FROM: CONTRAIL ROCKETS RESEARCH AND DEVELOPMENT

SUBJECT: LDRS 25 O MOTOR FAILURE ANALYSIS

DATE: 8/11/2006

On July 1st, 2006 at LDRS 25 in Amarillo, Texas Contrail Rockets suffered a motor failure. The Motor which failed was the new Contrail 152mm O-6300. This is currently the most powerful rocket motor certified by Tripoli Rocketry Association. Contrail Rockets Owners, Tom B. Sanders and Tom R. Sanders have completed a full analysis of the failure of the 152mm Hardware and Reload. The Following Report explains the cause of the failure.

Tom B. Sanders, Owner of Contrail Rockets, built and planned to do a Level 3 Attempt at LDRS using a 12 Inch Diameter, 17 Foot Tall, 200+ Pound Rocket. The Rocket was to fly on the Contrail O-6300 Reload. During preparation for LDRS the rocket saw a very large amount of moisture and humidity, which swelled some of the cardboard parts of the rocket. During assembly and preparation for the Level 3 flight the O-6300 got stuck in the motor mount tube which had swelled from the humidity.

In an attempt to get the motor case properly installed in the rocket, it was set onto the motor case which was partway into the rocket body. Multiple attempts were made to put weight and force onto the rocket in an effort to force the rocket body over the motor case. The Motor Case moved slightly, but would not go the entire way up the motor mount tube. After an RSO Inspection it was decided the motor would not be a safety issue because it was retained from the forward bulkhead and had been lodged in the motor mount tube and would not move. While attempting to force the motor into the motor mount tube, it was found that the fill line was possible damaged inside the combustion chamber. After an inspection of the line it was not believed to be issue and the rocket was sent out to the pad to be launched.

The Weather and Temperature at LDRS proved to be an important factor into the failure of the O-6300 as well. With temperature reaching into the High 90's the pressure of the Nitrous Oxide was higher than desired for a hybrid motor. The O Motor, when finally set up at the pad started to fill, and after approximately 5 minutes burst the main fill line inside the combustion chamber. This burst allowed for the entire quantity of Liquid Nitrous Oxide to dump onto the fuel grain. After a quick analysis of the burst line, it was found that a patch could be put into the line and a second fill could

be attempted. The Rocket was never removed from the rail, and all work on the motor was done by removing the nozzle assembly and patching the line inside the combustion chamber.

The Second Fill was attempted as it approached the closing time for the range. Again after approximately 5 minutes of filling the motor had a leak at the same point as before. The Patch in the line had let go, and proceeded to dump the liquid Nitrous Oxide which was in the motor onto the fuel grain a second time. This cooling and heating of the grain (Thermal Cycling) will induce a rapid shock to the grains which can produce small cracks throughout the grain. Similar occurrences happen in Black Powder motors which have been temperature cycled from the natural heating and cooling which they encounter. Another similar example of what happened is when Hypertek Brand Grains see a leak or dump into the combustion chamber with out being fired they will crack and if fired will blow apart the grain part way into the burn. The Cracking of the grain can produce a less structurally sound material, which is prone to having fuel "stripped" off during the burn.

After the second failed fill attempt Tom B. Sanders decided that it would be best if the rocket was pulled from the launch pad, and another attempt be made the next day. Due to the high temperatures at LDRS it was decided that the Nitrous Tanks should be cooled with ice prior to the rocket being loaded onto the pad, or the tanks being brought out. 40 Pounds of ice was used to ice the tanks and bring the temperature down in the heat. This brought the Nitrous Tanks down to a pressure of approximately 650 PSI when the fill began that morning. This over chilling of the Nitrous Tanks was an overcompensation for the high temperatures. During the fill, it was found that the Nitrous Tanks underwent what is known as "Expansive Cooling" as a result of the Nitrous Oxide in the tanks being transferred to the O-6300 Reload.

The O-6300 took approximately 30 minutes to fill with the nitrous oxide pressure where it was. Immediately prior to retreating to a safe distance Tom R. Sanders looked at the pressure gauge once the motor was filled and noticed it read a pressure of 500 PSI. With the motor filled with Nitrous Oxide and pressure mounting to get the rocket off, The Rocket was fired anyways. This was a mistake on the part of the flyers, for not being more careful, and patient with the setup and filling of the motor.

After a 10 count the rocket was ignited. The rocket lifted off and began moving skyward. Approximately 2 seconds later the motor suffered a catastrophic failure, resulting in the destruction of the lower half of the rocket, and motor hardware. The Rocket had only reached a few hundred feet when the failure occurred. The Following paragraphs will outline what Contrail Rockets believes to be the progression of events during the flight and failure.

Below is a picture by picture analysis and explanation of what was going on. All Photos are Taken by Ray LaPanse. A Special Thanks to Ray for the Very Helpful Photos.

Above Photo Shows Ignition of O-6300. The Motor is just now coming up to full pressure and thrust. In less than .25 Seconds the motor will be operating at 2800 Pounds of Peak Thrust.

Above Photo Shows the rocket as it just leaves the Rail. Still there is no sign of any issue with the motor. Note that the rocket is 17 Feet Tall, and 12 Inches in Diameter.

Above Photo Shows the Motor as it begins to have a regressive Thrust Curve. Over the 4.5 Second Burn the Motor will Reduce in thrust from 2850 Pounds to 0 Pounds.

Above Photo: At this point during the burn the motor has "choked" itself up. The photo shows parts of the fuel grain which have been cracked from the previous days frostings and temperature cycling being ejected from the motor. The Flame is severely reduced due to the lack of flow into and out of the combustion chamber.

Above Photo Shows the Grain parts after the leaving the combustion chamber. These Parts of the grain were what had clogged the nozzle during the motor burn. The Grain Spit itself out and during that time the flame from the motor had disappeared. At this time the grain was compromised. While still burning and very hot, the thrust from the motor was severely diminished.

Above Photo Shows a continued movement of the rocket upward. The nozzle of the motor is believed to be partially clogged still, and is creating an environment in which the flame front of the motor is moving upwards into the Nitrous Tank portion of the hardware. It is believed that the Low Tank Pressure in the Motor allowed for the flame front to move up into the Nitrous Tank faster than if the motor was fired under optimal conditions.

Photo Above Shows the Complete Destruction of the Lower ½ of the Rocket. Immediately before this point the flame front had moved from the combustion chamber into the Nitrous tank and allowed for a "flashback" situation.

The Failure of the 152mm O-6300 was a learning experience for many. We here at Contrail Rockets have devised new safety measures to ensure that incidents such as this one do not occur again. The O-6300 Motor is currently the highest thrust motor which has been certified by Tripoli Motor Testing.

Current and New customers of the O-6300 all receive a video instruction manual and written instructions as well as a set of guidelines and regulations of how the motor should be prepped and fired. There are limitations to every motor. It has been found that the O-6300 Motor should not be fired with excessively low Nitrous Pressure.

Just a few weeks after the failure of the O-6300 Motor at LDRS a cluster of 6 of these motors was used by the group who requested the first O-6300 motor hardware and reloads. Video and Pictures of this record breaking flight will become available in the near future. The rocket which flew on the 6 O-6300 Motors had a combined impulse of over an R-20000. All motors performed with 100% Success. A True testament to the power and reliability of Contrail Motors.