ATI TDA 5A Aerosol Generator Evaluation

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Abstract

Oil based aerosol "Smoke" commonly used for testing the efficiency and penetration of High Efficiency Particulate Air filters (HEPA) and HEPA systems can produce flammability hazards that may not have been previously considered. A combustion incident involving an aerosol generator has caused an investigation into the hazards of the aerosol used to test HEPA systems at Hanford.

Introduction

While conducting an "In-Place" aerosol test, the Ventilation and Balance group experienced a combustion incident using the ATI TDA 5A aerosol generator. The incident was described as a "Pop" with a large puff of smoke and a flash coming from the end of the flex hose used to transmit the aerosol to the filter housing being tested. As a result of this incident the Ventilation and Balance group started testing the aerosol production, operating configuration and flammability of aerosol materials in the ATI TDA 5A aerosol generator. The purpose of this paper is to discuss the results of this testing and make recommendations for the use of the ATI TDA 5A generator.

Discussion

The ATI TDA 5A aerosol generator is used to generate aerosol "Smoke" to challenge HEPA filters and their systems. The generator consists of an oil reservoir, a gas plumbing system with regulator, furnace block and two, 350W heating elements with thermostatic controls. The aerosol material, in this case Emery 3004, is propelled using low pressure nitrogen (4-6 psi) into the furnace. In the furnace it is heated to almost twice the flash point of the material (FP of Emery 3004 is 420° F) where it is vaporized. The vapor then exits the furnace through a nozzle where it re-condenses in the atmosphere to form an aerosol of known droplet size. (See figure #1)

When using the TDA 5A in the field to perform an in place aerosol test, a 2" diameter flexible hose is used to transmit the aerosol from the generator to the injection port of the filter housing being tested. A stainless steel adaptor is used to connect the hose to the generator. The "Adapter" used at Hanford was originally designed and manufactured on site. (see figure # 2)

