# Assembly Guide:

# User Constructed $CO_2$ Vaporizer for Use with a Swine Depopulation System

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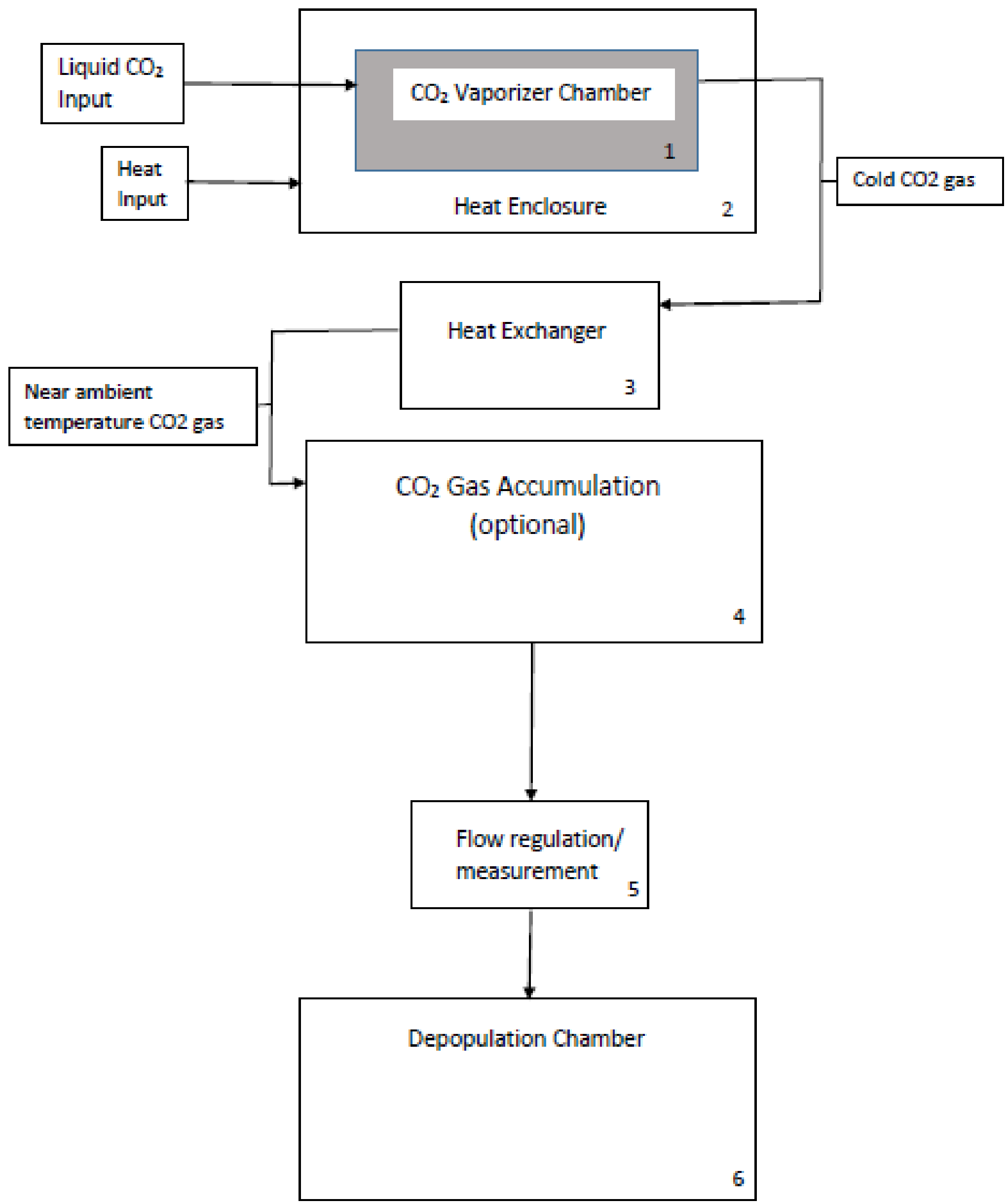
# System Schematic (Details provide in subsequent slides)



