TEAM

035

Air Quality Improvement Device for Hydrogen Sulfide (H2S) in Industrial Settings

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Introduction

Hydrogen sulfide (H_2S) is a toxic gas that endangers workers in oil & gas industry health and can cause environmental damage if leaked. To mitigate these risks, a system combining real-time detection, advanced filtration, and chemical adsorption can be used.

Problem Statement

Leaking H_2S from oilfield wells presents health and environmental hazards, highlighting the inadequacy of existing safety solutions.

Final Target Specification

1. >90% efficiency of components
2. <5 Sec filter activation after detection
3. >99% filter naturalization (H2S)
4. Cost-effectiveness (10 to 20%)
5. Using Stainless Steel for the body
6. Easy replacement of filters & sys maintenance

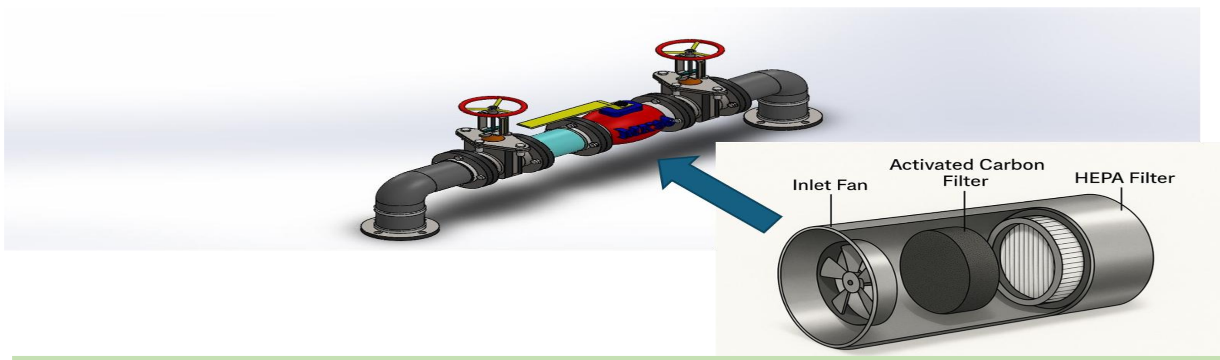
Project Constraints

1. Device location in oilfield wells
2. Operating in pressure range (1 to 35 bar)
3. Operating in Temp range (-20 to 60 C)
4. H2S detection as low as 1 ppm
5. Filtration through activated carbon and HEAP filters

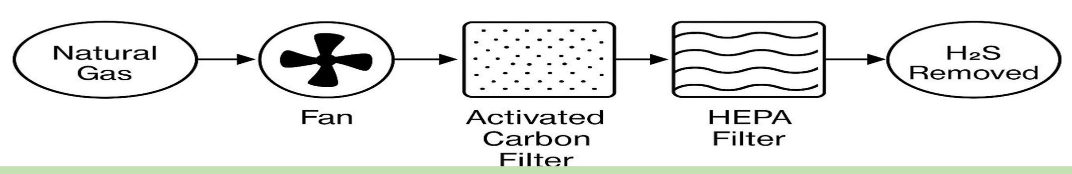
Project objectives

- Detect & filter H_2S leaks instantly
- Neutralize gas through chemical reaction
- Improve reliability & reduce expenses

