

Mixing and Recovery Performance of Triplet Impinging Injectors with Varying Flow Areas for Detonative Combustion

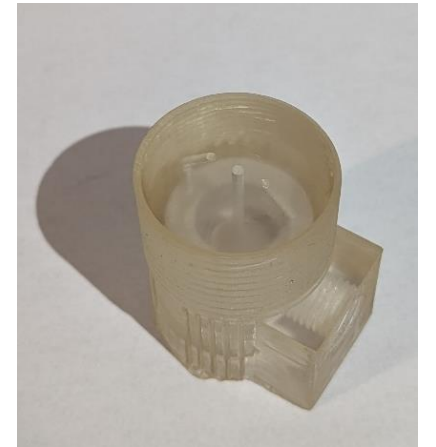
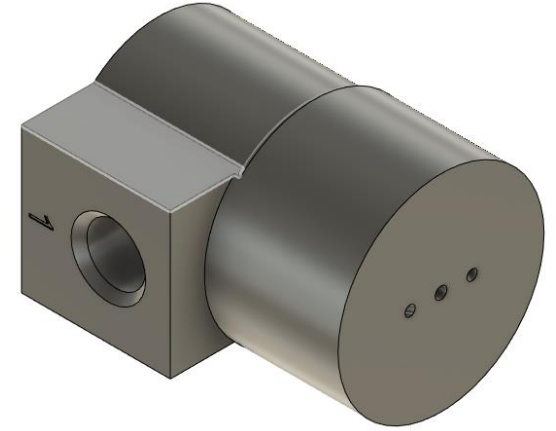
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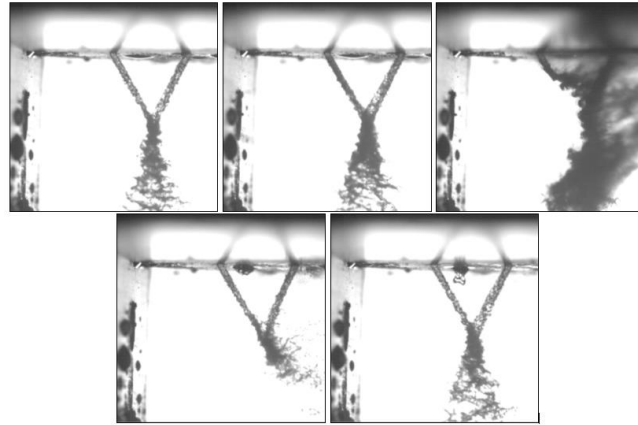
SciTech, January 23 – 27, 2023

Scope

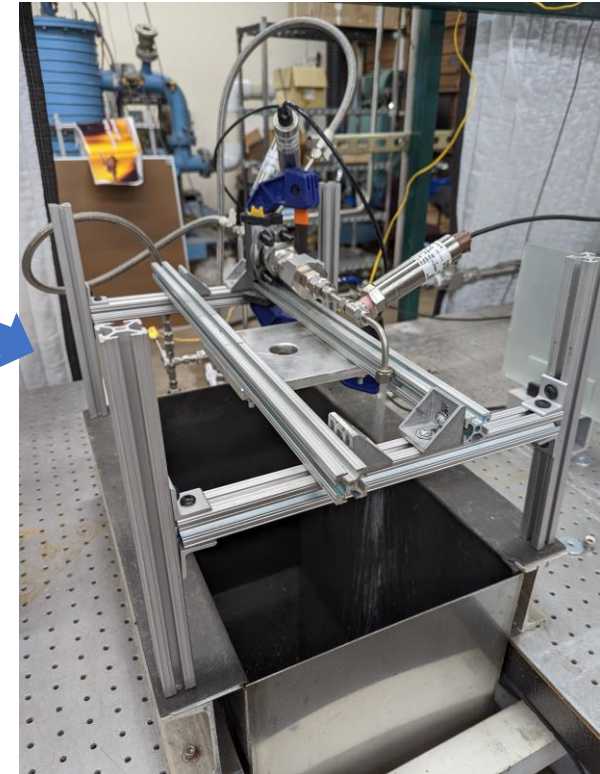
- Purpose: Rapid Injector Development for RDRE Applications
 - Resin Printed Triplet Impingement Injectors
 - 4 Injectors with Constant Fuel to Oxidizer Fluid Flow Area Ratios
 - Decrease in Total Fluid Flow Area
 - Simulant Spray Test
 - Cold Flow Forward and Reverse Flow
 - Detonation Channel Backflow and Recovery Experiment



