

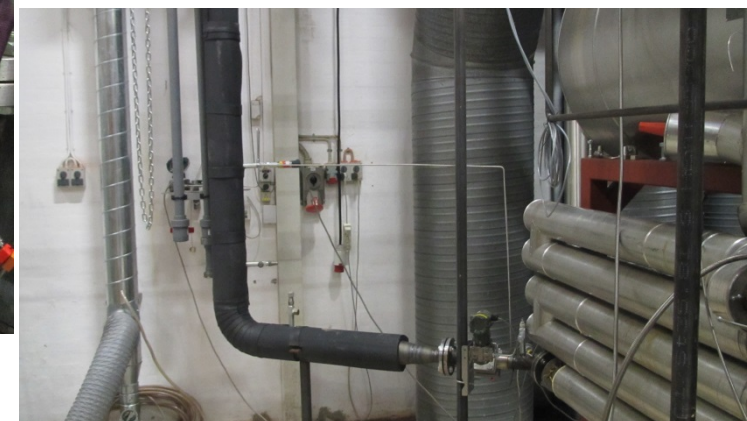
Laboratory test HBX-Vapor Quality Sensors

under stationary conditions

Test program for the sensors is carried out under **stationary laboratory conditions** with ammonia at **Danish Technological Institute** in Aarhus.

Tests performed with 2. generation electronic used for the HBX-VQ sensors.

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Laboratory test

With different positions, flow directions and sensors



The **8 most likely mounting configurations** in real life has been chosen for the test setup at DTI.

Sensor positioned with flow in **horizontal straight pipes**

Sensor positioned **in 90° pipe bendings** with flow **going up, down or to same level** – **counter flow and co-current flow**

2 types of **in-line sensors** (HBX-IN 2")

2 sizes of **rod-style sensors** (HBX-ROD $\frac{3}{4}$ " and 1")

Laboratory test

In-line and rod-style sensors with different flow directions

- HBX-IN – two types of in-line sensor, respectively regular and splash
 - **Straight line horizontal piping**
- HBX-rod $\frac{3}{4}$ " – counter flow in horizontal to horizontal elbow
 - **Counter flow horizontal piping**
- HBX-rod $\frac{3}{4}$ " – co-current flow in horizontal to horizontal elbow
 - **Counter flow horizontal piping**
- HBX-rod $\frac{3}{4}$ " – counter flow in horizontal to vertical downwards elbow
 - **Top inlet of P-trap**



