THE VENTURI TUBE AS A LIQUEFIED-GAS FLOW MEASURING DEVICE

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Introduction

Continuing interest in flow measurement techniques for liquefied gases, coupled with a sponsor's request to test a specific device as part of an assistance program covering various theoretical and experimental studies in the field of cryogenics, has led to the research reported in this paper.

Using a Venturi as the fluid metering device and liquid hydrogen as the test fluid, flow rates ranging from 34 to 1002 liters/min were achieved, tabulated, and plotted in relation to discharge coefficients in the conventional manner. Experimental accuracies were listed and discussed to the extent that they influence the test results.

An examination of this work, together with a comparison of results obtained here and with other devices elsewhere, should serve to indicate the usefulness of a Venturi as a low-temperature fluid meter.

Description of Apparatus

A Venturi meter of conventional design, with the exception of an infinite inlet diameter (Fig. 1), was used in this work primarily to determine the usefulness of such a device in the measurement of cryogenic fluid flow rates. The Venturi throat was approximately 1/2 in. in diameter, and the downstream tube was 1 in. The Venturi meter inlet was located on the centerline of the tank, roughly 6 in. from the bottom. Throat and upstream pressure tap lines and also the vapor bulb line, made of thin monel tubing, were bundled together within a vacuum-jacketed tube (see Fig. 2) which was terminated at the same level as the entrance to the Venturi. The upstream pressure line was open to the tank contents at this point, while the throat tap extended to a four-hole piezometer ring connection. A 14-gauge copper wire was soldered along the length of the bundle of three thin-walled monel tubes, terminating about 2 in. above the lower end of the jacket. The copper wire was used to force a temperature of about 40°K at the point of termination, thereby preventing any liquid from rising in the tubes which could introduce an error in the pressure measurements. The bundle of tubes was located at the axis of the jacket by means of small Teflon washers spaced every 18 in. along the tubes.

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An elevation assembly drawing of the 625-gal dewar used in this study is presented in Fig. 2. The inner vessel was supported within the outer shell by means of a 15-in.-diameter stainless steel cylinder, fastened between central portions of the two dished heads, as shown in the drawing. The diameter of this cylinder was chosen to provide a manway into the test container for relatively easy access to the internal instrumentation. Evacuated perlite was the insulating medium; a static insulating vacuum of $10^{-15}$ was achieved in the cold, hydrogen-filled dewar.

![Fig. 1. Venturi meter; material—brass.](image1)

![Fig. 2. 625-gal test dewar.](image2)

Essentially all critical test components were attached to the manway cover, thereby providing an orderly means for placing, removing, and examining internal equipment when necessary, with a minimum of difficulty. Horizontal, bright stainless steel baffles (Fig. 3) were spaced at regular intervals within the access cylinder to minimize hydrogen gas circulation, and heat radiation, in this region. They were soldered to the fill, vent, and instrument lead tubes. Another common method of insulating a zone (such as that illustrated by Fig. 3) which may be exposed to temperatures approximating $300^\circ K$ on one side and something less than $100^\circ K$ on the other is to build an evacuated-powder or high-vacuum insulated plug with a cylindrical stainless steel wall. However, in the case of a moderate- or high-pressure-rated container, the plug must be built to withstand vessel design pressure, implying relatively heavy plug walls. As a consequence of the thermal conduction characteristics of various materials involved, the hydrogen gas baffle arrangement provided a better heat barrier across the manway than an evacuated plug of adequate pressure rating. For this reason, and for the sake of simplicity and economy, the former construction was used. It may be of interest to note