Emission Compliance for the Steel Pickling MACT: The Next Step

by Richard D. Hall,
KCH Services, Inc., Forest City, NC

INTRODUCTION

On June 22, 1999 the Environmental Protection Agency issued the final rule to reduce emissions of toxic air pollutants from sources in steel pickling facilities. The NESHAP for Steel Pickling Facilities-HCl Processes, was proposed on September 18, 1997. Air toxics are those pollutants known or suspected to cause cancer or other serious health effects. This paper provides an overview of the final regulation and the main control technology, wet scrubbers, used for emission compliance.

Implementation of the rule is expected to reduce HAP emissions by more than 2500 tons per year from current levels. The EPA's rule will reduce emissions of two toxic air pollutants: hydrochloric acid and chlorine. Hydrochloric acid is emitted from processing tanks used in continuous and batch pickling lines, acid regeneration plants, and storage vessels containing virgin or regenerated acid. Chlorine is emitted from acid regeneration plants.

Chronic exposure to hydrochloric acid has been reported to cause gastritis, chronic bronchitis, dermatitis, and photosensitization. Acute exposure to high levels of chlorine in humans may result in chest pain, vomiting, toxic pneumenitis pulmonary edema, and death. Both hydrochloric acid and chlorine are gases commonly absorbed in wet scrubbers by the chemical phenomenon known as mass transfer.

AFFECTED SOURCES

This rule applies to all facilities that pickle steel using hydrochloric acid or regenerate hydrochloric acid and are major sources or are part of a facility that is a major source. The EPA estimates that 62 of 80 steel pickling facilities using hydrochloric acid and all 8 acid regeneration plants currently in operation, six of which are collocated with pickling facilities, are affected by this rule.

Affected sources that apply to this rule include the following:

1. All new existing steel pickling facilities that pickle carbon steel using hydrochloric acid solution that contains 6 percent or more by weight HCl and is at a temperature of 100 deg. F or higher.
2. All new and existing hydrochloric acid regeneration plants.
3. The rule does not apply to facilities that pickle carbon steel without using hydrochloric acid, to facilities that pickle only specialty steel, or to acid regeneration plants that regenerate only acids other than hydrochloric acid.

Affected Source	Emission Standard
Packing Line:	
Existing	HCl concentration in air pollution control device or process exhaust gas no more than 18 parts per million by volume (ppmv) or Air pollution control device minimum HCl collection efficiency of 97%
New	HCl concentration in air pollution control device or process exhaust gas no more than 6 ppmv for continuous lines and 18 ppmv for batch lines or Air pollution control device minimum HCl collection efficiency of 99% for continuous lines and 97% for batch lines.
Hydrochloric acid regeneration plant:	
Existing	HCl concentration in air pollution control device or process exhaust gas no more than 25 ppmv and Cl_2 concentration in air pollution control device or process exhaust gas no more than either 6 ppmv or a source-specific maximum concentration limit.
New	HCl concentration in air pollution control device or process exhaust gas no more than 12 ppmv and Cl_2 concentration in air pollution control device or process exhaust gas no more than 6 ppmv.
Hydrochloric acid storage vessel:	
Existing & New	Cover and seal all openings and route emissions to air pollution control device or alternative control system and Use enclosed line or local fume capture system vented to air pollution control device or alternative control system at each point where acid is exposed to atmosphere.

DEFINITIONS

Carbon Steel means steel that contains approximately 2 percent or less carbon, 1.65 percent or less manganese, 0.6 percent or less silicon, and 0.6 percent or less copper.

Steel Pickling means the chemical removal of iron oxide mill scale that is formed on steel surfaces during hot rolling or hot forming of semi-finished steel products through contact with an aqueous solution of acid where such contact occurs prior to shaping or coating of the finished steel product. This definition does not include removal of light rust or scale from finished steel products or activation of the metal surface prior to plating or coating.

Steel Pickling Facility means any facility that operates one or more batch or continuos steel pickling lines.

Hydrochloric Acid Regeneration Plant means the collection of equipment and process configured to reconstitute fresh hydrochloric acid pickling solution from spent pickle liquor using a thermal treatment process.