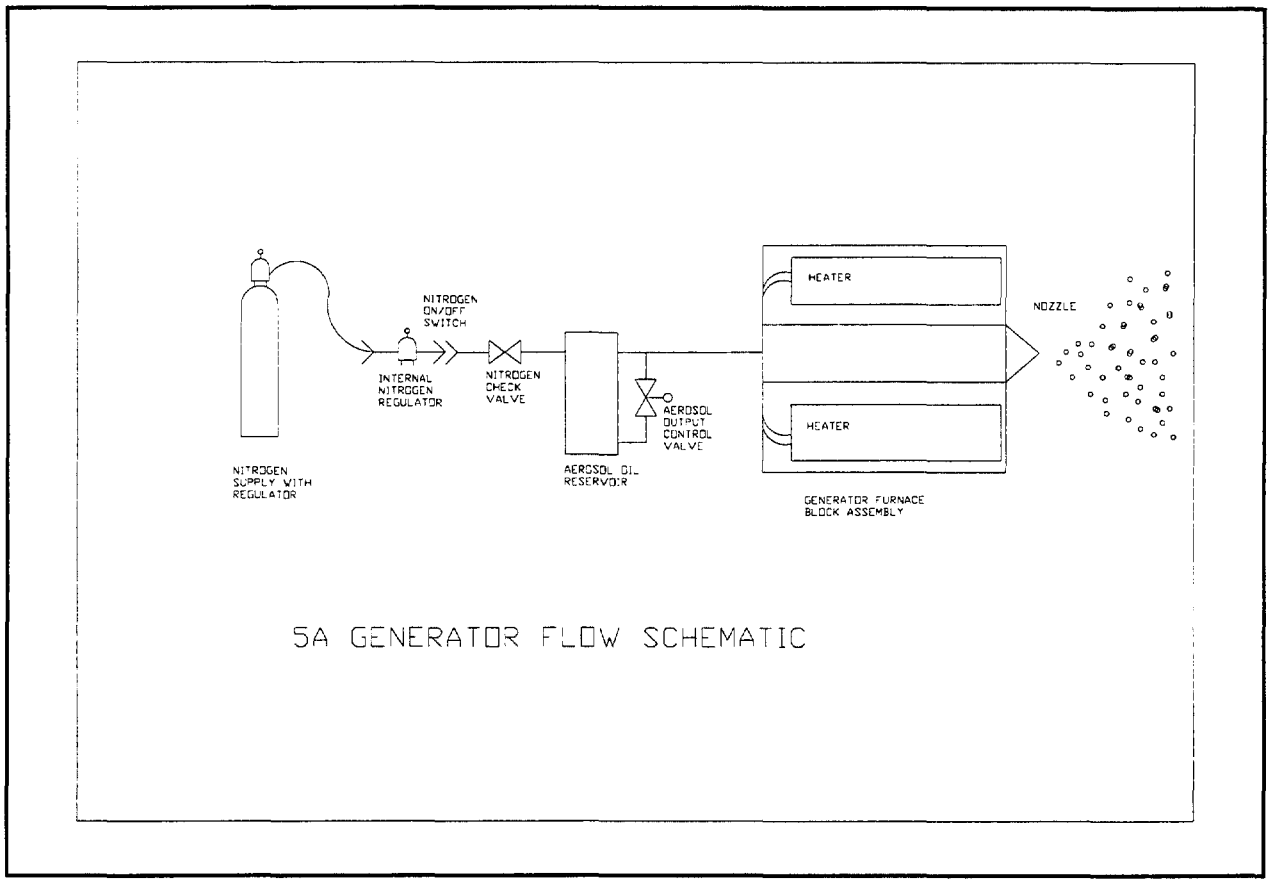

Figure 1

After the incident the nitrogen supply to the TDA 5A was analyzed to determine it's purity and was found to be within specification. The TDA 5A was dismantled and checked for operation, it was well within operating parameters and in good operating condition. The Emery 3004 aerosol material was drained from the unit and visually examined for foreign matter or discoloration. The material was found to be free from foreign material and was not discolored. The generator was re-assembled and bench tested. The generator performed within all specifications.

Having found nothing wrong in the generator or the supply materials, the operation of the generator was examined next. The operating procedure for the TDA 5A generator, 7-GN-52 was reviewed and met all factory operating instructions. The next area to examine was the hose assembly that is used to transmit the aerosol to the injection ports. While bench testing with the hose assemblies and the hose transitions, it was discovered that combustion could be produced in certain operating configurations when the flow of nitrogen to the generator was interrupted. It was this discovery that initiated the following testing.

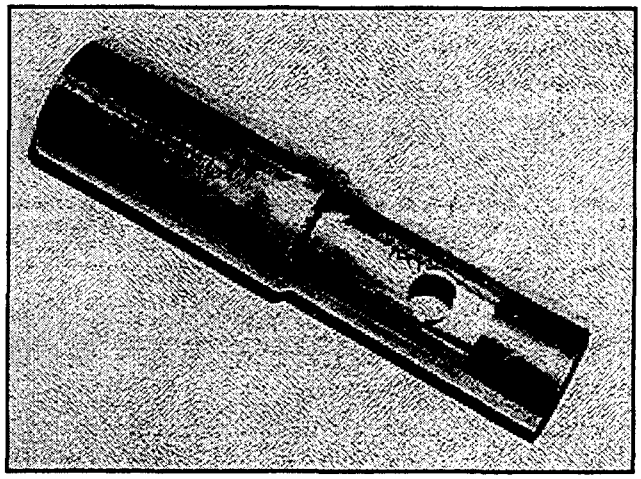

Figure 2

Purpose

Investigate the aerosol production and flammability characteristics during the loss of nitrogen, of the ATI TDA 5A Aerosol Generator and produce a safe configuration in which to operate the generator even in the event of loss of nitrogen.

Method

Operational testing of the 5A in varying configurations to simulate shop and field conditions.

