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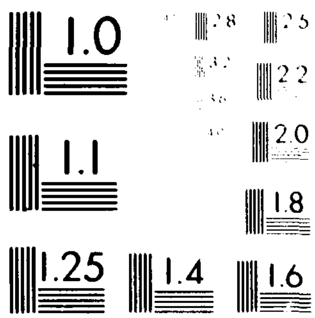
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EXPOSURE

vol. 8 no. 3 a newsletter for ocean technologists

Transmittance and Temperature Sensor Flow Step Response

The National Water Research Institute of Canada (NWRI), Burlington, Ontario, has recently redeveloped a multiband transmittance sensor for use in a transmittance and temperature profiling system. The transmittance sensor is a greatly modified Martek model XMS.* While the internals are completely different from the Martek unit, the 250 mm nominal path length corner cube and flow chamber assembly are identical.

An accurate transmittance profile is nearly always wanted. A fast profile is also desirable to minimize ship station time. These often conflicting requirements mean that the system's limiting time constant is important.

Profiling systems rarely specify the flow time constant. This is unfortunate because many sensors used in a profiling mode are not speed limited by the electronics but rather by the water flow past the sensor's active volume. NWRI's transmittance sensor (and by implication Martek's as well) is no exception. See Figure 1.

To determine the flow time constant, the sensor was mounted rigidly on a tow carriage. A plastic bag was fitted over the sensing volume and secured with an elastic band. A string was tied to the other end. Nigrosin dye was injected through the bag to reduce the water transmittance to between 15 and 25 percent. The carriage was sped up to a simulated profiling speed of 1 m/s. The bag was removed while under way and the output variation was recorded on a fast chart recorder as the transmittance rose to the tow tank's clear water value.

*Mention of a manufacturer does not imply endorsement or rejection of a commercial product for a particular application.

July 1980

FIGURE 1.

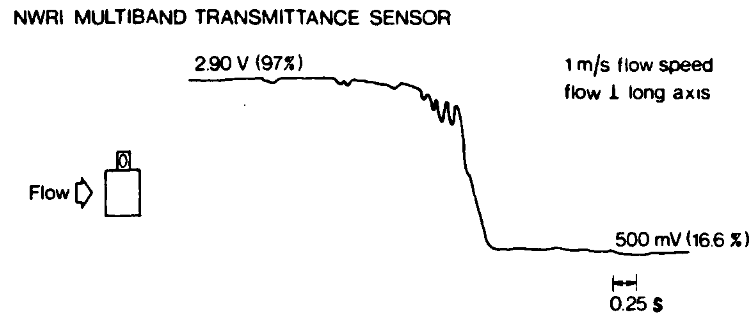
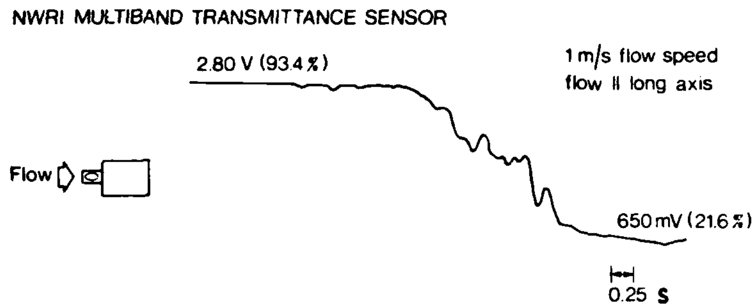


FIGURE 2.



