On Using a Critical Orifice to Control Flow Rate

by

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- Required Operational Characteristics
- Some Advantages of Using Critical Orifices
- Formulae Used by Various Researchers
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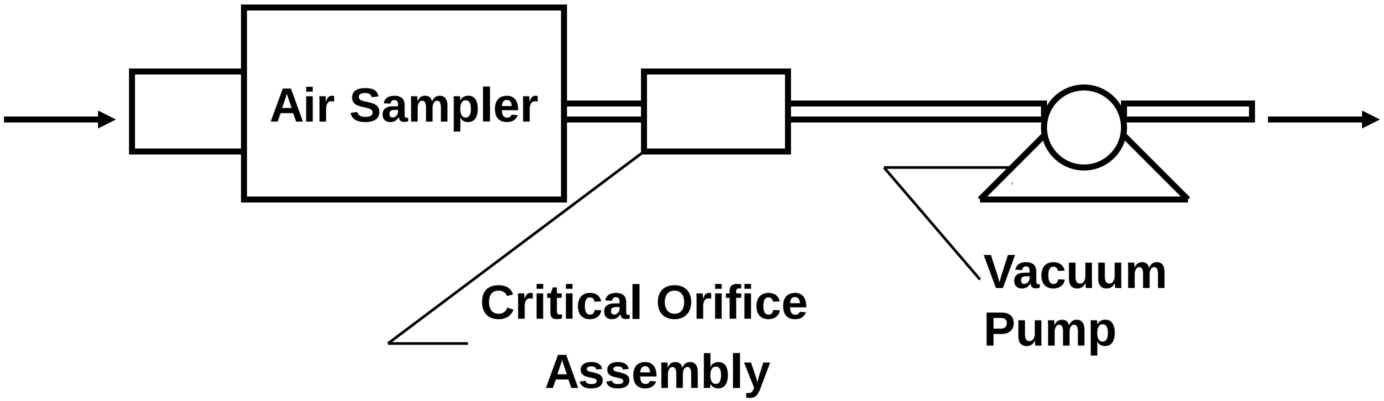
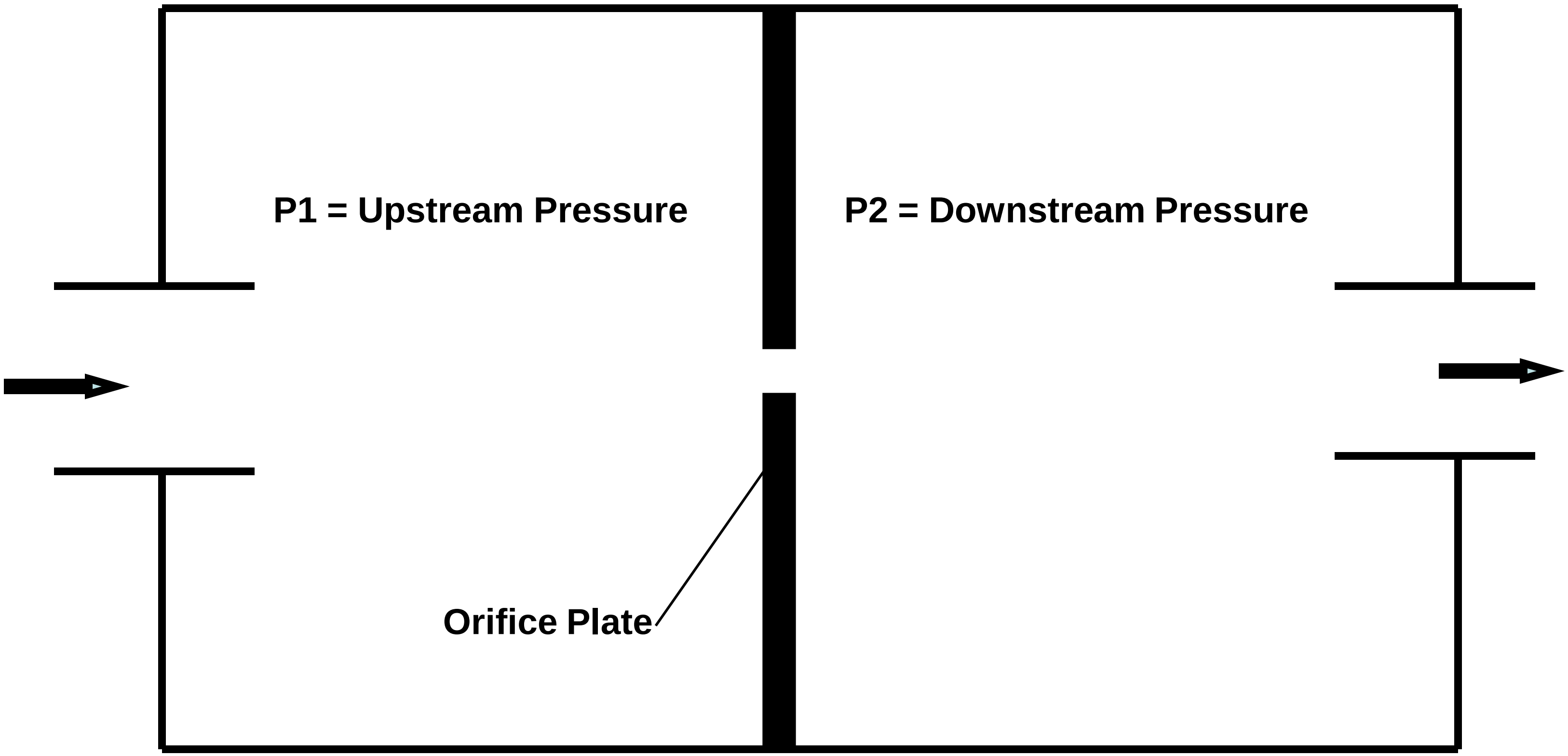
- Construction of a Critical Orifice Using Common Fittings
- Some Problems Associated With Critical Orifices
- Construction of a Critical Orifice Using Common Fittings
- Some Conclusions on Gravel Gerties