Laboratory test

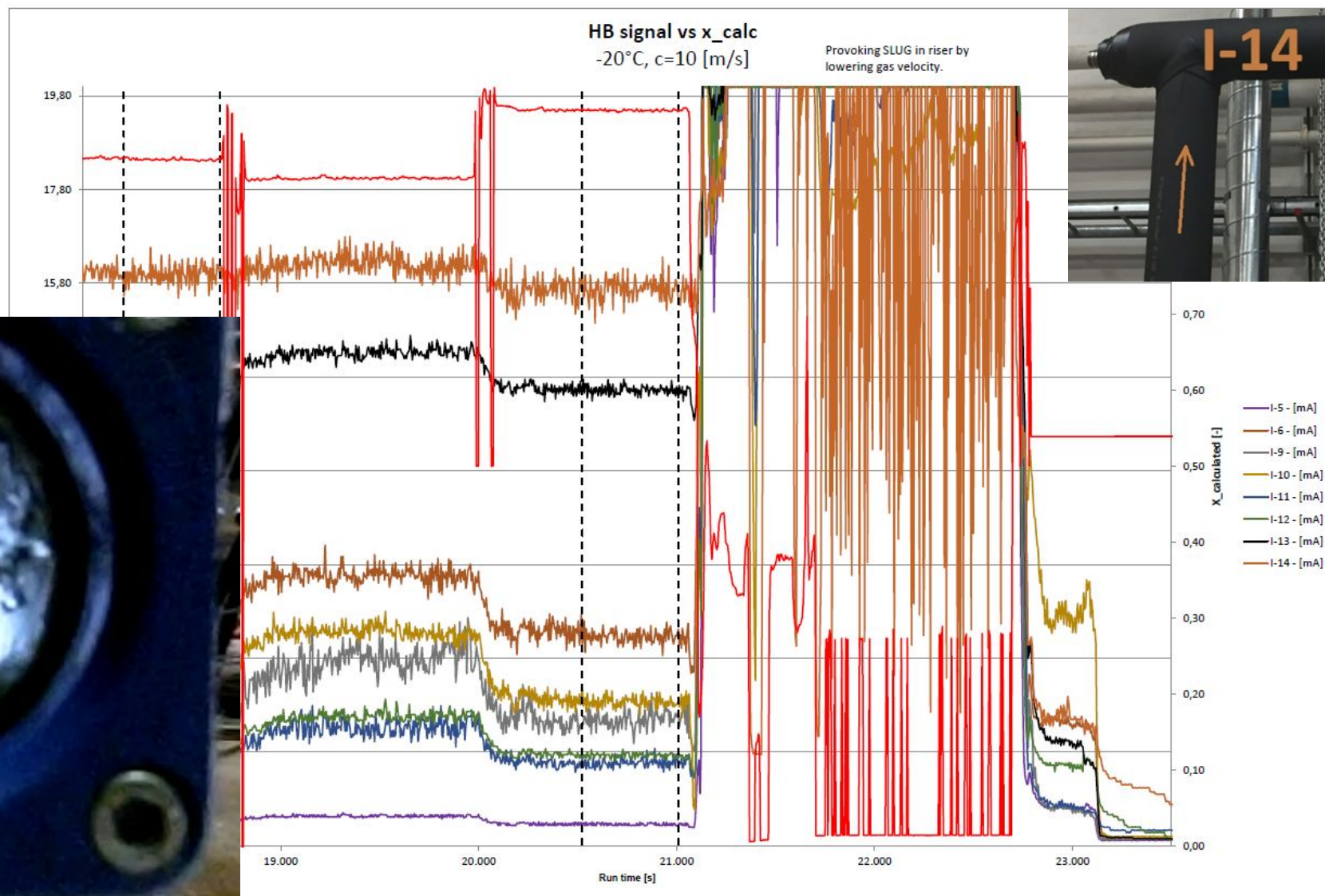
In-line and rod-style sensors with different flow directions

- HBX-rod 1" – co-current flow in vertical downwards to horizontal elbow
 - **Buttom inlet of P-trap**
- HBX-rod 1" – counter flow in horizontal to vertical upward elbow
 - **Buttom riser position**
 - **Buttom outlet of P-trap**
- HBX-rod 1" – co-current flow in vertical upward to horizontal
 - **Top riser position**



Laboratory test

Sensor detecting slug in riser at low gas velocities conditions



Laboratory test

Test result: Sensor output values (average) for in-line sensor HBX-IN 2"

