



Battery Thermal Runaway Testing New Bedford Fire Department Live Fire Training Center



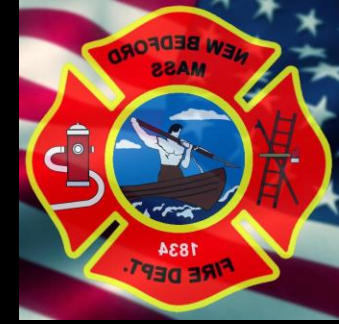
Organizations

- New Bedford Fire Department
- The Hazmat Guys
- Massachusetts Department of Fire Services
- Telops
- Blackline
- FLIR
- FarrWest
- Redwave



Objectives

- Differences in State of Cell Charges
- Emitted Gases
- Capabilities of Meters
- Limitations of Overpacking





18650 Cells



Material : Lithium-ion battery

Name : ICR18650-26F

Type : 18650

Capacity : 2600mAh

Voltage: 3.6-3.7V

Charging voltage : 4.2V

Discharge voltage : 2.75V

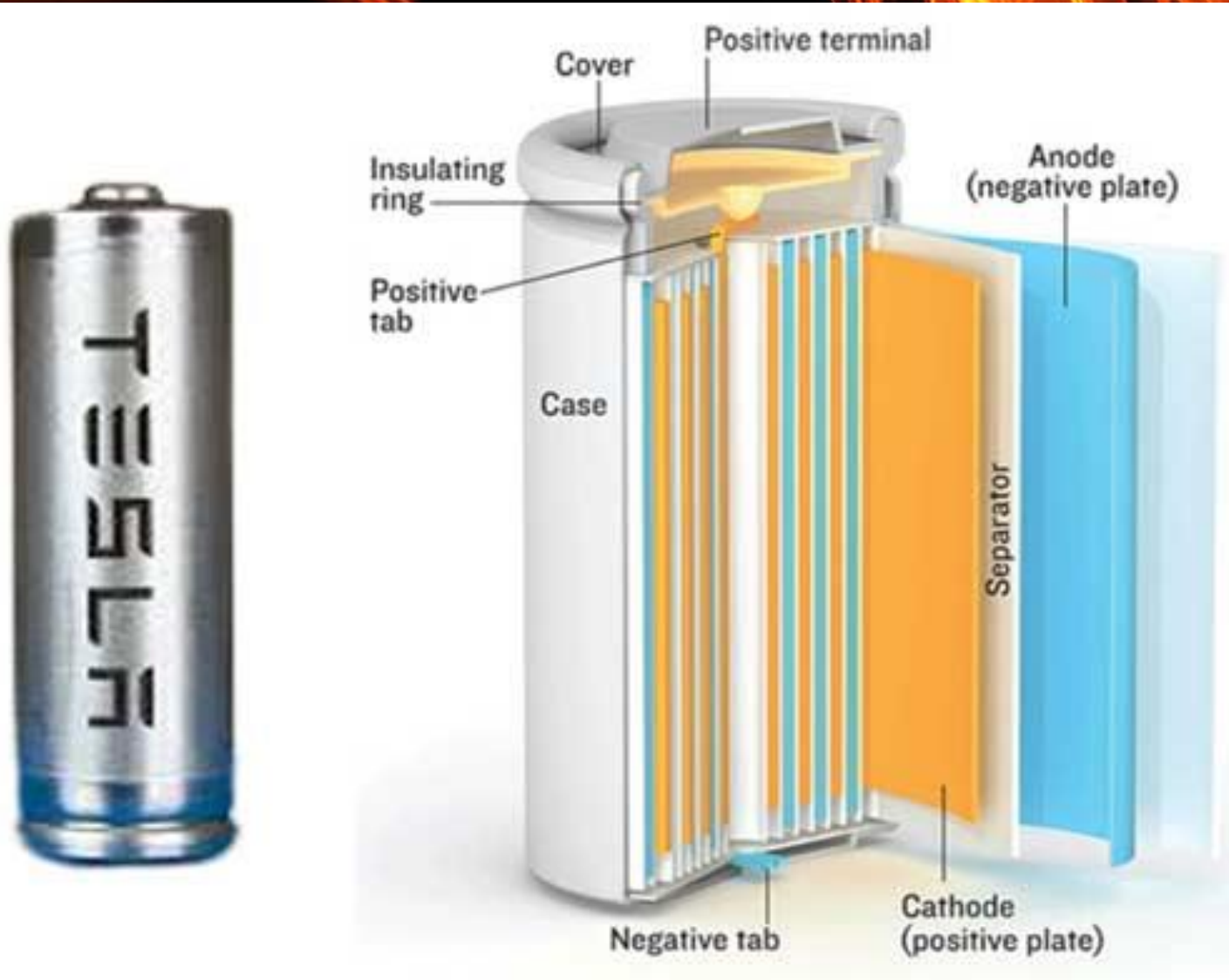
Cycles : 1500 times

Size : 65mm*18mm

