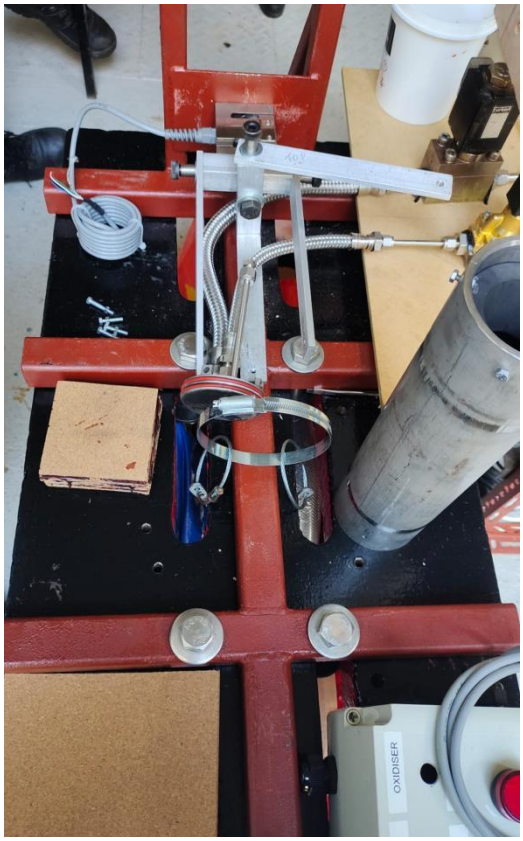
CRANSEDS HYBRID ENGINE DOCUMENTATION

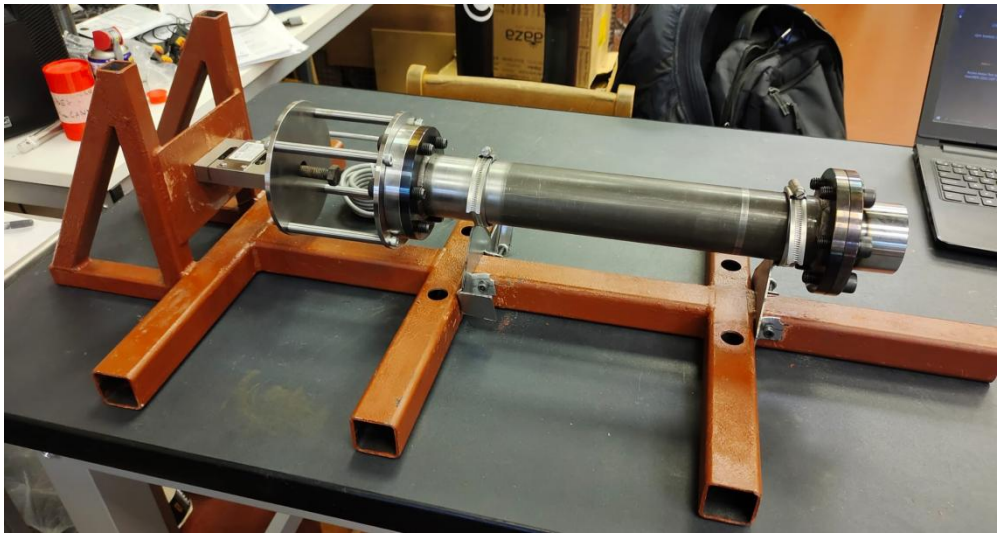
30 JUNE 2023

1. Structure

Test structure of last year - Inspected for cracks or failure points - none detected.



Initially assembled structure



Materials:

Components (already procured, manufactured, and assembled in structure)	**Material**
Test Stand base	Mild Steel
Thruster assembly back plate	Mild Steel
Thruster assembly front plate	Mild Steel
Thruster assembly connector	Mild Steel
Injector plate	Mild Steel
Injector flange	Mild Steel
Side flanges	Mild Steel
Combustion chamber	Mild Steel
Nozzle casing	Mild Steel
C-D Nozzle	Graphite
Support fixtures	Zinc plated steel
Bolts	Steel Grade A2 and Grade M8.8
Radial and Axial O rings	Nitrile
Gasket sheet	Aramid fibers, bonded with NBR
Fuel Insulation liner	High density cork liner
Resin and hardener for liner	Aerodux 185 resorcinol phenol liquid resin and HRP155 hardener
Ignition wire	Nichrome wire AWG 28

