PHANTOM®

2020
CASE STUDY

Phantom Cameras Shine in Recent Ballistics and Material Tests for Aerospace Components

Vision Research recently supplied its high-speed imaging equipment and expertise to two companies—shedding light on aircraft fire extinguishing systems and satellite springs.

From firing 50-caliber bullets at fire extinguishers, to activating retractable satellite springs, it's all in a day's work for aerospace engineers. Due to the fast, often explosive nature of various testing processes in this industry, it pays to utilize advanced high-speed imaging systems, which allow the engineers to analyze missile launches, ballistics, material tests and more.

Not all high-speed cameras are created equal, however—especially when it comes to imaging critical aspects of aerospace tests that would otherwise remain invisible to the eye. It's important to select cameras that balance a number of variables, including fast recording speeds, high resolution and light sensitivity. Aerospace tests are often conducted in extremely demanding environments. The cameras need to be ruggedly constructed so they are able to withstand extreme temperatures and intense vibration.

In this article, we will explore how the Phantom Ultrahigh-speed and VEO High-speed cameras were used to record the testing processes for two components—fire extinguishing units and retractable springs. These analytic tools were able to shed new light on the design and performance of the aerospace devices.

VISION RESEARCH

AMETEK®
MATERIALS ANALYSIS DIVISION

CASE STUDY #1: FASTER THAN A SPEEDING BULLET

Ameron Global Product Support, a company that specializes in aviation safety components, tests its fire suppression systems by shooting 50-caliber rounds at extinguishers in the middle of the Mojave Desert. Because these units are often used in military aircraft, they need to be able to survive gunfire—particularly, tumbling bullets.

"We also have to make sure the bullets don't produce any shrapnel as they pass through each vessel," explains Souvanh Bounpraseuth, Director of Engineering for Ameron. "Doing so ensures they meet military specifications."

Because speeding bullets are imperceptible to the naked eye, Vision Research supplied its Phantom v2640 and v2512 high-speed cameras—the fastest four-megapixel and one-megapixel cameras available, respectively. The cameras were selected for their ability to strike a unique balance between fast recording speeds and high resolution: the v2640 is capable of 6,600 frames per second (fps) at full 2048 x 1952 resolution, while the v2512 achieves 25,000 fps at full 1280 x 800 resolution—and up to 1,000,000 fps at reduced resolutions.

"In addition to high recording speeds, ballistics applications like this require cameras with very fast shutters—only a few microseconds," explains Gene Nepomuceno, Field Applications Engineer for Vision Research. "I did a test shot where I recorded the 50-caliber bullet firing from the barrel at 80,000 frames per second," Nepomuceno says. "When you play back the footage, you can clearly see the grooves of the slug and the rotation of the bullet as it travels through the air. You can't see these kinds of details with other high-speed cameras."

IDEAL FOR REMOTE ENVIRONMENTS

Due to the remote location of the gunfire tests, it was also critical that the high-speed cameras withstand harsh environments. "On the one hand, we didn't have to worry about lighting because we were outside," Nepomuceno says. "We also had the desert as our backdrop for the shots—making it easy to identify the bullet in the frame. But the temperature routinely hits over 100 degrees Fahrenheit."

Set-up for high-speed testing

Again, the Phantom v2640 and v2512 cameras were the right choice for the job. They incorporate active cooling and a white housing to minimize heat absorption. In addition, both cameras can be powered by battery and utilize the Phantom CineMag—removable, non-volatile media—for quickly downloading high-speed video. Thanks to these features, the cameras are a flexible yet durable equipment choice for deserts and other remote locations.

Phantom Ultrahigh-speed v2640 and v2512 cameras

RECORDING THE GUNFIRE

In terms of setup, the Ameron engineers had constructed a three-sided berm with a backstop for the bullets, as well as a ramp with a rubber slab on top. Hitting this pad during the tests caused the bullets to enter the fire suppression vessels sideways rather than straight on. "It's called tumbling," Nepomuceno explains. "When you look at the target after firing the bullet, the puncture isn't a nice, perfect hole. It looks more like a keyhole. Withstanding tumbling is one of the military requirements the extinguishers have to meet."

