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CARBON ADSORBER FIRE EXTINGUISHMENT TESTS

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CARBON ADSORBER FIRE EXTINGUISHMENT TESTS*

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ABSTRACT

Activated-carbon adsorbers in air-cleaning systems should be protected from fire. However, as they can ignite under unusual conditions, an adequate extinguishing system should be installed ready for use. This study examines some available systems.

The Savannah River-style cell (24 X 24 X 12 inches), containing approximately 60 pounds of 6-14 mesh carbon, was used for these tests. Single-head spray nozzles and arrays delivering up to 36 gallons per minute (gpm) at operating pressures to 150 psig, with patterns from fog to solid cone were tried using plain water and water with wetting agent. Under the conditions of this test, water sprays did not extinguish the fire as long as air continued to flow.

Liquid nitrogen was used successfully as an extinguishing agent under the same conditions. The rate of application to a single adsorber was 20 liters per minute for seven minutes.

Introduction

FIRE!

Such an alarm means trouble for everyone. To personnel responsible for the air-cleaning system installed in a building housing radioactive materials, fire can mean loss of occupancy for a prolonged period or contamination of the surroundings—a far greater problem in urban areas. This report deals with the problem of fire in the last component of high efficiency air-cleaning systems—activated-carbon adsorbers.

In 1966, E. I. duPont Co. (Savannah River Plant) asked us to verify laboratory ignition-point tests on activated charcoal. We tested a full size Savannah River-type adsorber for ignition point in our facility

*Work performed under the auspices of the U.S. Atomic Energy Commission.

for testing HEPA filters at high temperatures. Our fire department personnel were standing by; however, they failed to quench the ignited adsorber with CO_2 even though 495 pounds were used. Extinguishment was finally accomplished with water immersion. On later ignition point tests, the fire was satisfactorily extinguished by applying water at 7.5 gpm directly to the fire area with a solid-cone square-pattern nozzle attached to a wand.

Last year, we started a series of tests to determine optimum characteristics of an installed sprinkler system for extinguishing fires in multiple-cell carbon adsorber systems. Various nozzles were gathered, with delivery capabilities ranging from less than one to more than 18 gpm at pressures up to 150 psig. Figure 1 shows the nozzles tested.

Method

We standardized test conditions to permit meaningful comparisons. For these tests, Mr. Gilbert of AEC Health and Safety Div., Washington, D.C., furnished refurbished adsorber cells which had been loaded from a single batch of activated charcoal to ensure common burning characteristics.

The top left quadrant, looking downstream, was instrumented by inserting 5 iron-constantan thermocouples in the inlet side and 5 in the discharge side. The nozzle system was set up outside the test rig to check the size and completeness of coverage for a 24- by 24-inch area. The nozzle was then placed in the test rig at the distance determined.

The test sequence consisted of preheating the apparatus to 400°F, igniting the instrumented area with a torch, permitting a two-minute preburn to simulate detection delay, and starting the water spray. At ignition plus six minutes, external heat was removed. The progress of extinguishment was followed by observing through view ports upstream and downstream and by watching the temperature indicators.

Results

The results were disappointing. As shown in Table I, a variety of nozzles, with varied spray patterns, volumes, pressures, and additives, were unsuccessful under the test conditions. After several minutes of spray time, when test failure was certain, we had to terminate the test.

Repeated stopping and starting of the air flow while leaving the water spray on can extinguish the fire. However, even when the thermocouples indicate extinguishment, the fire may rekindle from a small hot spot if water is discontinued and air flow remains constant.

The above manual method of extinguishment gave rise to another series of tests. An air-cylinder-actuated slide valve was installed in the system just upstream of the exhauster. "On" and "off" times could be set for desired periods, and a stop could be adjusted to prevent complete closure of the valve. This permitted tests to be run with flow variation (e.g., 1000 cfm for 10 seconds and 200 cfm for 20 seconds), which simulated an actual situation where the exhaust system needed to be reduced to assist the extinguishment, rather than being completely shut off. It did help, but complete extinguishment still did not occur.

Failure on every test of installed water systems made a different approach necessary. We decided to try liquid nitrogen (LN) because of two of its properties —cooling effect and inerting. However, our Maintenance Machinists found that some regular water-spray nozzles did not produce a spray with LN. They built the nozzle shown in Fig. 2 to solve the problem.