Schematic Diagram of a Critical Orifice in Use



Schematic Diagram of a Critical Orifice



P2 = 0.53 P1

Some Advantages of Using Critical Orifices

- Compact, Useful in Remote Applications
- Relatively Inexpensive
- Reliable
- Accurate
- Flow Rate Ranges 100 mL/min to Several L/min

M.D. Hoover

Provides an Equation

$$Q_{L/min} = 263\ C_v\ D^2\ \sqrt{T_0}$$

C_v = **coefficient of discharge, 0.6 to 1.0**

T_0 = **degrees in Rankin, 535 = 76 ^{0}F**

D = **diameter of the orifice in inches**

Solving for D

(M.D. Hoover)

$$D = \sqrt{\frac{Q_{L/min}}{263 C_v \sqrt{T_0}}}$$

William C. Hinds
Gives the Approximate Diameter at STP

AEROSOL TECHNOLOGY, Properties, Behavior and Measurement of Aerosol Particles

John Wiley & Sons, New York, NY 1982

$$Q = 1180\ K\ A_0$$

where **Q = flow rate in L/min,**

A_0 = orifice area in cm^2, and

K = 0.61.

Hinds Equation Simplifies to:

$$D \text{ inches} = 1.56 \times 10^{2} \sqrt{Q}$$

where

Q = flow rate in L/min

For other than STP, Hinds gives:

$$Q_{STP} = \propto \frac{P}{\sqrt{T}}$$

where $\quad P$ = pressure,

and $\quad T$ = temperature

Equation to Calculate Hole Diameter

$$D = 1.66 \times 10^{-2} \sqrt{\frac{Q \rho_a \sqrt{T_1}}{C_\pi P_1 \quad \pi}}$$