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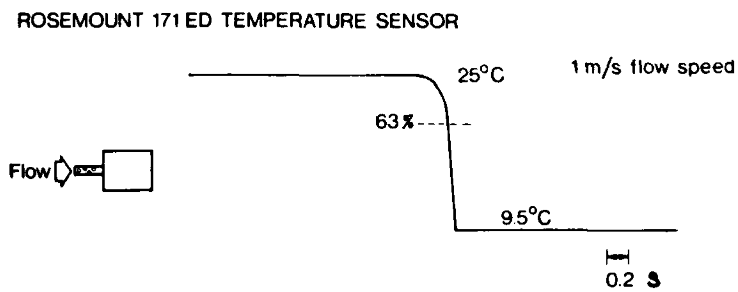


This procedure was done for two sensor orientations: one with the flow perpendicular to the ports and the long axis of the sensor, and the other with the flow parallel to the ports and to the long axis of the sensor. As expected, the first orientation had better flow characteristics for clearing the active volume. The time required to 63 percent of final reading was 0.34 seconds and to 98 percent was about 1.7 seconds. This was repeated at a tow speed of 0.5 m/s with nearly identical results. The second orientation times are 1.4 seconds and 5 seconds, respectively, for the 63 percent and 90 percent values. See Figure 2.

Care should be taken when extrapolating these time constants to other speeds because the hydrodynamic flow past the sensing volume may very well be nonlinear. Also, the curves presented do not exactly follow a classical single pole response. One can make the conclusion, however, that these time factors can result in delay and distortion in the profile, particularly in areas of high transmittance variation with depth.

This type of test was carried out using a Rosemount Model 171 ED temperature sensor. This sensor incorporates the sensing element and signal conditioning in a single underwater case. A plastic bottle filled with an ice water slurry was mounted over the sensor probe. This bottle was rapidly pulled off, as before. The time required to attain 63 percent of the final reading was 65 ms at 1 m/s. See Figure 3. This compares favorably with the manufacturer's 60 ms value at 3 ft/s. The time constant is not greatly affected by flow speed. The values at 50 mm/s and 20 mm/s are 70 ms and 90 ms respectively. This particular sensor appears to follow a single pole response reasonably well. The small fluctuations observed are due to temperature gradients in the tow tank.

It was found that the temperature compensation of the model 171 ED electronics varies considerably and can affect profile readings. Three of these sensors were taken from a 25°C fluid and immersed in a cold water bath, which has a short term instability of 2 to 3 m°C. A 60 m°C, 110 m°C, or 120 m°C overshoot was observed for a 20°C step--the amount of overshoot depending on the sensor. This overshoot returned to the nominal value after about 30 minutes. The amount of overshoot is linear with the temperature differential between the two baths. A reverse of this overshoot was also observed going from a cold bath to a 25°C fluid. To confirm that it was indeed the amplifying electronics and not the platinum element causing the effect, the element alone was immersed. The magnitude of the effect was substantially reduced. A residual error was observed, probably due to conduction between the element and the electronics body. To reduce this electronic drift, 1/2 inch (12 mm) neoprene was wrapped around the electronics body. Syntactic foam could also be used should the sensor be used at great depth. Figure 4 shows the substantial reduction in the temperature shift when the neoprene was used. The magnitude of the peak to nominal error was reduced

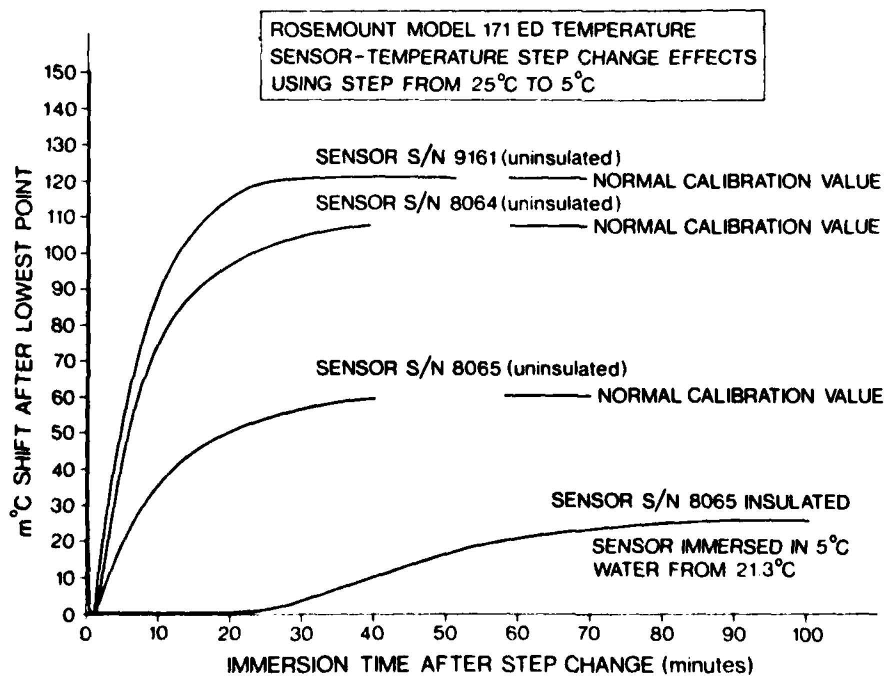
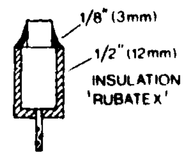