EMISSION STANDARDS FOR EXISTING SOURCES:

Steel Pickling – The maximum allowable emission rate for HCl shall not exceed 18 parts per million by volume (PPMV) or shall achieve a mass emission rate for HCl representative of at least 97 percent collection efficiency.

Hydrochloric Acid Regeneration Plants – The maximum allowable emission rate for HEL shall not exceed 20 PPMV. The maximum allowable emissions rate for chlorine (Cl_2) shall not exceed 6 PPMV.

EMISSION STANDARDS FOR NEW OR RECONSTRUCTED SOURCES:

Steel Pickling – (Continuous) The maximum allowable emission rate for HCl shall not exceed 6 PPMV or shall achieve a mass emission rate for HCl representative of at least 99 percent collection efficiency.

Batch – The maximum allowable emission rate for HCl shall not exceed 18 PPMV or shall achieve a mass emission rate for HCl representative of at least 97 percent collection efficiency.

Hydrochloric Acid Regeneration Plants – The maximum allowable emission rate for HCl shall not exceed 12 PPMV. The maximum allowable emission rate for chlorine (Cl_2) shall not exceed 6 PPMV.

COMPLIANCE DATES

The owner or operator of an affected existing steel pickling facility and/or hydrochloric acid regeneration plant subject to this rule shall achieve initial compliance with the requirements no later than June 22, 2001.

The owner or operator of a new or reconstructed steel pickling facility and/or HCl acid regeneration plant subject to this rule that commences construction or reconstruction after September 18, 1997 shall achieve compliance with the requirements immediately upon start-up of operations.

MAINTENANCE REQUIREMENTS

The owner or operator shall prepare an operation and maintenance plan for each emission control device to be implemented no later than the compliance date. The plan shall be incorporated by reference into the source's title permit.

For a scrubber emission control device, as a minimum, the plan must include:

1. Monitoring and recording the scrubber pressure drop once per shift while the scrubber is in operation.
2. Perform maintenance per the manufacturer's recommended intervals on fresh solvent pumps, recirculating pumps, discharge pumps, and other liquid pumps, in addition to exhaust system and scrubber fans and motors associated with those pumps and fans.
3. Perform cleaning of internals and mist eliminator sufficient to prevent buildup of solids or other fouling.
4. Quarterly inspection and maintenance of the following:
   A. Cleaning or replacement of any plugged spray nozzles or other liquid delivery devices.
   B. Repair or replacement of missing, misaligned, or damaged baffles, trays, or other internal components.
   C. Repair or replacement of mist eliminators as needed.
   D. Repair or replacement of heat exchanger elements, if used, for controlling the temperature of fluids entering or leaving the scrubber.
   E. Adjustment of the damper settings for consistency with the required airflow.

1. The owner or operator shall initiate corrective actions within one working day of detection of an operating problem and complete as soon as possible.
2. The owner or operator must maintain a record of each inspection including each item in #4 above of this section and such record shall be signed by the responsible maintenance official, also showing the date of each inspection, the problem identified, a description and date of the repair, replacement, or other corrective action taken.

PERFORMANCE TESTING

1. Submit site specific plan and notify administrator 60 days prior to performance test date.
2. Receive approval of site specific plan.
3. Conduct performance test to determine collection efficiency or mass emissions.
4. Compliance will be determined by the average of three consecutive runs or by the average of any three of four consecutive runs under normal process operations.
5. Establish operating parameter valves during testing for the minimum scrubber make-up water flow rate and minimum recirculation water flow rate by monitoring no more than every 15 minutes and taking an average.
6. For HCl Regeneration Plants the amount of iron in the spent pickle liquor shall be determined for each run by sampling the liquor every 15 minutes and analyzing a composite of the samples.
7. For HCl Regeneration Plants the owner or operator may propose an alternative concentration standard if the plant cannot achieve a 6 PPPM level when operated within design parameters.
8. Test Method 26A "Determination of Hydrogen Holide and Halogen Emissions (from Stationary Source) Isokinetic Method"

MONITORING REQUIREMENTS

1. Conduct performance tests annually or according to an alternative schedule that is approved by the applicable permitting authority, but no less frequently than less than every 2 ½ years or twice the title V permit term.
2. Monitor and record scrubber flow rates at least once per shift while the scrubber is operating.
3. Each monitoring device shall be certified by the manufacturer to be accurate within 5 percent and calibrated per the manufacturer's instructions.