where

ρ_a = density of air 1.29 g/L at STP

P_1 = upstream pressure, 14.7 PSI at STP

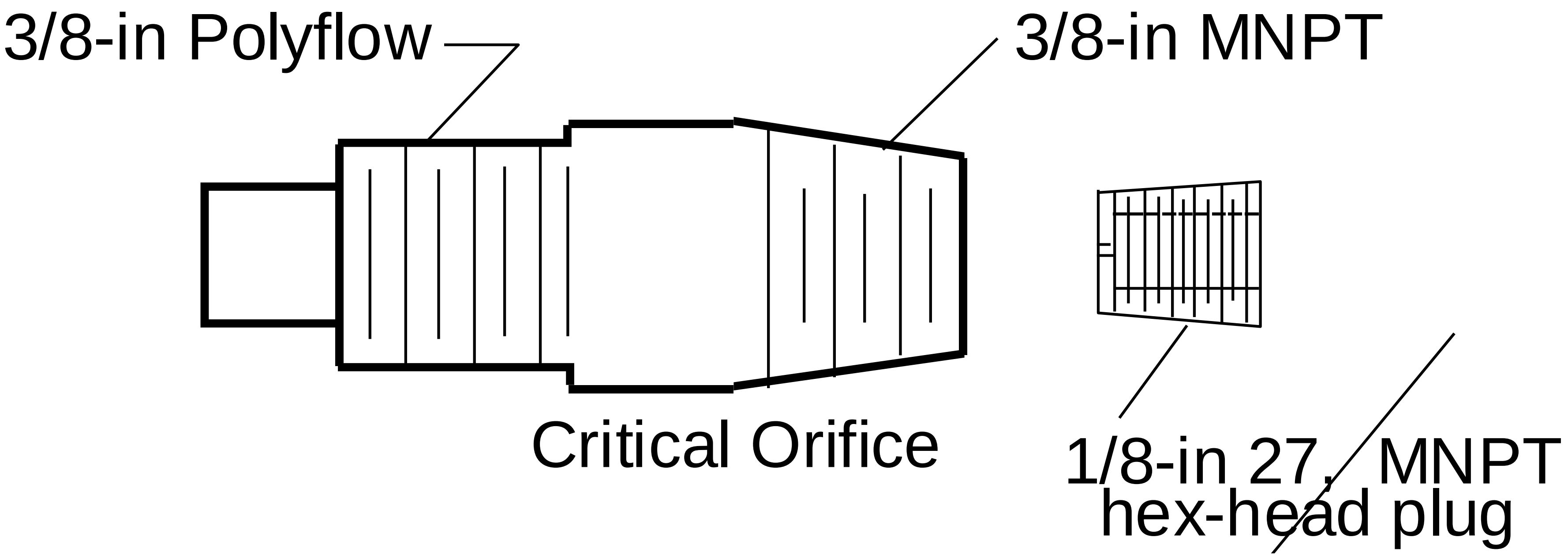
Cv = coefficient of discharge, 0.6 to 1.0,

