

On Using a Critical Orifice to Control Flow Rate

by

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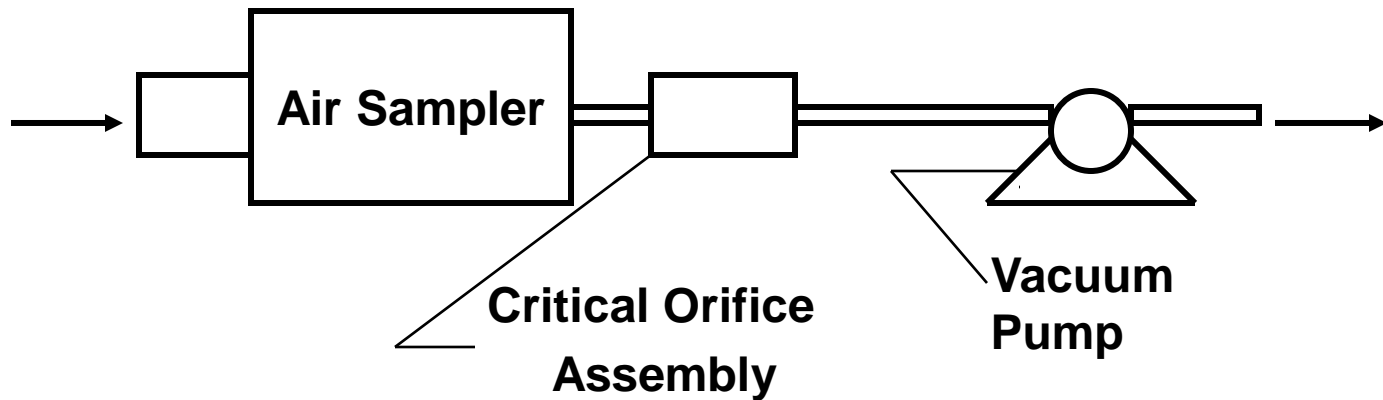
and