NOTIFICATION REQURIEMENTS

1. Notify the applicable permitting authority that the facility is subject to the requirements.
2. If facility is new or reconstructed source, notification shall not be submitted later than October 20, 1999, for start-up prior to June 22, 1999.
3. For start-up after June 22, 1999, notify the Administrator in writing that the source is subject to the standards no later than 120 days after the initial start-up.
4. If owner or operator intends to construct or reconstruct an affected source, notify the Administrator, in writing, of the intended construction or reconstruction.
5. Submit intention to conduct performance test and site-specific test plan at least 60 days before the performance test is scheduled to begin.

6. Submit notification of compliance status and report the results of any performance test.

For Further Information

Pick up an information packet from KCH Services, Inc. Booth #   or leave your business card and one will be sent to you.

The final rule can be downloaded from EPA's website under "recent actions" at the following address: http://www.epa.gov/ttn/oarpg. For further information about the rule, contact James Maysilles of the EPA's Office of Air Quality Planning and Standard at 919-541-3265.

Wet Scrubber Technology

Wet scrubbers are commonly used for abatement of exhaust gases from HCl steel pickling operations. Many wet scrubbers in operation are achieving less than expected emission results and many require frequent shutdown due to problems that can be eliminated or reduced with proper design and operation.

The goal of this section is to familiarize the owner/engineer/operator of common design and process errors that lead to undesirable conditions, frequent maintenance, and safety hazards. Design, process and operation suggestions will be provided in order to maximize wet scrubber performance and operation.

The following five topics will be addressed: (1) root causes of poor scrubber operation, (2) design of wet packed bed scrubbers to meet the HCl steel pickling MACT NESHAP, (3) maximizing design and operation to reduce cost of ownership, (4) developments in liquid distribution design and (5) techniques for reduction or elimination of biological growth.

Root Causes of Poor Scrubber Operation

It is implausible to assume that a scrubber is functioning properly if the pump is on and fan is drawing air. Various items within the scrubber unit and supporting equipment must be checked and maintained after installation and start-up. Even with proper operation and a good checklist, poor design can lead to less than desirable operating conditions and upsets.

Inadequate Sump Fluid Replenishment

For scrubbers using overflow or blowdown to maintain fresh solution, the fresh water make-up rate must be adequate to maintain the concentration gradient between the liquid and gas phase. The concentration gradient for a given unit is dependent upon a number of variables and if not maintained the efficiency of a system can drop quickly and significantly. In some cases, if the gradient is lost, contaminants can be stripped from solution. In these cases, the inlet loading of a particular contaminant can be lower than the tested outlet concentration.

Mentioned earlier, two techniques for sump replenishment are overflow and blowdown with the overflow method being more common and simple to operate with no instrumentation other than a rotometer. Fresh water is added through an adjustable flow meter at a continuous rate while the sump liquid overflows into the scrubber drain at a predetermined location. In the blowdown method, liquid is forced to drain by the recirculation pump. If blowdown is inadequate, the rate of scaling and algae growth will increase. Sedimentation will also increase. Sump level controls and solenoid valves or flow control valves have to be provided in the recirculation piping to allow fluid to be discharged at a determined rate. In either method, the make-up water rate must be greater than the "to drain" rate due evaporation losses which can be from 2 to 4 gpm depending on weather conditions and operating temperatures. This is the key point for keeping the concentration gradient in check.

Pumps

Improper Pump Size

To determine pump size and selection for a given unit it is necessary to perform hydraulic calculations for the recirculation system. Three parameters affect the required design head of a pump: friction losses through piping and fittings, pumping height, and pressure loss of nozzles. If add-in items, such as basket strainers, are not accounted for in the design of a system the pump flow rate will suffer and this, in turn, can effect efficiency.

Pump Logistics

Pumps that are subjected to adverse conditions due to location or water level can lead performance problems. A low sump operating level can create vortexing and the pump will start to suck air, which will quickly deteriorate the volume and pressure of the pump.