T_1 = upstream pressure in Rankin=535 R = 76 ^{0}F

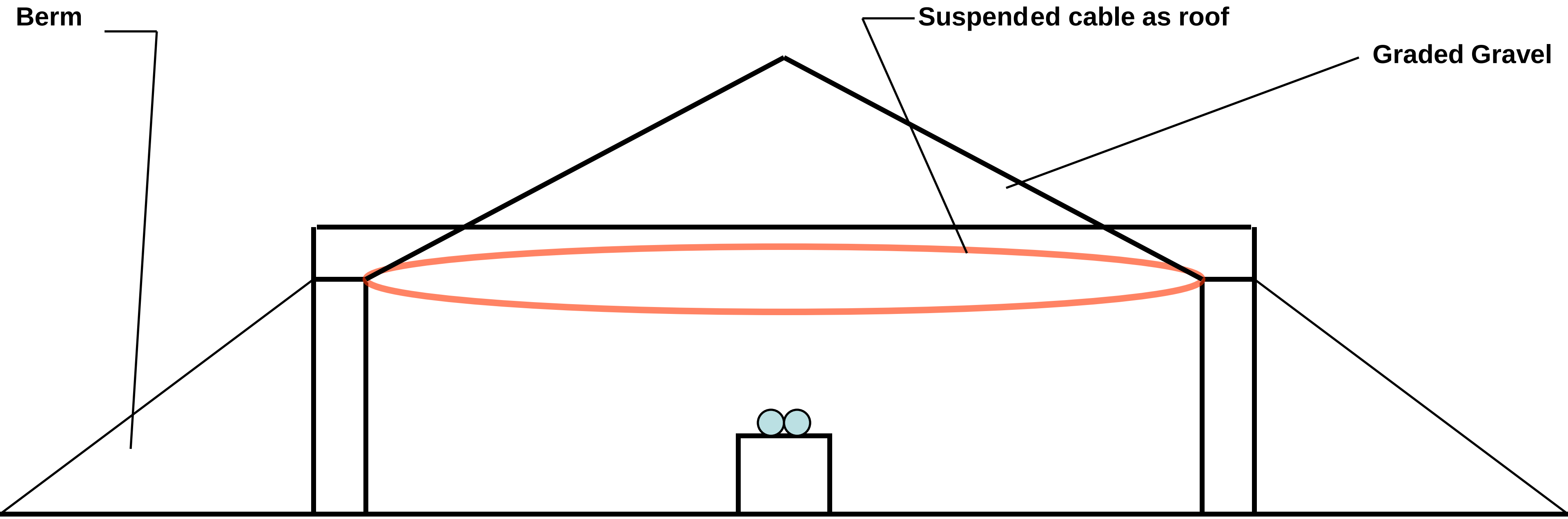
Q = flow rate in L/min, and

D = orifice diameter in inches.

