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Gas removal systems associated with dredge pumps: phase b, October 1964

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Dredge Pump Research

GAS REMOVAL SYSTEMS ASSOCIATED WITH DREDGE PUMPS: PHASE B

by

John B. Herbich

Fritz Engineering Laboratory Report No. 310.4

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CIVIL ENGINEERING DEPARTMENT
FRITZ ENGINEERING LABORATORY
HYDRAULICS DIVISION

GAS REMOVAL SYSTEMS ASSOCIATED WITH DREDGE PUMPS: PHASE B

Status Report No. 3

Prepared by

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Prepared for

U. S. Army Engineer District, Philadelphia
Corps of Engineers
Philadelphia, Pennsylvania

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LIST OF CONTENTS

PREFACE

The following report summarizes the studies performed during the period August 1, 1964 to October 15, 1964, at the Hydraulics Division of Fritz Engineering Laboratory, under terms of Contract No. DA-36-109-CIVENG-64-72. Earlier studies were described in two status reports (Fritz Laboratory Reports No. 310.1(1)* and No. 310.2(2)*) and a project report dated June, 1964 (Fritz Laboratory Report No. 310.3(3)*).

The project report completed the work undertaken under Phase A of the project entitled "Gas Removal Systems Associated With Dredge Pumps".

The current status report summarizes the studies conducted under Phase B of the project.

Dr. John B. Herbich is the project director and Dr. Adnan Shindala is the project supervisor, they are assisted by Messrs. A. Amatangelo, instructor and Mr. G. Bagge, research assistant. Professor W. J. Eney is head of the Civil Engineering Department and Fritz Laboratory and Dr. L. S. Beedle is the director of Fritz Engineering Laboratory.

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*Numbers in parenthesis refer to references on page 10.

I. INTRODUCTION

The scope of work under Phase B of the project was subdivided into two parts as follows:

Part 1:

a. Formulation of test program; planning the various series of tests and planning the sequence of tests within each series; determining the parameters to be studying, and distinguishing between dependent and independent variables. Development of the facility layout; determining space requirements for the test facility and physical arrangement of apparatus; determining the components needed in the test setup. Development of special facility details; establishment of piping runs and design of special pipe details; design of tanks, foundations, and other structures; design of instrumentation and controls; specifications for special equipment. Development of detailed step-by-step test procedures; sequence of control operations, adjustments and read-outs; design of data sheets; and establishment of curves to be plotted for study.

Part 2:

b. This shall consist of the development of a complete test schedule. The schedule shall be in the form of a bar graph for each separable test or series of tests. Bar graphs shall be on a time scale of x days of time zero (which will be the data of receipt of Notice to Proceed with Phase C). The bar graphs shall indicate any notable milestones at suitable points, and a scale of percentage of completion shall also be carried along each graph.

II. COMMENTS ON LETTER OF MAY 22, 1964 FROM U. S. ARMY ENGINEER DIVISION, NORTH ATLANTIC, AND ON LETTER OF JUNE 1, 1964 FROM U. S. ARMY ENGINEER DISTRICT, PHILADELPHIA

For completeness of project records, the following comments are offered:

(a) <u>page 2, 3rd paragraph</u>

Of particular interest is the statement "the gas drawn into the suction line causes appreciable decrease in vacuum". If this can be proven to be a correct cause-and-effect relationship, then vacuum control of gas removal equipment should be given serious consideration.

<u>Comment</u>:

It would indeed be of interest to determine the feasibility of vacuum control of gas removal equipment. This might be done by means of providing a valve in the suction line of the vacuum pump which could operate automatically and which could be actuated by the dredge pump vacuum. This is just a possibility and it will require further investigation.

(b) <u>page 2, 4th paragraph</u>

The statement that the gas removal systems as now existing on dredges "are not totally effective" is questioned since no adequate means are presently available to evaluate the absolute effectiveness of gas removal system. It is considered that one of the objective of the proposed model tests is to develop the measuring technique necessary to obtain sufficient data for the evaluation of gas removal effectiveness.

Comment:

The above statement was based on personal conversations and the opinions of the field personnel who, had the experience of using gas removal systems. However, it is agreed that the effectiveness of such systems can not be fully evaluated until adequate means of gas removal are developed, which is one of the main objectives of the current project.

(c) page 4, last paragraph

The statement "If actual conditions are to be duplicated in the laboratory, gas has to be introduced into the suction line" is considered too exclusive. The gas could already be in the water before it enteres the suction line in the form of absorbed gas. Also, the possibility exists that no gas need be used if the generation of water by a suitable heating device can serve the purpose.

