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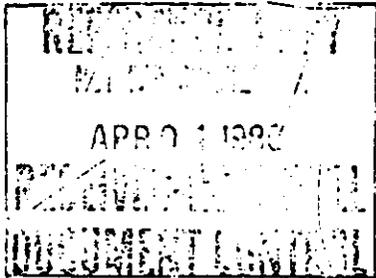
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PUREX FILTER SAFETY ANALYSIS STUDY

R. L. Walser

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PUREX FILTER SAFETY ANALYSIS STUDY

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February 1980

APPROVED FOR PUBLIC RELEASE 10/17/90
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Prepared for the Department of Energy by
Rockwell Hanford Operations under Contract DE-AC06-77RL01030

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INTRODUCTION

The June 30, 1978, Purex Plant Preliminary Safety Analysis Report⁽¹⁾ postulated an explosion of the ammonium nitrate contained in the No. 1 and No. 2 deep bed Fiberglas* prefilters for the main exhaust system as the accident with the second highest risk (release x frequency). The postulated explosion was associated with either a cell fire or spontaneous combustion under stagnant conditions. Hazards Research Corporation (HRC), Denville, New Jersey, contracted (Service Agreement-844) to perform tests to determine if the postulated accident is credible. These tests, conducted during the fall of 1978 and spring of 1979, are described in Appendices A, B, and C, and the results are summarized below. The heat transfer characteristics of the system and the effect of moisture on the ammonium nitrate were investigated in separate studies (Appendices D, E) and are also discussed briefly in this report.

SUMMARY

The significant findings of the HRC study are listed below:

- The ammonium nitrate occluded on the prefilters could not sustain a detonation and would not be capable of thermal runaway reaction even if subjected to high temperatures (170° C, which is the melting point of NH_4NO_3) for extended periods (24 hours) in stagnant air.
- Irradiation of the organic (plant solvent condensed in the filter) results in decomposition into lighter, volatile products which diffuse rapidly out of the prefilter beds further reducing the possibility of reaction.
- Even under high confinement and initiating energy conditions much more severe than are credible in the Purex prefilters, approximately 8.7 times the ammonium nitrate estimated in the No. 1 prefilter would be required to sustain a detonation.
- The prefilter matrix will not detonate, even with shock loadings orders of magnitude greater than could be attained mechanically as a result of a solvent fire.
- Pressures of about 3 Kg/cm² (43 psig) and temperatures of about 240° C are required for a thermal explosion of ammonium nitrate sensitized with wax (hydrocarbon) or chloride. These conditions are not credible in the Purex filters.

* Trade name of Owens-Corning Corporation, Toledo, Ohio.

- Sustained sudden impingement of very high temperature vapor/air or flames would only melt and decompose the ammonium nitrate even at concentrations 7.5 times the estimated value.
- Although the filter media directly exposed to an acetylene/air torch flame (10 minutes) was embrittled, the properties of the remaining filter media were essentially unaffected.

The above findings support the conclusion that the ammonium nitrate contained in the No. 1 and No. 2 Purex deep bed Fiberglas* prefilters for the primary building exhaust is safe under any credible accident conditions. A heat transfer study also shows that the temperature increase in the filter under stagnant conditions is not significant. Although exposure of the prefilters to high humidity air has been postulated to present an operating problem,⁽²⁾ other work^(3,4) indicates the effects would be beneficial and are not a safety concern.

DISCUSSION

The No. 1 and No. 2 Purex filters are shown on drawings H-2-55016 and H-2-58574, respectively. The prefilters consist of seven feet deep beds of fiberglass with areas of 2500 and 2880 square feet for the No. 1 and No. 2 units, respectively. The installed density of the fiberglass filter media in the first prefilter varied from 0.7 pound per cubic foot (lb/ft³) at the top to 3.3 lb/ft³ at the bottom. The filter media was installed in the second prefilter in five separate layers with densities of 0.7, 0.7, 1.5, 1.5, and 3.0 lb/ft³, respectively, starting at the bottom. The prefilter was designed for 92.0 percent removal of all particles 0.7 micron in diameter or greater.

Each filter has an after-filter made up of 132 American Air Filter Company deep bed filter units. Each unit is packed with 1/2-inch of No. 25 Filterdown** and 1/2-inch of No. 50 FG Filterdown. The density of the No. 25 media is 1.4 lb/ft³ and the No. 50 media is 1.2 lb/ft³. Collection of entrained moisture in this material may result in a breach of the units following a rapid increase in pressure. The units consist of five wedge-shaped pockets supported in a grid on frames. There is 6,600 ft² of area in the after-filter and an air velocity of 20 ft/min. up through the media at design capacity. The collection efficiency of the after-filter is 98.8 percent for all particles 0.7 micron in diameter or greater, giving an overall design filter collection efficiency of 99.9 percent.⁽⁴⁾ Recent tests indicate an overall collection efficiency of 99.968 percent for all particles greater than 0.3 micron in diameter.

* Ibid., p. 1.

** Trade name of American Air Filter Co., Louisville, Kentucky.

Airflow is down through the first prefilter which contains an estimated five to seven thousand pounds of ammonium nitrate crystals imbedded within the upper two feet of the prefilter. Airflow is up through the second prefilter which contains an estimated three to five thousand pounds of ammonium nitrate crystals imbedded within the lower two feet of the prefilter.⁽⁵⁾ The filters are operated in parallel with about 35-40 percent of the 120,000 cfm total airflow through the first filter and 60-65 percent through the second filter.⁽⁶⁾

The distribution and amount of ammonium nitrate contained in the filters are based on visual inspections and chemical analyses of core samples taken from the first prefilter in 1964 and 1969. The analytical data⁽⁷⁾ were extrapolated to estimate the current inventory using ammonia analyses of air samples taken prior to the filters under various process conditions and the flow through each filter while in service. The airflow was assumed to be uniformly distributed over the filter beds to result in uniform ammonium nitrate concentrations of 1.86 to 2.60 and 1.04 to 1.74 lb/ft³ for the upper and lower two feet of the first and second prefilters, respectively. A minimum ammonium nitrate concentration of 2.7 lb/ft³ was used in the HRC experiments which are discussed in Appendices A, B, and C.

As stated in the summary of this report, the HRC test results show the accidents postulated in Reference 1 are not credible. Also supporting this conclusion are the results of a heat transfer study using the "HEATING 5" computer program (Appendix D). This study, conducted for a vertical strip at the center of the No. 2 prefilter, which has the poorest heat transfer characteristics, showed that the maximum temperature increase in the prefilter would be only 36° F if airflow through the filter was stopped for a prolonged period. This calculation assumed a heat source equal to more than ten times the estimated fission product inventory was linearly distributed in the bottom 2.5 feet of the prefilter. Assuming a heat source slightly greater than the estimated fission product inventory distributed in the same manner resulted in a calculated temperature increase of only 2.8° F. (The fission product inventory listed in Table 9.3 - 19 of Reference 1 for the No. 1 prefilter was used as the base. Using time in service, quantity of fuel processed, and airflow through each filter, the fission product inventory of the No. 2 prefilter is expected to be lower.)

Appendix F expressed a concern regarding the possible deleterious effect of moisture on safety of the ammonium nitrate contained in the prefilters and Reference 2 attributed the formation of a crust found on top of the No. 1 prefilter in 1964 to the exposure of ammonium nitrate solids to moist air. However, the Appendix E engineering study shows that exposure of the prefilters to high humidity air is unlikely and would at worst result in the gradual formation of additional crust with a corresponding increase in differential pressure (dp) across the prefilters and reduction in air flow through the system. In contrast, other work^(3,4) shows that, depending upon the moisture content and

length of exposure, high humidity air is beneficial in improving the capacity of the system by partially dissolving the ammonium nitrate and/or redistributing the particles through the prefilter. Exposure of the prefilters to high humidity air is not a safety concern for the following reasons:

- Any increase in dp and corresponding reduction in airflow would be gradual over at least a several day period allowing appropriate corrective action such as reducing the number of operating fans and/or placing the third filter in parallel operation.
- No increase in radionuclide releases would occur unless one of the prefilters was breached, which is highly improbable.
- The efficiency of the prefilter filter media is not affected by exposure to moisture.⁽⁸⁾
- The final filter would not be affected even if the prefilters were washed on the upstream side with water sprays at a controlled rate.⁽³⁾

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HAZARDS RESEARCH

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PUREX FILTER SAFETY ANALYSIS STUDY

HRC Report 4152

- to -

Rockwell International Corporation
Rockwell Hanford Operations
Energy Systems Group
Richland, Washington

February 23, 1979

Submitted by:



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SUMMARY

The hazard potential of ammonium nitrate/organic chemical mixtures occluded on fiberglass filter medium was evaluated by two series of experiments. Mixtures based on 60 wt.pct. ammonium nitrate with fuel-poor, stoichiometric, and fuel-rich proportions of organic chemical (and specific inerts), were mechanically occluded on Fiberglas 115K filter medium. The occluded medium was then subjected to high-confinement, high-impulse detonation experiments and to extended thermal incubation experiments. No indication of detonation potential was observed at the specified overall density of 4.5-5.5 lbs./cu.ft. No indication of self-heating was observed in incubations at 170°C of up to 24 hours in uncirculated air. It was concluded that the specified mixtures in the specified range of densities could not sustain a detonation, and would not be capable of thermal runaway reaction even if subjected to high temperatures for extended periods.

This work was performed by Hazards Research Corporation under Rockwell Hanford Operations Service Agreement SA-844, Prime Contract No. EY-77-C-06-1030.

This report summarizes the results of a series of experiments performed by Hazards Research Corporation, Denville, New Jersey, for Rockwell International Corporation, Rockwell Hanford Operations, of Richland, Washington, under Service Agreement SA-844, Prime Contract No. EY-77-C-06-1030. Contact with Rockwell International Corporation was maintained through Mr. John Bourgeault (Administrative) and Mr. Ron Walser (Technical).

The purposes of this program were:

- (1) Determine whether the Purex fiberglass filter beds can become detonable at 60 weight percent ammonium nitrate with various other contaminants.
- (2) Evaluate the thermal explosion potential of the Purex fiberglass beds as a function of ammonium nitrate concentration with various other contaminants.
- (3) Assess the air flow requirements for cooling the Purex fiberglass filter beds.

A. MATERIALS

The fiberglass filter medium used in these experiments was supplied by Rockwell Hanford Operations; it was identified as Fiberglass 115 K.

Chemicals used to prepare contaminated filter medium samples were supplied by Hazards Research Corporation from the following sources:

Ammonium Nitrate: (NH_4NO_3) Baker "Analyzed" 99.5% b.w. min.
Iron Oxide: (Fe_2O_3) Baker "Analyzed" 98. + %.
Dust*: (Sodium silicate-9-hydrate) $(\text{Na}_2\text{SiO}_3 \cdot 9\text{H}_2\text{O})$ Baker "Analyzed"
Uranyl Nitrate Hexahydrate: $(\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O})$ Baker "Analyzed" 99 +%
Organic Liquid: Fuel Oil, #2, common heating oil.

*In the original proposal, calcium silicate or equivalent inert was specified; as the material is simply an inert, and the sodium silicate-9-hydrate was more readily obtainable, the substitution was considered inconsequential.

B. DESCRIPTION OF PROCEDURES

Task 1. Sample Preparation

As it was considered impractical to supply samples from the Purex filter beds in an operational mode, simulated occluded filter bed samples were produced by mechanical preparation of occluding mixtures and distribution of the mixtures in appropriate quantities of fiberglass medium. The specific compositions evaluated were considered to represent worst case conditions (for detonability studies) and/or representative extreme cases where specific worst case conditions could not be clearly rationalized (for thermal reaction studies), on the basis of compositions originally proposed for evaluation by Rockwell Hanford Operations.

Specific compositions evaluated in each Task are given in the Results of Experiments (Section C) below. The sample preparation procedure was the same in all cases.

First, all solids other than the Fiberglass 115 K were combined in the proper proportions for the various sample compositions by rotation mixing in closed vessels. The solids mixtures were then divided into smaller lots; each lot was "wet" with an appropriate quantity of fuel oil and mixed again for a period of 24 hours. It has been demonstrated that this method produces high quality ANFO explosives reproducibly on a number of occasions in HRC laboratories.

Fiberglass was separated into small lots of weight calculated to produce the desired final density (1.5 lbs/cf) in each experimental vessel; these lots were gently separated into relatively thin layers, over which the premixed occludant was distributed in the appropriate quantity. It was found that the occludant could not be satisfactorily expelled through sifting screens, as originally proposed, and accordingly a rougher but uniform distribution was achieved by simpler means. The contaminated filter medium was then rolled to form a cylinder of the desired shape and slid into the previously prepared experimental vessel (all were tubular). End caps were screwed into place as required and the open top was covered with aluminum foil until the sample was used.

Task 2. Detonability Study

This task consisted of eight individual experiments, three small scale and five larger scale detonation velocity measurement trials. The procedure is basically analogous to the Card Gap Test procedure for evaluation of military compositions (U. S. Army TB 700-2

Chapter 3, paragraph 3-12), except that card gapping is not performed. All trials are performed without spacer cards between the donor charge and the sample, and velocity of propagation is monitored by the constant current resistance wire technique. In this method, the velocity probe consists of a fine, skip-wound resistance wire of essentially constant resistance per unit length, cased in an aluminum tube. A constant current power supply delivers sufficient voltage to the wire to maintain a constant current through the wire to ground; thus the voltage of the power supply is a direct measurement of the length of wire in the circuit for any given constant current. As an advancing shock wave crushes the aluminum tube onto the wire, the wire is shorted to ground at the tube and circuit resistance drops, causing a drop in power supply voltage proportional to the length of wire consumed. By monitoring the power supply voltage as a function of time with an oscilloscope-camera system, a record easily convertible to distance per unit time is obtained, and changes in velocity are apparent.

