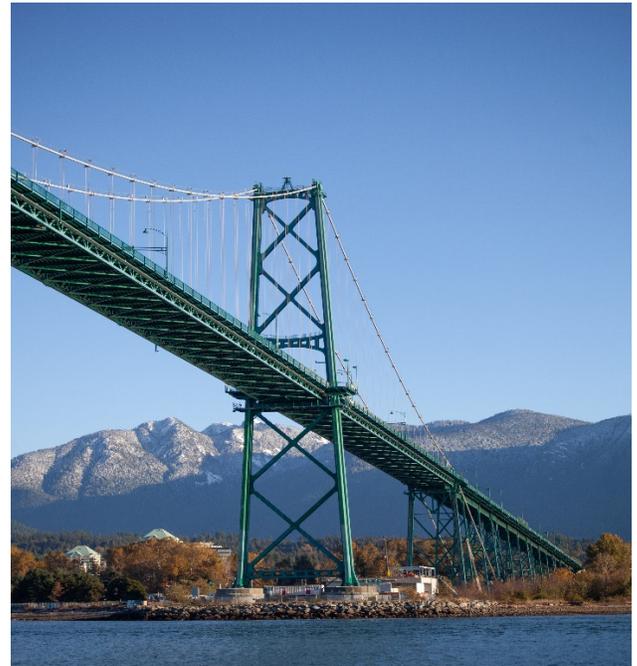




SEATTLE GALVANIZING COMPANY

The Northwest's Largest Galvanizer



Seattle Galvanizing Company, Inc.

Arlington Spin Project

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1 What is Hot-Dip Galvanizing

Hot-dip galvanizing (HDG), is the process of dipping fabricated steel into a kettle or vat containing molten zinc. The process is inherently simple which provides a distinct advantage over other corrosion protection methods. While the steel is in the kettle, the iron in the steel metallurgically reacts with the molten zinc to form a tightly-bonded alloy coating that provides superior corrosion protection to steel.

1.1 Spine Line Galvanizing

Spin galvanizing is a hot-dip process that utilizes a centrifuge anchored to a galvanizing kettle (or a spinner located above it) for immersing small to medium scale components in molten zinc. A tightly bonded alloy coating forms on the steel, providing long-term, durable protection from the devastating effects of corrosion, while the centrifuge or spinner removes excess molten zinc to ensure coating uniformity, quality fit, and precise functionality.

2 Galvanizing Process

The hot-dip galvanizing process (*Figure 1*) has been used since 1742, providing long-lasting, maintenance-free corrosion protection at a reasonable cost for decades. Although hot-dip galvanizing has been utilized to protect steel for generations, the galvanizing process continues to evolve with new technologies and creative chemistries. The three main steps in the hot-dip galvanizing process are surface preparation, galvanizing, and post-treatment. The process is inherently simple, which is a distinct advantage over other corrosion protection methods.