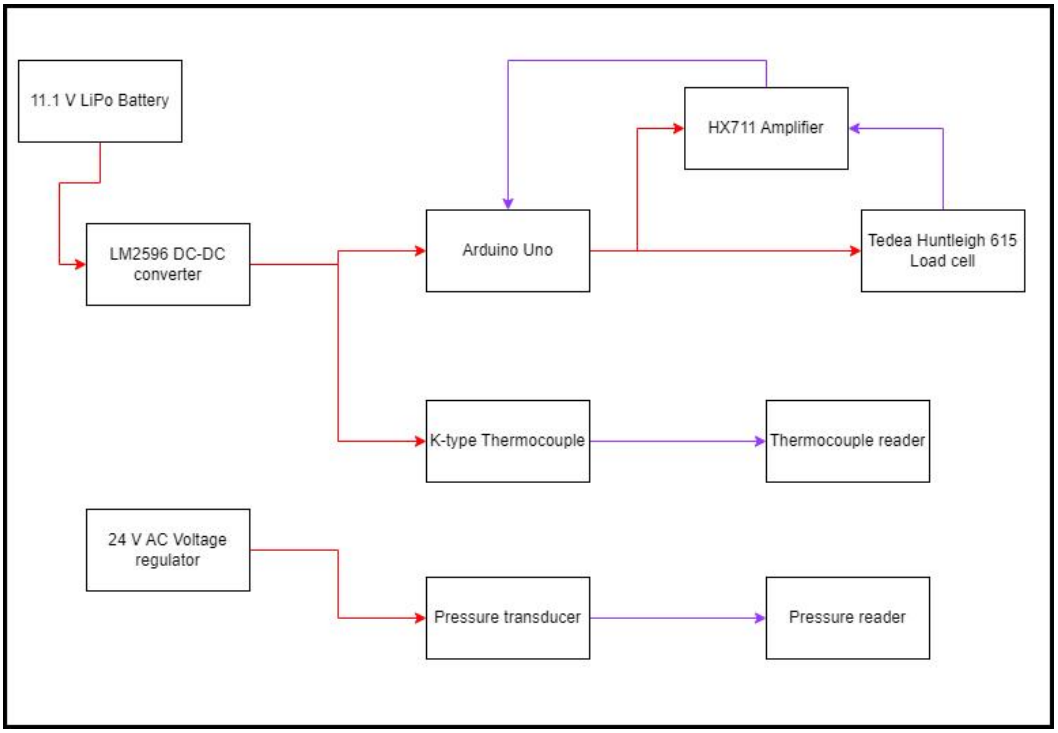
Metal and plastic machining of structural components performed by manufacturing shop of test facility, Cranfield University, every part and engineering drawing supervised by David Thompson.

<u>Attachments</u>:

a. **Mild Steel certification sheet**
b. **Graphite data sheet**
c. **Ring clamp certification sheet**
d. **Gasket certifications**
e. **O rings data sheet**
f. **Cork liner data sheet**
g. **Liner resin and hardener data sheet**

2. Data Acquisition System

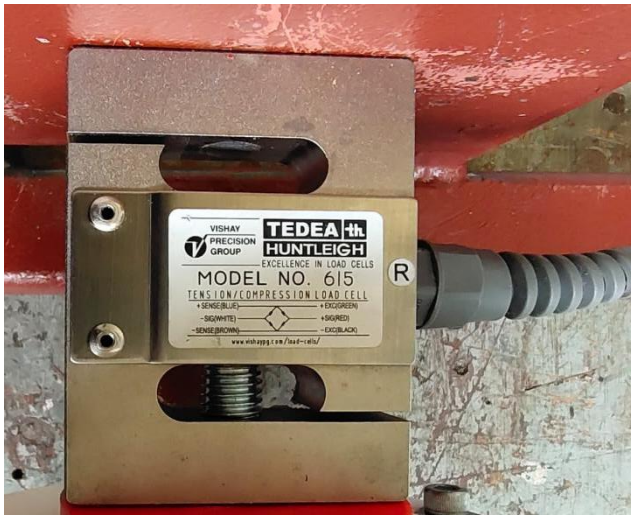
DAQ has 4 parts:



Overall DAQ system assembly schematic

a) Load cell

Single in-line load cell connecting combustion chamber to the engine test stand axially.
Only one Tedea Huntleigh 615 steel load cell for upto 100 kg with separate arduino circuit.



Load cell Arduino circuit mounted on test bench tower behind the blast shield.

b) Thermocouples

Five K-type thermocouples used (3 on combustion chamber, 2 on nozzle casing). Connected with heat measurement units at the test facility.