**Vaporizer Chamber** – should be a gas tight vessel capable of withstanding 500-600 degree Fahrenheit and with a pressure relief valve installed to prevent pressure buildup.  We have utilized 55-gallon metal drums as well as 250 and 500 gallon, used propane tanks

**The liquid $CO_2$ connection is critical. Check with your $CO_2$ supplier to make sure you have the correct connects available to enable their trucks to connect to your system. A pressure drop valve is necessary near the inlet of the tank to prevent dry ice formation in the feed hose or truck valve.**

Needle valve used to drop the liquid $CO_2$ pressure

Liquid CO2 connection to truck

**Heat Enclosure** – designed to improve heat transfer to the vaporizer chamber. It should be exhausted to prevent excess backpressure on the heaters.

Concrete block can be stacked without mortar to create an enclosure around the vaporizer tank

The heat capacity and number of heaters will be determined by the desired $CO_2$ flow rate. Each cubic foot of chamber capacity will require about 600 btu/hr heat capacity. Heat input can be supplied from several sources but kerosene, torpedo style heaters are readily available and provide more consistent output than propane fueled heaters.

Kerosene heaters positioned into openings in block walls

# Planning for Mass Depopulation

1) Decide on chamber size, i.e. trucks, corral, pit.

2) Determine volume of chamber (length x width x depth)

3) Determine required flow rate (volume/5 minutes)

4) Size components according to required flow rate. To prevent dry ice accumulation and raise the temperature of the $CO_2$ gas to near ambient temperature, for each cubic foot of chamber capacity will require approximately 600 btu/hour of heat capacity

# Planning for Mass Depopulation

Example:

1) Decide to use a pit that is 10’ wide, 40’ long, and 3’ deep

2) Determine the volume: 10’ x 40’ x 3’ = 1,200 cu. ft.

3) Determine required $CO_2$ gas flow rate: To fill the chamber volume in 5 minutes: 1,200 cu.ft./5 min. = 240 cu. ft./min.

4) Heat requirement: 1,200 cubic feet chamber capacity x 600 btu/hr capacity = 720,000 btu/hour (If 125,000 btu/hr heaters are available, it would require 6 of them.

**Heat Exchanger** – to prevent cold $CO_2$ gas from being introduced into the chamber the $CO_2$ gas temperature should be increased to near ambient temperature.  This can be accomplished by adding a metal heat exchanger coil inside the heat enclosure.

See Section C for heat exchanger plumbing detail

**Flow Regulation** – To meet the AVMA requirement the depopulation chamber volume must be filled over a 5-minute period. A blower can be used to move the $CO_2$ gas from the accumulation bag to the chamber. To ensure proper flow rates, a field constructed venturi and monometer can be assembled (see section A). Blower may need modification to assure no air is being pulled in around the shaft.

**Depopulation Chamber** – Sized to accommodate the farm needs and the capabilities of the vaporizer unit. Deliver $CO_2$ to the floor of the chamber. Since CO2 is heavier than air the lower part of the chamber must gas tight. Earthen pits or sealed truck bodies could be utilized as chambers.

**$CO_2$ Gas Accumulation (optional)** – a gas collect/temporary storage bladder will help provide a more consistent flow of gas to the depopulation chamber.  Bladders can be constructed with plastic sheeting by taping the seams or Ag Bag silage storage bags by folding/clamping the ends.