Improper Addition of Scrubbing Liquor

Inadequate addition of scrubbing liquid can reduce performance of scrubbers. For sufficient absorption of HCl and chlorine gases, caustic is added to the sump to maintain a basic pH to enhance efficiency.

Location of pH Probe

A common error with pH control systems is location of the pH probe versus the location of the chemical supply injection. Locating a pH probe within 12 inches from the chemical injection pipe will not give true indication of the pH of the scrubber liquid. The pH controller and on/off switch for chemical injection will continually chase each other.

Velocity Profile

Unfortunately, scrubbers have velocity constraints that play a key role with performance. Once a scrubber is in operation the cross sectional area has forever been established. The likelihood of adding an extra 50 to 75 ft2 is cost prohibitive. If a unit is designed for 10,000 cfm and the fan is exhausting 14,000-cfm, the performance and efficiency decreases while the pressure loss increases. Exceeding the design velocity profile of a unit effects mist eliminator performance, absorption, and evaporation losses.

Channeling Caused by Plugged Spray Nozzles

Spray nozzles can be an operator's nightmare and the cause of frequent and expensive unplanned shutdowns. Plugging should be expected when using scrubbers that incorporate spray nozzles. When a nozzle plugs, the area of packing directly below is not receiving liquid. This will create an area where no absorption is taking place and therefore decreases the efficiency of the scrubber.

Channeling Caused by Poor Air Distribution and Rectangular Housings

In vertical scrubbers, inlets are located 90 degrees from air direction through the packed tower. The incoming air stream must make an abrupt 90-degree turn into the packing. Very few scrubbers are designed to account for this abrupt turn. Air follows the path of least resistance. Air will continue straight through the inlet to the back wall of the vessel where it is disturbed and will spiral and vortex up through the packed bed section. This channeling creates dead spots within the packed bed. The now channeled air streams will pass through the packed bed at higher velocities below the designed retention time.

Air will also follow the same general undisrupted path through rectangular scrubber housings. Dead spaces are common in rectangular vertical and horizontal scrubber housings. Design for these units must also account for air distribution inefficiencies. Theoretical analyses suggest decreases in performance for units without proper design.

Inadequate Mist Eliminator

Due to the vapor pressure of HCl and the concentrations and temperatures common to steel pickling operations the mist eliminator selection is of critical importance. A chevron baffle mist eliminator is capable of effectively removing mist sizes only down to 10 micron. In steel pickling operations HCl gas will condense into mist sizes ranging from several hundred micron to sub-micron levels. As a minimum, a composite mesh pad mist eliminator should be used to remove 99% of HCl mist down to 1 micron. In certain applications, an even finer or more efficient mist eliminator may be required.

Biological Growth

Build-ups of biological growth in packed bed sections and mist eliminators will adversely affect performance of scrubbers. In acid scrubbers, where pH is typically maintained in the 8 to 9 ranges and higher, biological growth is a commonality. Without treatment, the growth can create areas of channeling and increase the pressure drop through the scrubber.

Design of Wet Packed Bed Scrubbers to Meet the HCl Steel Pickling NESHAP

L/G Ratio – 12 to 20 gpm/1000 cfm or 3 to 5 gpm/ft2

Velocity - 400 to 500 fpm

Configuration – Vertical (Counter Current) Round Vessels

Air Distribution Enhancement – Use Packing Support Beams as turning veins for

proper air distribution

Liquid Distribution – Overflow Weirs with V-Notches (min. 12 drips points/ft2)

Packed Bed Depths – Based on inlet loading, minimum 5 feet

Packing Size – Minimum 40ft2/ft3 of surface area

Mist Eliminator – Composite mesh pad 99% efficient at 1 micron as a minimum

Material of Construction – Polypropylene (UV inhibitor in sunlight)

Maximizing Design and Operation to Reduce Cost of Ownership

Pumps

Include a redundant pump and ensure control system is capable of automated switchover in case of loss of pump or low flow. Utilize pressure gauges and flow meters on discharge piping. Oversize pumps by 125% to ensure adequate capacity and operation.

pH Control System

It is best to monitor pH away from the chemical injection area. To measure pH as it exits the packed bed section, utilize a catch cup just below the packing to capture liquids falling from above. The catch shall be plumbed to the exterior portion of the unit where liquid will gravity flow through the pH probe and down back into the sump area.

