Reference Material
for
The Safe Design
of
Perchloric Acid Fume Hood
Exhaust Systems

M.K. plastics
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SERVING THE NEEDS OF MODERN INDUSTRY

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M.K. Plastics *Plastifer*® MVT
PERCHLORIC ACID EXHAUST SYSTEM

Dry perchloric acid crystals are unstable, and when subject to shock or vibration, can explode. (An analogous compound to perchlorates is nitroglycerine.) The problem of exhausting perchloric acid vapors is that the vapors condense and then crystallize in the exhaust system. The crystallized, or dried, perchloric acid is very unstable, such that vibration or shock waves to the duct and exhaust fans system can result in an explosion. This vibration, caused by fan operation or general maintenance, may cause the crystals within the system to dislodge and also cause the explosion. Perchloric acid, though, can be neutralized with water and flushed from the exhaust system.

In addition, perchloric acid is extremely corrosive, and it is recommended that exhaust system components (ductwork, fans, etc.) be fabricated of no less than 316 SS or fiberglass.

The exhaust system should be smooth with no crevices, corners, or edges that can collect perchloric crystals, making it difficult (if not impossible) to flush the lodged crystals with water. As is understood, the greatest collection device of particulate (or in this case, perchlorate particles) would be the exhaust fan.

The M.K. Plastics Plastifer® MVT PERCHLORIC ACID EXHAUST SYSTEM has no moving parts in the air stream. It operates, using the principle of induced draft incorporating a blower that is external to the perchloric acid vapor exhaust. This external blower injects clean outdoor air into a venturi (incorporated in the exhaust stack) which induces flow from the perchloric acid fume hood. In addition, the external blower on the Plastifer® MVT PERCHLORIC ACID EXHAUST SYSTEM is isolated from the exhaust duct by a flexible connection which reduces the vibration in the ductwork, increases safety.

This unique design does not allow perchloric vapor to contact the blower, so that the fan impeller does not become contaminated with a build up of perchloric acid crystals.

Integral to M.K. Plastics Plastifer® MVT PERCHLORIC ACID EXHAUST SYSTEM is a wash system located at the discharge of the venturi stack. This wash system floods the venturi with water which dissolves and flushes away any of the perchloric crystals that are deposited on the smooth interior of the fiberglass stack.

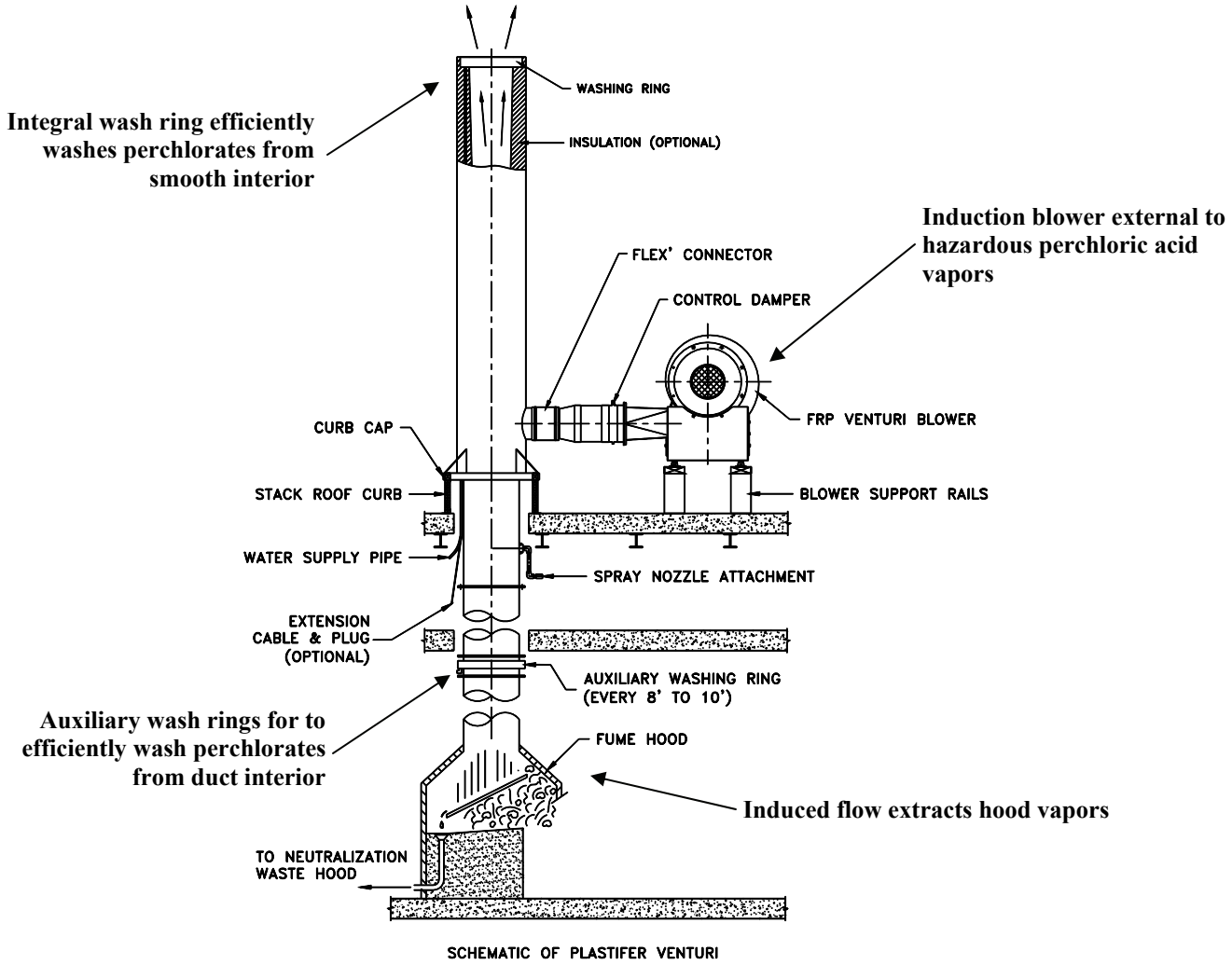
As part of this system, M.K. Plastics supplies (if required) auxiliary wash rings to be installed every 10’-12’ of vertical ductwork.