FIGURE 4.



from about 60 m°C to about 25 m°C presumably because the rate of heat loss/gain had been reduced and the self heat of the electronics maintained a more stable electronics temperature. It is instructive to point out that the immersion time of the transducer should be specified when the transducer is insulated and it is to be used for profiling. The sensor should not be immersed for more than 20 minutes for maximum relative accuracy. If a fixed position, long-term measurement is wanted, the sensor should be immersed for at least 1.5 hours for maximum absolute accuracy. It should also be pointed out that if the temperature sensor is used with another profiling instrument, say for example a transmissometer, for maximum accuracy the sensor should be placed well away from obstructing elements such as the transmissometer or a protective cage. Moreover, the transmissometer and cage should be thermally insulated to prevent heat from these bodies affecting the temperature measurement. Ship heat, solar radiation, and flow drag would also have to be considered should these accuracies be needed. It is indeed fortunate for us that accuracies of better than 100 m°C are rarely required for routine limnological profiles.

Roland J. Desrosiers received both his undergraduate and graduate education in electrical engineering at the University of Toronto. He has attended short courses in optics at the Universities of Rochester, Arizona, and Wisconsin. He has been employed as an electro-optical systems engineer at the National Water Research Institute since 1973. His technical interests include designing and adapting instruments which use light as the medium to measure the properties of Canada's lakes and rivers.

Ken Mollon completed an apprenticeship as an "Instrument Maker" in the United Kingdom, and trained as an aircraft instrument technician in the R.A.F. He also received an O.N.C. from the Luton Technical College. His work experience includes industrial instrument calibration and servicing, missile development, computer maintenance, wind tunnel instrumentation, and 15 years with Canadian Westinghouse in electronic instrument maintenance and calibration. He has been employed for the past 8 years by Canada Centre for Inland Waters in the Engineering Services Section, Calibration Laboratory; making a total of 35 years in instrument related work.

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Tape Fouling Problem: AANDERAA Thermistor Chains

During the major field experiment of the Joint Air Sea Interaction Project (JASIN), conducted from July to September 1978, three Aanderaa thermistor chains were deployed beneath a spar buoy (W.H.O.I. mooring 653). Of these three instruments, two failed early in the experiment because the magnetic tape fouled. The tape recorder unit used in these instruments is also used in other Aanderaa instruments and a report on the fouling incidents was thought to be of general interest. A description of the tape-fouling problem and a possible reason for its occurrence follows.

The JASIN instrumentation consisted of a recording unit and a 30 m thermistor string. The three recording units used had serial numbers 271, 272, and 273 and were moored at depths of 76.9 m, 59.7 m, and 47.5 m, respectively, with the thermistor strings extending above the recording units.

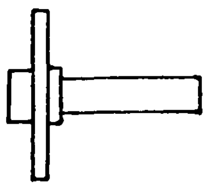
The two instruments which failed had serial numbers 271 and 273. In both of these instruments the magnetic tape was discovered wound around the capstan. The means by which the tape initially fouled is not clear and we can only speculate as to what actually happened. Once the tape fouled, the capstan wound the tape from both the upper and take-up spools. As more tape accumulated on the capstan the pinch roller was pushed out of the way increasing the pressure exerted on the capstan until the batteries could no longer drive the motor.