The small scale experimental samples were contained in Schedule 80 stainless steel tubes 2" in i. d. (2.5" o. d.) by 8" in length, closed at the bottom with a thin plastic film. The top was covered with a 4" x 4" x 0.375" thick cold rolled steel witness plate; for these experiments a fine hole was drilled in the plate to permit insertion of the detonation velocity probe near the inside wall of the tube. At the plastic film bottom a 160 gm. RDX donor charge was placed composed

of two pellets (stacked) 2" in diameter. Detonation of the donor charge produces a 5500 m/sec plane detonation wave entering the sample material through the film. The velocity probe determines the characteristics of the wave as it passes through the sample; for a concentrated sample, the velocity decays rapidly (e. g. - in sand), but for a dispersed sample such as this, the incoming velocity may show attenuation or may remain a constant, depending on the degree of resistance the sample offers. The condition of the witness plate, the recovered tube, and any recovered sample are used as supplementary criteria for existence of a detonation; a high order reaction in the sample breaks and "holes" the plate, the tube is shattered and the sample is completely consumed. In this particular set of trials, the first was a blank (Fiberglas 115 K alone) for comparison, and the second and third were stoichiometric with respect to the ratio of organic (fuel oil) to oxidizer (ammonium nitrate).

Larger scale experiments, while similar to the TB 700-2 Card Gap Test, are based on the adaptation of the constant current resistance wire technique employed at RVO-TNO, Rijswijk, The Netherlands. The experimental vessel is 2-1/2" diameter Schedule 160 common steel pipe 48" in length, with both ends threaded and closed with high strength forged steel pipe caps. The probe (~30" long) is inserted through a fine hole in one cap; the donor charge of 240 grams of RDX (three pellets stacked) is placed inside the opposite pipe cap, through which the electric detonator is passed. The

confinement (one of the most influential extrinsic parameters for promoting detonation) in this latter system is much higher than in the small scale system described above, and the length of sample is six times greater, allowing more time for detonation to stabilize and be detected. The criteria for detonation are similar, except that, for these trials, in addition to the velocity probe evidence and physical residues evidence, a primercord/lead sheet witness was added. Through a 0.25" hole in the pipe cap opposite the donor charge, the end of a 10 ft. piece of primer cord was inserted into the sample. The opposite end was passed between the sides of a folded sheet of lead (approximately 4" x 4" x 0.25" thick). In such an arrangement, a detonation in the sample ignites the primer cord, which detonates along its length and shatters the lead sheet witness at its opposite end. Recovery of the (undamaged) lead sheet indicates absence of a detonation in the sample.

In this group of trials, two were stoichiometric with respect to organic and oxidizer, one with average levels of "dust" and uranium salt, and one with maximum levels. The other three reached the extremes of fuel to oxidizer, with average levels of "dust" and uranium salt. (All trials had average levels of iron oxide and standard density of Fiberglas 115 K with a maximum level of oxidizer per weight of filter medium.)

Task 3. Thermal Explosion Potential Study

This task consisted of sixteen trials, eight smaller scale and eight larger scale, one of each scale with eight compositions. The small scale experiments were performed using 2" i. d. by 8" long (2.5" o. d.) stainless steel schedule 80 tubes closed at the base with 2.5" x 2.5" thick stainless steel plates (welded) and open to the atmosphere at the top. The experimental vessels contained 4" deep samples (at the bottom of the tubes); a stainless steel-jacketed i-c thermocouple attached to the rim extended to the midpoint of the sample. A second thermocouple was attached to the exterior skin of the tube to monitor environmental temperature. Each vessel was placed in a thermostated electric heating unit and brought to 170°C at a rate of 2-5°C per minute, and maintained at that temperature for 24 hours. The criterion for self-heating was an increase in sample temperature above the bath temperature.

For the larger scale, confirmatory experiments, the vessels were 6" i. d. by 24" long carbon steel pipe, closed at one end with a pipe cap. The sample depth was 18" (at the bottom); a stainless steel jacket i. c. thermocouple extended to 6" from the bottom in the middle of the sample. The heating rate range was 1-5°C per minute and all heating units were electrical; the procedure was the same as for the small-scale trials.

Task 4. Air Flow Requirements

On the basis of self-heating characteristics of the samples in Task 3 described above, the heat generation rate was to have been calculated for

each system that self-heated. The air flow required to remove this heat was to be estimated using standard chemical engineering heat transfer calculations.

C. RESULTS OF EXPERIMENTS

Task 1. Sample Preparation

The specific compositions required for all Task 2 and Task 3 experiments were prepared without incident. It was found that the proposed mechanical distribution method (fine sieves) could not be satisfactorily used, so rougher screens were used with new paint-brushes as drivers to obtain an essentially uniform distribution of contaminant (occludant) mixture on the Fiberglas 115 K matrices.

Task 2. Detonability Study

The following sample mixtures were used in this task:

<u>Sample</u>	<u>AN</u>	<u>Oil</u>	<u>Fe₂O₃</u>	<u>Dust</u>	<u>UNH</u>
1	60	3.4	2	2	1
2	60	3.4	2	6	2
3	60	2.0	2	2	1
4	60	5.0	2	2	1
5	60	8.0	2	2	1

All figures in weight percent; balance Fiberglas 115 at 1.5 lbs. / cu. ft.

AN: Ammonium Nitrate

Dust: Sodium silicate-9-hydrate

Oil: #2 Heating Oil

UNH: Uranyl Nitrate Hexahydrate

a) Small Scale Trials

The following results were obtained with three small scale trials:

<u>Trial</u>	<u>Sample</u>	<u>Velocities (m/sec)</u>	<u>Remarks</u>
1	Fiberglas 115	3000 decay	Plate bowed, broken (3 pcs.) Tube "flowered" on witness end.
2	1	3950 2850	Plate bowed, broken (4 pcs) Tube "flowered" & peeled about 3" on witness end, tube irregularly bulged.
3	1	3650 2200	Plate bowed. Tube irregularly bulged. slightly "flowered" on witness end.

The preliminary conclusion drawn from the above data was that no trial gave evidence of a sustained detonation, although energy release by the AN system was apparent in Trials 2 and 3.

b) Large Scale Trials (RVO-TNO Procedure)

The following results were obtained with five large scale trials:

<u>Trial</u>	<u>Sample</u>	<u>Velocity (m/sec)</u>	<u>Detacord</u>	<u>End Cap</u>	<u>Tube</u>
1	1	indet.	No	Popped	42"; bulged at end
2	2	indet.	No	Popped	39"; bulged at end
3	3	indet.	No	Torn Off	36"; end torn off
4	4	(3200?)	No	Lost	42"; bulged at end
5	5	indet.	No	Broken	42"; bulged at end

The specific conclusion drawn from the above data was that no trial gave evidence of a sustained detonation, although energy release from the AN System was apparent in all trials. The initial 6" of the tube is always destroyed, as that zone contains the three 2" booster pellets, so 42" is the maximum amount of tube recovered in any trial. The apparent increased damage exhibited in trial #3 was attributed to a weakness in the tube; other tubes were bulged, but in trial #3 the bulging was apparently greater than the tube could withstand. The bulging does not occur with dense samples such as pure ammonium nitrate prills, but in low density samples the donor wave is not attenuated, and the reflection and reinforcement of the donor wave near the end of the tube is sufficient to cause bulging. The bulging is comparable to the "flowering" of the smaller scale tubes due to reflection from the witness plates.

Task 3. Thermal Explosion Potential Study

The following sample mixtures were used in this task:

<u>Sample</u>	<u>AN</u>	<u>Oil</u>	<u>Fe₂O₃</u>	<u>Dust</u>	<u>UNH</u>
1	60	3.4	2	2	1
2	60	3.4	6	6	2
3	60	2.0	2	2	1
4	60	5.0	2	2	1
5	60	8.0	6	6	2
6	60	5.0	6	6	2
7	60	8.0	2	2	1
8	60	2.0	6	6	2

All figures in weight percent; balance Fiberglas 115 K at 1.5 lbs./cu. ft.

AN: Ammonium Nitrate Dust: Sodium silicate-9-hydrate

Oil: #2 Heating Oil UNH: Uranyl nitrate hexahydrate

The above samples were subjected to small-scale thermal explosion studies and large scale thermal explosion studies as described in Section B above. The results in both cases were essentially identical with all samples. The temperature monitored in the sample tracked very closely the temperature monitored at the vessel wall. Both attained the desired maximum in about 30 minutes in the small-scale trials and in about 5 hours in the large-scale trials. Thereafter no fluctuations occurred in the sample temperature that did not follow similar fluctuations in the vessel wall temperature.

Subsequent to completion of the experiments, a physical inspection of the contents of the experimental vessels was made. The following observations apply to all sixteen samples:

(1) Fiberglass at the top was white and "ashy", embrittled by heat treatment;

(2) Fiberglass in the body was dirty yellowish-brown, similar to oily rags; iron oxide was visible and other powdery substances were visible;

(3) Fiberglass at the bottom was stuck to the shell. Additional inspection showed a white cake was causing adhesion to the base cover. The cake dissolved at the periphery under a brief cold water jet, but

was recovered largely intact. The recovered cake dissolved quickly in cold water when the jet was applied again.

The conclusions drawn from the above data were that the sample systems did not undergo any significant exothermic decomposition during incubation, but that fusion of the ammonium nitrate during the 24 hour exposure had occurred due to impurities in the ammonium nitrate and/or the influence of the admixed contaminants. The recovered cake, presumably ammonium nitrate, was a heavily concentrated material during the incubation; because of conditions of the test neither the rate of fusion and segregation of the ammonium nitrate from the Fiberglas 115 K nor the amount of oil vaporized during the incubation could be estimated.

Task 4. Air Flow Requirements

As no exothermic activity was discernable in the sixteen thermal explosion trials of Task 3, no heat rejection rate calculations were made. There was no data on which to base a calculation. Also, an earlier Rockwell study has shown that the maximum equilibrium temperature of the filters containing ten times the expected radionuclide content with no air flow is only 116°F.

D. DISCUSSION

The experimental results obtained in this program support the following conclusions:

1) The Purex Filter Beds, with the indicated levels of contaminants and overall density, do not sustain a detonation, even under conditions of extremely high confinement and extraordinary initiation stimulus.

2) The Purex Filter Beds, with the indicated levels of contaminants and overall density, do not enter an exothermic decomposition leading to thermal explosion at temperatures up to 170°C (which is the melting point of ammonium nitrate), even when incubated at 170°C for periods of approximately 24 hours.

The above conclusions are in accord with prior expectations, based on information previously developed concerning ammonium nitrate systems. The low bulk density of the ammonium nitrate system and the dilution by inerts preclude detonation and thermal explosion in the Purex Filter Beds.

The Purex Filter Bed #1 is described as containing up to 7000 lbs. of ammonium nitrate crystals in the upper two feet of the bed across a cross-section of 2500 square feet. A stoichiometric quantity of organic (hydrocarbon) would be about 5% by weight, or about 368 lbs. The total combined density of ammonium nitrate-fuel oil would be about 1.47 lbs./cu. ft. If the ammonium nitrate itself were to constitute 60% by weight of the bed, the bed would contain approximately 4300 lbs. of inerts, providing an inert diluent density of 0.86 lbs./cu. ft., for a total density of 2.33 lbs./cu. ft. By comparison, the density of ANFO (95% ammonium nitrate, 5% fuel oil) is of the order of 66 lbs./cu. ft. On the basis of general experience, it would be considered extremely unlikely that a detonable mixture at 66 lbs./cu. ft. would still be capable of sustaining a detonation after a 45-fold reduction in density and a 2-for-3 by weight dilution with inert materials. To illustrate the effect of dilution on detonable mixtures, information generated at Hazards Research

Corporation in the past* indicated that trinitrotoluene distributed in water slurries thickened with small amounts of gellant would not propagate detonations at 40 wt. %, but did propagate detonation at 60 wt. %. For nitrocellulose, the No. Go level was 55% and the GO level was 65%. The energy transmission and conservation characteristics of such experimental materials would be far superior to the mixtures of the present program, however, as the bulk density was on the order of that of water.

In general, experience also has indicated that mixtures capable of undergoing thermal explosion at normal densities do not yield thermal explosions at greatly reduced densities. Further, substantial evidence has been accumulated to indicate that ammonium nitrate and/or ANFO mixtures do not autoaccelerate to thermal explosion unless confined under their own vapor pressures or decomposition

*"Detonation Propagation Tests on Aqueous Slurries of TNT, Composition B, M-9 and M-10", Report on Contract DAAA-21-73-C-0772 dated November 1973. Technical Report 4584, Picatinny Arsenal, Dover, New Jersey.

*"Detonation Propagation Tests on Aqueous Slurries of RDX, HMX, M-1 and Nitrocellulose", Report on Contract DAAA-21-73-C-0772 dated April 1977. Contractor Report AR2CD-CR-77002, U. S. Army Armament Research & Development Command, Dover, New Jersey.

pressures to levels of approximately 45 psig.** In the case under consideration, the materials individually and collectively may very well undergo thermal decomposition, but the easy dissemination of vapors produced in the incubation period prevents accumulation of heat and/or active species in the decomposition zone(s). The thermal explosion experiments indicate that the latter effect is sufficient to preclude a thermal runaway even when the mixture is at very high temperatures (relative to those experienced in air filtration) with no supplementary air flow through the mixture at all.