Mark D Hoover & Larry E Bowen

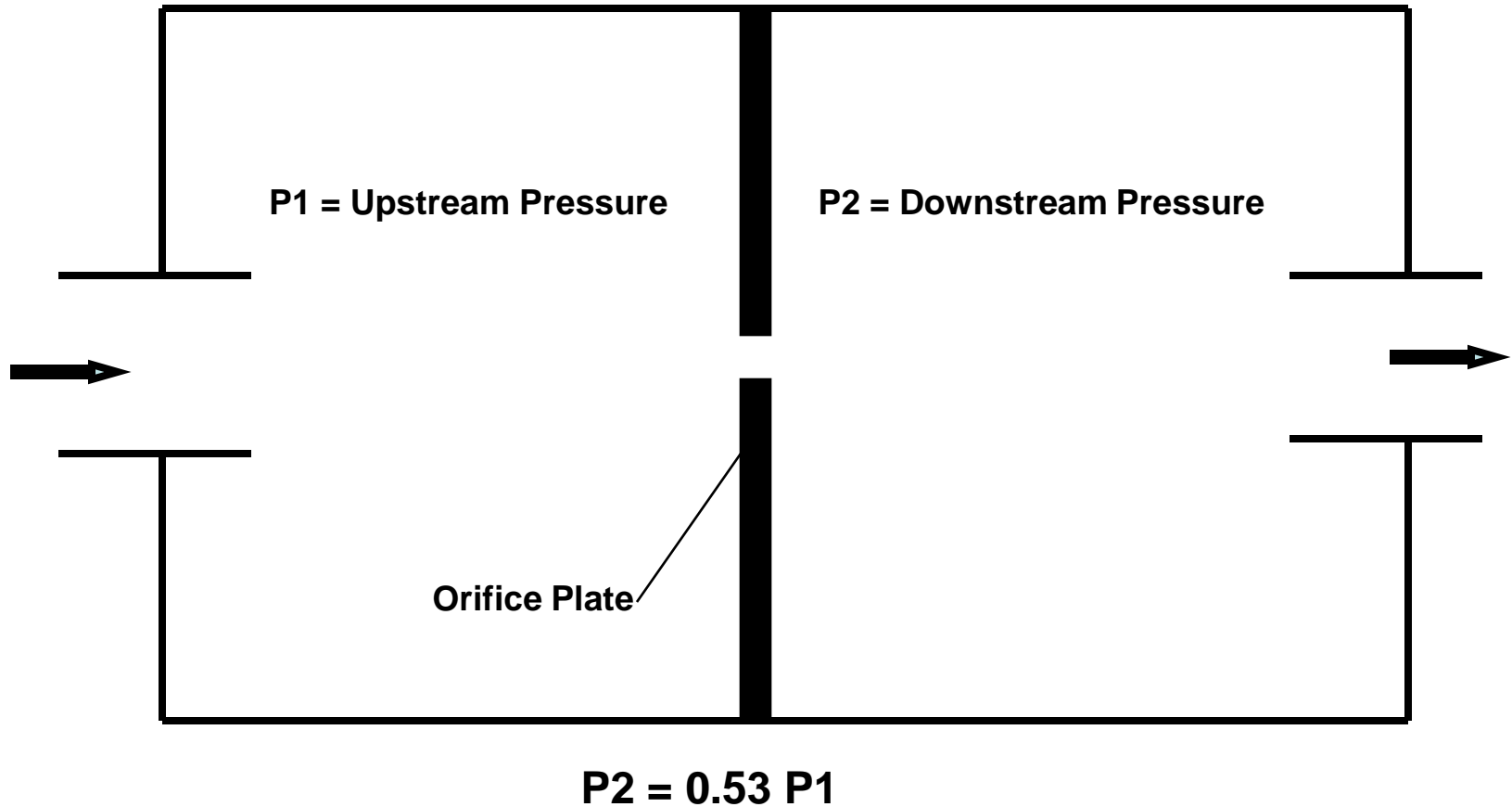
Contents

- Schematic Diagram of a Critical Orifice
- Required Operational Characteristics
- Some Advantages of Using Critical Orifices
- Formulae Used by Various Researchers
- Applications in Gravel Gertie Testing (weapons safety)
- 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



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

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

C_v = coefficient of discharge, 0.6 to 1.0

T_0 = degrees in Rankin, 535 = 76 °F

D = diameter of the orifice in inches

Solving for D

(M.D. Hoover)

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

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,

A₀ = orifice area in cm², 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:

$$Q_{\text{STP}} = \infty \frac{P}{\sqrt{T}}$$

where
and

P = pressure,

T = temperature

Equation to Calculate Hole Diameter

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

where

ρ_a = density of air 1.29 g/L at STP

P_1 = upstream pressure, 14.7 PSI at STP

C_v = coefficient of discharge, 0.6 to 1.0,

T_1 = upstream pressure in Rankin=535 R = 76⁰ F

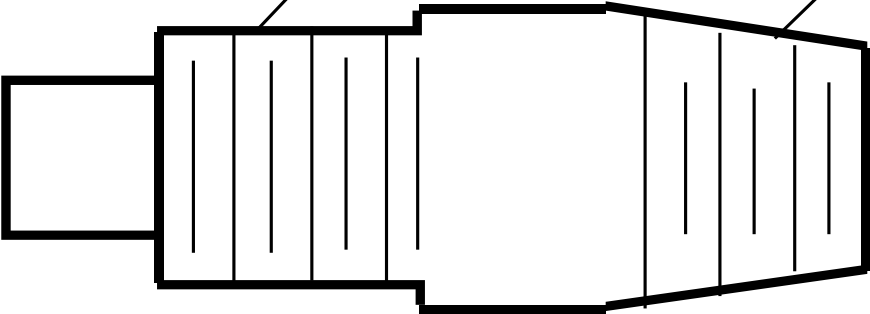
Q = flow rate in L/min, and

D = orifice diameter in inches.