The amount of tape wound around the capstan was approximately 50 feet. Knowing the length of tape, the sampling interval, and the amount of tape used per sample we determined that the tape was fouled sometime within the first 3 days of the experiment.

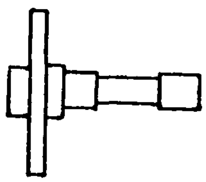
When the instrument operates properly, the capstan, with the help of the pinch roller, pulls the magnetic tape past the tape head. As the capstan advances the tape, a spiral wire spring, which passes over the capstan and around the lower spool holder, drives the take-up spool and keeps the tape between the capstan and the take-up spool taut. It appears that the tape could foul if tape tension between the capstan and the lower spool is not maintained. This could occur if either the spiral wire drive spring were damaged (stretched or broken) or the lower spool became bound and could not be driven by the spiral wire. Since the spiral wire springs on the JASIN instruments were in good condition, we suspected problems with the take-up spool.

In a preliminary inspection of the lower spool holders we found that the take-up spool jammed when the hub nuts on instruments 271 and 273 were overtightened. We could not, however, jam the take-up spool by over-tightening the hub nut on instrument 272. If we assume that the hub nuts on instruments 271 and 273 were not tightened to the point of jamming prior to their deployment, then there had to be another mechanism responsible for their failure in JASIN. We therefore performed several cold tests on all three instruments. Each instrument was set up as it had been for the JASIN experiment. The take-up spools on all three instruments were initially free to move. The temperature at which the cold test was made was approximately 8°C. Instrument 272 functioned properly during the 24-hour cold test. However, instruments 271 and 273 failed; the tape was found at the bottom of the pressure case with some tape wrapped around the pinch roller.

A more detailed inspection of the lower spool holders on all three instruments revealed that a brass shaft on which the lower spool mounts differed between the instrument that worked and the two that did not. A sketch of the two types of shafts is shown in Figure 1. The smooth shaft (Figure 1a) was installed in



(a)



(b)

FIGURE 1. A cross-sectional view of the two types of brass shafts used to hold the lower take-up spool. The newer version (a) was installed on instrument number 272. The older design (b) was found on instruments 271 and 273.

instrument number 272, which worked well, while the other type of shaft (Figure 1b) had been fitted to the other two instruments. According to Aanderaa Instruments (Christopher Newman, Woburn MA), the smooth shaft (Figure 1a) is a newer design intended for use with the Delrin take-up spool drive pulley. The previous type of shaft with the turned middle section dates back to when the take-up spool drive pulley was made of bronze. When cooled, the Delrin take-up spool drive pulley contracts, leaving insufficient clearance on the old style shaft and thus causing the lower spool to jam. Instruments 271, 272, and 273 were assembled during a transition period and one instrument was fitted with the new design shaft while the other two were fitted with the older version. Once instruments 271 and 273 were retrofitted with new shafts the take-up spools functioned properly during additional cold tests and could not be jammed by intentionally overtightening the hub nut.

Prior to their use in the JASIN experiment, the Aanderaa thermistor chains had been deployed in a 1977 experiment (late summer) in Massachusetts Bay. During this experiment, instrument 271 was deployed six times without any failures; however, the maximum deployment period was less than 4 hours. Instrument 272 was deployed once for 5 days and functioned properly throughout the deployment. Number 273 was deployed only once for a period of 27 hours; upon recovery, the tape was found wound around the capstan. In the case of instrument 271, it appears that the short deployment periods were not long enough to cool the instrument sufficiently to jam the take-up spool.

Considering the performance of the instrumentation during the Massachusetts Bay and JASIN experiments, it appears that the cold environment and the equilabration time were the deciding factors as to whether or not the tape would foul. The tape-fouling problem which our Aanderaa instruments experienced under cold conditions seems to have been eliminated when shafts of the design shown in Figure 1a, obtained from Aanderaa, were used to replace shafts of the design shown in Figure 1b.

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