Thus, the results, while providing a direct experimental basis for the conclusions first mentioned in this section, are in accord with past experience, theoretical considerations, engineering judgement, and previously developed information.

**"A Compendium on the Hazards of Water Transportation, and the Manufacture, Handling, Storage and Stowage of Ammonium Nitrate and Ammonium Nitrate Fertilizers", Report to the U. S. Coast Guard by the National Accademy of Sciences (Contract No. Tcg. 38325) (1953)

APPENDICES

During the review meeting at Rockwell Hanford Operations, Richland, Washington, on January 31, 1979, three questions were presented that appear properly treated as appendices to this report. Although not perse part of the program, they are associated with the interpretation of results. These are as follows:

- 1) Does irradiation of the organic materials (tributyl phosphate type compounds) on the filter bed create any increase in sensitivity?
- 2) Can the results of this program be applied directly and unequivocally to an accident scenario proposed in RHO-CD-400 (C. 5-59-67)?
- 3) Can any additional experimental work be performed to increase confidence in the interpretation of the detonation experiment results of this program?

Each question forms the subject of a short appendix on the following pages.

Appendix A

Anticipated Effects of Irradiation of Organic Components

Irradiation of organic materials is known to cause decomposition to smaller fragments; the same is true for irradiation of certain inorganic compounds (e. g. -water). The irradiation of hydrocarbon compounds produces hydrogen and/or lower molecular weight hydrocarbons such as methane; the specific products are dependent on the frequency and intensity of the irradiation and the nature of the compound being irradiated.

In the specific case of a tributyl phosphate, the only possible products are hydrogen and lower molecular weight hydrocarbons; all such products are gases at normal temperatures and pressure, and will therefore diffuse rapidly out of the filter beds. The end result will be the same whether the air is flowing or not; only the diffusion rate will change, as air passage increases the rate of removal of the gaseous products.

No more sensitive condition is caused by irradiation; in fact, the removal of fuel from the filter beds reduces the possibility of reaction. Further, the experimental use of fuel oil is a more rigorous condition than the actual presence of tributyl phosphate, as the available fuel is much greater in the specified proportion of fuel oil than in the tributyl phosphate.

Appendix B

Application of Results to Accident Scenario

An excerpt from RHO-CD-400: C. 5. 8 ("Uncontrolled Chemical Reaction--Explosion in the Canyon No. 1 Main Exhaust Filter") was reviewed after the results of this experimental program were transmitted to Rockwell Hanford Operations. The excerpt deals with a posited possible violent decomposition/explosion in the main exhaust filter, either as a result of a solvent fire or thermal runaway under stagnant air condition.

The results of the program bear directly on the latter initiation mode, which was demonstrated to be not possible. The beds gave no indication of temperature increases even at high temperatures for extended periods, when in a stagnant condition.

The reaction potential in event of a solvent fire has not been directly assessed in the program. If the product gases reaching the filter are below 170°C, thermal runaway will not occur, as has been shown. The filter matrix will not detonate, even under extremely high shock loadings (orders of magnitude greater than could be attained mechanically as a result of a solvent fire). The response to incident temperatures above 170°C has not been directly evaluated in this program,* but the reaction potential of the filter bed will probably be on the order of the damage potential from the product gas wave itself. The effect of a high temperature incident product gas wave will surely cause some disruption of the filter bed matrix; the temperatures required for forcing a violent

*170°C is the temperature at which ammonium nitrate liquefies.

decomposition of the occluded ammonium nitrate mixture under effectively zero confinement would be substantially higher than 170°C , possibly on the order of 300°C - 600°C . Engineering judgement indicates that the damage to be anticipated from the incident product gas wave would be equal to or outweigh any damage potential from the occluded ammonium nitrate in all but the rarest cases.

Appendix C

Additional Experimental Effort That Can Be Of Value

Possibly valuable additional effort falls into two categories, one dealing with detonability concerns and the other dealing with reaction potential under high temperatures suddenly applied (Ref. Appendix B).

1) Detonability of Filter Beds

Although the data presented in HRC Report 4152 are considered conclusive in demonstrating that the occluded filter beds cannot sustain a detonation, some additional confidence may be achievable by performing trials to estimate the loading density required for a detonation. The specified loading density is 1.47 lbs./cu.ft. of stoichiometric ammonium nitrate/fuel oil mixture in a matrix of Fiberglas 115K at 1.5 lbs./cu.ft. (assuming sufficient fuel oil to be present on the bed). In the experimental procedure, Fiberglas 115K at 1.5 lbs./cu.ft. was occluded mechanically with 3.58 lbs./cu.ft. of stoichiometric ANFO and 0.56 lbs./cu.ft. of inert occludants. The normal approximate loading density for ANFO is 66 lbs./cu.ft. Experiments were performed with the equivalent of approximately 2.5 times the described levels in this program; it may be desirable to examine behavior at 5 and 10 times the described level of occludant, using premixed ANFO, or 7.35 lbs./cu.ft. and 14.7 lbs./cu.ft. occlusion on Fiberglass 115K at 1.5 lbs./cu.ft. (the inerts should be disregarded).

(It is worth noting that blasting ANFO is produced only from ammonium nitrate produced for the purpose, as the degree of intimacy of mixing between the AN and FO determine the detonation characteristics. Common AN fertilizers can form explosives with fuel oil, but they are poor.)

2) Response to Sudden High Temperature Exposure

In response to the area of concern specified in RHO-CD-400 (Ref. Appendix B) not addressed by this program (i. e. - impingement of high temperature gases from a solvent fire), it may be of value to perform experiments of a severe nature. Pads of Fiberglas 115K at 1.5 lbs./cu. ft. occluded at 3.58 lbs./cu. ft. stoichiometric ANFO (inerts not used) may be prepared in various sizes suitable for experimental work. Sizes ranging from 6" x 6" x 3" to 24" x 24" x 24" may be of interest. Starting with the smaller pads horizontally mounted in suitable frames, a series of experiments can be performed in which the pad is exposed to torch flames by rotation of a remote torch holder into position. The results would be monitored by 8 mm (Super 8) motion picture film. The first objective would be to determine whether a propagating and destructive reaction occurs with any size pad; a second objective would be to evaluate the intensity of reaction (by use of a measured background, so that a permanent record of the fireball size would be made). If found desirable, Bikini gages could be used to estimate the pressure waves produced, if any.

(Grossly comparable experiments with powdered high explosive produced only a strong fire; no detonation was obtained.)

PHOTOGRAPHS

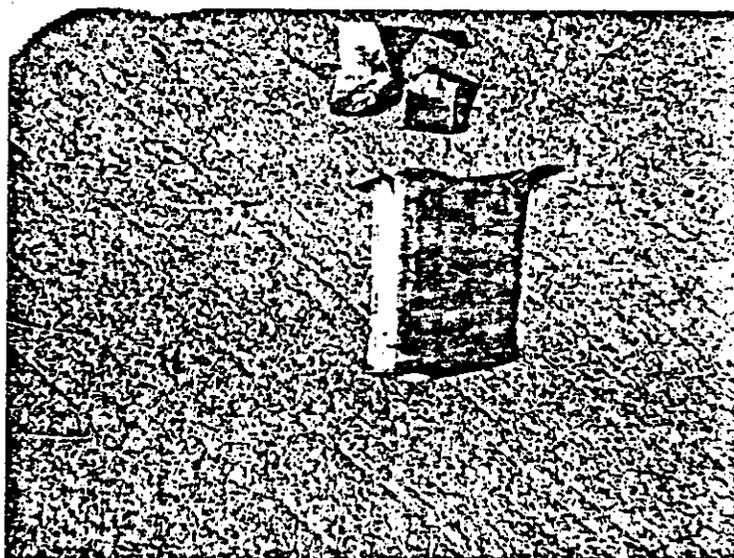
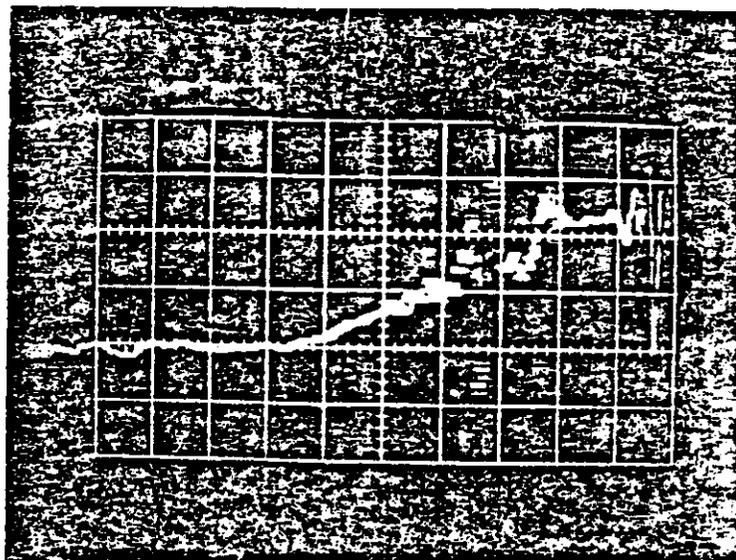


Plate 2. Small Scale Detonation Trial 1 (Fiberglas 115K alone)

Photographs of sample preparation operations failed to develop properly.

Inasmuch as sample preparation is long since completed, no photographs are available. As the photographs do not seem particularly informative for purposes of this report, it was considered superfluous to set up and photograph simulated operations.

Plate 1. Sample Preparation

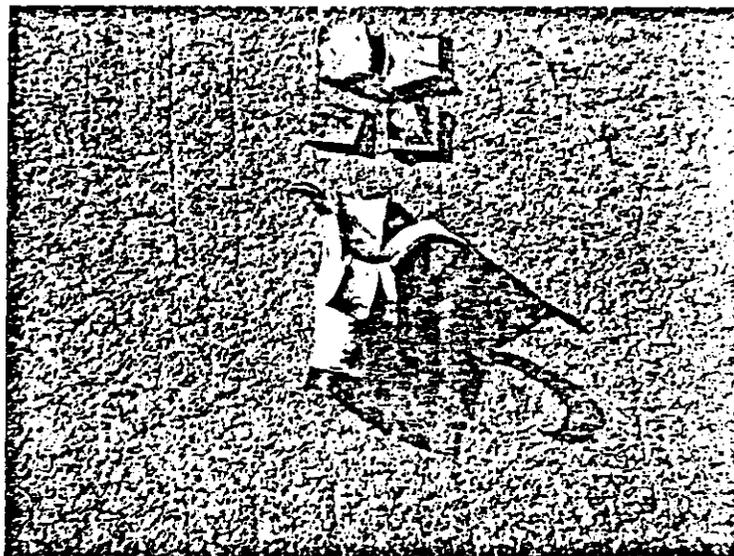
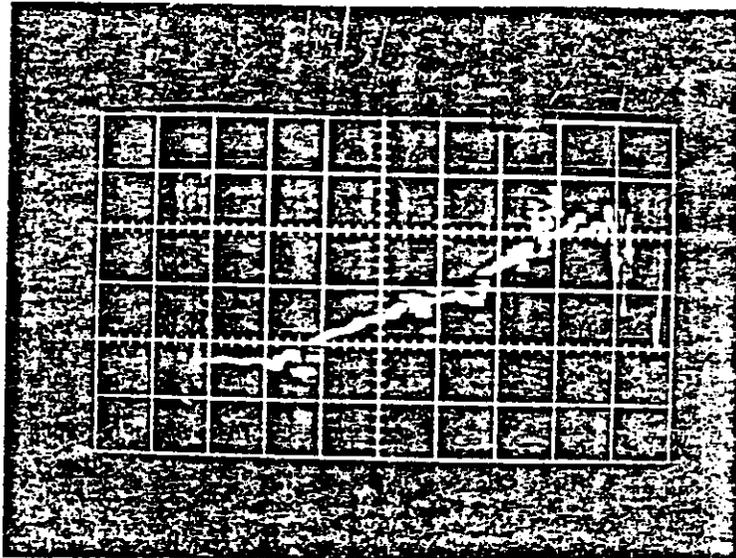


Plate 3. Small Scale Detonation Trial 2 (Mixture 1)

