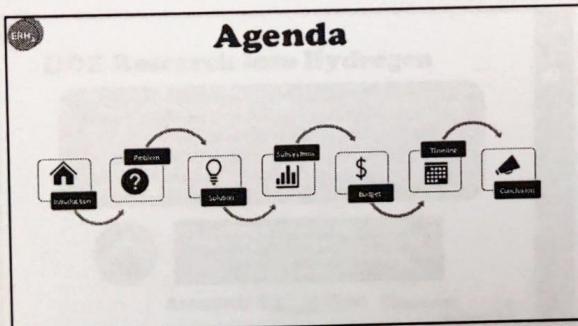


12:08 start
12:39 stop

Hannah



AIC



Don't read agenda items

Anush

The image contains three side-by-side photographs. The first, labeled 'Wind Tunnel', shows a room with a large wind tunnel setup. The second, labeled 'Robotics Lab', shows a vehicle chassis mounted on a test stand. The third, labeled 'Propulsion Lab', shows a rocket engine test stand with a plume of exhaust. Each photograph has its caption below it.

Sacobs

Embry-Riddle does *not* have

Energy Labs

Energy Classrooms

Viewable Demonstrations

Sacob

The screenshot shows a news article from the "DOE Research into Hydrogen" section. The article discusses the DOE's research into multiple uses for hydrogen gas, including its potential as an alternative energy source. It highlights Embry-Riddle's role in creating an energy demonstrator to teach the general public about hydrogen fuel and storage. A funding notice for clean hydrogen production, storage, transport, and utilization is also mentioned, along with a grant amount of \$32 million.

DOE Research into Hydrogen

The DOE is researching multiple uses for hydrogen gas, producing the need for more hydrogen. This creates interest within Embry-Riddle to create an alternative energy demonstrator that teaches the general public about hydrogen fuel and storage.

Funding Notice: Clean Hydrogen Production, Storage, Transport and Utilization to Enable a Net-Zero Carbon Economy

Amount: \$32 million *seems small*

Tech

Generate and Store Hydrogen

ERH2's purpose is to create a demonstrator to generate and store hydrogen.

Rylan

The diagram consists of three overlapping circles arranged horizontally. The first circle on the left contains the text "Alternative Energy Storage". The middle circle contains the text "Scalable Production Rate". The third circle on the right contains the text "Sole Source of H₂ on Campus". The circles overlap, suggesting a synergistic relationship between the three benefits.

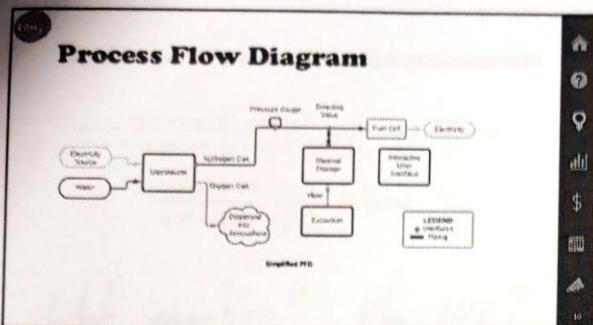
Dglan

The diagram illustrates the ERH₂ System. On the left, a vertical stack of horizontal bars represents the **Electrolysis** process. A tube leads from this to a **Material Storage** tank in the center. A **Pressure Gauge** is positioned between the electrolysis and the storage tank. Above the storage tank is a **Diverting Valve**. From the top of the storage tank, a tube leads to the right, labeled **Fuel Cell**. A blue curved arrow labeled **Nichrome Wire** points from the bottom right towards the fuel cell area.

Brief overview

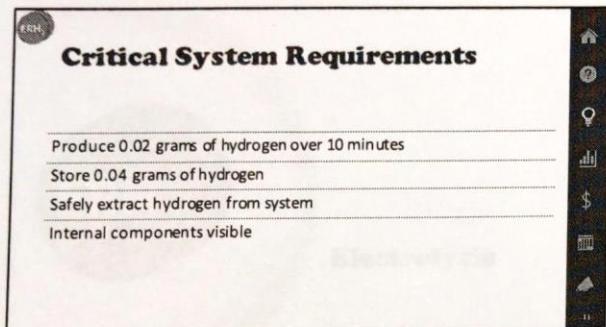
Need Modes of Operation.

Tesla



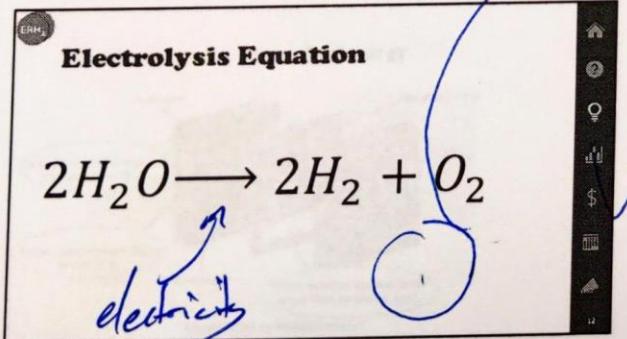
- Numbers to describe operation.
- Operating modes.

