ROCKET ENGINE TEST FACILITY – GRC BUILDING No. 205 HAER No. OH-124-B
(Rocket Propulsion Test Facility-Propellant Transfer and Storage Area Building 205)
NASA Glenn Research Center
Cleveland
Cuyahoga County
Ohio

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

REDUCED COPIES OF MEASURED DRAWINGS

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Great Lakes Support Office
1709 Jackson Street
Omaha, Nebraska 68102

February 27, 2003

HISTORIC AMERICAN ENGINEERING RECORD

ROCKET ENGINE TEST FACILITY – GRC BUILDING No. 205
(Rocket Propulsion Test Facility – Propellant Transfer and Storage Area Building 205)

HAER No. OH-124-B

Location: NASA Glenn Research Center
Cleveland
Cuyahoga County
Ohio
UTM: 17.427550.4584040

Quadrangle: Lakewood, Ohio 1:24,000

Date of Construction: ca. 1962-65

Engineers: H. K. Ferguson Company

Present Owner: National Aeronautics and Space Administration – Glenn Research Center

Present Use: Excess equipment storage.

Significance: The Rocket Engine Test Facility Complex is a National Historic Landmark, and Building 205 is included in the description of the site on the National Historic Landmark nomination form. Building 205 is located approximately 170' northeast of the Rocket Engine Test Cell in Building 202. The significance of Building 205 lies in its relationship to the entire reactant distribution system for the Rocket Engine Test Facility. Building 205 housed a compressor and automated control system used to pressurize gaseous helium to 6,000 pounds per square inch (psi) for distribution throughout the complex. Compressed helium was used as the energy source to pump liquid oxygen into rocket engines during testing. Building 205 was constructed ca. 1962-65.

Project Information: This documentation was initiated on May 15, 2002, in accordance with a Memorandum of Agreement among the Federal Aviation Administration, National Aeronautics and Space Administration (NASA), The Ohio State Historic Preservation Officer, and the Advisory Council on Historic Preservation. The City of Cleveland plans to expand the Cleveland Hopkins International Airport. The NASA Glenn Research Center Rocket Engine Test Facility, located adjacent to the airport, must be removed before this expansion can be realized. To mitigate the removal of this registered National Historic Landmark, the National Park Service has stipulated that the Rocket Engine Test Facility be documented to Level I standards of the Historic American Engineering Record (HAER). This project was initiated to fulfill that requirement.

Historian: Robert C. Stewart Historical Technologies, West Suffield, Connecticut

Description:

Building 205 is located approximately 170' northeast of the Rocket Engine Test Cell in Building 202. The single-room, one-story structure covers a surface area of about 1,710 square feet. The light construction consists of framing made of pipe uprights welded to channel iron cross members. Light I-beams support the roof. Opaque fiberglass panels form the exterior walls, while translucent fiberglass panels cover the gabled roof and admit natural light into the building interior. Sheathing has been removed from the front of the building. Building 205 is a purely functional building devoid of any ornamentation. The significance of this building lies in its relationship to the liquid oxygen distribution system for the Rocket Engine Test Facility.

Function:

The Rocket Engine Test Facility did not use conventional electrically driven centrifugal pumps to deliver liquid oxygen to the test cell. The safe handling and transport of liquid oxygen posed special problems, since this substance boils at –183°C and specialized pumps and piping materials are needed to safely transfer it from one vessel to another. With its low boiling point, significant evaporative losses can occur during transfer. At the Rocket Engine Test Facility, liquid-nitrogen-filled jackets surrounding the major pipes minimized the loss of liquid oxygen. With a boiling point of –195.8°C, the liquid nitrogen in the pipe jackets prevented the liquid oxygen from boiling, and thereby minimized evaporation.[1] Losses of liquid nitrogen were inconsequential in their impact on accurate test results, but as a reactant in the test engines, the liquid oxygen had to be carefully measured to obtain valid test data. The liquid oxygen tank in the Building 202 oxidant pit was also jacketed in a bath of liquid nitrogen.[2]

When the Rocket Engine Test Facility complex was built in 1957, commercially available mechanical pumps for handling cryogenic fluids were not ideally designed for forcing liquid oxygen at high flow rates into rocket engines during testing. To overcome the problems inherent in pumping liquid oxygen directly, the designers developed an indirect pumping system. The system used pressurized gaseous helium to transfer the pumping energy of electrically driven compressors to the liquid oxygen supply system. Building 205 housed the compressor and automated control system used to pressurize helium gas to 6,000 psi for use in pumping liquid oxygen.

The compressor in Building 205 pressurized the helium, which was then piped to the liquid oxygen tank in the Building 202 oxidant pit. An inlet at the top of the main liquid oxygen tank connected it to the gaseous helium supply system. The inlet to the liquid oxygen outlet pipe was located below the level of liquid oxygen in the tank. Control valves admitted pressurized helium at 4,000 psi with a flow rate of up to 3.5 pounds per second into the tank. The pressurized helium

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[1] John H. Perry, ed., *Chemical Engineers' Handbook* (New York: McGraw Hill Book Company, Inc., 1959), 111.