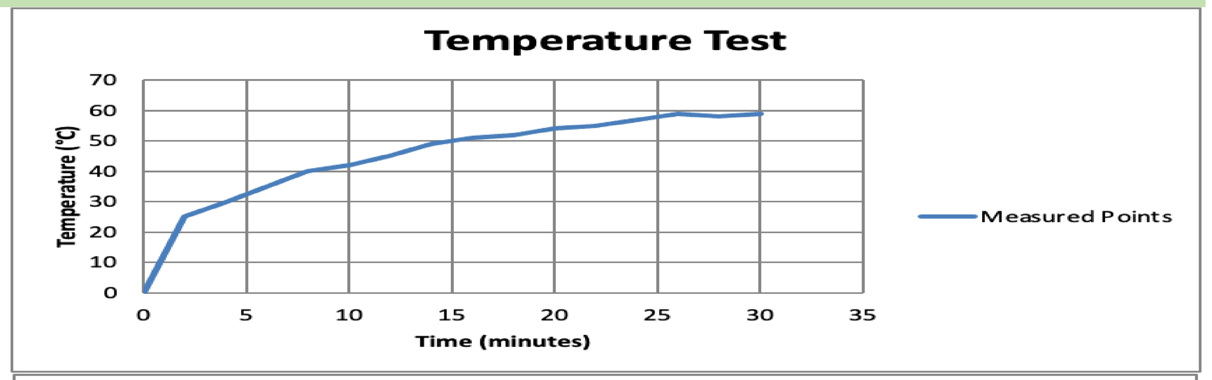
Device Components

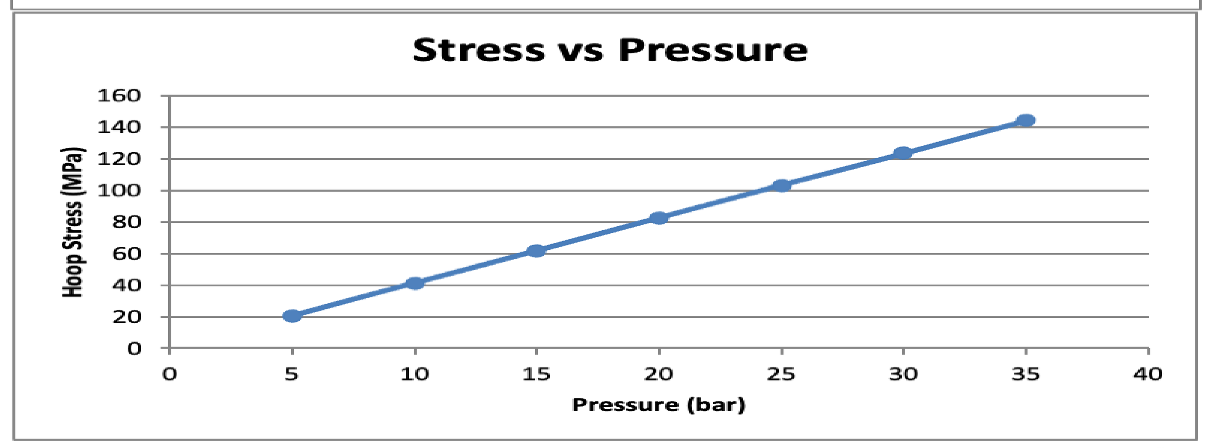


Process Flow Diagram



Temp & Press Verification





Internal Diameter (D)	0.33 m
Wall Thickness (t)	0.004 m (4 mm)
Material	Stainless Steel (AISI 304)
Yield Strength (σ_y)	215 MPa
Minimum Pressure	5 bar = 0.5 MPa
Maximum Pressure	35 bar = 3.5 MPa
Assumed as	Thin-Walled Cylinder ($D/t = 82.5 > 10$)

- σ_h = PD / 2t, FOS= σ_y / σ_h

Pressure (bar)	Hoop Stress σ_h (MPa)	Factor of Safety (FOS)
5	20.63	10.42
35	144.38	1.49

OR Model

- This OR model was formulated to obtain a weighted efficiency of 90% of the selected material while utilizing <30% of the budget:

Decision Variable: $x_{ij} = \begin{cases} 1, & \text{if part } j \text{ from category } i \text{ is selected} \\ 0, & \text{otherwise} \end{cases}$

Parameters: cost_{ij}: cost of part j from category i, efficiency_{ij}: efficiency of part j from category i, weight_i: weight of category i

$$\min \sum_{i \in \text{categories}} \sum_{j \in \text{parts}} \text{cost}_{ij} \cdot x_{ij}$$

s.t.

