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CRYOGENIC CONSULTANTS, INC.
1176 NORTH IRVING STREET • ALLENTOWN, PA. 18103 • (215) 439-0419

July 16, 1986

Mr. Kelly Dixon
Fermilab
P.O. Box 500
Mail Stop 310
Batavia, Illinois 60510

Subject: Fermilab Subcontract 94362, Task Order #002 R-2

Dear Kelly:

I am submitting herewith CCI Report 593-119 entitled "Evacuation of the Trough and Pit Following a Spill from the LAr Dewar". Should you have any questions or comments, please do not hesitate to call.

Very truly yours,

CRYOGENIC CONSULTANTS, INC.

Jerry B. Gibbs
Process Engineer

JBG/eaj

cc: P.C. Vander Arend

Encls: CCI Report 593-119

CCI Report 593-119

EVACUATION OF THE TROUGH AND PIT FOLLOWING A SPILL FROM THE LAr DEWAR

Prepared Under Subcontract No. SC-94362
Task Order #002 R-2

By

Cryogenic Consultants, Inc.
Allentown, PA

For

Fermilab
Batavia, IL

July 14, 1986

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EVACUATION OF THE TROUGH AND PIT FOLLOWING A SPILL FROM THE LAr DEWAR

I. INTRODUCTION

This report addresses the problem of removing argon liquid and vapor from the pit area of the MW Experimental Hall following a release of liquid argon from the LAr dewar (E-706 LAC). Several previously issued CCI reports (References 1-6) dealing with the safety aspects of liquid argon in general and this project in particular provided background for this study.

Following a failure of either the LAr dewar 3" liquid fill and withdrawal line or the 2" beam window, argon liquid and vapor will accumulate in the pit. The cold argon vapor (~90°K) has a density of approximately 0.36 lbs/ft^3 and will "flow" into the pit along with the liquid. Additional vapor will be generated in the pit as a result of heat transfer from the walls to the liquid argon. If the vapor is not exhausted from the building at a rate equal to or greater than the generation rate, vapor will eventually "spill over" the pit and trough walls onto the MW Experimental Hall floor creating an ODH condition.

II. DISCUSSION

This discussion assumes that the trough and pit are insulated as described in CCI Report 593-116, and that the LAr dewar is fully charged and equilibrated at 1.136 ata (2.0 psig). The condition of the LAr in the dewar is important. As liquid is discharged to atmosphere from a failure, flashing will occur and the amount of liquid which will flash is a function of the equilibrated condition of the liquid. The higher the dewar pressure, the greater the amount of flash. To minimize vapor from this source, the dewar pressure should be maintained at 1.136 ata or less.

The vapor generation rates presented in this report were calculated based on the assumption that discharge through the 3" line during a failure is single phase, ie no flashing occurs in the line. This is a "worst case" assumption. In reality, flashing will occur in the 3" line creating a two-phase flow condition which will increase pressure drop and reduce the LAr discharge rate. The flash vapor will of course add to the vapor load generated by heat transfer and as such should be kept to a minimum by maintaining the LAr dewar pressure as close to 1.0 ata as possible.

As described in CCI Report 593-116, the vapor generation rate due to heat transfer to the spilled LAr through the surfaces of the trough and pit is 61.0 acfm of cold (90°K) vapor. If the dewar were equilibrated at 1.0 ata, this would represent the entire vapor load which would need to be evacuated to prevent as ODH. An additional 100 acfm of cold vapor would be generated from flashing if the dewar were equilibrated at 1.136 ata (2.0 psig). This 100 acfm rate represents an average value and would be generated only while LAr is discharging from the rupture.

Assuming the dewar is equilibrated at 1.136 ata, the maximum argon vapor generation rate to be evacuated during failure would be 161 acfm of cold vapor, or

$$SCFM = 161 \left(\frac{300}{88.4}\right) = 547 \text{ at } 1.0 \text{ ata and } 300°K$$

A system to remove this volume of argon vapor from the pit and trough is required. A further requirement is that the exhaust gas have a minimum oxygen concentration of 17.8% which is the lower limit for a 0 (zero) ODH classification. Mixing sufficient room temperature air with cold argon vapor to produce a 17.8% O_2 mixture will also result in a mixture temperature of approximately 276°K (36°F).

The preferred method for removing the argon vapor is via a blower located in the corner of the pit at close to floor level, as shown in Figures 1, 2 and 3 in Appendix A. Blower capacities as a function of % O_2 in the mixture for an argon vapor generation rate of 550 SCFM is shown in Table I.