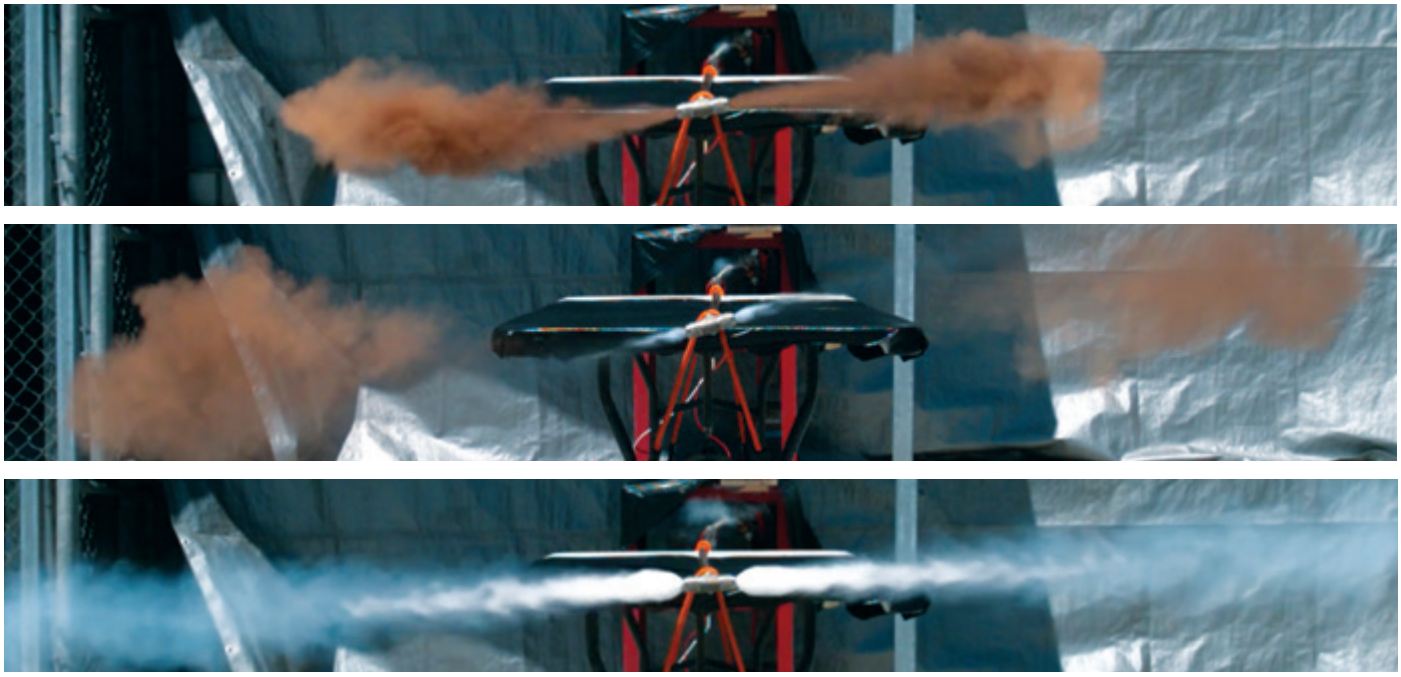
Nepomuceno set up the Phantom cameras so that they looked over one side of the berm and recorded the tests at 51,000 fps (768 x 576) with a 10-microsecond shutter. While most of the vessels survived the gunfire, one unit did break apart when it was struck. "But thanks to the high-speed footage, we could see where and how the rupture occurred," Bounpraseuth says. "This kind of information helps us go back and refine the design."

OBSERVING HALON 1301 DISCHARGE

In addition to the gunfire tests, the team recorded discharge tests at Ameron's facility. This process involved pressurizing the fire extinguishing vessels with nitrogen to discharge Halon 1301—a fire suppression agent often used in military equipment. While discharge tests are standard for the industry, the high-speed cameras helped the engineers visualize the process in a new way. The cameras also helped the team capture things they wouldn't otherwise have noticed.

"During one of our trials, the entire bottle discharged in one second—which is normal," Nepomuceno says. "But the tube connecting the bottle to the table whipped around like crazy. When we played back the video, we noticed it was because there was a leak in the tube, due to either a bad coupling or hose. We wouldn't have known that without the cameras."

"The Phantom cameras gave us extra visual information on how many of our standard product tests are proceeding," Bounpraseuth adds. "They let us see aspects of the processes that we otherwise can't—and allow us to supply better, safer fire suppression systems to our customers."



High-speed frames from discharge test

CASE STUDY #2: HIGH-SPEED CAMERAS SPRING INTO ACTION

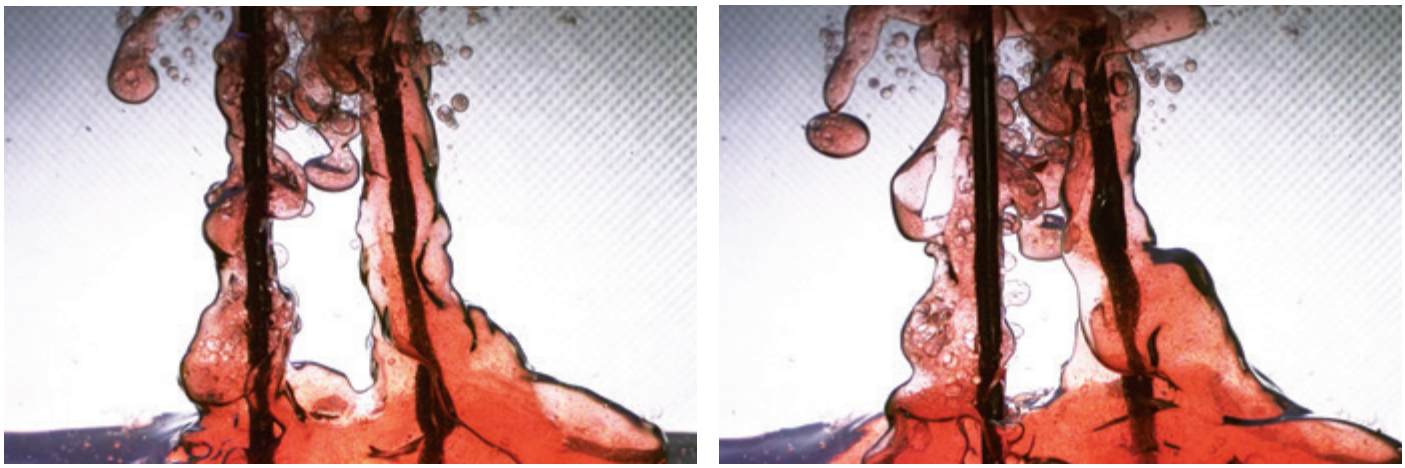
Since the 1960s, the self-activating, extendable STACER spring has been the technology of choice for remote satellite antennae. But the company behind this device hasn't been able to observe its mechanics—until now.