Iteration 1

Bench top testing was conducted in the Ventilation and Balance (V&B) shop using an ATI 5A aerosol generator #8527 filled with Emery 3004 and various configurations of hose transitions (see figure #3). The transitions used were stainless steel pipe assemblies that were modified to fit inside of the TDA 5A "Nose" and have 2" flexible hose attached to it. The transition (referred to as V&B transition) is 8" long with a 5/8" quench hole situated approximately ½" away from the "Nose" of the generator (Figure # 2). Some of the transitions tried had quench holes of varying sizes and configurations drilled in the transitions as will be noted in the test results. Aerosol concentration was measured using and ATI 2EN photometer #702-23-10-011. Relative concentrations were recorded from the Gain and Stray Light controls on the ATI 2EN.

The attempt to produce flame was accomplished by interrupting the flow of nitrogen to the aerosol generator. The nitrogen flow interruption was accomplished by turning the aerosol switch on the face of the TDA 5A to off and also by shutting off the nitrogen bottle at the regulator (see figure #1). In all cases the nitrogen was left off for at least 20 seconds. All tests

were performed at least three times for repeatability. Results were averaged and the data and observations for each test configuration are recorded in appendix A (Appendix provided upon request).

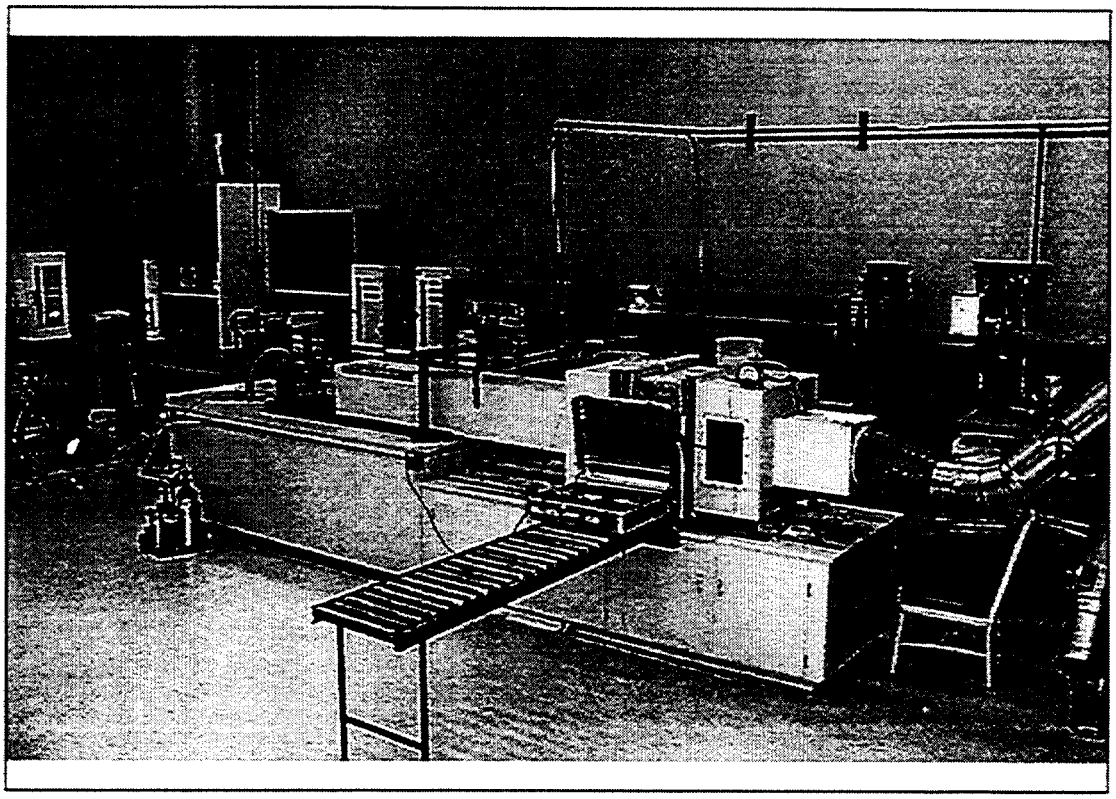

Figure 3

Iteration 2

Testing was continued out doors with the same TDA 5A generator with the original V&B transition and the transition modified with 3 holes. Attached to the transitions, were 9' sections of 2" diameter blue flexible hose. In field testing the hose is used to transmit the aerosol to the injection ports of air cleaning systems. The flexible hose was led to a portable fan that would be used to simulate the negative draw of an injection port. The interruption of nitrogen was accomplished in the same manner as in iteration 1. No attempt was made to quantify aerosol concentrations. Results and observations are recorded in appendix B (Appendix provided upon request).

