Patrick Watson

Team Three

MCEN 4151

12/06/23

RS25 Vapor Cloud

November 15, 2023 2:47 PM

Acknowledgements:

Thank you to the test director of E1 complex, Chris Mulkey, for letting use the video for this project and checking to make sure that it would be okay to use!

Background

The RS25's original sole purpose was to provide main propulsion to the Space Shuttle. The RS25 burns Hydrogen and Oxygen at a staggering total mass flow of 1,134 lbs/s of propellants with an oxidizer to fuel ratio of around 6. The RS25 produces over 400,000 lbs of thrust at sea level and increases in thrust to over 500,000 lbs force in vacuum due to lower ambient pressure. The Space Shuttles utilized 3 RS25's and a pair of solid rocket boosters (SRB) to reach orbit. The Space Shuttle program's first flight was in 1981 and went on to be the pride of NASA and all Americans. However, after two in flight failures, Columbia and Challenger with the latter happening in 2003, there were growing calls to retire and replace the Space Shuttles with rockets from the private sector. In 2011 the Space Shuttle program was officially retired, and RS25 production ceased. However, production has started again with the rise of the Space Launch System (SLS). SLS was conceived to send mankind back to the moon but with the stipulation that it must use as many Space Shuttle parts as possible. Which meant that the RS25 would serve again to propel mankind to space on SLS. Engines are once again being tested and validated at the NASA Stennis Space Center in preparation for SLS. The RS25 is being tested on the A1 stand where the stand was originally made to test the second stage of the Saturn V rocket, S-II, in the 1960's. Other notable engines that have been tested on the stand are the J-2X and the XRS-2200 Linear Aerospike. The A1 stand utilizes a large flame diverter that has many 3/8-inch holes drilled into it to deliver 170,000 gallons of water per minute. The water prevents the hot exhaust plume of the RS25 from destroying the flame diverter and excavate the ground. Each hole is inspected after each test to make sure that they are in working condition to prevent a hot spot that would melt the large flame diverter. As the water is vaporized it turns into a large cloud. This cloud will move across Stennis Space Center and create local weather storms.

Description

Capturing the test can be difficult. The test goes on for 500 seconds, but it can be hard to predict when the test starts. Additionally, the test is incredibly loud and hearing protection is recommended. In this photo is one of the latest 500 second tests of the RS25 on test stand A1. A1 is roughly 200 feet tall and it is apparent that the vapor cloud has grown in height to maybe three times the height of A1. The RS25 engine is nestled on the lower two decks with the liquid hydrogen and liquid oxygen tanks above. The video and photo were taken from roughly half a

mile away next to the E1 complex, where other rocket engines are tested. The video and photos taken were shot on an iPhone 14 pro. A camera was not readily available when the call was given for the test to commence. Similarly, setup would have been more intensive with the Nikon D7500 and might have caused me to miss the startup of the engine.

Setting	iPhone 14 pro Picture	iPhone 14 pro Video
Focal Length	77	24
ISO	32	-
Shutter Speed/FPS	1/132s	60 FPS
Aperature	f/2.8	f/1.78
Image Size (Pixels)	4032x3024 (2016x1512 Web)	3840x2160 pixels (2742x1322 Cropped)

Table 1: Photo and Video information

Per Apple, the iPhone 14 pro has a field of view of 120 degrees. The video and photo are largely unedited. The video has been cropped to focus on the A1 stand better and remove the A2 stand from view. The RGB curve was mostly left unchanged because the iPhone 14 pro does a great job out of the box in color balance. For the most part the image and video both look both spatially and time resolved. Although admittedly, the video framing could have been better by placing the A1 stand in the bottom right third (like in the cropped video) and showing more of the vapor cloud. After 3 minutes into the hotfire, rain from the vapor cloud started to fall on us.

Figure 1: Unedited (left) vs. edited (right).

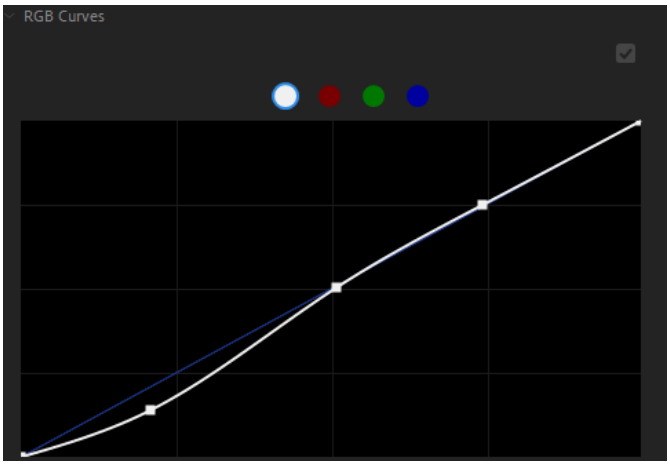

Figure 2: Small change made at the dark end to help make the vapor cloud pop.

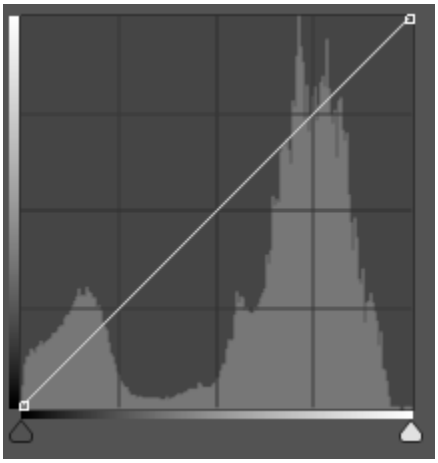

Figure 3: Unedited RGB curve for the photo.

Conclusion

I am very happy with my video and image taken. I feel very lucky to be at the Stennis Space Center during the time that an RS25 was being tested. Although this is not my first RS25 hotfire, it always makes me overly excited to see one. I was trying to be very deliberate about how I framed my video to make sure that I could capture as much of the vapor cloud as possible and feel like I still underestimated the size of the vapor cloud. I learned a lot while looking up the topic and over the Summer I got the chance to tour the A1 stand and all of this makes me appreciate RS25 testing that much more. I also feel very fortunate to be able to work at SSC for my employer.

References:

A-1 Test Stand - NASA, www.nasa.gov/wp-content/uploads/2021/09/a-1_test_stand_v1.pdf. Accessed 7 Dec. 2023.

"RS-25." *Wikipedia*, Wikimedia Foundation, 2 Dec. 2023, en.wikipedia.org/wiki/RS-25.

"Stennis Space Center." *Wikipedia*, Wikimedia Foundation, 18 Nov. 2023, en.wikipedia.org/wiki/Stennis_Space_Center.