[2] Drawing No. CF-101233 – 12/14/55.

pushed the liquid oxygen into the outlet pipe and out to the test rig at the rate necessary to obtain the engine's maximum thrust.[3]

History:

The structure currently known as Building 205 was not part of the original 1955-57 Rocket Engine Test Facility construction phase. Building 205 does not appear in a 1957 photo of a Rocket Engine Test Facility scale model that represented the facility as originally constructed. The model shows a series of large outdoor metal tanks and a small compressor or other piece of equipment just south of the current site of Building 205.[4] A 1962 aerial photograph of the Rocket Engine Test Facility shows outdoor tanks and a tanker truck on the site of Building 205.[5] The current Building 205 appears, however, on aerial photographs of the Rocket Engine Test Facility dating to 1965 and 1971.[6] Original construction drawings could not be found for Building 205, possibly because it is a small prefabricated shed.

Building 205 supported Rocket Engine Test Facility operations until the entire facility was deactivated in 1995. Fiberglass cladding has been removed from the main (east) elevation of the building, and the original equipment has been removed from the interior. Building 205 is currently used for surplus equipment storage. The Rocket Engine Test Facility complex, including Building 205, is scheduled for demolition to make way for the expansion of Cleveland Hopkins International Airport.

Conclusion:

The Rocket Engine Test Facility oxidant distribution system was an ingenious solution that used simple, proven technology to transfer liquid oxygen at controlled flow rates into test engines that required large amounts of oxidant for short periods. In conjunction with the load cells that weighed the liquid oxygen, this distribution system also enhanced the accuracy of gravimetric measures of the flow rate and total usage of oxidant during a test. Building 205 played a key role in the operation of this system from its construction ca. 1962-65, until the Rocket Engine Test Facility closed in 1995.

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[3] Drawing No. CE-101632 – 8/16/55.

[4] NASA Photo Number C-45264 (1957).

[5] NASA Photo Number C-60674 (1962).

[6] NASA Photo Numbers C-65-1270 (1965), C-65-1271 (1965), and C-71-3283 (1971).

Sources of Information/Bibliography

A. Engineering Drawings:

NASA Lewis Research Center – Cleveland, Ohio 44135
Facility Plan and Equipment Layout
RETF Area Master Plan S-40 – Drawing No. CF 101539 – 2/03/84

NASA Lewis Research Center – Cleveland, Ohio 44135
High-Pressure Propellant System for Rocket Engine Test Facility
Oxygen System Schematic Diagram
Drawing No. CF-101233 – 12/14/55

NASA Lewis Research Center – Cleveland, Ohio 44135
Rocket Engine Test Facility
Oxidant Tank Details
Drawing No. CF-101632 – 8/16/55

B. Interviews:

Repas, George, Hardware Design Engineer
Interview by the author, 15 November 2002
West Suffield, Connecticut, Telephone interview, Hardlines Design Company, Columbus, Ohio

C. Secondary Sources:

Butowsky, Harry. "Rocket Engine Test Facility, National Register of Historic Places Nomination." Washington, D.C.: United States Department of the Interior, National Park Service, 1984.

Dawson, Virginia P. "Rocket Propulsion Research at Lewis Research Center," 28th Joint Propulsion Conference AIAA/SAE/ASME/ASEE, July 6-8, 1992, AIAA-92-31230. NASA Contractor Report 189187.