TABLE I

Blower Capacity vs. % O_2 in the Mixture

Blower Capacity, SCFM	3650	4000	5000	6000	7000	8000
Argon Vapor, SCFM	550	550	550	550	550	550
Air Required, SCFM	3100	3450	4450	5450	6450	7450
Oxygen in Mix, %	17.79	18.03	18.60	18.98	19.26	19.46

A blower capacity of 6000 SCFM was selected. Under normal conditions the oxygen concentration of the exhaust will be approximately 19%. This capacity provides a safety factor of 65%, ie the argon generation rate could increase by as much as 65% from 547 SCFM to 902 SCFM and still maintain a 17.8% O_2 concentration in the mix. The blower discharge should be ducted to atmosphere through the west wall of the MW Experimental Hall into the area between the Counting House and the MW Experimental Hall, as shown on Figures 1, 2 and 3. Exhausting in this area will not create a hazard. The exhaust gas is only slightly more dense than the air, having a molecular weight of 29.97 as compared to 28.97 for air. The velocity of the gas mixture as it exits the building will result in turbulence and mixing with atmospheric air. Atmospheric air currents will further promote dispersal of the argon mixture. The argon will not "separate out" so that there is no danger of an ODH occurrence developing outside of the building.

In the event that the argon generation rate for one reason or another exceeds the 902 SCFM design maximum for this system with a 6000 SCFM blower, the danger of an ODH within the building becomes a reality. However, before an ODH could develop outside of the pit and trough, the suction temperature to the blower would fall below acceptable levels. That is, there would be more cold argon vapor and less warm air in the mixture to the blower suction. One or more temperature alarms on the blower suction ductwork would alert personnel to this impending danger. An oxygen monitor with an audible alarm to sample the blower discharge would be a desirable safety addition. This instrumentation will assure adequate warning of a possible ODH occurrence.

III. RECOMMENDATIONS

1.) Install a 6000 SCFM blower to evacuate an argon/air mixture from the pit and trough and exhaust the mixture to atmosphere. A suggested configuration is shown on Figures 1, 2 and 3.

2.) Equip the blower suction ducting with low temperature alarms.

3.) Install an oxygen monitor and alarm in the blower exhaust ductwork.

A request for quotation (Appendix A) for the proposed exhaust system described herein has been sent to five blower manufacturers. The nature of their response to this RFQ will determine subsequent actions. A list of the companies receiving this RFQ is as follows:

- Brucker Co., Elk Grove Village, IL (Greenheck Fan Co.)
- Roots Dresser, Connersville, IN
- Penn Air Co., Lionville, PA (American Fan Co.)
- Quickdraft Corp., Canton, OH
- ebm Ind., Unionville, CT

IV. REFERENCES

1. Failure Mode Analysis/LAC Cryostat, prepared for the University of Rochester (PO U-17288), dated March 30, 1984.

2. CCI Report No. 593-104, Analysis of the Effects of a Large Liquid Argon Spill at the D.O. Detector, dated July 2, 1984.

3. CCI Report No. 593-105, Updated Analysis of the Effects of a Large Liquid Argon Spill at the D.O. Detector, dated July 31, 1984.

4. CCI Report No. 593-110, ODH Analysis for a Liquid Argon Spill from the University of Rochester LAC Cryostat, dated December 6, 1984.

5. CCI Report No. 593-113, Analysis of LAr Calorimeter Emergency Venting Systems, dated March 12, 1986.

6. CCI Report No. 593-116, ODH Analysis of the LAC Building, dated June 25, 1986.

APPENDIX A

QUOTATION NO. 59301

CRYOGENIC CONSULTANTS, INC.

1176 NORTH IRVING STREET • ALLENTOWN, PA. 18103 • (215) 439-0418

REQUEST FOR QUOTATION

PRICES REQUIRED BY: August 4, 1986

DATE ISSUE: July 16, 1986

REQ'D. SHIPPING DATE:

TO:

SHIPPING DESTINATION

1. F.O.B.	2. SHIPPING POINT	3. TERMS

ITEM	QTY	DESCRIPTION	4. SHIP PROMISE	5. NET UNIT PRICE
1	1	Argon Vapor Evacuation System as shown on the attached sketches, the system generally consisting of a blower and motor, controls, and associated ducting. The purpose of the system is to evacuate argon vapor from the pit as it is being generated by first mixing the argon vapor with sufficient room temperature air to maintain a <u>minimum</u> exhaust gas oxygen content of 17.8% and then exhaust the mixture to atmosphere. The blower and ductwork are to be located approximately as shown on the sketches. Minor adjustments are acceptable.		