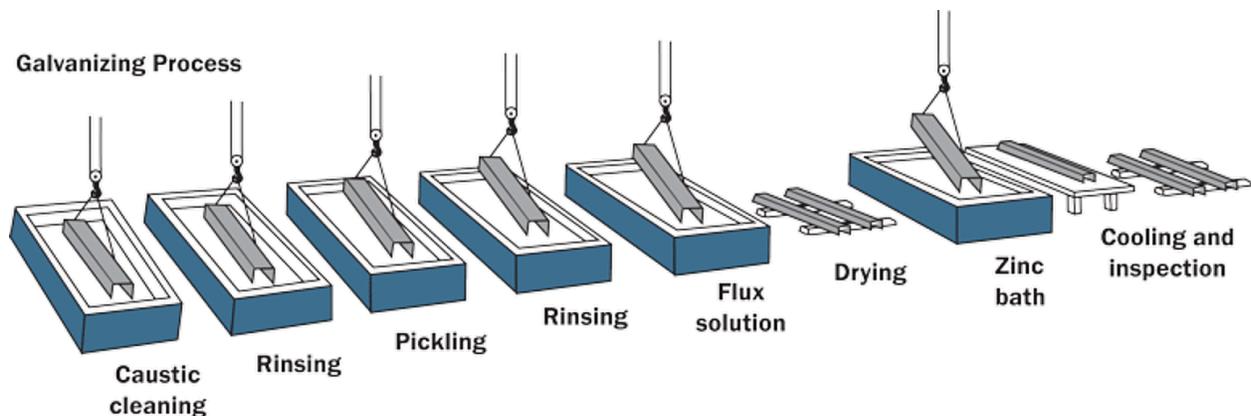


Figure 1: Model of the Hot-Dip Galvanizing Process

2.1 Caustic Cleaning

Material is immersed in a heated caustic solution to remove grease, dirt, oil, and water-based paints. This process will also remove any contaminants that cannot be removed by normal chemical cleaners (ie. welding slag, splatter, lacquer, and oil-based paints).

2.2 Caustic Rinse

Material is immersed in fresh water to remove any excess chemicals.

2.3 Acid Pickling

Material is immersed in a diluted Hydrochloric Acid solution to remove all rust, mill scale, and any other surface contaminant.

2.4 Acid Rinse

Material is immersed in fresh water to remove any excess acid and iron salts.

2.5 Fluxing

Material is immersed in a heated aqueous Zinc-Ammonium Chloride solution. This process will remove any remaining impurities, moisture, and oxide film from the steel. Flux acts as a bonding agent to the molten zinc.

2.6 Drying

Material is placed in a holding area for a certain amount of time. This will ensure the Flux is air-dried and best prepared before entering the molten Zinc.

2.7 Galvanizing

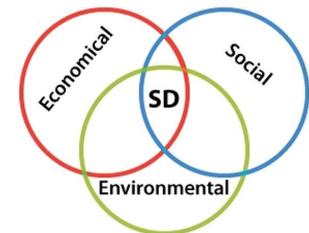
Material is immersed in a molten Zinc mixture. Molten Zinc is heated to 840°F. Material will be removed from the Zinc mixture when the coating thickness meets and exceeds relevant ASTM standards

2.8 Inspection

Material is inspected for any imperfections and is tested by American Galvanizer Association certified inspectors to ensure compliance with ASTM standards.

3 Sustainability

Sustainable development is the social, economic, and environmental commitment to growth and development that meet the needs of the present without compromising the ability of future generations to meet their own needs. As the social pressure continues to mount to construct the built environment sustainably, specifiers and owners are becoming more invested and analytical in the materials they choose. Sustainability is intrinsic to hot-dip galvanized steel and is a message the galvanizing industry promoted long before sustainable design became a trend. Hot-dip galvanizing (HDG) is a proven steel corrosion protection system that transcends time with minimal economic or environmental impact. Not only does hot-dip galvanizing provide decades of maintenance-free longevity, but its primary components, zinc and steel, are natural, abundant, and 100% recyclable, making hot-dip galvanized steel an infinitely renewable building material. Utilizing hot-dip galvanized steel ensures less natural resources are consumed, fewer emissions are output, and less money is spent over the life of a project.



3.1 HDG Environmental Advantages

The production of any building material requires material and energy inputs and emission and waste outputs. The key to sustainable development is to ultimately lower the environmental impact of producing a product, through optimization of manufacturing. Specifiers who are committed to sustainable development have pushed for more transparency and objective measures of building materials' environmental impact in order to select those with less burden to current and future generations. Hot-dip galvanized (HDG) steel has a number of environmental advantages that minimize the impact to the environment over the life of the project.



Reused HDG Railing

3.1.1 Natural, Abundant Materials

Hot-dip galvanized steel is made from two naturally occurring, abundant elements - zinc and iron ore. Iron ore (steel), the base metal, is the 4th most abundant element in the Earth's crust. Zinc, which comprises 98% of the hot-dip galvanized coating, is a natural, healthy metal. Zinc exists naturally in the air, water, and soil and is the 24th most abundant element in the Earth's crust. More than 5.8 million tons of zinc is naturally cycled through the environment by plant and animal life, rainfall, and other natural phenomena. In addition to being natural and abundant, zinc is essential to life. All living things, from the smallest microorganisms to humans require zinc to live. Zinc is critical to growth as it plays a role in cell division, growth, and wound healing. It also plays an important part in daily functions such as breathing, digestion, reproduction, and cognition. And of all micronutrients, zinc has the strongest effect on our immune system which can help prevent disease and fight infection. Zinc is often used in fertilizers to fortify crops and promote growth. As zinc is already naturally found in and cycled throughout the environment, the use of hot-dip galvanized steel is not introducing disruptive or harmful elements to the eco-system.



