U.S. Army
Aberdeen Test Center
Fire Suppression Test Facility
Aberdeen Proving Ground, Maryland

Crew Compartment
Alternate Agent Test Program

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The US Army Aberdeen Test Center (ATC) at Aberdeen Proving Ground, Maryland, is one of the Army's premier test sites for fire suppression testing and evaluation. A wide array of test equipment, instrumentation and facilities **are** employed to conduct carefully controlled, instrumented fire tests involving military equipment, fuels, ammunition and combustible materials for evaluation of various **Halon** alternative extinguishing agents in combating these fires. One of the vehicular test programs underway at ATC is the Crew Compartment Halon Alternate Agent **Program** sponsored by the US Army Tank-Automotive Research, Development and Engineering Center (TARDEC), Warren, Michigan.

TARDEC has spearheaded a number **of** studies to reduce the vulnerability of combat vehicles to explosively-formed fuel-mist (EFFM) fires. **EFFM** fires in combat vehicles result from the dynamics **of** a shape-charge jet **as** it penetrates the outer **wall** of the vehicle, travels **through** and ruptures a portion of the fuel cell, and then breaches the bulkhead separating the fuel cell area from the crew compartment. Fuel vapor, either entrained in the path of the jet and/or forcefully expelled from the ruptured fuel cell, enters the crew compartment and ignites. This process **may** only take milliseconds to materialize, hence TARDEC's push in the 1970's through the 1980's lo develop and field high-speed fire detection and suppression systems capable of detecting and extinguishing **EFFM** fires within **250** milliseconds. Halon 1301, **as** it turn out, is highly effective in combating **EFFM** fires, therefore Halon 1301 systems have **been** installed in many Army combat vehicle crew compartments. With the demise of Halon 1301 **as an** acceptable fire extinguishing agent, TARDEC has recently established the crew companment alternate agent program to test various candidate extinguishing agents in combating EFFM fires.

An effective alternate fire extinguishing agent/suppression system must meet certain survivability and logistical criteria. The agent must not deplete the ozone, and must have relatively low global warming potential and low atmospheric lifetime. Neat agent concentrations required to extinguish the **EFFM** fires must not exceed toxic **levels,** and the thermal/chemical by-products of the agent as it extinguishes the fire must not exceed toxic levels. It must extinguish fires before the threshold for second degree burns for crew members is exceeded. **EFFM** fires develop rapidly and may engulf the entire crew area within tens of milliseconds, therefore rapid dispersion and wide coverage of the agent is necessary in order to mitigate thermal and toxic fumes hazards to crew members. Not only must the agent be effective and non-toxic, but existing, fielded combat vehicles constrain the size, configuration and placement of extinguishing systems. This places an **upper** limit on the total volume of extinguishing agent that can be used inside a fielded vehicle.

ATC personnel have acquired and instrumented an excess, tactical armored vehicleas a **EFFM** fire test bed. Many, but not all of the interior components inside the crew area have been removed, for example the turret basket remains. All stowage items and combustibles have been removed. Viewing ports have **been** cut into the sides of the test **bed** through which video and high-speed cameras view and record the events. Fine-wire thermocouples and heat flux gages are suspended inside the crew compartment to **measure** time versus temperature and time versus energy transients. Infrared sensors have been installed to monitor and record fire intensity levels, and may be used to discharge extinguishing agents upon reaching a predetermined intensity level. Piezoelectric pressure gages are used to measure crew area air pressure during the events. Toxic fumes instrumentation are under development to measure toxic fumes by-products resulting from the decomposition of fluorinated extinguishing agents and the combustion of hydrocarbon fuels.

A ***2.5*** cu. ft., reinforced aluminum fuel tanks have been fabricated from 1/8" thick aluminum sheets. The fuel tank is placed **on** the rear, right **sponson** of the crew compartment. **as** close to the right side wall of the vehicle as possible. 10 gal. of JP-8 fuel, healed lo approximately 150 deg. **F.,** is poured into the tank. A replaceable aluminum armor window has been bolted onto the side of the test bed vehicle adjacent to the fuel cell. **A** shape-charge munition is placed outside the removable window, pointed in the direction of the fuel cell and center of the crew compartment. Initiation of the warhead allows the shape-charge jet to penetrate the wall and fuel cell, initiating the fuel-mist fire inside the crew compartment. Extinguishing agent is discharged based on a predetermined time delay following initiation of the warhead.