On page 6 is the reference from **Industrial Ventilation Handbook** published by the ***American Conference of Governmental Industrial Hygienists***, Lansing, Michigan, figure VS-35-03. In accordance with note 9 of this standard, each perchloric exhaust system should have its own exhaust fan and use for vertical ducting only. It is not recommended to use elbows or horizontal duct runs in a perchloric exhaust system.

The material used in the M.K. Plastics *Plastifer*® MVT PERCHLORIC ACID EXHAUST SYSTEM that is in contact with perchloric acid exhaust vapor is fiberglass, and is corrosion resistant to perchloric acid.

MVT Plastifer

Venturi Perchloric Exhaust System



Advantages of the…

MVT Plastifer
Venturi Perchloric Acid
Exhaust System

- Induction Fan system, With Blower External to Exhaust.
- Corrosion Resistant Fiberglass Reinforced Plastic.
- No Coating to deteriorate and corrode base metal.
- Spark Proof.
- Smooth Internals With No Crevices or Bends.
- No areas for Perchloric crystals to deposit.
- Thoroughly Cleaned By Integral Wash System.
- Insulated Stack.

DESIGN RECOMMENDATIONS FOR PERCHLORIC ACID EXHAUST SYSTEMS

1. Perchloric acid fume hoods are single use hoods and should only be used for perchloric acid digestions.
2. Each perchloric acid fume hood shall have its own exhaust system. Perchloric acid fume hoods should not be manifolded together.
3. Use 316 Stainless Steel, unplasticized PVC or fiberglass duct and exhaust system components for corrosion resistance.
4. Use an induction exhaust system where the blower is out of the exhaust air stream so none of the perchloric vapors pass through the blower (per CRC Laboratory Safety Handbook, page 154, paragraph 4, see attached)
5. Install only vertical duct runs without elbows if possible (install perchloric fume hoods as close as possible to exhaust system.)
6. Install auxiliary wash rings in vertical ductwork every 10'-12'.
7. If horizontal duct runs must be used, install spray rings every 4'-5' feet, with spray rings installed up and down stream of each elbow.

SOME OF THE PROBLEMS THAT EXIST WITH OTHER SYSTEM DESIGNS

The recommended materials for systems exhausting perchloric acid vapor are 316 stainless steel, FRP, PVC. Coatings are not recommended with the exception of porcelain on steel, requiring all corners and edges be rounded and the assembly be fully welded. Few fan manufacturers use porcelain as a coating or have complete 316 stainless steel fans. Either way, the use of spray nozzle to wash the fan may not be sufficient to clean the impeller properly as mentioned above.