Comment:

The above comment implies that the water used in this study would first be saturated with the gas which will then be liberated in the suction line. This procedure will make the problem of monitoring the amount of gas liberated as well as the total flow of gas much more complicated. At the present time it is planned to inject free gas at some point along the suction line. This point will probably be close to the drag head. Vaporizing of the water will probably not be feasible as (a) it would necessitate a heating device, (b) the plexiglas piping will not stand the high temperatures, and (c) the pump would experience cavitation.

(d) <u>page 5, top paragraph</u>

A third method that uses single-flow measurements only may be applicable, e. g. measure the combined flow before the gas comes out of solution (single-phase flow) and separately measure the flow streams after separation by the gas removal equipment.

Comment:

Since free gas is to be injected in the suction line, single-phase flow will be of major interest, however, it is planned to use monitoring devices to determine the amount of free and dissolve gases at various locations of the pumping system.

(e) <u>page 6, 4th paragraph</u>

It is assumed that the angle of the pipe will be given appropriate consideration in designing the laboratory setup.

Comment:

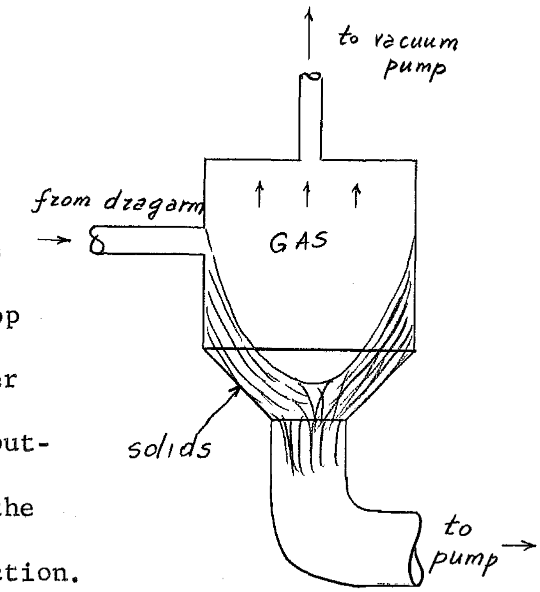
The angle of the pipe was discussed at a meeting in the Philadelphia office on May 25, 1964. A dredging depth of 40 feet would be used, this represents 5 feet in the model facility.

(f) <u>page 9, 2nd paragraph</u>

Since the mixture is "pumped tangentially at high velocities into a cylinder" the pressure drop across the device may be excessive for use on the suction side of the dredge pump where any loss in pressure would have an adverse effect on the solids handling capability of the dredge. Separation of gas on the discharge side of the dredge pump would be of little value in hopper dredge operations.

Comment:

The Philadelphia office commented that "inspite of losses, the idea of an accumulator using the vortex principle to separate gases is intriguing. Gases could be removed from the top center of the vortex. The bottom of the chamber could be funnel shaped; solids whirled to the outside of the chamber could slide downward with the funnel which would be connected to the pump suction. The drop toward the dredge pump might recoup some of the energy loss in the vortex.



This idea will be considered in designing the experiments for Phase C of the project.

(g) page 9, 3rd paragraph

Use of vanes in trunion and other elbows may warrant further consideration.

No comments.

(h) page 14a, 3rd paragraph

Obtaining very low pressure is not a basic objective but rather the removal of gasses that would otherwise unload the dredge pump. Therefore, multi-staging, compressors or condensers are not considered necessary.

No comments.

(i) page 16a, 1st paragraph

Since the ejector is essentially a fixed suction pressure device, the selection of peak design point should be compatible with dredge pump performance. Backflow into suction when the steam jet is shut off is of no consequence in our application.

No Comments.

(j) page 16a, 3rd paragraph

Capacity to eject "dirty gases" is an advantage when the maintenance of vacuum pumps is taken into consideration.

Comment:

Maintenance is an important item and should be considered in an economic evaluation of the proposed system. The Philadelphia office made the following comment: "In spite of vastly inferior efficiencies, water-driven ejectors are preferred by many dredge operators for evacuation of gases. This is due to the fact that water ejectors, like steam ejectors, can handle "dirty gases" and the ejector internals are easily replaced by ships' personnel on the other hand the rotary vacuum pumps, though highly efficient, suffer from carry over of solids with the gases into the pump. These solids grind away the rotors, destroy the pump clearances and seriously reduce the pump performance. These pumps must be returned to the manufacturer for repair, at high cost. While it is not within the scope of these experiments to evaluate differences between types of "vacuum pumps", it should be kept in mind that important differences do exist, and certain aspects of the experiments may be influenced by the possibility that some information may be of more or less value when one type of pump or another is used.