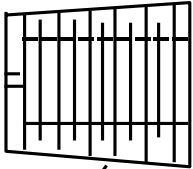
Critical Orifice Made from Brass Fittings

3/8-in Polyflow

3/8-in MNPT

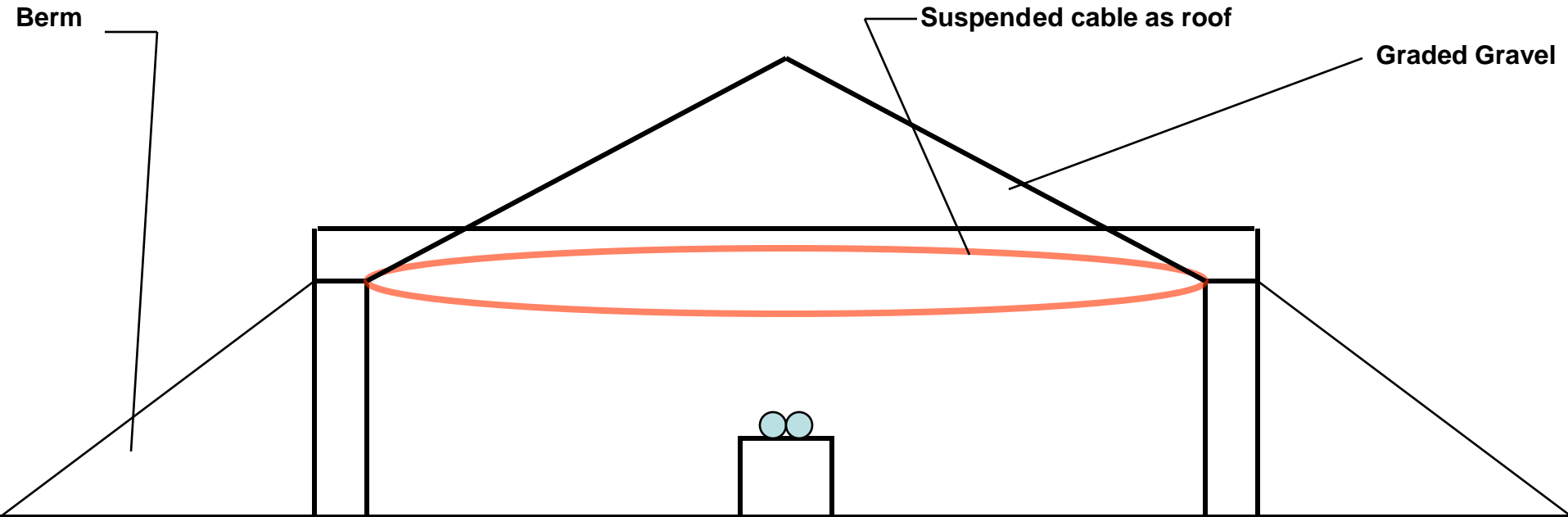


Critical Orifice



