EFFECTIVE NEW TECHNOLOGIES FOR THE ASSESSMENT OF COMPLIANCE WITH THE BALLAST WATER MANAGEMENT CONVENTION

A project financed by the Federal German Maritime and Hydrographic Agency

Project Status Informal Document for the IMO BLG session 17, February 2013

In March this year the Federal German Maritime and Hydrographic Agency – BSH, Hamburg, Germany asked SGS Institut Fresenius GmbH, Germany, and Prof.Dr. Nick Welschmeyer, Moss Landings Marine Laboratories, California, USA to undertake a ballast water research and development project: *Effective New Technologies for the Assessment of Compliance with the Ballast Water Management Convention.* The project objectives are twofold: (i) the development of a representative sampling technique and procedures and (ii) the definition of adequate methods for rapid, onboard ballast water analysis. The project is supervised and managed by Dr. Lothar Schillak, marine biologist from SGS. The project is based at the Institute for Nautik and Maritime Technologies (INMT) of the University of Flensburg, Germany. The INMT provided all infrastructure for the necessary test rigs and to execute hydraulic, marine biological, chemical and microbiological test series.

The project used the in-house DN250 natural seawater supporting system at INMT (maximum volume flow of 300m³/h) to test different sampling ports and the sampling system itself.

To deliver representative sampling the project tested two different types of sampling ports: the isokinetic "*bend*" type and the "L"-shaped "*Pitot"*-type. The preliminary results indicate that neither the length of the sampling pipe nor the diameter impacts significantly on the ratio between number and size of particles in the main pipe and in the sampling pipe. A comparison of both types of sampling ports reveals that the isokinetic "*bend*" type yields a higher ratio than the "*Pitot"* type. Subsequently samples taken with the isokinetic "*bend*" type sampling port are more representative than those taken via the "*Pitot"*-pipe.

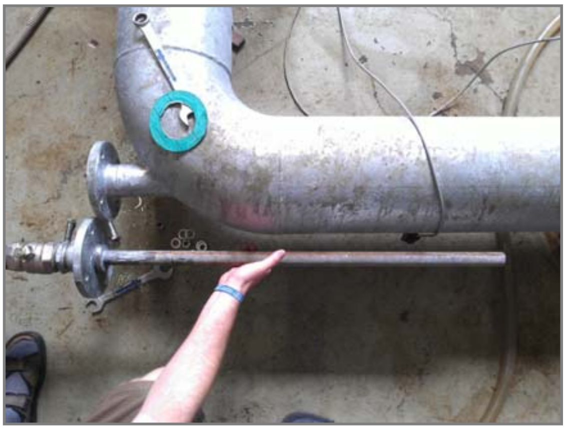
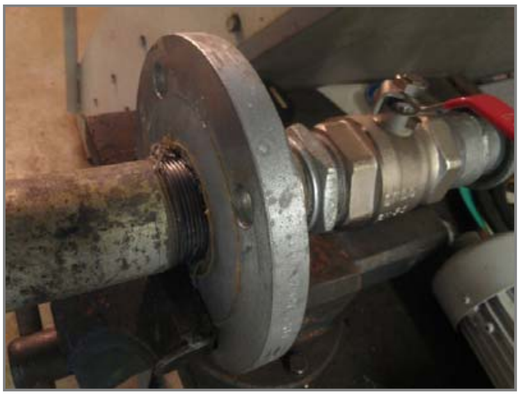


Figure 1 : Isokinetic sampling port “bend” type



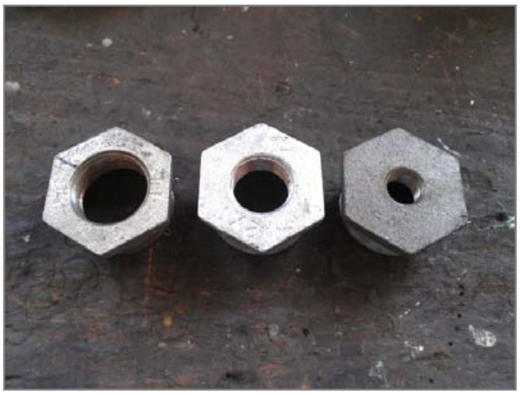


Figure 2 : Isokinetic sampling port “*bend*” type, adapters for variations in diameter

With the isokinetic “bend” type sampling ports several test series were conducted with different sampling pipe diameters as well as several test series with different length of the sampling pipe inside the main pipe.

