PLUM BROOK

MOTION PICTURE SCRIPT

#2 Script

Intro - 30 s

The need for a testing station remote from Cleveland became evident in the mid 1950's. A testing station for potentially hazardous work including reactors was required to provede safety for both the public and personnel associated with the research efforts. This need led to the establishment in 1956 of an auxiliary facility now called the Plum Brook Station.

P-1 40 s

The Plum Brook Station is located on a site 4 miles south of Sandusky, Ohio which is on the shores of Lake Erie. Sandusky is approximately 50 miles from Cleveland. In contrast to Cleveland's 400 acres, the Plum Brook Station includes 6500 acres. Due to the size of the station and the precautions taken, large scale operations can be safely conducted with nuclear reactors, hydrogen, and fluorine systems. The land occupied by the NASA Plum Brook Station was acquired from the Army through a gradual lease and then transfer process.

P-1A 17 s

The Army had established a TNT manufacturing plant during World War II on the farm acerage that included a small stream named Plum Brook. As will be illustrated, many changes have been made since those days to accomplish NASA's mission.

P-2 0 time	Omit
P-3 30 s	An unused power plant building left from Army Ordnance days was renovated to provide space for testing hydrogen propellant tanks.
P-3A	In the chamber liquid hydrogen rocket fuel tanks up to 18 feet in diameter can be tested. During tests vacuum conditions are maintained and a 10,000 pound actuator is used to shake the rocket fuel tanks. Expulsion and storage characteristics of the tanks are investigated.
P-4 10 s	A large dynamic stand was found necessary to make ground tests of the Atlas-Centaur-Surveyor combination.
P-4A 15 s	An Atlas booster was mounted on the stand and NASA engineers used a complicated system of stanchions and cables. These cables apply forces similar to those encountered during an actual Atlas-Centaur mission.
P-4B 11 s	Above the booster, a Centaur test vehicle was mated to the Atlas followed by a dynamic test model of the Surveyor spacecraft on top of the Centaur.

P-4
29 s

The 130 foot stand is equipped with an electromagnetic shake device to simulate aerodynamic forces encountered on lift-off of the rockets.

Information obtained from testing here at Plum Brook provided design criteria for latching mechanisms used in the Surveyor. The simulated wind loads tests showed that the buckling that takes place in flight actually increases the strength of the Atlas-Centaur combination.

P-4C
new
13 s

Due to the prevailing wind conditions at Cape Kennedy on May 30, 1966 the Surveyor would not have been fired if this strength increase had not been discovered earlier at Plum Brook.

P-5
19 s

At the liquid hydrogen pump site pumps of various designs can be tested at speeds to 25,000 revolutions per minute. Liquid hydrogen is supplied to the pump via 14,000 gallon truck dewars and also from 34,000 gallon railroad dewars.

P-5A
14 s

Experimental results to date for centrifugal pumps show that new design methods give improved pump performance. Information obtained here will be used for both chemical and nuclear propulsion.

P-6
25 s

A heat transfer facility at Plum Brook provides the capability of testing nuclear rocket nozzles and components. The facility's heat exchanger will supply hot hydrogen gas that will simulate temperatures normally encountered in a nuclear rocket reactor. Hydrogen gas will be supplied from high capacity, high pressure tank cars.

P-6A
45 s

The heat exchanger is fifty feet below ground level and the exhaust tank is 88 feet high. When it becomes operational, hydrogen will be passed over a bed of carbon balls that are induction heated. The carbon balls will transfer heat to the hydrogen. 57,000 cubic feet per second of hydrogen gas at 4000° R will be supplied to the test section. The velocity of the gas will be 12,000 feet per second. Following tests with the rocket nozzles in the test section, it is planned to use this facility as a hot gas supply for hypersonic aerodynamic research - another area of prime concern for NASA.

P-7
30 s

In the 26 million dollar space propulsion facility are a cylindrical tank (center), shops (right), cryogenic equipment (left) and office space (front).

The heart of the facility is the cylindrical tank 100 feet in diameter by 120 feet high. Inside, temperature conditions at altitudes up to 100 miles above the earth will be produced. The simulation of this environment in a tank of such tremendous size will provide a needed and safe capability for the country.

