

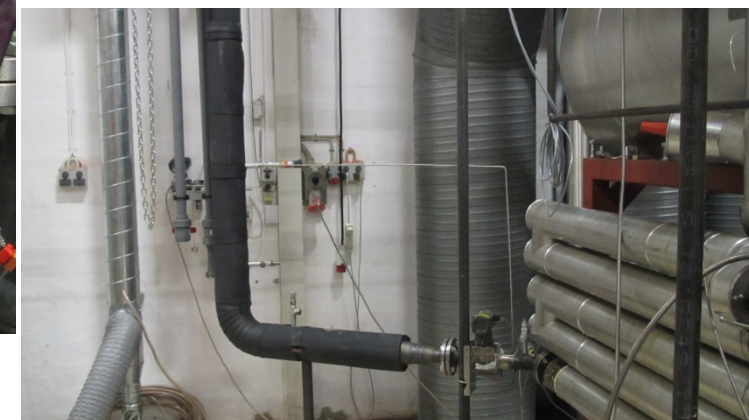
Laboratory test HBX-Vapor Quality Sensors

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.

Svenn Hansen
Refrigeration and Heat Pump Technology
Mail: sha@teknologisk.dk



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

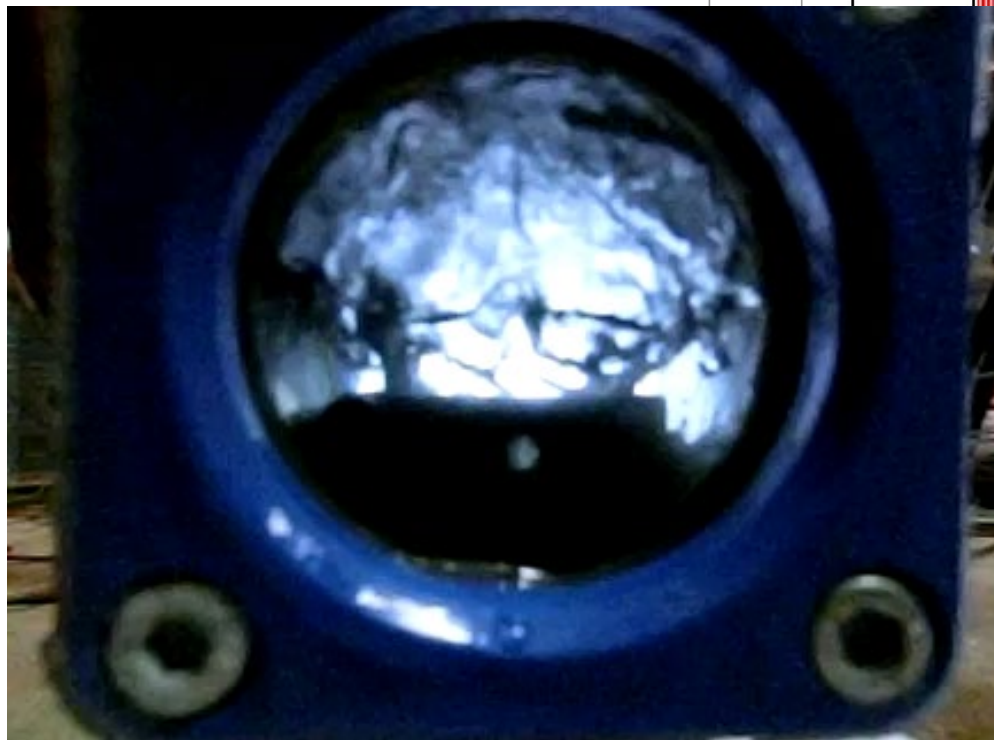
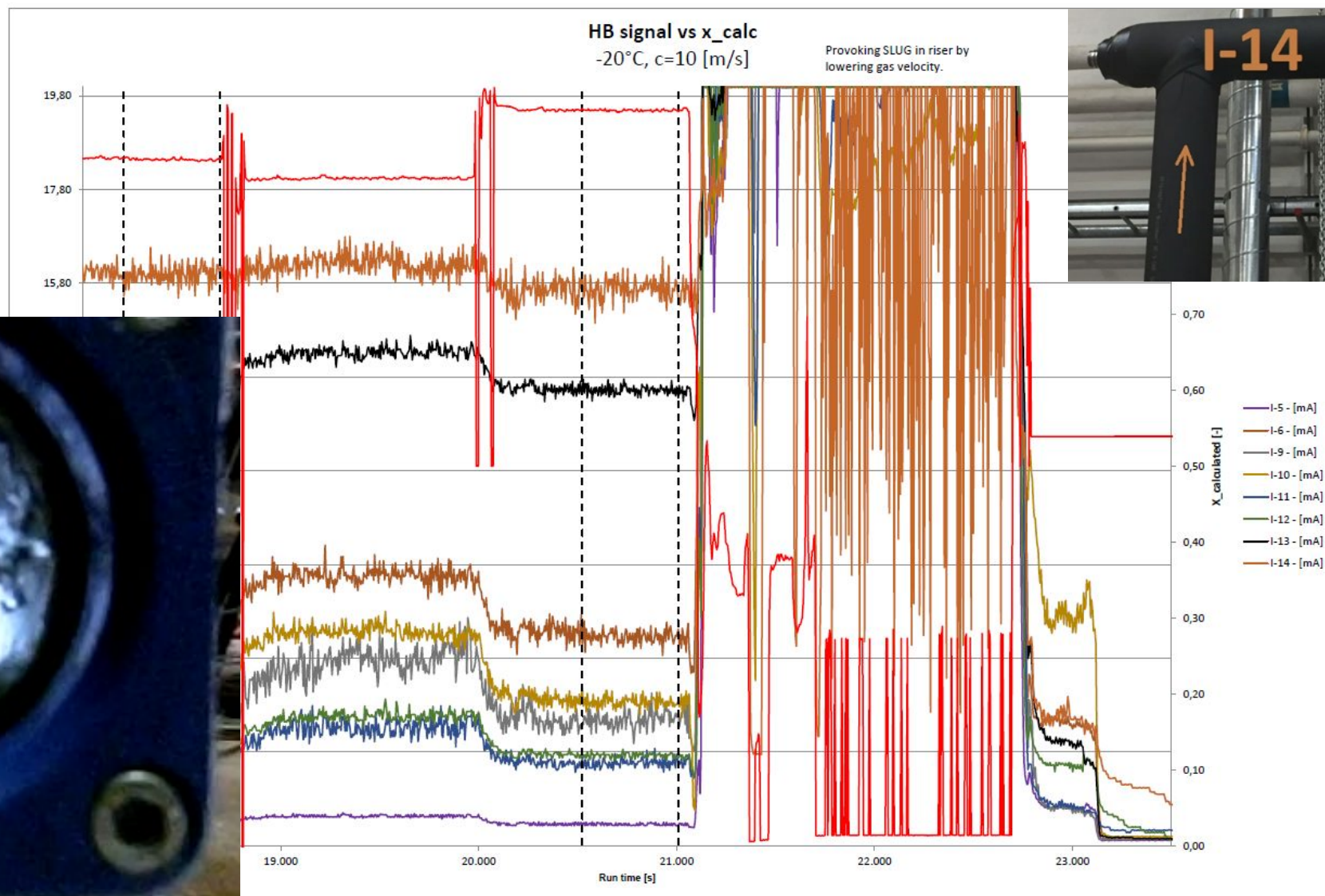
In-line and rod-style sensors with different flow directions