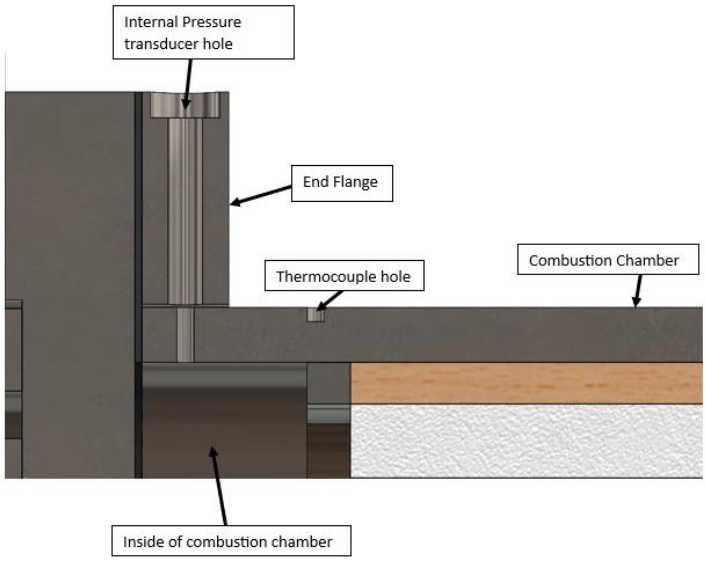
RS 206-3722 thermocouple reader will be used at least 3 m apart from the engine test bench.

c) Pressure transducer

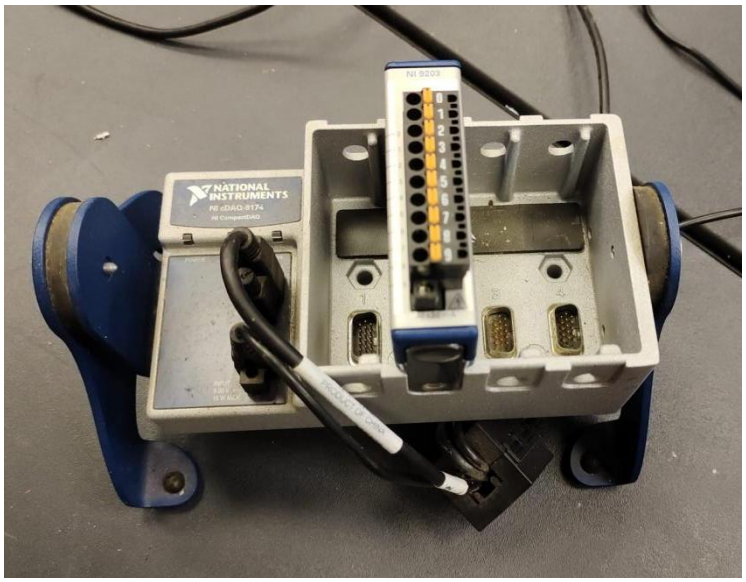
Pressure transducer PX119 1.5 KGI used (8-32 V, 4-20 mA), 2 pin configuration (will be tested today (30 Jue 2023)).

Connected with NI LabView adapter for measurement of the results.

Pressure transducer is measuring the internal combustion chamber pressure. The cross section of the chamber for connecting the transducer is depcited in the figure below



Pressure transducer logger will be at least 3 m away from the engine test bench.