3.1.2 Infinitely Renewable Resources

In addition to being natural and abundant, both zinc and steel are infinitely recyclable without the loss of any physical or chemical properties. This means rather than being down-cycled into other products or uses, zinc and steel can be used as zinc and steel again and again, without compromising their integrity. Therefore, when considering the life-cycle assessment (LCA) of hot-dip galvanized steel, it is a cradle-to-cradle product, as there is essentially no "grave" to the zinc or steel.

The 100% recyclability of hot-dip galvanized steel is a great benefit to minimizing environmental impact, but it is only half of the story. The fact the primary components of hot-dip galvanizing, zinc and steel, can be recycled is important, but there are two measures of recyclability that ultimately define the positive contribution to the environment: recycling rate and reclamation rate.

Recycling content is the amount of a product produced from recycled sources. Reclamation rate measures how often a product is actually recycled at the end of its useful life. Steel is the most recycled material in the world, and zinc also has a very high reclamation rate. This leads to a high recycling rate, as the reclaimed zinc and steel is often put right back into use. The table below shows the Recycling and Reclamation Rates for both zinc and steel:

	Zinc ¹	Steel ²
Reclamation Rate	80%	100%
Recycling Rate	30%	70%
¹ International Zinc Association (IZA) Zinc Recycling, 2004 ² Steel Recycling Institute Steel Lakes LEED with Recycles Content, March 2009		

The steel recycling rate in the table encompasses all steel types. When it comes to hot-dip galvanized steel, the story is even better, as the recycling rate of structural steel is more than 90%. The recycling rate of zinc is lower primarily because there is not enough zinc available to reclaim to create recycled product - its durability and longevity allows it to stay in use for decades.

4 Stormwater

The U.S. Environmental Protection Agency (USEPA) developed the National Pollutant Discharge Elimination System (NPDES) stormwater program to regulate stormwater discharges from sources, such as, municipal separate storm sewer systems (MS4s), construction activities, and industrial activities. Stormwater discharges are generated by runoff from land and impervious areas (paved streets, parking lots, and building rooftops) during rainfall and snow events. The runoff often contains pollutants like trash, chemicals, oils, and dirt/sediment in quantities that could adversely affect water quality in rivers, streams, lakes, and coastal waters. The NPDES permitting system is designed to prevent stormwater runoff from washing harmful pollutants into local surface waters. To protect these water sources, companies use best management practices (BMPs) to filter out pollutants and/or prevent pollution by controlling it at its source. For industrial activities, the USEPA established specific stormwater permitting regulations for eleven categories. The Standard Industrial Classification (SIC) code for hot-dip galvanizing is under Fabricated Metal Products (SIC 3479) which is one of the eleven categories (Sector AA, Fabricated Metal Coating and Engraving) of industrial activity.

Depending on the permitting authority, either USEPA or authorized permitting states, galvanizers may be required to obtain a NPDES permit before discharging stormwater from their facility. The NPDES permit establishes benchmark levels that are used to determine the overall effectiveness of a facility's Storm Water Pollution Prevention Plan (SWPPP) in controlling the discharge of pollutants to receiving waters. If the permit's benchmark value is exceeded, current regulations require modifications to the SWPPP. Benchmark monitoring is required for those galvanizers with a NPDES permit. For those galvanizers with a USEPA NPDES permit, quarterly benchmark monitoring is required. Galvanizers that are located in an authorized NPDES permitted state should verify their benchmark monitoring frequency since they may be different.

4.1 Stormwater Issues

A concern for some hot-dip galvanizing facilities is being able to meet the stormwater permit's benchmark levels for zinc. USEPA's multi-sector general permit has a default zinc benchmark level of 0.117 mg/L. For states that have their own stormwater permit, the zinc benchmark level may be higher or lower. Some hot-dip galvanizing facilities have spent a considerable amount of money on their best management practices (BMPs) and pollution control equipment to meet their stormwater permit's benchmark levels.