Experimental Setup



Steady
State
Cold
Flow

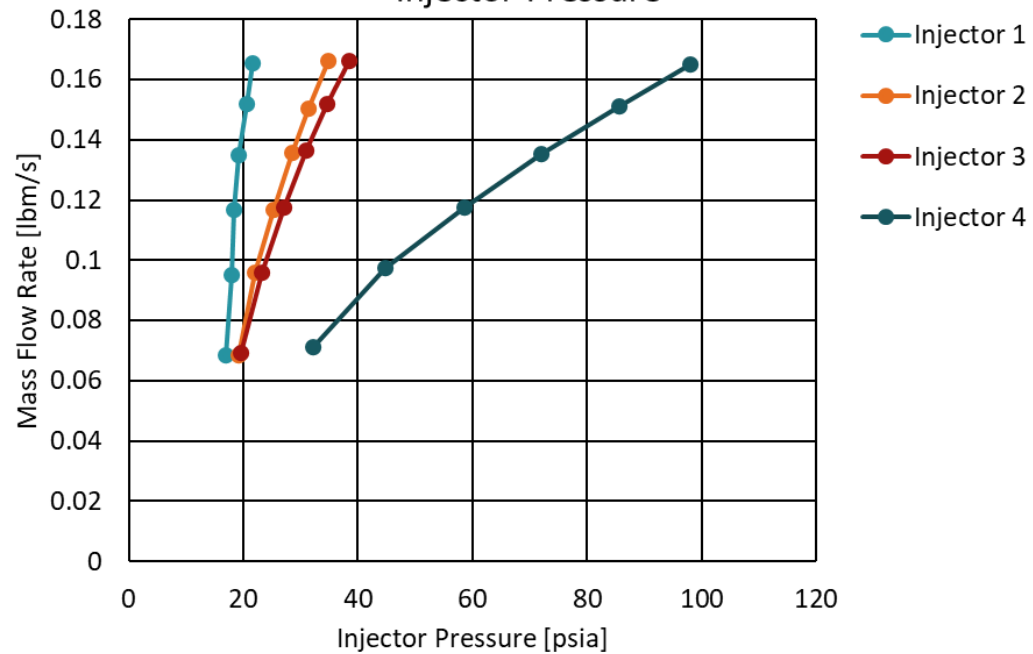


Detonation Channel Recovery

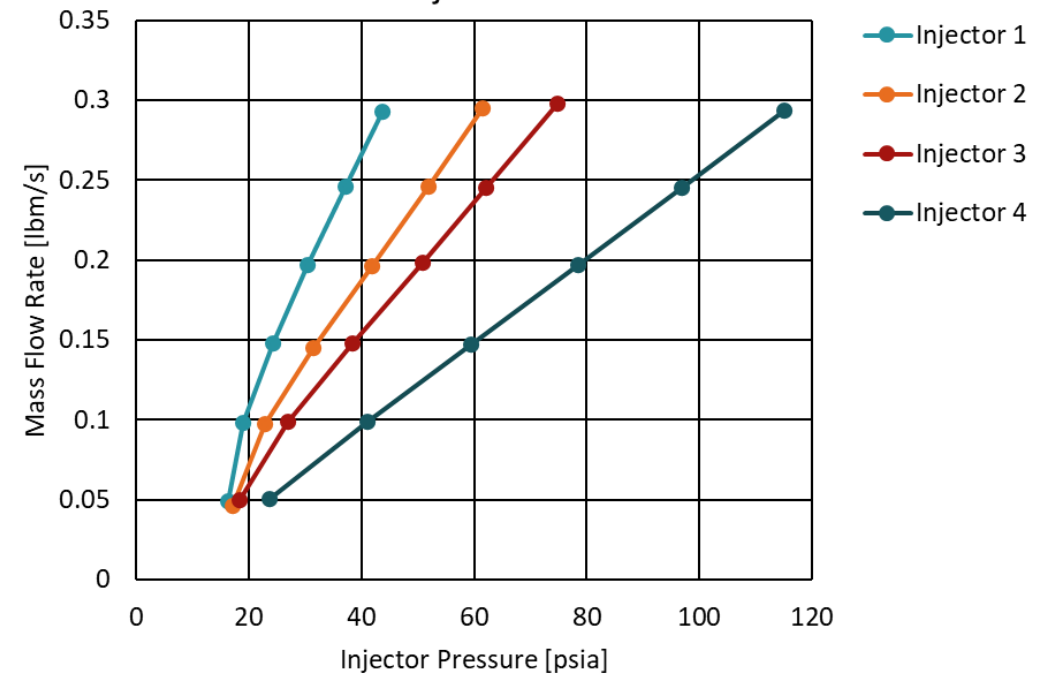