Weight : 46g

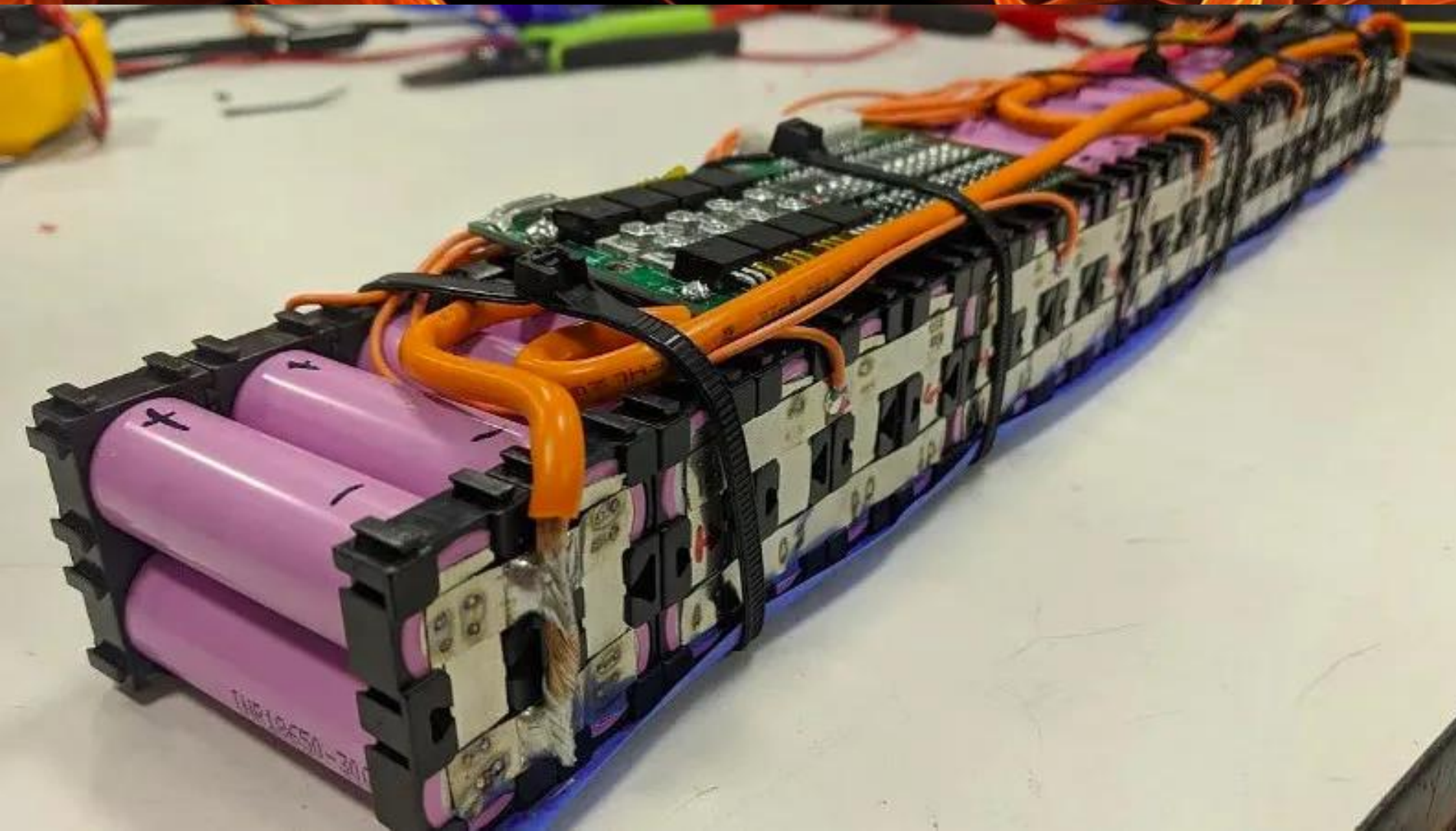


18650 Cells





18650 Battery Module

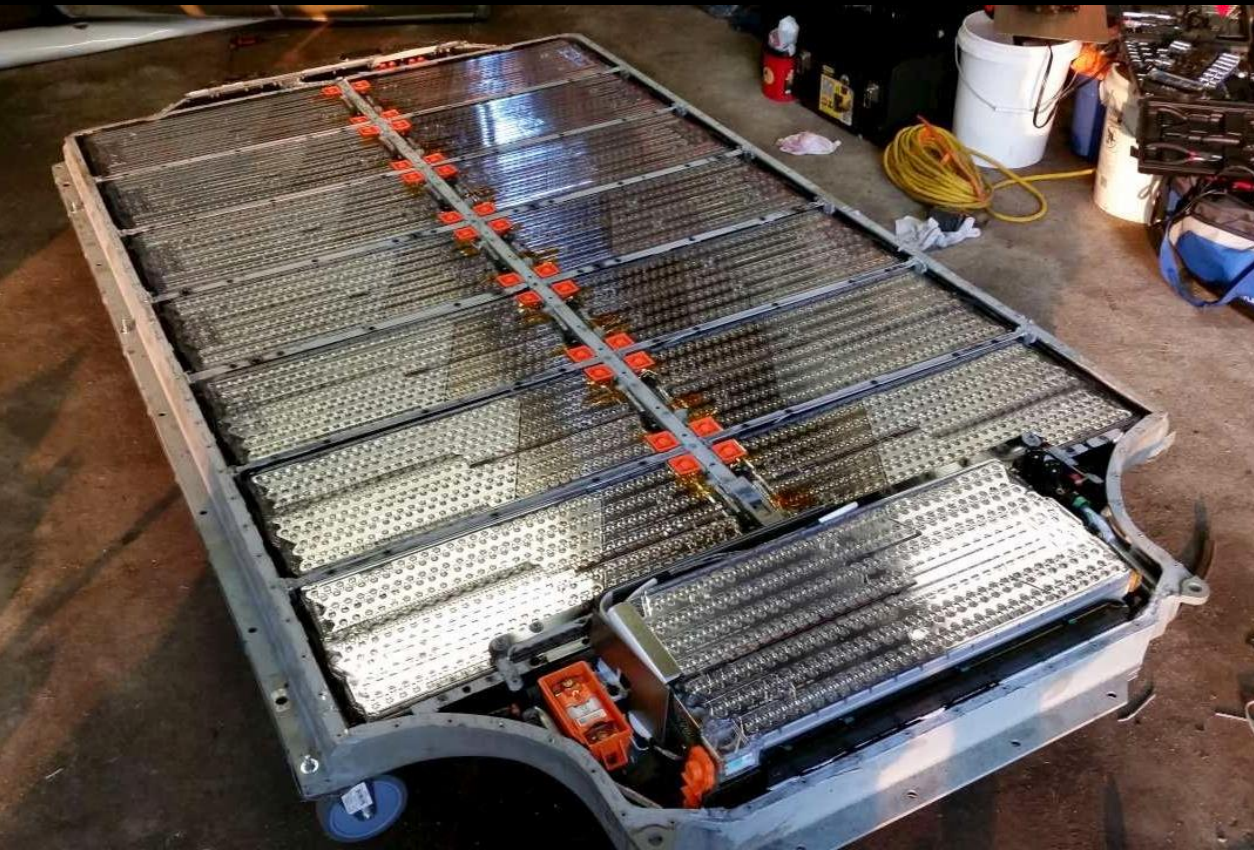




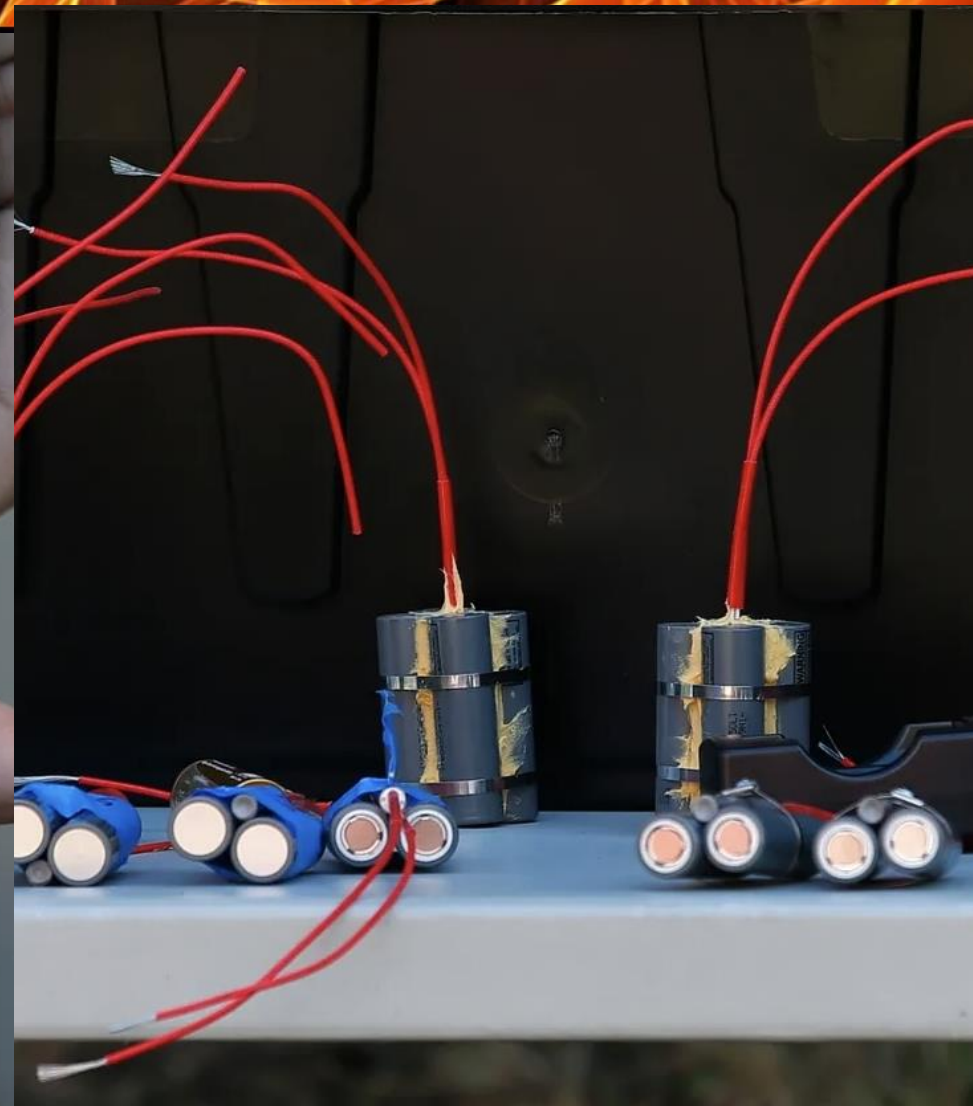
18650 Battery Pack



The most popular battery pack supplied by Tesla contains 7,104 18650 cells in 16 444 cell modules capable of storing up to 85 kWh of energy