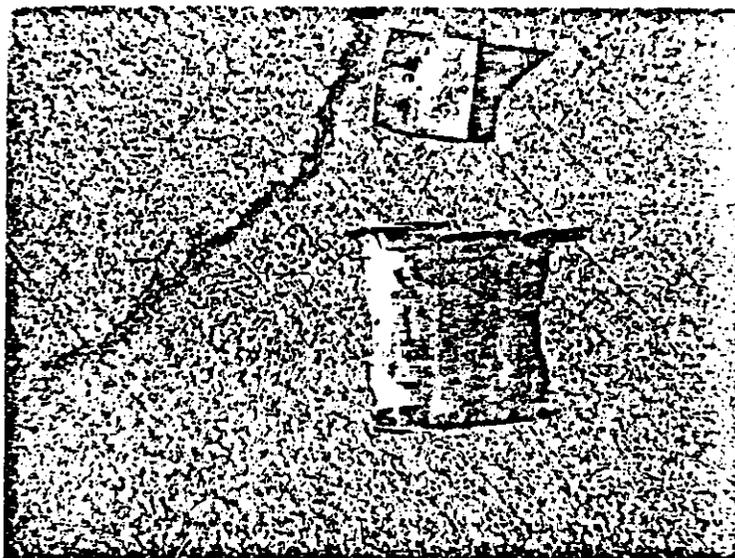
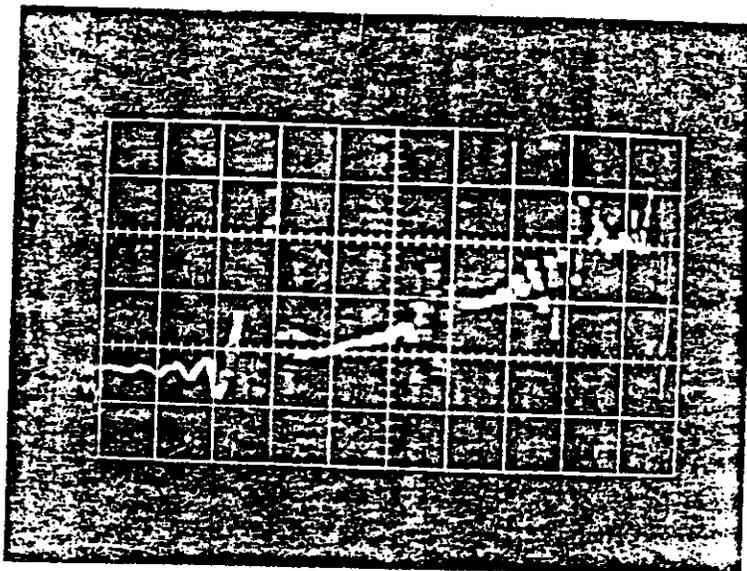


Plate 4. Small Scale Detonation Trial 3 (Mixture 1)

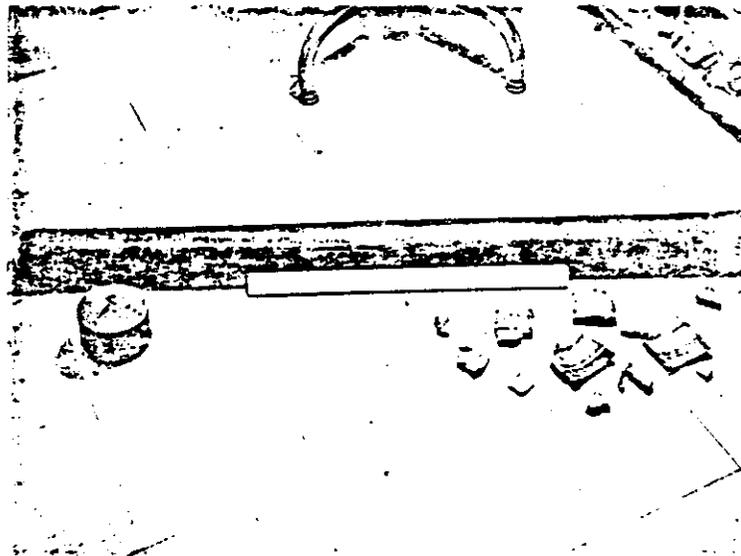
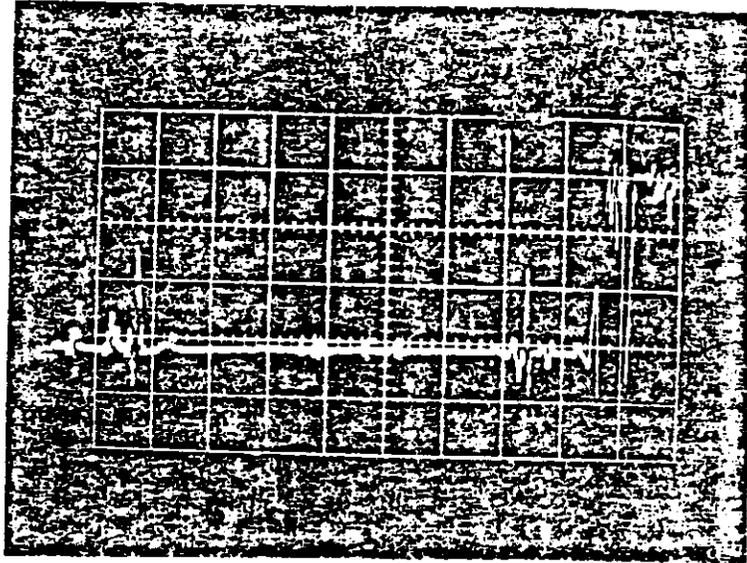


Plate 5. RVO-TNO Detonation Trial 1 (Mixture 1)

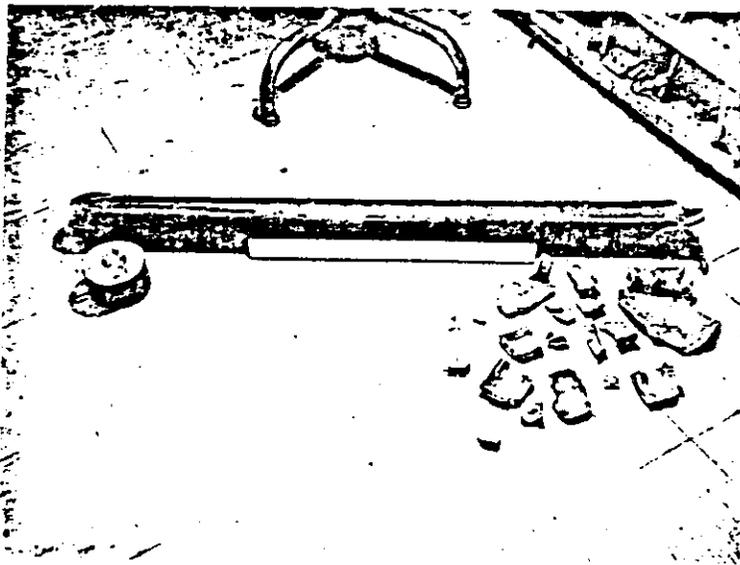
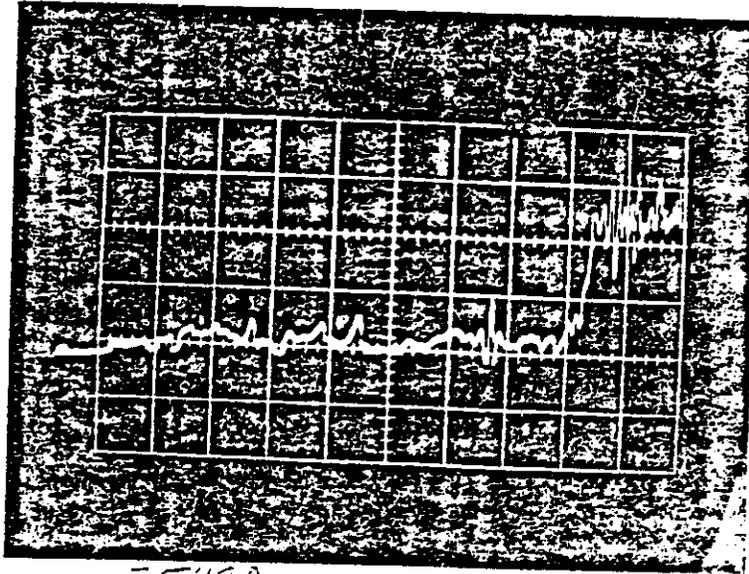


Plate 6. RVO-TNO Detonation Trial 2 (Mixture 2)

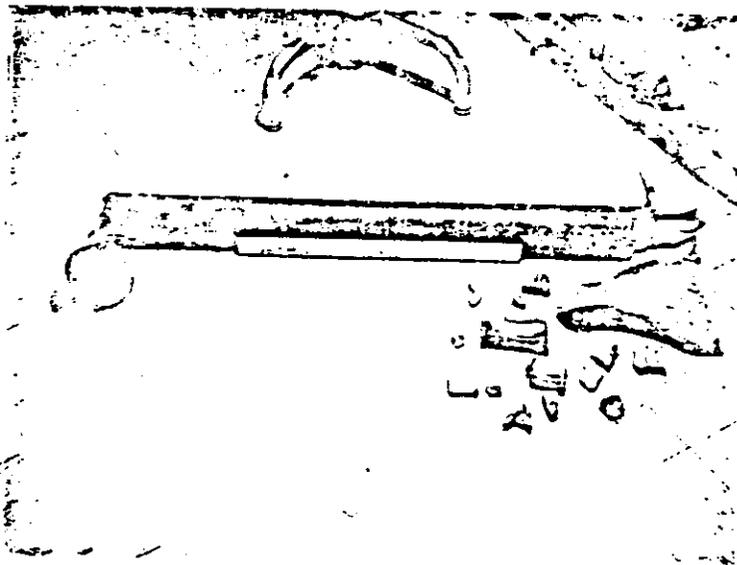
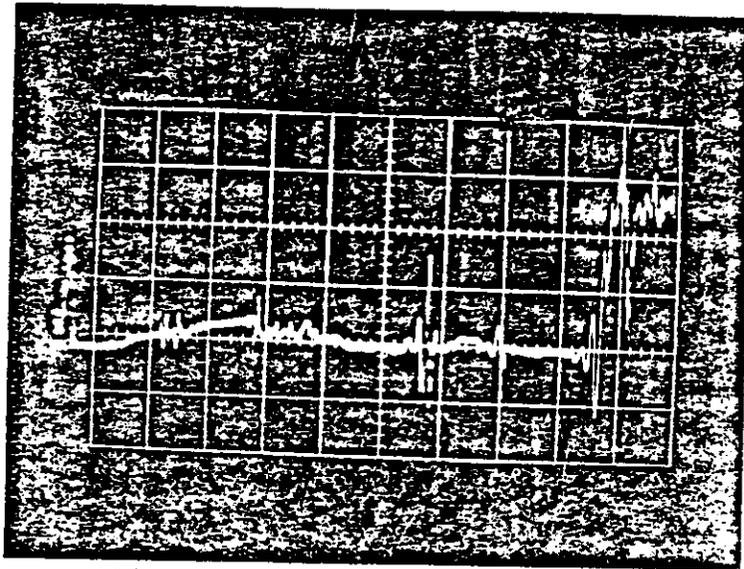


Plate 7. RVO-TNO Detonation Trial 3 (Mixture 3)

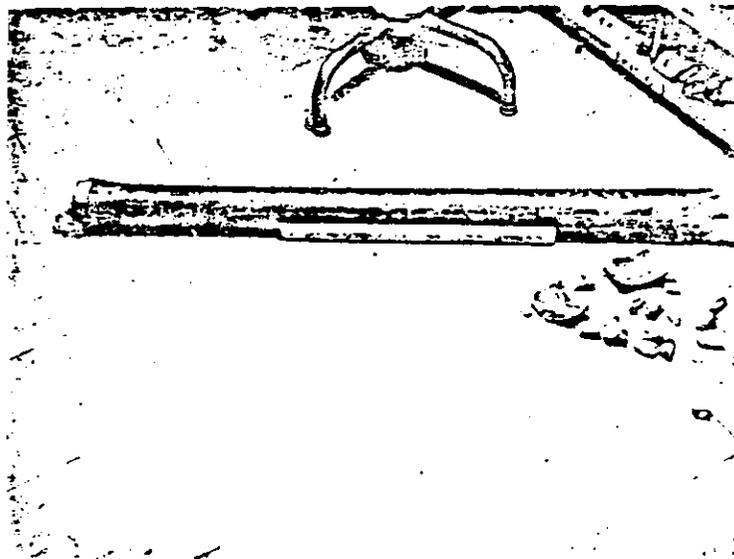
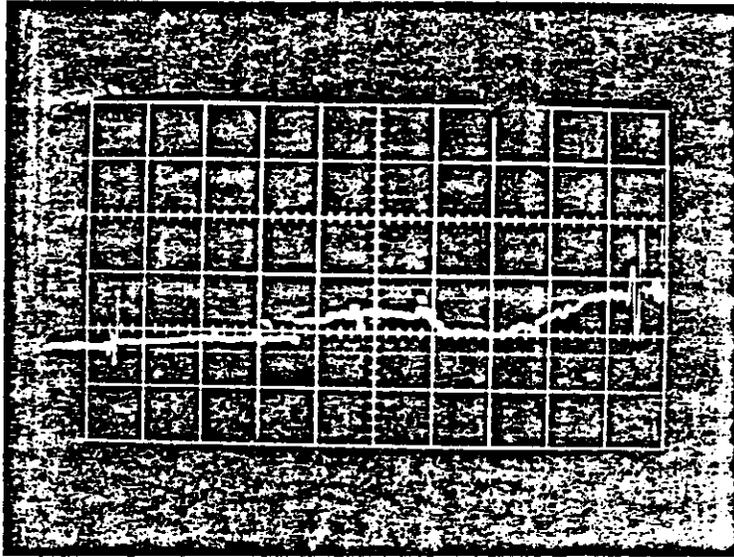


Plate 8. RVO-TNO Detonation Trial 4 (Mixture 4)