Fire suppression testing with shape-charge munitions is ultimately the final test of whether or not an extinguishing system is effective in combating EFFM fires. Unfortunately, tests conducted with shape-charge munitions **are** expensive, time consuming and *destructive*. ATC personnel are developing a ballistic fireball simulator (BFSim) to be used to test candidate fire suppression systems and agents in a more cost effective and less time consuming manner that actual ballistic tests. The BFSim uses high pressure nitrogen gas (up to 1200 psi) to rapidly force hot ***JP-8*** (150 deg. F **plus)** through a small diameter, multi-orifice spray nozzle into the crew area of the test bed vehicle. The spray is started between 1/10 and 1/4 second before being ignited with a high energy spark device. The time between spray start and ignition can be varied, along with the configuration of the nozzle and spray pressure. The crew test bed will be outfitted with the same instrumentation **as** for the ballistic test.

In general, the BFSim generated fire does not develop as rapidly as the EFFM fire and may not be as intense. Never-the-less, the BFSim **will** provide a relatively inexpensive, flexible and fast means by which various candidate extinguishing agents and systems can undergo preliminary testing against fuel-mist fires.

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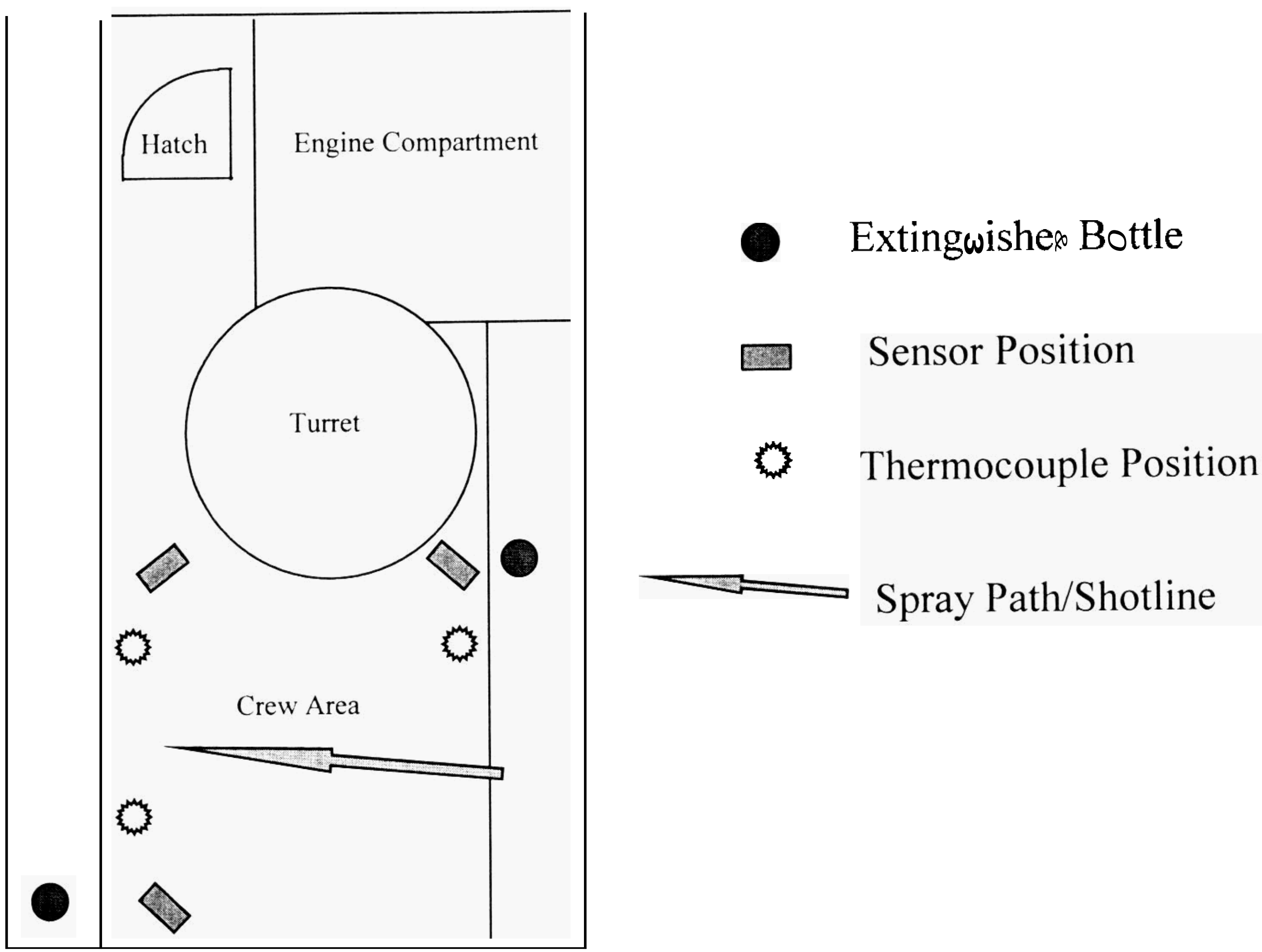
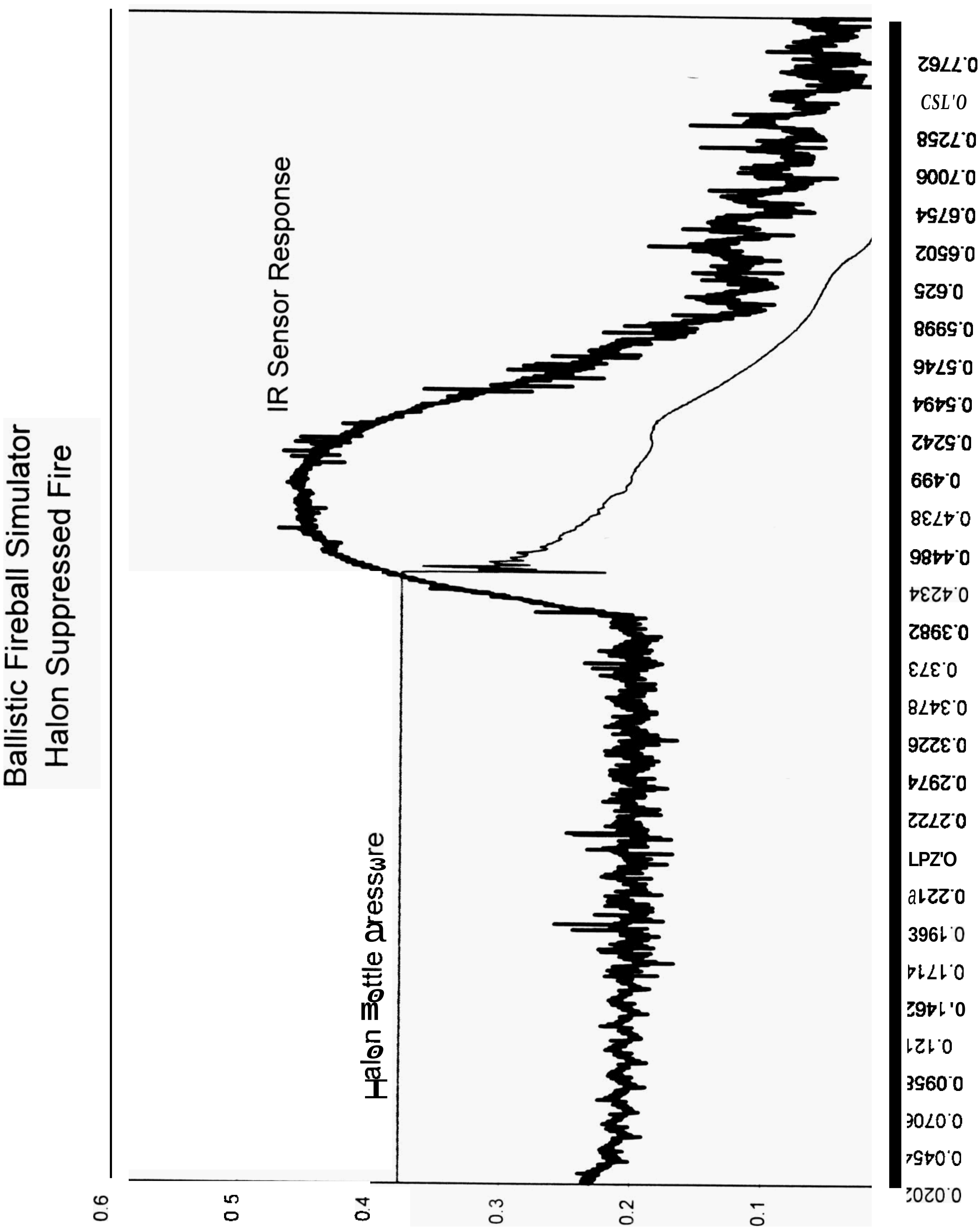
Crew Compartment (not to scale)