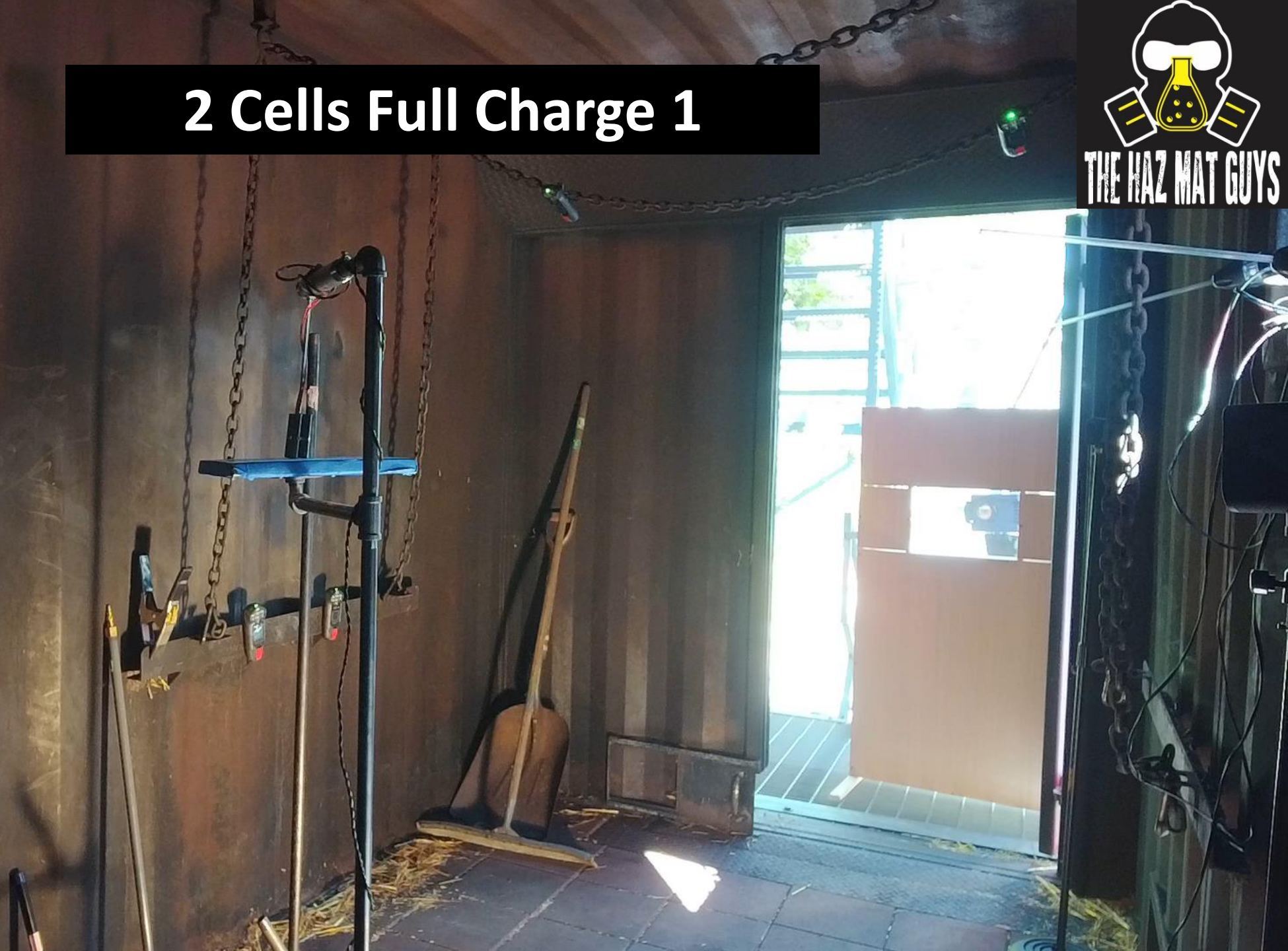


The Setup



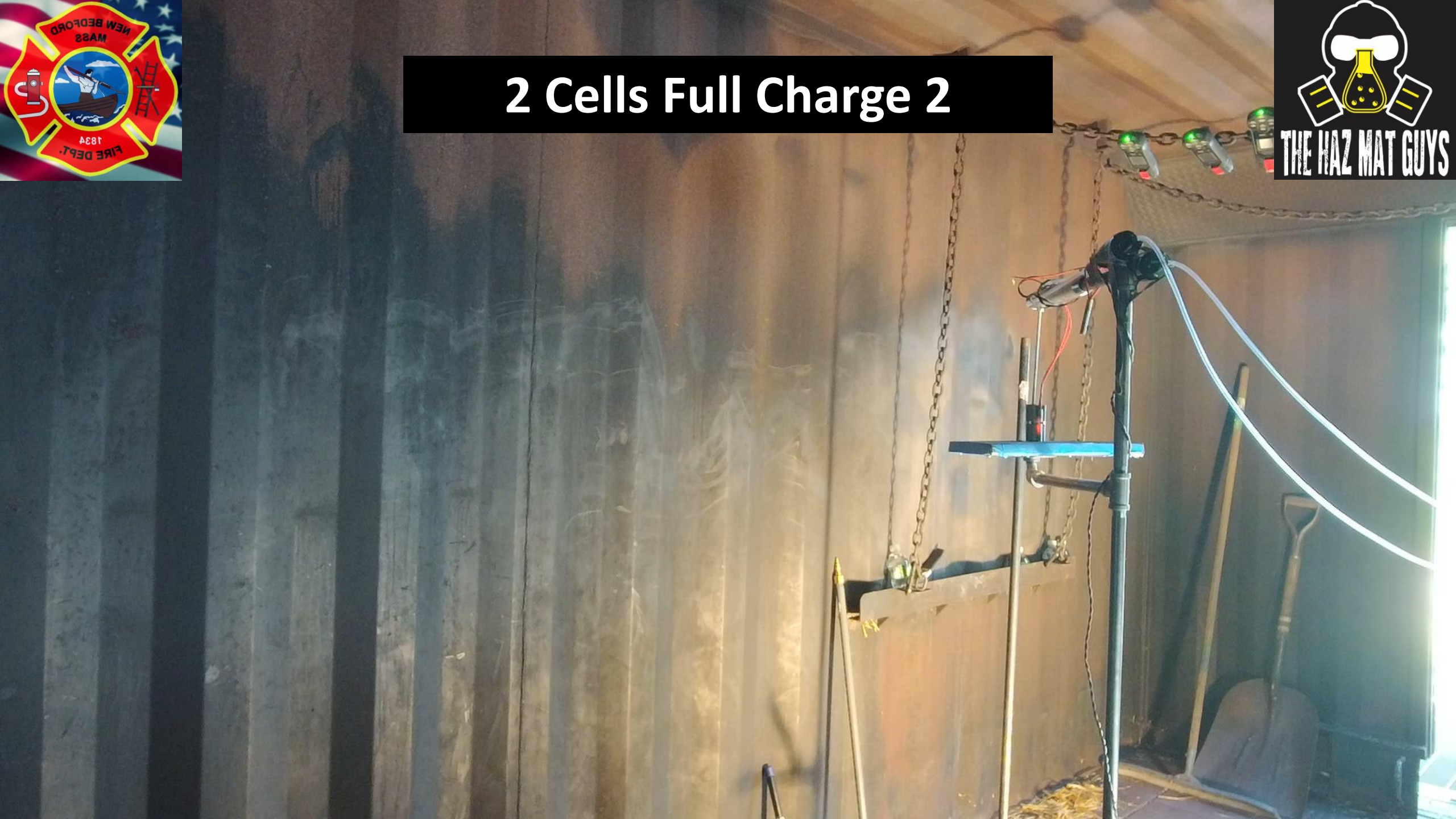


2 Cells Full Charge 1



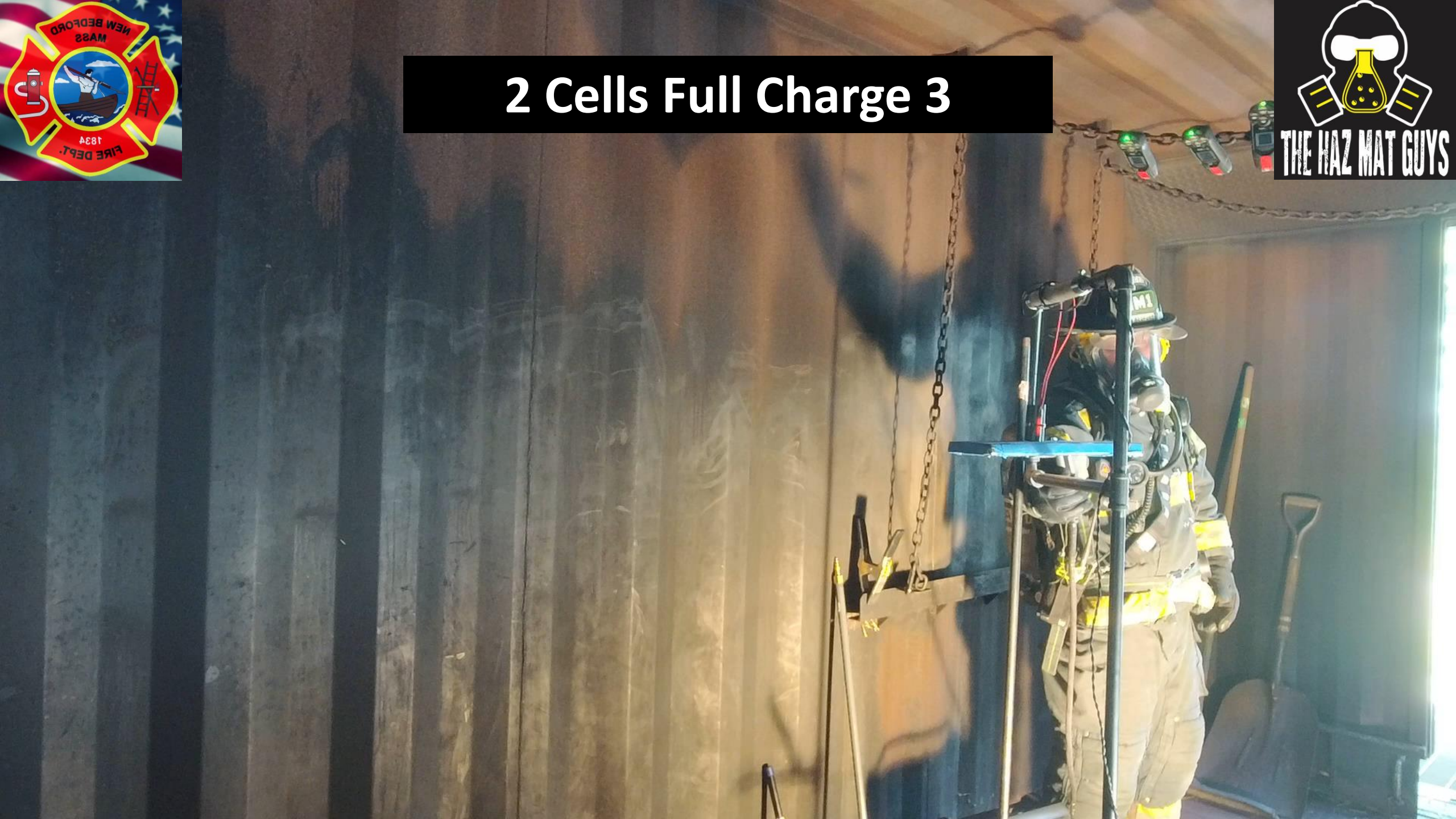


2 Cells Full Charge 2



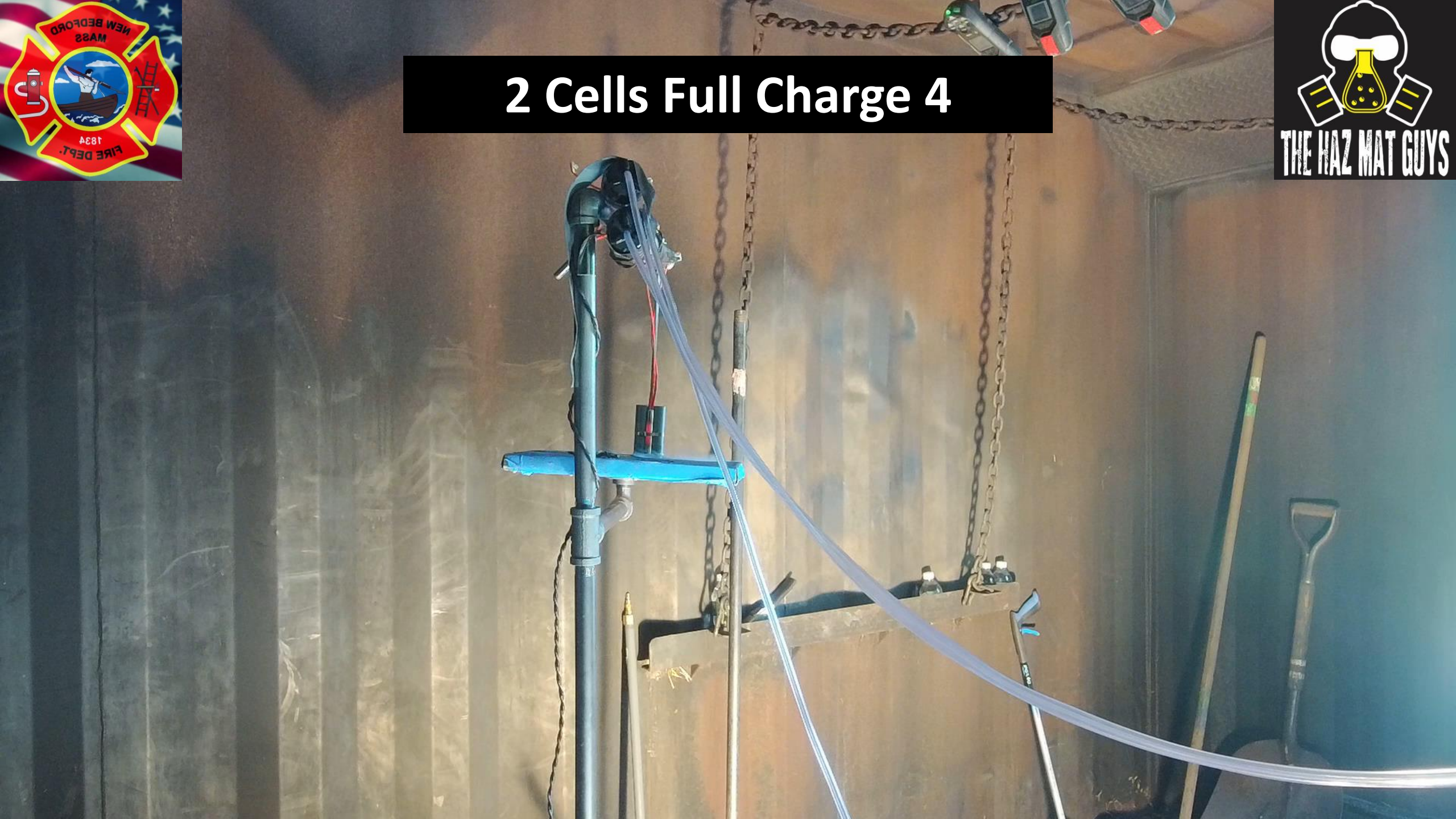


2 Cells Full Charge 3



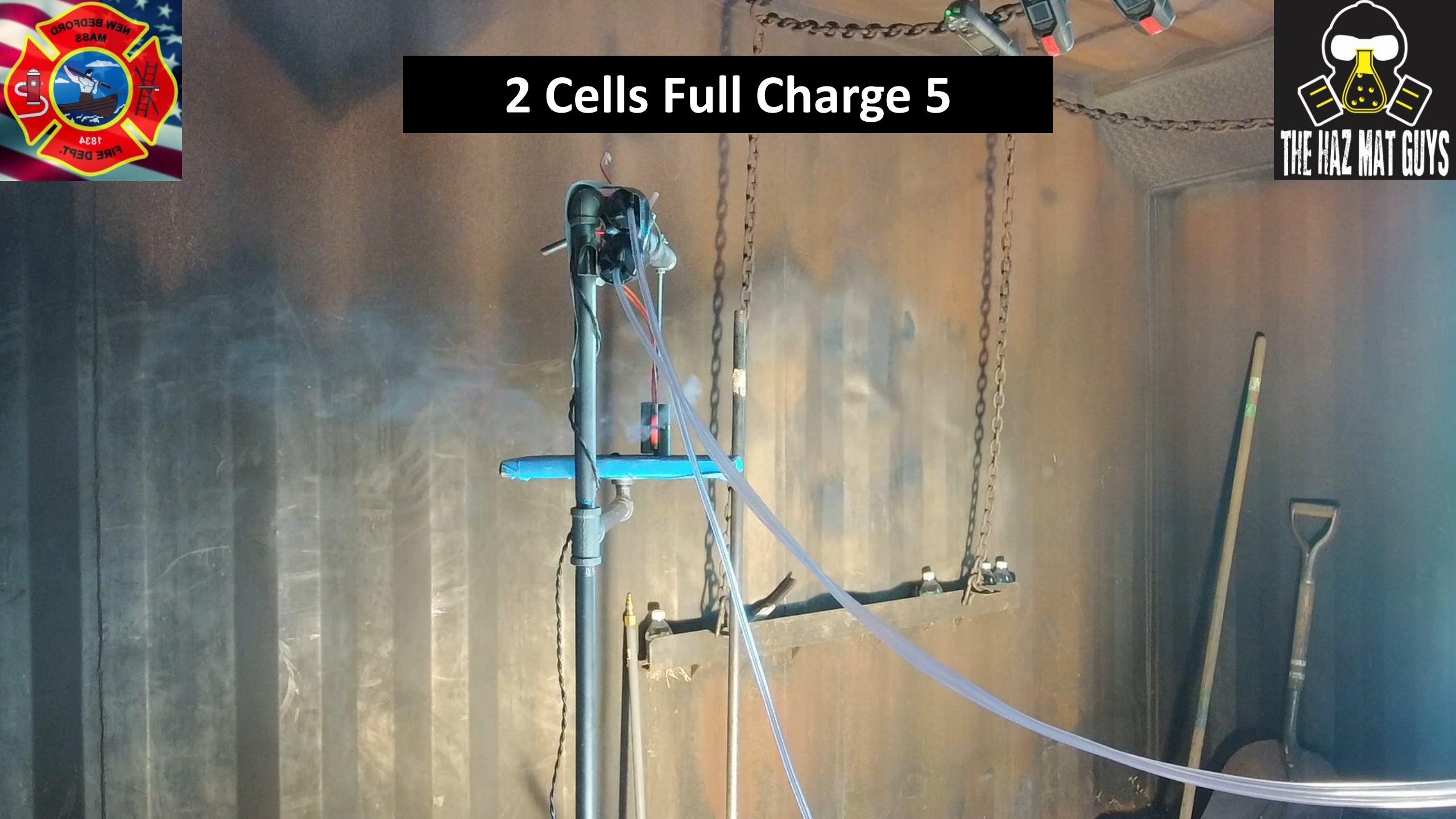


2 Cells Full Charge 4



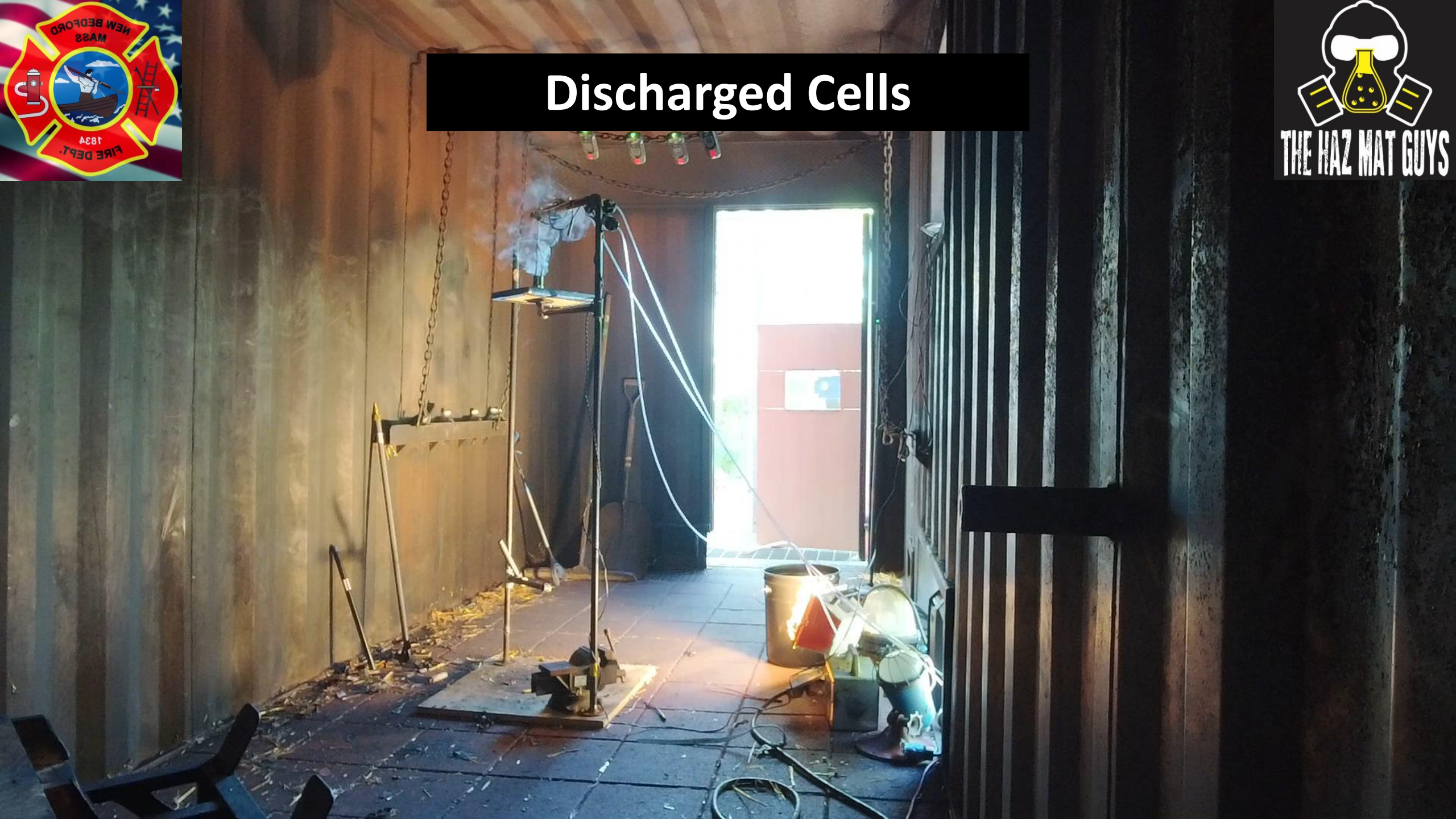