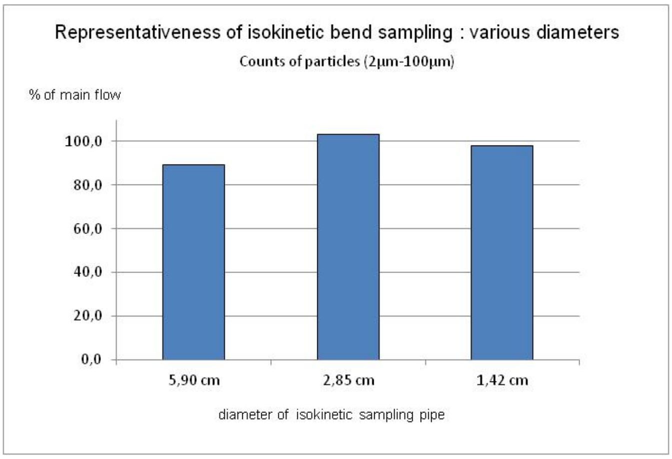


Figure 4 : Isokinetic sampling port “*bend*” type, various diameter of sampling pipe

For the test series with different lengths of the sampling pipe the definition of “*length*” (L) follows the theory of isokinetic sampling. “L” is the strait length of the sampling pipe from the intake to the beginning of the bend (cf. figure 5). The results of the test series are displayed in figure 6.

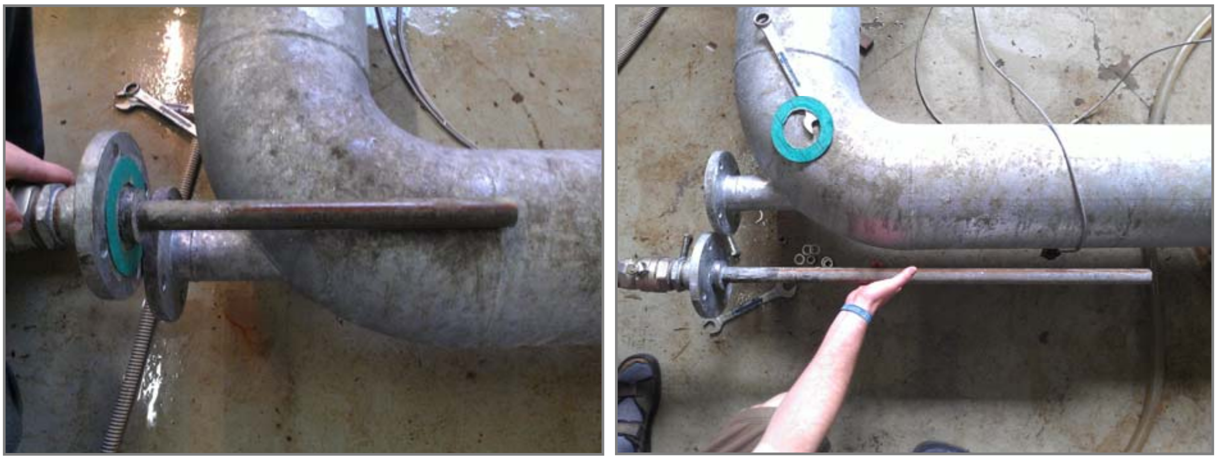


Figure 5 : Isokinetic sampling port “*bend*” type : definition of “length”, left: 0 cm, right: 50 c