Jacob



-
-
-
-
-

Hannah



Show half reactions

-
-
-
-
-

Titan

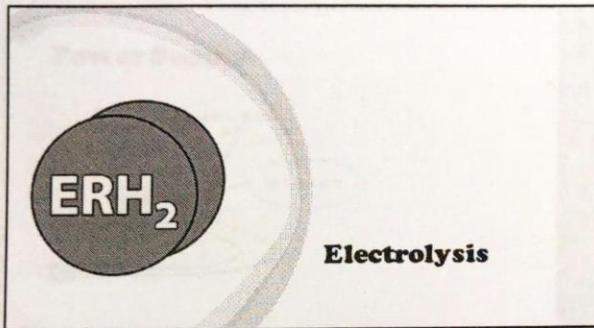
Hydrogen Production Requirement

Power wanted (kW) * Time(sec.)
 Percent Eff of fuel cell * Lower heating value ($\frac{KJ}{kg}$) = Amount needed (g H₂)

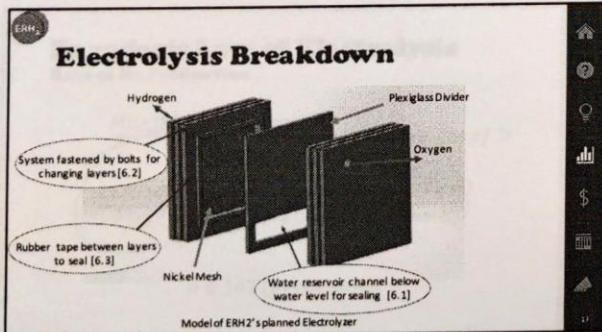
$$\frac{.001kW * 600 \text{ (sec.)}}{0.25 * 120,000 \left(\frac{KJ}{kg}\right)} = .02 \text{ (g H}_2\text{)}$$

what equation? Why LHV?
 why not Gibbs free energy?

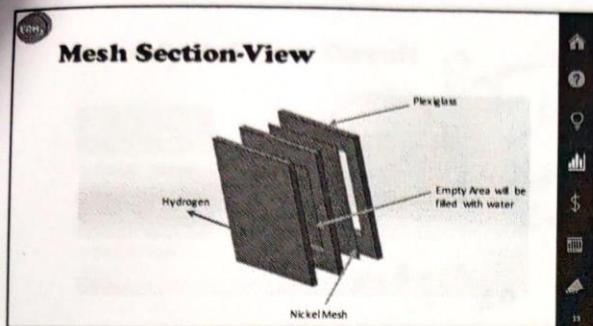
Titan



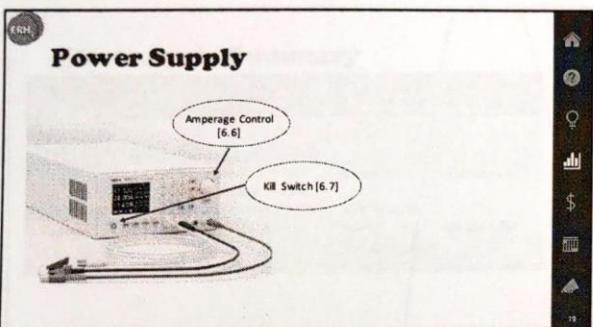
Grant



Grant



Grant



20 amp limit?

Grant

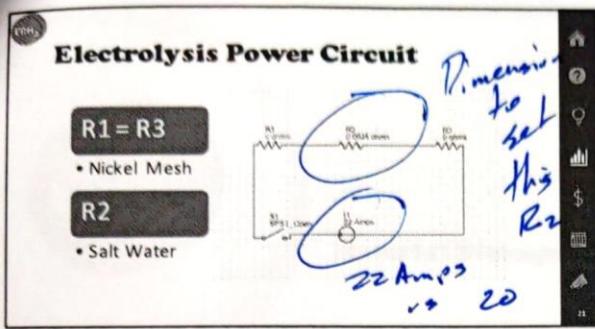
Faraday's Law of Electrolysis
Rate of H₂ Production

$$\frac{\text{Max theoretical Current}}{\text{Valence}} * \text{Molar weight of H}$$

$$\frac{22.89 \text{ (C)}}{1 \text{ (s)}} * \frac{600 \text{ (s)}}{96,485 \text{ (C)}} * \frac{1 \text{ (mol H}_2\text{)}}{2 \text{ (mol e}^-\text{)}} * \frac{2.007 \text{ (g H}_2\text{)}}{1 \text{ (mol H}_2\text{)}}$$

$$= 0.142 \text{ (g/10min H}_2\text{)}$$

Grant



Dimensions to set this R2

22 Amperes vs 20

Grant

Electrolysis Summary

Requirement	Design	Expected Performance	Verification
6.1	The hydrogen and oxygen will be separated at creation	100%	Fuel Cell Runs
6.2	The system was designed to be sandwiched together into different layers making it replaceable	Life of bolts used	It will come apart
6.3	Ability to bolt together	The life span of seals	It will come apart

