AFRL-RX-TY-TR-2008-4523

ACTIVATED CARBON FIBER CLOTH ADSORBER

Ken Kessler

Hunter Manufacturing Company
30525 Aurora Road
Solon, OH 44139

MARCH 2008

Interim Report for 7 September 2005 – 7 September 2007

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TYNDALL AIR FORCE BASE, FL 32403-5323

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14. ABSTRACT

Regenerative filtration based upon activated carbon cloth (ACFC) and direct ohmic heating is being investigated for both environmental and military applications. Although these Electrothermal Swing Adsorbtion (ESA) systems have been demonstrated at the bench and pilot scale, further development is needed for scale up and manufacturability. This project consisted of the design, manufacture and testing of a tenth scale Vapor Phase Removal and Recovery System (VaPRRS) filter prototype. The adsorption filter created during this project would function as the primary adsorption filter in a VaPRRS used during the painting of United States Air Force aircraft wheel wells. The VaPRRS is expected to replace the single use filters currently used in this application and provide performance and overall system cost benefits.

15. SUBJECT TERMS
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Final Report

Contract FA8651-05-C-0302
Activated Carbon Fiber Cloth Adsorber

Submitted to:

Dr. Pat Sullivan
United States Air Force
Tyndall AFB, Florida
March 30, 2007

Presented by:

Mr. Ken Kessler
Hunter Manufacturing Company
30525 Aurora Road
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PROBLEM STATEMENT

Regenerative filtration based upon activated carbon cloth (ACFC) and direct ohmic heating is being investigated for both environmental and military applications. Although these Electrothermal Swing Adsorption (ESA) systems have been demonstrated at the bench and pilot scale, further development is needed for scale up and manufacturability.

PROJECT RECAP

The project consisted of the design, manufacture, and testing of a tenth scale Vapor Phase Removal and Recovery System (VaPRRS) filter prototype. The adsorption filter created during this project would function as the primary adsorption filter in a VaPRRS used during the painting of United States Air Force aircraft wheel wells. The VaPRRS is expected to replace the single use filters currently used in this application and provide performance and overall system cost benefits.

I. INTRODUCTION

As a matter of normal maintenance, the United States Air Force regularly repaints the wheel well areas of their aircraft. These become chipped during the take off and landing process. In an effort to simplify this process, carts have been developed that allow the planes to be painted inside of a hangar without having to "empty" the hangar which saves many man hours. The carts seal against the plane and form an enclosed sealed area in which the paint and solvent fumes are contained. Granular carbon filters are currently used to remove contaminants from the air before being released back into the hangar. These filters are thrown away when they become filled. If a cleanable, or regenerative filter could be devised, not only could the expense of replacement filters be eliminated, but any solvent fumes could be recovered and disposed of in an efficient manner. Possible uses for recovered solvent include reuse, burning for heat energy, and recycling.

This report details the investigation into regenerative filtration based upon an Electrothermal Swing Adsoprtion (ESA) cycle. ESA systems are a category of the more familiar Temperature Swing Adsorption (TSA) systems which use a temperature difference, or swing, to adsorb and desorb materials of interest. ESA filters utilize electricity to heat the sorbent material creating the temperature swing. Regenerative filters can be used to remove contaminants from air or water steam. These contaminates can then be collected and recycled or disposed of.

A typical regenerative filter is comprised of two (2) filter beds. The filter beds alternate between Adsorption Mode and Regeneration Mode, as shown in **Figure 1**. In the Adsorption Mode, contaminated air flows through the adsorber, at temperature T_1, and the contaminants of interest are adsorbed by the sorbent. After a predetermined time the contaminated air stream is stopped and the filter is placed into the Regeneration Mode. In Regeneration Mode the sorbent is heated to a selected temperature and clean air is introduced into the filter usually in the opposite flow direction. The heated sorbent releases, or desorbs, its contaminants into the air stream cleaning itself for the next adsorption cycle.

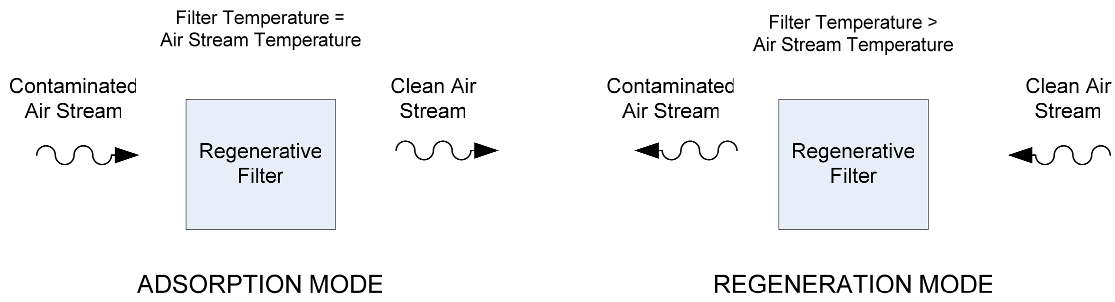

Figure 1. – *The two modes of a TSA filtration system, Adsorption and Regeneration.*

The adsorber studied in this report utilizes the patented VaPRRS Technology. Briefly, its make-up is an Activated Carbon Fiber Cloth Adsorber which utilizes electricity to provide direct ohmic heat to the sorbent material. This adsorber concept, which previously had been demonstrated at the bench and pilot scale, was analyzed to determine its most manufacturable configuration and a tenth scale prototype was constructed and tested.

As a manufacturer of Nuclear, Biological and Chemical (NBC) Filtration Systems for the United States Military and Homeland Security projects, Hunter Manufacturing Company is uniquely suited to participate in this development process. Hunter currently produces the majority of NBC filters in the ten to two hundred cubic feet per minute (10-200 CFM) range. Hunter also produces systems for mobile and stationary applications which allow the use of multiple sets of the 200 CFM filters to meet larger requirements.

The following report consists of three (3) sections.

- First various concepts are explored in a **Design Phase** to determine the best configuration for the prototype filter.
- During the assembly phase a **prototype filter** was constructed.
- Finally, during the testing phase, the prototype **filter was exposed to contaminate filled airstream** and its filtration performance measured.

II. DESIGN PHASE

The design phase consisted of the determination of the key sorbent bed design parameters, the development of several sorbent bed designs, and the evaluation of these designs against the key design parameters. The parameters considered in this process ranged from filtration bed design considerations, to assembly concerns and finally system integration issues. Once the evaluation period was completed, the best design would be selected and a prototype filter was built.

Key Design Parameters

The key parameters determined during this development process could be separated into three areas.

