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Joint Actinide Shock Physics Experimental Research (JASPER) Facility Overview

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Figure 1: Two-Stage Light Gas Gun

Abstract

The JASPER Facility will utilize a Two-Stage Light Gas Gun (see Figure 1) to conduct equation-of-state (EOS) experiments of plutonium and other special nuclear materials. The overall facility will be discussed with emphasis on the Two-Stage Light Gas Gun characteristics and mission. The primary and secondary containment systems that were developed for this project will be presented. Primary gun diagnostics and timing will also be discussed.

Introduction

A Joint Test Organization (JTO) identified a need for a Two-Stage Light Gas Gun Facility to conduct Special Nuclear Material (SNM) Equation of State (EOS) experiments. A siting study team was assembled with members from Bechtel Nevada, Lawrence Livermore National Laboratories, Los Alamos National Laboratories and Sandia National Laboratories. Eight sights were screened and the Nevada Test Site was

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selected to house the new gun. Construction began in April 1999 and a new gun was purchased from Thiot Ingenierie, France. The first full-up experiment was successfully conducted on March 19, 2001. To date the gun has launched projectiles ranging in mass from 16.5 grams to 26.5 grams to a velocity of 7.4 km/sec.

28mm/89mm Two-Stage Light Gas Gun

Gun data:

- Pump tube
  - 11.5 meters long with one joint
  - 89 mm bore diameter
  - Four piston velocity stations
  - Positive locks to secure the gun in firing position repeatable shot to shot
  - Piston, 4.5 kg (10 lbs), High Density Polyethylene and Copper/Paraffin slurry mixture for increased mass
  - Washing machine to clean bore, post shot provided (see Figure 2a and 2b)

- Launch tube
  - 8.1 meters long single piece barrel
  - 28 mm internal bore diameter
  - Projectile mass range 16.5 g to 26.5 g
  - Cleaning and light hone provided

- Acceleration Reservoir (AR)
  - Taper 3.9º half angle
  - Two piece sleeve design pressed together
  - Designed for 2 each, 5 ksi break diaphragms
  - Pressure gauge in break diaphragm holder to indicate diaphragm rupture time and measure initial projectile base pressure
  - Assembled hydraulically (1150 bar typical)

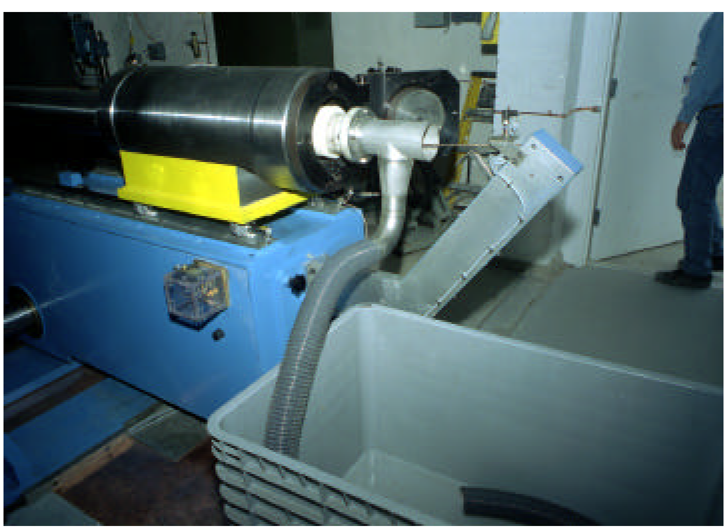

Figure 2a: Pump Tube-Cleaning Machine at Breech

Figure 2b: Pump Tube Cleaning Machine at Acceleration Reservoir

The gun is mounted on a split rail and one unique feature is that the entire mounting rail, which supports the pump tube, is moved to the side to bring the pump tube and launch tube into cleaning positions. The rail is supported by four large linear bearings and is moved with an air motor and screw assembly.

The gun assembly, as supplied by Thiot Ingenierie, employs a pump tube cleaning machine, (see Figure 2a and 2b), which consists of a cleaning head with multi-port high pressure jets using soap and water as a media to clean the pump tube and breech. This cleaning system has proved reliable and has done a remarkably good job of cleaning these components. The cleaning process is a three-step process. First the pump tube is washed with high-pressure soap and water solution. This is done in one pass of the cleaning head through the pump tube in each direction. This process is repeated with a rinse of clean water, followed by a rinse of passivation solution to keep the barrel from rusting.

