INVESTIGATION INTO THE LOOSENING OF RISERS IN CARBON-DIOXIDE CYLINDERS FOR FIXED FIRE-EXTINGUISHING SYSTEMS ABOARD SHIPS

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1. INTRODUCTION

For the sake of safety to man, cargo and ship we find aboard cargo ships fire-extinguishing systems consisting of a number of integral connected carbon-dioxide cylinders. Inspectors of the Dutch Director-General of Shipping and Marine Affairs found in the last few years during the legal inspections aboard ships an outstanding great number of cylinders with loose risers. To become familiar with the problem to deal with, figure 1 shows the cylinder and a useful detail of the quick-release valve. The cylinder is 270 mm wide and 1450 mm long and made of wrought steel, designed for a test pressure of 150 bar. The cylinder is shut with the quick-release valve in which a riser (dip tube) is screwed. The liquid carbon-dioxide (about 45 kg) is contained in the cylinder with a pressure of about 60 bar at room temperature.

The riser is of utmost importance. After releasing the valve, the carbon-dioxide has to be transported to the protected room as a liquid. In the regulations is laid down "when a carbon-dioxide fire extinguishing installation is put into operation it must, within 2 minutes, be possible to admit into the room involved 85% of the amount of carbon-dioxide prescribed" [3]. This rule can only be met with the riser in correct position. Actually each loose riser means a non-functioning cylinder and a dangerous sham safety.

In spite of the alarming findings of the inspectors, the people concerned with the assembling of the cylinders and installation of the complete systems aboard ships reacted incredulous. Risers that can not be touched by something nor by someone "have nothing to hold, haven't they?". In the past not too much attention was given to the fitting of the riser in the valve. Only a few manufacturers have written instructions giving mounting torque and use of a sealant. The rest uses transmitted customs based on craftman's experience.

The question remains if a riser, fitted according to the current and accepted methods, can work loose after a period of time, thus creating a perilous situation. Eliminating all possible environmental attacks to the riser, at the end shock and vibration seem to be the only possible causes that affect the riser connection with the unwanted results mentioned.

Wieringa, H (ed), Experimental Stress Analysis.
2.1 Vibration - Natural Frequencies

In analyzing a shock and vibration problem the first step is to study natural frequencies and damping factors. The resonance frequency of a one-sided clamped beam can be calculated by [4]:

\[ f_n = \frac{a_n \sqrt{EI}}{2\pi \mu l^4} \]  

(1)

Where:
- \( E \) = Young's module (N.cm\(^{-2}\))
- \( I \) = moment of inertia (cm\(^4\))
- \( \mu \) = mass per unit of length (kg.cm\(^{-1}\))
- \( l \) = length of riser (cm)
- \( a_n \) = coefficient for the various forms of vibration

\[ a_1 = 3.52 \]
\[ a_2 = 22.0 \]
\[ a_3 = 61.7 \]
\[ a_4 = 121.0 \]

For the experimental verification, a steel riser was firmly clamped to a shaker table and vibrated in the frequency range 5-150 Hz. The response characteristic is given in figure 3. Natural frequencies found: 7.6 Hz, 48.2 Hz and 134.0 Hz with damping factors for the three modes: 0.6%, 1.6% and 0.3%. The damping is so small that large amplification factors can be expected at the resonance frequencies; in the first mode \( Q = 87 \). In figure 2 the first two modes are shown.

It may be remarked here that the frequencies corresponding to the first mode are certainly to be expected aboard ships, and passed through anyway during manoeuvring activities.

FIGURE 1: fire-extinguisher cylinder with detailed quick-release valve

FIGURE 2: a) first bending mode, \( f = 7 \) Hz  
   b) second bending mode, \( f = 40 \) Hz