Critical Orifice Made from Brass Fittings



XC of a Gravel Gertie



Explosion of Gravel Gertie

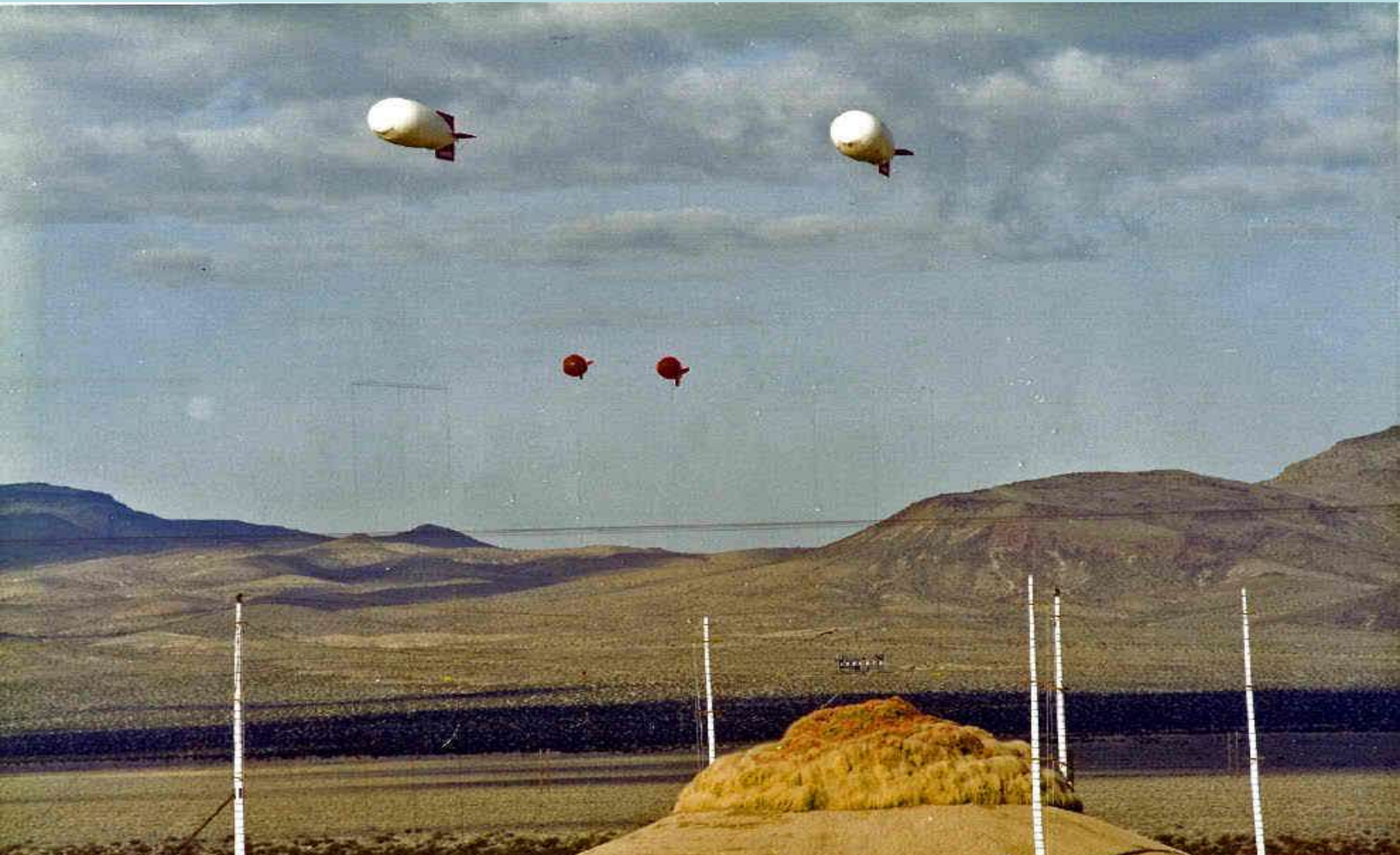
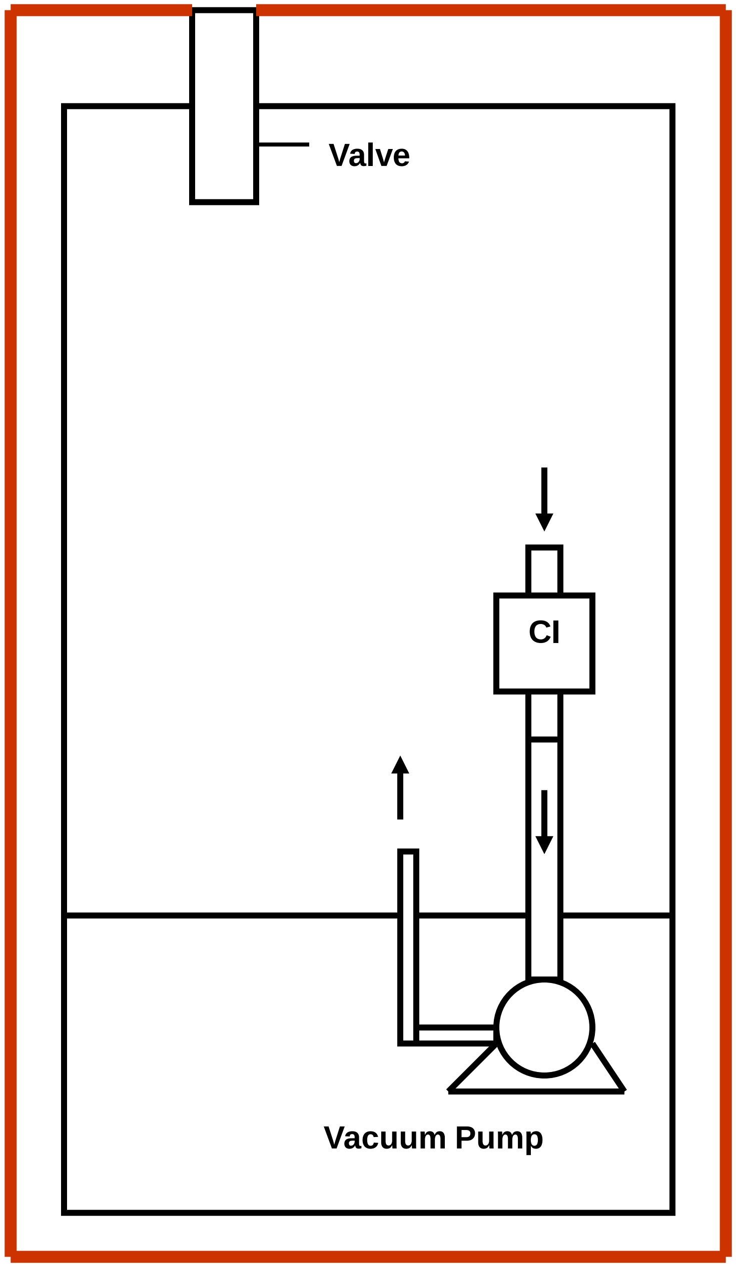