Placing a plenum, horizontal duct or an elbow before the fan is not recommended as per note 6 and 9. For the plenum, you do not have rounded corners. It is difficult to wash and slope a horizontal duct before the fan and a 90 degree elbow is a sharp turn. Again, in all these cases, ease of cleanliness is paramount. Sharp corners of a plenum cannot be effectively cleaned. Horizontal runs require washing minimum every 4 feet and elbows are to be washed before and after.

When servicing a fan that is contaminated with perchloric acid, the dangers to the service personnel are considerable. Contact with interior of the fan (i.e. replacing a direct drive motor where impeller must be removed) is hazardous.

On page 6 is the reference from the ***CRC Handbook of Laboratory Safety***, CRC Press, Boca Raton, FL, 1990. Page 280 has a section entitled "Dismantling an exhaust ventilation system suspected of contamination with Perchlorates." Please note "Point. 2: The entire system was washed for 12 hours just prior to dismantling …"

PERCHLORIC ACID HOODS

Perchloric acid is extremely dangerous because it is a very strong oxidizer. When the acid reacts with organic material, an explosive reaction product may be formed.

- Do not use perchloric acid in a hood designed for other purposes. Identify Perchloric Acid Hoods with large warning signs.
- Provide exhaust ventilation and room supply air with minimal challenge to the hood.
- Utilize local exhaust ventilation within the hood to minimize condensation of vapors inside the hood.
- Locate all utility controls outside the hood.
- Materials of construction for this type of hood and duct must be nonreactive, acid resistant, and relatively impervious. AVOID ORGANIC MATERIALS unless known to be safe. Stainless steel type 316 with welded joints is preferred. Unplasticized polyvinyl chloride or an inorganic ceramic coating, such as porcelain, is acceptable.
- Ease of cleanliness is paramount. Use stainless steel with accessible rounded corners and all-welded construction.
- The work surface should be watertight with a minimum of 0.5-inch dished front and sides and an integral trough at the rear to collect the washdown water.
- Design washdown facilities into the hood and duct. Use daily or more often to thoroughly clean perchloric acid from the exhaust system surfaces.
- Each perchloric acid hood should have an individual exhaust system. Slope horizontal runs to drain. Avoid sharp turns.
- Construct the hood and duct to allow easy visual inspection.
- Where required, use a high-efficiency (greater than 80%) wet collector constructed for perchloric acid service. Locate as close to the hood as possible to minimize the accumulation of perchloric acid in the exhaust duct.
- Use only an acid-resistant metallic fan protected by an inorganic coating or an air injector.
- Lubricate the fan with a fluorocarbon-type grease.
- Locate the fan outside the building.
- The exhaust discharge must terminate out-of-doors, preferably using a vertical discharge cap that extends well above the roof eddy zone. See Figure 8.6.

ACGIH® WORLDWIDE	PERCHLORIC ACID HOOD DATA	
	DATE **02-91**	FIGURE **VS-35-03**

velocity, are placed at the rear or, occasionally, to the side of the work bench close to the level of the bench top. This design takes advantage of the fact that most solvents are heavier than air. Air flowing across the surface would entrain the vapors from the tray and exhaust them through the slots at the rear of the work bench. The fumes would not have an opportunity to rise into the worker's breathing area, but would be pulled back and away from the worker. A modified version of this system is used for silk screening. In this version, the entire circumference has either an aerodynamic slot around the edge or the last several inches close to the edge of the table top are perforated with hundreds of holes through which, in both cases, air is pulled down prior to being exhausted. There are consumer range tops for cooking built on this principle which work very well. Smoke from the food being prepared rarely rises more than an inch or two above the cooking surface before being captured and exhausted.

3.2.2.2.8. Perchloric Acid Hood

Individuals working with perchloric acid and perchlorates must be trained in procedures which will let them conduct their research with maximum safety. These are extremely dangerous materials.

There is an extensive section later on the problems of working with perchlorates and perchloric acid. This section will be restricted to a discussion of the critical factors which are applicable to the proper performance of perchloric acid hoods. It will be sufficient to say at this point that perchloric hoods are designed to avoid accumulation of precipitates from perchloric acid or to avoid perchloric acid from coming into contact with materials with which it may react vigorously and explosively. Hoods used for hot perchloric acid use should not be used for research with other types of materials. The hood should be prominently labeled with a sign stipulating that it is for perchloric acid work only. Exhaust systems should not be manifolded into a common exhaust plenum.