The Acceleration Reservoir is manufactured in two parts and from two different materials. A tough steel outer shell and the inner tapered section of hard steel. They are press fit together to give the AR additional strength. The launch tube is a single piece barrel, supported at six locations, five on the mounting rail and one inside the Secondary Containment Chamber. The launch tube/AR/pump tube joints are assembled hydraulically to a pressure typically 1150 bar. The propellant train is ignited using an exploding bridge wire to drive a mechanical firing pin into a 30-06 cartridge.

The JASPER Facility will support the following Campaigns:

1. Campaign 1: Primary Certification – JASPER data will be an important component of the tools required to certify the performance and safety of any rebuild or aged primary.

2. Campaign 2: Dynamic Material Properties – JASPER will provide materials response data used in the development of EOS and strength models for Special Nuclear Material.
3. Campaign 8: Material Lifetimes – JASPER will help provide a validated basis for determining when components must be replaced and when new manufacturing facilities are required.

Containment Systems:

Secondary Containment Chamber (SCC):

The Secondary Containment Chamber (See Figure 3), was designed to contain a hydrogen deflagration and provide containment if the Primary Target Chamber (see Figure 4) fails. There are several unique features incorporated into the SCC design. First, the rear door is hydraulically operated, double o-ringed and secured with a locking ring, no bolts are required. Second, the launch tube is offset below the centerline of the tank to maximize the working area within the tank. Third, a stable aluminum floor is provided to walk and work on. Finally, a blast shield is mounted just off the muzzle of the launch tube to strip gas from the projectile during its one-meter of free flight to the target. In addition the blast shield mount provides a base for the final launch tube support and houses Optical Beam Breaks and the film holder for the flash x-rays. The Optical Beam Break is a velocity measuring system, which has proven accurate, and reliable, it is used to measure projectile velocity and provide dynamic signals to trigger the explosively driven Ultrafast Closure Valve.

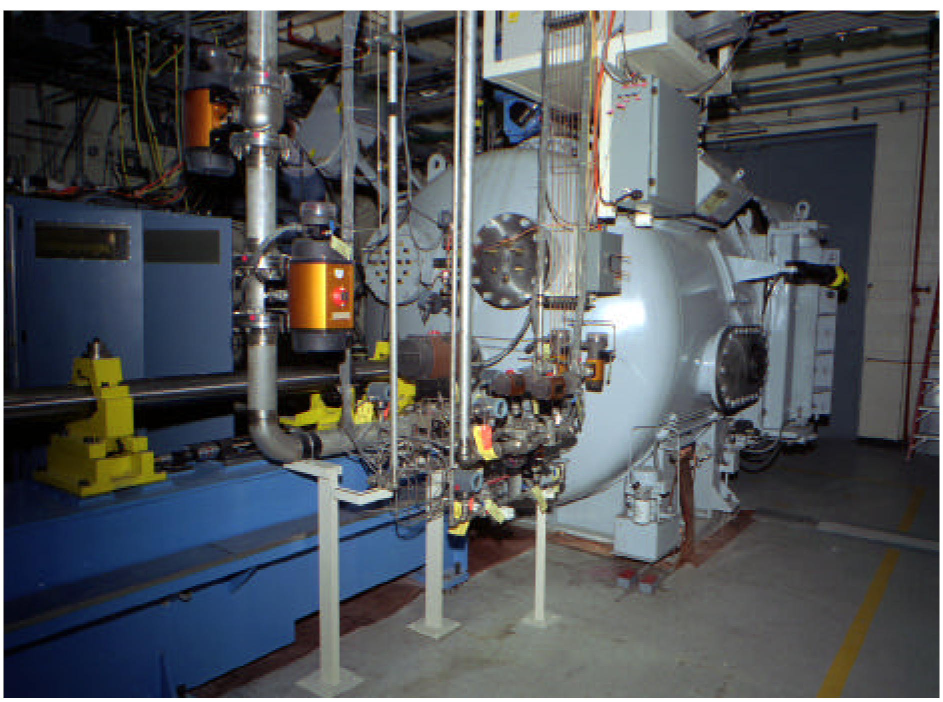

Figure 3: Secondary Containment Chamber

Primary Target Chamber (PTC):