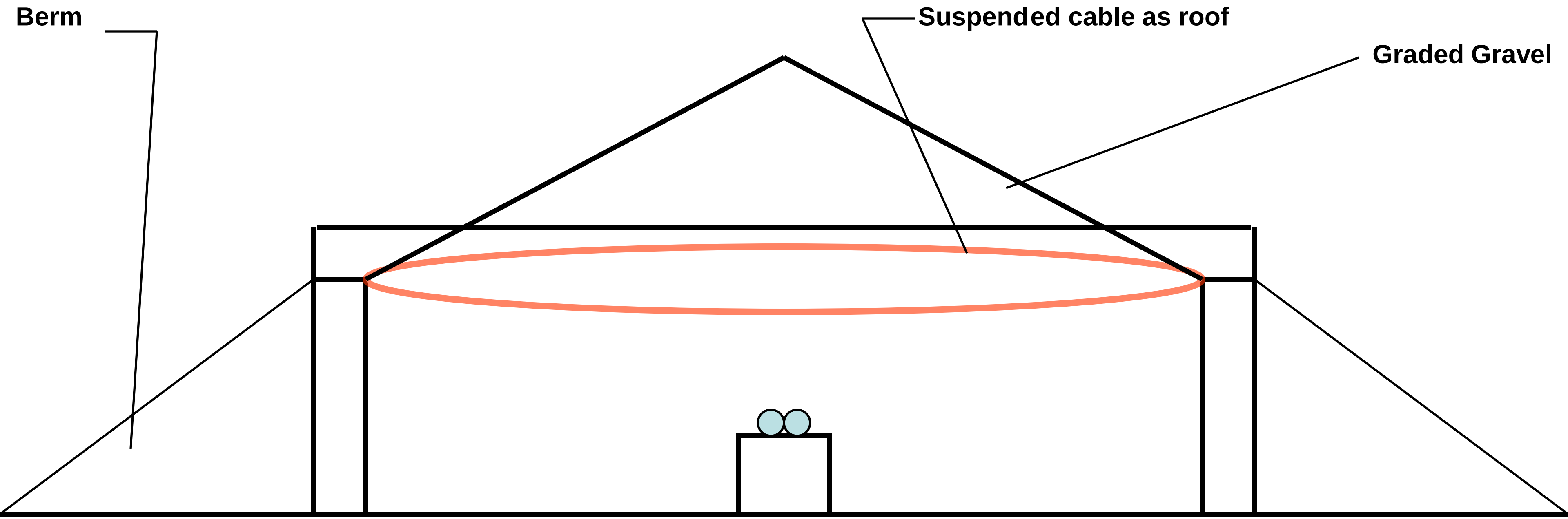
Table of Air Samplers Used on Gravel Gertie Test

Sampler Array	PTP ESP	Filters	7-Stage CI	Total No.
Inside Gravel Gertie, 20 L Exp. Proof			6	6
5-Pole Mounted, 3-Level	15	15	15	45
Overhead Array, Horizontal & Vertical	10	10	12	32
Balloon-borne Sampling Curtain	10	40	40	90
Fallout Trays, 1600 ft Radius				2000