# **Section A:**

Field Assembled Venturi Meter
for
Measuring $CO_2$ Gas Flow Rate

# Checking CO2 flowrate with PVC venturi

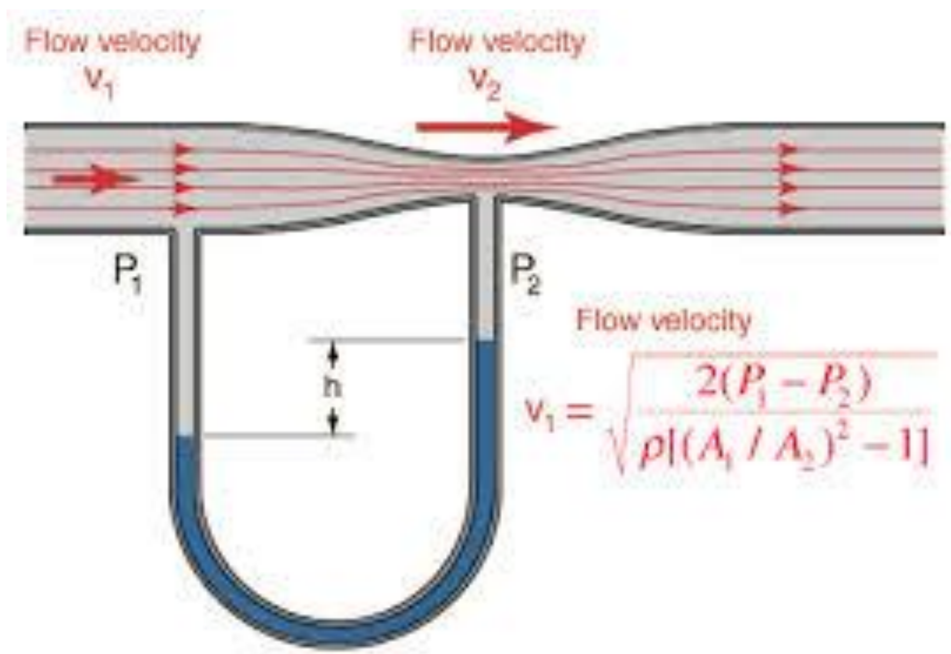
## Construct venturi from standard PVC parts as follows:

- Two pieces of 6” sch 40 PVC pipe at least 12” long
- Two 6”x 4” PVC reducers (www.mcmaster.com PN 4880K688 or similar)
- One piece of 4” sch 40 PVC pipe 6” to no more than 24” inches long
- Two barbed hose fittings (www.mcmaster.com PN 91465K11 or similar)
- 10 foot length of Tygon tubing (www.mcmaster.com PN 6516T54 or similar)