1/8-in 27 MNPT
hex-head plug

XC of a Gravel Gertie



Explosion of Gravel Gertie

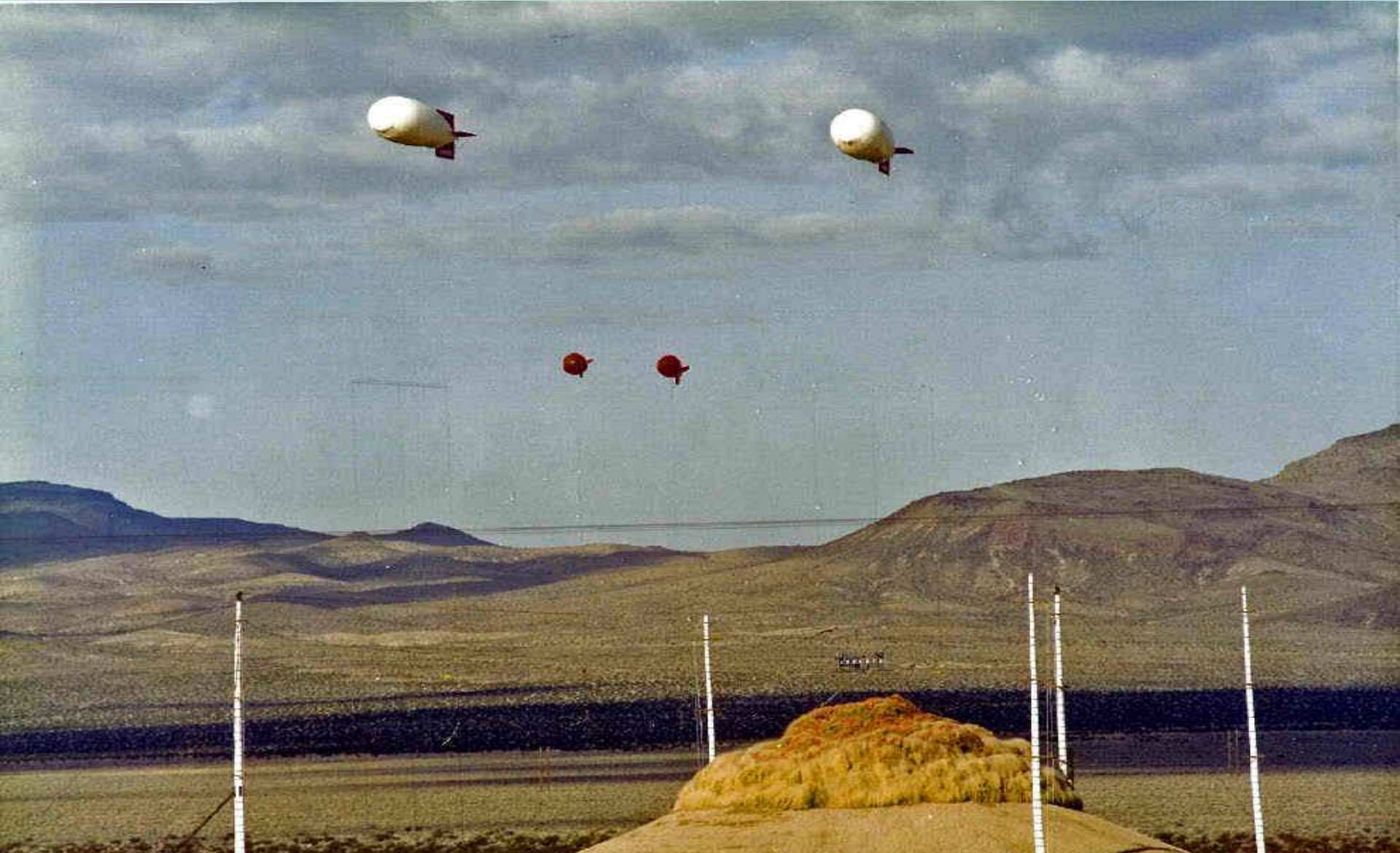
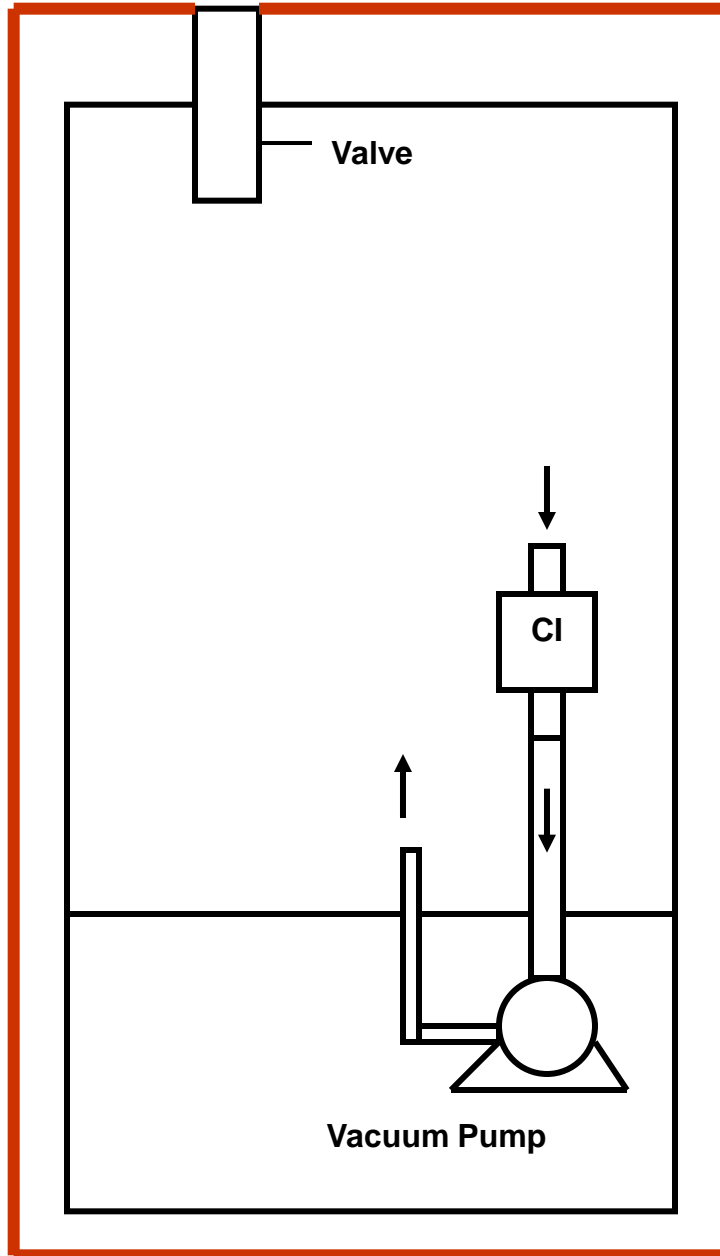