2 Cells Full Charge 5



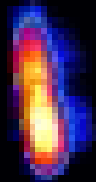


Discharged Cells





**50 % Discharged Cell
Over Heated
Full Speed**





**50 % Discharged Cell
Over Heated
25% Speed**





Full Charge Cell Punctured Full Speed





Full Charge Cell Punctured 25% Speed



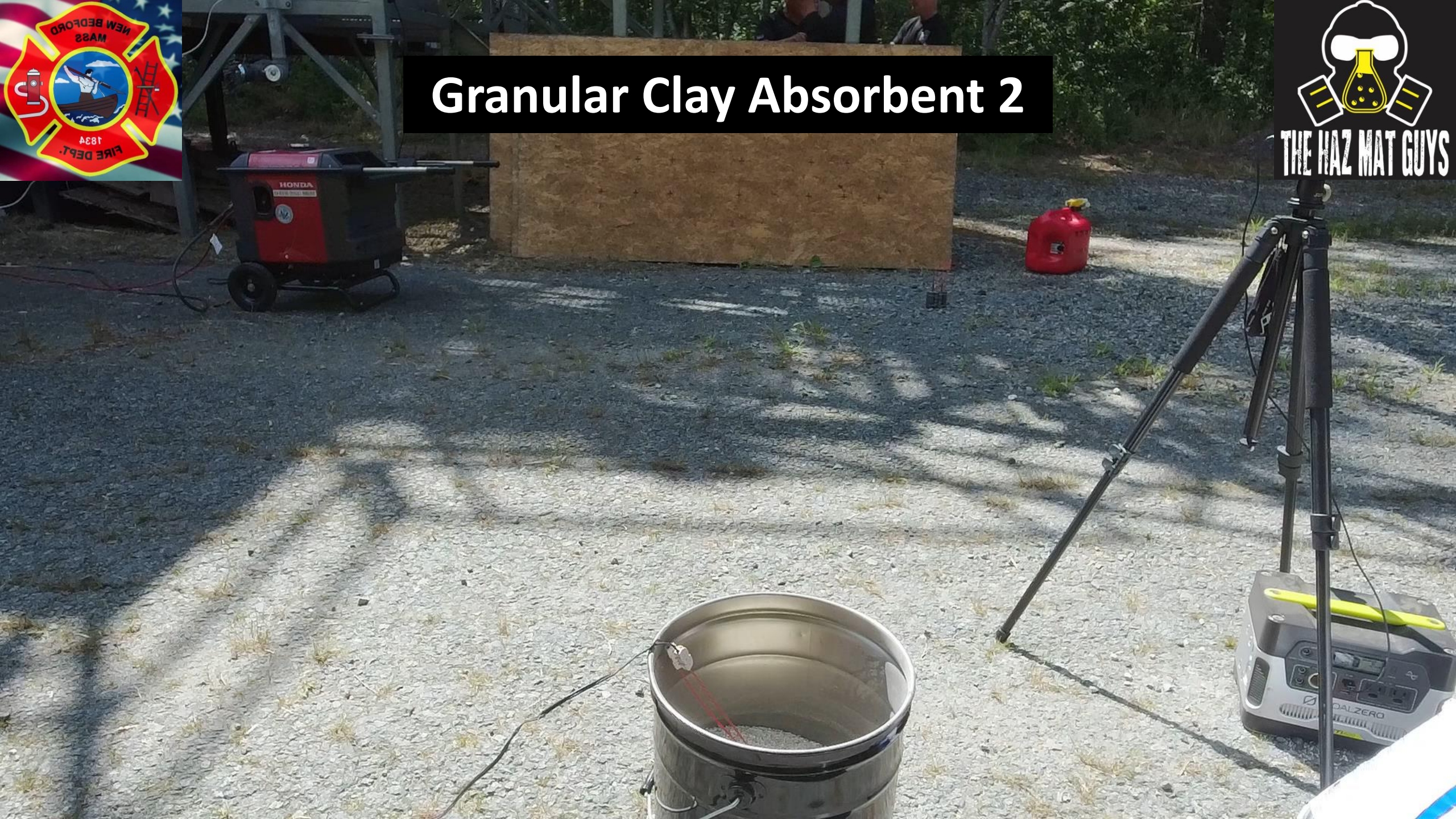