Assemble as shown on the following slides

# How can we measure $CO_2$ flow rate on-farm for meeting AVMA recommendation

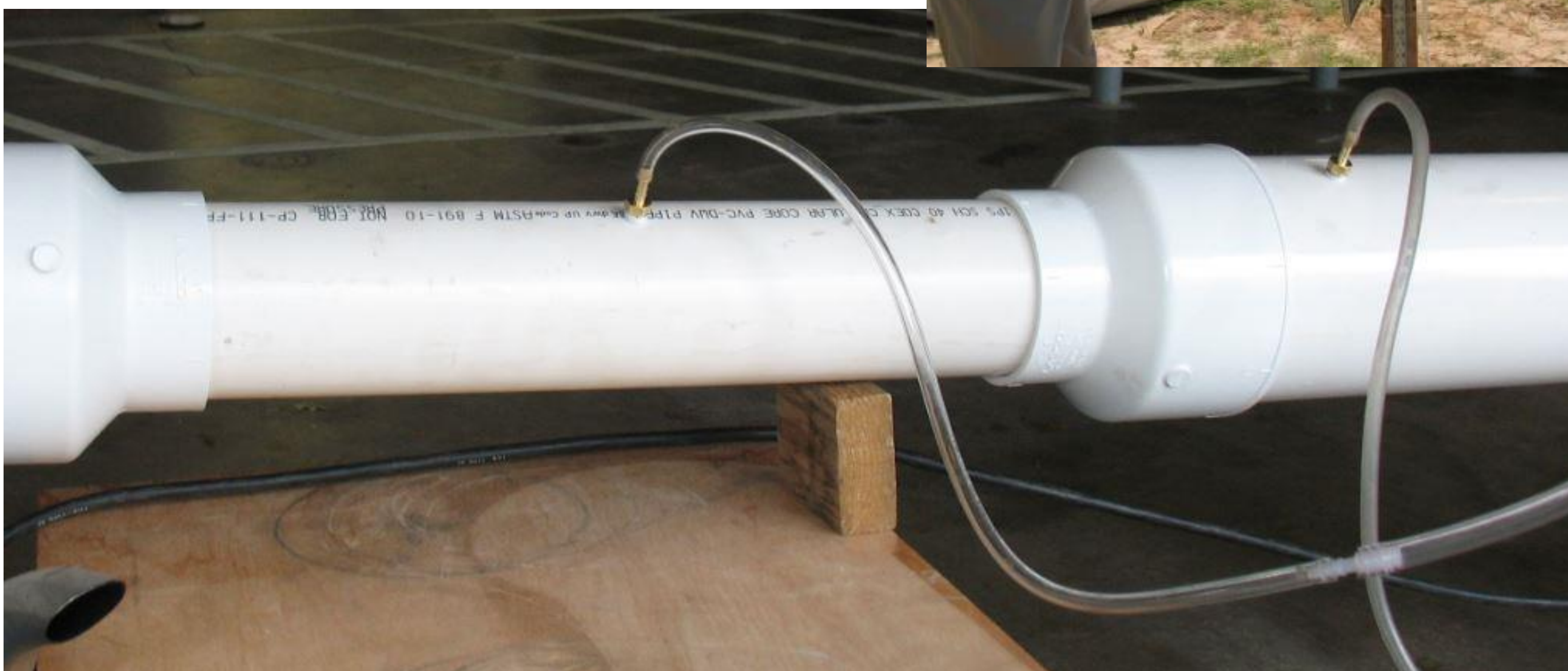
- We want to avoid needing expensive rotometers etc.
- The venturi principle comes to mind… but a farmer could not make this from off-the-shelf parts… we can modify it…