Ballistic Fireball Simulator
Halon Suppressed Fire
IR Sensor Response
Halon Bottle Pressure
0.6
0.5
0.4
0.3
0.2
0.1
0.0202
0.0454
0.0706
0.0958
0.121
0.1462
0.1714
0.1966
0.2218
0.2722
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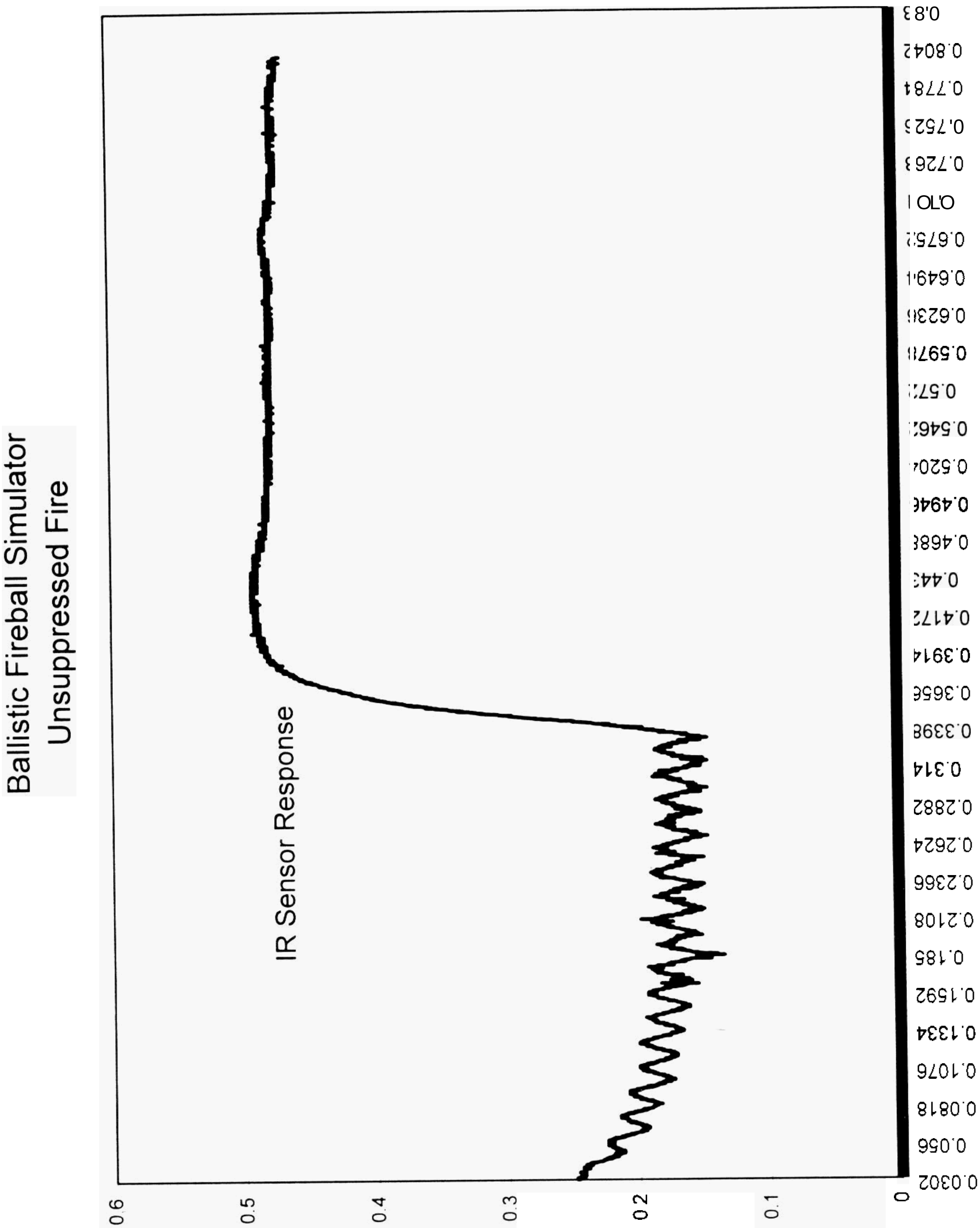
Ballistic Fireball Simulator
Unsuppressed Fire
IR Sensor Response