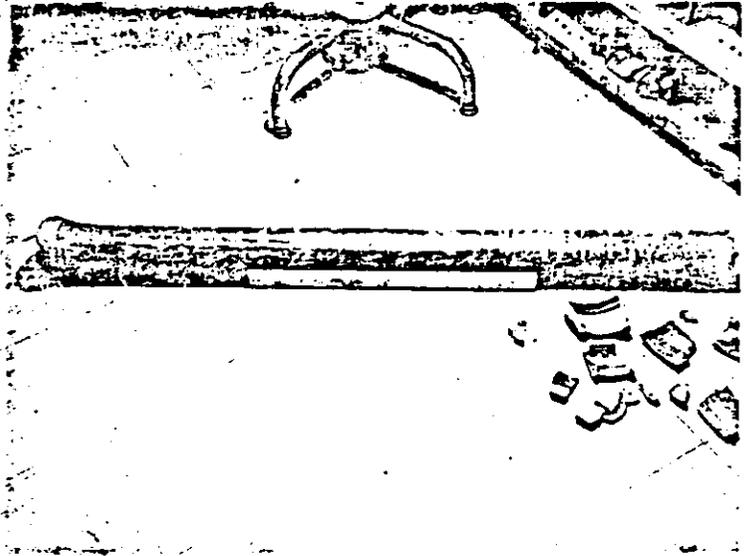
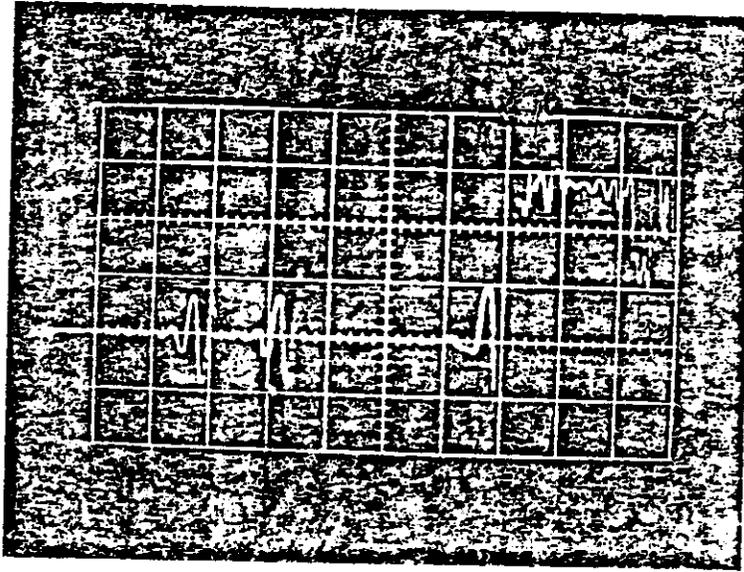


Plate 9. RVO-TNO Detonation Trial 5 (Mixture 5)



Plate 10. Small Scale Thermal Explosion Equipment

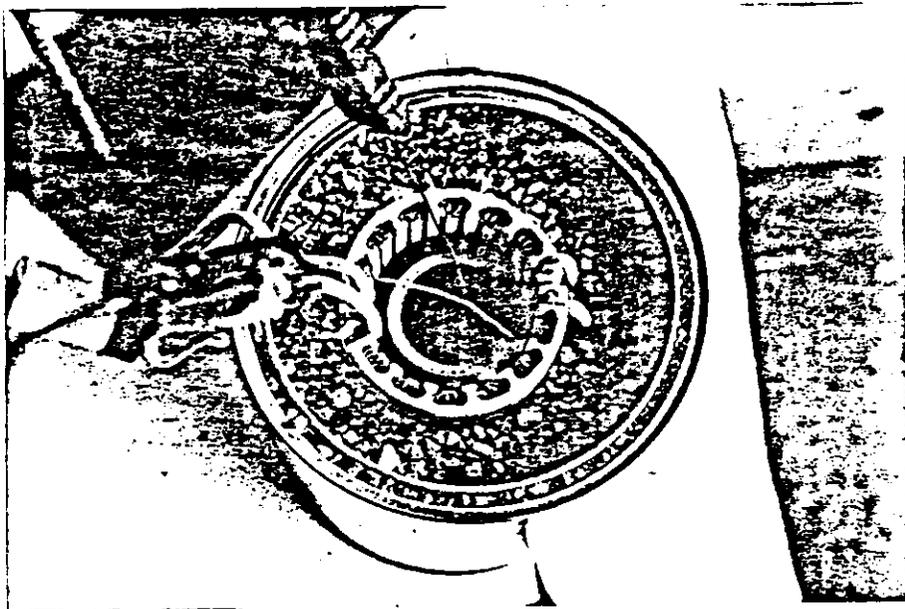
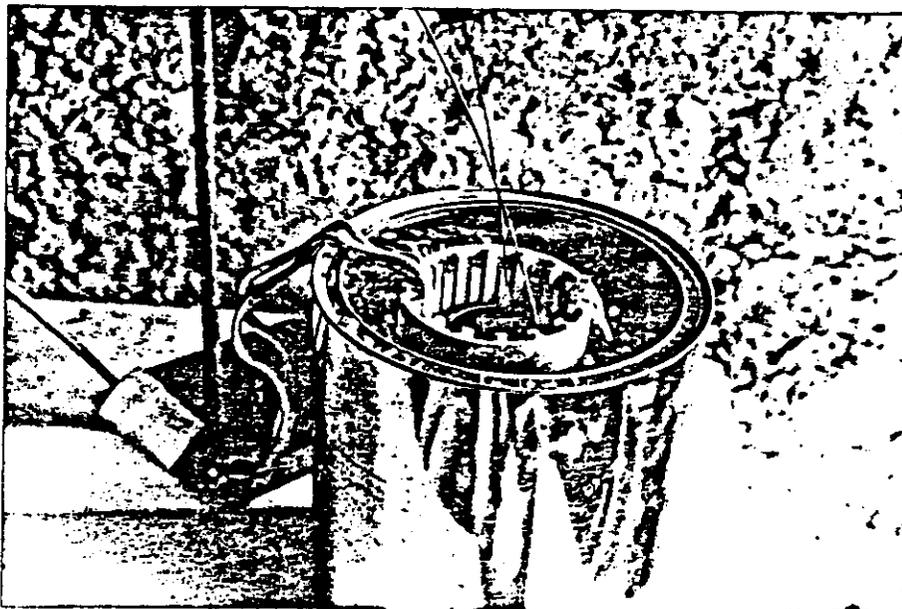


Plate 11. Small Scale Thermal Explosion Equipment

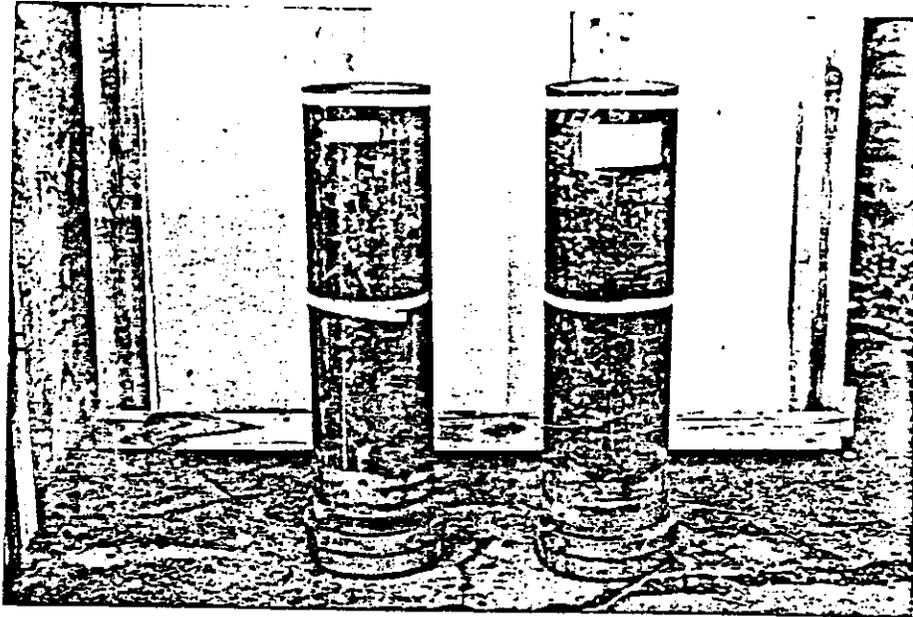


Plate 12. Large Scale Thermal Explosion Equipment

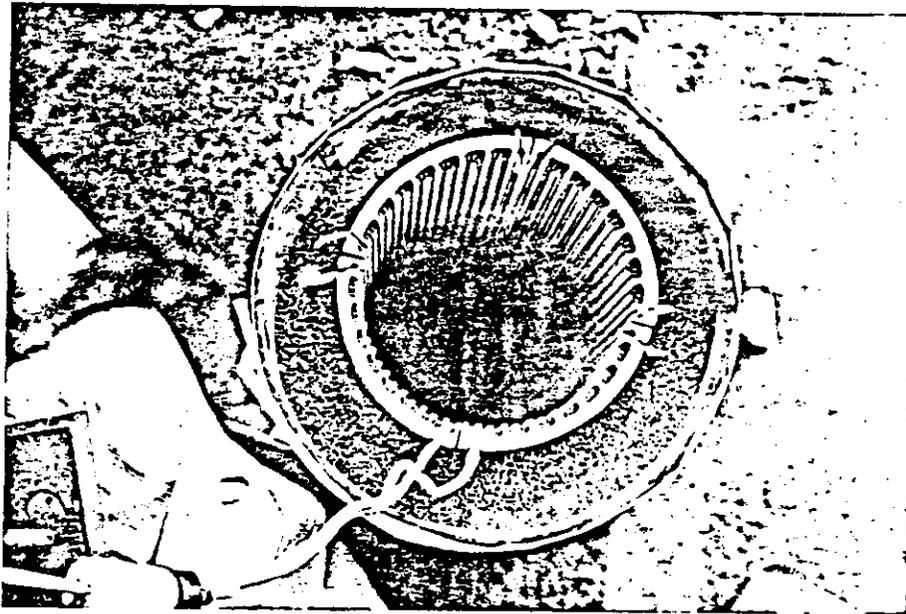
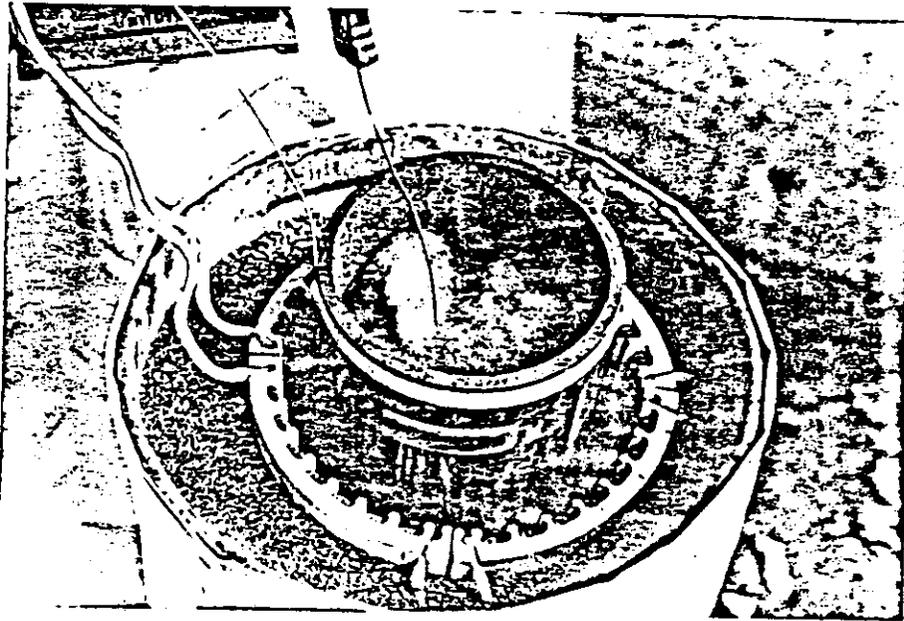


Plate 13. Large Scale Thermal Explosion Equipment

HAZARDS RESEARCH

CORPORATION

Fire and Explosion Hazards Evaluation

DENVILLE, NEW JERSEY 07834

201-627-4560

PUREX FILTER SAFETY ANALYSIS STUDY

(CONTINUED)

HRC Report 4152

SUPPLEMENT

- to -

Rockwell International Corporation
Rockwell Hanford Operations
Energy Systems Group
Richland, Washington

May 31, 1979

Submitted by:



William J. Cruice, M. S.
Associate Chief Scientist

Approved by:



Chester Grelecki, Ph. D.
Chief Scientist

T00233

SUMMARY

The work discussed in this supplement represents an extension of work previously reported regarding the hazard potential of ammonium nitrate/organic chemical mixtures occluded on fiberglass filter medium.

Two specific questions were addressed to improve confidence in the results of the initial body of work. These were:

1) At what level of occlusion is the system capable of propagating a detonation, even under extreme confinement and extreme initiation energy levels?

2) What response can be expected if the occluded filter medium should be exposed to sudden high temperature gases, as from a vapor/air combustion?

In this program, experimental results indicate the following responses:

1) The threshold level of ANFO occlusion at which Fiberglas 115 filter medium at 1.5 lbs/cu.ft. (medium) will sustain detonation is between 11 and 14.7 lbs/cu.ft., representing 88% to 91% ANFO by weight. This is approximately 8.7 times the estimated level of occlusion present and about 3.6 times the level of occlusion examined in the main body of work. This threshold applies only under high confinement and severe initiating energy, much more severe conditions than are credible in the Purex Filter.

2) Sustained sudden impingement of very high temperature vapor/air flames have negligible to no effect on the occluded medium other than to fuse and incrementally decompose the occlusion, even at occludent levels of 11.0 lbs/cu.ft. 7.5 times that estimated to be present in the Purex Filter. At levels in the Purex Filter, the response would be even less.

This report summarizes the results of a series of experiments performed by Hazards Research Corporation, Denville, New Jersey, for Rockwell International Corporation, Rockwell Hanford Operations, of Richland, Washington, under Service Agreement SA-844, Prime Contract No. EY-C-06-1030, as modified. Contact with Rockwell International Corporation was maintained through Mr. John Bourgeault (Administrative) and Mr. Ron Walser (Technical).