Grant

Follow through

Electrolysis Summary

Requirement	Design	Expected Performance	Verification
6.4	Will be made of plastic	Nonconductive	Voltmeter
6.5	Will use 12-gauge wire	Rated for 20 amp	National Electrical code
6.6	Will set power supply to max 20 amps	Max 20 amps	Power supply read out
6.7	Have an on off switch	100%	System turns off

Grant

Material Storage

System Requirements

1.2

"The system must store 0.04 grams of hydrogen gas."

4.1

"The material storage efficiency (hydrogen in vs. hydrogen out) must be at least 50%."

Hannah

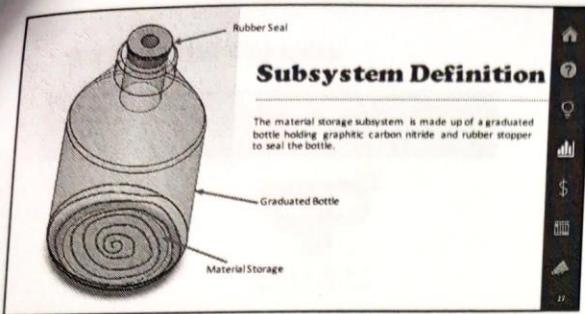
Lithium-Doped Graphitic Carbon Nitride [Li₂C₄N₃/Li₂C₄N₄]

Gif showing

*Is this
a surface-only
phenomenon?*

*H₂ getting
trapped.*





Hanna!

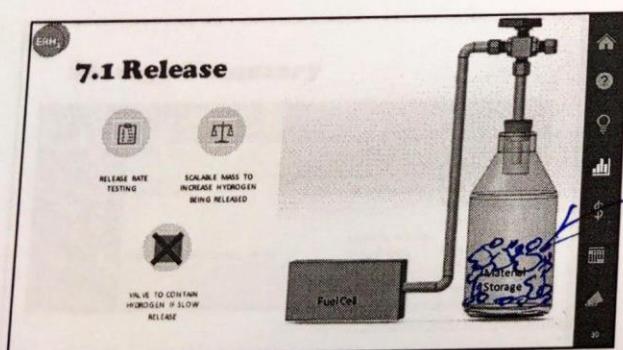
Equations

$$E_{Molar} = \frac{m_{H_2out} - m_{H_2in}}{m_{H_2in}} \quad m_{Stored} = m_{initial} - m_{final} \quad \%_{wtH_2} = \frac{m_{Stored}}{m_{final}} * 100$$

Where:
 $E_{Material}$ = Material Efficiency
 m_{H_2in} = Mass of hydrogen into the material storage system
 m_{H_2out} = Mass of hydrogen leaving the material storage subsystem.
 m_{Stored} = Mass of hydrogen stored in material storage
 $m_{initial}$ = Mass of the storage before hydrogen is introduced
 m_{final} = Final mass of the material after hydrogen loading
 $\%_{w/w} H_2$ = Weight percentage of hydrogen in the material storage

Hannah

7.1 Release



show material (or show how it is)

7.2 Material Capacity

it was found that the gravimetric and volumetric densities of hydrogen in both $Li_2C_4N_3$ and $Li_2C_4N_4$ were greater than 10 wt% and 100 g/L respectively [Wu et al.]



CIPET सि पे ट
Centre - platform - practice - Partners



Hannah

7.3 Material Needed

4% yield Urea to Graphitic Carbon Nitride



Can be done on campus.

What's needed / process?

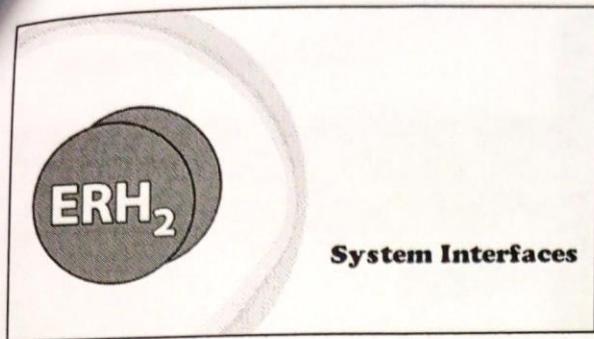
Pyrolysis

Hannah

Storage Summary

Requirement	Design	Expected Performance	Verification
7.1	Extraction heats material to release temperature.	Releases at least 0.02 grams per 10 minutes	Runs the fuel cell Numerically, Greater than 2%
7.2	Doped graphitic carbon nitride	Capacity of 10% wt hydrogen	Testing
7.3	2 grams of Graphitic Carbon Nitride	Synthesize 50 grams for 4% yield	Greater than 2 grams