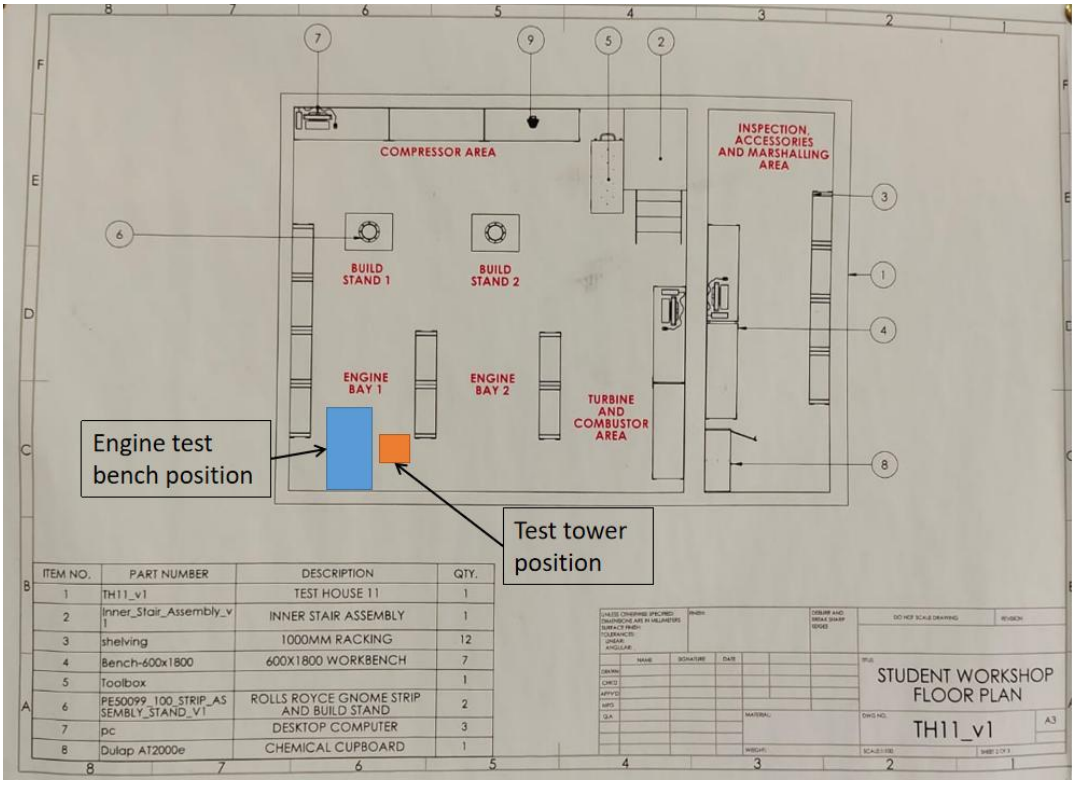
Pressure transducer DAQ logger through LabView

Pressure transducer at least 11 cm away from the combustion chamber casing outer surface

Pressure transducer connection: 1/4 inch swagelok tube fitting to 3/8 inch swagelok tube fitting to 1/4 inch NPT female adapter for the transducer

d) Cameras

Mobile phone cameras will be mounted on possible tripod stands. The following locations for the camera placement have been described through the following diagram.



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	TH11_v1	TEST HOUSE 11	1
2	Inner_Stair_Assembly_v1	INNER STAIR ASSEMBLY	1
3	shelving	1000MM RACKING	12
4	Bench-600x1800	600X1800 WORKBENCH	7
5	Toolbox		1
6	PE50099_100_STRIP_ASSEMBLY_STAND_V1	ROLLS ROYCE GNOME STRIP AND BUILD STAND	2
7	pc	DESKTOP COMPUTER	3
8	Dulap AT2000e	CHEMICAL CUPBOARD	1

Engine test bench position in TH 11

Camera location #1

FOV of camera at location #1

Camera location #2

FOV of camera at location #2

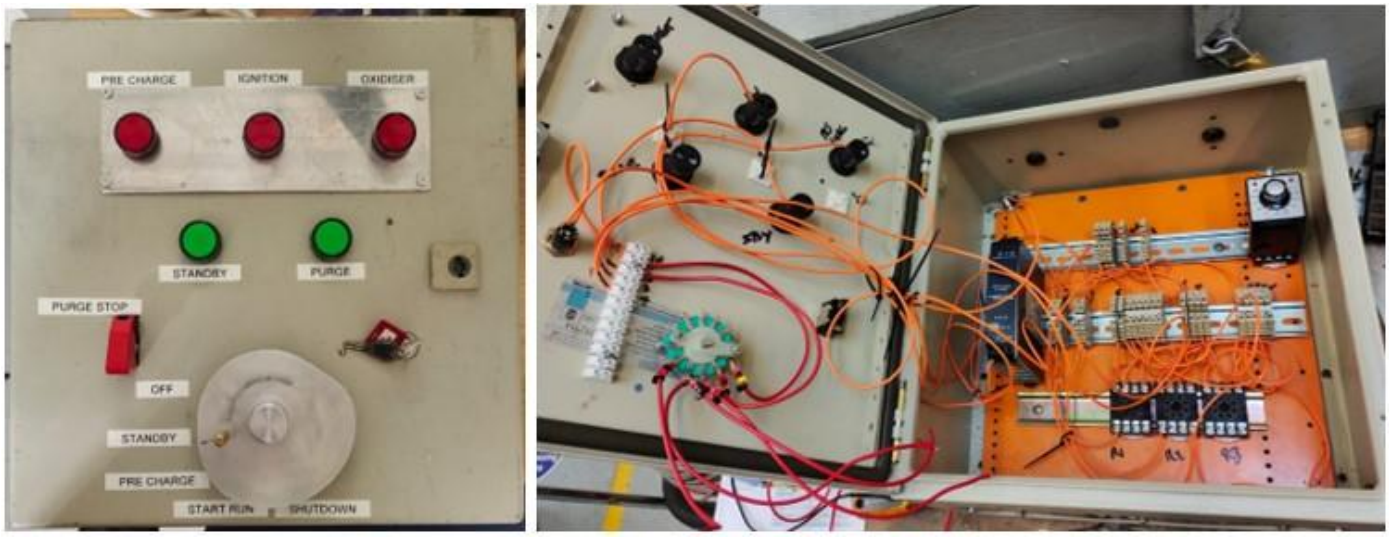
Attachments:

a. **Pressure transducer PX119 data sheet**

b. **Tedea huntleigh load cell data sheet**
c. **NI compact DAQ-9174 for pressure transducer**
d. **RS 206-3722 Thermocouple reader**

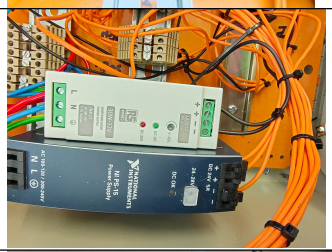
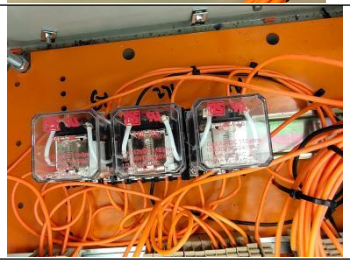
3. Control Box System

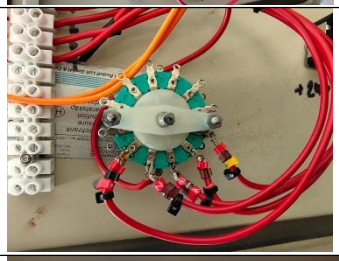
Assembled and created by Kevin (test facility staff)



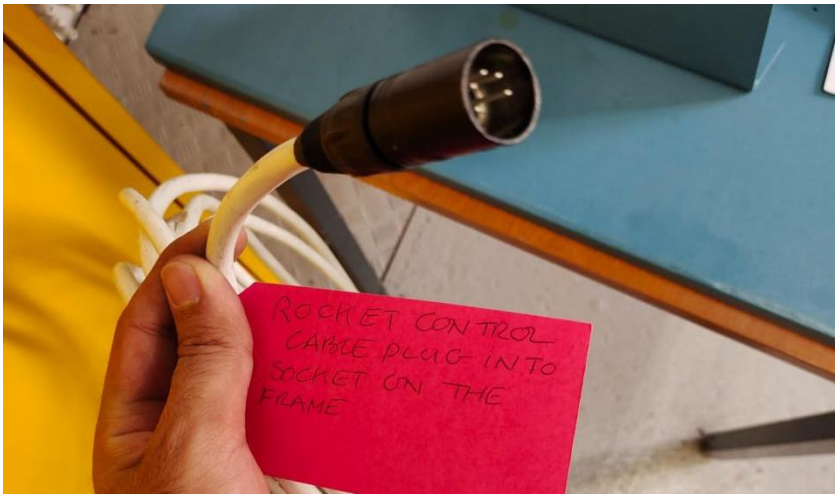
Control box for the hybrid engine hot test firing