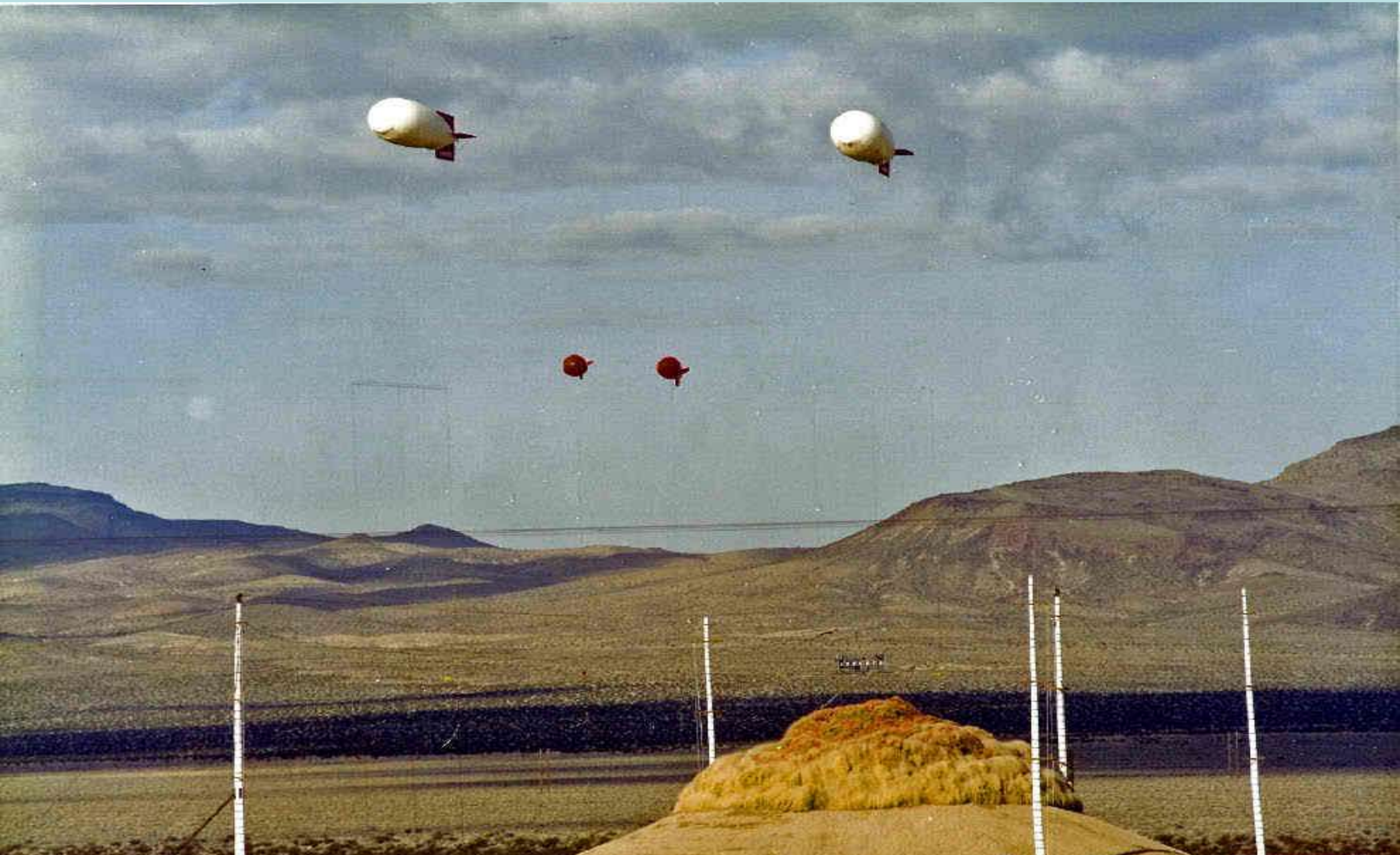
Explosion Proof Air Sampler



XC of a Gravel Gertie



Explosion of Gravel Gertie



Summary

- Evaluate Sampling Problem
- Determine if a Critical Orifice is Appropriate Strategy, if yes,
- Choose One of the Formulae to Calculate Orifice Size
- Make an Orifice as Outlined
- Calibrate On Site with a Dry Test Meter or a Bubble Meter
- Use as Flow Rate Control Device

Explosion of Gravel Gertie