AN UNDERWAY TOWED PUMPING SYSTEM FOR TRACE METAL ANALYSIS

Bob J. Taylor

Engineering Development Laboratory
Office of Marine Technology/NOAA
Rockville, Maryland 20852

ABSTRACT

An Underway Towed Pumping System designed for trace metal studies is described. The objective of the development is to provide a system which can be used to deliver continuous water samples from depths up to 50 meters to a shipboard chemistry laboratory for near real-time analysis of trace metal pollutants.

The system consists of a towed body, a two-part cable assembly, a control and monitoring console, and shipboard handling equipment. All components of the system that contact the sampled water are Teflon to help reduce trace metal contamination.

The system is portable and can be easily deployed using equipment found on most oceanographic vessels. The flexibility of the design suggests that it may be a valuable tool for other ocean survey and pollution monitoring applications.

1. INTRODUCTION

The National Ocean Survey's (NOS) Engineering Development Laboratory started work on the Underway Towed Pumping System (UTPS) in 1978 at the request of NOS' newly established Ocean Dumping and Monitoring Division. The new division has responsibility for monitoring chemical dumpsites along the U.S. east coast and the Gulf of Mexico. The UTPS is being developed to provide a system which can deliver continuous water samples from depths up to 50 meters to a shipboard chemistry laboratory for near real-time analysis of trace metal pollutants.

Fabrication and field testing of the initial system were completed in August 1979, and the first open-ocean cruise took place in September 1979. Improvements since the field test have included the integration of a passive, low-drag towed body and the addition of a temperature sensor. The water delivery tube and electrical cable assembly have also been redesigned to improve the performance and reliability of the components.

The existing configuration supplies seawater to the towing vessel's chemistry laboratory through an all-Teflon pump and tubing system. Chemical analysis equipment (particle counters and iron

auto analyzers have been used to date) installed in the laboratory is used to provide near real-time information about the composition of the dumpsite plume. Discrete samples may also be taken for analysis ashore.

2. SYSTEM DESCRIPTION

The system configuration (Figure 1) is divided into four functional subsystems: the towed body, the tube and cable assembly, the control and monitoring console with water flow manifold, and deck handling equipment.

Figure 1. Underway Towed Pumping System

The towed body (Figure 2) houses the Teflon pump including a motor, temperature sensor, pressure sensor, and a pressure housing which contains multiplexing electronics for the temperature and pressure signals. The 3/4 horsepower pump motor is a 220-volt, single phase unit which drives the Teflon centrifugal pump through a magnetic coupling at 3450 revolutions per minute. A quartz pressure transducer is used to monitor the depth of the towed body, and a precision thermistor is used to measure the temperature of the surrounding water. The towed body weighs 500 kilograms including 450 kilograms of lead ballast plates encapsulated in a polyurethane potting material.

Figure 2. Towed Body

The tube and cable assembly (Figure 3) is a two-part configuration utilizing a separate wire rope to sustain the towing load and a cable bundle containing the Teflon water delivery tube, electrical cables, and rope fillers. The cable bundle is overbraided with a nylon jacket and covered with ribbon-type fairing. Snap shackle connections braided into the jacket at 1-meter intervals are used to connect the cable bundle to the towing wire rope during deployment. Compression sleeves on the wire rope prevent the snap shackles from sliding; hence the loading on the tube bundle is distributed uniformly along the wire rope during towing operations.

The control console (Figure 4), which is normally located inside the chemistry laboratory, contains digital readouts for temperature, flow rate, depth, motor monitoring functions, and a strip chart recorder for temperature and depth data. The water flow manifold, also located in the laboratory, allows the user of the system to divert water through various flow paths depending on his particular sampling needs.

Figure 3. Tube and Cable Assembly.
Note the reel stand in the background.