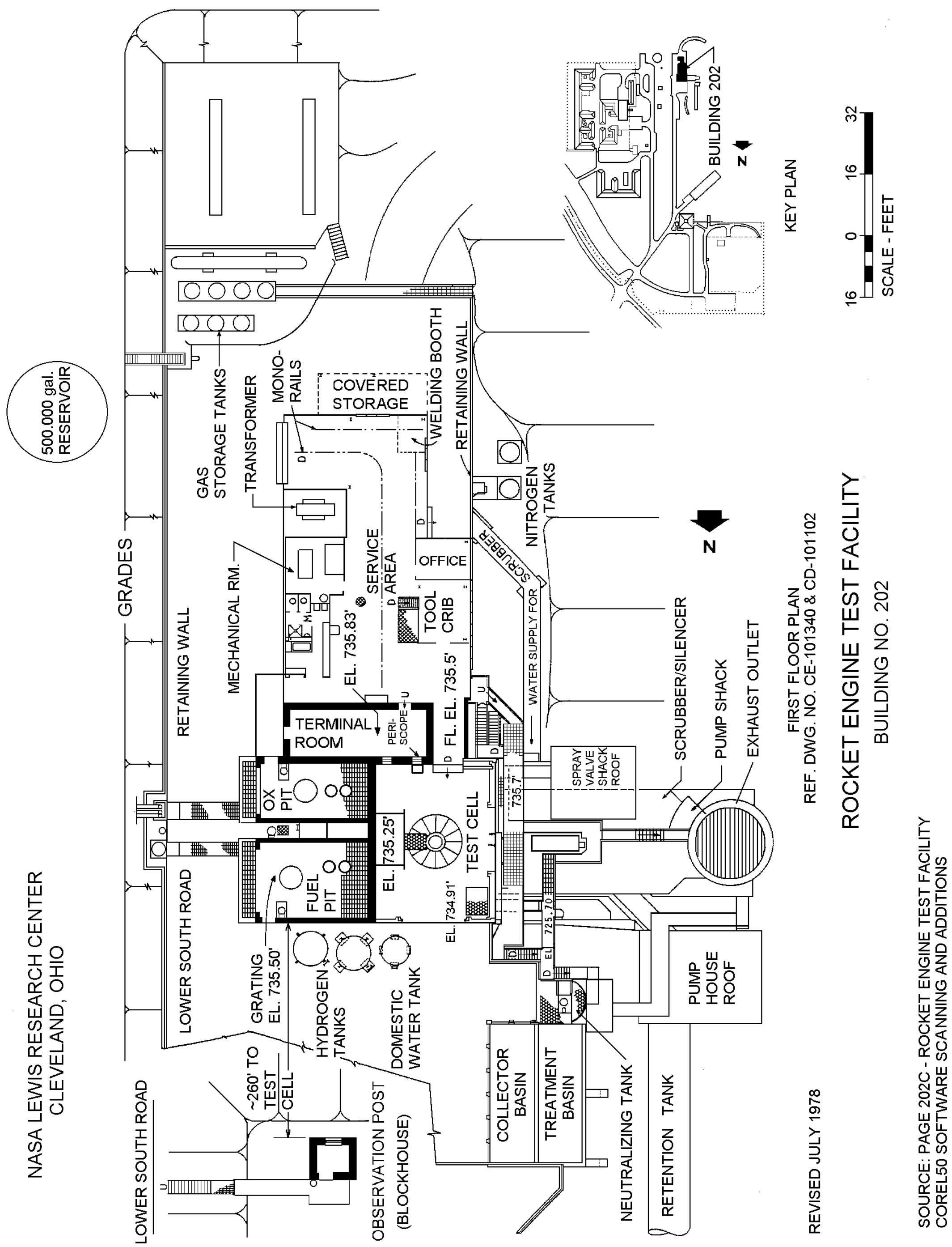
National Aeronautics and Space Administration. "Historic Photographs of the Rocket Engine Test Facility, 1955-1995." On file at NASA Plumbrook Research Center, Sandusky, Ohio.

Perry, John H., Ph.D., ed. *Chemical Engineers' Handbook*. New York: McGraw-Hill Book Company, 1950.

Sloop, John. *Liquid Hydrogen as a Propulsion Fuel.* Washington, D.C.: NASA Special Publications No. 4404, 1978.

Thomas, Wayne. "Description of the Rocket Engine Test Facility." Cleveland: Lewis Research Center, 1984.


427510 Blockhouse
427550 Buildings 205 and 206
4584075 Building 206
4584080 Blockhouse
Building 205 4584040
BM 759
RIVER EDGE
BROOK PARK RD
ROCKY
640
NASA-Glenn Research Center
Radio Tower
Tank
CLEVELAND
INTERNATIONAL
AIRPORT
750
770
Rocket Engine Test Facility Control Room Building 100
Blockhouse
206
205
Rocket Engine Test Facility Building 202
N
Location Map - Rocket Engine Test Facility
Ancillary Buildings
GRC Buildings 205, 206 and Blockhouse
USGS Lakewood, Ohio Quadrangle 1:12500


NASA LEWIS RESEARCH CENTER
CLEVELAND, OHIO
500.000 gal. RESERVOIR
GRADES
RETAINING WALL
LOWER SOUTH ROAD
GAS STORAGE TANKS
TRANSFORMER
MONO-RAILS
COVERED STORAGE
WELDING BOOTH
RETAINING WALL
MECHANICAL RM.
SERVICE AREA
OFFICE
TOOL CRIB
EL. 735.83'
FL. EL. 735.5'
TERMINAL ROOM
PERI-SCOPE
NITROGEN TANKS
SCRUBBER
WATER SUPPLY FOR
OX PIT
FUEL PIT
TEST CELL
EL. 735.25'
EL. 734.91'
735.7'
725.70
SPRAY VALVE SHACK ROOF
SCRUBBER/SILENCER
PUMP SHACK
EXHAUST OUTLET
PUMP HOUSE ROOF
GRATING EL. 735.50'
HYDROGEN TANKS
DOMESTIC WATER TANK
~260' TO TEST CELL
OBSERVATION POST (BLOCKHOUSE)
LOWER SOUTH ROAD
COLLECTOR BASIN
TREATMENT BASIN
NEUTRALIZING TANK
RETENTION TANK
REVISED JULY 1978
FIRST FLOOR PLAN
REF. DWG. NO. CE-101340 & CD-101102
ROCKET ENGINE TEST FACILITY
BUILDING NO. 202
N
BUILDING 202
KEY PLAN
16 0 16 32
SCALE - FEET
SOURCE: PAGE 202C - ROCKET ENGINE TEST FACILITY
COREL50 SOFTWARE SCANNING AND ADDITIONS
BY R.C. STEWART - NOVEMBER 2002