A discussion on whether the benchmark levels for zinc are achievable for hot-dip galvanizing facilities has been talked about during AGA's Environmental Subcommittee teleconferences. Current benchmark levels developed by USEPA are based on the hardness of the receiving water body and does not consider the fate of zinc in natural waters and remain relative to the total zinc concentration. The development of bioavailability-based water quality standards has evolved over the past 30 years since the current USEPA Ambient Water Quality Criteria (AWQC) were established. One development is the International Zinc Association's (IZA) biotic ligand model (BLM) for zinc to determine the amount of zinc that is bioavailable for organisms.

4.2 What is the BLM?

The development of the BLM was motivated from the need to better represent the fate and effects of metals in natural waters receiving point and non-point source inputs. The BLM considers multiple factors that influence metal bioavailability, including dissolved organic carbon, pH, alkalinity, calcium, and other major ions. The USEPA has recognized the use of BLM for copper, but the same recognition for zinc has not been realized yet. The USEPA Office of Water has suggested that facilities that are impacted by the zinc levels in stormwater should petition their state agencies to recognize the state of the science for assessing zinc. The modeling framework used in this study was developed by Windward Environmental (Version 2.1.2; available at http://www.hydroqual.com/wr_blm.html). The BLM was used to estimate short-term (acute) Ambient Water Quality Criteria (AWQC) for zinc in the surface waters adjacent to galvanizing facilities. Information on the development and application of the BLM used in this study can be found in the paper Application of the U.S. EPA Guidelines in a Bioavailability-based Assessment of Ambient Water Quality Criteria for Zinc in Freshwater.

4.3 AGA Stormwater Study

The objective of the AGA stormwater study was to compare stormwater benchmark derivation approaches, the biotic ligand model (BLM) versus USEPA's hardness-adjusted, for several galvanizers in North America. Stormwater samples were collected from hot-dip galvanizing facilities to populate the BLM to calculate a site-specific stormwater discharge. Hot-dip galvanizing facilities were selected based on their response from an AGA stormwater survey regarding stormwater conveyance, treatment, and permitting. The survey asked the following questions:

1. Do you have a zinc benchmark limit below 0.6 ppm?
2. Does your facility discharge to a creek, stream or river?
3. Does your facility discharge to a wetland area on property owned by the facility?

4. Does this wetland ultimately discharge to a creek stream or river?
5. Has your facility implemented BMPs for zinc and/or petroleum compounds?
6. Does your facility have storm events where large volume sheet flow rinses the zinc materials off your property?
7. Does your facility have a stormwater treatment system?

From the survey results, the sites were prioritized based on three factors:

1. Availability of surface water quality criteria at or near the facility
2. Stormwater discharge occurring into a receiving stream or wetland
3. Currently permitted under a state-issued stormwater zinc benchmark.

Three galvanizing facilities were approached based on the survey results and they agreed to collect samples for the study. The galvanizing facilities represented a widespread area of North America, with facilities in OH, OR, and WV.

4.3.1 Phase 1

The first phase of the study collected stormwater samples from three galvanizing facilities to populate the biotic ligand model. Galvanizing facilities were given sampling procedures and were asked to collect two separate samples from their stormwater outfalls and their receiving stream adjacent to their site. All samples were analyzed for total and dissolved zinc, dissolved organic carbon (DOC), pH, alkalinity, and major ions.

Results from Phase 1

All sites successfully collected and analyzed stormwater samples on more than one occasion. Due to the limited number of receiving water samples collected at each site, surrogate water quality data was obtained from selected U.S. Geological Survey (USGS) stations to help populate the biotic ligand model. Measured water quality data collected within 20 miles of a galvanizer was included as surrogate data, providing up to 63 additional samples for each site.

The relative consistency between the samples collected by galvanizers and those retrieved from the USGS database supported the use of surrogate data for the derivation of a bioavailability-based stormwater benchmark. Table 1 includes the measured water quality data as an average concentration (range) for water bodies adjacent to the galvanizers (USGS data).