Key Parameters	Considerations
Filter Design	• Considered only items relative to filter performance
Manufacturability Factors	• Capable of integration
Future Systems	• Identified a series of performance parameters

Previous design work and the final system application have been combined to determine several facets of the final design. The sorbent material to be used has been identified as a carbon cloth material, specifically American Kynol ACC-5092-20. Experimentation had also established the required sorbent bed thickness at ten (10) layers of cloth. The regenerative cycle required meant that the filter components would see temperatures as high as five hundred degrees Fahrenheit.

1. The filter design parameters can be separated into two areas.
   The first group of parameters is related to the sorbent bed design. These parameters are directly related to the filter's performance.
2. The second group of parameters is associated with the other components of the filter. These are defined by the expected operational environment and operating mechanics of the filter. They include environmental, thermal, electrical and physical requirements.

The final considerations as key design parameters include manufacturability and system integration issues. Although the filter design is at an early stage of the process, clearly any design pursued must be both manufacturable and be capable of integration with the complete painting system. As a result manufacturability and overall system integration need to be considered as part of this process.

As part of the sorbent bed design process the following performance related parameters were identified.

1. Maximize the residence time of the contaminated air stream within the sorbent bed.
2. Uniform distribution of the airflow across the sorbent bed face.
3. The sorbent bed design must allow for even ohmic heating during the regenerative portion of the cycle.

Although filter residence time is an important parameter in all filter designs, it is especially important in this design due to the thinness of the sorbent bed. The longer the air stream is in contact with the sorbent bed the more opportunity that any contaminates present will be removed.

The incoming air stream must also be uniformly distributed across the sorbent bed. Uniform distribution of the air stream insures even use of the sorbent bed. This is imperative if the design is to make maximum use of the available sorbent material.

As stated earlier, the heating during the regenerative cycle of the filter is obtained by passing current through the sorbent cloth. In order for this to be effective, the cloth must be heated evenly across its surface and the other materials used in the filter construction should be nonconductive to prevent bypass.

The second group of parameters also presented some challenges. These include requirements for the filters operating environment, thermal design, electrical design, and spatial requirements. Although these properties are not directly involved in the removal of contaminants from the air stream they are critical to the proper operation of the filter.

Because the filter is directly involved in the painting process it is not likely to be exposed to any external environmental extremes. There are two (2) design concerns emanating from the operational environment. First, the temperature of the filter could reach five hundred degrees Fahrenheit during the regenerative process. Second, since the filter will be exposed to solvents used during the painting process, any components must be chemically resistant.

Filter Design Considerations

The first filter design parameter discussed will be the residence time of the contaminated air inside the sorbent bed. Since the thickness of the sorbent bed and the volumetric flow rate through this filter are fixed, there is only one method available to maximize the air stream residence time: maximizing the sorbent face area. Maximizing the available sorbent face reduces the air stream velocity, allowing more effective removal of contaminates.

The second filter design parameter involves equalizing the air flow across the filter material. If the air flow across the filter is unbalanced, then some parts of the sorbent will be exposed to more contaminants than others. These areas will "fill up" before the rest of the filter and pass contaminants. In order to make the best use of the available sorbent material, it is necessary to assure that the air flow is uniformly distributed across the sorbent face.

The design concerns regarding the filter's operating environment can be split into parameters concerning the external and internal filter environments. The filter is used during the painting process of aircraft; therefore the filter operates in a controlled environment. There are no extremes of temperature, humidity, or other environmental factors that would adversely affect the filter.

The interior of the filter is exposed to some challenging environmental conditions. These include exposure to high temperatures, five hundred degrees Fahrenheit, and exposure to various solvents used during the painting process. As a result of these conditions, chemical resistance and temperature resistance are prime considerations for any materials exposed to the interior of the filter.

The next two (2) design factors are a result of the regenerative cycle used with this filter. During the solvent recovery process the interior of the filter is heated to approximately five hundred degrees Fahrenheit. This heating is accomplished by allowing electricity to flow through the carbon cloth filter material. Obviously, all materials in contact with the filtering material be nonconductive. This forces all of the current through the filter material and maximizes the heating effect.

The thermal insulating properties of the material are also important to the filter design. If the materials used in the filter construction are excellent thermal insulators then a minimum of heat energy will be lost through them. This will result in more of the heat being retained in the filter and a more efficient overall package. Parts having a high thermal resistance all will tend to keep the generated heat inside the filter resulting in less loss to the environment and lower overall electrical requirements.

Additional consideration will be given to the manufacturability of the various alternatives. Specifically, the ability to obtain and manufacture the various components must be part of the design evaluation process. Although this is not the highest priority consideration for all items, it is an important one, especially for decisions that will shape the final filter design. Any item for which a configuration change would impact the filter performance must have its manufacturability as a primary consideration. This will prevent redesigns in later steps, and prevent future performance problems caused by difficult to produce items.

Finally the physical requirements of this filter must be considered. In this case the filter is a prototype design and will be subjected to far greater handling than the actual filter. This handling will result not only from the expected number of tests but also the fact that these test will occur in a number of locations across the country. This will result in a far more challenging physical environment than the production filter will be expected to encounter. Because of this, the filter will need to be built of materials that will remain rigid and not degrade after repeated exposure to the high temperatures, solvent exposure, and handling stresses.

Filter Design

The discussion of the final filter design will be broken into three areas. First the design options and down selection process for the sorbent bed configuration will be discussed. Similarly, the construction of the remainder of the filter will also be considered. In all cases it will be shown how the key design parameters discussed above were used as guides during the decision making process.

In order to increase the residence time of the contaminated air within the filter, two (2) sorbent bed shapes were explored. These two (2) options were a pleated configuration and a bag configuration. These two (2)alternatives will be discussed below.

The first option explored for the sorbent was a pleated configuration. This concept has been explored in the particulate filtration industry. Manufacturers of these products have settled on pleating as the most cost effective solution to their problem as evident by its widespread use throughout automotive, commercial, and residential products. **Figure 2** shows a typical pleated filter configuration. The residence time through the filter can be controlled by increasing or decreasing the number of pleats. Care must be taken to insure that the pleats are spaced so that the flow is even across the entire surface, preventing local areas of high velocity. A support structure may or may not be required depending upon the shape of the pleated material.