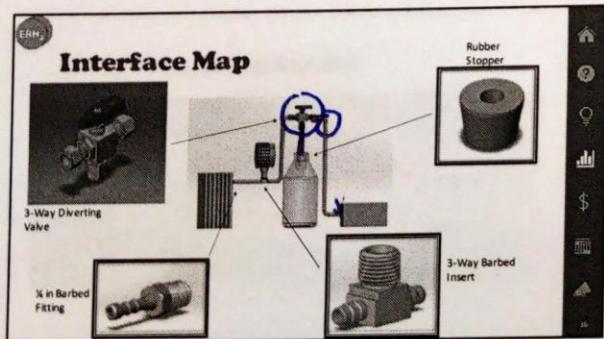
-
-
-
-
-
- Titan

System Requirements

System Requirement 4.4 mandates that all subsystem interfaces must be sealed.

Style vs. slide 25

-
-
-
-
-
- Titan



Specs on interfaces.
"PTFE tubing" ←
Material specs for use w/ it?

Titan

More barbed fittings.

Misc. Interfacing Table

Type of Interface	Name	Price	Interface Point
Plastic Epoxy	Plastic Epoxy Putty	\$5.83 per 2 ounces	Electrolyzer to piping connection
Electrical Epoxy	Fire Barrier Sealant	\$11.28 per 10.3 ounces	Electrical Epoxy for Electrolyzer
Gasket Tape	NEMA 12	\$15.55 per 10 feet	Internal Electrolyzer Interfaces
Pipe Gasket	Gasket	\$0.79 each	Threaded Connections
Plastic Epoxy	J-B Weld	\$9.76 per 2 ounces	Electrolyzer Water Storage Casing
Threaded Connections	Made Inhouse	1/2 inch Aluminum Stock	To be Decided

? carbon filament?

Tibor

Detecting Leaks

ERH 2 will follow ASHRAE
Bubble Method under
Chapter 29.9 Leak
Detection in the 2017
edition ASHRAE
Handbook.



Surat ASHRAE

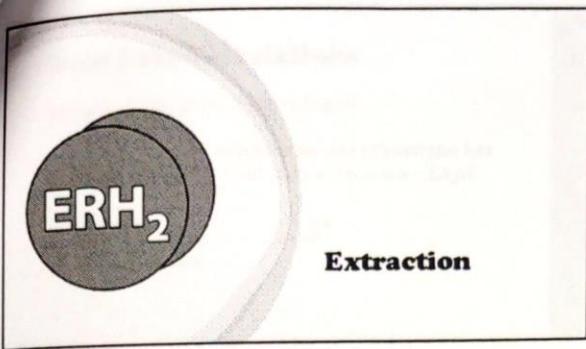
standard for use in HVAC systems.

Any H₂ reactions w/ CO₂? → w/o
Titan w/o H₂

Integration Summary

Requirement	Design	Expected Performance	Verification
R.1	The electrolyzer fitting moves hydrogen gas from the electrolyzer to the piping.	No leaks	Bubble Test
R.2	The pressure gauge fitting moves hydrogen gas from the piping to the pressure gauge.	No leaks	Bubble Test
R.3	The rubber stoper fitting moves hydrogen gas from the 3-way diverting valve to the material storage.	No leaks	Bubble Test

Titan



Tesla

System Requirements

 2.1 "The system must allow for safe extraction of hydrogen gas without risk of major leaks."	 4.3 "The material storage to fuel cell system must be able to run for 10 minutes."
---	---

Tesla

Heating Element – Nichrome Wire

• Type: Resistance Wire • Material: Nichrome 80 Alloy (from 80% Ni, 20% Cr)	• Specification: ASTM B837 • Temperature Rating: 1177°C (2100°F)
10 AWG 22 AWG 200 ft	

-Remington Industries

How much power?

Amp limits?

Tesla

Heat Loss Calculations

Energy Loss, 10ft. Of wire @ 300°C: 2.683W

Heat Rate Out = Conduction loss + Convection loss
Conduction loss = $h_{air}A_1\Delta T$ Convection loss = $-kA_2\Delta T$

$h_{air} = 2.5 \text{ for still air}$
 $A_1 = .0038m^2$ (50% surface area)
 $A_2 = .0019m^2$ (25% surface area)

$K = 11.3 \frac{W}{m \cdot K}$
 $\Delta T = 280^\circ K$

Tesla

Voltage Input Calculations

Voltage Requirement: 2.402V

$Q = V^2/R$

$Q = 2.683W$ $R = .705 \frac{\Omega}{m} \cdot 3.048m$ (10ft.)

Tesla

> 1 amp.