Table 1.

Facility	pH		DOC (mg/L)		Hardness (mg/L as CaCO ₃)	
	Galvanizer	Surrogate	Galvanizer	Surrogate	Galvanizer	Surrogate
A	8.2	8.3 (7.9-8.6)	8.41	4.1 (2.8-6.8)	131	260 (90-350)
B	6.9	7.5 (7.2-7.9)	6.98	4.8 (1.2-14)	90	120 (40-310)
C	6.5	7.3 (6.7-7.9)	1.6	3.7 (0.4-7.3)	210	60 (20-130)

Stormwater Benchmark Derivation

Current methods for determining stormwater benchmarks for zinc include site-specific adjustment for two variables:

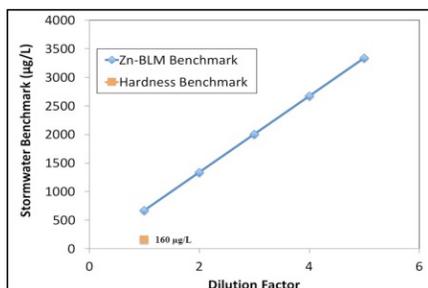
1. Magnitude of the benchmark using hardness adjustment to the total zinc concentration, and
2. The in-stream dilution factor of the receiving water upon complete mixing with the stormwater.

Since seasonal hardness fluctuations are relatively minor, the influence of time-varying water quality is not considered significant in the current approach. However, when allowing for the influence of multiple water quality constituents (DOC, hardness, and pH), time-varying changes may result in considerable differences in the benchmark. The USEPA Fixed Monitoring Benchmark approach was used to account for the range of benchmark estimates calculated for each hot-dip galvanizing site. For the AGA study, the in-stream flow of the stormwater into receiving waters was not characterized. Instead, a dilution factor for each site was varied between 1 (no dilution) and 5 (receiving stream has five times the flow of stormwater) to illustrate the potential variability in the benchmark.

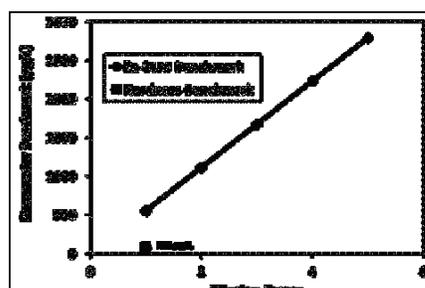
Galvanizer's Stormwater Benchmark Derivation

A six-step process was applied to the stormwater data collected in Phase 1 (Appendix). Results for the three galvanizing sites represent a range of possible outcomes that occur when considering site-specific conditions. The estimated Fixed Monitoring Benchmark (FMB) represents the concentration of dissolved zinc that could be present in the receiving stream for short-term periods of time without causing adverse ecological effects. The bioavailability-based FMB, under a zero dilution scenario (dilution factor = 1), is equal to or greater than the current hardness-based stormwater benchmarks for zinc at all three facilities (Figure 1-3). Under a fivefold dilution scenario, the bioavailability-based FMBs are 5 to 24 times greater than the current hardness-based benchmarks.

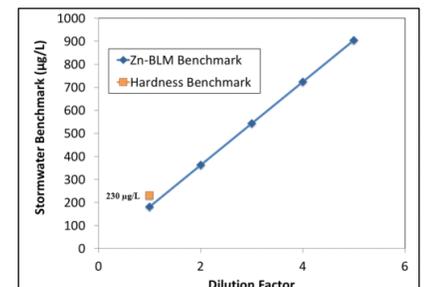
Figure 1. Comparison of stormwater benchmarks using a bioavailability-based approach (Biotic Ligand Model (BLM)) and a hardness adjustment. Currently, most hardness-based stormwater benchmarks do not include a dilution factor. The default dilution factor = 1 for zinc.