At the review of the report of the original work authorized under the referenced Service Agreement ("Purex Filter Safety Analysis Study," HRC Report 4152 dated February 23, 1979), two questions remained unanswered:

1) At what level of occlusion of the Fiberglas 115K with ammonium nitrate/organic chemical does the chemical system propagate a detonation? (Results of the originally authorized work indicated that the occludent mixture would not propagate a detonation at 60% b. w. ammonium nitrate with stoichiometric fuel oil and small quantities of inerts, the filter medium density being 1.5 lbs/cu. ft.)

2) What response can be expected if the occluded filter medium should be exposed to sudden high temperatures, as from a vapor/air combustion? (Results of the originally authorized work indicated that the occludent mixture would not self-heat under extended incubation at 170°C, the fusion temperature for the ammonium nitrate, at concentrations as indicated above.)

The objective of this extension of the Service Agreement was to provide answers to these questions.

A. MATERIALS

All materials used in these experiments were identical to those described in the referenced prior report.

B. DESCRIPTION OF PROCEDURES

Samples for all experimental procedures were prepared in accord with the procedures outlined in the referenced prior report as Task 1.

For the sake of simplicity, inert occludent (dust and uranyl nitrate hexahydrate) were omitted from the samples made for this work. The occludent was stoichiometric ammonium nitrate/fuel oil mixture.

Task 6. Detonability of Filter Beds

The procedures followed for this evaluation were those described in the referenced prior report under Task 2 "small scale studies." The basic configuration was a sample container fabricated from an 8" length of Schedule 80 stainless steel tubing, 2" in i. d., equipped with a constant-current resistance wire detonation velocity probe and a 4" x 4" x 0.375" thick cold rolled steel witness plate. The booster charge was 160 gm. of RDX.

Sample concentrations evaluated are indicated in "C. Results.." below.

Task 7. Response to Sudden High Temperature Exposure

Two separate experiments were performed at two different scales:

The initial experiment was performed using a sample container 8" long by 2" in diameter (composition pipe) mechanically loaded with occluded Fiberglas 115K (medium at 1.5 lbs/cu. ft. occluded with 11.0 lbs/cu. ft. of ANFO). The erect, charged container was mounted in a ring stand and an acetylene/air torch was applied to the exposed sample on the bottom. The experiment was repeated with a new sample and container. In both

trials, motion picture records were made to supplement visual observations.

The second experiment was performed using a sample container 7' long by 12" in diameter (light stove pipe) mechanically loaded for the bottom 2' with occluded Fiberglas 115K at the same concentration specified above; the remaining (upper) 5' was charged with new Fiberglas 115K at 1.5 lbs/cu. ft. The erect, charged container was mounted on a support frame and a dual-head acetylene/air torch was applied to the exposed sample on the bottom. The experiment was repeated with new sample and container. In both trials, motion picture records were made to supplement visual observations.

C. RESULTS OF EXPERIMENTS

Task 6. Detonability of Filter Beds

The following experiments were performed with the indicated results:

<u>ANFO</u>	<u>Fiberglas 115K</u>	<u>Result</u>
7.35#/cf	1.5 #/cf	Negative. Plate bowed & broken. Tube belled & bulged, but one piece. (Single)
11.0#/cf	1.5#/cf	Negative. Plate bowed & broken. Tube peeled 1.5"-3"; remainder only bulged. (Duplicated)
14.7#/cf	1.5#/cf	Positive. Plate bowed & broken. Tube in 1"x 5" strips, many smaller pieces. (Duplicated)

Reproductions of oscilloscope traces and photographs of physical residues are attached at the end of this supplement.

Task 7. Response to Sudden High Temperature Exposure

In all cases, the primary result was fusion and luminous decomposition of ammonium nitrate falling from the sample. No explosions or

violent reactions were experienced. In all cases the torch flame was applied continuously for a period of over ten minutes. In the smaller scale experiments, the composition pipe burned; in the larger experiments the metal pipes were recovered with no damage to pipe or sample not obviously attributable to the torch flame. Directly-exposed medium was embrittled; the balance of the medium was essentially unaffected as to properties.

D. DISCUSSION

The difference in physical evidence between the positive result at 14.7#/cf occludent and the negative result at 11.0#/cf occludent demonstrates the character of detonative reaction. The estimated occludent level in the Purex Filter is approximately 1.47#/cf, roughly equivalent to the Fiberglas 115K density. These experiments indicate that more than 7.5 times that level is required to create a condition under which a detonation can be sustained under high confinement and with extreme initiating energy. The confinement condition of the experiment cannot occur in the Purex Filter, which is vastly larger in cross-section. The threshold for detonative propagation in the Purex Filter would therefore be still higher occludent concentrations than 11.0#/cf.

The result of the flame exposure experiments is quite definitive. At the indicated contaminant levels (11.0#/cf), there is essentially no potential for hazardous response of a fire or explosion nature, even under sustained exposure to high temperature flame. The indicated levels of occludent are 7.5 times the estimated occludent levels in the filter.

The sustained flame is greatly more intense than could result from an upstream vapor/air combustion, and yet no significant response is obtained.

Motion picture records of flame exposure experiments were forwarded to Rockwell Hanford Operations under separate cover.

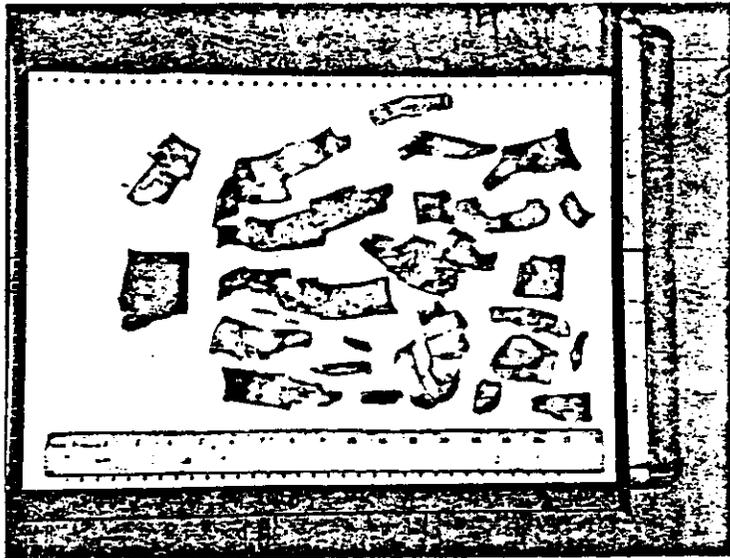
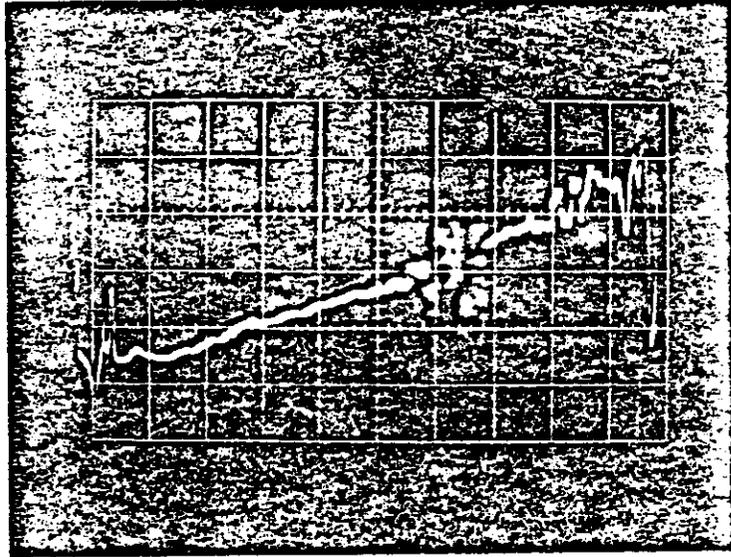


Plate 1. Small Scale Detonation Trial 9 (14.7 #ANFO/cu. ft.)

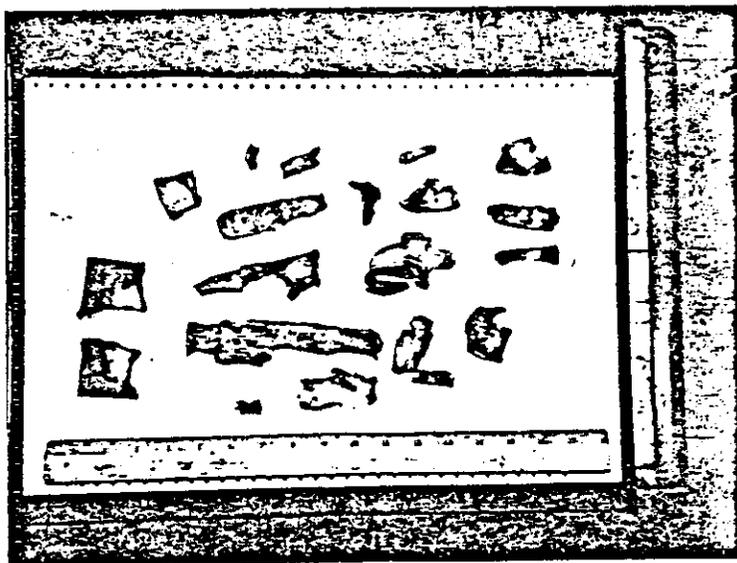
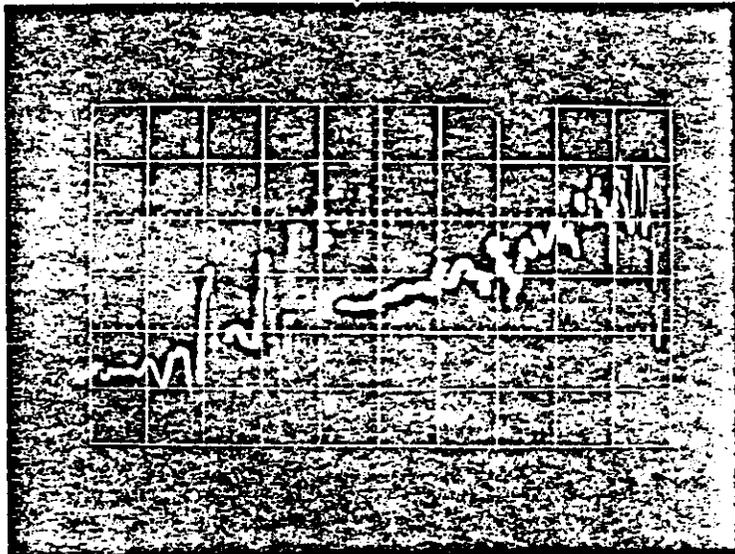


Plate 2. Small Scale Detonation Trial 10 (14.7 #ANFO/cu. ft.)

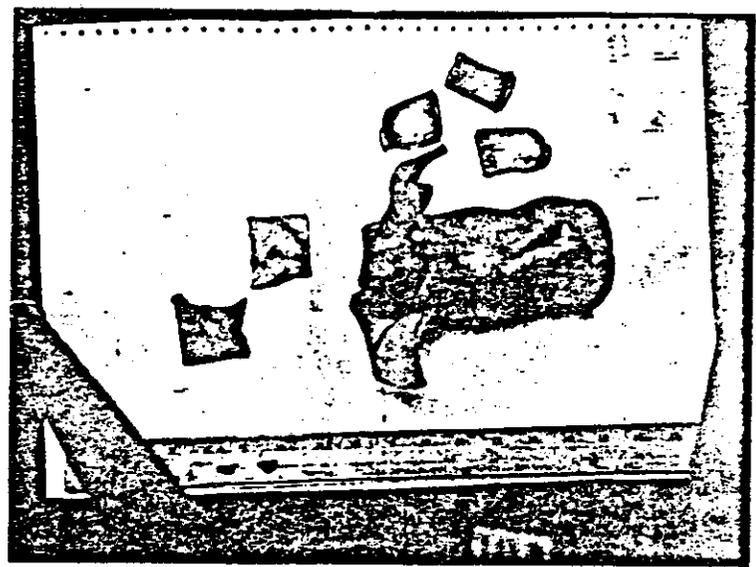
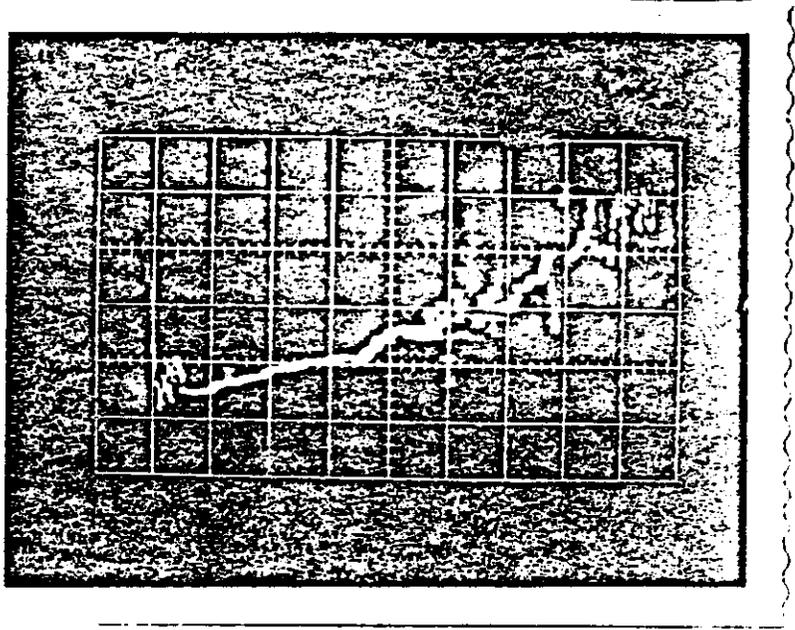


Plate 3. Small Scale Detonation Trial 11 (11.0 #ANFO/cu. ft.)

