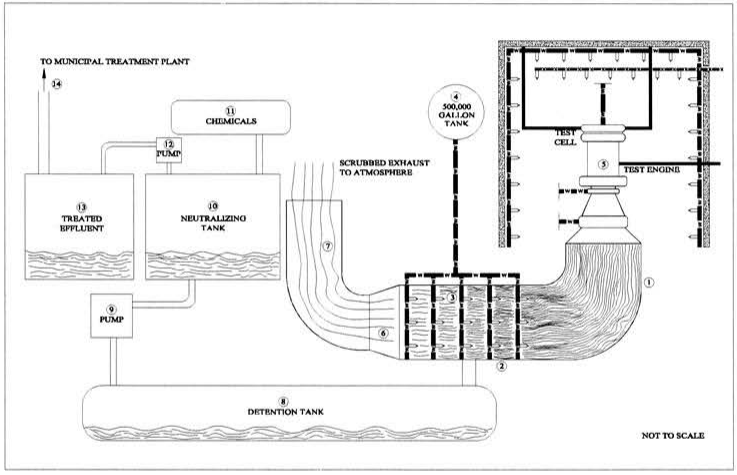
ROCKET EXHAUST FLOW CHART

The Rocket Engine Test Facility (RETF) is located near the Cleveland Municipal Airport, a number of metropolitan parks, and a series of residential neighborhoods. Because of this urban setting, it was essential to control the exhaust emissions and loud noises generated during rocket engine tests. NASA addressed these problems by including mufflers and silencers in the original design. In addition, both the original high-thrust vertical test stand and the low-thrust horizontal stand added in 1984 discharged exhaust into a scrubber/ silencer. This device removed combustion by-products from the rocket engine exhaust and decreased noise levels.

Scrubbers (1) are devices that use a liquid to remove gases and dispersed particles from an exhaust stream. At the RETF, the scrubber condensed the hot exhaust produced by rocket engine tests. As the exhaust cooled and reached its dew point, the condensed exhaust was trapped in water and sprayed into the scrubber's chamber. The water was then collected for treatment and disposal.

The RETF scrubber was mounted on concrete foundations designed to support engines capable of producing up to 100,000 lbs. of thrust. However, the collective weight of mounts, plumbing controls, and instrumentation limited the facility's capability to testing engines that exerted less than 20,000 lbs. of thrust.

The main component of the scrubber system was a horizontal tank (2) measuring 100' long by 25' in diameter. The tank contained five water spray bars (3) fitted with nozzles that produced a heavy acrosol spray. During test runs, water from a nearby reservoir (4) flowed through the acrosol nozzles at a rate of 50,000 gallons per minute. Rocket engines (5) mounted on the original test stand vertically exhausted hot gases into one end of the tank. The engines discharged this exhaust at velocities ranging from 9,000 to 12,000 feet per second (fps), and at temperatures of approximately 6,000°F. This exhaust was trapped in the water spray coming from the nozzles. Inside the tank, the exhaust stream velocity slowed to 25 fps, and much of the exhaust was converted to steam.



Additional water sprays condensed the steam. The other end of the tank ended in a transition elbow (6) that led to a vertical stack (7). This stack measured 20' in diameter and rose to 79'7" in height. Any remaining water vapor and non-condensable exhaust gas exited the vertical stack at a temperature of 160°F and a velocity of 20 fps. Several burners near the rocket exhaust source ignited any hydrogen or other fuel not consumed by the engine. These burners prevented unburned fuel from building to explosive levels inside the scrubber.

Water, condensed steam, and combustion by-products trapped by the scrubber drained into a 20,000 - gallon detention tank (8) located adjacent to Abram Creek, at the lowest point in the RETF complex.

Wastewater was retained in this tank until the day's test program was completed, when the wastewater was pumped (9) to a neutralizing tank (10). Chemical technicians analyzed the wastewater and determined the quantity and type of additive needed to neutralize acidity or alkalinity, so that the pH value would meet municipal wastewater standards.

Chemicals (11) added to the neutralizing tank reacted with combustion by-products in the wastewater. Some fuel/ oxidizer combinations produced highly corrosive acidic by-products. The use of fluorinc created hydrofluoric acid by-products, and mixing a calcium compound with the hydrofluoric acid/ water mixture in the neutralizing tank produced a stable, solid precipitate of calcium fluoride. The wastewater was then re-tested and pumped (12) into a holding tank (13). The treated water was finally pumped into the municipal wastewater treatment system (14).

Engineers monitored the scrubber/ silencer system from the control room in Building 100. Pilot lamps on a control board panel represented the scrubber layout and enabled technicians and engineers to observe the system's operating status. From 1957-1959, RETF testing was restricted to engines using rocket propellant (RP), a refined grade of kerosene, and liquid oxygen as the reactant. In the 1960s, RETF researchers used reactants such as nitrogen tetroxide, unsymmetrical dimethyl hydrazine, and fluorine. Use of these chemicals required an extension of the scrubber's exhaust stack to guarantee thorough exhaust treatment. A transition cone was mounted on top of the original 1957 exhaust stack, which reduced the diameter of the stack opening to 6' and extended the height to 118' above grade. A flare stack at the top of the scrubber stack was installed to burn residual hydrogen.

The RETF scrubber/ silencer was an engineering solution to a significant waste treatment problem. This system was crucial to maintaining a clean, low-noise environment near the RETF.

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SHEET 5 of 12

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