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0302
0.056
0.0818
0.1076
0.1334
0.1592
0.185
0.2108
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0.2624
0.2882
0.314
0.3398
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0.5204
0.5462
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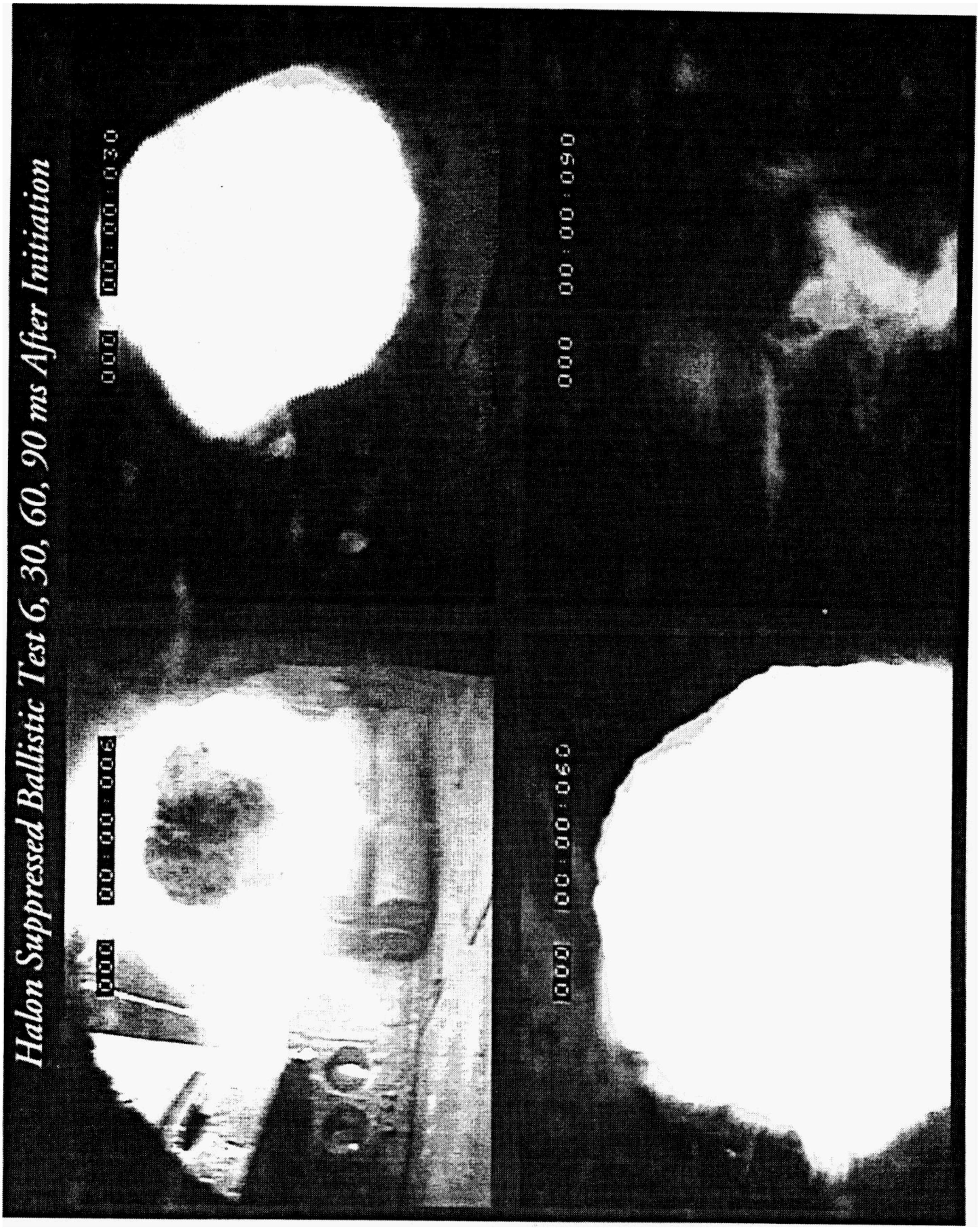
0.83


