Safe Range Procedures at the Launching Site

1st Hot Fire Test

March 6th, 2019

# Introduction

Experimental Rocketry is a daunting task. It was well known during the 50’s and 60’s during the Mercury and Apollo era as the most ‘daring job in the world.’ This document details the procedures necessary to conduct a preliminary hot fire test for the UNH Students for the Exploration and Development of Space (SEDS) Project Runaway program. With a launch site approved in a sandpit on Garrity Road in Lee, NH, it is now our responsibility to to take maximum advantage of the safeguards that have been built into it. You can blow yourself up on a so-called ‘safe’ range just as easily as you can in your own basement, simply through carelessness and failing to establish simple and orderly routines that are easy to follow. Any high school football player knows the importance of carrying out his individual assignment on every play, no matter how pointless it may seem in a hundred run-throughs. But the time always comes when that particular assignment is the key to success or failure for the entire play – perhaps the game. It is crucial for the operation of UNH’s first hot fire test and any further tests to establish similar routines for the overall operation of the launch site and for every individual who has an important assignment. We must impress upon every member of the team the importance of following these procedures *every time* we conduct a test-firing.

# Positions and Responsibilities

The following are the positions and responsibilities to be assigned to individuals in UNH SEDS. These are the essential positions necessary to assure the smooth operation of UNH SEDS’ test and launch site.

## Range Officer

He is in complete charge of the launching site. No action is taken without his direction. He gives all orders, makes all decisions. His place should be at the control center.

## Safety Officer

He is responsible for checking all critical points of the operation in advance to make certain that safety regulations are being followed. Responsible for instruction of all personnel in safety precautions. No firing takes place until he has given his clearance to the Range Officer. Verifies the safety of all personnel on the field throughout the entire time people are on the field.

## Launch Center Officer

He is responsible for establishing the procedures to be followed in the launch center and for supervising the handling and preparation of all essential components for a test-fire. Certifies that the launch center is clear before firing can proceed.

## Key Man

Carries the launch key on person to decrease the likelihood of any pre-emptive test-fire or launch. Takes direct orders from the Range Officer.

# Range Procedure

All procedures must be handled systematically and logically. The range procedure is split up into four parts. They are: *prefiring procedure*, *firing procedure*, *in-test procedure*, and *post firing procedure.* Each of these periods has a definite end and a definite beginning. The prefiring period ends when all preparations for the launching have been made and all personnel are undercover ready for ignition. The inflight period ends when the test fire is finished. The post firing period ends when all data have been collected and a critique of the operation has been concluded.

## Prefiring Procedure

1. *Field Layout:* The field designated for preliminary testing is located on Garrity Road in Lee, NH. The field contains a circular pit made of concrete that will serve as the test area. Our test stand with the engine attached will be placed inside the pit, containing the test and any debris that could eject in the case of a test failure. If necessary, there are additional concrete blocks in the field that could be used to build the structure walls higher. The safe area will be located approximately 200 feet from the test area behind a large pile of burned brush. This will ensure that none of the team members or spectators have direct line of sight to the test area. An electronic cart will be in the field, containing data collection instruments. It will be located as far from the test area as possible, while still being able to collect accurately. The control center responsible for starting the test will be right next to the safe area, allowing for a small window for line of sight as the instruments need a direct line of sight. The Range Officer and the Key Man will be the only people at this table during the Firing Procedure. They will immediately move to the safe area as soon as the test begins. Finally, the field will be lined with caution tape, and safety officers will be on sight, ensuring that nobody enters the area of the field during test.
2. *Briefing:* Conduct an outline of the operation to all participants, each individual is reminded on his instructions and duties, and any special actions involving a departure from normal procedure should be detailed. The range officer details this briefing with the assistance of the Safety Officer and Launch Center Officer. This briefing should be held on a prominent piece of ground from which the salient features of the launching site are visible for all.
3. *Firing Station:* Immediately after the briefing is concluded all personnel move to their assigned stations.
4. *First Reports:* As each person reaches their assigned station they must report to the fire control center that they are in position and ready to perform their assignment. This communication will be ideally done through a walkie talkie. The Range Officer and his/her assistants must systematically check off each station on a chart as its report is received and initiate follow-up action in the case of stations not reporting in.
5. *All Clear in the Launching Area:* When all stations are reporting in, the Range Officer announces “All clear in the launching area” and gives the order for the rocket positioning and preparation to start.
6. *Rocket Positioning:* The rocket is moved to the Launching Center by the Launch Center Officer, Safety Officer and two assistants. The Safety Officer has the ignition device in his possession at all times. The ignition device is then inserted. The Safety Officer makes a final check of the launcher and engine, and order the Launch Center Officer and the two assistants out of the pit. With the igniter hanging out of the nozzle of the engine, the Launch Safety Officer brings the long 20 foot lead, outside of the barricade and attaches it to the Launch Box to give control of launch to the Control Center. The Safety Officer then report ‘Ready in the Launching Pit.’
7. *Take Cover:* Upon receiving the ‘ready’ from the Safety Officer, the Range Officer announces “Ready in the Launching Pit” and “Take Cover.” All persons are then required to get behind protective barricades provided for them until the ‘All Clear’ signal is given by the Range Officer post-launch.