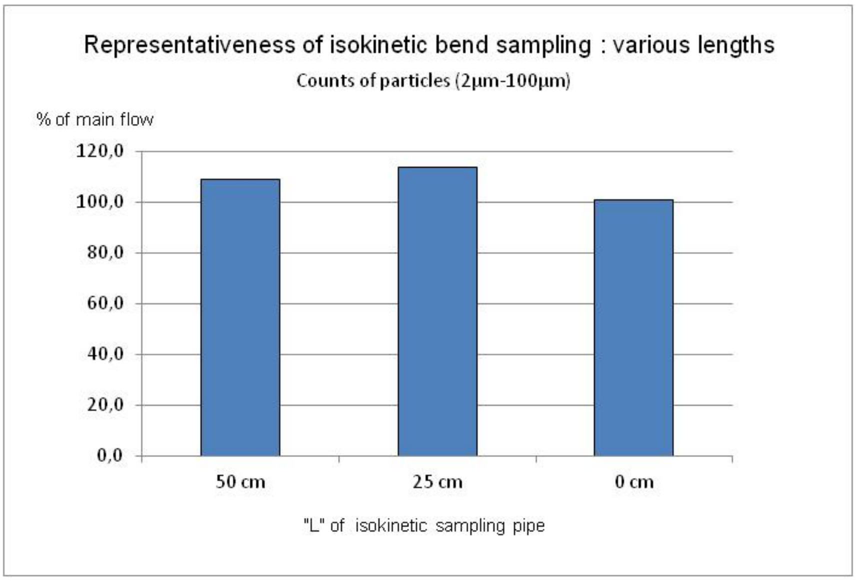


Figure 6 : Isokinetic sampling port “*bend*” type : representativeness of different length

For the comparison of the representativeness between the two sampling port types only one test series has been conducted to date. The isokinetic sampling port “*bend*” type was equipped with a sampling pipe of 50 cm length with diameter of 2,85 cm. The isokinetic sampling port “*Pitot*” type was equipped with a straight length of 15cm and a diameter of 2,85 cm.

Figure 7 shows the isokinetic sampling port “Pitot” type. The results of the comparison are displayed in figure 8.

Figure 7 : Isokinetic sampling port “*Pitot*” type installations, left: inside main pipe with view upstream; right: sampling port with valve

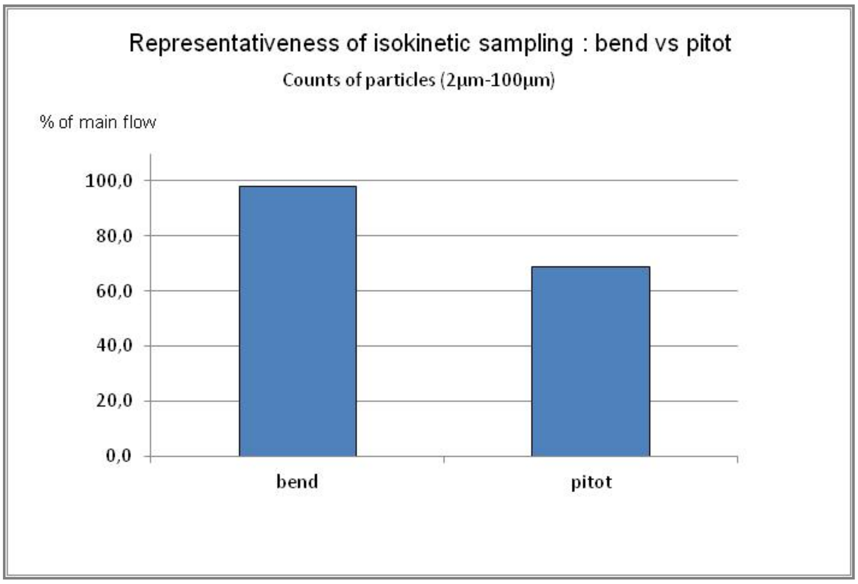


Figure 8 : Isokinetic sampling ports : comparison of representativeness

Test series with the isokinetic sampling port “*Pitot*” type with various lengths and diameters still have to be executed. The isokinetic sampling port will then be equipped with pipes of the same diameter as the pipes for the isokinetic sampling port “*bend*” type (cf. figure 4). This enables for the comparison of both types regarding the representativeness of samples taken with all various lengths and diameters.

The sampling system as displayed in figure 9 comprises a filter cascade which allows for large sample volumes as the ballast water is flushed back to the main ballast water pipe system after having passed the filters. Three filter components according to the IMO size classes >50µm, >10µm<50µm and bacteria (0,2µm) are inbuilt.