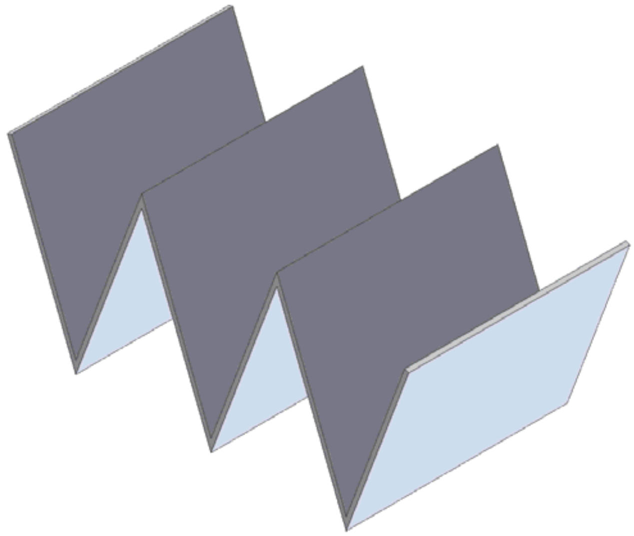

Figure 2. Pleated Sorbent Material – *Pleating allows the designer to increase the amount of sorbent material within a given filter size.*

The second option consisted of a bag configuration, as shown in **Figure 3**. This arrangement is similar to the pleated configuration except that air also flows out of the top and bottom of the individual bags. Many of the benefits described in the pleated section are also obtained with this configuration. The available sorbent face area can exceed that of a pleated configuration depending upon the construction. In order to obtain even airflow across all of the sorbent, the dimensions of the bags, the spacing between bags, and the spacing between the bags and the surrounding housing must be carefully considered. A support structure is required to hold open each of the bags and allow an even airflow to enter all. The main negative of the bag arrangement is that it requires seams which will be exposed to the contaminated air stream. Any seam method used in this design must be leak free and capable of withstanding the tough environmental conditions present inside the filter without degradation.

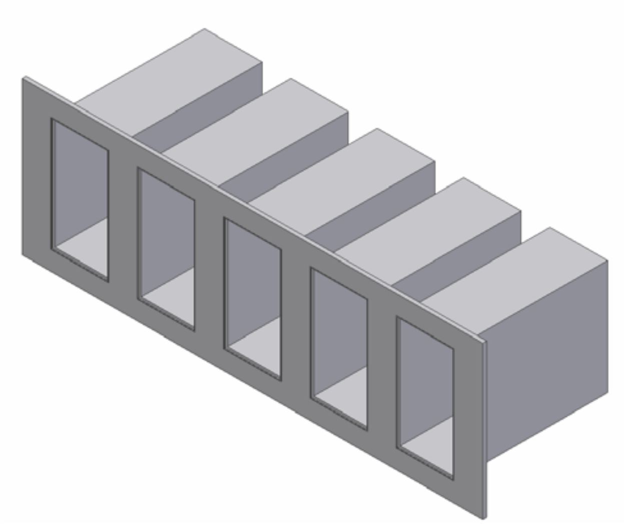

Figure 3. Bag Filter Arrangement – *The sorbent material can also be arranged in a multiple bag configuration.*

This support structure has some complex performance requirements. First it must support and allow air to pass through the bag during both the filtration and regeneration cycles. The structure must not interfere with the ohmic heating used in the regenerative cycle by either providing a bypass path for the electricity or by causing a delay in the heating and cooling process due to its additional thermal mass. Additionally, the structure must be rugged enough to survive the environmental conditions inside the filter, including solvent exposure and high temperatures.

The two (2) designs discussed above were then evaluated based upon the parameters discussed. As shown in **Figure 4**, the pleated sorbent design was the choice for the prototype filter. The bag design may have an advantage in airflow residence time because it allows for more sorbent material in the filter design. However, assuring that there is the balanced airflow through the unit, required to make use of the added material, is more difficult than with a pleated design. The regenerative cycle also favors the pleated design due to its uniform sorbent bed shape. The varying cross-section of the bag design almost assures uneven current flow through the sorbent material possibly creating hot spots and generally reducing the efficiency of the regenerative portion of the cycle. The most difficult obstacle to overcome is the seaming required. The ability to make the leak free seams required by this design in a manufacturing environment would be very challenging. These seams must also withstand frequent exposure to solvents and elevated temperatures compounding these challenges. The support structure for the individual bags is another complexity of the bag design that the pleated design does not show. The elimination of this component provides benefits in both manufacturability and durability.

Feature	Pleated Sorbent	Bag Shaped Sorbent
Performance	X	
Residence Time		X
Even Airflow	X	
Regenerative Cycle	X	
Manufacturability	X	
Durability	X	

Figure 4. Sorbent Shape Comparison Chart – *The chart compares the merits of a pleated and bag shaped sorbent configurations.*

Once the sorbent design was chosen, the rest of the filter could then be designed. The basic concept was to create a pleated filter similar to those used in many everyday applications. The difference in this case is the extreme operational conditions found inside this filter. Any materials chosen for use must be able to withstand exposure to solvents and temperatures near five hundered degrees Fahrenheit.

Figure 5 shows the basic filter configuration. Simply put, the filter design would consist of a box frame that would provide support and protect the pleated media. The inside of the frame would have a groove where sealing material would be poured to seal the long edges of the pleated material. The short edges of the pleated material would be sealed in an overlapping manner with a clamping strip, which would not only eliminate leaks but also provide the method of transmitting the electrical current required for the regeneration process. Supports in the form of thin nonconductive rods will be used to support the pleated material as required by airflow considerations.