Facility A



Facility B



Facility C

Phase 1 Conclusion

This phase of the study provided proof of principle evidence that the stormwater benchmarks for zinc could increase 5-500% using a bioavailability-based approach, relative to the current hardness adjustment used by the USEPA and authorized permitting states. Furthermore, use of bioavailability-based approaches did not result in more conservative benchmarks. Each of the sites showed water quality characteristics that provided favorable improvement of zinc toxicity. The combined implementation of bioavailability and in stream dilution factors would produce FMBs that are 5 to 24 times greater than the current hardness-based benchmarks for these sites.

4.3.2 Phase 2

Following recommendations from Phase 1, dedicated sampling regimes were designed and implemented for three facilities. The objective was to collect at least three receiving stream samples (upstream of outfall) throughout one year to better represent potential changes in water conditions over time. Three galvanizing facilities were selected, including two from Phase 1 (Facilities A and C), and a galvanizing facility in Alabama (Facility D). The same methods were applied for sample collection and analysis, data preparation, bioavailability modeling, and interpretation of results as used in Phase 1.

Results from Phase 2

Table 2 lists the resulting bioavailability-based FMBs for the three galvanizing facilities. The estimated FMBs represent the concentration of dissolved zinc that could be present in the receiving stream for short periods of time (e.g., hours, such as during storm events) without causing adverse ecological effects. As a conservative generalization, stormwater benchmarks should include a dilution of three to five. Under a threefold dilution scenario, the bioavailability-based FMB can be up from 4 to 400 times greater than the current benchmark.

Table 2.

Facility	Benchmark, µg/L dissolved zinc	Number of Samples
A	848 5-16 times greater than benchmark	4
B	4088 130 to 400 times greater than benchmark	3
C	1037 4 to 13 times greater than benchmark	10

In comparing the bioavailability-based FMBs of Phase 1 to Phase 2, Facility A and C showed an increase with the addition of the galvanizing receiving stream sample data. Facility A went from 714 to 848 µg/L. Facility C showed an increase from 241 to 4088 µg/L. Details of these analyses can be found in Figures 3-5 of Appendix.

Conclusions

The IZA and AGA study provided evidence that stormwater benchmarks for zinc could increase using a bioavailability-based approach, relative to the current hardness adjustment used by the

USEPA and states. The resulting benchmarks for the participating galvanizing facilities showed that the benchmark could increase four times to as much as 400 times greater than the current hardness-based benchmarks for these sites. The recommendation for hot-dip galvanizing facilities that may be having difficulties meeting their benchmarks is to use the information from this study to discuss site-specific options with state regulatory authorities. Targeted sampling programs and the FMB calculations that were performed in this study can be initiated at sites where stormwater compliance is being challenged.

5 Air Monitoring Summary

In the hot-dip galvanizing industry, chemical substances are monitored to ensure the air quality inside the plant does not exceed the permissible exposure limits (PEL) set by the Occupational Safety and Health Administration (OSHA) and the threshold limit values (TLV) set by the American Conference of Governmental Industrial Hygienists (ACGIH). Personal air samples are the most representative of actual exposures because employees move continuously among the various surface preparation baths leading up to the galvanizing kettle and are only in areas intermittently for short periods. To measure personal exposures, sampler inlets are suspended from employees' collars in the breathing zone to represent exposures through inhalation.

The following substances are included in this report: ammonium chloride, cadmium, chromium, hexavalent chromium, hydrochloric acid, lead, nickel, respirable dust, sodium hydroxide, sulfuric acid, total particulates, zinc, zinc chloride, and zinc oxide (Note: facilities will have one or another of these substances, i.e. hydrochloric or sulfuric acid). The air monitoring summary compiles the personal air samples from galvanizing members and provides a historical basis for air quality assessment in member galvanizing plants. This third compilation also includes personal air sampling on hexavalent chromium and respirable dust that was not included in the previous two summaries. Overall, the air monitoring data that was submitted to the American Galvanizers Association (AGA) were below the PEL and TLV.

This Environmental, Health & Safety Note will include the general patterns of the personal air samples, explanations for samples that had high concentrations above the PEL, and comparisons between previous air data. The compilation of data from the air sampling includes histograms and statistical information about the tested chemical substances. The appropriate PEL and TLV levels for the different chemical substances are shown in Table 1.