Vessel Pressure

Maximum Vessel Pressure: 40.43 psia
Champagne Bottle: 90psia
Soda Can: 30psia



Based on what calc?
How much air? H_2 vs. H_2O

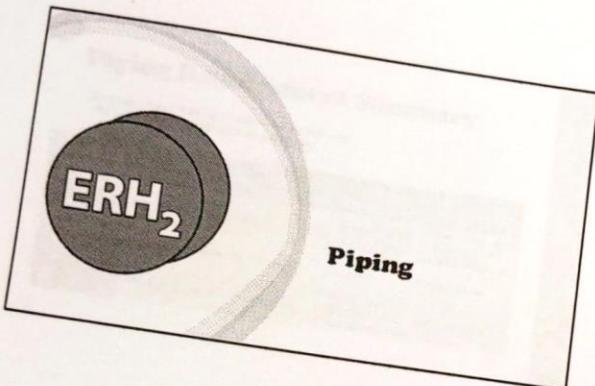
Tesla



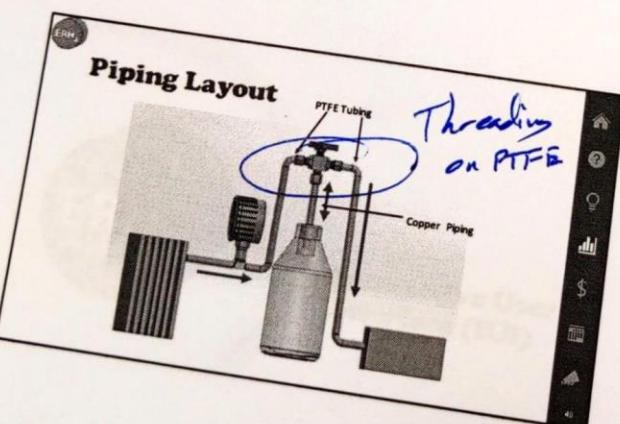
2014-2015

Requirement	Design	Expected Performance	Verification
R.1	Nichrome wire achieves steady state temperature of 300°C	Hydrogen release from storage medium	Fuel cell produces electricity
R.2	Voltage supplied to Nichrome wire ≈ 2.4V	Steady state temp. < 350°C	Thermal Imaging

Tesla



Jacob



System Reg's ?

Grand animations. Should use much earlier w/ system overview.

Jacob

Heat Transfer Analysis

1. Use a 6in long pipe at constant 100°C that reduces internal gas temperature from 300°C to 150°C to determine flow regime.
2. Analyze 0.0001in long sections where pipe is average temperature of internal and external air.

K convection, inside: 13.48 (W/m²K)
K convection, outside: 20.35 (W/m²K)

To reduce the gas from 300°C to 50°C, the copper pipe must be 1.65 inches long.
Conduction through the pipe is negligible. Convection on the outside and inside of the pipe have similar magnitudes.

→ E-3

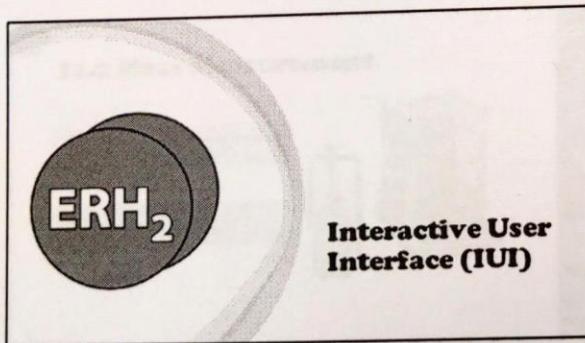
Jacob

Piping Requirement Summary

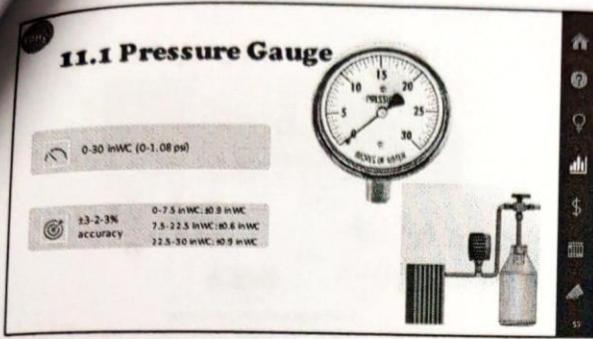
Hard Copper Pipe 0.5" OD x 0.05" Wall Thickness x 2.63" Long
PTFE Tubing 0.31"ODx 0.03" Wall Thickness x2' Long

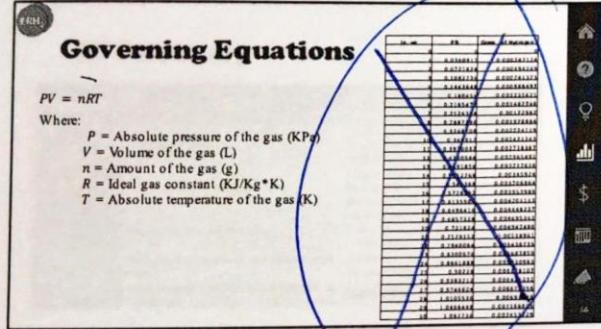
Requirement	Design	Expected Performance	Verification
10.1	PTFE tubing and copper pipe.	Transportation of hydrogen gas	Pressure gauge, mass of material storage, operation of fuelcells
10.2	Material chosen to withstand pressures.	No leaks	Bubble method
10.3	Copper piping sufficiently transfers heat.	Temperature reduced to 50°C at diverting valve	Thermal imaging