P-8
20 s

Reinforced concrete six feet thick will surround the vacuum chamber and the space tank to provide shielding and protection against nuclear radiation. The facility was designed for NASA by Kaiser Engineers Division of the Kaiser Company in California. Facility completion is expected in 1967.

P-8.1
15 s

The SNAP 8 reactor and its associated system,

P-8

solar power generation equipment and liquid metal loops will be tested inside the space tank.

P-8.2
15 s

A new research facility is also being constructed to test space vehicles and upper stage rocket engines. Vacuum startup tests for chemical rocket engines using new fuels will be possible.

P-8A
40 s

As mentioned, efforts directed to nuclear rockets are also conducted at Plum Brook. In a nuclear rocket, liquid hydrogen stored in a tank at -430° F, is passed through a pump to increase its pressure. Nuclear energy in the reactor heats the flowing hydrogen and the expansion of the hydrogen in the nozzle produces the thrust to propel the vehicle. Understanding of the dynamic transient characteristics of an engine and some of the more important subsystems such as the propellant feed system are important to the success of the nuclear rocket and other improved engine systems.

P-9 In this effort extensive use has been made of these two dynamic
55 s engine simulation stands.

The one on the left, B-1, has been used for investigations on turbopumps, fluid instabilities in the engine flow passages, and equipment performance evaluations.

The one on the right, B-3, is a 200 foot high facility used for nonnuclear simulation tests with hydrogen such as will be needed for interplanetary travel.

The ejector system, used to obtain altitude test conditions, is common to both these facilities and also to the Heat Transfer Facility that we saw earlier.

The hydrogen used is burned off using the stack. In this B-3 facility a liquid hydrogen tank is located in the top of the tower.

P-9A This tank contains 46,000 gallons of liquid hydrogen. When the
70 s valve is opened during a run, hydrogen flows through the pipe to the research pump and turbine. After passing through the outer nozzle walls for cooling, it is ducted to the top and through the non fueled reactor. After exiting through the nozzle, it goes to the stack where it is burned.

The components such as the pump, the simulated reactor and nozzle are arranged in a close coupled configuration. Thus the heat transfer, flow and dynamic interaction effects of the different components found here simulate a flight-type nuclear rocket engine system during the early part of a startup.

Using a MARK IX turbo pump, a nonfueled Kiwi reactor, and a modified nozzle, tests were run to see if the system would bootstrap. Bootstrap is the term used to describe the startup of an engine flow system when no external power is supplied to the system.

P-9B
33 s

A series of cold flow tests has verified the altitude bootstrap capability of this nuclear rocket system. These tests showed that the pump pressure would rise at the low flow rate conditions and the system, although in the stall region for a time, would achieve the 10,000 rpm design condition. On the basis of these results at Plum Brook confidence was gained prior to investigations with a real nuclear rocket reactor system that were made at the Nuclear Rocket Development Station in Nevada.

P-10
20 s

Investigations using a fueled nuclear reactor are also made at Plum Brook. The heart of the 15 million dollar facility, the reactor, is housed within the cylindrical dome. This 3/4" containment shell is one of the more impressive safeguards used against accidental release of radioactivity.

P-11-3 Operation of the reactor requires cooling water to flow through
11 s it. This water, heated by the reactor, gives up its heat to a secondary water system.

P-10 The secondary water, not in contact with the reactor, is piped
46 s underground, and dissipates its heat to the atmosphere in the cooling tower.

Water and any air vented to the atmosphere are carefully measured for radioactivity. Only after assurance that there is no hazard, are they released at the reactor site.

The assembly test and storage building located near the reactor building provides space needed for assembly and pre-irradiation testing of large experiments prior to their being placed into the Plum Brook Reactor.

Adjacent to the reactor building and connected to it by water canals, the hot laboratory complex allows remote handling of experiments after irradiation in the reactor.

P-8A In nuclear rocket systems, the advanced technology relies heavily
37 s on chemical rockets because of common problems. Thus both chemical

and nuclear systems require a tank, pumps, turbine, and a nozzle. The energy process used - chemical or nuclear - is the basic difference. In a nuclear system the effects of radiation on a material - predicted by the pioneer E. P. Wigner - must be determined. The combination of tank and pipe materials at -430° F and a reactor has to be checked for the effect on the material.