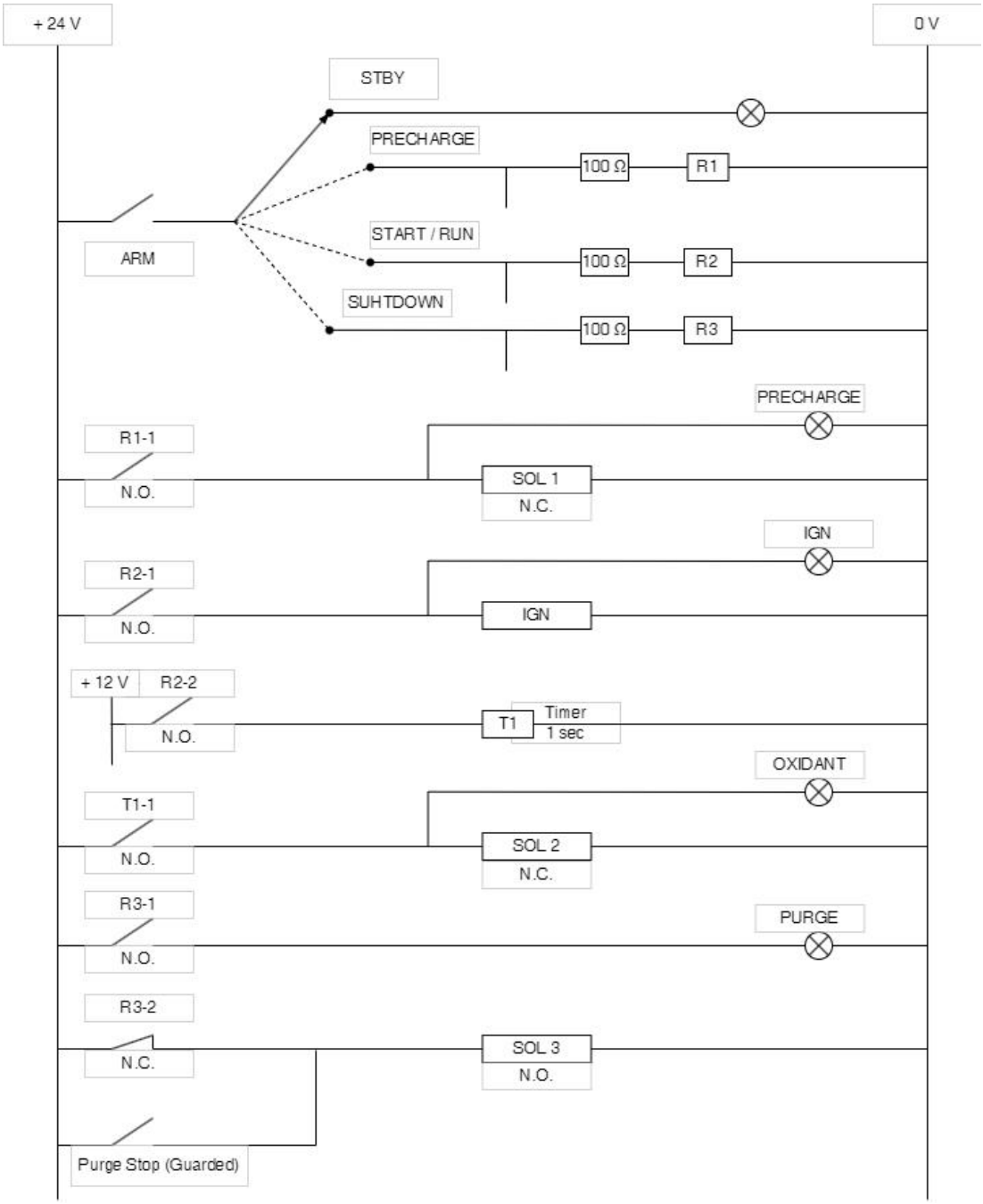
All components employed were selected and assembled by the test facility staff with the available components as follows:

Component Name	Specs	Image
RS relay socket	RS 403-235	
RS Pro Power Supply	30 W - 12 V	
National Instruments Power supply	NI PS-15, 100-200 / 200-240 V	
Plug in power relay	RS 348-756, 10 A switching current DPDT	

Insulated mode interface switches	-	
5- Mode pin switcher	-	
Tempatron temperature controller	110-240 V AC supply voltage	
Relay buses and connectors	Colour coded	-

Control box and test bench electrical interface used is **5-pin A-coded M12 socket connector.**