For conventional hoods, and their variants which have been covered in Sections 3.2.2.2.1 to 3.2.2.2.6, the discussion of appropriate ducts and exhaust fans has been deferred to separate sections. However, perchloric fume hood systems are uniquely dangerous and will be treated as an integral concept.

Perchloric hoods are usually constructed with an integral liner of a single piece of stainless steel, such as 316 stainless, which will resist the effects of the acid, although PVC can also be used as a liner. The liner should have cover corners and as few seams as possible to allow ease of decontamination. In order to avoid the build up of perchloric precipitates in the hood and duct system, a hood intended to be used for perchloric acid work must be equipped with a rinse system which will make it possible to thoroughly flush the interior of the hood and ductwork with water. This may be done with a manual control system or an automatic system which at the end of a work session, will come on and rinse the system for 20 to 30 min. A combination of an automatic system which can be bypassed for additional rinses is preferable if the researcher feels they are needed.

The ductwork should also be stainless or PVC. Caution must be exercised to ensure that, during installation, workers do not use standard organic caulks to seal the joints. Organic materials, when contaminated with perchloric acid, are highly flammable and dangerous, and such joints will also tend to leak, allowing perchloric acid

to escape outside the ductwork. Under circumstances which would allow this errant material to be exposed to heat or to receive a sudden shock, the result could be a fire or an explosion in the space outside the duct. The most desirable procedure for stainless steel ducts is to weld the sections of ducts together. Since this will require heliarc welding, it is a relatively expensive procedure compared to welding ordinary steel ductwork. Some fluorinated hydrocarbon materials can be used as a sealant if welding is not feasible.

It is recommended that the interior fittings of a perchloric acid hood should be nonsparking and that the lights should be explosion proof. This concept should be extended to any apparatus placed in the hood. With the dangers already represented by perchloric acid, there should be no contributory factors which could initiate an explosion. PVC ductwork can be employed instead of stainless steel, but it would be much less likely to remain intact in the event of a significant fire exposure. However, if the ductwork is enclosed within a 2-h fire-rated chase, as it usually should be, this would not be a serious drawback.

The ductwork for a perchloric acid hood should have as few bends as possible and be taken to the roof in the shortest, most direct path. No horizontal runs should be permitted, and even slopes of less than 60 to 70° should be avoided wherever possible. For aesthetic reasons, architects prefer to place exhaust ducts away from the edge of a building where they cannot be seen easily. As a result, in some older designs, horizontal runs of 100 ft or more of perchloric fume hood exhaust ducts have been observed. Even if a washdown mechanism were incorporated in the design, it would be unlikely to come into contact with and clean the upper portion of the duct in the horizontal section. In one instance where a perchloric hood was installed below grade in the basement of a building, the exhaust duct first was run horizontally for approximately 75 ft under the floor of an adjacent section of the building. An exhaust fan was installed in this horizontal run and then the duct was run vertically for three floors. When this was discovered, the horizontal section of the ductwork beyond the fan had corroded through and perchloric acid crystals were observed on the external surface of the duct and on the ground below it. This became a major and costly removal project.

As a minimum, the blades and any other portion of the exhaust fan which might come into contact with the perchloric fumes should be coated with PVC, teflon, or another approved material which will resist the effects of the perchloric acid. An induction exhaust fan, where none of the fumes actually pass through any part of the motor or fan, is recommended. Under no circumstances should the exhaust fumes be directed down upon the roof to be absorbed in the roofing material. The contaminated roofing material could itself constitute a danger. The exhaust point should be well above the roof to avoid the fumes readily reaching any portion of the roof prior to dilution by the outside air. The washdown mechanism should be capable of cleaning the entire duct, from the point of exhaust all the way back to the hood. The washdown system plumbing should automatically drain when shut off to avoid rupturing the supply lines due to freezing in the winter. The rinse water may be permitted to drain directly into the sanitary system, where it will be quickly diluted.

7. Dispose of any unused anhydrous acid at the end of each day by dilution and neutralization.
8. Contact of the anhydrous acid with organic materials will usually result in an explosion.
9. Any discoloration of the anhydrous acid requires its immediate disposal.

Acid Disposal

Spills. Perchloric acid spilled on the floor or bench top represents a hazard. It should not be mopped up, nor should dry combustibles be used to soak up the acid. The spilled acid should first be neutralized and then soaked up with rags or paper towels. The contaminated rags and paper towels must be kept wet to prevent combustion upon drying. They should be placed in a plastic bag and sealed and then placed in a flammable waste disposal can. If the spill can be rinsed down a chemical drain, neutralization of the wetted area is recommended, followed by additional rinsing.