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

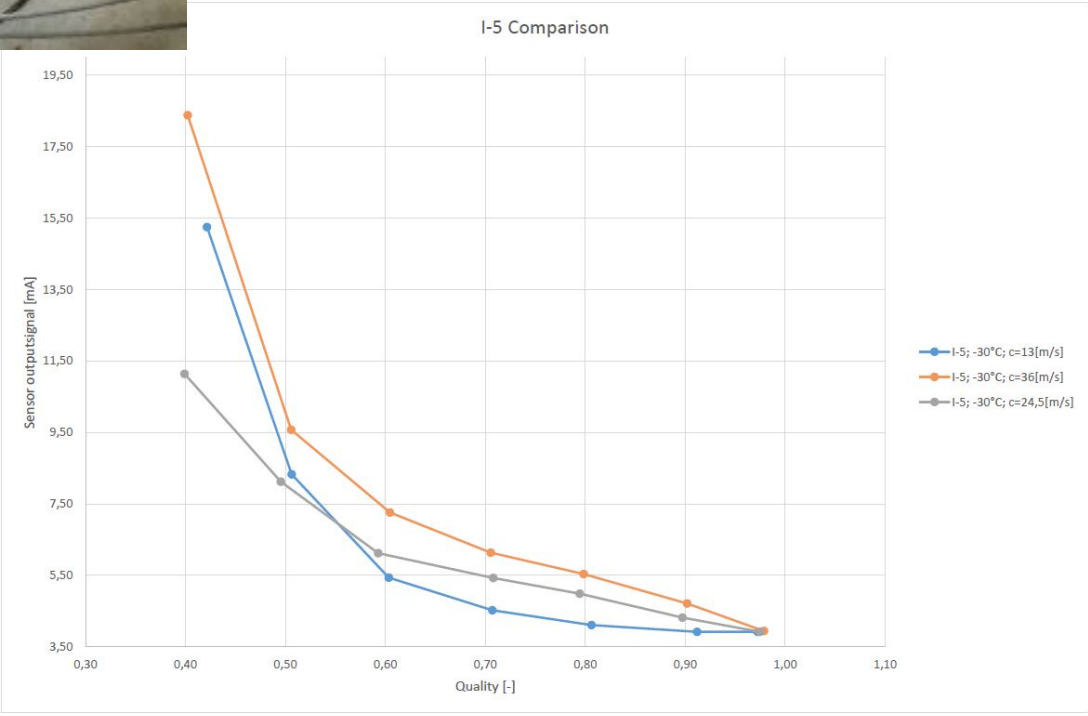
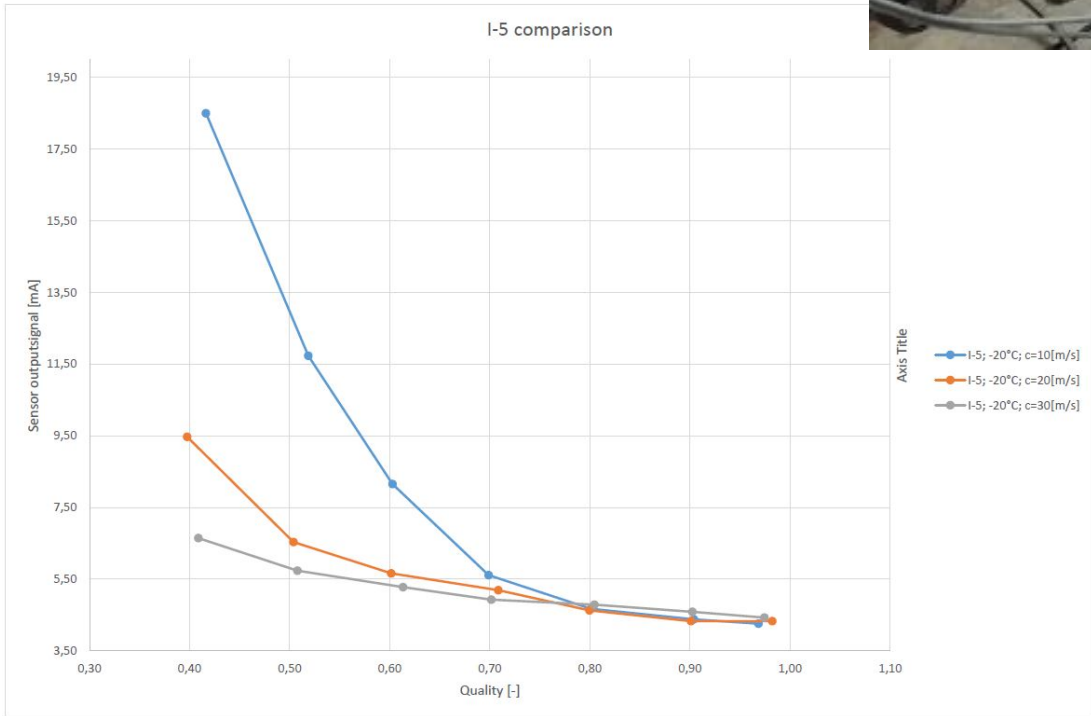
Temperature: $\pm 20^{\circ}\text{C}$

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