WE QUOTE YOU AS STATED ABOVE

PROVIDE THE INFORMATION REQUESTED IN BLOCKS 1 THRU 5 TO RECEIVE CONSIDERATION, ENTER YOUR FIRM'S NAME, SIGN, AND MAIL YOUR QUOTATION TO THE INDIVIDUAL IDENTIFIED BELOW.

COMPANY NAME:

SIGNATURE

NAME: (Type or Print)

TITLE: DATE:

THIS QUOTE IS VALID

YOUR RESPONSE TO THIS REQUEST MUST BE BASED UPON THE SPECIFICATIONS WHICH ARE PART OF THIS REQUEST. ANY EXCEPTIONS SHALL BE CLEARLY SPECIFIED IN YOUR QUOTATION.

CRYOGENIC CONSULTANTS, INC.

SIGNED:

BY: Jerry B. Gibbs

TITLE: Process Engineer

CRYOGENIC CONSULTANTS, INC.
1176 NORTH IRVING STREET • ALLENTOWN, PA. 18103 • (215) 439-0419

REQUEST FOR QUOTATION

QUOTATION NUMBER: 59301

DATE ISSUED: July 16, 1986

TO:

NOTES:

Specifications are as follows:

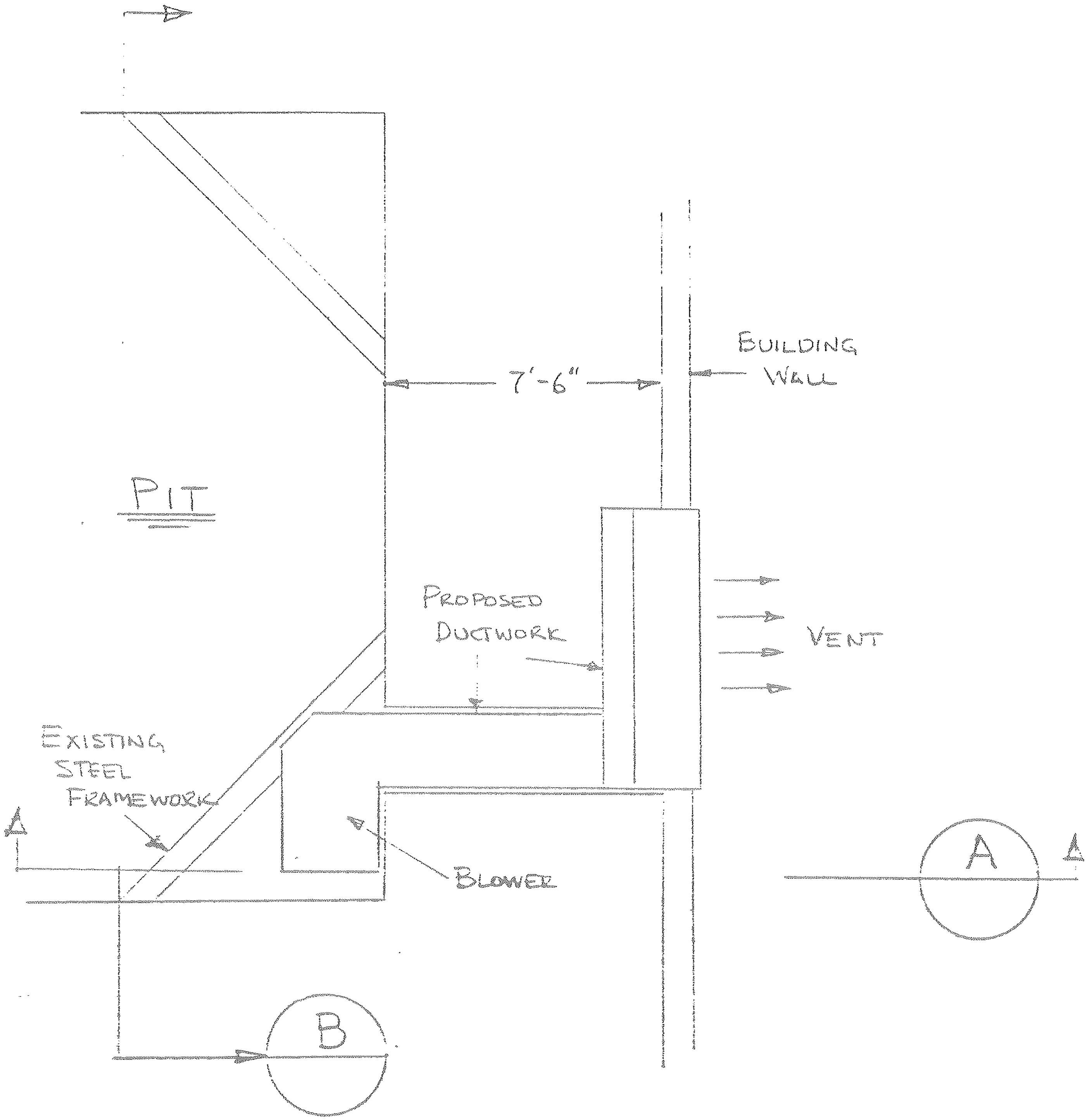
Blower Capacity:	6000 SCFM
Suction Pressure:	14.7 psia
Suction Temperature:	32°F to 100°F
Gas Composition:	Volume Fraction (Dry Basis)
N_2	0.7093
O_2	0.1903
A	0.1001
CO_2	0.0003
	1.0000
Moisture:	Relative Humidity at 85°F = 90%
Electrical:	240/440V, 3ϕ, 60HZ

