DALHOUSIE UNIVERSITY
FACULTY OF ENGINEERING

Hail Cannon

Rayleigh SOLAR TECH

Department of Mechanical Engineering

Kiera Chang: *Tactical Execution Manager*
Alex McGaw: *Firing Systems*
Connor Murdock: *CAD and Material Selection*
Dave Worth: *Platform Systems*

Team 20

Project Description

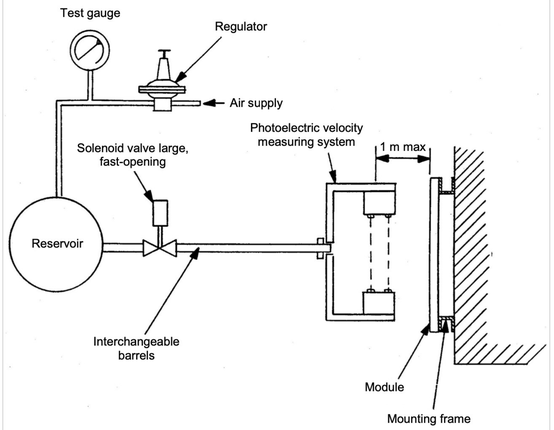
Rayleigh Solar Tech Inc. follows the IEC61215.2[1] standard when developing their innovative perovskite solar modules. The test (MQT 4.17[1]) is an impact test that evaluates the module's ability to survive hailstorms.

Team 20 was tasked with creating the testing apparatus for the hail test, including:

1. Ice Cannon 2. Ice Ball 3. Panel Mounting

The setup will be used for R&D, aiding with material and encapsulation method selection.

Example setup[1]



Requirements

1. Meet MQT 4.17[1] test requirements
2. Focus on 35mm or 45mm diameter ice ball
3. Provide a rigid and adjustable mount for the solar modules
4. Ability to perform testing consistently and accurately
5. Total cost under $2000
6. Be able to store the system in a small area (smaller than a 3' x 3' footprint)
7. Safety procedure for setup and operation

Pneumatic Launcher Calculations

Calculations[2] are based on 35mm (1.5") ice ball launching requirements:

Ice Ball Diameter (D) (mm)	Velocity (v) (m/s)	Mass (m) (g)	Barrel Length (L) (m)
35	27.2	20.7	0.06

$$P_{required} = \frac{mv^2}{2AL} \qquad Re = \frac{\rho v D}{\mu}$$

$$P_{loss} = P_{loss,valve} + P_{loss,valve} = \left(\frac{Q}{C_v}\right)^2 SG + \frac{fL\rho v^2}{2D}$$

A – Cross-section area; SG – septicity gravity; C_v - Valve coefficient; f – friction factor; Q – flow rate

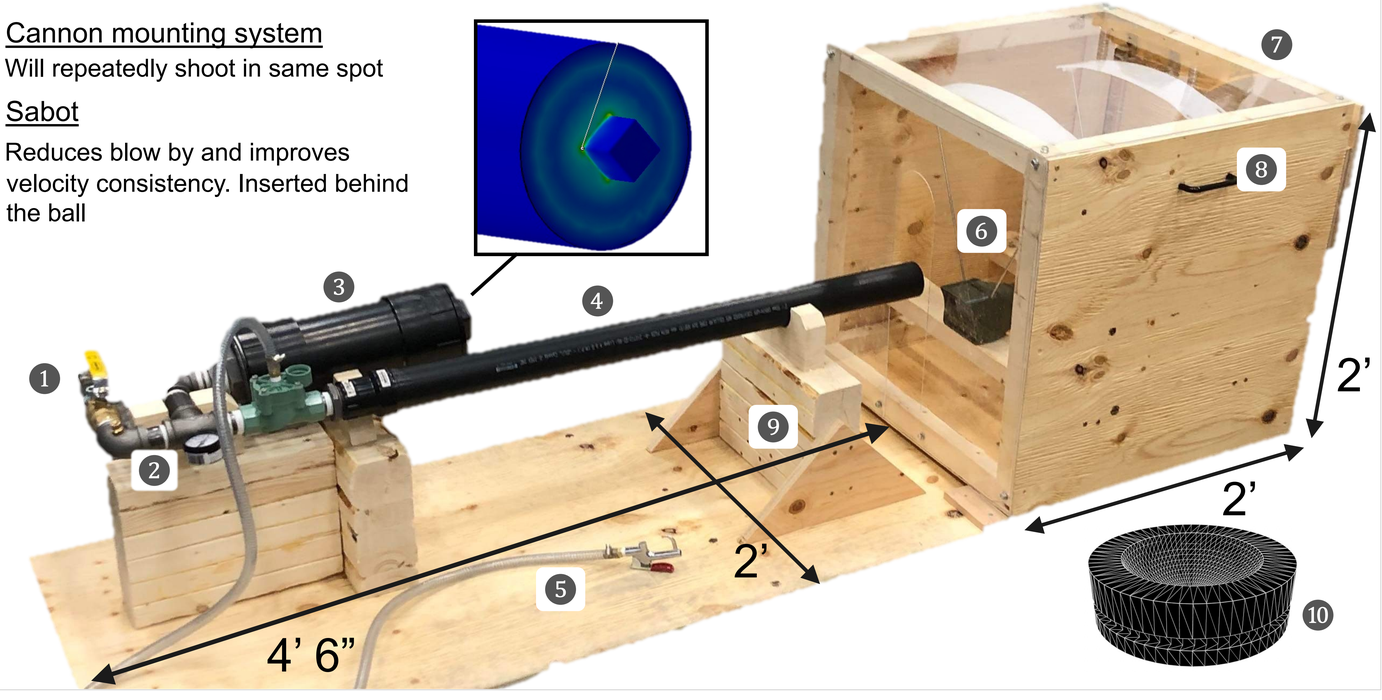
Required psi	Total pressure lost to barrel, pipes, valve (psi)
19.4	0.903