Figure 3 shows the system for introducing the liquid nitrogen. A pressure of 35 psig of nitrogen was sufficient to discharge the contents of the Dewar (about 150 liters) in seven minutes. The LN method was tried three times, and was successful each time. The preheat and preburn times were the same as for the water spray tests. Of course, a delivery rate of 20 liters per minute of completely vaporized liquid amounts to about 500 cfm, which halves the exhaust rate temporarily. There is no reignition if the cell is thoroughly chilled, an added bonus.

Observations, Suggestions and Plans

During some tests, a "sheath" of steam appeared to surround the jet of flame issuing from the cell. High-speed movies were taken in an effort to study this phenomenon, but it did not develop during the movie sequences. I believe it is caused by a small amount of water getting to the fire and turning into a steam cushion which prevents water from penetrating sufficiently to extinguish the fire.

The high-speed movies did show one phenomenon not observed visually. When the water hits the hot charcoal, there is a momentary flare-up lasting about a second. This has not been investigated and its cause is not known.

The hand method of extinguishing used during ignition-point testing suggested an array of 24 nozzles, four in each of the six pleats on the upstream side of the cell. A single test with 0.12 gpm per nozzle was unsuccessful. At preparation time for this paper further tests with larger nozzles have not been made. It is hoped that the results can be presented at the reading of the paper.

Another method to be tried is the use of Halon 1301*. Portable hand extinguishers will be used to determine if the method has enough promise to warrant full scale tests.

Steam has also been suggested as a possible extinguishing agent. However, as no steam is available and our portable systems are too small, this method has not been tried.

Summary

Installed carbon adsorber banks must be protected from fire, whether caused by spontaneous ignition from radioactive decay, high organic chemical loading, or an external ignition source. However, installed sprinkler systems of reasonable gallonage have not yet been successful as fire extinguishers under the test conditions discussed.

Liquid nitrogen can be used as an extinguishing agent but must be readily available. Zone detection and extinguishment would be the only practical way for large installations.

*Trademark - E. I. duPont Company.

Table I. Spray nozzles used and their characteristics.

Experiment No.	Nozzle Make	Model	Spray Characteristics	Remarks	Flow (gpm)	Back Pressure (psig)	Distance, Nozzle to Adsorber (in.)
69-10	Spraying Systems	3/4 7G-5	Multijet, Fog		4.8	20	25
69-11	Spraying Systems	1/2HH29 SQ	Square-solid cone		6.5	5	25
69-12	Spraying Systems	1/2HH 35W	Round-solid cone		7.5	48	15-1/2
69-13	SPRACO	Fire Fog #668WA	Round-solid cone		13	20	11
69-14	SPRACO	Fire Fog #668WA	Round-solid cone	One upstream - one downstream	13 ea.	20	11
69-15	SPRACO	Fire Fog #668WA	Round-solid cone	One upstream - one downstream	18.4 ea.	50	11
69-16	SPRACO	Fire Fog #668WA	Round-solid cone	One upstream-one downstream; solvoid wetting agent at 1 gal/ 1000 gal.	18.4 ea.	50	11
69-17	Spraying Systems	1/2HH29 SQ	Square-solid cone	W/solvoid wetting agent at 1 gal/1000 gal.	6.5	15	26
69-18	Spraying Systems	1/2HH 35W	Round-solid cone		7.5	20	11
69-19	Spraying Systems	1/2HH 35W	Round-solid cone		7.5	20	10-1/4
69-20 } 69-21 }	Spraying Systems	1/2HH29 SQ	Square-solid cone	4 nozzle array one nozzle at center of each quadrant.	7.5	2	11-1/2
70-22	Spraying Systems	1/4HH12 SQ	Square-solid cone	4 nozzle array, one nozzle center of each quadrant 1000 scfm - 10 sec 200 scfm - 20 sec	7.5 total	45	14
70-23	Spraying Systems	1/2HH29 SQ	Square-solid cone	same as above	10	5	15-1/4

Table I (cont'd)

Experiment No.	Nozzle Make	Model	Spray Characteristics	Remarks	Flow (gpm)	Back Pressure (psig)	Distance, Nozzle to Adsorber (in.)
70-24 70-25 70-26	Fabricated	—	Square pattern	Liquid nitrogen	5.3 (20 LPM)	35	13-1/2
70-27	Spraying Systems		Solid cone	24 - 4 per each of six pleats	3.5 total	40	3/4