$$\sum_{j \in \text{parts}} x_{ij} = 1 \quad \forall i \in \text{categories}$$

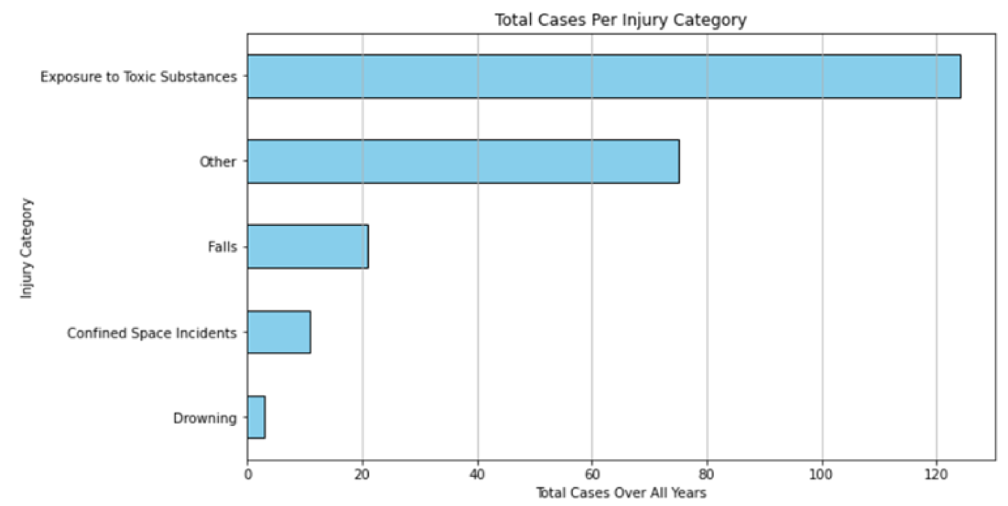
$$\sum_{i \in \text{categories}} \sum_{j \in \text{parts}} \text{cost}_{ij} \cdot x_{ij} \le 0.3 \cdot \text{budget\_limit}$$

$$\sum_{i \in \text{categories}} \sum_{j \in \text{parts}} \text{weight}_i \cdot \text{efficiency}_{ij} \cdot x_{ij} \ge \text{min\_efficiency}$$

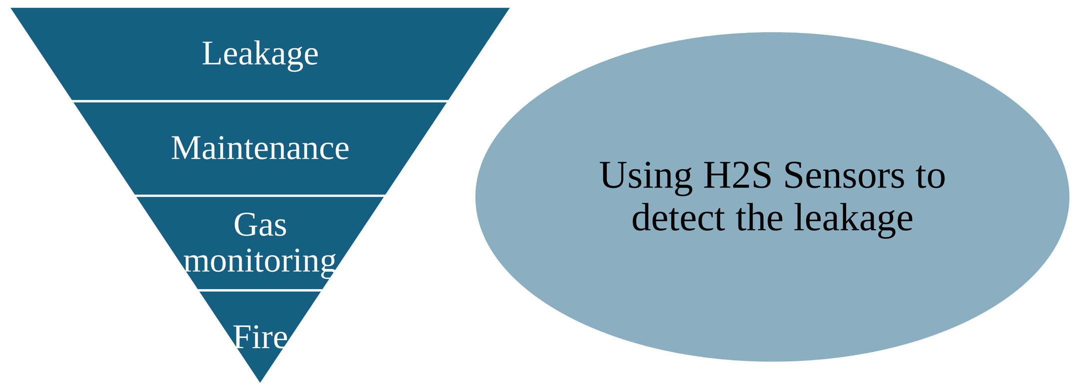
$$x_{ij} \in \{0, 1\} \quad \forall i, j$$