Cold Flow Results

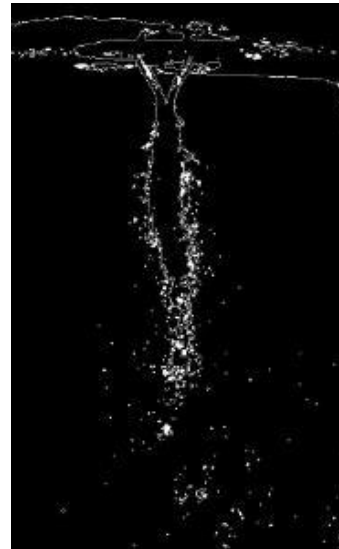
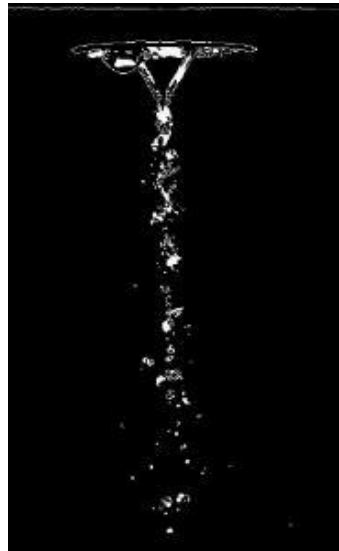
Liquid Simulant (Fuel Port) Mass Flow Rate vs. Injector Pressure