RETF PRESSURE VESSEL LIST

REF LTR	SERVICE	No OF VESSELS	WORKING PRESSURE (PSIG)	CAPACITY	WATER VOLUME	VESSEL DWG No	PRIMARY RETF SYST DWG No	REMARKS
A	GH_2	6	4000	389,388 SCF	1431 FT^3	CF622676 &7	CF620915 CF623224	4K H_2 BOTTLE FARM
B	GN_2 GH_2 GHe	3	6000	290,012 SCF	900 FT^3	CF622417	CR622663	6K BOTTLE FARM
C	LH_2	1	1500	1,309 GAL	175 FT^3	CE79784	CF621961 CF623224	RUN TANK
D	LH_2	1	5000	995 GAL	133 FT^3	CE101406	CF-1232	RUN TANK
E	GHe	4	4000	159,292 SCF	586 FT^3	CF622675	CF620915	4K He BOTTLE FARM
F	GN_2	2	2935	199,659 SCF	1000 FT^3	CF622577	CF622689	
G	LOX	1	1500	411 GAL	55 FT^3	CE101632	CD623223	
H	LOX	1	5000	396 GAL	53 FT^3	CE101843	CF101233	
I	HYDRO CARBON	2	35	411 GAL/EA	55 FT^3	CR101635	CF622505	
J	HYDRO CARBON	1	5000	587 GAL	78.5 FT^3	CF622578	CD622504	
K	WATER	1	1500	1,309 GAL	175 FT^3	PF23152	CD621877	8-BALL
L	WATER	1	5000	587 GAL	78.5 FT^3	CF622578	CD622262	
M	GOX	1	2200	50,000 SCF		(NASA TUBER)	CD621916	
N	GHe, GN_2	1	6000	98,785 SCF	300 FT^3	CF622417	CF101525 CR622663	6K BOTTLE FARM
P	LN_2	1	150	28,000 GAL	37436 FT^3	CF639419 CF639420	CC154448	DEWAR N-83
Q	LN_2	2	100	150 GPM			CC154448	PUMP
R	LN_2	1	65	4K-8K GAL	534.8 FT^3 1069.6 FT^3			VENDOR DEWAR
S	LH_2	1	125	18K GAL	534.8 FT^3 1069.6 FT^3	CF101535	CF112127	DEWAR H-54
T	LH_2	1	6K	60K CFH			A455762	VAPORIZER
W	GHe	1	6K	160 SCFM			CF623225	COMPRESSOR
X	GHe	1	2400	50K-75K SCF				MOBILE TUBERS
Y	GHe	1	2400	50K-75K SCF				MOBILE TUBERS
AA	CO_2	1	350	$2\frac{1}{2}$ K	334.25 FT^3			VAPORIZER TANK
AB	CO_2	1	3600	8K	1069.6 FT^3			STORAGE TANK
AC	CO_2	1	60	8K	1069.6 FT^3			STORAGE TANK
AD	LN_2	2	4K	500 GAL	66.85 FT^3			VAPORIZER TANK
AE	LOX	1	2200	2160 GAL	288.79 FT^3		CF621574	DEWAR
AF	GN_2	9	4K		1513 FT^3	8 MP 1199 4 MP 1568	CF101541	2K N_2 BOTTLE FARM
AG	GH_2	1	2400	50K-75K SCF				MOBILE TUBERS
AH	GH_2	1	2400	50K-75K SCF				MOBILE TUBERS
AI	LN_2	1	6K		1.6 GPM		CF101541	VAPORIZER
AJ	LN_2	1	55	4000 GAL				DEWAR
AK	LN_2	1	600	160 SCFM	300 GAL	CD101333	CF623225	DEWAR
AL	GHe	1	2400	50K-75K SCF				MOBILE TUBERS
AM	GN_2	2	2800		52.9 FT^3	CD141356		GN_2 BOTTLES
AN	GHe	1	1500	13K SCF				
AO	LOX, LN_2	1	500	400 GAL	53.47 FT^3	53124M 30A100		RUN TANK
AP	N_2H_4	1	1000	30 GAL	4.01 FT^3	53133M 30A100	53133M 30A000	RUN TANK

HISTORIC AMERICAN ENGINEERING RECORD

INDEX TO PHOTOGRAPHS

RETF BUILDING 205 HAER No. OH-124-B
NASA Glenn Research Center
Cleveland
Cuyahoga County
Ohio

Jeff Bates, Hardlines Design Company, Field Photographer, May 2002
NASA Information Technology Center (ITC), Copywork Photographer, November 2002