Safety Factor for actual fabrication = 3

Cannon Design

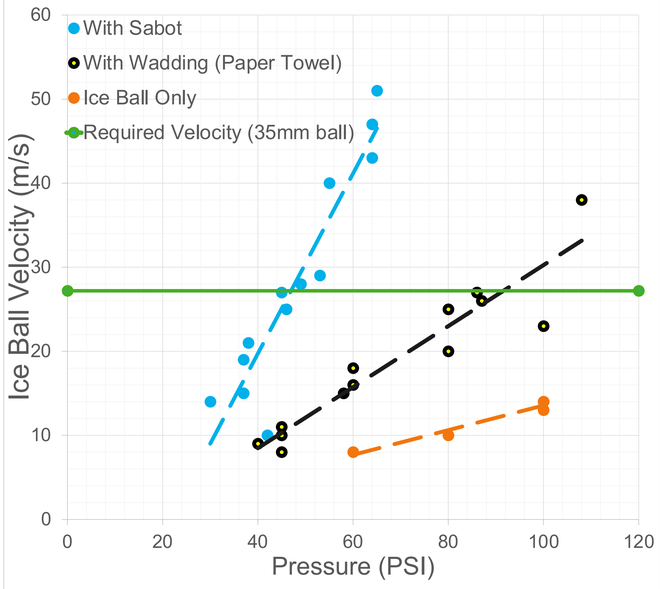
Mechanism Selection → Calculations → FEM analysis → Orientation Selection → Fabrication → Test

1. Compressed air connection
   Powered via air compressor
2. Release valve and gauge
   Safely depressurize system
3. Pressure chamber
   Safe under 300psi on FEA
4. Interchangeable barrels
   Can be unscrewed with ease
5. 6' remote firing mechanism
   Fire at a safe distance
6. Chronograph
   Measures ice ball velocity
7. Mounting surface
   Mounting of the panel
8. Firing Enclosure
   Detachable from cannon base. Easily movable with handles
9. Cannon mounting system
   Will repeatedly shoot in same spot
10. Sabot
    Reduces blow by and improves velocity consistency. Inserted behind the ball



Testing (35mm ball)

Ice Ball Velocities with Various Firing Methods



1. Firing ice ball with sabot reaches required velocity at a much lower pressure
2. Linear approximation shows that 48 psi is required to reach 27.2 m/s using the Sabot

Design Summary and Highlights

Total cost under $1500. Design setup is portable, collapsible and adjustable. Provides support for R&D and saves money on impact and durability testing of solar modules before sending them to professional standard testing facilities.

Some highlights of the design are:

1. Interchangeable barrels
2. Easy to assemble and adjust
3. Operates on <100 psi air supply
4. Ability to operate from safe distance

Recommendations and Next Steps

1. Continue testing to optimize testing pressure
2. Iterate sabot method to improve velocity consistency
3. Insert LED lights into enclosure to optimize chronograph reliability
4. Determine best storage location and orientation
5. Continue with other ice ball sizes

References

All pictures without reference are created or taken by the team

1. IEC. (2016, March). IEC 61215-2.
2. Yost, M., Martin, Z., & Odon, L. (2019). *The Design and Fabrication of a Compressed Air Cannon.*