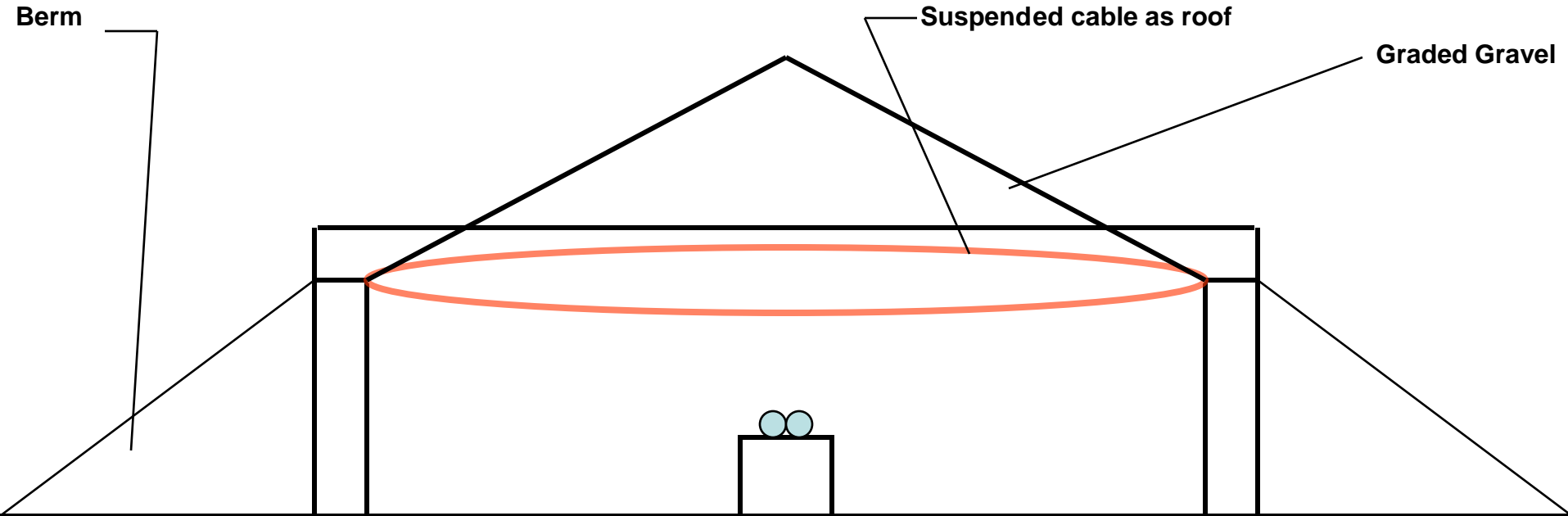
Table of Air Samplers Used on Gravel Gertie Test