The Primary Target Chamber (see Figure 4 and Figure 5), fits into the Secondary Containment Chamber and is aligned and locked into place for each experiment. The Primary Target Chamber contains the Actinide target, deployment system and exact constraints assembly for alignment plus target diagnostics. The Primary Target Chamber has a separate vacuum system protected through dual HEPA filters. Experiments are conducted in a vacuum of 50 millitorr or less. The target is remotely deployed and docked into alignment just prior to the gun firing. The Primary Target Chamber is designed to withstand the loading conditions generated during gun firing and projectile/target impact. The projectile is detected and velocity measured real time during one-meter of free flight; signals are provided to close the explosively driven valves. The Ultrafast Closure Valve is explosively closed in less than 100 ìsec and is triggered while the projectile is still in free flight thus sealing the Primary Target Chamber before contamination can escape into the Secondary Containment Chamber. A gate valve is also provided and closed post shot,

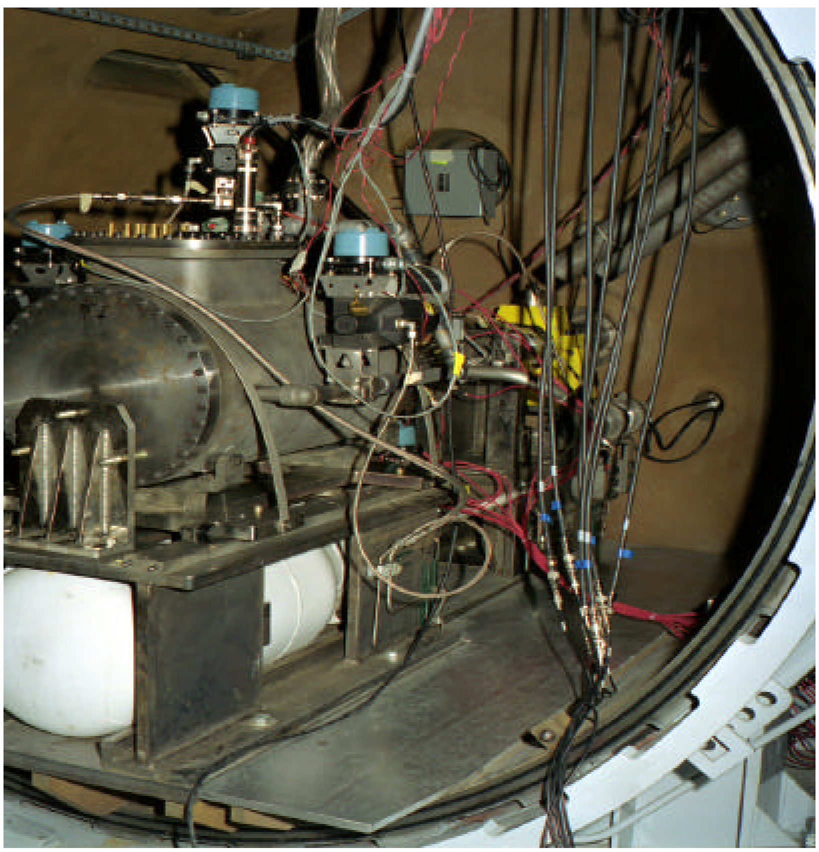

Figure 4 Primary Target Chamber Installed Inside the Secondary Containment Chamber

timing signals for these valves are derived from several sources. We utilize a CW x-ray to detect the projectile as it exits the launch tube and four OBB stations to measure velocity and time-position the projectile in flight.