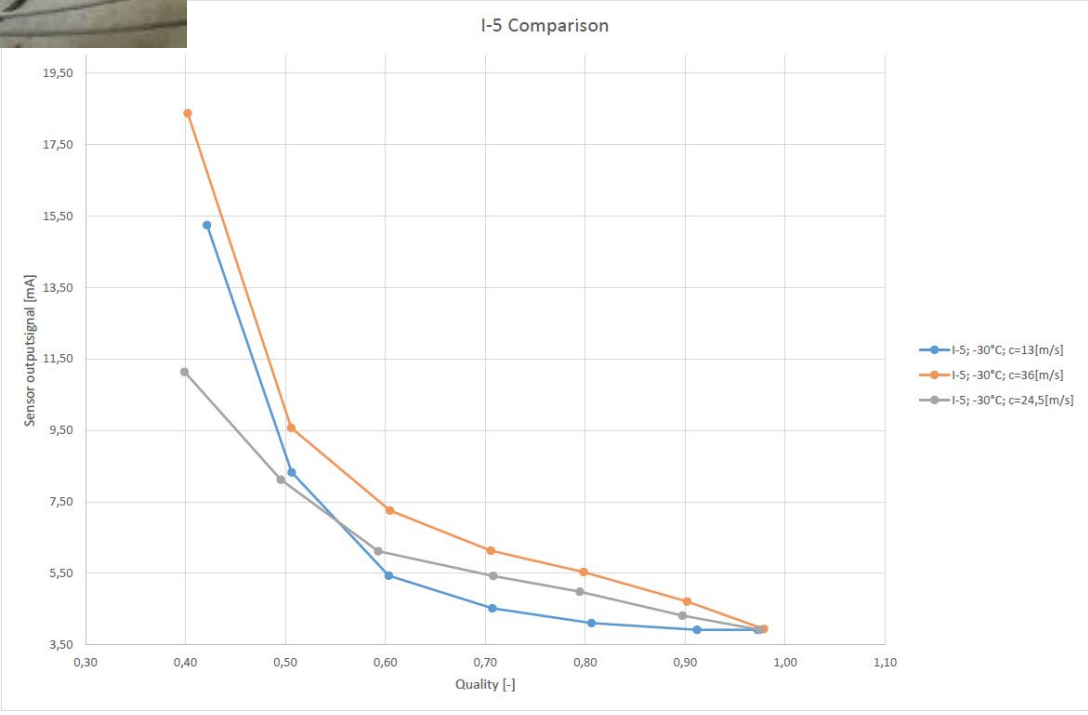
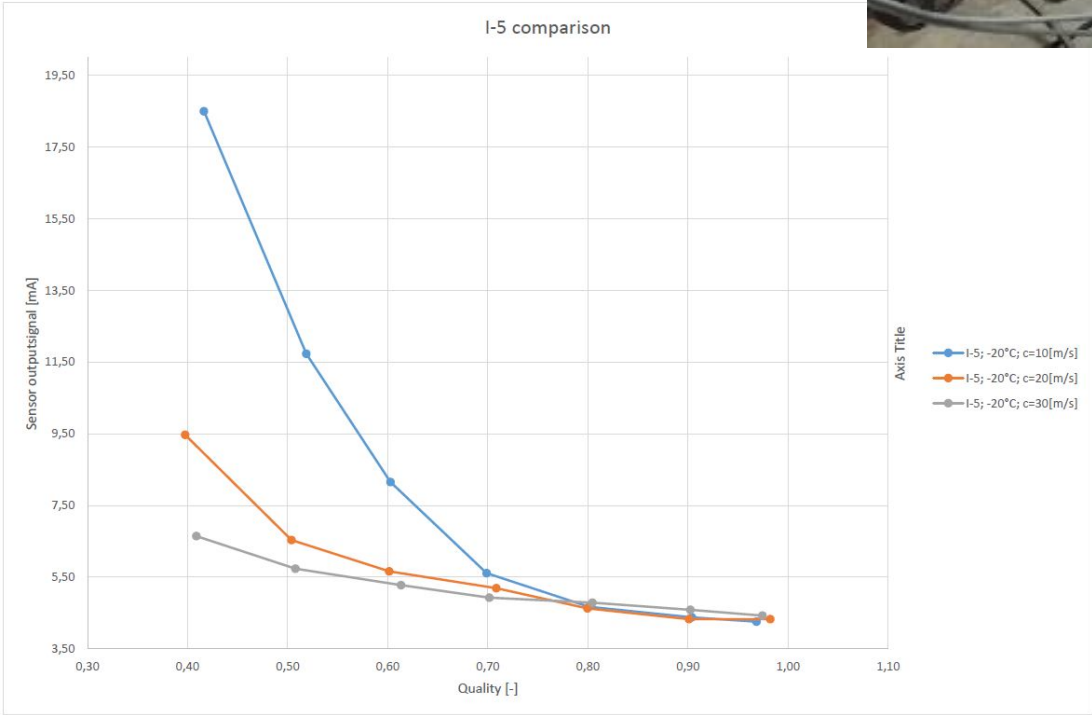
Temperature: $\pm 20^{\circ}\text{C}$

Flow velocity: 10, 20 and 30 m/s



Temperature: $\pm 30^{\circ}\text{C}$

Flow velocity: 10, 20 and 30 m/s



Laboratory test

Some results and conclusions

The sensors are **very quick** and reacts **without time delay**

In-line sensor **measures all**, **rod-style sensor** needs to be **positioned for best representative measurement**

The sensors sees the gas and liquid mixtures in the **range of X from 0,4 to 1**

The **position of the sensor** in the piping at the outlet of an evaporator **is sensitive** (liquid in bottom of pipe)

Different output values for different temperatures and flow directions (counter flow and co-current flow)

Site test

Of the sensor installed in “real system” under real conditions

A site test was carried out at a **cold store in Denmark using tunnel freezers.**

Each tunnel have four evaporators and thus four risers. **At the top of each riser a HBX-rod sensor is installed.**

The sensors shows a clear picture of what is going on inside the riser.



Site test

Of the sensor installed in “real system” under real conditions

One evaporator is not performing