Hyperphysics.phy-astr.gsu.edu
Accessed 10/20/14

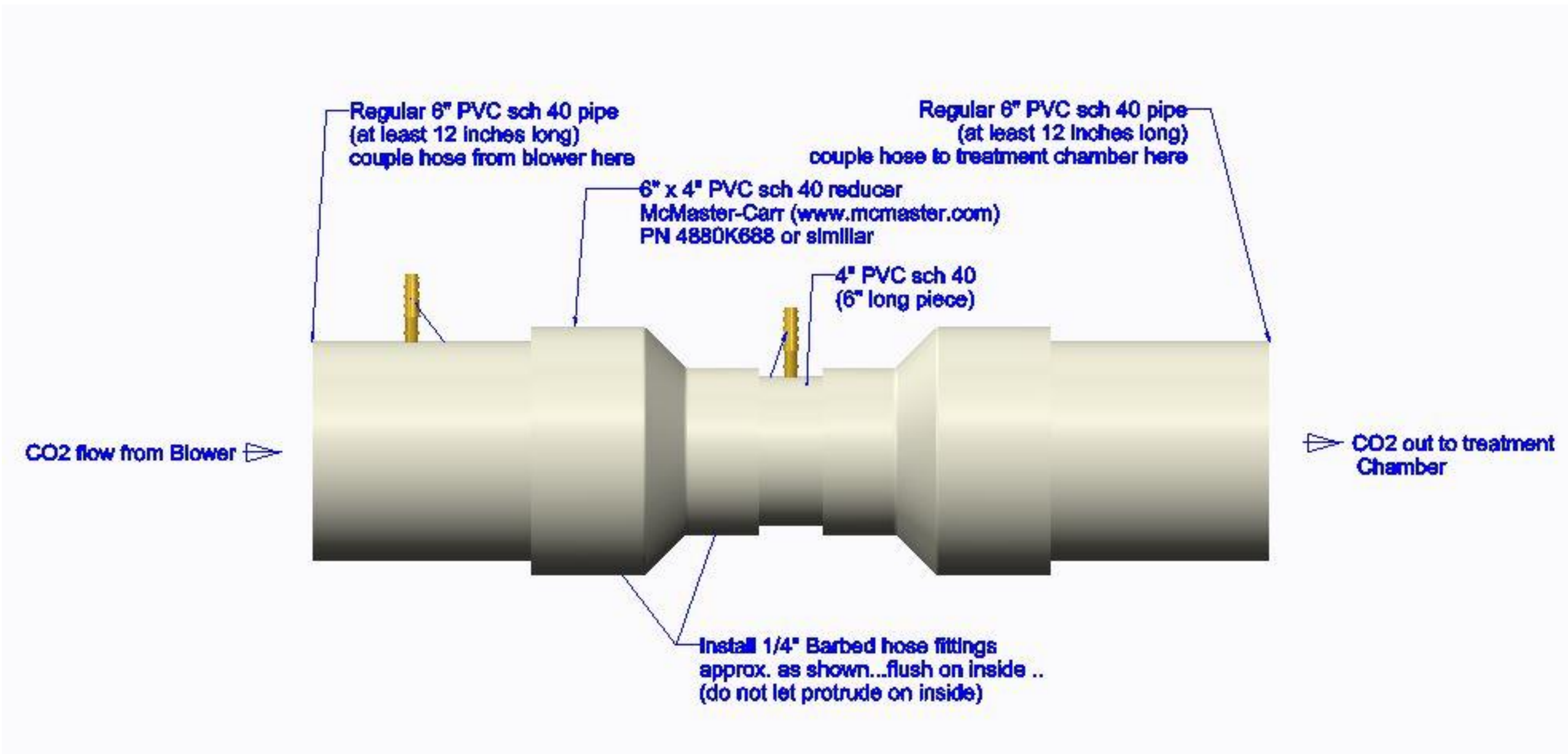
# Venturi with common parts

Two 6”x4” PVC reducers with standard PVC pipe sections….