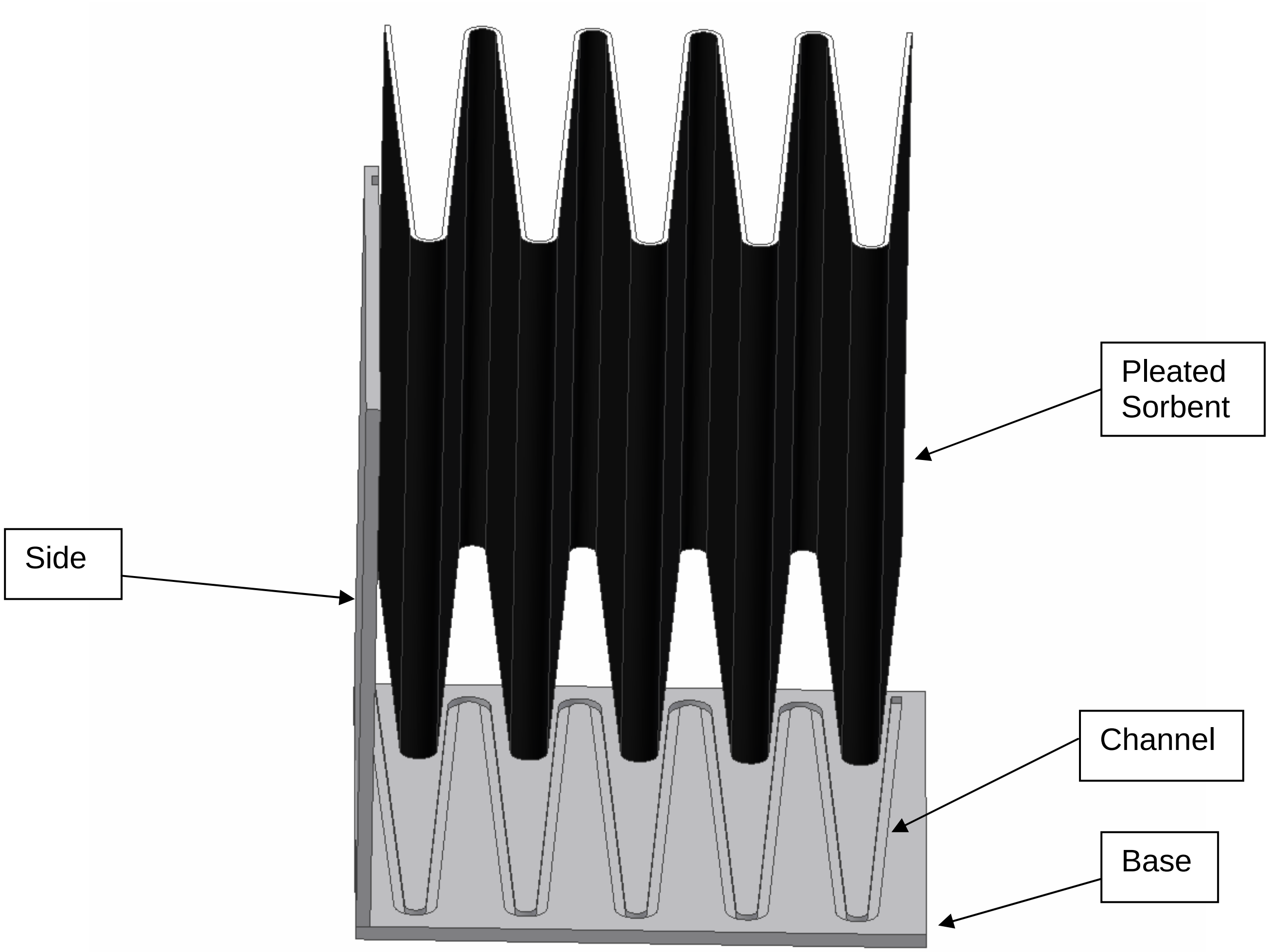

Figure 5. Basic Filter Configuration – *The pleated filter configuration has a proven record of manufacturability.*

Once the configuration of the filter has been decided, it remains to choose the materials to execute the design. In this case, materials need to be selected for the frame of the filter and to seal the edges of the sorbent material to the frame. Torlon 4203, Electrical Grade, was chosen as the frame material. The sealant of choice is Aremco Products 529.

The primary consideration in the design of the frame was the desire that the frame be able to withstand the rigors of the testing and evaluation process. This means that the prototype frame needs to withstand considerably more handling than the corresponding production frame. Consideration was also given to the possibility that the conditions encountered during testing may occasionally exceed the requirements of the production models. As a result of these concerns, Torlon 4203 was chosen for the frame material.

Torlon is the highest performing melt processable plastic. It has superior resistance to elevated temperatures and is capable of performing under severe stress conditions at continuous temperatures to 500 ºF. Its extremely low coefficient of linear expansion and highcreep resistance deliver excellent dimensional stability over its entire temperature range. Torlon 4203 provides the electrical insulation characteristics required in this application, and is commonly used in electrical connectors and insulators due to its high dielectric strength. **Figure 6** outlines the basic material properties of the selected material.

Property	Test Method (ASTM or UL)	Torlon 4203
Density (lb/in^3)	D792	0.051
Water Absorption (%)	D570	0.4
Tensile Strength (psi)	D638	18,000
Tensile Modulus (psi)	D638	600,000
Tensile Elongation at Break (%)	D638	10
Flexural Strength (psi)	D790	24,000
Flexural Modulus (psi)	D790	600,000
Compressive Strength (psi)	D695	24,000
Compressive Modulus (psi)	D695	700,000
Hardness, Rockwell	D785	E80(M120)
IZOD Notched Impact (ft-lb/in)	D256	2.0
Coefficient of Linear Thermal Expansion (x 10^{-5} in/in/ºF)	D696	1.7
Heat Deflection Temperature (ºF) @264 psi	D648	532
Glass Transition Temperature (ºF)	D3418	527
Max Operating Temperature (ºF)	-	500
Thermal Conductivity (BTU-in/ft^2-hr-ºF)	C177	1.80
Flammability Rating	UL94	V-0
Dielectric Strength (V/mil) short time, 1/8” thick	D149	580
Dielectric Constant at 1 MHz	D150	4.2
Dissipation Factor at 1 MHz	D150	0.026
Volume Resistivity (ohm-cm) at 50% RH	D257	>10^{16}

Figure 6. Torlon 4203 Properties – *The properties of Torlon 4203 make it an excellent choice for the regenerative application.*

The selection of the sealant material is also driven primarily by the internal environmental conditions of the filter. The primary considerations are the solvent exposure and the high temperatures present during operation. As a result of these concerns, Aremco Products Aremco-Seal 529 was chosen. Aremco-Seal 529 is a silicone sealer and conformal coating for applications to 600 ºF. It demonstrates exceptional electrical, moisture, and chemical resistance and is normally used to seal tubular heaters, and electrical and electronic devices.

During the assembly of the prototype filter some difficulties were encountered in applying the Aremco product. In discussions with Aremco Application Engineers, this application was unique in their experience. Although they had no doubts that the product could meet the physical requirements, some concern was expressed about the standard method of application. Typically, this material is used as a conformal coating product. In this application the product needs to be applied in a much thicker manner than is typical. The engineers had no doubts that the product would perform well once cured, but that the actual curing time for the required thickness would have to be determined during the build.

Filter Assembly

The build of the filter proceeded without difficulty, although some minor problems were encountered during the curing of the sealant material. The sorbent material was cut to the required size and ten layers were fastened together along the edges. These layers were then wound around support rods into the pleated shape required by the design. The ends were sealed to sides of the filter and clamped in place to assure good electrical contact with the terminals. Each end of the filter assembly was then filled to the required depth with sealant compound and put through the curing process. During the initial attempts we attempted to cure too much sealant at a time. Because the sealant was thicker than ideal, the curing process was slow and bubbles formed in the material. These bubbles, although somewhat unsightly, had no negative effect on the functionality of the filter.