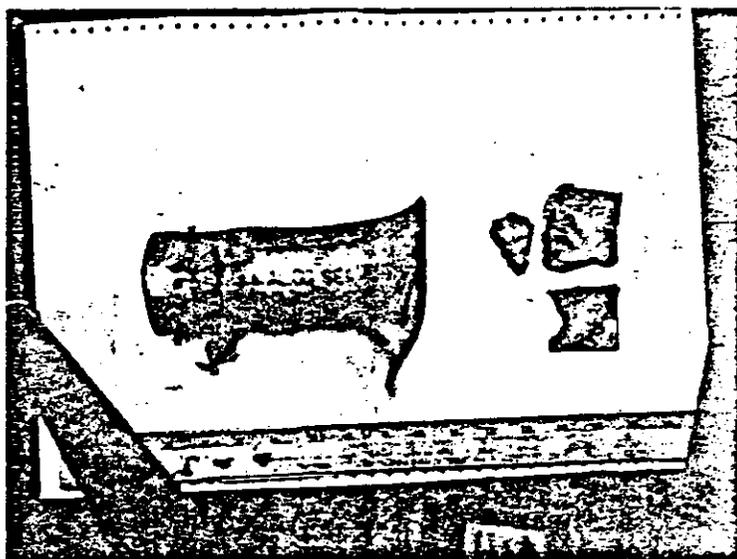
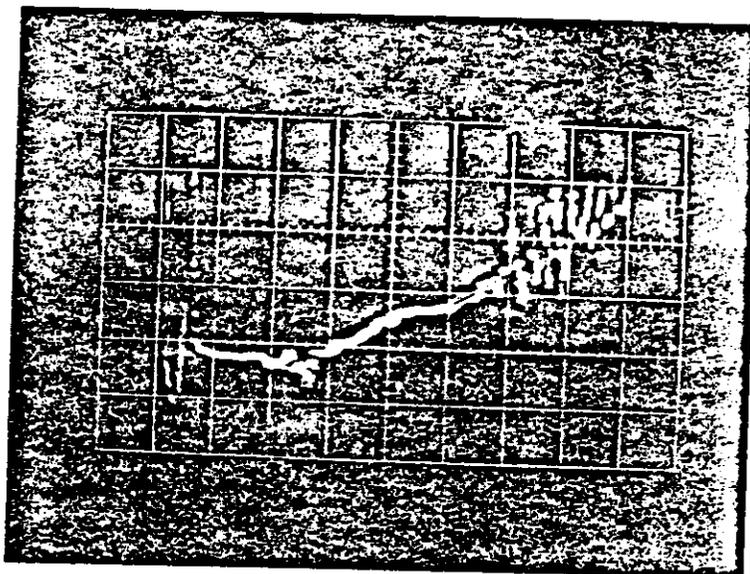


Plate 4. Small Scale Detonation Trial 12 (7.35 #ANFO/cu. ft.)

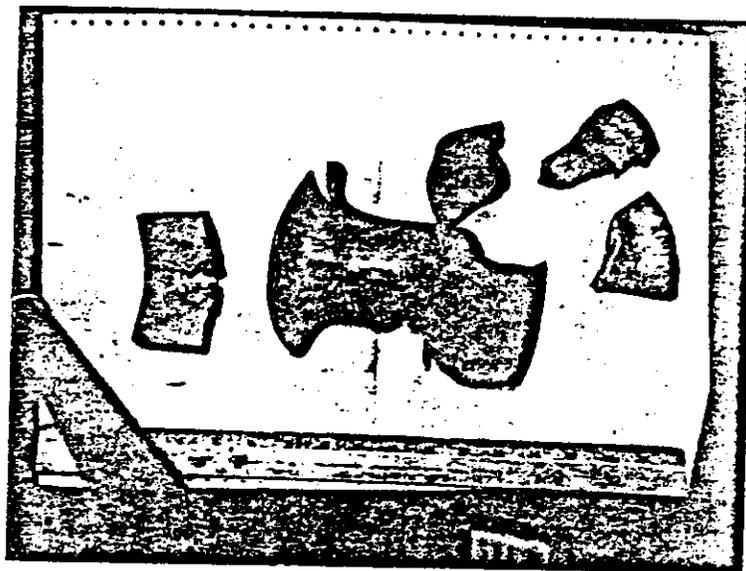
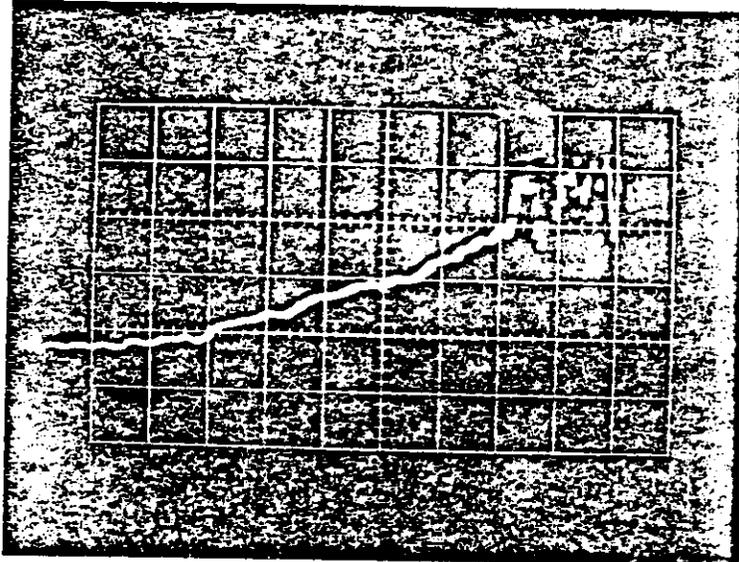


Plate 5. Small Scale Detonation Trial 13 (11.0 #ANFO/cu. ft.)

HAZARDS RESEARCH

CORPORATION

Fire and Explosion Hazards Evaluation

DENVILLE, NEW JERSEY 07834

201-627-4560

June 28, 1979

Rockwell Hanford Operations
P. O. Box 800
Richland, Washington 99352

Re: HRC 4152

RHO-SA-844

Attention: Mr. Ron Walser

Gentlemen:

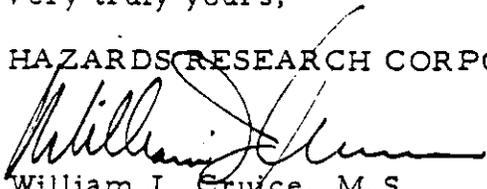
In response to your inquiry regarding the effect of chlorine on the thermal explosion characteristics of ammonium nitrate systems, we have examined the NAS report referenced on p. 15 of HRC Report 4152 for pertinent information. One of the abstracts in the NAS compendium was "The Explosibility of Ammonium Nitrate", Explosife 5, 34-36 (1952), F.F. Braconier and A.H. Delsemme.

The work indicated that unstabilized ammonium nitrate sensitized with wax or chloride could enter thermal explosion at pressures as low as 3 Kg/cm^2 (43 psig) at temperatures on the order of 240°C . As the definition of thermal explosion threshold is somewhat arbitrary, the phrasing "about 45 psig" is considered appropriate. There is no work specifically addressed to the combined effects of petrochemicals and chloride, but chloride was not a specified contaminant in the filters in any event. The key point is that confinement to create pressure is required to produce thermal explosion. In the conformation experienced in the filter, it seems impossible to achieve such confinement, particularly since the AN liquefies at 170°C and the petrochemicals volatilize at lower temperatures, producing segregation of the species.

If further questions arise, please feel free to contact me.

Very truly yours,

HAZARDS RESEARCH CORPORATION


William J. Cruice, M. S.
Vice President
Associate Chief Scientist

WJ/sb

T00233

Internal Letter



Rockwell International

Date: June 16, 1978

No: 60411-78-0734

TO: (Name, Organization, Internal Address)

- R. L. Walser
- Separations Process Support
- 202-A/Tr1. 1/200 East

FROM: (Name, Organization, Internal Address, Phone)

- D. W. Everly
- Waste Concentration
- 2750-E/200 East
- 2-2881 Ext. 240

Subject: Heat Transfer Study on the Process Exhaust System of the Purex Facility

Introduction

A heat transfer study on the process exhaust system of the Purex facility was performed. The study was conducted on the filter system with the assumption of no flow through the concrete duct system. Material generating heat at 140 BTU/hr in each separate filter was used for this study. The case for an order of magnitude increase of the heat generation (1400 BTU/hr) was considered. The computer program, "HEATING 5", was used for the study.

Summary

The results of the study show that the maximum temperature in the filter system at steady state after all flow through the concrete ducts has ceased is 82.8°F for 140 BTU/hr of heat generating material. For the case of an order of magnitude increase in heat generating material, the maximum temperature in the filter system is 116°F.

Assumptions

1. A constant value of 2 BTU/hr ft² - °F was assumed for the heat transfer coefficient from the soil surface to atmospheric air at 80°F.
2. The temperature of the water table, a depth of 252 feet below the soil surface, was constant at 70°F.
3. An insulated boundary was assumed between Filter No. 1 and Filter No. 2.
4. An insulated boundary was assumed at a distance of 10.5 feet from each filter due to surface obstructions.
5. A linear distribution of the heat generating material in the first 2.5 feet of the filter was assumed.

R. L. Walser
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6. Heat was transferred in the air space in the filter system by natural convection and radiation.

Data

Temperature of atmospheric air	80.0°F
Heat transfer coefficient from soil surface to air	2.0 BTU/hr-ft ² -°F
Temperature of water table	70°F
Depth of water table	252.0 Ft
Thermal conductivity of soil	0.25 BTU/hr-ft °F
Thermal conductivity of concrete	0.5 BTU/hr-ft °F
Thermal conductivity of air	0.016 BTU/hr-ft °F
Thermal conductivity of filter material	0.02 BTU/hr-ft °F
Thickness of soil on filter system	2.0 Ft
Heat generating material in filter	140 BTU/hr

Discussion

Figure 1 is a plan view of the filter system, information taken from drawing numbers H-2-55018, H-2-58544, H-2-58542 and H-2-58574. The computer model was at section AA on Figure 1. This cross section is where the highest temperatures for the filter system should occur. The computer model used for the heat transfer study is shown on Figure 2. Figures 3 and 4 show the computed temperature distribution at steady state for the computer model.



D. W. Everly
Waste Concentration

DWE/db
Att.

cc:
S. S. Bath
D. G. Harlow
D. L. Merrick
W. E. Ogren
LB

T00233

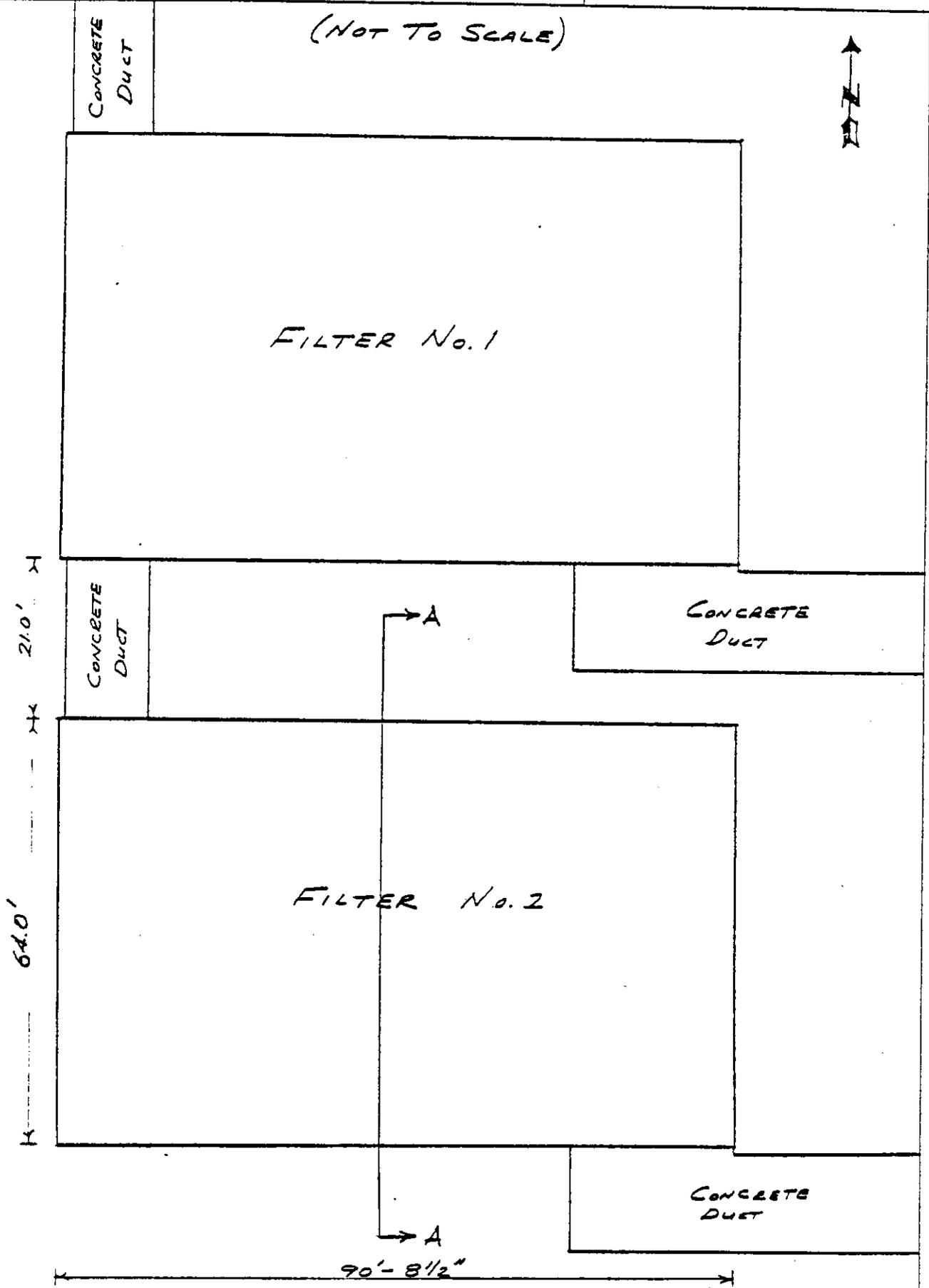


FIGURE 1. PLAN VIEW OF FILTER SYSTEM

(NOT TO SCALE)