Gas Simulant (Ox Port) Injector Mass Flow Rate vs. Injector Pressure

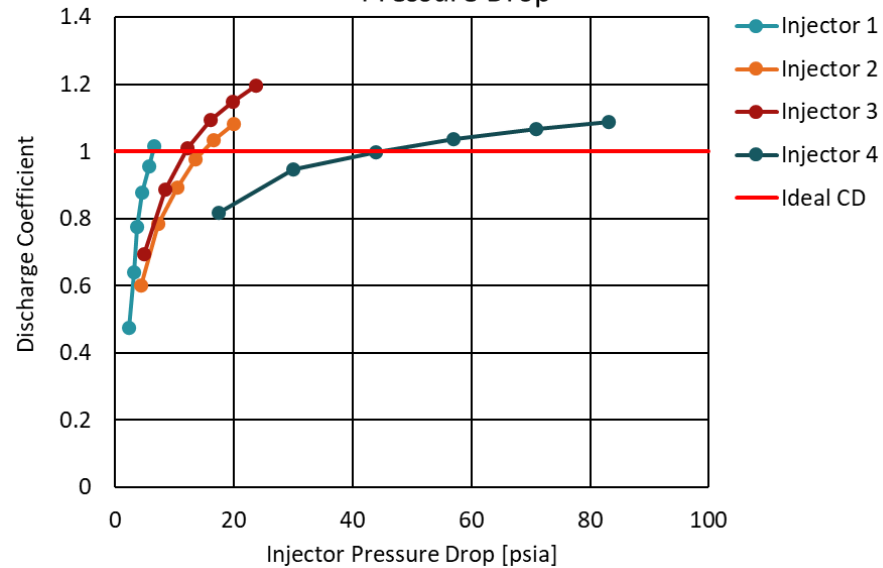


Spray

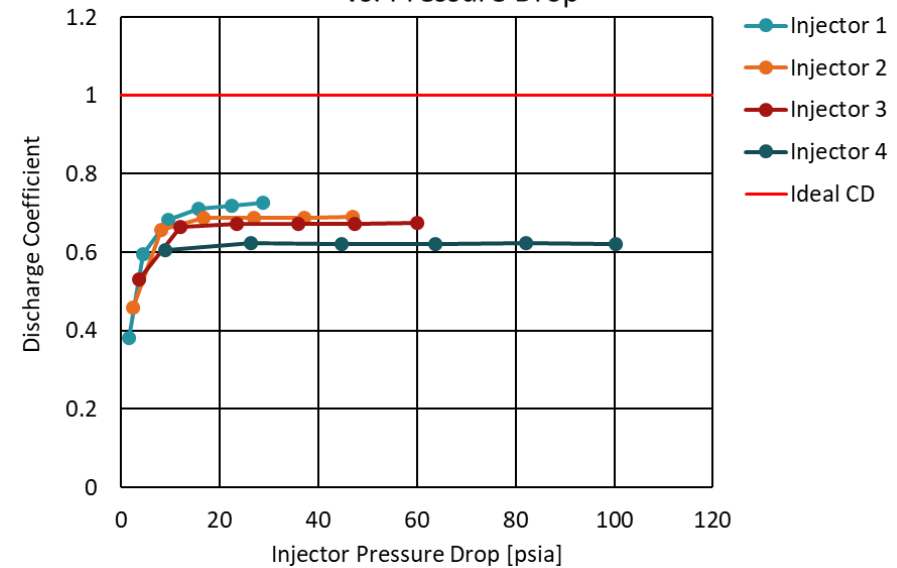


Injector Discharge Coefficients

Liquid Simulant (Fuel Port) Discharge Coefficient vs. Pressure Drop



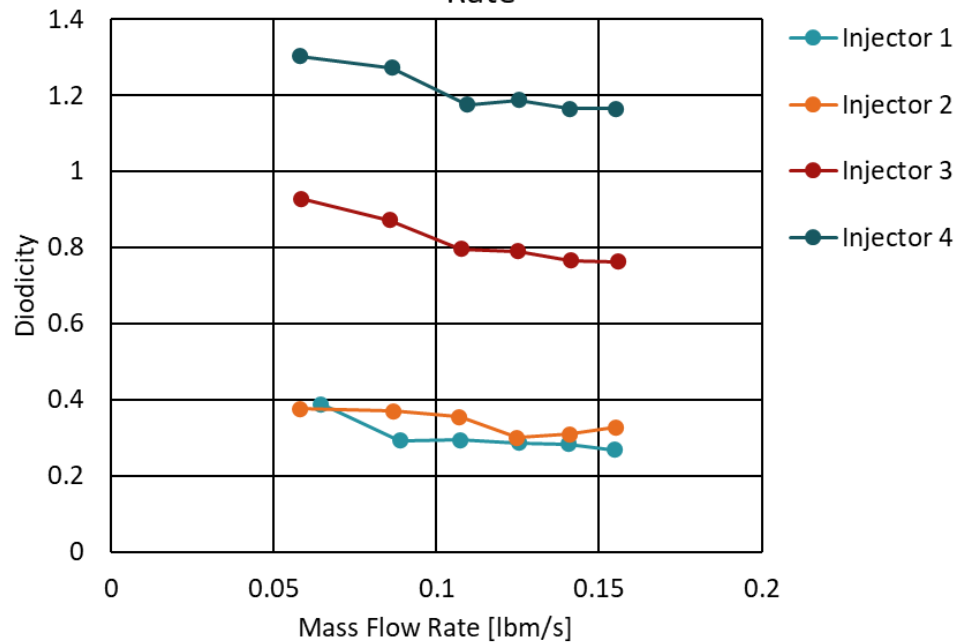
Gaseous Simulant (Ox Port) Discharge Coefficient vs. Pressure Drop