Figure 4. Control and Monitoring Console

The deck handling equipment (Figure 5) consists of the ship's oceanographic winch for the towing wire rope, an "A" frame or crane, the fish cradle, and a hand cranked reel stand for the tube bundle. The system is compact enough to allow sampling operations aboard relatively small vessels. The initial field tests were conducted aboard a vessel 16.5 meters in length.

Figure 5. Underway Towed Pumping System Aboard Survey Vessel

The specifications for the Underway Towed Pumping System are shown below:

Tow Speeds	0 - 5 knots
Tow Depths	2 - 50 meters
Flow Rate	6 liters/minute
Sample Transport Time	200 seconds
Material	All water delivery system components are Teflon (TFE or FEP)

3. SYSTEM DESIGN AND TESTS

Design trade-off studies were conducted for four of the system's major component areas: the pumping subsystem, the tow cable configuration, the tow body configuration, and water sample handling materials.

Trade-offs were made between on-deck suction pumping and submerged positive pumping aboard the towed body. The attainable suction lift from an on-deck pump is limited by water vaporization, pump cavitation, and pressure leakage, which would require a larger tube diameter than that for a submerged system. The larger tube diameter would in turn require more depressor weight, expensive fairing, and would increase the sample transport time. A submerged pump and motor were selected.

Two alternative configurations were considered for the tow cable arrangement: an integrated double-armored cable and a two-part configuration with separate towing wire rope and cable bundle. Computer analyses were conducted to determine cable scope versus tow depth and ship's speed (see Figure 6). The results of the trade-off analysis indicated that for the depth and tow

speeds of interest, the less costly two-part configuration should be utilized.

Figure 6. Results of Towed Body and Cable Computer Analysis

Winged and non-winged (dead weight) tow bodies were considered for the Underway Towed Pumping System. Additional computer analyses were conducted to help match the towed body to the cable configuration that had been selected. One of the major concerns for the towed body design was the ease with which the body could be deployed and recovered without risk of body damage. A non-winged, dead weight depressor was selected.

A literature survey was conducted to help determine what materials might be useful in the system. Teflon, polyethylene, Delrin, and Noryl were candidates. Although Teflon must be handled carefully to prevent kinking, it was found that the contamination risk associated with using Teflon would be much lower than with the other materials.

Component and system tests have been conducted in the laboratory and under field operating conditions. The system's electronic components were subjected to temperature and humidity tests. Hydrodynamic tests of the towed body at speeds up

to 8 knots were conducted at the David W. Taylor Naval Ship Research and Development Center at Carderock, Maryland.

Sample smearing and contamination have been of particular concern to the system users and to the Engineering Development Laboratory. Tests which address those problems are currently being conducted at the National Ocean Survey's Test and Evaluation Laboratory in Washington, D.C.

Figure 7 shows preliminary data from the contamination testing. Fresh and salt water samples containing four different concentrations of copper (0, 5, 50, and 100 parts per billion) were pumped through the system. The difference in copper concentration between the test sample at the pump intake and the delivery tube outlet is shown on the ordinate axis. Note that the maximum difference is less than 1 part per billion. Additional tests will be conducted for cadmium, iron, zinc, and lead.

Figure 7. Preliminary Data from Copper Contamination Tests

Field tests of the system have been conducted on Chesapeake Bay and at the 106-mile Ocean Waste Disposal Site off the New Jersey coast. Preliminary results from the testing indicate that the system meets design goals.

4. POTENTIAL FOR FUTURE DEVELOPMENT

It has become evident that on-station bottle sampling techniques are inadequate for highly variable environments such as those found at ocean chemical dumpsites. The need for efficient sampling techniques becomes even more evident when one considers the cost of operating oceanographic vessels.

The underway towed sampling system described here is an attempt to address those types of problems, but additional development is required to realize the full potential of such a system. Plans for future development include increasing the depth capability to 100 meters and installing additional sensors. Longer term plans call for developing an on board data acquisition and data management system which will allow the system user to modify his sampling strategy on site by displaying real-time of near real-time data.

REFERENCES

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