Figure 9 : Test stand of sampling system (explanations see text)

Figure 9 displays the components of the sampling system mounted to a test stand. Two large filter housings carry nylon mesh filters with 50µm and 10µm mesh size. Two smaller filters (2,5µm and 0,2µm; left hand side) are installed in a bypass that deviates by a smaller isokinetic pipe. Volumes counts at bottom of the test stand allow for the monitoring of the sample volumes.

The isokinetic port installed at the ballast water main pipe is directly connected with a tube to the 50µm filter housing (right hand side). Another tube connects the valve of the sampling system test stand (blue) with the back flush port installed in the main pipe of the ballast water main pipe.

The ballast water flushes from the isokinetic sampling port at the ballast water main pipe through the filters and back into the ballast water main pipe.

From various hydraulic and marine biological test series these are the main data:

- ⇒ Maximum pressure tested : 2,5 bar
- ⇒ Maximum volume flow tested: 287 m^3/h
- ⇒ Maximum flow velocity tested: 1,67m/s
- ⇒ Largest volume for one sample: 17,2m^3
- ⇒ Longest, uninterrupted, failure free run: 16 h

To install such a sampling system onboard a ship and connect it to the ballast water pipe system simple flanges (DN65) are needed.

The marine biological test series executed with the test stand revealed that a flow velocity of 1,0m/s in the sampling system should not be exceeded in order to ensure that the target organisms are not killed during filtration. Ideally a flow velocity around 0,5m/s should be maintained during the sampling process.

This finding presets the dimension of the sampling pipe installed in the isokinetic sampling port. Following hydraulic principles the diameter of the isokinetic sampling pipe should be smaller than the diameter of the pipes used in the sampling system. Mathematical calculations with data from various publications regarding the dimensions of ballast water pipe system installed on various type of ships (bulk carrier, container, VLCC, OBO, etc.) show that a diameter of 2,85 cm of the isokinetic sampling pipe ensures a subsequent flow velocity of < 1m/s for almost all types of ships.

At present the three filter components of the test stand are transferred into a portable, modular system, comprising three modules (>50µm, >10<50µm, 2,5µm+0,2µm) equipped with easy and quick connection units to be fitted to eachother and to the ballast water pipe system, too. The modular system will be ready for first test series in the second half of November.

For the rapid onboard analysis of ballast water the project concentrates on different methods: Fluorescence-di-acetate (FDA, IMO size class >10<50µm), Pulse-Amplified-Modulation Fluorometry (PAM, IMO size classes >50µm and >10µm<50µm), Adenosin-triphosphate Fluorometry (ATP, all three IMO size classes) and Fluorescence-in-situ-Hybridisation (FISH, IMO size class bacteria). Except for the PAM method it was necessary to further develop the other methods for the analysis of ballast water in regard of the seawater chemistry and the special conditions under which ballast water analysis has to be executed. One of the main targets in developing these methods was to allow for fast “sample-to-result” times.

FDA : FDA is a non-fluorescent compound which, when hydrolyzed by biological enzyme activity, yields fluorescein, a highly fluorescent compound that clearly marks ‘live’ cells with optically-induced green fluorescent emission. During laboratory tests and tests with ballast water on ships in operation a correlation was found for the concentration of Fluorescein-di-acetate and the organism density in sample. So far only the IMO size class >10µm<50µm were investigated. The time needed from sample to results is only a few minutes.

ATP: ATP is the energy carrier in each living cell. Extracted from the cells and processed by adequate chemical compounds one molecule exhibits exactly one fluorescent signal. During laboratory test with cultured marine microalgae and natural seawater from different marine regions a clear correlation was found for the concentration of ATP and the organism density in a sample, especially in very low densities, close to the IMO limit values. This correlation was found for all of the three IMO size classes >50µm, >10µm<50µm and bacterial. As for FDA, the time needed from sample to results ranges within only a few minutes.

FISH: So far FISH has been tested for the concentration of E.coli in seawater. The further development of FISH for Enterococci and Vibrio cholera is under way. The estimated time needed from sample to qualitative and quantitative results is estimated to be approximately 8 hours.