Jacob



Ryan

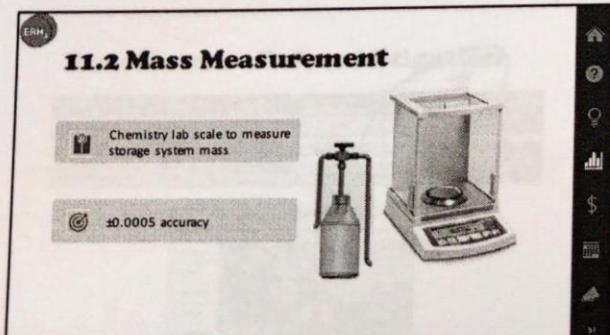




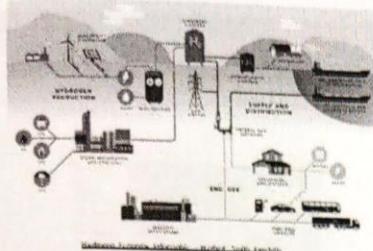
Any air?

T is also increasing

Figure would be better.



11.3 Infographic



Dylan



IUI Summary

Requirement	Design	Expected Performance	Verification
11.1	0-30 inWC Pressure Gauge	Display accurate pressure of system	Visual Inspection
11.2	Chemistry lab digital scale	Display mass of hydrogen in storage system	Visual Inspection
11.3	Hydrogen Economy Infographic	Inform about hydrogen economy	Visual Inspection
11.4	Pressure gauge and scale have measurement displays	Display measurements	Visual Inspection
11.5	Pressure gauge and scale have English units on the displays	English Units	Visual Inspection

Dylan



Risk Matrix - Before Mitigation

Area of Operation at Risk	Hazard	Severity	Opportunities for Prevention or Mitigation		Probability	Overall Award Rating
			Safeguards	Likelihood		
Overall System	Explosion	Hydrogen Leak, Venting	Source	Low	Low	Low
Electrical	Mechanical	Short Circuit	Prevent, Monitor	Medium	Medium	Medium
Electrical	Fire	Vacuum Oxygen	Planned inspection	Low	Low	Low
Electrical	Ozone	Ozone in atmosphere	Captain	Medium	Medium	Medium
Heating Element	Burn	Corrosive Heating Element	Warning Signs	Occasional	Medium	Medium

Titan

Risk Probability	Risk Severity			
	Catastrophic	Critical	Medium	Minor
1 = Frequent	10	10	10	10
2 = Likely	10	10	10	10
3 = Unlikely	10	10	10	10
4 = Remote	10	10	10	10
5 = Minimal	10	10	10	10

ERH

Risk Matrix - After Mitigation

Risk on Operability of Task	Impact	Probability	Overall Rated Risk
Critical System	Extinction	Very High	Extinction
Operational	Unrecoverable	High	Extinction
Workshop	High	Medium	Extinction
Activities	None	Low	Extinction
Existing Element	None	Very Low	Extinction
			Extinction

Risk Probability	Risk Recovery				
	Contractor	Owner	Manager	Team	Individual
1 = Possible	95	90	85	80	75
2 = Likely	90	85	80	75	70
3 = Reasonable	85	80	75	70	65
4 = Reasonable	80	75	70	65	60
5 = Improbable	75	70	65	60	55

What's the mitigation?

Mica insulation?

ERH

Budget

Break down by subcategory

	Cost
Shots	\$150.00
Urea	\$30.00
Hydron Chloride 30gms	\$17.90
Plastic	\$84.56
Flame Retardant Plastic	\$36.85
Mach X-2	\$72.00
PTFE Tubing x 25ft	\$62.25
F4 Thread Adapter x 2	\$1.12
Bolts	\$7.00
Copper Pipe (DN)	\$5.49
Baked T Ring x 2	\$24.28
Baked Fitting x 3	9.02
Graduated Bottles	\$1.64
Nichrome Wire 20gauge x 50ft	\$12.00
Solder	\$30
Rubber Plug	\$10.42
Insulation Tape (25ft)	18.55
Drying Valve	\$12.84
Spanner	\$10
nuts	\$2.20
Other Plastic	\$88.04
Power Supply	\$285.99
Total	\$1,154.37