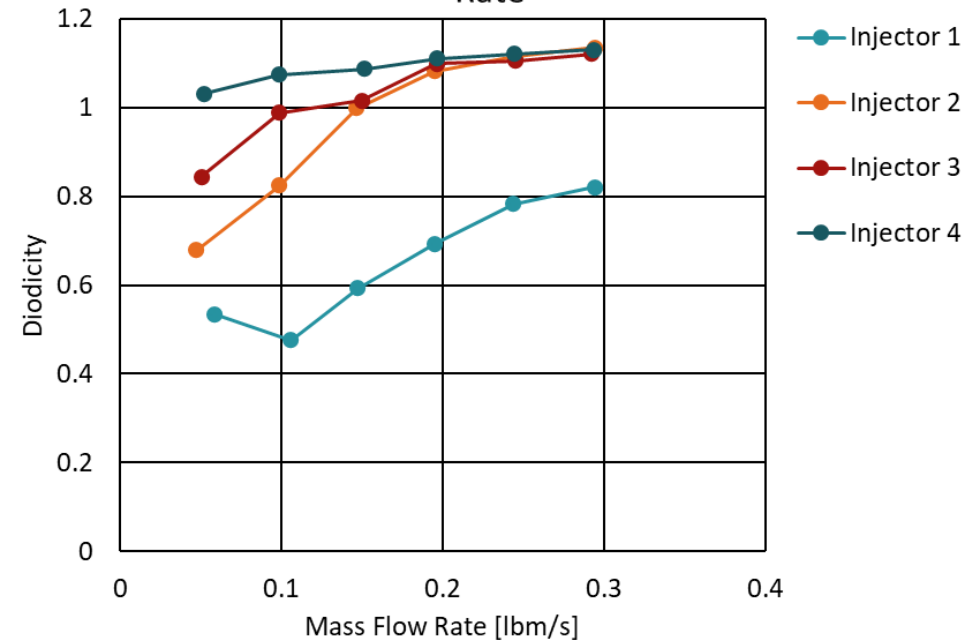
	A_F/A_0 Modeled	A_F/A_0 Actual	A_F/A_0 Calculated
Injector 1	1.5	1.13	1.9
Injector 2	1.5	1.2	1.9
Injector 3	1.5	1.14	2.0
Injector 4	1.5	1.18	2.0