P-11-1
15 s

To investiage such effects small cylindrical test specimens are used at Plum Brook. These specimens have threaded ends to grip and pull them to determine their strength. Measuring apparatus is used to evaluate elongation during pulling.

P-11-2
20 s

The test specimen is placed at the forward end of a piece of equipment called a cryostat which maintains the specimen at low temperature and contains the gripping and pulling apparatus. The operations for this experiment are conducted by Lockheed Aircraft under contract to NASA.

P-11-3
20 s

After the specimen is placed in the cryostat, the cryostat is placed in a test hole in the Plum Brook Reactor where it is bombarded by radiation. Many other experiments can also be run simultaneously using the fifty odd test holes available in the reactor.

P-11-4
28 s

While the test specimen is being irradiated, refrigeration equipment (shown on the right) maintains it at 430° F below zero even though the specimen is subject to the intense heat from the reactor. Measurements and readings of the strength are taken with equipment (to the left) while the reactor is running. It was found that the ductility of an aluminum alloy decreased ______% after exposure to irradiation while at the low temperature.

P-11-5
20 s

After irradiation the cryostat is removed and may be taken inte the hot laboratory through the containment shell. A cask is used that encloses the radioactive cryostat. The shielding provided by the cask permits personnel to come very close to the cask without any hazard from the radiation.

FC-2
40s

In the hot laboratory, the radioactive cryostat is placed behind thick shielding walls made of dense concrete. The operator is protected from the radioactivity stemming from the cryostat. Using remote manipulators that lead through the thick walls the operator may disassemble the cryostat to remove the tested specimen and insert a new one. Skilled operators using special tools and leaded glass windows can perform the same functions remotely that ordinarily would be done by a mechanic working with hand tools.

P-11A Other experiments at the reactor include tests on nuclear rocket
10 s components, (63-05)

P-11B and insulators for use with nuclear thermionic diodes. (63-10)
7 s

P-7 The Space Propulsion Facility, in the future, will house a com-
13 s plete SNAP-B system including a reactor. The activation of the concrete material used around the tank had to be determined.

P-11C Concrete specimens (64-04) were placed in one of the test holes
8 s of the reactor to make this determination.

P-11D Investigations on thermal conductivity of fuel have been made
11 s using thermocouples to measure temperature (63-02) while the specimen is inside the reactor.

P-11-3 These efforts in the Plum Brook Reactor augment other research
10 s and development efforts that are conducted at the Lewis Research Center in Cleveland.

Summary 30 s	In summary it is seen that the Plum Brook Station provides capability for investigations:
P-3	on tanks for cryogenic propellants,
P-4	dynamics testing,
P-5	pumps,
P-6	heat transfer,
P-9A	controls interaction,
P-8	will provide capability for assessing space effects on power generations systems,
P-11-3	and different experiments using the reactor.

END PB MOVIE

Transition	The Plum Brook Station is administered by the Lewis Research Center in Cleveland. The Lewis Research Center also houses a branch of the Space Nuclear Propulsion Office.

The Space Nuclear Propulsion Office or SNPO is a joint organiation of the Atomic Energy Commission and the National Aeronautics and Space Administration. The SNPO has the responsibility for the management of the development of nuclear rocket propulsion systems in both agencies. The Cleveland extension of SNPO is responsible for the technical and administrative direction of the NERVA program. NERVA is an acronym for Nuclear Engine for

Rocket Vehicle Application. SNPO-C has been assigned responsibility for the NERVA activities of Aerojet General Corporation and its subcontractors, the design of test facilities at the Nuclear Rocket Development Station required for NERVA, and related research and development activities.

The Cleveland extension of SNPO maintains liaison with the Lewis Research Center of NASA which, as a part of its nuclear rocket activities, lends support in nonnuclear areas to the NERVA program.

P-12
20 s

Some of this support has been illustrated by efforts being conducted at the Plum Brook Station near Sandusky. Much of the SNPO activities are conducted at the Nuclear Rocket Development Station. The Nuclear Rocket Development Station is located in the southwestern corner of Nevada near Los Vegas.

FC-3
12 m

NRDS movie