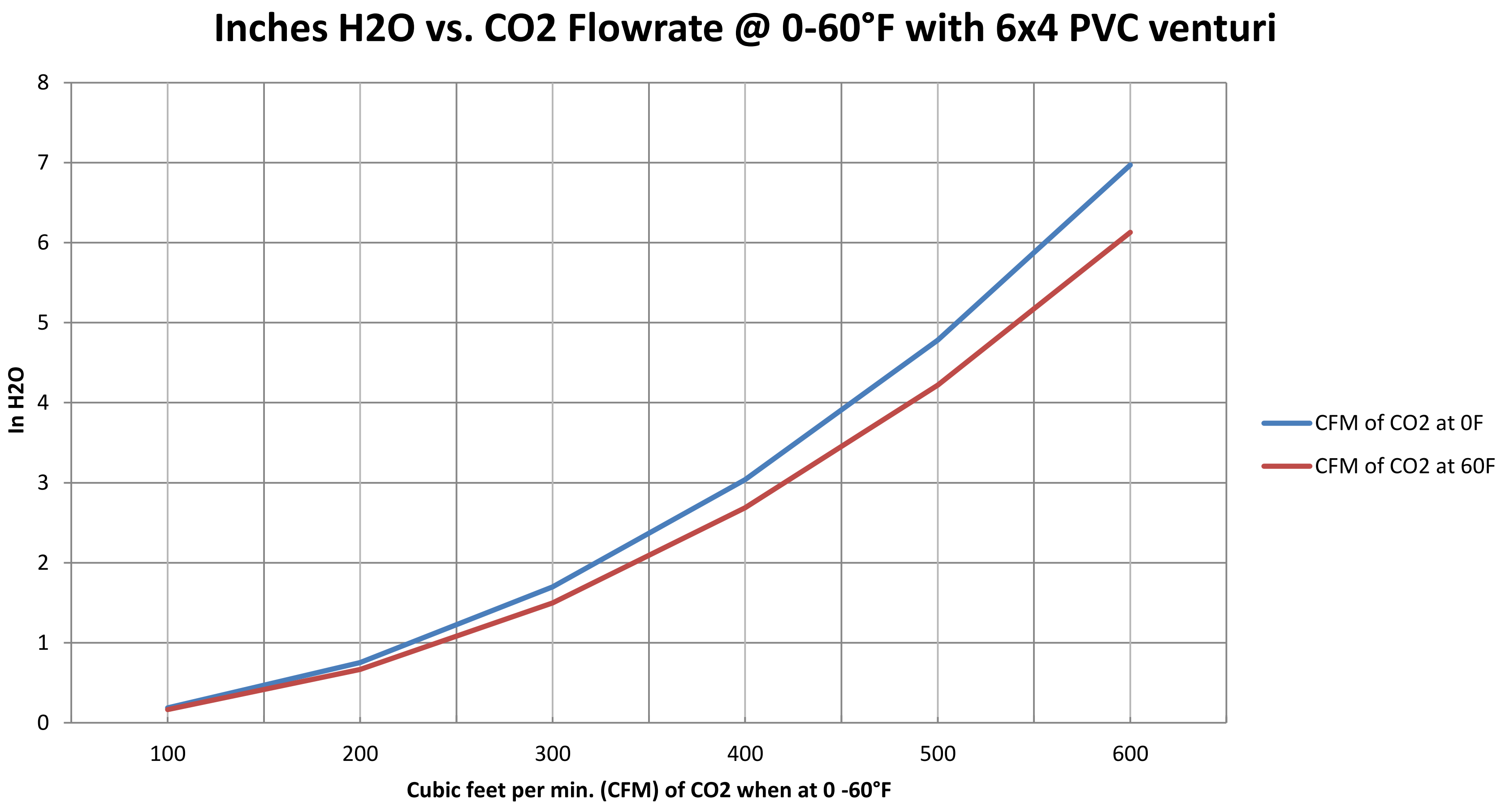
# Reading the differential pressure in inches of water (H2O)

# The PVC Venturi from standard PVC components



# Blower and venturi with manometer

# Flowrate of $CO_2$ (0-60°F) as function of Inches of water differential pressure



# Section B:

## Materials List for a Vaporizer System Capable of Serving a Chamber with a Volume Capacity of 1,200 Cubic Feet

# Materials List
# for a
# $CO_2$ vaporization system
# to serve a
# 1,200 cu. ft. chamber
# (including optional gas accumulation bag)

# Material List

1. recycled LP storage tank, 500 gallon, horizontal design w/all OEM fittings, valves, and gauges removed
2. bulk CO2 Hose Fitting, ACME P/N 320-000-15, 1 ½” MNPT x 2.250-6 Acme thread
3. threaded reducer, 1 ½”x 1” FNPT
4. 90 degree threaded street elbow, 1” female X 1” male NPT
5. needle Valve Assembly, 1” FNPT, Parker P/N 9-5302-100
6. pressure safety valve, 15 PSI, McMaster- Carr P/N 9024K12
7. 2 - 2" quarter turn ball valves, McMaster- Carr P/N 47865K28
8. miscellanous 2” schedule 40 steel pipe and 2” fittings for heat exchanger
9. 6 - 125,000 Btu/hr Torpedo Heaters – kerosene fuel - Grainger P/N 3VE50
10. 130 - 8”x 8” x 16” concrete cinder blocks, approximately
11. 3 - 12-ft x 26-in 31-Gauge Plain Corrugated Steel Roof Panel
12. 6 - 25 ft. extension cords
13. 2 - 5 outlet power strip, 15 amp capacity