Iteration 3

The next round of testing was conducted using the same 5A generator, a second 5A #8880 filled with Di2-Ethylhexyl Sebacate (DOS) oil and a TDA 5B acquired from ATI. The 5B is basically a reworked 5A with the oil reservoir enlarged and a digitally controlled thermostat for the furnace. The furnace, heating elements, plumbing and nozzles are all identical to the 5A. All

3 units would be bench tested without a transition, with the V&B transition, an ATI transition and ATI transition with 9' of 1" tygon tubing. The ATI transition is fabricated from aluminum and is designed to fit over the "Nose" of the generator and then reduce down to 1" pipe fitting. There are 3 holes 1" X 1.25", cut in to the transition and spaced 120° radially around the body of transition to allow in a large amount of quench air (Figure #4). A 9' piece of 1" diameter tygon tubing was slipped on over the end of the transition and this was used to transmit the aerosol to the injection ports. This is a typical configuration found at other DOE sites. Results are documented in appendix C (Appendix provided upon request).

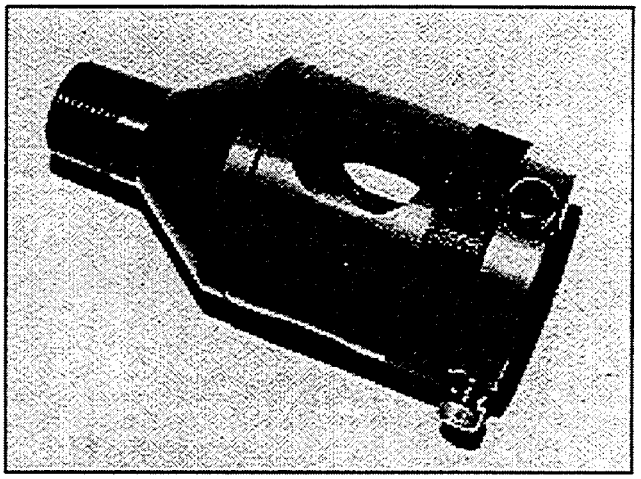

Figure 4

Iteration 4

A re-designed transition piece was fabricated and tested. The transition was made to attach to the outside of the "Nose" of both the 5A and 5B generators and to hold a section of 4" flexible hose 4" away from the generator providing an open air space around the nozzle of the generator (Figure # 5). Testing was conducted using the 5A generators with Emery 3004 and DOS oil and the 5B generator with Emery 3004. All testing proved that the transition had no effect on the quantity, quality or temperature of the aerosol produced. The generators performed as if there was no transition or hose attached. **We were not able to produce any combustion reaction using this new transition.** The 4" hose worked well in transmitting the smoke to injection ports. Results are documented in appendix D (Appendix provided upon request).