TOTAL HEAT GENERATION = 1400 BTU/hr
IN FILTER

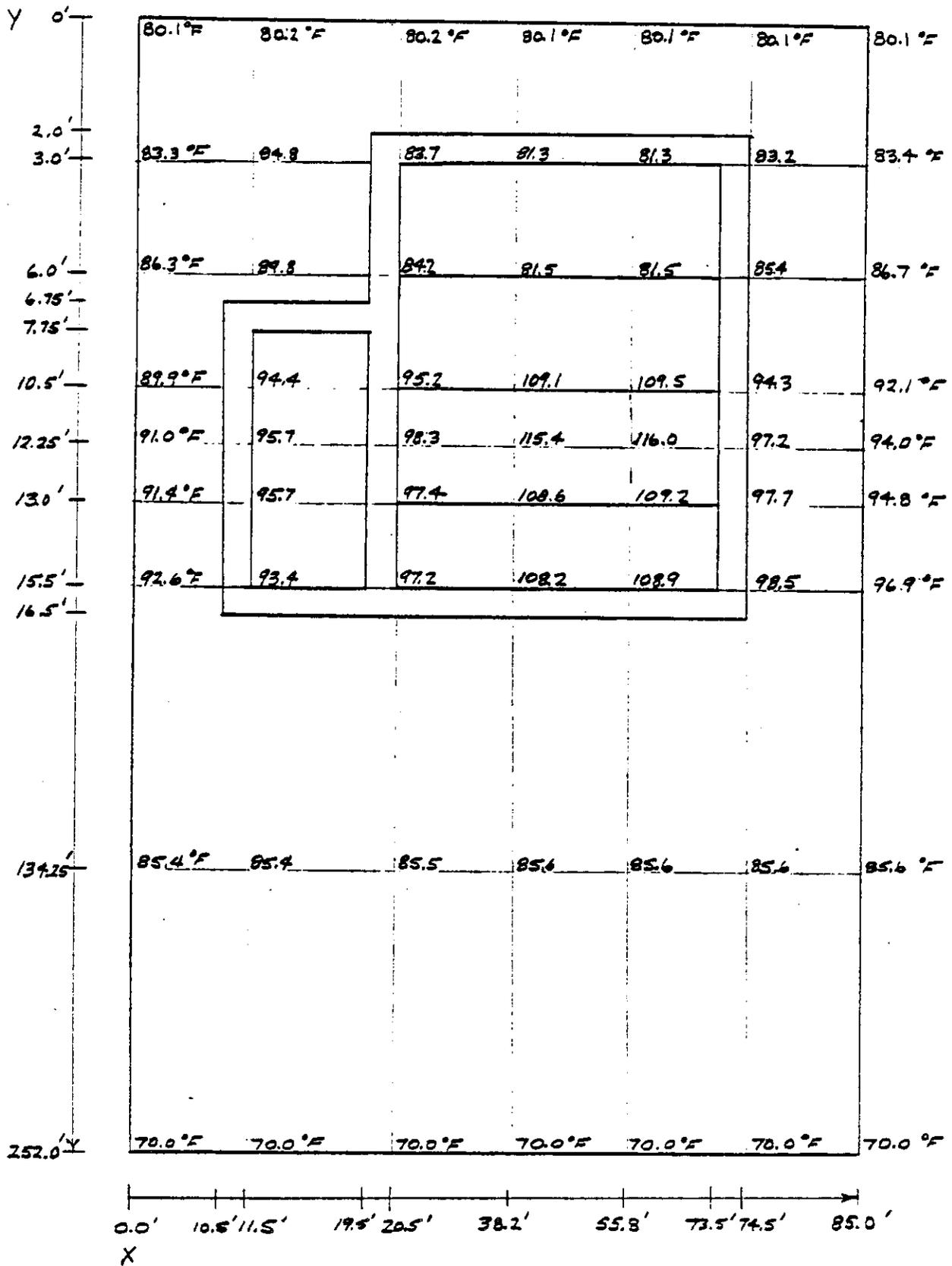


FIGURE 4. TEMPERATURE PROFILE

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NATIONAL
 ENGINEERING
 CONSULTANTS
 INC.



Internal Letter

Rockwell International

Date: June 21, 1978

No. 60422-78-079

TO: (Name, Organization, Internal Address)

. B. F. Campbell
 . Purex Operations Department
 . 202-A, 200-E

FROM: (Name, Organization, Internal Address, Phone)

. R. L. Walser
 . Separations Process Support Unit
 . 202-A/Tr. 1, 200-E
 . 2-2165

Subject: Effect of Moisture On Purex Deep Bed Prefilters

- Ref: (a) HW-82318, May 28, 1964, J. P. Duckworth et al, "Summary Report On The Purex Canyon Ventilation Exhaust Filter"
- (b) HW-82737, June 10, 1964, E. A. Coppinger, "Loading and Washing of Purex Ventilation Filter Model"
- (c) ARH-SA-9, July 31, 1968, B. E. Clark, et al, "Reclamation of a Partially Plugged Glass Fiber Ventilation Filter at the Hanford Purex Nuclear Fuels Reprocessing Plant"
- (d) Letter, February 13, 1970, R. L. Hobart to G. C. Oberg, "No. 1 291-A Ventilation Filter Progress Report on Washing Studies"
- (e) Personal Communication, December 12, 1977, R. M. Wallace of Savannah River Laboratory to R. L. Walser
- (f) Letter, April 14, 1978, A. J. Low to D. C. Bartholomew, "Purex Ventilation System No. 1"

Introduction and Summary

Reference (f) expressed a concern regarding the possible deleterious effect of moisture on safety of the ammonium nitrate collected in the Purex Ventilation System No. 1 (canyon) prefilters. Reference (a) also attributed the formation of a crust found on top of the number one prefilter in 1964 to the exposure of the ammonium nitrate solids to moist air.

However, an engineering study indicates that exposure of the prefilters to high humidity air is unlikely and would at worst result in the gradual formation of additional crust with a corresponding increase in differential pressure (dp) across the prefilters and reduction in air flow through the system. Indeed, depending upon the moisture content and length of exposure, high humidity air could be beneficial in improving the capacity of the system by partially dissolving the ammonium nitrate and/or redistributing the particles through the prefilter.

In summary, exposure of the Purex canyon ventilation system prefilters to high humidity air may present an operating problem, but is not a safety concern for the following reasons:

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June 21, 1978

- Any increase in dp and corresponding reduction in air flow would be gradual over at least a several day period allowing appropriate corrective action such as reducing the number of operating fans and/or placing the third filter in parallel operation.
- No increase in radionuclide releases would occur unless one of the prefilters was breached which is highly improbable.
- The efficiency of the prefilter filter media is not affected by exposure to moisture (Reference (e)).
- Reference (b) studies indicate the final filter would not be affected even if the prefilters were washed with water sprays.

Additional information is presented in the following discussion.

Discussion

The Purex canyon ventilation system currently has two deep bed filters operating in parallel. Each unit has two glass fiber bed sections, the pre-filters, and the cleanup or final filters. In the first unit, the prefilter is a seven foot deep bed free-packed with 115-K Fiberglas^(R) to an average density of ~ 1.5 pounds per cubic foot. The second prefilter is also a seven foot deep bed consisting of five separate layers, each packed with a different density of 115-K Fiberglas^(R). The area of each prefilter available for air flow is 2500 square feet. The cleanup filter in each unit consists of 132 American Air Filter Company "Deep Bed Filter" elements that are each one inch thick with an area of 50 square feet. Air flow is down through the number one prefilter and up through the number two prefilter.

The number one filter handled the entire canyon ventilation system exhaust air flow of approximately 125,000 cubic feet per minute (cfm) from the time of plant construction (1955) to April 1964. Through mid-March, 1964 the dp across the prefilter slowly rose from 3.0 inches water gauge (3.0" w.g.) to 4.4" w.g. with a relatively constant 2.1" w.g. dp across the cleanup filter. However, beginning in late March, 1964, the total filter dp increased from 6.6" w.g. at a flow of 117,500 cfm to 12.0" w.g. at 93,600 cfm over a twelve day period. It was first thought that the increasing dp and decreasing flow were caused by excessive moisture in the filter. However, humidity measure-

(R) Registered, Owens Corning Fiberglas Company, Inc.

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a flush volume of 25 ml/cm² removed 75 percent of the ammonium nitrate from the model, a volume of 190 ml/cm² removed only 42 percent of the ammonium nitrate from the filter core sample. These volumes would be equivalent to a total of 15,000 gallons and 116,000 gallons, respectively, for the entire prefilter area. The lower removal efficiency for the filter core sample was attributed to differences in particle distribution and channeling plus the presence of an organic film. These studies have not been pursued due to personnel changes, program changes, and the apparent large flush volume required for removal of a significant amount of ammonium nitrate.

RL Walser
R. L. Walser
Staff Engineer *WEO*

RLW/pd

cc:

D. C. Bartholomew
W. A. Blyckert
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W. E. Ogren
G. J. Raab
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R. E. Van der Cook
R. L. Walser ✓

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B. F. Campbell
Page 3
June 21, 1978

ment data obtained by various methods all indicated that the relative humidity of the stream is routinely less than thirty percent ($< 30\% \text{ RH}$) and did not exceed $51\% \text{ RH}$ during a four week period. The accumulation of water is improbable at these relative humidities (Reference (c)).

A bypass around the number one filter to an above ground filter was installed as a temporary corrective measure until the number two filter was placed in exclusive service in January, 1965 through the summer of 1967. The number one filter was restored to exclusive service on September 25, 1965 after passing 10,000 cfm of 80-90% RH air through the prefilter for a total of seven weeks. This treatment reduced the total dp across the filter at 115,000 cfm from 20+ " w.g. to 7.5 " w.g. Operation of the number one unit was satisfactory to January 6, 1968 when a significant downward trend in flow started. By March 9, 1968 the total dp across the number one unit had increased to 8.4 " w.g. at a reduced flow rate of 83,000 cfm. Although no problems of contamination were associated with the reduced air flow, the number two unit was placed in parallel operation on March 13, 1968. Both filters remain in operation with no further attempts made to reduce the dp across the number one unit.

Restoration of the number one filter unit was based on analyses of core samples taken in 1964 which indicated a high ammonium nitrate content of the surface crust, data from dp traverses which indicated most of the dp was across the surface crust and the reference (b) study. In that study, it was found that exposure of the Purex filter model, partially loaded with ammonium nitrate-sand dust, to air with less than 60% RH resulted in no change in the crust appearance or dp. Passing air with more than 60% RH through the filter model resulted in a reduced dp which did not increase after drying. Washing the filter model with small increments of water resulted in about 75 percent removal of the ammonium nitrate with a dp reduction to near that of the unloaded filter. A hard white crust formed, resulting in a significant dp increase, during the drying cycle between the initial washes. Neither the final filter dp nor appearance changed during these tests.

Removal of the ammonium nitrate from the number one prefilter by flushing with water has been studied in the laboratory (Reference (d)). Water flushing has also been performed annually at the Savannah River Plant to remove ammonium nitrate from vessel vent filters containing the same type filter media as in the Purex prefilters (Reference (e)). The laboratory study indicated that removal of ammonium nitrate from the filter model was much more efficient than from an actual filter core sample. Whereas

Internal Letter



Flockwell International

Date: April 14, 1978

TO: (Name, Organization, Internal Address)
D. C. Bartholomew

FROM: (Name, Organization, Internal Address, Phone)
A. J. Low

2-2226

Subject: Purex Ventilation System No. 1

This calls your attention to a Purex Safety concern, but it has no impact on the issuance of the Purex Preliminary SAR.

There is some hearsay of past event (s) of the deleterious effect of moisture on the ammonium nitrate formed or collected on the Purex Ventilation System No. 1 prefilters. We have discussed this some with engineering personnel but could not conclude from the discussions that there is not a need for an engineering assessment of this potential problem. There may already be such an assessment, but we have not researched this.

Our point here is to insure that this is not a safety concern that is overlooked at the time the final SAR is prepared and when plant operations resume.

A. J. Low

AJL/tp

cc:

- W. A. Blyckert
- B. F. Campbell
- M. H. Curtis
- J. B. Fecht
- W. F. Heine

FILE

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