sensitive

The pump must receive and accelerate fluid. Tank pressure, line losses, vehicle acceleration, and temperature all affect inlet state.

Simply having liquid remaining does not guarantee adequate margin.

3 — Possible effects

Cavitation can degrade performance and create vibration, noise, and local loads. In demanding turbomachinery it must be considered in design and test.

This lesson remains qualitative and does not provide operating thresholds for a real engine.

4 — The reasoning pattern

Compare inlet conditions with fluid properties and preserve margin. If temperature rises, vapor pressure can change; if losses rise, pressure available to the pump can fall.

This is a coupled fluid-thermal-dynamic problem.

Three complete examples: change one assumption to understand

Before each calculation, identify where every number comes from and whether it is measured, conventional, assumed, or calculated.

Example A — conceptual margin

Inlet pressure 300 kPa, reference vapor value 200 kPa: simple margin=100 kPa.

TEACHING ASSUMPTION, not an engine criterion.

Example B — additional losses

If 60 kPa extra loss lowers inlet to 240 kPa, simple margin=40 kPa.

Margin falls sharply without changing remaining liquid quantity.

Example C — higher vapor reference

Inlet 300 kPa but vapor reference 260 kPa: margin=40 kPa.

Fluid temperature/property can change the problem at the same inlet pressure.

Inverse calculation

If a conceptual exercise margin is 80 kPa and vapor reference is 200 kPa, inlet pressure would need at least 280 kPa in this simplified model.

Common trap and result check

Trap: turning the lesson's simple pressure difference into a sizing rule. Real criteria use specific definitions, properties, and tests.

In a real engine system, a conceptual result must later be checked against fluid properties, margins, tests, and qualification.

Exercises and answers

Function

Explain the function of each block without jargon.

Sensitivity

Halve one assumption and predict the consequence.

Limit

Name one reason the teaching model is insufficient for a real engine.

Primary and educational sources

• NASA Glenn - Liquid Rocket Engine

• NASA Glenn - Mass Flow Rate Equations