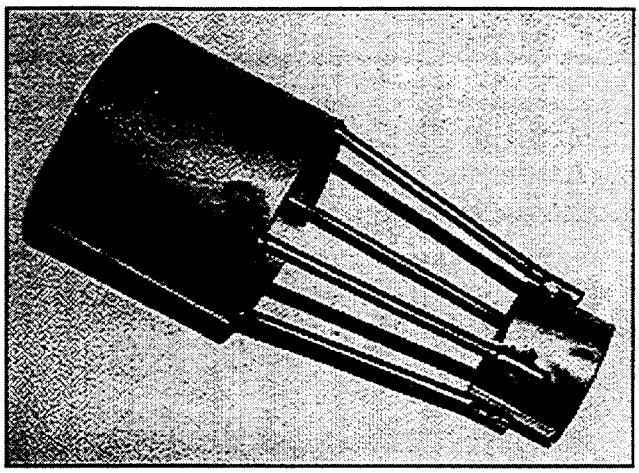

Figure 5

General Observations

Throughout the investigation and testing of the aerosol generators it was obvious that none of the generators used with any of the aerosol materials or transition configurations, posed any hazard of self generated combustion unless the flow of nitrogen was disrupted.

- The aerosol stream from the generator using DOS did not self ignite as the Emery 3004 did. .
- Both aerosol smokes, Emery 3004 and DOS are combustible. The flash points of both materials is very close, Emery 3004 432° F and DOS 430° F.
- When exposed to an ignition source, a dense stream of aerosol will burn. The burn will continue until the aerosol is consumed or the flow is stopped. The nitrogen propellant used in the generator does not preclude combustion.
- The Emery aerosol used with the V&B transition configuration and also the ATI transition configuration did self-ignite during the inadvertent loss of nitrogen.
- Used in any transition configuration or generator the DOS aerosol did not self- ignite during the inadvertent loss of nitrogen.
- The Emery aerosol used with **the re-designed transition configuration did not self-ignite during the inadvertent loss of nitrogen.**

Conclusions

The V&B transition did not allow enough quench air into the area surrounding the nozzle of the generator thereby allowing the vapor to recondense on the wall of the transition or the hose. The re-designed transition provides the same quench air as if there were no transition used.

The possibility of self or auto ignition occurring during the use of the TDA 5A generator or the 5B comes from the interrupting the flow of nitrogen. Configurations or aerosol materials used are contributing factors only.

Corrective Actions And Recommendations

Upon completing the evaluation of the aerosol production and flammability characteristics of the ATI TDA 5A aerosol generator, the Ventilation and Balance group has taken the following corrective actions in it's testing operations and make the following recommendations:

Corrective Actions

- The entire Ventilation and Balance crew has been re-trained to the operating procedure for the 5A generator, 7-GN-52. During this re-training we also reviewed the proper installation, inspection and maintenance of the nitrogen lines and regulators.

- A simple safety switch cover has been installed on the aerosol switch on all ATI TDA 5A generators. This switch cover requires the operator to lift the cover before being able to turn off the aerosol switch, thus reducing the chance of accidentally interrupting the flow of nitrogen before stopping the oil flow.

- All original V&B transitions have been removed from service and will be disposed of properly. Transitions have been fabricated to the new design and are being placed in service.

- A copy of this report will be put into the Ventilation and Balance Required Reading Book for current actions and future reference.

Recommendations

- Ventilation and Balance recommends the continued use of Emery 3004 in the ATI TDA 5A generator as the challenge aerosol for "In Place Aerosol Testing" at the Hanford Site. The generator should be used without a transition or used with the newly designed transition and hose assembly described in Iteration 4 of this document.

- Forward a copy of this test document to the Design Authority, Jim Kriskovich for concurrence and disposition.

- A copy of this document should be forwarded by Fluor Daniel, Lockheed Martin Hanford Company to Air Techniques Incorporated.
- A copy of this document should be forwarded to Linda Calderon of Environmental Health and Safety for Company wide distribution.
- A copy of this document should be forwarded to the DOE Site Lessons Learned Organization for the development of a "Lessons Learned" for complex wide distribution.

Acknowledgments

Thank you to Air Techniques Incorporated, ATI for the loan of the 5B generator and for a wealth of technical information on their aerosol generators.