Halon Suppressed Ballistic Test 6, 30, 60, 90 ms After Initiation
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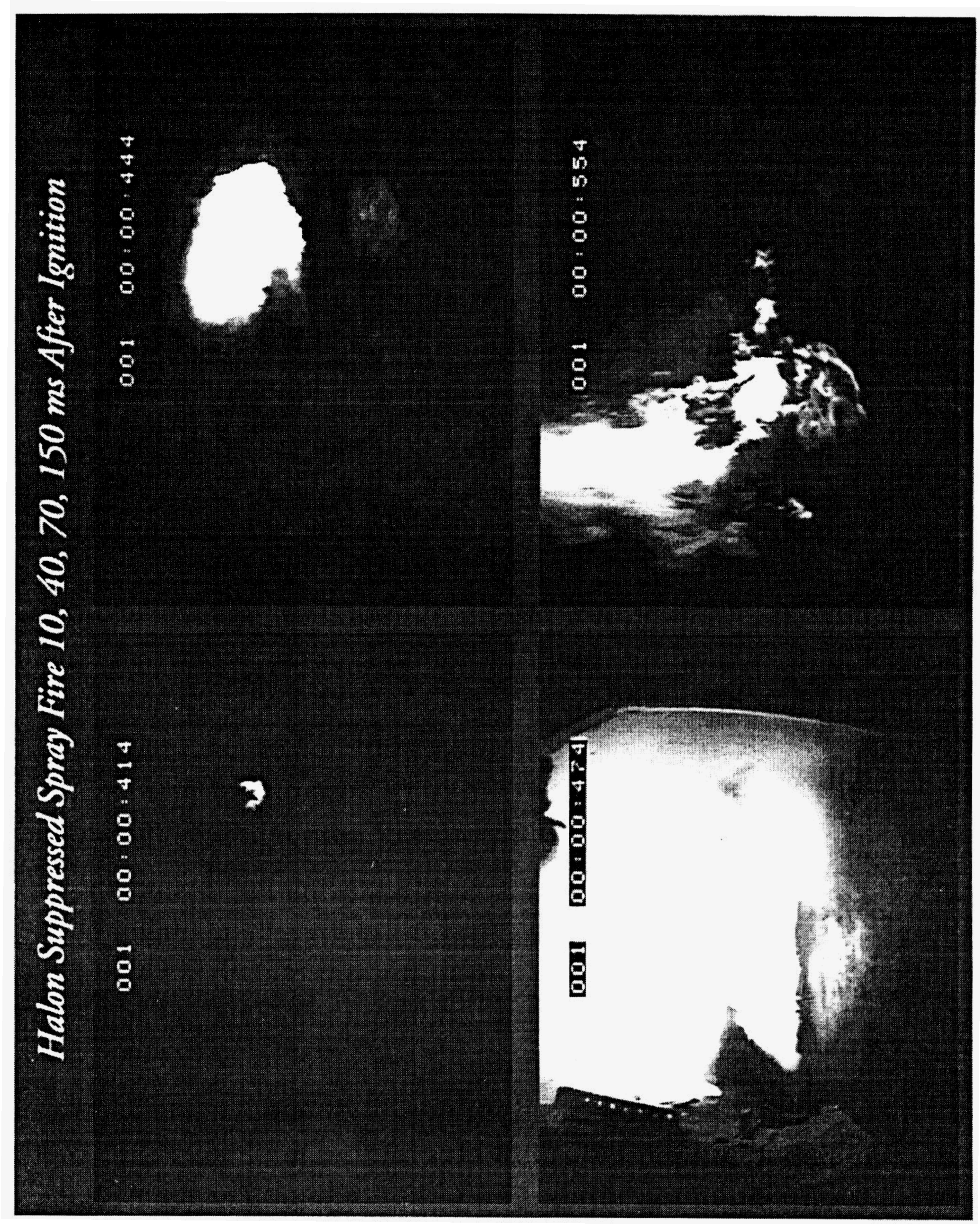
000 00:00:030
000 00:00:060
000 00:00:090