Injector Diodicity

Liquid Simulant Injector Diodicity vs. Mass Flow Rate



Gas Simulant Injector Diodicity vs. Mass Flow Rate

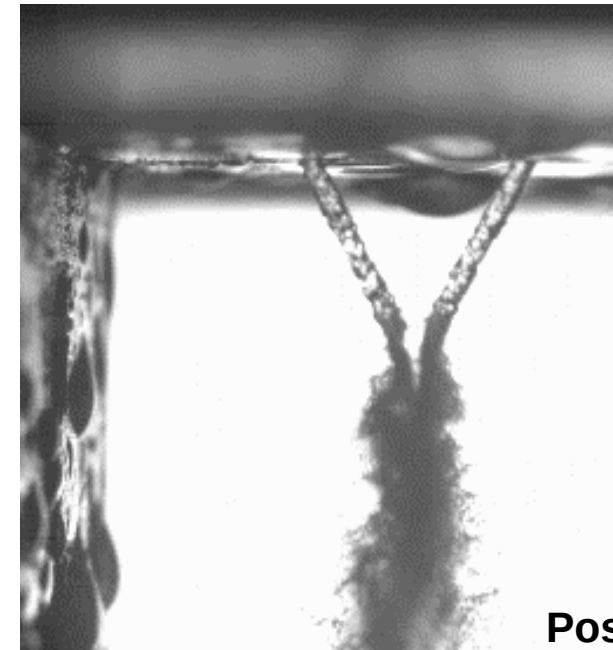


$$D = \frac{\Delta P_{reverse}}{\Delta P_{forward}}$$

Recovery Tests



Position 1

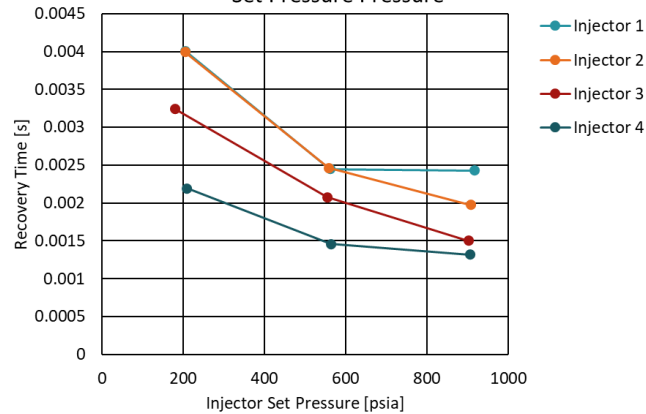


Position 2

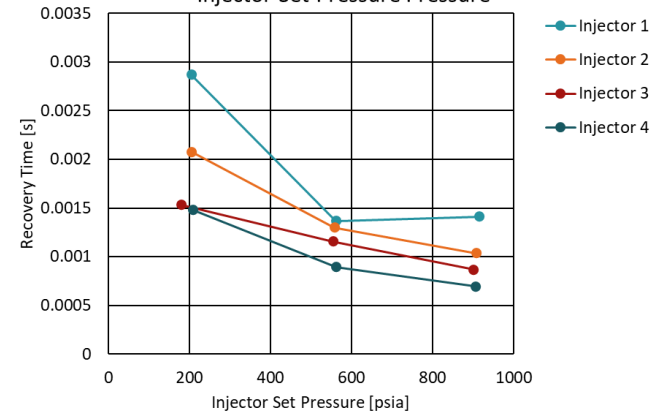


Recovery Times

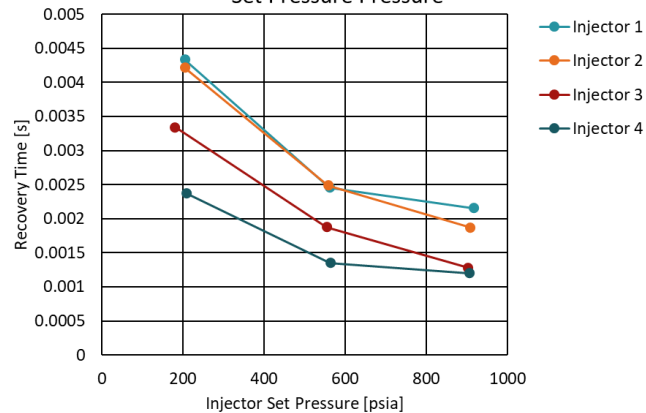
Position 1 Injector Full Recovery Time vs. Injector Set Pressure



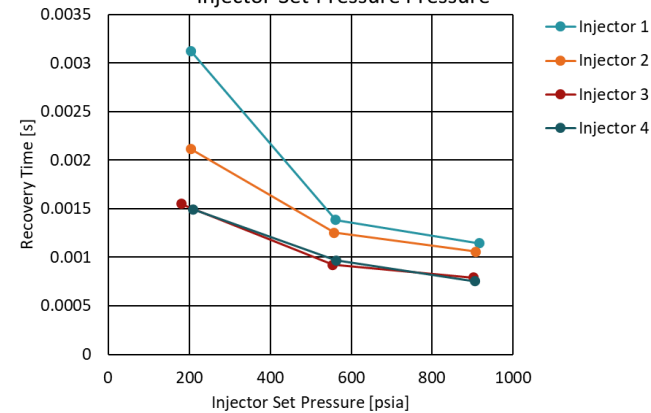
Position 1 Injector Impinger Recovery Time vs. Injector Set Pressure