OH-124-B-1	CONTEXT VIEW OF BUILDING 205, SHOWING HYDROGEN TANKS IN FOREGROUND AND BUILDING 202 EXHAUST SCRUBBER STACK IN BACKGROUND. VIEW LOOKING SOUTHWEST FROM TOP OF MOUND EAST OF BUILDING 205.
OH-124-B-2	CONTEXT VIEW OF BUILDING 205, LOOKING NORTHWEST, SHOWING SOUTHEAST CORNER OF BUILDING 205, WITH BUILDING 206 IN BACKGROUND.
OH-124-B-3	CONTEXT VIEW OF BUILDING 205, LOOKING SOUTHWEST FROM ACCESS ROAD.
OH-124-B-4	CONTEXT VIEW OF BUILDING 205, LOOKING SOUTHEAST.
OH-124-B-5	NORTHWEST CORNER OF BUILDING 205, LOOKING SOUTHEAST.
OH-124-B-6	SOUTHEAST CORNER OF BUILDING 205, LOOKING NORTHWEST.
OH-124-B-7	EAST ELEVATION OF BUILDING 205, LOOKING WEST.
OH-124-B-8	INTERIOR OF BUILDING 205, LOOKING SOUTHWEST.
OH-124-B-9	HISTORIC PLAN DRAWING OF BUILDING 205, JULY 1978. NASA GRC DRAWING NO. CC-18263. (ON FILE AT NASA GLENN RESEARCH CENTER).

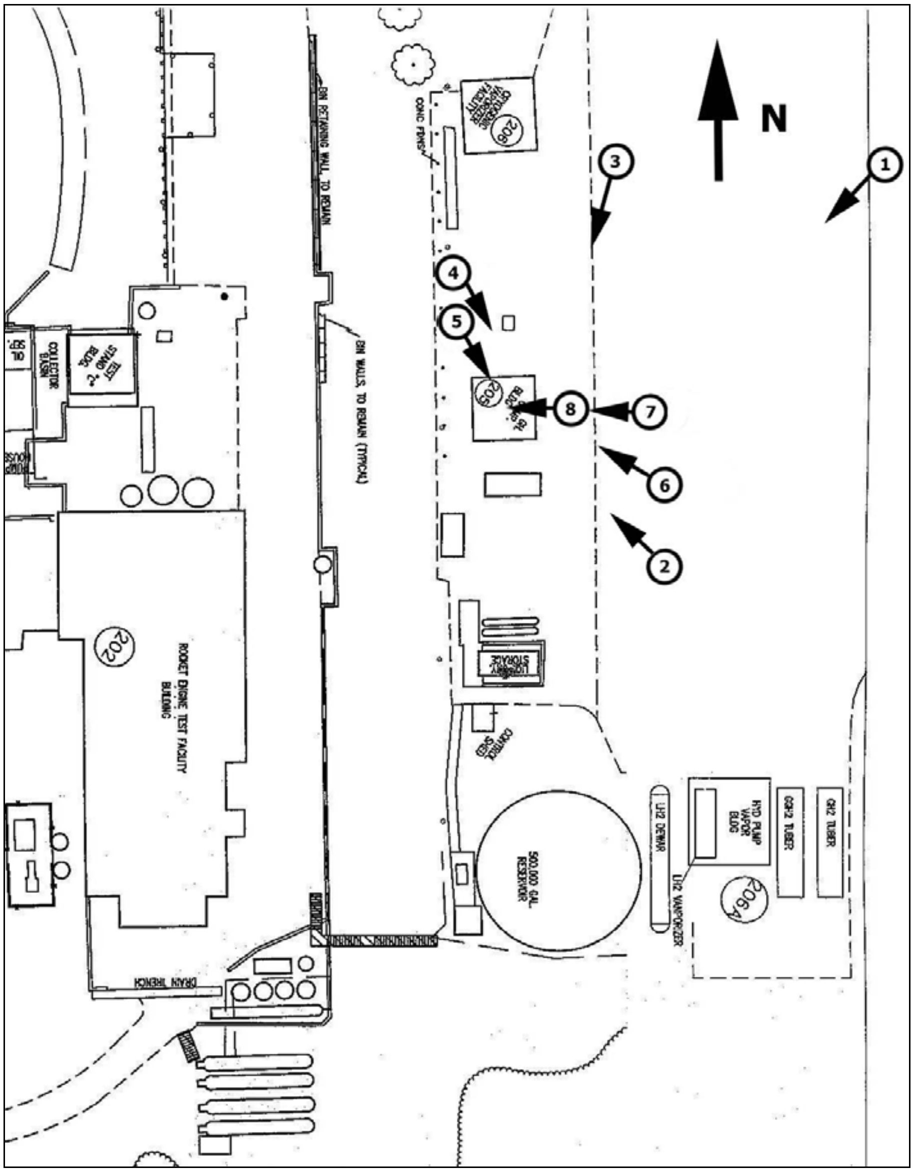
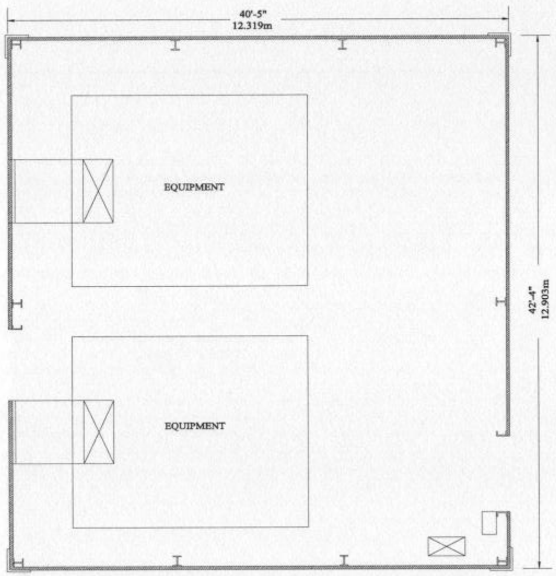