Halon Suppressed Spray Fire 10, 40, 70, 150 ms After Ignition
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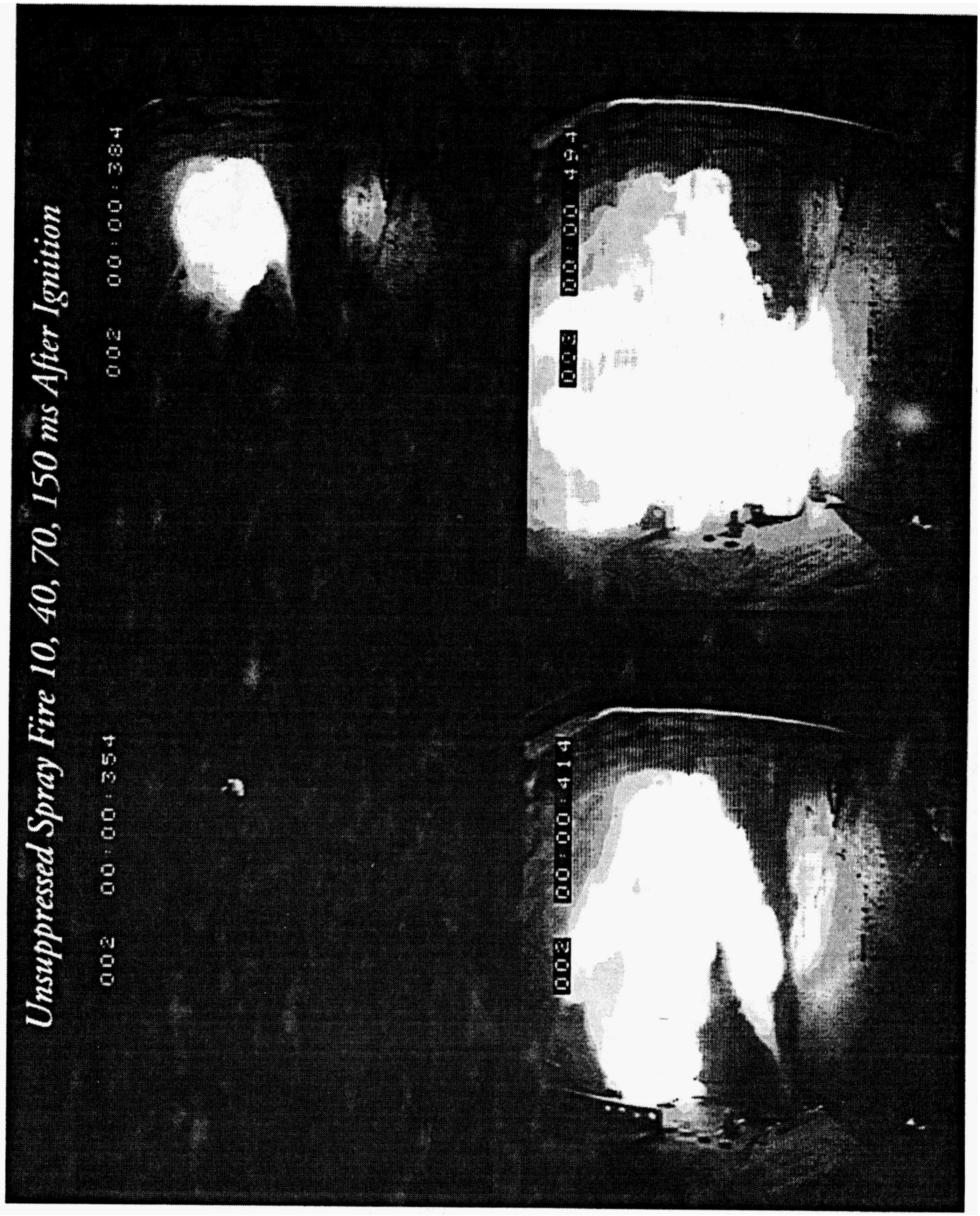
001 00:00:444
001 00:00:474
001 00:00:554