Position 2 Injector Full Recovery Time vs. Injector Set Pressure

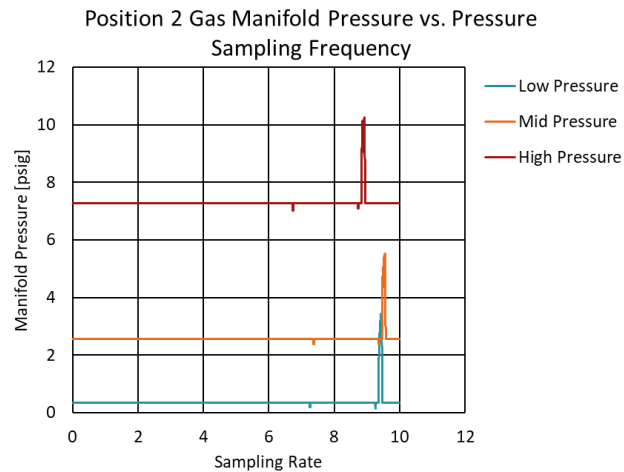
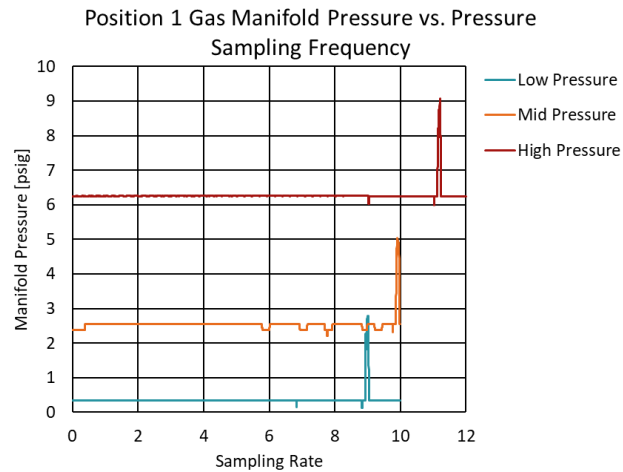


Position 2 Injector Impinger Recovery Time vs. Injector Set Pressure

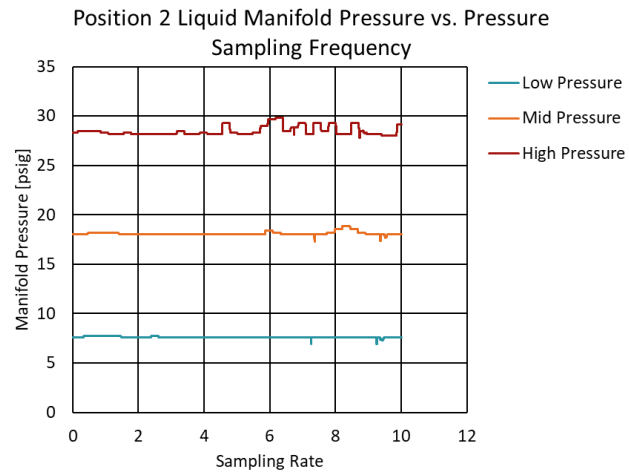
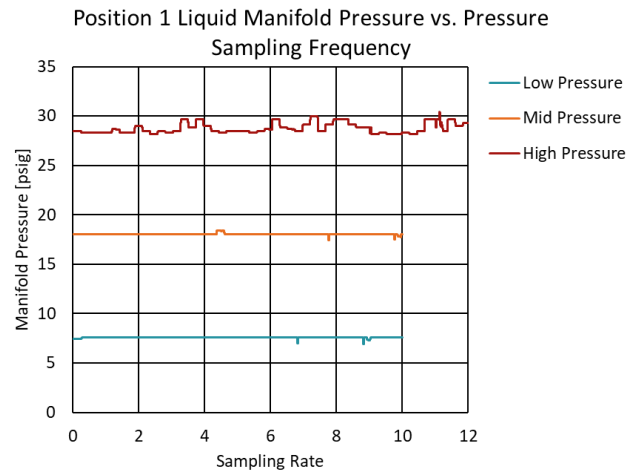


**Ideal CH₄-OX Detonation
Single Wave Mode ~ 10.5 kHz
or 0.095 ms. Shortest
recovery time is 0.7 ms.**

Manifold Pressures



**Peak Manifold Pressures
Approximately + 3.0 psig
for Gaseous Simulant**



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Conclusions

- Smaller flow areas and orifices had shorter recovery times and higher diodicity.
 - Even shortest recovery times were an order of magnitude longer than a single wave mode detonation traversing a 3" RDRE.
 - Slightly shorter recovery times for triplets in position 2 orientation.
- Substantial shrinkage in resin printed parts.
- Smaller orifices showed better liquid atomization.
- Smaller orifices required higher manifold pressures to reach the same mass flow rates.
- Recovery tests manifold pressures suggest the gaseous simulant line was not choked at the injector.

