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# Study of the sealing performance of tubing adapters in gas-tight deep-sea water sampler

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**ABSTRACT:** *Tubing adapter is a key connection device in Gas-Tight Deep-Sea Water Sampler (GTWS). The sealing performance of the tubing adapter directly affects the GTWS's overall gas tightness. Tubing adapters with good sealing performance can ensure the transmission of seawater samples without gas leakage and can be repeatedly used. However, the sealing performance of tubing adapters made of different materials was not studied sufficiently. With the research discussed in this paper, the materials match schemes of the tubing adapters were proposed. With non-linear finite element contact analysis and sea trials in the South China Sea, it is expected that the recommended materials match schemes not only meet the requirements of tubing adapters' sealing performance but also provide the feasible options for the following research on tubing adapters in GTWS.*

***KEY WORDS:*** Tubing adapters; Deep sea; Finite element analysis; Sealing performance.

## INTRODUCTION

The utilization of abnormal information of symbolic gases to find active minerogenetic area is one of the important prospects in the current exploration of ocean floor resources (Kelley et al., 2002; Milkov et al., 2004; Lilley et al., 1995; Kelley et al., 1998; Radford et al., 1998; Houghton et al., 2001; Nakayama et al., 2002). Huang et al. (2012) proposed that the underwater environment (e.g., high pressure) makes underwater resource exploration increasingly challenging, especially in deep sea. Research shows that gases such as $CH_4$, $H_2S$, $CO_2$ and $H_2$ in seawater are important tracers for exploration of marine resources such as deep-sea hydrothermal fluids, cold spring, natural gas hydrate, and so on. Lilley et al. (1995), Kelley et al. (1998) and Radford et al. (1998) all suggest that the full analysis of gas type and content in sea water plays a significant role in marine scientific research and exploration of marine resources. Thus, it is necessary and critical to converse gases in seawater. If gases leak from the water with the change of the environmental factors such as temperature and pressure in the process of sampling, transmission and transfer, the collected data cannot accurately reflect the gas components in the samples (Huang et al., 2011).

Tubing adapters, as connection devices are widely used to connect sampling chamber and sampling valve in GTWS. Tubing adapters with good sealing performance can ensure the transmission of seawater samples without gas leakage and can

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be repeatedly used. When the companies and institutes such as General Oceanics, HYDRO-BIOS and WHOI used engineering plastics and metal materials such as PVC, PTEF, PEEK, Stainless Steel 316 and titanium alloy to manufacture water samplers, only the anti-corrosion and preventing sample contamination were taken into account. Sealing performance of different materials, however, was analyzed insufficiently (Li, 2003; Taylor et al., 2006; Sauter et al., 2005).

In this paper, after the introduction of GTWS and its tubing adapters, the sealing performance of tubing adapters, tubes and water sampler bottle, each made of different materials, was analyzed by non-linear finite element contact analysis method with software ANSYS according to GTWS's real condition. Furthermore, recommendatory materials match schemes of tubing adapters, tubes and water sampler bottle were derived both in theory and practice. The results of presented analysis provide theoretical guidance for engineering application of GTWS. In addition, the reliability and tightness of GTWS were tested respectively in tank and high pressure vessel. The sea trials were also carried out in the South China Sea to test the gas tightness of GTWS, and the gas-tight seawater samples were obtained by GTWS. The seawater samples could be transmitted without gas leakage nor contamination and the tubing adapters can be used repeatedly. The goals of no-contamination and non-leakage sample transmission were successfully achieved. Consequently, the sealing performance of the GTWS was verified both in theory and practice.

## GAS-TIGHT DEEP-SEA WATER SAMPLER AND TUBING ADAPTERS

The integrity of gas content of seawater is required in marine scientific research and marine resources exploration and the GTWS is the major device of seawater sampling and storing, which is indispensable in seawater sampling. Tubing adapter is the key connecting device in GTWS, used to connect sampling chamber and sampling valves. Fig. 1 is the schematic diagram of a small volume GTWS developed by Zhejiang University and its prototype is shown in Fig. 2. With such sampler, about 180 *ml* seawater could be collected. The water sampler bottle is made of Stainless Steel 316, and Tubing Adapters, tubing and globe valve are made of PEEK. The sealing performance of the tubing adapter directly affects the GTWS's gas tightness. PEEK tubing adapters with excellent sealing performance ensure the transmission of seawater samples without gas leakage or contamination and can be used repeatedly.

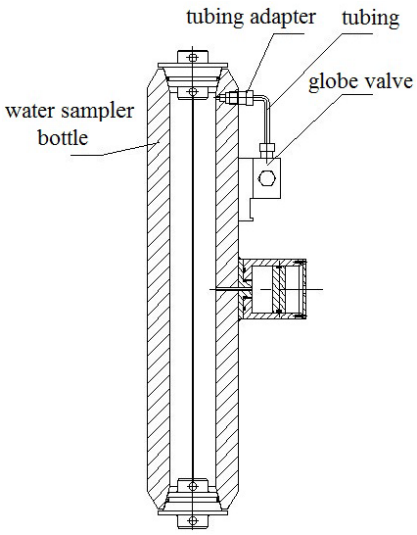


Fig. 1 Design schematic diagram of the small volume GTWS.

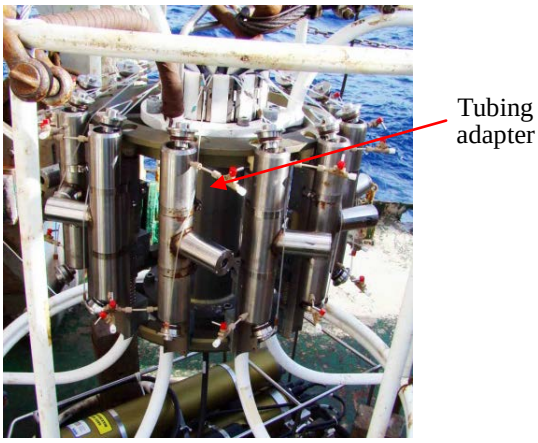


Fig. 2 Prototype of the small volume GTWS.

## THEORETICAL ANALYSIS OF TUBING ADAPTERS'S SEALING PERFORMANCE

In our research, the way of seal between tubing adapters and sampling chamber is static contact seal. Its sealing mechanism is to add pressure to the contact sealing surfaces to form a fully fitted sealing ring. The counterforce of the sealing ring is larger than the medium pressure, which can prevent the medium from entering thus the goal of sealing can be achieved. In the previous research of Gu (2000), on the micro level, the basic mechanism of static contact seal is that the sealing materials, in plastic