The road to calibrating Ultrasonic Acoustic Doppler Current Meters in the Swiss towing tank for hydrometric instruments

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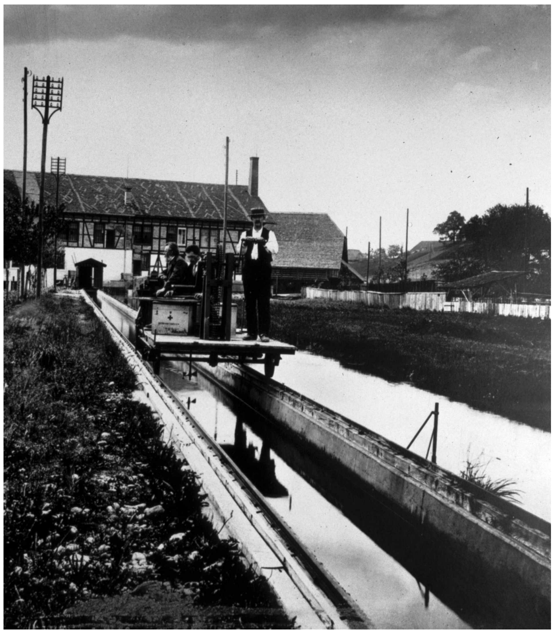
Abstract

The accredited calibration facility for hydrometric current meters in Ittigen, Switzerland, offers calibration services in the range from 0.02 m/s to 10 m/s for the following types of flow meters: hydrometric impellers, magneto-inductive and Acoustic Doppler Current Meter (ultrasonic measuring instruments).

The calibration procedure of Acoustic Doppler Current Meters (ADC) is not identical to the calibration procedure for hydrometric impellers or magneto-inductive instruments. This presentation reports about the finding of a technique to be able to calibrate ADCs and gives a short description about the Calibration procedure.



Introduction

The Swiss calibration laboratory for hydrometric instruments started its work in 1896 with a tow tank of 180 m length, 1.2 m width and 1.4 m in depth (Picture above on the right).

A new tank was constructed in 1951, now with a length of 140 m but a width of 4 m and 2 m in depth. Up to 1990 only current meters had been calibrated.

In 1968 the trolley of 1951 was replaced by a new one with the current velocity range from 0.02 m/s to 10 m/s (Picture on the right).

In 1990 we started to study ways how to calibrate other instruments than impeller current meters. First we received the accreditation for magneto-inductive velocity meters.

But more popular and more often used became the Acoustic Doppler Current meters (ADC), so we wanted to be able to calibrate these instruments as well.

Finding the perfect sediment

Because the ADC use the suspended sediments in the water to detect the velocity, we had to find a way to keep small particles in suspension in the water of the tow tank, so that we can run the measuring instrument through the still water and see some reflections from the particles.

In a first test, we put some very fine sand from one of our gauging stations in the tow tank, and hoped that after stirring it up, the particles would stay long enough in suspension.

With an irrigation tube, like they are used to water the herbs in gardens, we tried to stir up the sand, by pumping air trough this tube (Picture on the right).

Samuel Graf, who was the head of the calibration tank from 1997 to 2008, was searching for a material that is very powdery and has the specific weight of water. He found a product from EMS Chemie called Grillamid L16. It has the specific weight of 1008 kg/m3 which is very close to water. But this powder did stick together and build clumps that settled down on the bottom.

From HSVE in Hamburg Mister Graf received the hint to use Vestosint 1111 from Degussa. This product has a specific weight of 1016kg/m3 (at 23°C) and works better because it doesn't stick together as much as the Grillamid did.

Both products are a Polyamide 12, are non-toxic and can be used in the food industry, for example for storage containers.

When a material was found that worked for the measurement, there was still the question how to mix the powder in the water, in such a way that the particles are uniformly distributed.

After the experience with the irrigation tube, we thought that the particles of our powder must be „placed" in the water. To disperse the particles very evenly, we pumped some water from the tank in a mixer, where we mixed up the powder with the water and let it flow back somehow in the middle range of the tank. A lot of work and perhaps not necessary.

Even when Polyamide 12 doesn't harm the environment, it's still plastic and because man brings a lot of plastics in the biosphere, we thought it would be nice to have particles in our tow tank that are in some kind „organic".

Our chemistry employee had the idea to use the spore of Lycopodium (Picture on the right), witch is often used for tracer measurement in the water, and we thought that it could work. So we bought a little of these spores and made tests in comparison with the Vestosint 1111.

We mixed the two products in water in two plastic tanks. With an Acoustic Doppler Current Meter we measured the dispersion and concentration of the suspended particles using the Signal to Noise ratio. We figured out that the Lycopodium stays longer in suspension than the Polyamide. So we bought 15kg of this stuff and when we changed the water in our tank we added the Lycopodium instead of the Vestosint.

After a few weeks, the spores of this Lycopodium were sticking on the wall of the tank and none was in suspension in the water. Now I have to mention that the tow tank is made from cement, while our test basins were made from Polyester. So here is a difference between the containers we didn't think about.

We learned: The Lycopodium spores go in the pores of the cement while the Polyamide grains don't.

Finding a mixing method

Again we changed the water and added our old product, the Vestosint 1111, to the water. But now we simply strew the powder in the tank when we let new water flow in. This way we used the turbulences of the water (pouring into the tank), to mix the powder up - and this worked quite well. Especially because we always stir the water up before a Doppler calibration procedure. To stir up, we use 3 special rods that we fix on the trolley and let it run a couple of times through the tank. (Picture on the right)

We do this because, we figured out, that when we calibrate over a long time only at low velocities like 1 m/s, 2 m/s, 3 m/s the particles in the water aren't distributed evenly any more.

A question was also how many particles do we need to have a good signal response. So first there was the idea to measure the turbidity with a optical system, but then we got the pragmatic way and simply added particles to the water until we had a good signal to noise ratio (SNR_{dB}) on the Doppler instruments. Typically 20 dB is a ratio where all instruments can be calibrated. Most instruments need just a little bit more than 10 dB.

Calibration procedure

While the machine can capture the pulses of current meters, measure the time and the distance automatically; for the ADC instruments a person has to be on the trolley and start the measurement. So this asks a little bit of experience. The person must know when the acceleration of the trolley is over, when the part of constant velocity begins and when the braking starts, so that the measuring sequence of the instrument proceeds during the part of steady velocity. Then the clocks of the Trolley and the ADC instrument must be harmonised.

Furthermore it's important to know how fast the measuring procedure of the instrument is, because it must have the possibility to complete a measurement but it must terminate before the braking of the trolley starts.

For example a FlowTracker of SonTek needs at least 11 seconds to finish a measuring cycle. At a speed of 2.5 m/s and a distance of 100 m of steady velocity, we have time for two measurement and 18 seconds for start/stop handlings, and that's what we do.

The Calibration Laboratory for hydrometric instruments in Ittigen Switzerland is accredited according to ISO standard 17025

Since January 2011, on behalf of the Federal Office for the Environment (FOEN), the Federal Office of Metrology (METAS) is in charge of the operation of the calibration facility for hydrometric current meters:

The Federal Office of Metrology (METAS) maintains the national calibration standards of Switzerland, ensures their international recognition and disseminates them with sufficient accuracy to Switzerland's research, economy and society. METAS takes the necessary steps to ensure that the measurements required for the protection and safety of the population and the environment are made correctly and in compliance with the applicable laws and regulations.

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