Table 1: The OSHA PEL and ACGIH TLV Levels for Chemical Substances that can be Monitored in the Air of a Galvanizing Facility

Chemical Substance	PEL (mg/m ³)	TLV (mg/m ³)
Ammonium Chloride (fume)	10.0*	10.0
Cadmium	0.005 ^b	0.01 ^b
Chromium	0.1 ^a	0.5 ^b
Hexavalent Chromium	0.005	0.05 ^c / 0.01 ^d
Hydrochloric Acid	7.0 ^a	2.98 ^a
Lead	0.05 ^b	0.05 ^b
Nickel	1.0	1.0 ^b
Respirable Dust	5.0	NE
Sodium Hydroxide	2.0 ^b	2.0 ^a
Sulfuric Acid	1.0	1.0 ^b
Total Particulates	15	NE
Zinc	NE	NE
Zinc Chloride	1.0 ^b	1.0 ^b
Zinc Oxide	5.0 ^b (fume) / 10 (STEL) / 15 (total dust)	5.0 ^b / 10 (STEL)

NE – Not Establish | *OSHA proposed PEL – currently not enforced a Ceiling Limit | b Time Weighted Average | c Water soluble Cr(VI) compounds as Cr |

Compilation of Data

The AGA asked member galvanizers to submit any air monitoring data that was performed in the years 2007 and later. Air monitoring information was collected from 56 galvanizing facilities and was compiled according to each chemical substance. The information on the testing lab reports included the number of samples taken, location of the sample (employee's job duties), air concentration level, and sometimes testing methodology.

After the data was entered and compiled, histograms were created for each chemical substance. In Appendix 1, the histograms display the number of individual samples with the air monitoring concentrations for the three air monitoring summaries. The appropriate PEL and TLV values and the mean and standard deviation are also included on the histograms. In Appendix 2 are tables with statistical analysis of the new air monitoring information that was collected. The tables are broken down by the chemical substance that was being monitored.

Results

The air monitoring data is summarized in Table 2 and includes the number of samples and companies that submitted test results. The mean and standard deviation values were calculated for each chemical substance. The number of samples above the PEL, the percent of samples that were above the limits, and the number of companies above the limits are also shown in Table 2.

Table 2: Summary of the 2007-2016 Air Monitoring Survey Results

Name of Substance	Number of Samples	Number of Companies Tested	Mean Value (mg/m ³)	Standard Deviation (mg/m ³)	Number of Samples Above the PEL	Percentage of Samples Tested Above the Limit	Number of Companies Above Limit
Ammonium Chloride	36	19	0.309	0.333	0	0	0
Cadmium	98	23	0.0005	0.0007	0	0	0
Chromium	61	14	0.004	0.008	0	0	0
Hex. Chromium	71	18	0.001	0.001	0	0	0
Hydrochloric Acid	68	24	1.151	2.105	3	4	3
Lead	192	44	0.005	0.007	0	0	0
Nickel	124	33	0.002	0.003	0	0	0
Respirable Dust	40	9	0.534	0.752	0	0	0
Sodium Hydroxide	32	15	0.114	0.207	0	0	0
Sulfuric Acid	55	21	0.230	0.263	1	2	1
Total Particulates	157	30	1.848	1.534	0	0	0
Zinc ^a	183	40	0.511	0.677	---	---	---
Zinc Chloride	68	24	0.364	0.331	2	3	2
Zinc Oxide	91	22	0.396	0.785	1	1	1

^aThere is not an established PEL or TLV for zinc

The majority of the data showed air monitoring concentrations below the PEL and TLV. There were a few substances that had samples that tested above the limits. For samples that tested above the PEL, the majority of the samples were barely over the PEL and were often retested at the galvanizing facility at later dates with results below the limits.

6 Baghouse

Baghouse dust collectors are a fabric filter air-material separators employed for particulate removal from manufacturing and other industrial operations to keep dust and solid particulates from entering the workplace or being released into the atmosphere. In effect, baghouses are industrial-scale fabric filter systems used as air pollution control devices.

6.1 How Does a Baghouse System Work

Among dust collection systems, baghouses are the most widely used. The reasons why are twofold: baghouses are both highly efficient and cost-effective. Baghouse systems are engineered to collect, capture, and separate dust and particulates from the air.