P.c chart



ERH

Schedule

Start Date	End Date	Duration
2023-09-01	2023-09-01	0 days
2023-09-01	2023-09-02	1 day
2023-09-02	2023-09-03	1 day
2023-09-03	2023-09-04	1 day
2023-09-04	2023-09-05	1 day
2023-09-05	2023-09-06	1 day
2023-09-06	2023-09-07	1 day
2023-09-07	2023-09-08	1 day
2023-09-08	2023-09-09	1 day
2023-09-09	2023-09-10	1 day
2023-09-10	2023-09-11	1 day
2023-09-11	2023-09-12	1 day
2023-09-12	2023-09-13	1 day
2023-09-13	2023-09-14	1 day
2023-09-14	2023-09-15	1 day
2023-09-15	2023-09-16	1 day
2023-09-16	2023-09-17	1 day
2023-09-17	2023-09-18	1 day
2023-09-18	2023-09-19	1 day
2023-09-19	2023-09-20	1 day
2023-09-20	2023-09-21	1 day
2023-09-21	2023-09-22	1 day
2023-09-22	2023-09-23	1 day
2023-09-23	2023-09-24	1 day
2023-09-24	2023-09-25	1 day
2023-09-25	2023-09-26	1 day
2023-09-26	2023-09-27	1 day
2023-09-27	2023-09-28	1 day
2023-09-28	2023-09-29	1 day
2023-09-29	2023-09-30	1 day
2023-09-30	2023-10-01	1 day
2023-10-01	2023-10-02	1 day
2023-10-02	2023-10-03	1 day
2023-10-03	2023-10-04	1 day
2023-10-04	2023-10-05	1 day
2023-10-05	2023-10-06	1 day
2023-10-06	2023-10-07	1 day
2023-10-07	2023-10-08	1 day
2023-10-08	2023-10-09	1 day
2023-10-09	2023-10-10	1 day
2023-10-10	2023-10-11	1 day
2023-10-11	2023-10-12	1 day
2023-10-12	2023-10-13	1 day
2023-10-13	2023-10-14	1 day
2023-10-14	2023-10-15	1 day
2023-10-15	2023-10-16	1 day
2023-10-16	2023-10-17	1 day
2023-10-17	2023-10-18	1 day
2023-10-18	2023-10-19	1 day
2023-10-19	2023-10-20	1 day
2023-10-20	2023-10-21	1 day
2023-10-21	2023-10-22	1 day
2023-10-22	2023-10-23	1 day
2023-10-23	2023-10-24	1 day
2023-10-24	2023-10-25	1 day
2023-10-25	2023-10-26	1 day
2023-10-26	2023-10-27	1 day
2023-10-27	2023-10-28	1 day
2023-10-28	2023-10-29	1 day
2023-10-29	2023-10-30	1 day
2023-10-30	2023-10-31	1 day
2023-10-31	2023-11-01	1 day
2023-11-01	2023-11-02	1 day
2023-11-02	2023-11-03	1 day
2023-11-03	2023-11-04	1 day
2023-11-04	2023-11-05	1 day
2023-11-05	2023-11-06	1 day
2023-11-06	2023-11-07	1 day
2023-11-07	2023-11-08	1 day
2023-11-08	2023-11-09	1 day
2023-11-09	2023-11-10	1 day
2023-11-10	2023-11-11	1 day
2023-11-11	2023-11-12	1 day
2023-11-12	2023-11-13	1 day
2023-11-13	2023-11-14	1 day
2023-11-14	2023-11-15	1 day
2023-11-15	2023-11-16	1 day
2023-11-16	2023-11-17	1 day
2023-11-17	2023-11-18	1 day
2023-11-18	2023-11-19	1 day
2023-11-19	2023-11-20	1 day
2023-11-20	2023-11-21	1 day
2023-11-21	2023-11-22	1 day
2023-11-22	2023-11-23	1 day
2023-11-23	2023-11-24	1 day
2023-11-24	2023-11-25	1 day
2023-11-25	2023-11-26	1 day
2023-11-26	2023-11-27	1 day
2023-11-27	2023-11-28	1 day
2023-11-28	2023-11-29	1 day
2023-11-29	2023-11-30	1 day
2023-11-30	2023-12-01	1 day
2023-12-01	2023-12-02	1 day
2023-12-02	2023-12-03	1 day
2023-12-03	2023-12-04	1 day
2023-12-04	2023-12-05	1 day
2023-12-05	2023-12-06	1 day
2023-12-06	2023-12-07	1 day
2023-12-07	2023-12-08	1 day
2023-12-08	2023-12-09	1 day
2023-12-09	2023-12-10	1 day
2023-12-10	2023-12-11	1 day
2023-12-11	2023-12-12	1 day
2023-12-12	2023-12-13	1 day
2023-12-13	2023-12-14	1 day
2023-12-14	2023-12-15	1 day
2023-12-15	2023-12-16	1 day
2023-12-16	2023-12-17	1 day
2023-12-17	2023-12-18	1 day
2023-12-18	2023-12-19	1 day