Unsuppressed Spray Fire 10, 40, 70, 150 ms After Ignition
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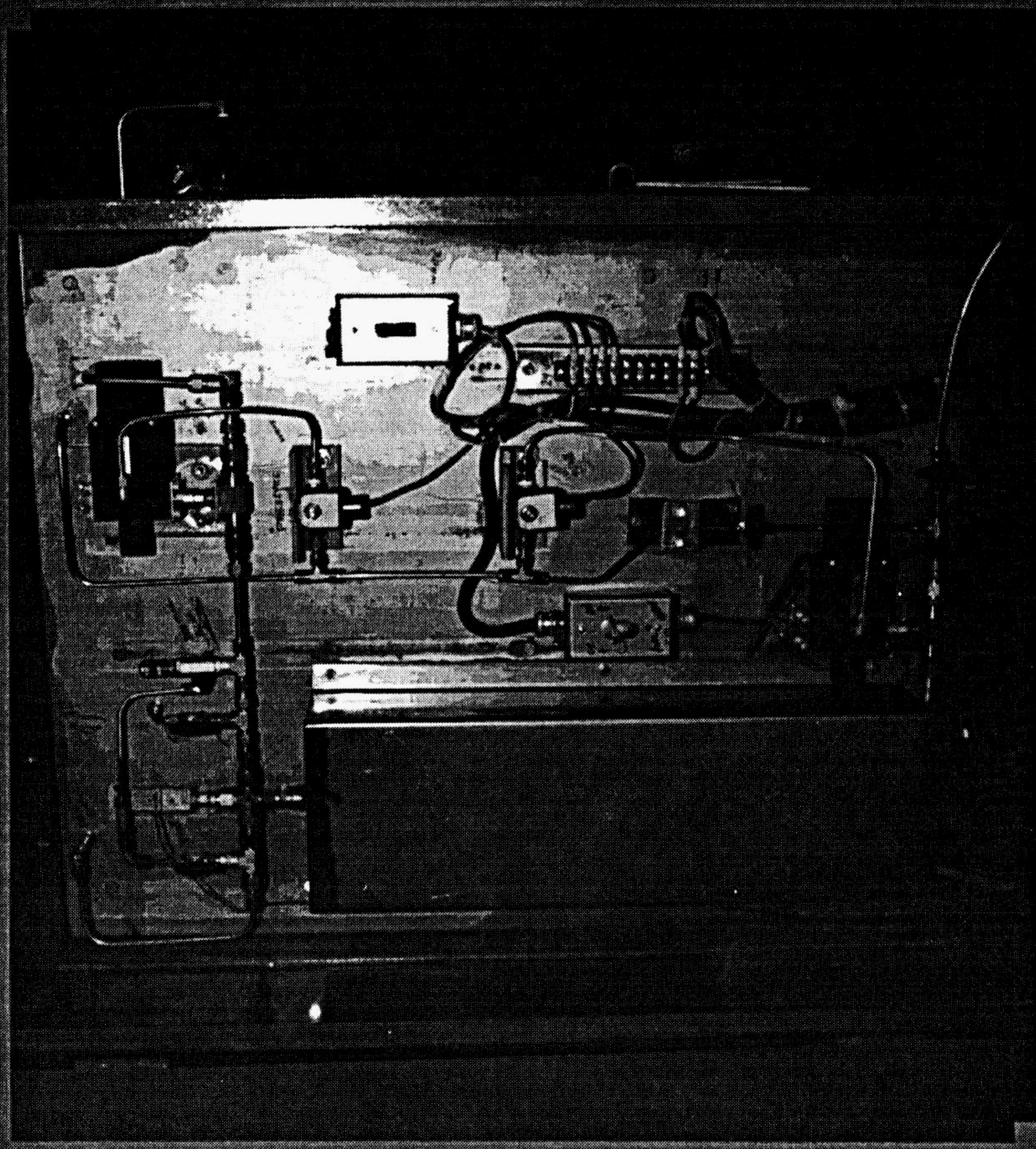
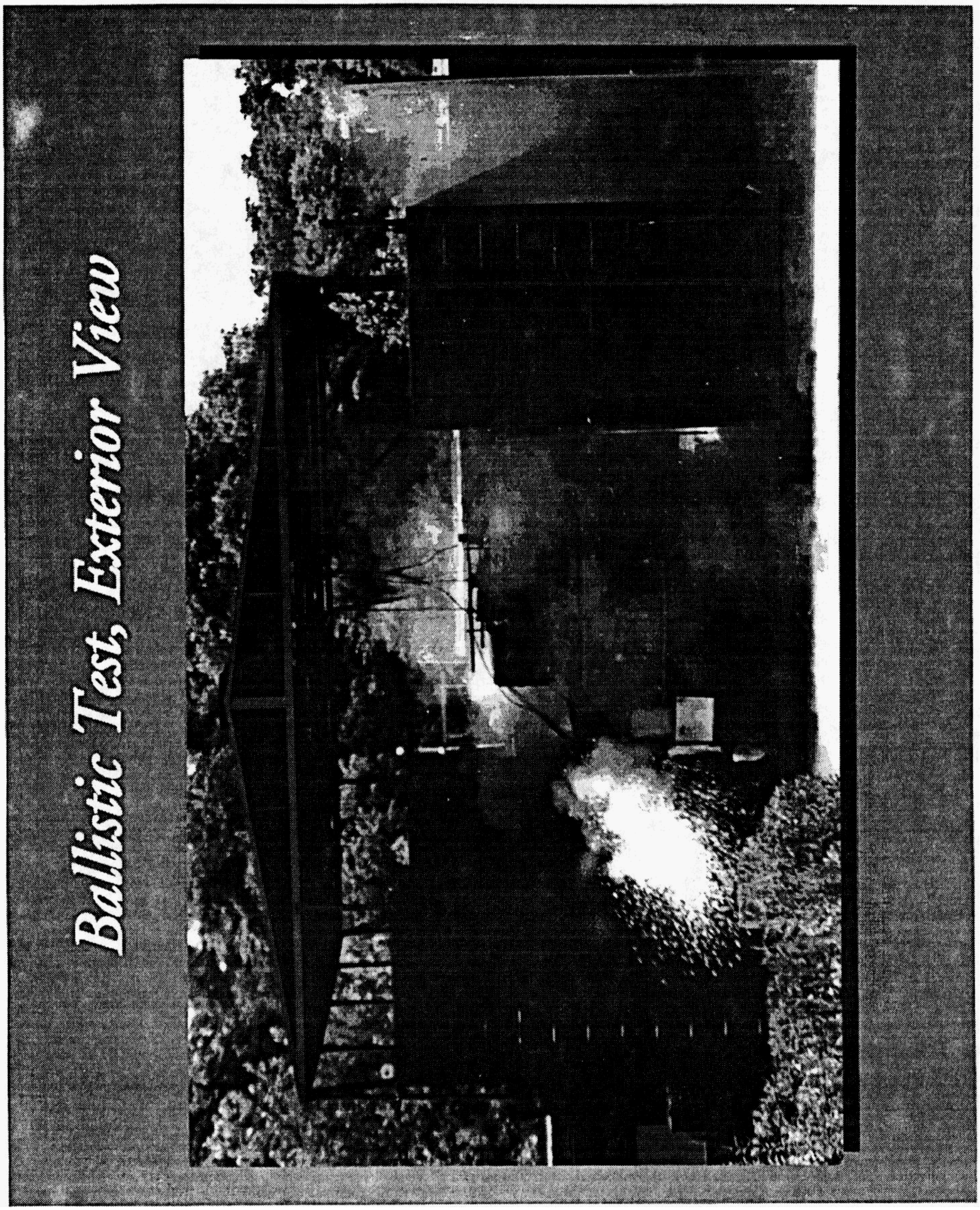
002 00:00:384
002 00:00:414
002 00:00:494

Ballistic Fireball Simulator Apparatus




Ballistic Test, Exterior View