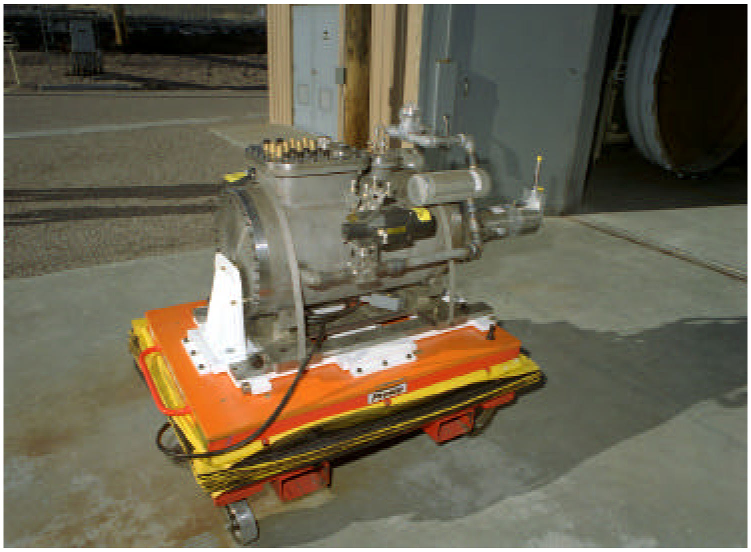

Figure 5: Primary Target Chamber on Its Cart

Timing and Control, and Diagnostic Capabilities:

Diagnostics and Timing and Control data recorded on a typical experiment measure or check the following categories of gun and facility conditions. Just prior to the "fire pulse" the Control System checks these areas for proper operation, the Control System, Facility Alarms,

Figure 6: Control Room

Gun Assembly (interlocks), Run Safe (unmanned area), Secondary Containment Chamber (vacuum, integrity and valve position), Pump Tube Pressure, Gun Diagnostics, Target Diagnostics, Target Docking (alignment), Ultrafast Closure Valve Trigger System, Primary Target Chamber condition (vacuum and valve positions), input optical levels for trigger signals, final instrumentation status and the Firing System are checked and verified. The JASPER Facility has a variety of diagnostic equipment and capabilities. On each experiment these signals are recorded, breech pressure, piston velocity pins 1 – 4, projectile base pressure, Continuous x-ray detection of projectile passage, Optical Beam Break signals (1 – 4), Flash x-rays (two stations), PZT output signal indicating the Ultrafast Closure Valve has fired, target impact and physics data. The following is a list of instrumentation that we are currently using or have on hand.

- Optical Beam Breaks developed for projectile velocity measurements and timing
- 300 KV Scandiflash flash x-rays, 2 channels
- Continuous cw x-ray and 1 MHz detector
- TDS 694c, Digital Oscilloscopes, 20 channels, 10 GHz sampling rate
- TVS 641a, Digitizers, 48 channels, 200 MHz sampling rate
- SR-620, Time Interval Meters, 4 channels
- VALYN VISAR, 7-channels with associated 10 watt Coherent doubled Nd:YAG laser
- In addition, there is the usual set of laboratory measurement equipment, including lower-bandwidth scopes, pulse generators, power supplies, meters, etc.