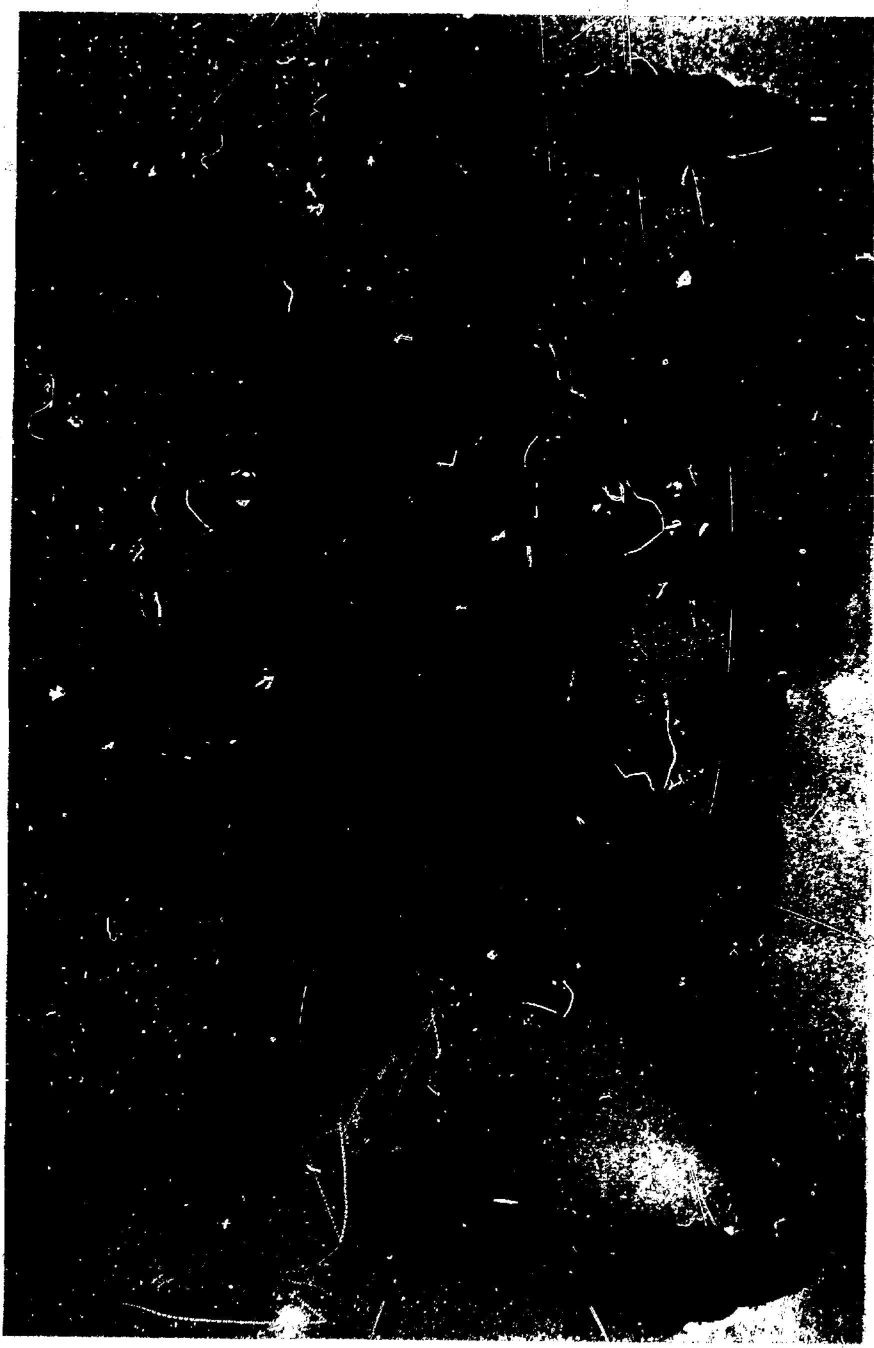

Fig. 1. Nozzles used.

