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LAGRANGIAN CONTINUITY EQ.:

$$\frac{DS}{Dt} + S \nabla \cdot \underline{u} = 0$$

IF $\nabla \cdot \underline{u} = 0$, THEN:

$$\frac{DS}{Dt} = 0 \Rightarrow S \text{ IS CONSTANT ALONG PARTICLE PATHS.}$$

STEADY FLOW \Rightarrow PARTICLE PATHS = STREAMLINES

$\Rightarrow S$ IS CONSTANT ALONG STREAMLINES.

NEED S BE CONSTANT THROUGHOUT MEDIUM?

No, FOR EXAMPLE CONSIDER THIS SETUP:

OIL | WATER | OIL
↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ STREAMLINES

S IS CONSTANT ALONG STREAMLINES BUT NOT THROUGHOUT MEDIUM.