Hunter Spring Products has provided flat spring and reel solutions for the aerospace industry for decades. Its unique STACER—Spiral Tube and Actuator for Controlled Extension and Retraction—spring is a popular self-deployment solution for probes and antennae on satellites in orbit, as well as for solar array support structures, linear actuators and energy absorbers.

The STACER is a tubular mechanical device that requires no external force to activate—making it ideal for remote environments like outer space and the deep sea. Made from a spiral-wound, overlapping and pre-stressed metal strip, the restrained STACER stores in a compact, cylindrical coil. When deployed, it extends rapidly under its own power into a full-length, self-supporting tube and can reach lengths of 35 feet.

"Because it's such a fast-acting mechanical device, there was never a good way to actually see what happens to the STACER as it deploys," says Jon Royer, Product Manager at Hunter Spring Products.

To overcome this challenge, Vision Research supplied its Phantom VEO 710 and VEO 640 high-speed cameras to record the spring's deployment process. "The cameras gave us a unique opportunity to look at how the spring transitions from rest to full extension," explains Royer. "The spring is made up of thinly coiled material. The cameras let us finally see the physics behind this design as the spring rotates out of its canister."



High-speed frames from submerged spring test

LIGHTING REQUIREMENTS

Because it was critical to see inside the canister as the spring exited, Vision Research took extra care to set up the cameras out of the spring's extension path. "We had to make sure the spring would miss the lens after being deployed," explains Kyle Gilroy, Field Applications Engineer at Vision Research. "On top of that, we had to use multiple, high-intensity LEDs to light this application properly and avoid shadows."

The use of extra lighting is common for high-speed recording, as the process requires more light than regular photography. Typically, doubling the camera's frame rate also doubles the amount of light required by the subject. LED lights, in particular, offer an inexpensive, lightweight and low-energy solution for high-speed applications. They leverage DC power, eliminating the flicker that appears in high-speed videos, and are also battery-powered—translating to greater flexibility in the field.

Although additional lighting is often required, Vision Research designed its Phantom cameras to utilize as much light as possible. The Phantom VEO 710, for example, features a 35mm, 1-megapixel CMOS sensor with 20-micron pixels, achieving high light sensitivity even at fast recording speeds.

SPEED AND IMAGE QUALITY

In addition to meeting the spring application's sensitivity requirements, the Phantom cameras properly balance high recording speeds and image quality—an achievement that makes them unique. "Other devices tend to sacrifice quality for light sensitivity or speed," Gilroy says. "But when we design our cameras, we stick to image quality first and foremost."

In terms of speed, the Phantom VEO 710 features frame rates over 7,000 fps and 1 million fps at reduced resolutions, making it ideal for traditional high-speed motion analysis in applications like microfluidics, ballistics testing and biomechanics. For applications requiring higher resolutions, the four-megapixel Phantom VEO 640 achieves over 1,400 fps at full resolution.

Phantom VEO 640S High-speed camera

Both cameras also leverage powerful 35mm CMOS sensors with a global shutter, exposing each pixel to light simultaneously. The large pixels result in increased sensitivity and interchangeable lens mounts create compatibility with a huge variety of SLR style optics, ensuring the highest image quality possible.

THE SPRING RECORDING PROCESS AND RESULTS

In addition to recording the normal deployment process, Vision Research recorded the STACER spring as it extended through various media, including water, alcohol and oil. These latter shots enabled the team to observe and understand the transition from rest to extension in greater detail. "We could see what the spring takes with it as it exits the canister—like the bubbles spiraling around the spring," Royer says.

Previously, Royer and his engineering team thought that the spring simply shoots out of the canister. "But the spring is more like a Chinese yo-yo with the tip piece rolling around the inside at high speeds," Royer explains. Thanks to these insights, Hunter Spring Products has decided to change how the STACERs are tested prior to delivery.

"The footage also gave us information on how we can manufacture our springs more accurately for our customers," Royer says.

To learn more about Vision Research high-speed systems and expertise, visit ***www.phantomhighspeed.com***

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