[Other recommendations in the literature are to wear a face shield and gloves while working on the spill. Cover the spill with a weak solution of sodium thiosulfate, and then transfer the slurry into a large container of water, where it should be neutralized with soda ash. After neutralization, it can be drained into the sewer, accompanied by abundant water.]

Disposal. Stir the acid into cold water until the concentration is less than 5%, followed by neutralization with aqueous sodium hydroxide, and then dispose of the resulting mixture in the sanitary system, accompanied by abundant water. [Larger quantities in the original unopened containers may be acceptable to a commercial hazardous waste vendor. If it is potentially explosive, the best option available is to hire a firm specializing in disposal of exceptionally hazardous materials. This will be expensive.]

DISMANTLING AN EXHAUST VENTILATION SYSTEM SUSPECTED OF CONTAMINATION WITH PERCHLORATES

Dismantling a laboratory exhaust system contaminated with shock-sensitive perchlorates is a hazardous operation, as evidenced by published and unpublished case histories. The procedures used by one university to reduce the hazards were described by Peter A. Breysse in the *Occupational Health Newsletter* (15[2, 3] 1, 1966) published by the Environmental Health Division, Department of Preventive Medicine, University of Washington. The problem, procedures, and confirmation of perchlorate contamination were reported as follows.

A short time ago, the manager of Maintenance and Operations was requested to dismantle and relocate six laboratory exhaust systems. The possibility of perchloric acid contamination of these systems was considered. An investigation indicated that several laboratories serviced by the exhaust systems were utilizing, or had in the past used, perchloric acid for wet washing of tissues. Furthermore, the exhaust hoods were constructed with sharp corners and cracks, permitting the accumulation of contaminants not readily noticed or easily removed. The ducts were made of ceramic material and contained numerous joints as well as a number of elbows — areas conducive to perchlorate build-up. Organic compounds were also used — to pack the duct joints, as an adhesive for the flexible connectors, and as a sealing compound for the fan.

Recognizing the potential dangers of dismantling these systems, the following procedures were established and successfully carried out.

1. It was deemed desirable to dismantle the systems on the weekend when occupancy would be at a minimum.
2. The entire system was washed for 12 hours, just prior to dismantling, by introducing a fine water spray within the hoods, with the fans operating.
3. The fans were then hosed down.
4. Fan mounting bolts and connectors were carefully removed. Nonsparking tools were and should be used throughout.
5. The fans were immediately removed to the outdoors. As an added precaution during removal, the fans were covered with a wet blanket.
6. After all the fans were taken outdoors, one fan at a time was placed behind a steel shield for protection during dismantling. This fan was again washed down.
7. Plate bolts were evenly loosened to remove the plate without binding. If a fan puller is necessary, it should be nonsparking.
8. All disassembled parts were washed and cleaned. The gasket material contained on the flanges was scraped off with a wooden scraper.
9. Ordinarily, the ceramic ducts would be removed by breaking them apart with a sledge hammer. In this instance, the ducts were washed down again just prior to and during dismantling. A high-speed saw was used to remove the duct work.

One of the flexible connectors and a piece of duct-joint sealing compound were collected and taken to the laboratory for examination. Qualitative analysis by X-ray fluorescence and chemical tests indicated the presence of perchlorates in both samples. While these procedures for dismantling and decontamination seem unduly severe, the uncertainty requires that they be followed.

[One of the problems in conducting such an operation is providing appropriate liability insurance. This question should be considered before doing such work in-house, and contracts for work done by outside vendors should have the provision of liability insurance as a specific requirement.]

Some additional words of caution include: (1) do not unscrew any nuts or bolts — cut them off after water flushing, (2) do not produce any impact upon the hood parts, and (3) do not cause any friction between parts of the hood or ducts during dismantling.

SUMMARY AND CONCLUSIONS

The use of perchloric acid is becoming increasingly widespread and the properties of both the acid and its derivatives make it likely that the trend will continue. Safety hazards associated with the use of perchloric acid may be reduced, provided that its hazardous properties are clearly recognized, the purpose of the acid in a process is fully understood, and measures are taken to avoid known possibilities.

It is, however, clear that no one should attempt to use perchloric acid who is not fully conversant with the chemistry of the material who has not made a careful appraisal of his operating conditions and techniques, and who exhibits an unsafe attitude about his work.