Budget quotation is acceptable but must include the following specific information:

Blower:
- Capacity, SCFM at 1.0 ata and 70°F
- Motor BHP
- Dimensions
- Location of Suction and Discharge Parts
- Discharge Pressure
- Description of Controls
- Price, including Motor and Controls

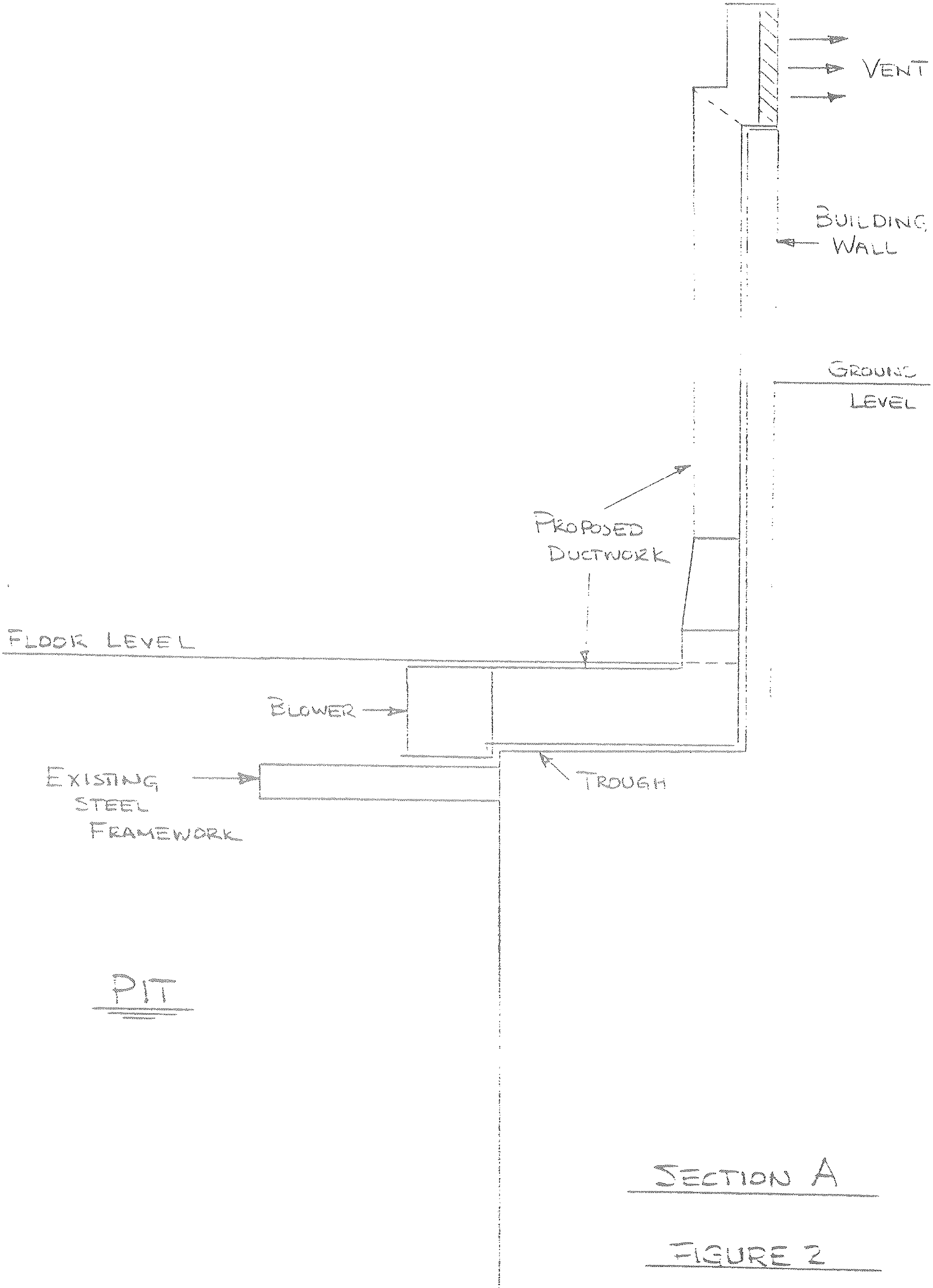
Ducting:
- Size and Length
- Price

Delivery Time



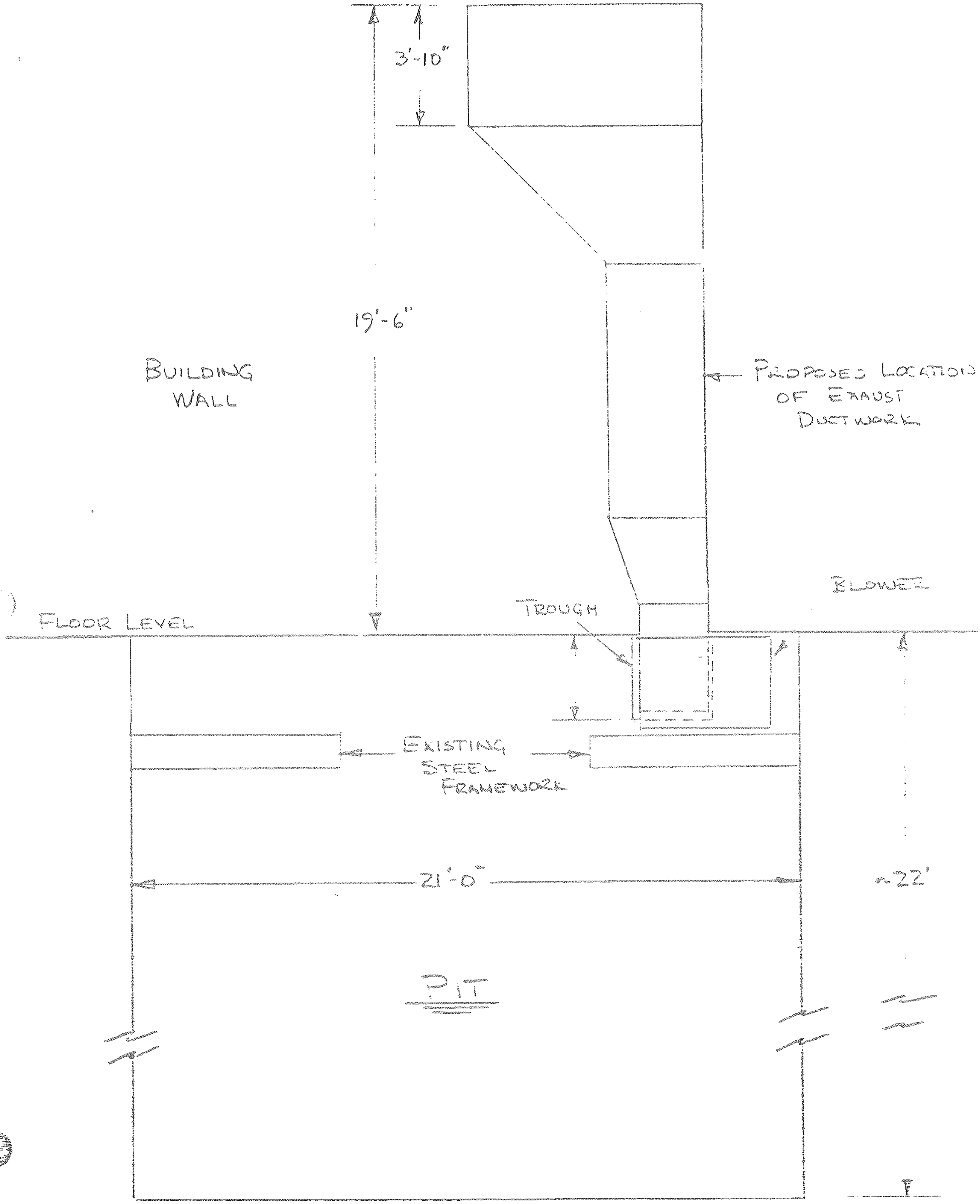
TOP VIEW

FIGURE 1



SECTION A

FIGURE 2



SECTION B FIGURE 3