Photo Key for Rocket Engine Test Facility Building 205

BUILDINGS 205, 206 AND OBSERVATION BLOCKHOUSE

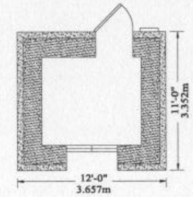


BUILDING 205 FLOOR PLAN

1/4" = 1'-0" 0 5' 10FT   1:48 0 3M

Building 205 is located approximately 170 feet northeast of the Rocket Engine Test Cell in Building 202. The structure covers a surface area of about 1,710 square feet. This building is lightly constructed, with a framing of pipe uprights that is welded to channel iron cross members. Light steel I-beams support the roof. The side of the building is sheathed with opaque fiberglass panels, while translucent fiberglass panels cover the roof.

The significance of Building 205 lies in its relationship to the reactant distribution system for the Rocket Engine Test Facility (RETF). Building 205 housed a compressor and an automated control system used to pressurize helium gas to 6,000 psi for distribution throughout the complex. Liquid oxygen boils at -183°C, which can make pumping and distribution of this substance difficult. Mechanical pumps available at the time for handling cryogenic fluids were not ideally designed for forcing liquid oxygen at high flow rates into test engines. To force liquid oxygen through the piping system and into test engines, the designer of RETF developed a pumping system powered by pressurized helium gas supplied by the compressor in Building 205. An inlet at the top of the main liquid oxygen outlet pipe was located below the liquid level. Control valves admitted pressurized helium at 4,000 psi that flowed at up to 3.5 pounds per second into the tank and forced liquid oxygen into the test rig.



OBSERVATION BLOCKHOUSE FLOOR PLAN

1/4" = 1'-0" 0 5' 10FT   1:48 0 3M

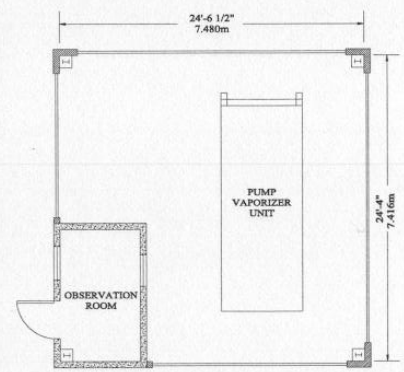
During the early years of operation at the Rocket Engine Test Facility (RETF), technicians and engineers relied on direct observation of engine firing tests to supplement instrument readings. One observation post was a large periscope in the terminal room of Building 202, which was adjacent to the test cell. A second viewing location was the Observation Blockhouse, which was a plain reinforced concrete bunker located approximately 260 feet north of the test cell. The blockhouse protected observers from flying debris in case of catastrophic engine failure during testing.

Built from 1955-1957, the Observation Blockhouse covers 132 square feet, and its reinforced concrete walls are 6" thick. Observers entered the bunker through a door in the north elevation. A ladder next to this door led to the roof. The south elevation has a deeply recessed thick glass window that measures approximately 4' wide and is divided into two sections by a vertical mullion. The window is about 18" high and allowed observers stationed inside the blockhouse to watch engine tests in Building 202. The blockhouse was equipped with an intercom system, emergency communications, and a telephone system to allow two-way contact with test stand engineers. The blockhouse also had a small switch panel with an "abort" button positioned below the observation window.

While there is photographic evidence that a closed-circuit television system was installed in the test cell as early as 1957, observers in the blockhouse were still needed to supplement electronic and video data. In 1972, however, RETF staff installed an additional closed-circuit television camera on top of the blockhouse. Additional lights installed in Building 202 enabled viewers in the RETF Building 100 control room to observe tests on a monitor. These modifications reduced the need to station observers in the blockhouse. As sensors, instrumentation, and computerized data reduction became more sophisticated, the information that could be provided by observers in a protected area was limited, and use of the blockhouse became increasingly rare.

Constructed in 1968, Building 206 was part of the gas distribution system for the Rocket Engine Test Facility (RETF). This building housed a liquid nitrogen vaporizer and a gaseous nitrogen compressor. This building covers 597 square feet and is sheathed in corrugated metal panels. Ventilation was an important consideration in the design of the building, so a vent was incorporated into the roof along the full length of the ridgeline. Louvered vents on the gable end of the building provided additional ventilation. A rolling shutter door about 16' wide on the building's gable end allowed access to the interior and machinery. An isolated control room featured a small window through which operators monitored the machinery bay. The control room had a switchboard of 12 explosion-proof switches for controlling motors and fans in the building. The building was also equipped with explosion-proof wiring, telephones, and lighting.