## Firing Procedure

1. *Safety Check – Second Reports:* The Range Officer calls for a final safety check and second reports from all positions. Positive reports are required from all stations and each is checked off on the fire control. Once all positions are reporting in, the field undergoes a final visual inspection by the Safety Officer and announces ‘Ready for Ignition’ once all people are confirmed to be under cover in the areas designated for them.
2. *Ready on the Field:* Once the Range Officer hears the final check in from the Safety Officer, the Range Officer can then give the final announcement and says “Ready on the Firing Line!”
3. *Prepare to Fire:* The Range Officer then instructs the Key Man to check the firing panel. The Key Man checks the firing panel to ensure it is locked and reports “Firing Panel Clear.” The Range Officer then gives the command, “Prepare to Fire.”
4. *Safety Officer Clears:* On the command of “Prepare to Fire,” the Safety Officer proceeds to the relax box outside of the Launching Center and closes the shunting switch to activate control to the Control Center. He then retreats to the Control Center and informs the Range Officer that it is clear to fire. The Range Officer then announces “Clear to Fire!” and, “You may fire at the count of zero!”
5. *Countdown:* The Range Officer then announces “Fifteen seconds to ignition!” The Key Man may then insert the safety key into the launch control box after making sure that all switches are still open. At ten seconds, the Range Officer begins to count down the remaining time until firing time using a public address system. At the command of “Fire!” (right after 1 second), the Key Man closes the switch.
   1. *NOTE:* If at any time any people on the field declare safety is being disturbed by airplane or unapproved member movement, the Range Officer needs to stop the countdown and reset until the safety of the field is confirmed again.

## In-Flight Procedure

1. *Maintain Cover – Open* *Firing Switch:* From the time of ignition and the end of the test, all members must maintain position under cover. As soon as combustion is seen, the Key Man resets the control box and pulls out the key and maintains possession of it until the day is complete.
2. *In-test Operations*: Since the safety requirements say no person shall be in the line of sight during test, there will be no visual of the engine for the estimated 15 second burn time. If however, the team senses through data collection that the test is taking a negative turn, a kill switch will be pressed to avoid fracture to the engine. A live camera feed will be utilized to give some visual aid of the test.

## Post-Firing Procedure

### For a Successful Firing

1. *“All Clear”:* Once the rocket has impacted on the ground or the test has completed, the Range Officer announces, ‘All Clear! Cease Firing!” All members can now move from under cover.
2. *Reset Safety Devices:* The Safety Officer now moves to the Launching Center and switches off the control from the Control Center to the Launching Center. The Safety Officer then reports “Relay Box Safe!” He then removes the wire leads and the spent igniter left behind by the rocket.
3. *Confirming Data Collection:* After the relax box has been shut off, the Range Officer then calls for reports on data measurement and collection within the Control Center. The data is saved and backed up immediately on multiple hard drives.
4. *Recovery of engine:* A recovery team is assigned to approach the test area and bring the engine back for packaging after 10 minutes of cool down has occurred.

### For an Unsuccessful Firing

1. *Handling a Misfire or “Dud” engine:* If the rocket engine misfires, open the switch and wait one minute. After the minute, close the firing switch again to attempt to ignite the engine again. If it still fails, all members must remain in cover for 5 minutes. The Safety Officer then crawls to the Launching Center relax box outside of the barricade and flips off the relay. The Safety Officer then returns back to the Control Center and informs the Range Officer that the relay box is shut off. The Range Officer then gives the go ahead to tip the engine using the rope lead installed prior to launching. All members must then wait another 5 minutes until the Launch Center team (consisting of only the Safety Officer and the Control Center Officer), while wearing protective gear around their entire body, return to the rocket on the launch rail and take all components off.
2. *“All Clear”:* Once the igniter is removed from the engine, the Rage Officer announces “All Clear!” The engine is then removed from the Launch Control Center and inspected.
3. *Reset Safety Devices:*  The Range Officer then commands a second check of resetting all safety devices.
4. *Confirming Data Collection:* If anything useful came of the test, the Range Officer must verify that all data has been saved and backed up on multiple hard drives.
5. *Critique and Evaluation:* Following each firing, no matter the outcome, and critique and evaluation must be undergone with a designated note taker. The Range Officer runs this with the assistance of the other Officers. The Range Officer can then call for a new igniter and test to occur during the same day.