2023-12-19	2023-12-20	1 day
2023-12-20	2023-12-21	1 day
2023-12-21	2023-12-22	1 day
2023-12-22	2023-12-23	1 day
2023-12-23	2023-12-24	1 day
2023-12-24	2023-12-25	1 day
2023-12-25	2023-12-26	1 day
2023-12-26	2023-12-27	1 day
2023-12-27	2023-12-28	1 day
2023-12-28	2023-12-29	1 day
2023-12-29	2023-12-30	1 day
2023-12-30	2023-12-31	1 day
2023-12-31	2024-01-01	1 day
2024-01-01	2024-01-02	1 day
2024-01-02	2024-01-03	1 day
2024-01-03	2024-01-04	1 day
2024-01-04	2024-01-05	1 day
2024-01-05	2024-01-06	1 day
2024-01-06	2024-01-07	1 day
2024-01-07	2024-01-08	1 day
2024-01-08	2024-01-09	1 day
2024-01-09	2024-01-10	1 day
2024-01-10	2024-01-11	1 day
2024-01-11	2024-01-12	1 day
2024-01-12	2024-01-13	1 day
2024-01-13	2024-01-14	1 day
2024-01-14	2024-01-15	1 day
2024-01-15	2024-01-16	1 day
2024-01-16	2024-01-17	1 day
2024-01-17	2024-01-18	1 day
2024-01-18	2024-01-19	1 day
2024-01-19	2024-01-20	1 day
2024-01-20	2024-01-21	1 day
2024-01-21	2024-01-22	1 day
2024-01-22	2024-01-23	1 day
2024-01-23	2024-01-24	1 day
2024-01-24	2024-01-25	1 day
2024-01-25	2024-01-26	1 day
2024-01-26	2024-01-27	1 day
2024-01-27	2024-01-28	1 day
2024-01-28	2024-01-29	1 day
2024-01-29	2024-01-30	1 day
2024-01-30	2024-01-31	1 day
2024-01-31	2024-02-01	1 day
2024-02-01	2024-02-02	1 day
2024-02-02	2024-02-03	1 day
2024-02-03	2024-02-04	1 day
2024-02-04	2024-02-05	1 day
2024-02-05	2024-02-06	1 day
2024-02-06	2024-02-07	1 day
2024-02-07	2024-02-08	1 day
2024-02-08	2024-02-09	1 day
2024-02-09	2024-02-10	1 day
2024-02-10	2024-02-11	1 day
2024-02-11	2024-02-12	1 day
2024-02-12	2024-02-13	1 day
2024-02-13	2024-02-14	1 day
2024-02-14	2024-02-15	1 day
2024-02-15	2024-02-16	1 day
2024-02-16	2024-02-17	1 day
2024-02-17	2024-02-18	1 day
2024-02-18	2024-02-19	1 day
2024-02-19	2024-02-20	1 day
2024-02-20	2024-02-21	1 day
2024-02-21	2024-02-22	1 day
2024-02-22	2024-02-23	1 day
2024-02-23	2024-02-24	1 day
2024-02-24	2024-02-25	1 day
2024-02-25	2024-02-26	1 day
2024-02-26	2024-02-27	1 day
2024-02-27	2024-02-28	1 day
2024-02-28	2024-02-29	1 day
2024-02-29	2024-03-01	1 day
2024-03-01	2024-03-02	1 day
2024-03-02	2024-03-03	1 day
2024-03-03	2024-03-04	1 day
2024-03-04	2024-03-05	1 day
2024-03-05	2024-03-06	1 day
2024-03-06	2024-03-07	1 day
2024-03-07	2024-03-08	1 day
2024-03-08	2024-03-09	1 day
2024-03-09	2024-03-10	1 day
2024-03-10	2024-03-11	1 day
2024-03-11	2024-03-12	1 day
2024-03-12	2024-03-13	1 day
2024-03-13	2024-03-14	1 day
2024-03-14	2024-03-15	1 day
2024-03-15	2024-03-16	1 day
2024-03-16	2024-03-17	1 day
2024-03-17	2024-03-18	1 day
2024-03-18	2024-03-19	1 day
2024-03-19	2024-03-20	1 day
2024-03-20	2024-03-21	1 day
2024-03-21	2024-03-22	1 day
2024-03-22	2024-03-23	1 day
2024-03-23	2024-03-24	1 day
2024-03-24	2024-03-25	1 day
2024-03-25	2024-03-26	1 day
2024-03-26	2024-03-27	1 day
2024-03-27	2024-03-28	1 day
2024-03-28	2024-03-29	1 day
2024-03-29	2024-03-30	1 day
2024-03-30	2024-03-31	1 day
2024-03-31	2024-04-01	1 day
2024-04-01	2024-04-02	1 day
2024-04-02	2024-04-03	1 day
2024-04-03	2024-04-04	1 day
2024-04-04	2024-04-05	1 day
2024-04-05	2024-04-06	1 day
2024-04-06	2024-04-07	1 day
2024-04-07	2024-04-08	1 day
2024-04-08	2024-04-09	1 day