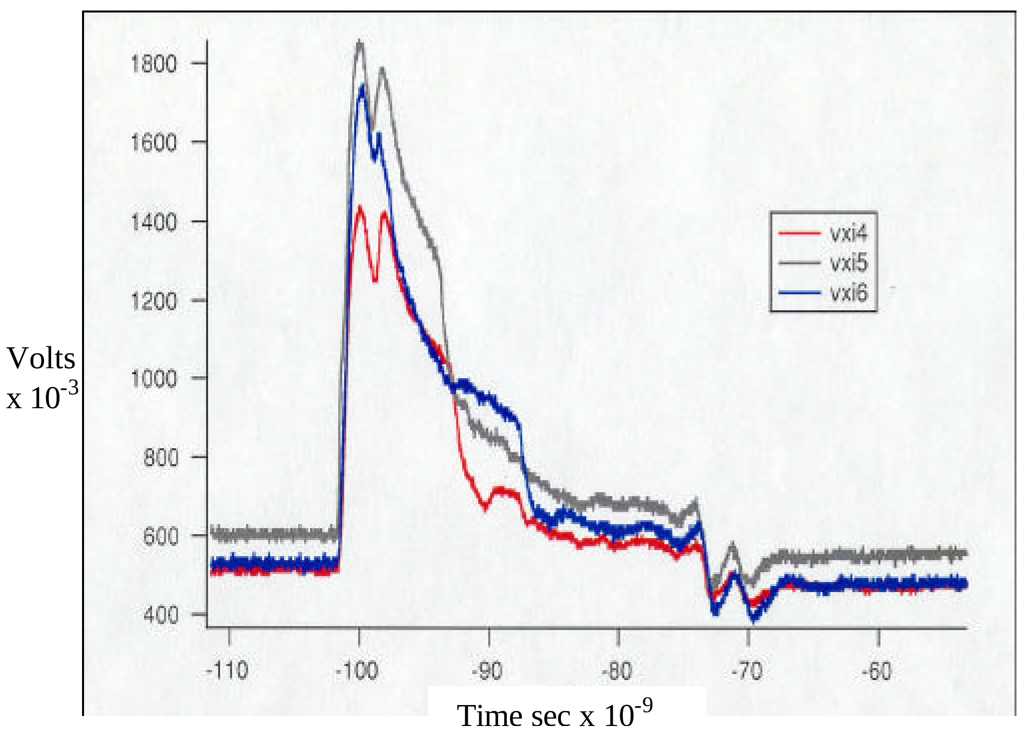

Figure 6: Time of Arrival Pin Data for Tilt and EOS Measurements

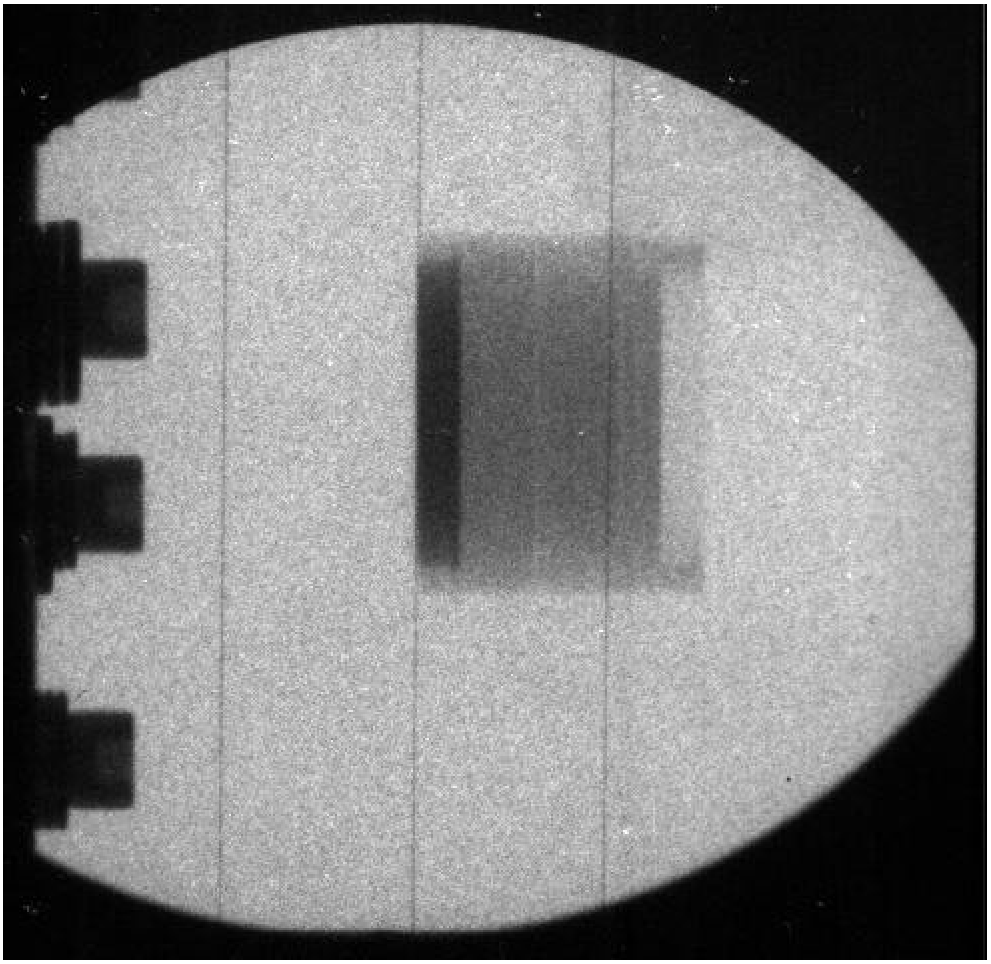

Figure 7: Flash X-Ray of Projectile in Flight

Conclusion:

The JASPER Facility is fully operational. The facility houses a new state-of-the-art Two-Stage Light Gas Gun, and a suite of EOS diagnostic instrumentation, which is also new and up to date. The containment system has been successfully tested. Equation of state data on known material is planned and will be compared to publish data to calibrate the gun and diagnostic systems.

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