

Experiments with scale models of oil collectors for subsea well blowouts—Part II

JEROME H. MILGRAM, CHRISTOPHER J. VON ALT and JAMES J. BURGESS

Department of Ocean Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA

A previous paper of the same title indicated the feasibility of the collection of oil by an open bottom collector above a blowout with a marine riser above the collector; the whole collection system being driven by gas lift from the blowout gas. That paper was based on small-scale laboratory experiments and it identified the salient dimensionless parameters governing those experiments. This paper describes laboratory experiments on a refinement of the collection system and also describes the results of intermediate scale experiments. The length scale of these experiments was about four times greater than laboratory scale and about one-fourth of full scale. Generally, the intermediate scale results are consistent with the laboratory predictions. Furthermore, two scale-dependent parameters have been identified. The effects of these have been included in an analysis of the results.

1. INTRODUCTION

In Part I, authors Burgess and Milgram¹ described the results of laboratory scale experiments on subsurface oil collectors. The collectors were of the inverted funnel-type intended for use immediately above the wellhead or blowout source. It was found that the fraction of blowout oil collected was primarily dependent on the Froude number F , and the phase ratio R , with these quantities defined by:

$$F = Q_T / (gh^5)^{1/2} \quad (1.1)$$

$$R = Q_T / Q_g \quad (1.2)$$

where Q_T is the total collected liquid flow rate passing through collector and riser, Q_g is the gas volume flow rate, g is the acceleration of gravity, and h is the vertical distance from the blowout source to the base of the collector.

As the Froude number and phase ratio were increased the fraction of blowout oil collected increased. So long as nearly all of the blowout gas was collected, the fraction of blowout oil collected was relatively insensitive to details of the collector shape. When the collector was made small enough for a substantial portion of the gas to avoid collection by rising beside the collector, an increase in the fraction of blowout oil collected was often observed to occur. This led to the conclusion that under many circumstances, a collection system could encounter more than the optimum amount of gas. As an aid in overcoming the reduction in collection efficiency resulting from excess gas, the gas separating collector described in Appendix B of Part I was devised. A few laboratory experiments with the gas separating collector are described in Part I. However, the range of test conditions was quite small and for that reason, some further experiments with the laboratory scale model of the gas separating collector were carried out and are described in the next section of this paper.

The laboratory scale experiments described in Part I have a length scale of approximately one-fifteenth of anticipated full scale. Complete dimensional similitude between laboratory scale and full scale does not exist with regard to Weber and Reynolds numbers. Perhaps the

most important consideration with regard to scaling errors involves the gas bubble sizes which are approximately equal in the laboratory and in full scale. Therefore, the ratio of bubble diameter to riser diameter is substantial in the laboratory but very small at full scale. In order to assess the possible effects of scaling, larger scale experiments were conducted and are reported in this paper. For these experiments, the length scale is approximately one-fourth of anticipated full-scale lengths.

2. FURTHER EXPERIMENTS WITH THE GAS SEPARATING COLLECTOR

Figure 1 shows a drawing of the laboratory model of the gas separating collector. As is described in Part I, it was initially planned that this collector would operate with most of the gas passing through the central riser with just enough gas escaping from the inner cone to the outer cone to drive the outer riser at maximum efficiency. In this condition, the interface between the continuous gas phase and the continuous water phase in the inner collector would be so low that nearly no liquid would pass through the central riser. The data presented in Appendix B of Part I were obtained for these conditions.

To operate a gas separating (henceforth called double) collector in the above way requires adjustment of the inner riser resistance, by means of a control valve, to make it suit the operating conditions. Subsequent experiments in the laboratory revealed an efficient mode of operation which did not require such an adjustment. This was to fit both the inner and outer collector with equal size risers and to collect liquid from both risers. Under conditions having a high Froude number and a high phase ratio, no gas would escape from the inner collector and only the inner riser would pump liquid. If the gas flow rate is increased from that yielding an efficient operating condition, the continuous liquid phase interface moves lower in the inner collector. Under conditions for which the inner collector operating alone becomes inefficient, some gas escapes from the inner collector to the outer collector and the outer riser begins pumping. With both risers operating, the total collected

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