Filter Testing

The filter was tested for leaks and to determine its total material capacity using the facilities of Hunter Manufacturing Company's Applied Research Laboratory. Facilities to determine the regenerative capabilities of the filter were not present at the Lab and therefore no testing of this function could be performed.

As requested, the initial testing was performed at the conditions shown in **Figure 7**. It was desired to continue the test for as long as possible with a minimum goal of the effluent concentration reaching fifty percent (50%) of the inlet concentration and the ultimate goal of completely saturating the filter. The results of the testing are shown in **Figure 8** below.

Condition	Requirement
Organic Vapor to be Adsorbed	Methyl Ethyl Keytone
Concentration	90 ppm
Airflow Rate through the Filter	100 cfm

Figure 7. Initial Test Conditions – *The filter was tested to determine whether a bypass path was present and to determine its capabilities.*

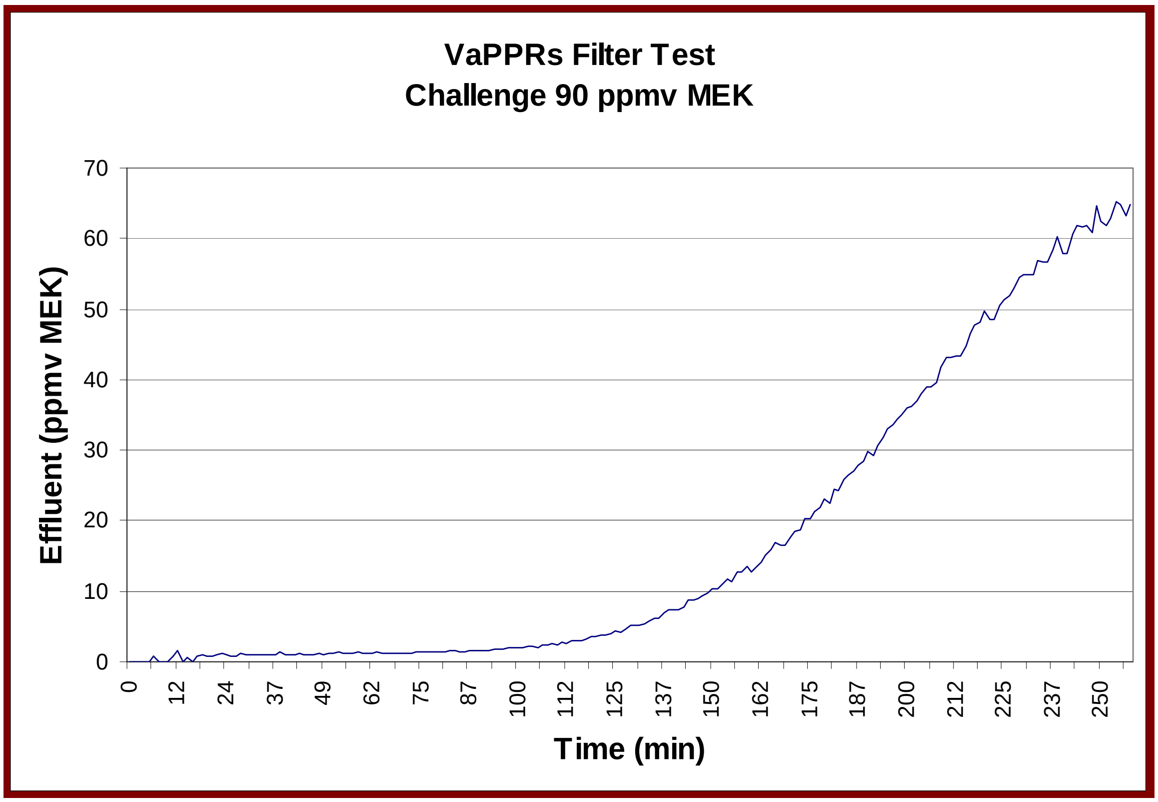

Figure 8. Filter Test Results – *The prototype filter was tested against MEK for over four hours.*

Appendix A

Drawings

SK4996

REVISIONS

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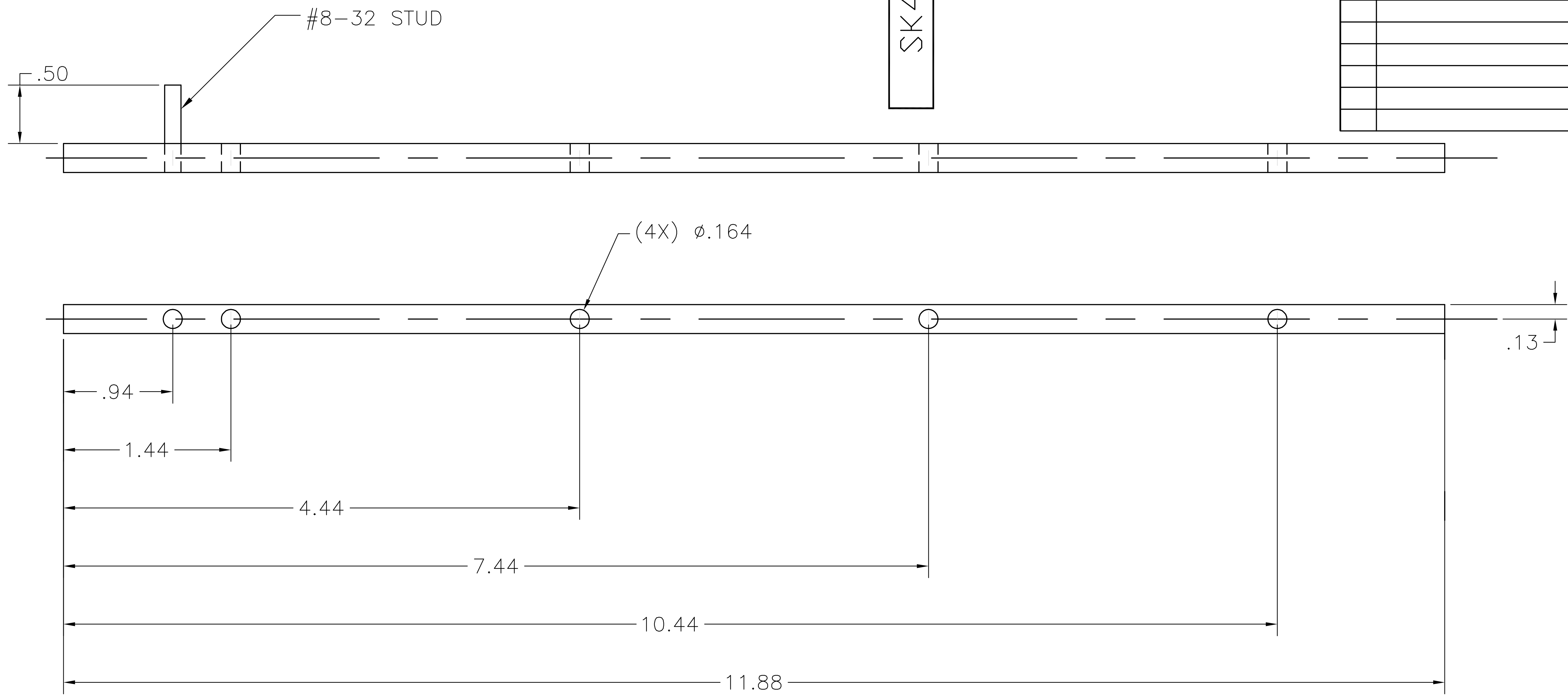

