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NASA TECH BRIEF
Lewis Research Center

Antipollution System to Remove Nitrogen Dioxide Gas

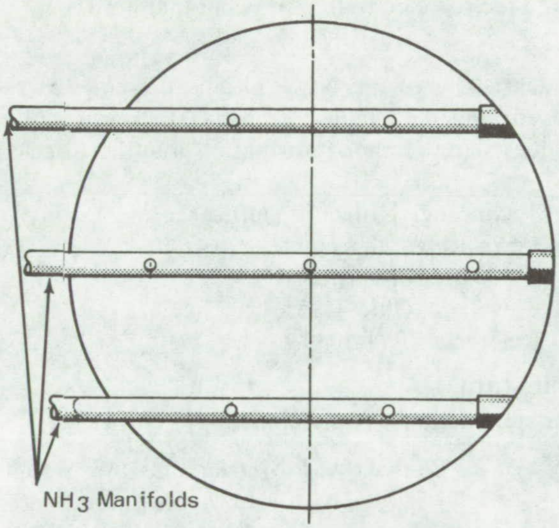
The problem:

A combustor test facility, developed for an advanced combustor research program, utilized an oxidant-rich hydrazine-nitrogen tetroxide rocket as a gas generator to simulate high enthalpy inlet flow conditions to the combustor. The high propellant flow rate was 45.4 kg/sec (100 lb/sec), and the exhaust was pumped to the atmosphere through a stack. The exhaust emissions contained sufficient NO_2, even from 5-sec test runs, to form large reddish-brown clouds which dispersed slowly and could drift and settle over nearby populous areas. Although the concentration of NO_2 in the drifting cloud was low, concern over possible effects on the adjoining communities dictated that the NO_2 level in the exhaust emissions be reduced essentially to zero and that the gases emitted from the stack be benign.

The solution:

A gas-phase reaction system utilizes ammonia (NH_3) as the reactant to remove the NO_2. Anhydrous ammonia was selected on the basis of its effectiveness in removing NO_2 from rocket exhaust emissions and its practicality for use in a high-volume-flow system.

The system consists of: (1) an ammonia injection and mixing section; (2) a reaction section (reactor); and (3) a scrubber section. All three sections are contained within the system ducting.



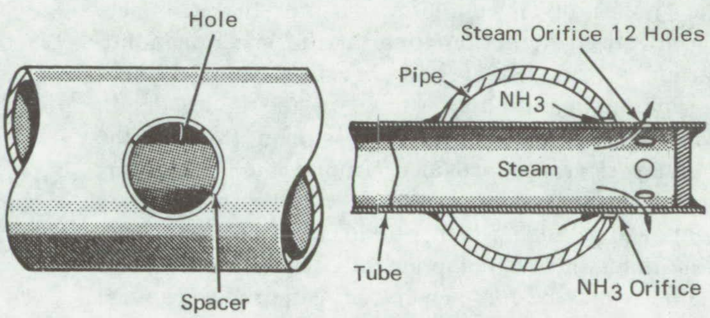


Figure 1. Ammonia-Steam Injector

How it's done:

The efficiency of NO_2 removal depends on both the reaction time and the ammonia concentration. The system design optimized the NO_2 - NH_3 reaction by providing long reaction time and excess ammonia beyond that required for stoichiometry.

The ammonia injection and mixing section (see Fig. 1) consists of a manifold system with multiple injectors to insure rapid and uniform injection and distribution of ammonia gas across the flow stream of the nitrogen-dioxide-containing gas. Liquid am-

(continued overleaf)

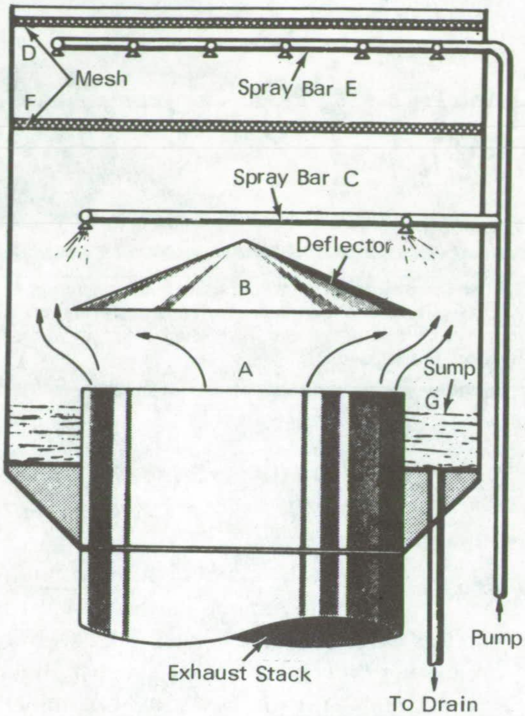


Figure 2. Exhaust-Stack Scrubber System

monia flow is metered and controlled ahead of the manifolds. The injector-mixer design may incorporate an auxiliary system to provide steam flow at the point of injection to insure the complete vaporization of the ammonia at the injection point. Steam is provided at each injection point through a separate manifold as shown in the figure detail. Ammonia is injected into the stream through the annular clearance provided around the steam line, and flows normal to the steam jets. The reactor is a contained volume which provides the required reaction time for the components. Reactor length and diameter may be complementarily adjusted to provide the required residence time within the duct system.

The scrubber section, Figure 2, is a high-surface-contact-area water curtain device through which the reactor flow is forced. Its action is three-fold: (1) Solid reaction products are washed from the gas stream; (2) excess ammonia gas is absorbed by the water and removed from the gas stream; and (3) the water is recirculated and excess NH_3 is absorbed, resulting in a solution capable of removing any unreacted nitrogen dioxide which might have passed the reactor.

Gases from the reactor enter the scrubber at A and are forced to the outer periphery of a deflector B. In this region, the gas contacts the highly atomized spray from multiple spray nozzles on spray bar C, located to effectively distribute liquid spray throughout the annular area around the periphery of B. A dewatering mesh at D removes atomized liquid and provides surface contact area. Second stage spray bars at E and a mesh at F serve the same purpose as their counterparts, C and D. Spray water is collected in sump G, returned to the pump inlet and recirculated to the spray bar manifold.

Notes:

1. At least 99% of the NO_2 initially present was removed, and the exhaust from the stack was white.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B71-10393

Patent status:

No patent action is contemplated by NASA.

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