Granular Clay Absorbent





Granular Clay Absorbent 2





Cellblock Open Bucket Meter Activation





Cellblock Open Bucket with Meters



Blackline Safety Multi Gas Meters

- % of the LEL Readings
- High CO Levels (Cross sensitivity to hydrogen)
- Hydrogen Sulfide (H₂S)
- Decreased and Increased O₂ Levels
- Hydrofluoric Gas Sensor Readings





FLIR/FARRWEST G510 GCMS



Toluene
o-Xylene
Ethylbenzene
2-chloro
acetophenone
Phenol
p-Cresol
Naphthalene

2-methylnapthalene
Biphenyl
Acenaphthylene
1,4 Dioxane
Propylbenzene
1,2,4-trimethylbenzene
p-Xylene
Styrene



30 Gallon Drum 2 Cells Overpacked in Cell Block 1





30 Gallon Drum 2 Cells Overpacked in Cell Block 2





30 Gallon Drum 2 Cells Overpacked in Cell Block 25% Speed





Cell Block Overpack Bag





Cell Block Overpack Bag 25% Speed



Lessons Learned



- The higher the charge level the more energetic the reaction
- Our meters can detect the off-gassing
- Cells off-gas early in runaway
- Off-gassing is highly toxic and flammable
- Overpacking does not completely eliminate the hazard