MATERIAL:
.25 X .25 300 SERIES STAINLESS STEEL

TOLERANCES
ALL DIMENSIONS EXCEPT WHERE OTHERWISE SPECIFIED

FRACT'S	DECIMALS	ANGLES
± –	XX± .03 XXX± .005	± –

DR. KLK — DATE 12/7/05
CHK. — RELEASED
NEXT ASS'Y.

CONTRACT NO.

HUNTER — Hunter Manufacturing Company, 30525 Aurora Road, Cleveland, OH 44139

TITLE: BUSS BAR VOC FILTER

HMC CODE IDENT. NO. 92878 — DRAWING NO. SK4996 — REV.

SCALE FULL — SHEET 1 OF 1

SK4995

REVISIONS

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TORLON 4203 OR 4503
ROD, .25 DIA 12 INCHES LONG

TOLERANCES
ALL DIMENSIONS EXCEPT WHERE OTHERWISE SPECIFIED

FRACT'S	DECIMALS	ANGLES
± –	XX± .03 XXX± .005	± –

DR. KLK | DATE 12/7/05
CHK. | RELEASED
NEXT ASS'Y.

CONTRACT NO.

HUNTER
Hunter Manufacturing Company
30525 Aurora Road
Cleveland, OH 44139

TITLE
ROD
VOC FILTER

HMC CODE IDENT. NO.	DRAWING NO.	REV.
92878	SK4995	

SCALE FULL | SHEET 1 OF 1

SK4994

REVISIONS

NO.	CHANGE	BY	DATE

ACTIVATED CARBON FILTER CLOTH

DIMENSIONS: 12" X 120"

TYPE: AMERICAN KYNOL ACC–5092–20

PURCHASE FROM:
AMERICAN KYNOL, INC.
427 BEDFORD ROAD
SUITE 130
PLEASANTVILLE, NY 10570

PHONE: (914) 769–0101
FAX: (914) 769–7004

TOLERANCES
ALL DIMENSIONS EXCEPT WHERE OTHERWISE SPECIFIED

FRACT'S	DECIMALS	ANGLES
± –	XX± .03 XXX± .005	± –

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NEXT ASS'Y.

CONTRACT NO.

HUNTER — Hunter Manufacturing Company, 30525 Aurora Road, Cleveland, OH 44139

TITLE: CLOTH, CARBON AIR FORCE REGEN FILTER

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92878	SK4994	

SCALE FULL — SHEET 1 OF 1

SK4992

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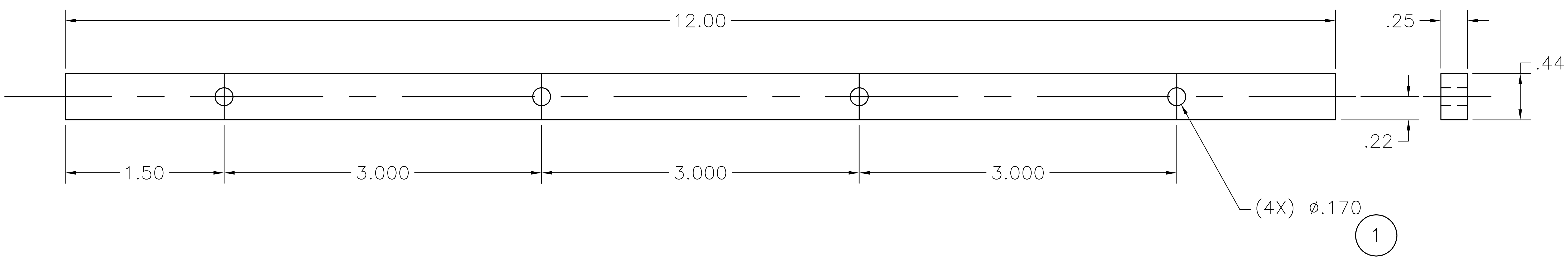

MATERIAL:
TORLON 4203 OR 4503

TOLERANCES ALL DIMENSIONS EXCEPT WHERE OTHERWISE SPECIFIED			CONTRACT NO.
FRACT'S ± –	DECIMALS XX± .03 XXX± .005	ANGLES ± –	Hunter Manufacturing Company, 30525 Aurora Road, Cleveland, OH 44139
DR. KLK	DATE 12/7/05		TITLE PLATE, EDGE SEAL VOC FILTER
CHK.	RELEASED		HMC CODE IDENT. NO. 92878
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			SHEET 1 OF 1