A nitrogen vaporizer essentially functions as a heat exchanger. Liquid nitrogen flowed through a network of pipes, the external surfaces of which were largely exposed. Fans drew ambient air over the exterior surface of this piping. The liquid nitrogen in the tubes then warmed and boiled to form gaseous nitrogen, which was then pressurized to 6,000 psi and piped throughout the RETF complex.



BUILDING 206 FLOOR PLAN

1/4" = 1'-0" 0 5' 10 FT   1:48 0 3M

DELINEATED BY: Hardlines Design Company, 2003

NASA ROCKET ENGINE TEST FACILITY RECORDING PROJECT

ROCKET ENGINE TEST FACILITY
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, LEWIS RESEARCH CENTER
CUYAHOGA COUNTY
CLEVELAND | OHIO | SHEET 12 of 12 | HISTORIC AMERICAN ENGINEERING RECORD OH-124-D

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-B-1

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-B-2

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

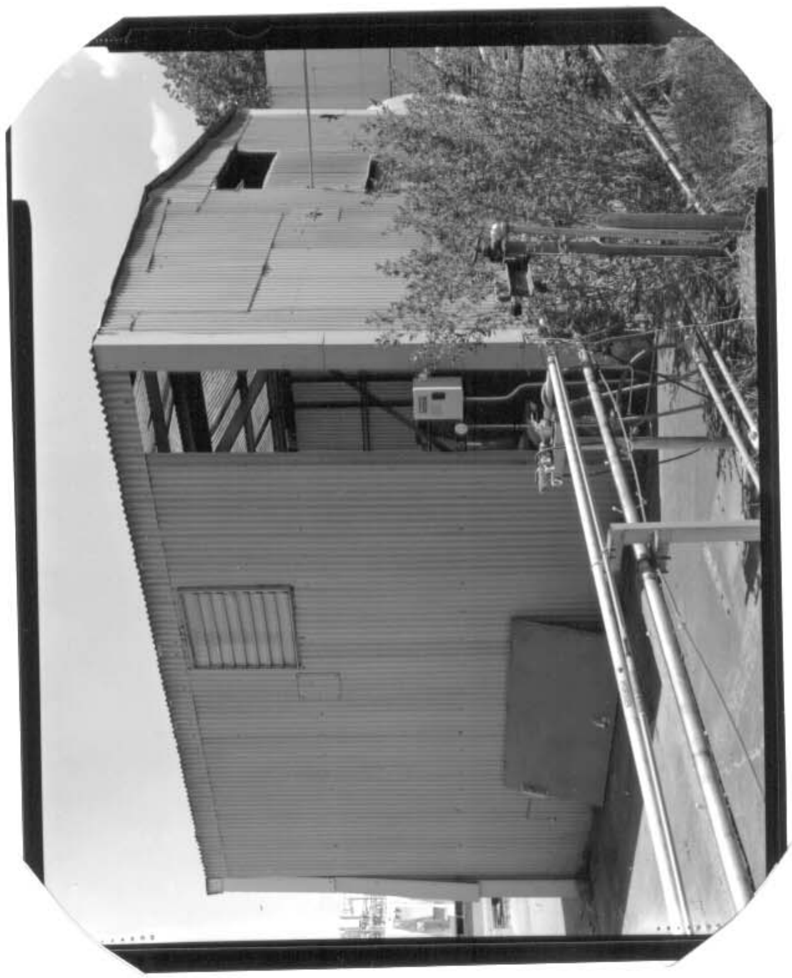
HAER No. OH-124-B-3