Risk assessment

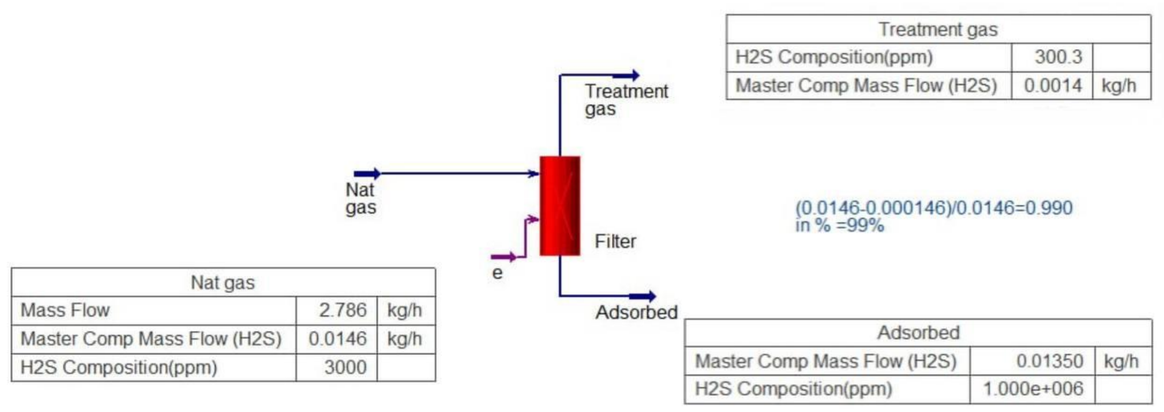
242 H_2S accidents from OSHA, grouped into 5 types.



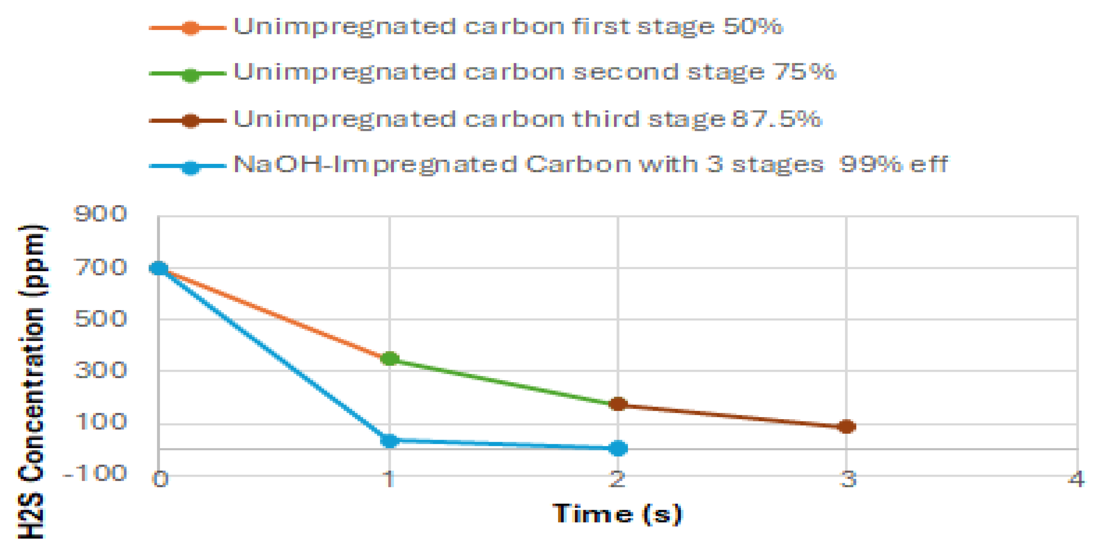
After filtration, 33 data points were grouped into 4 main causes.



Simulation of filters



Adsorber & H2S Sensor



Filter Volume =Pi x r^2 x L = 0.00085 m^3

Mass = Density x Filter Volume = 341.96 g

Mass of H2S = 0.15 x 341.96 = 51.3 g

Parameter	Specification
Detection Range	0–100 ppm H₂S
Power Supply	10–30 V DC
Power Consumption	0.12 W

Conclusion

The device effectively removes 99% of harmful pollutants, ensures worker safety, meets standards, and works reliably in harsh oilfield conditions.