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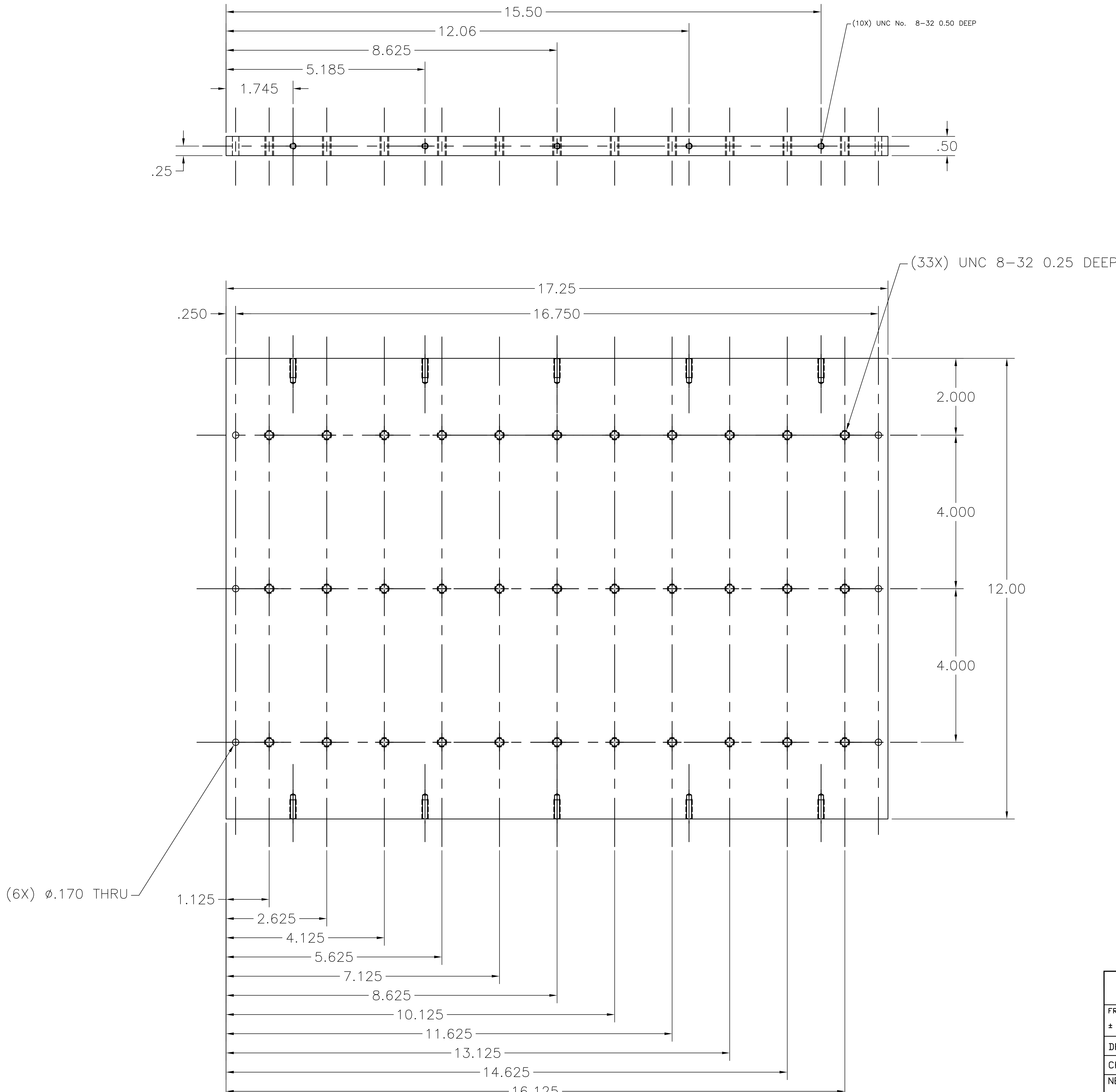

SK4991

MATERIAL:
TORLON 4203 OR 4503

TOLERANCES
ALL DIMENSIONS EXCEPT WHERE OTHERWISE SPECIFIED

FRACT'S	DECIMALS	ANGLES
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NEXT ASS'Y.

CONTRACT NO.