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-B-4

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-B-5

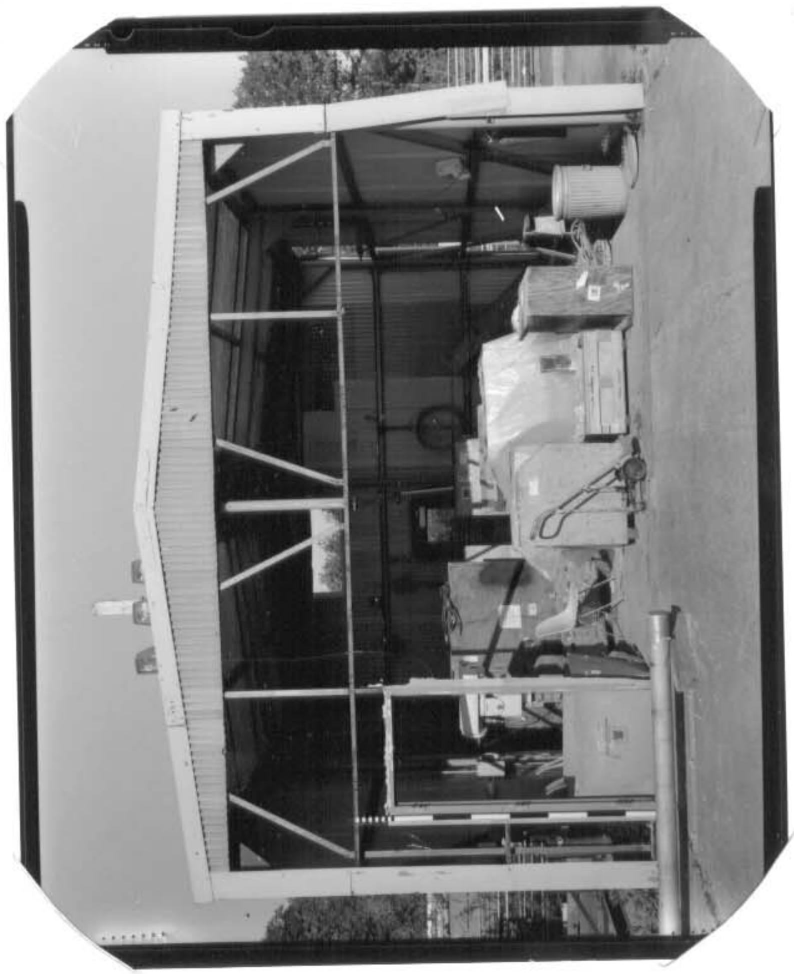


HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-B-6

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-B-7



HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

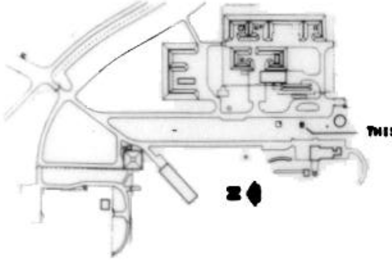
HAER No. OH-124-B-8

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

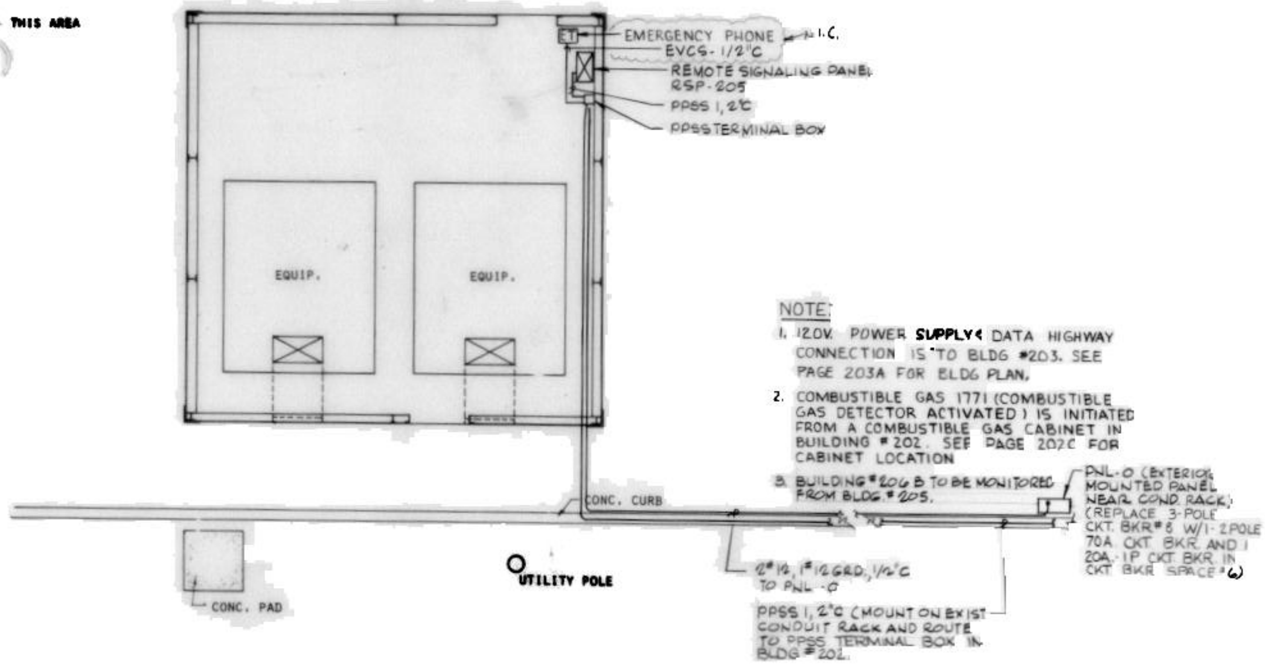
HAER No. OH-124-B-9

PAGE 205A

NASA LEWIS RESEARCH CENTER
CLEVELAND, OHIO
PROPRIETARY PROTECTIVE SIGNALING SYSTEM



KEY PLAN



SYMBOL LEGEND

- ⊠ PROPOSED REMOTE SIGNALING PANEL LOCATION
- ET EMERGENCY PHONE

N

FIRST FLOOR PLAN
REF. DWG. NO. CD-621016

SOUTH AREA PROPELLANT TRANSFER AND STORAGE AREA

BUILDING NO.
205

( ) AREA, SQ. FT.

SCALE 1/8" = 1'-0"
4 0 4 8

REVISED JULY 1978

R.E. WARNER & ASSOC.
LORAIN, OHIO
JOB NO. 8501465

KJA	WLB	
CBH	RKC	GEY

AUTHORIZED BY / DATE

NASA DR. NO.
CC-182683