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

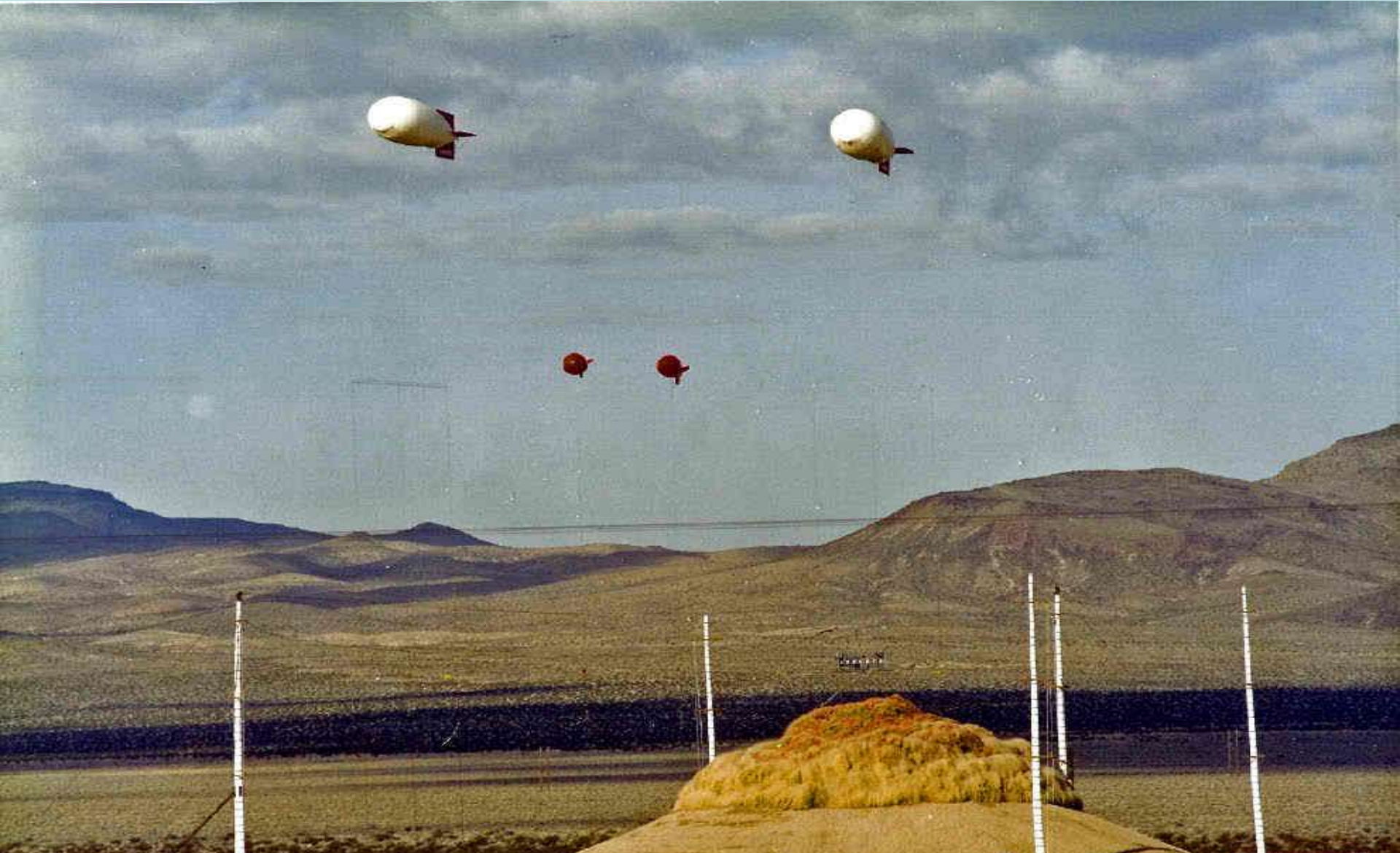
Explosion Proof Air Sampler



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