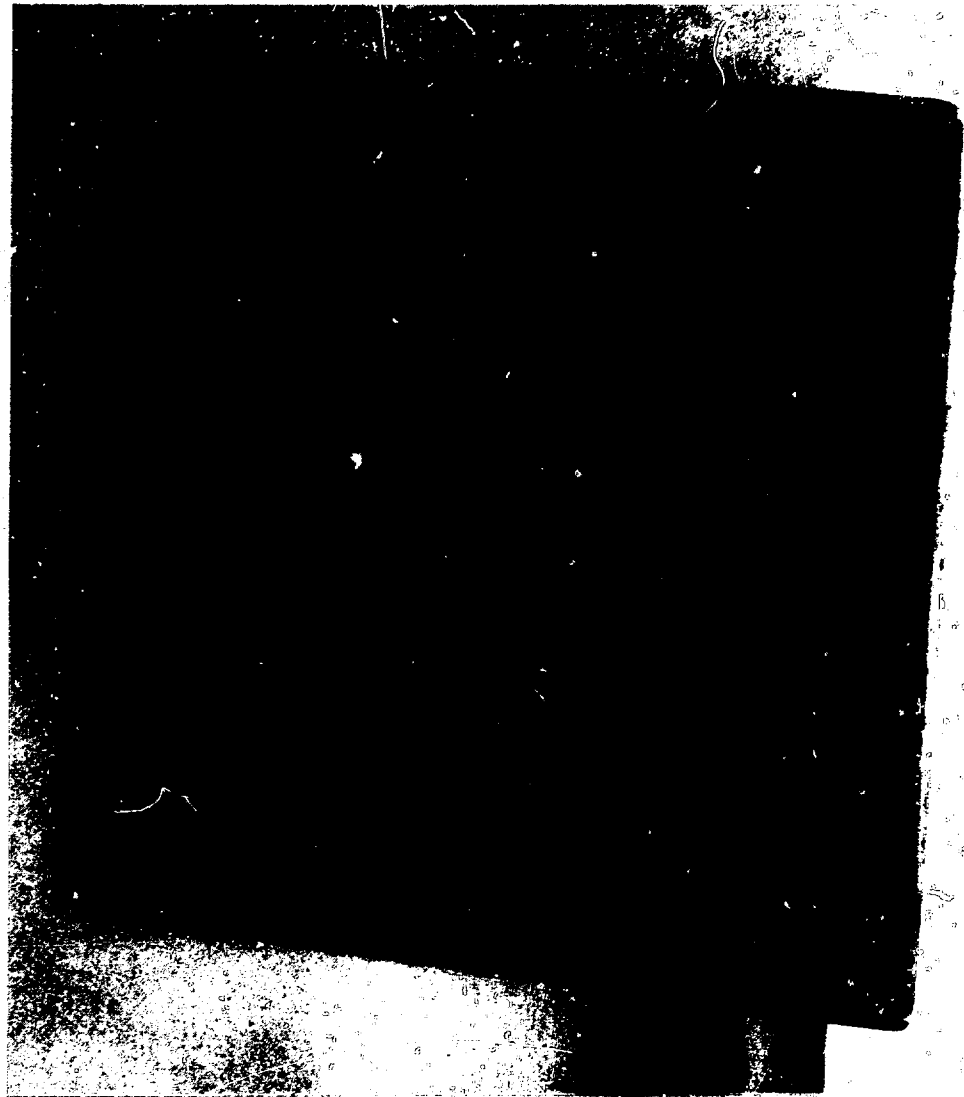

Fig. 2. Liquid Nitrogen nozzle.

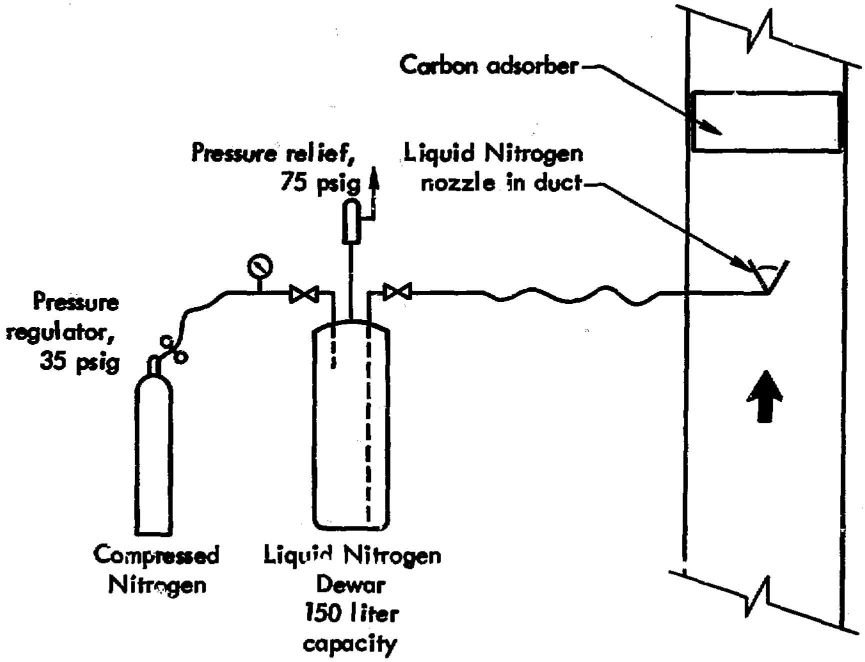

Fig. 3. Schematic, Liquid Nitrogen introduction.