HUNTER — Hunter Manufacturing Company, 30525 Aurora Road, Cleveland, OH 44139

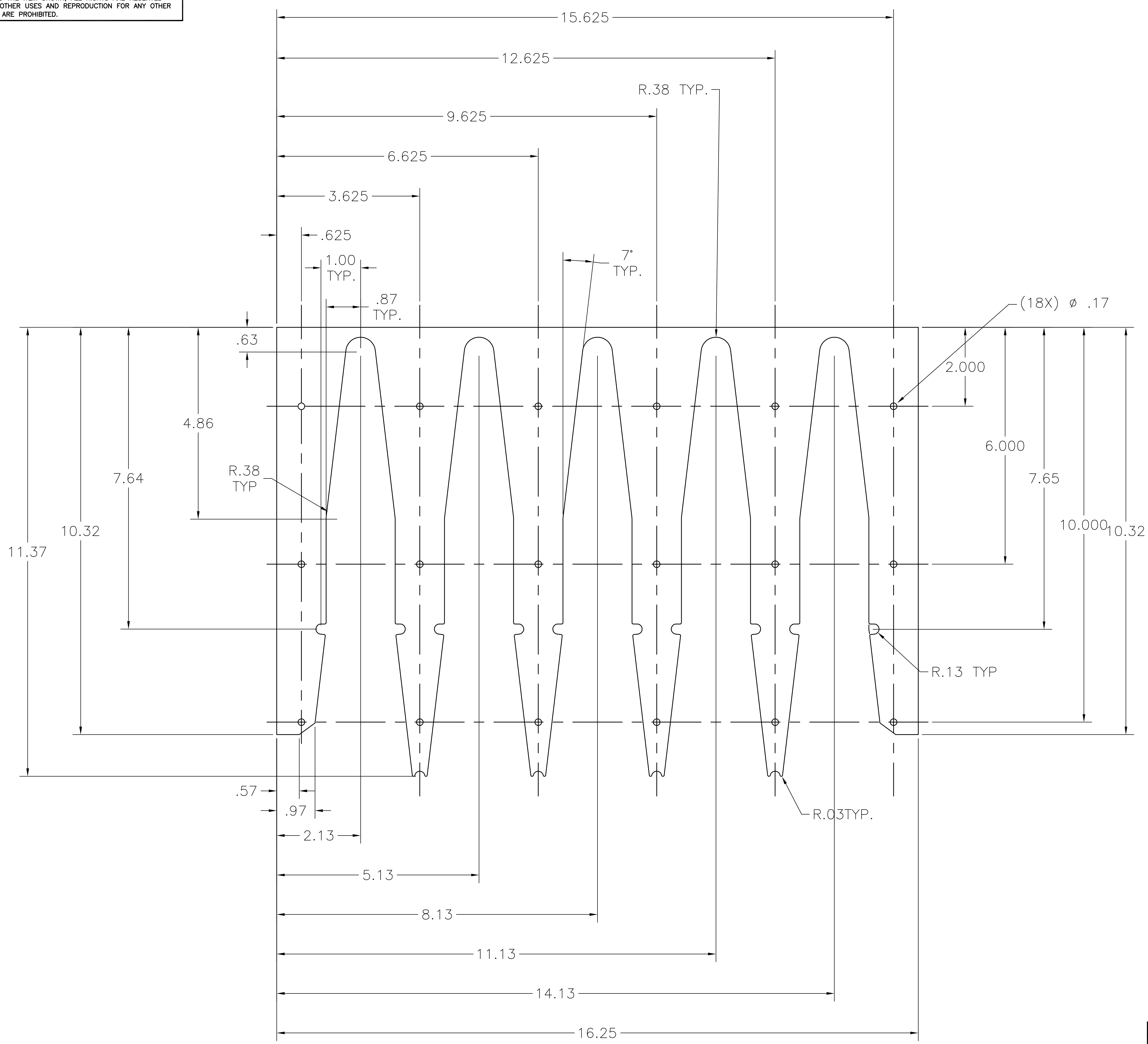
TITLE: PLATE, TOP/BOTTOM AIR FORCE REGEN FILTER

HMC CODE IDENT. NO.	DRAWING NO.	REV.
92878	SK4991	

SCALE 1/2 — SHEET 1 OF 1

REVISIONS

NO.		BY	DATE
1	REVISED DRAWING	KLK	11/9/06



SK4990 | 1

MATERIAL:
TORLON 4203 OR 4503

TOLERANCES ALL DIMENSIONS EXCEPT WHERE OTHERWISE SPECIFIED		
FRACT'S ± —	DECIMALS XX± .03 XXX± .005	ANGLES ± —
DR. KLK	DATE 12/7/05	
CHK.	RELEASED	
NEXT ASS'Y.		

CONTRACT NO.

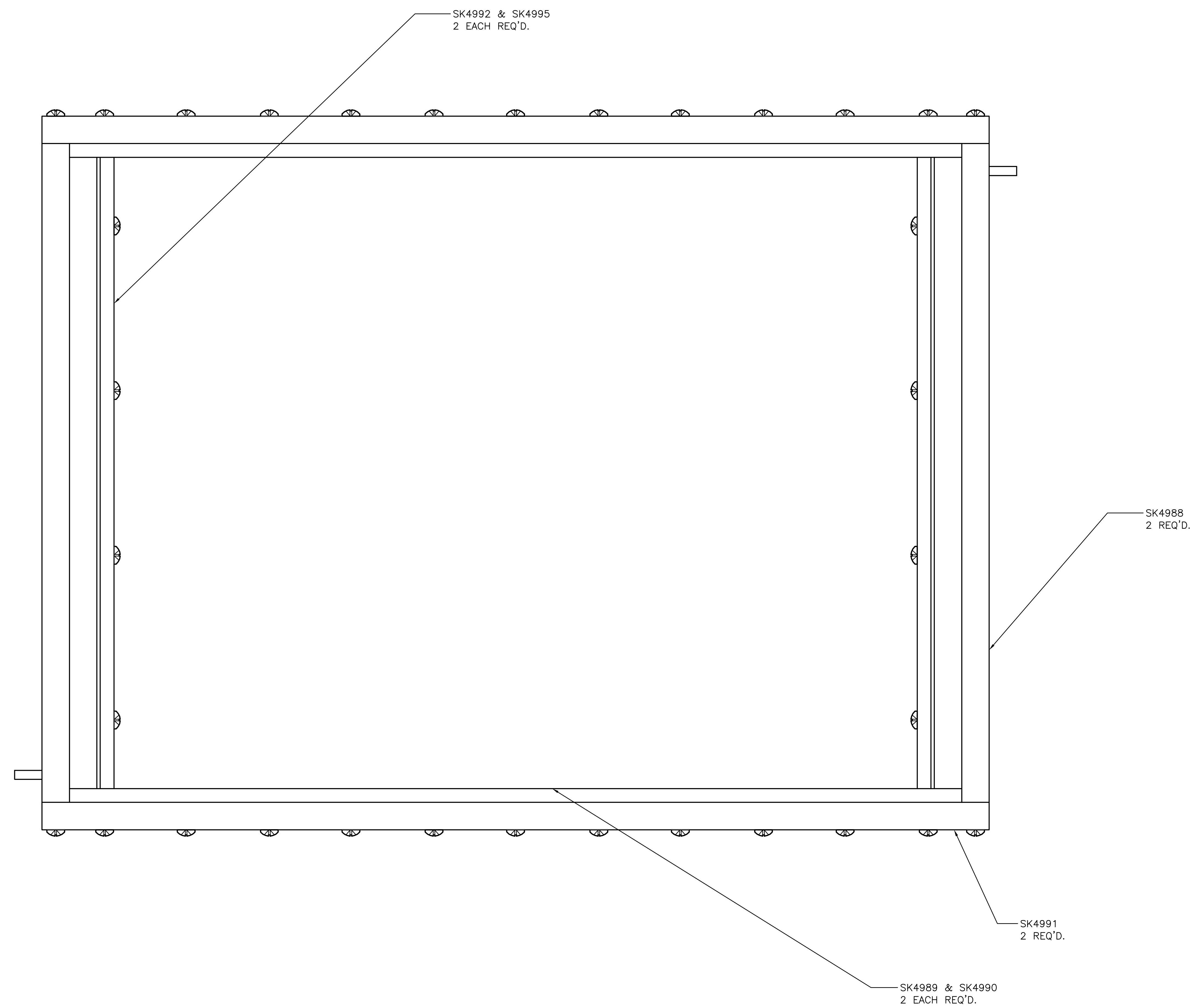
HUNTER — Hunter Manufacturing Company, 30525 Aurora Road, Cleveland, OH 44139

TITLE: PLATE, UPSTREAM SEAL VOC FILTER

HMC CODE IDENT. NO.	DRAWING NO.	REV.
92878	SK4990	1
SCALE 1/2	SHEET 1 OF 1	

REVISIONS

NO.		BY	DATE



SK5000 | 1

CARBON CLOTH AND SUPPORT RODS NOT SHOWN FOR CLARITY.

TOLERANCES ALL DIMENSIONS EXCEPT WHERE OTHERWISE SPECIFIED		
FRACT'S ± —	DECIMALS XX± .03 XXX± .005	ANGLES ± —
DR. KLK	DATE 12/7/05	
CHK.	RELEASED	
NEXT ASS'Y.		

CONTRACT NO.

HUNTER — Hunter Manufacturing Company, 30525 Aurora Road, Cleveland, OH 44139

TITLE: ASSEMBLY VOC FILTER

HMC CODE IDENT. NO.	DRAWING NO.	REV.
92878	SK5000	1
SCALE 1/2	SHEET 1 OF 1	