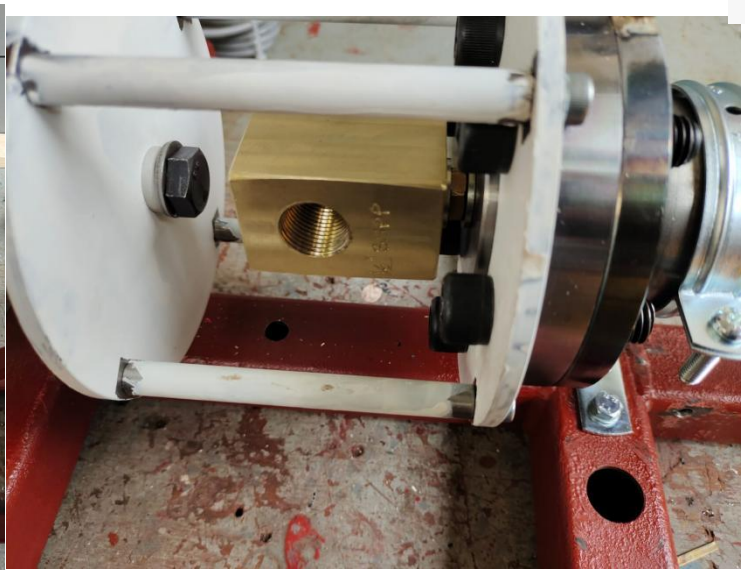


Control box schematics diagram

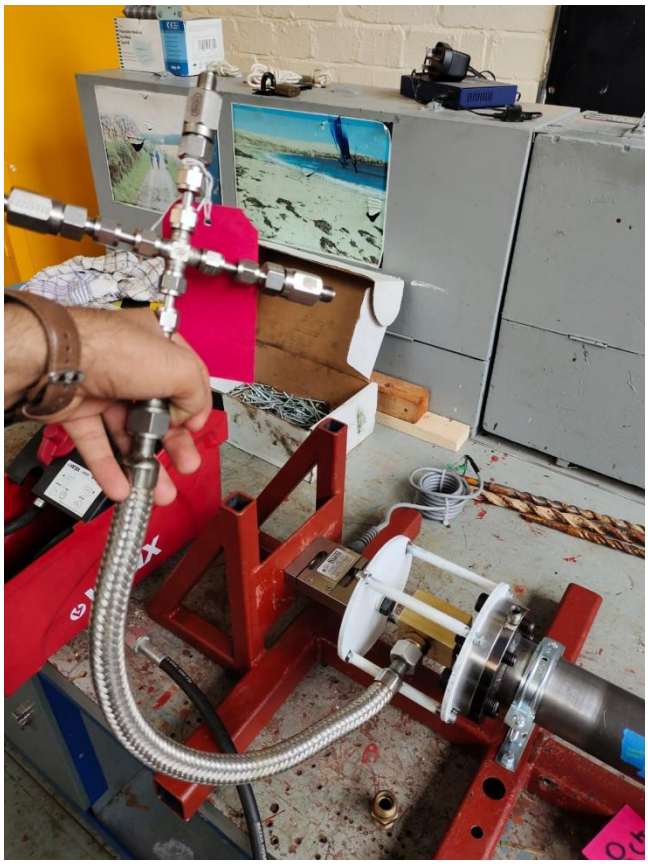
4. Feed Line System

Pipes : *in attachments*.

Feed line to the combustion chamber:

1/4 inch BSP to 1/2 inch BSP female connecting injecting brass adapter



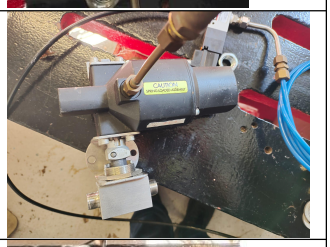
Steel braided feed pipe line after 4 way junction to the mouth of injecting brass adapter

The steel braided feed pipe with 3 closed off ends for the propellant feeds, and the combustion chamber have been pressure tested separately for 50 bars.

Pressure testing the steel braided feed pipe line

Pressure testing for the combustion chamber cylinder

Valves:

Component Name	Type	Quantity	Image
1/4 NPT Good BSI Max 316 SS Valve	Stop Valve	1	
7115G4Y 316 stainless 6000 psi valve	Stop Valve	1	
6133G4Y 6000 psi swagelok tube fitting check valve	Check Valve	3	
EN 837-1 dial	Regulator Dial	2	
Swagelok SS-43S4-31C valve	Pressure actuated valve	1	
solenoid valve VZ5420	5 port Solenoid valve	1	
Swagelok ss-45S8 valve	Pressure actuated valve	1	
shako sd91330DQSNT PU225S	Solenoid Coil valve	2	

Attachments:

a. 3/8 inch swagelok pipe datasheet

IMPERIAL TUBE - 316L					
Part No.	OD (inch)	Wall (inch)	Gauge	PMAX BAR	PMAX PSI
SST2-22	1/8	0.028	22	590	8550
SST2-22	1/8	0.036	20	741	10900
SST4-20	1/4	0.036	20	359	5200
SST4-18	1/4	0.048	18	524	7600
SST4-16	1/4	0.063	16	710	10300
SST6-20	3/8	0.036	20	231	3350
SST6-18	3/8	0.048	18	334	4850
SST8-20	1/2	0.036	20	177	2600
SST6-16	3/8	0.063	16	452	6550
SST8-18	1/2	0.048	18	259	3750
SST8-16	1/2	0.063	16	355	5150
SST12-16*	3/4	0.063	16	231	3350
SST16-16*	1	0.063	16	165	2400

b. Feed line schematic
c. Stop valve data sheet
d. Check valve data sheet
e. Regulator dial data sheet
f. Pressure actuated valves data sheet
g. 5 port solenoid valve data sheet
h. Solenoid coil valve data sheet