During the months to come further test series will be conducted which aim at:

- ⇒ The applicability of the transportable, modular sampling system on ships in operation
- ⇒ The definition of adequate sampling procedures during de-ballasting
- ⇒ The applicability and the verification of the analytical methods described above on ships in operation

Especially during the onboard test series additional emphasis will be put on the adequate sampling procedures answering the question *“How many samples of which volume should be taken when to best represent the quality of the ballast water ?”*

In addition the onboard test series will try to define the optimal analytical procedure, which might considerably reduce the total time needed for the analysis of the ballast water for all IMO target size groups (plankton >50µm, plankton >10µm<50µm and bacteria)

Preliminary, theoretical considerations led to the definition of 4 analytical levels each of which allows for the immediate termination of the onboard compliance testing. Figure 10 displays the different analytical levels I to IV.

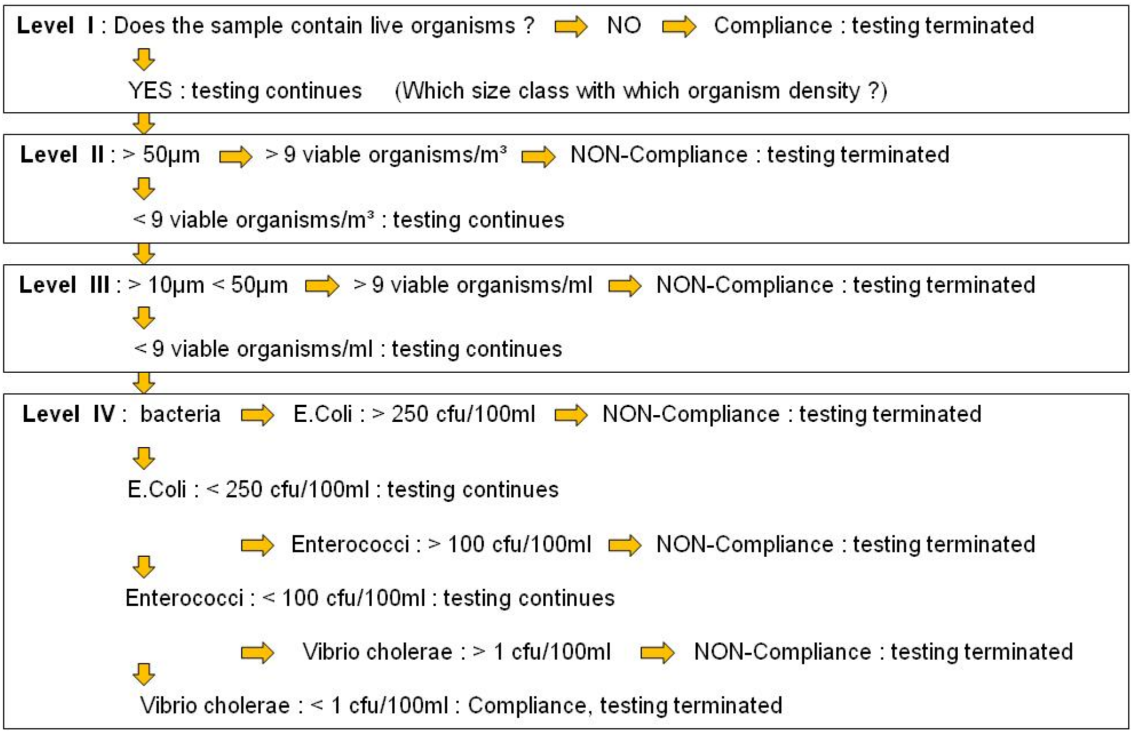


Figure 10 : Test stand of sampling system (explanations see text)

It is obvious that the analysis of the ballast water should start with the easiest method and the analytical method which is most complex should be executed on the last level IV. Thus analytical methods with a rapid protocol

from sample to result will be executed on the first three levels to ensure the onboard compliance test can be rapidly terminated on each of the levels I to III .

These test series indicated above (cf.previous page) are planned to start mid November and first results should be available by the end of the year 2012.

The submission of the final project report to the BSH is anticipated in January 2013. It is planned to present the essential facts and findings of the project within the frame of the IMO MEPC Session 65 in April/May 2013.