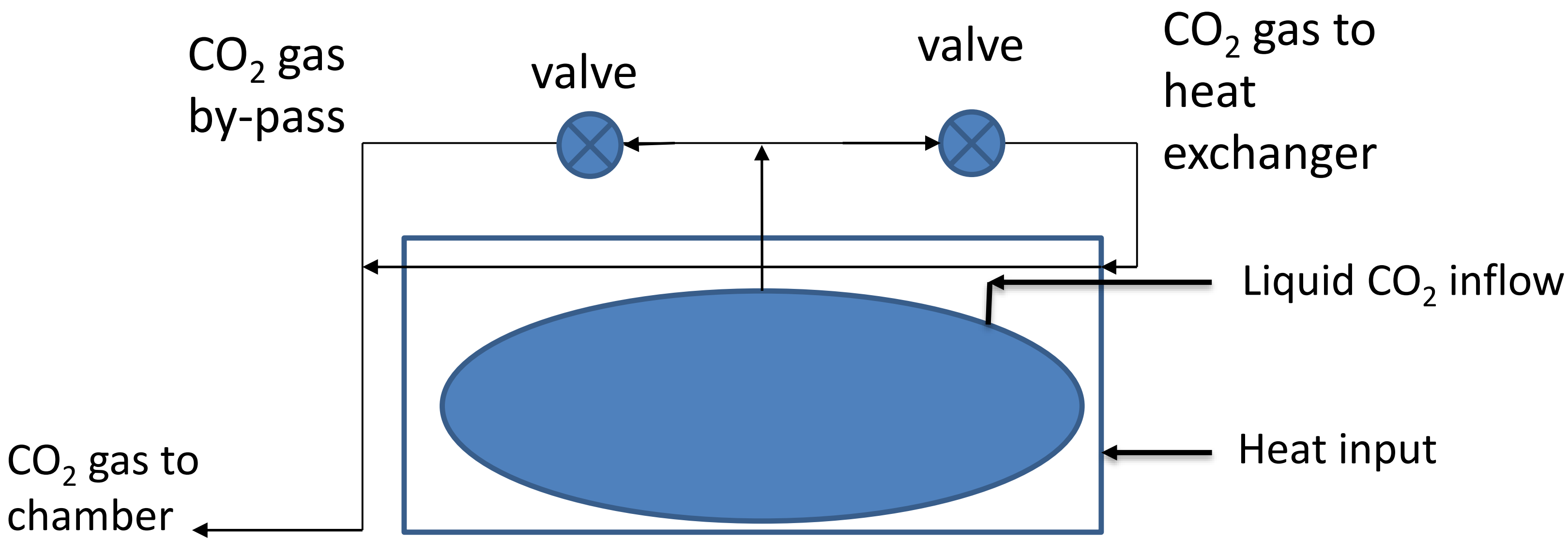
# Material List (cont.)

14. 4 - 2” x 4” x 8 ‘ wood for torpedo heater platform
15. miscellaneous wood shims to adjust height and position of heaters
16. kerosene fuel and fuel cans
17. 3” suction hose with cam lock fittings used to transfer $CO_2$ gas through 3”x2” venturi into Ag Bag for $CO_2$ storage
18. Ag Bag
19. 3” x 2” venturi with U – tube manometer
20. 3” PVC pipe with cam lock fitting and 3” quarter turn ball valve to connect 3” x 2” venturi to Ag Bag
21. roll of Gorilla tape – to secure and seal Ag Bag
22. 2 - 2” x 4” x 16’ lumber – Ag Bag clamp
23. 2 - 2” x 6” x 16’ lumber – Ag Bag clamp
24. 1 - 1 lb box of 3” deck screws, to assemble 1) 2x4 edgewise and 1) 2x6 to each other in a “T” configuration. A clamp is formed by placing 2 of these “T’s” on an overlapped section of the Ag Bag, and screwing the T’s together at the ends, outside of the Ag Bag material so as not to penetrate the material
25. Electric Blower to transfer CO2 gas from Ag Bag to euthanasia chamber

# Section C:

Heat Exchanger Plumbing

# Heat Exchanger Plumbing Diagram




Valves can be adjusted to regulate the flow of $CO_2$ gas through the heat exchanger to provide the appropriate $CO_2$ gas temperature to the chamber.