(k) page 37a, 2nd paragraph

Since "the static pressure drop for two-phase flow is always greater than the pressure drop for each phase flowing alone", it may be best to remove gas as soon as it forms rather than permit it to flow any appreciable distance along the suction line.

Comment:

As indicated before, it is planned to use free gas in the investigation. The location of gas injection has not been decided upon.

III. DEVELOPMENT OF THE FACILITY LAYOUT

The model will simulate the conditions on the suction side of the seagoing hopper dredge "Essayons" at a scale of 1:8. Through conversation with the U. S. Army Engineer District, Philadelphia, the dredging depth has been established at 40 feet. To accomplish this dredging depth and to allow sufficient working area the model pump must be elevated 6 feet 6 inches from the floor. (See Figure 1). This dictates that the model pump, control equipment, and supply tanks be re-located within the existing laboratory space. Details on the return pipe have not been included since it may be desirable to release the return flow in a tank other than the supply tank to insure proper control of the water-air mixture on the suction side of the pump.

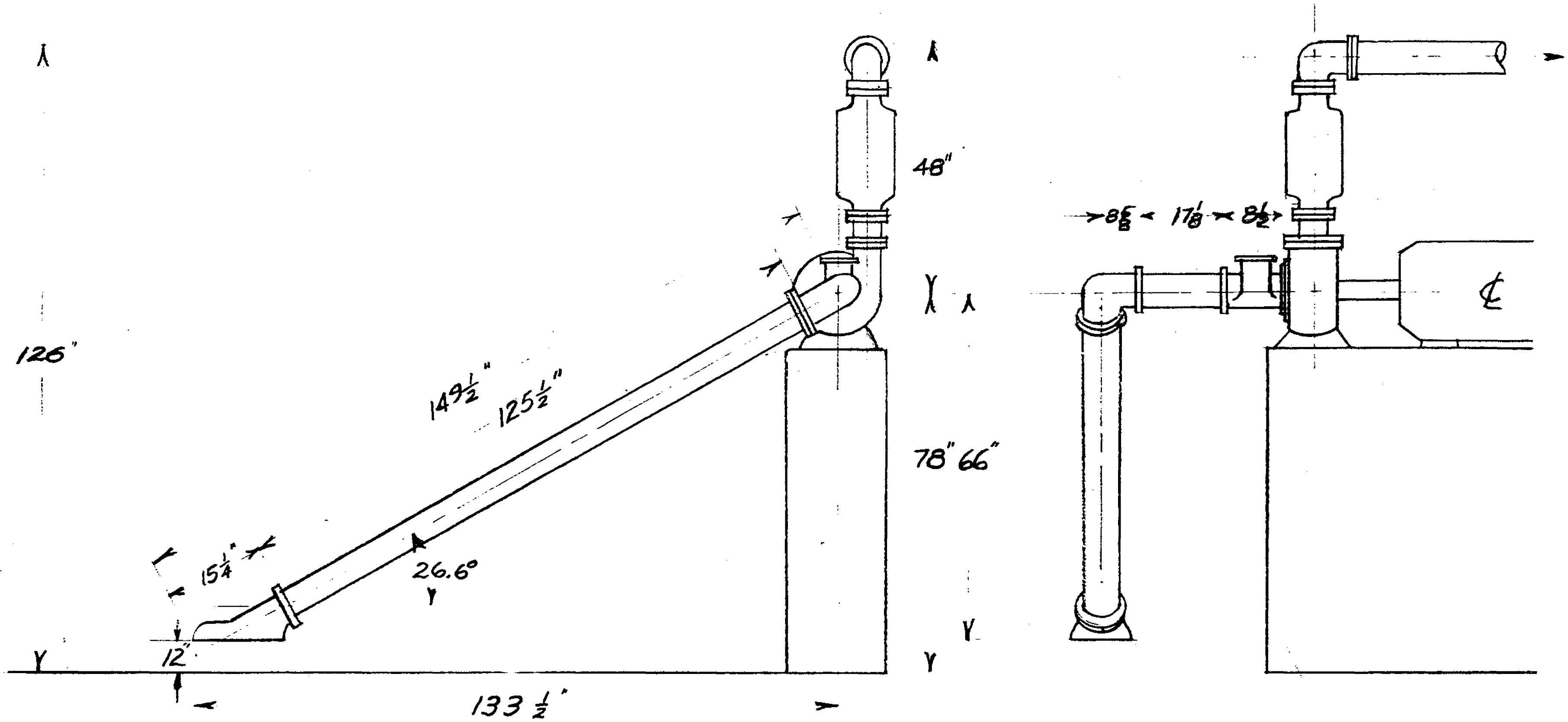


Figure 1 Proposed Facility. Elevation Views

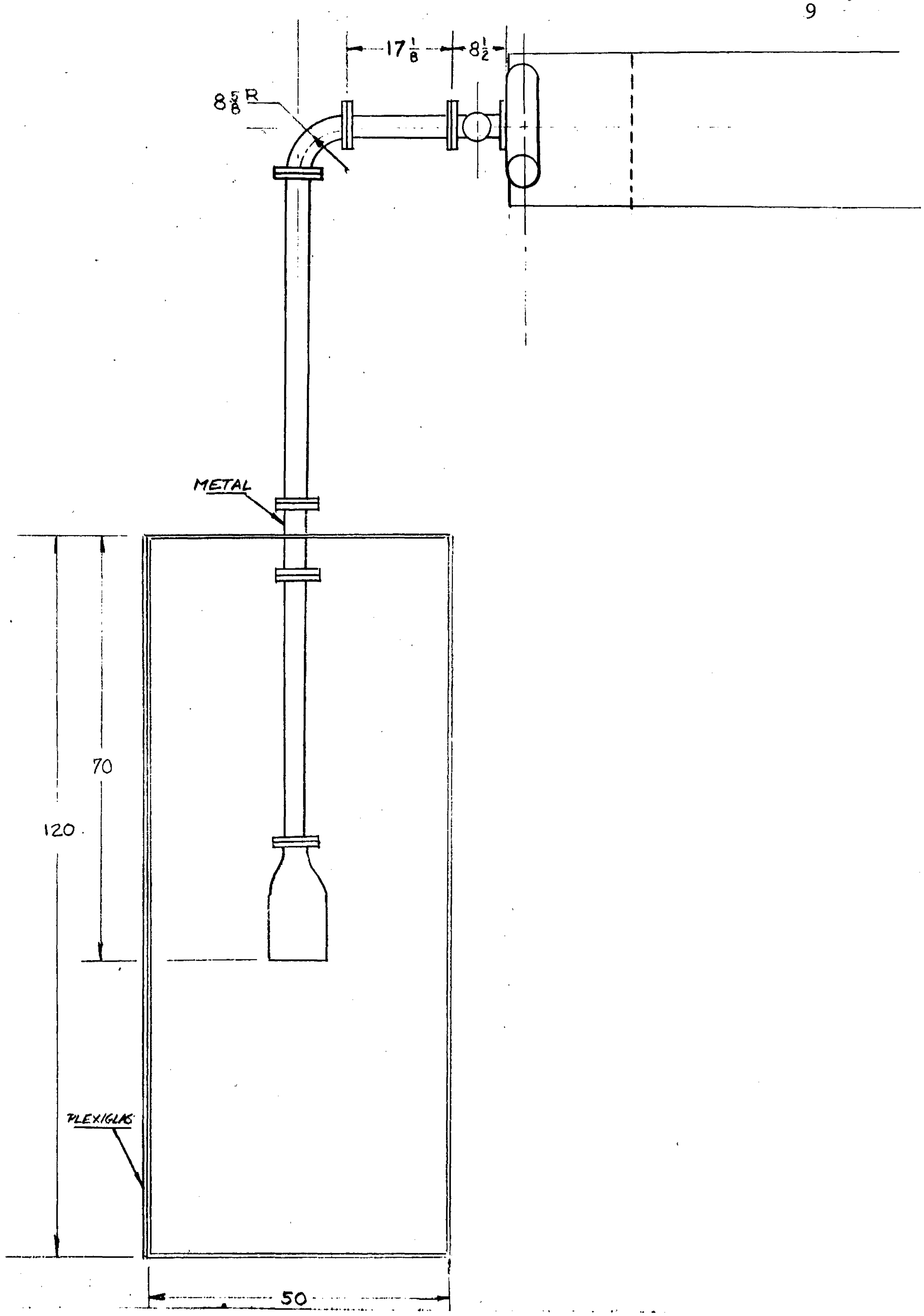


Figure 2 Proposed Facility. Plan View.

Note: Entire suction line will be transparent.
One side of suction tank will also be transparent

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