5. Risk and COSHH Assessment

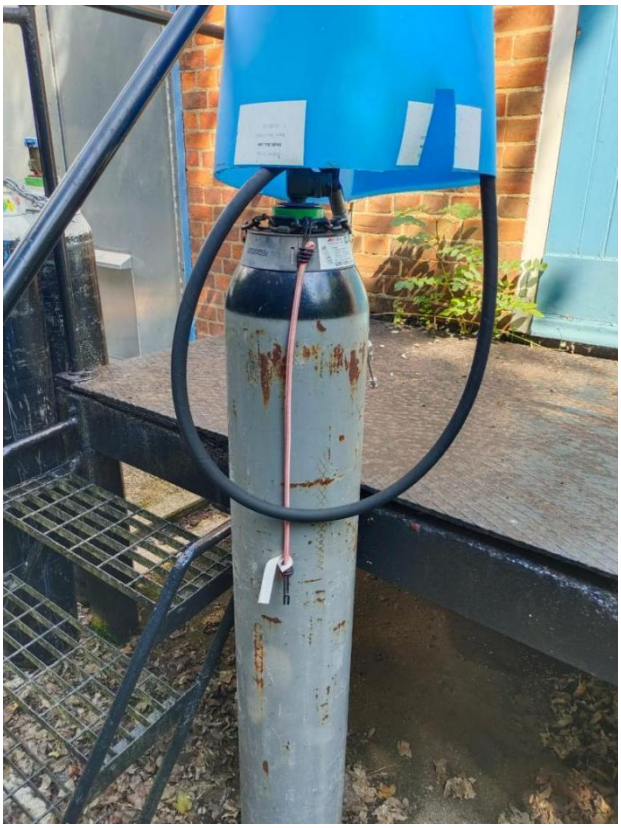
Attachments:

a. Risk assessment
b. COSHH assessment for N_2O

6. Propulsion

Propellant used:

Propellant	Quantity	Purpose	Pressure for the current design	Status
HDPE	0.91 kg	Solid fuel	-	Procured by team already
N2O	1.1 liter	Liquid Oxidiser	44.5 bars	To be purchased
O2	0.5 liter	Low pressure Precharger	40.5 bars	Already outside test house 11
N2	3 liter	High pressure purger gas	50 bars	Already outside test house 11



Nitrogen tank outside TH 11

Nitrogen tank regulator

Oxygen tank outside TH 11

Propellant bottles:

Propellant	Bottle Name	Bottle size	Purpose	Status
Nitrogen	Nitrogen gas tank	Type W	Purge gas	Outside TH 11
Oxygen	LOH tank	Type W	Precharge gas	Outside TH 11
Nitrous Oxide	BOC oxidiser tank	Type W / 10 liter	Oxidiser gas to be bough from BOC	To be bought (still no quote for 10 liter N2O)
Nitrous Oxide	Luxfer run tank	10 liter	Run tank (sits between BOC oxidiser tank and engine)	Procured by team (currently in TH 11)

Attachments:

a. **Time calculation**
b. **Temperature calculation**
c. **N2O data sheet**
d. **Luxfer tank spec sheet**

Luxfer cylinder range

This table shows the Luxfer cylinder range available from EffecTech in **quantities of 25 or under.**

If you would like more information or to request a quotation, please contact us.

Part number	Water volume	Service pressure	Length	Diameter	Weight	Test pressure	Specification	Thread size
	l	bar	mm	mm	kg	bar		
A8011Q	1	200	235	102	1.68	300	84/526/EEC	25E
P2778Z	5	200	460	152	7.02	300	84/526/EEC	25E
P2804Z	10	200	660	176	12.4	300	84/526/EEC	25E
P3029Z	20	200	960	204	24.4	300	84/526/EEC	25E
P2806Z	50	200	1500	250	57.06	300	84/526/EEC	25E

e. **Luxfer tank adapter data sheet**

7. Safety:

a) PPE kit

i. Safety boots (owned by team)
ii. Safety glasses (owned by team)
iii. Head covers (up to 35 dB - the ones employed in the whole test facility)
iv. Full length clothing
v. No synthetic cloth
vi. Lab overcoat

b) Fire Extinguisher

Last service in March 2023 with maintenance interval of approx. 1 year

c) Gas leakage lights (need to check)

d) Emergency Alarm (need to check)

e) Plume catcher

Will be put closer to the engine on a leveled ground, with 2 sandbags on each of the 4 corners.