Chemical injection should be as close to the pump suction as possible. Utilize a pipe with small holes to act as a sparging device as chemical is brought into the unit. Chemical should exit the pipe near the pump suction area. The holes in the pipe will allow sump water to mix with the neutralizing chemical prior to entering the recirculation piping. The pump impellers will provide an excellent means of turbulence and mixing to prevent the channeling of liquid through the piping and packed bed.

Instrumentation

Monitor and Alarm the following:
pH
Fresh Water Make-up
Pump Flow Rate
Pump Pressure
Pressure Drop (Scrubber and Mist Eliminator)
Sump Levels
Blowdown
Sump Temperature
Air flow and air temperature should also be monitored in the duct system at a suitable location before the scrubber.

Access Considerations

Design mist eliminators for ease of removal for inspection, cleaning and replacement. Mesh pad mist eliminators should be encapsulated in boxes to prevent potential by-pass and for ease of removal.

Access doors should be provided for an operator to enter the packed bed section, sump area, pump area, and liquid distribution section. The access for the sump area should be above water level to prevent leak points.

View doors should be provided for easy inspection of internals. Borosilicate glass works best as a window. It resists fading unlike clear PVC or Plexiglas and takes the heat of the high intensity lights. Locate widows between the water line and packing bottom, at the packed bed section, and at the liquid distribution section. Utilize slide shades to keep light from entering the scrubber where possible. Locate lights (300 watt minimum) 90 degrees from the inspection windows for operators to adequately inspect internals. At this angle, light back scattering from mist and droplets is minimal. Without the use of lighting, viewing is poor.

Biological Growth

Establish a biological growth treatment program for acid scrubbers prior to start-up.

Developments in Liquid Distribution

Overflow Weir Liquid Distribution System

Overflow weirs are comprised of an inlet header pipe with several smaller size pipe drops, a distribution box with several side spouts, and a series of weir troughs with V shaped notches configured along the sides of the troughs.

The overflow weir system works via gravity flow of the scrubbing liquid through the inlet header pipe. Liquid is evenly distributed through a series of drops as it flows through the header. The distribution box collects the liquid from the header and evenly distributes the liquid through a series of side spouts down to individual weir troughs. The weir troughs fill and overflow the V-notches down into the packed bed section.

Benefits of Overflow Weir Systems

1. Eliminates nozzles that are prone to plugging. Plugging creates dry sections that can lower overall efficiency.
2. Utilization of weirs offers a major reduction of mist versus nozzles. Nozzles work at higher pressures, which emit fine mist that get captured and carried

into the mist eliminator. Heavy loading of mist can overload a mist eliminator and liquid can get carried through.

3. Weirs work via gravity flow and are capable of high turndown, whereas, nozzles are designed to operate at a constant pressure range.
4. Weir systems operate with lower energy requirements. Hydraulic design for nozzles includes pumping height, friction losses, and nozzle pressure. Overflow weir design eliminates the design requirement for nozzle pressure, therefore, weir systems typically require 1/3 less total horsepower than nozzle systems.

Design

1. Minimum of 12 drip points per square foot.
2. Utilize in systems over 4' diameter.
3. Maximum velocity of 1200 fpm between the trough sections.
4. The system shall be built in components, not as a single device, to allow field adjustment of each component to ensure proper liquid distribution. Each trough and weir shall be field adjustable as well. The troughs shall include adjustable side plates to calibrate even flow over each V-Notch once the unit is field installed.
5. Design calculations shall verify balancing of liquid flow through each flow point from the header pipe to the V-Notches.
6. Design for deflections due to full liquid systems that can weigh as much as 30 to 60 pounds per square foot.

Techniques for Reduction of Biological Growth

- Acid wash the unit periodically or shock it with sodium hypochlorite (5% solution) to destroy algae and other biological organisms.
- Use a chlorinating or brominating system to destroy algae and other biological organisms.
- Field experiences suggest reduced growth in polypropylene constructed units versus FRP construction. Porosity and pinholes tend to be breeding areas, which are common in FRP units.
- Utilize sliding shades over all clear view doors to prevent light from entering the unit.