Baghouses utilize fabric filter bags or pleated filters arranged in rows and mounted vertically in a sheet metal housing. They are designed to receive dusty gas from fugitive or process sources, capture the particulates, and exhaust clean air. Typically, via an induced draft blower, the dusty gas stream is drawn into the baghouse through a duct system. The gas stream then passes through the filters while particles remain on the filter media surface, thus separating the particulates from the air. Over time, as the dust begins to build up and form a filter cake on the filter surface, various cleaning systems are used to remove the dust from the filters.

How the dust is collected and how the baghouse is cleaned depends on the type. The three most common baghouse cleaning systems are pulse-jet, shaker, and reverse-air. The main differences between these kinds of baghouses are described below.

6.2 Different Types of Baghouses

Pulse Jet Baghouse

The pulsejet or reverse-pulse baghouse is ubiquitous in industrial dust collection. These industry workhorses boast no moving parts in their basic configurations and allow collection efficiencies greater than 99.9%. In the pulse jet dust collector, the dusty airstream usually enters from below the bags or filters. It is pulled upwards through the filters, where dust is captured on the exterior surface, and clean gas passes through to the clean air plenum side for exhaust. When fabric filters are used, the bags are supported by internal wire cages. The pulse-jet cleaning cycle is controlled by a solid-state timer which sequentially pilots “pulses” of compressed air in the reverse direction of filtering into blow pipes mounted above each row of filters. When activated, the reverse pulse air pulses travel down the length of each bag in the given row, causing a ripple effect, dislodging and releasing the caked dust into the hopper at the base. A main advantage of the pulse jet baghouse is that it does not have to be taken off-line to clean the filters. With the dust removal programmed for regular or on-demand intervals, the system offers more complete cleaning and reconditioning of the filter bags than the other systems. Operating costs are minimal outside of the cost of compressed air for cleaning.

Shaker Baghouse

A shaker baghouse, as the name suggests, mechanically disposes of collected dust by shaking it out of the bags into a collection hopper at the bottom of the baghouse. In a shaker baghouse, filter bags are hung and tensioned from the top of the filter housing and attached with the bottom open, to the tube sheet. No internal cages are used for shaker bags. The airstream

enters from below the bags and is pulled upwards through the interior of the bags where the dust collects. The airstream passes through the filter bags trapping the contaminants on the dusty side. Clean gas is exhausted near the top of the collector. To clean a shaker baghouse, which normally uses woven filter bags, the airflow through the system must be periodically shut down, also referred to as being taken off-line, while mechanical shake-cleaning is employed. After the dust cake is released from the bags, it falls into a hopper at the bottom of the baghouse for removal.

Shaker-style baghouses are generally uncomplicated and are commonly employed where compressed air is not available. However, limitations exist for the application of shaker baghouses in that they cannot operate and clean continuously without periodic shut-down. Also, particle collection efficiencies are generally lower than other baghouses that use felted or pleated filter media.

Reverse Air Baghouse

There are two styles of reverse air baghouses. More common nowadays, especially with fibrous dust such as those from grain or wood processing, is around reverse air collector style, wherein dust collects on the exterior of the bags or filters. For cleaning, reverse air generated by the equipment fan or medium pressure blower is directed by a rotating arm over the bags, blowing reverse air into them to remove dust. This type of reverse air baghouse generates a lower cleaning air pressure than the compressed air pulses of a pulse jet. It is a low-pressure, high-volume cleaning system and cleans while online. This gentler cleaning method decreases wear and tear on the bags and saves on the cost of compressed air. The trade-off for the cost of compressed air, however, is the horsepower requirements and maintenance costs of the reverse air blower and moving parts.

An older type of baghouse, also known as reverse air, is often seen with rectangular housing and multi-compartments. Like a shaker unit, in this style, dust collects on the interior of the bags as the airflow rises. These types of reverse air baghouses have to be taken offline for cleaning, thus are often divided into compartments so one section at a time can be cleaned. Generally, an entire compartment is pressurized with a system fan in the reverse direction of filtration. Once activated, the pressure from the reverse airflow causes the filter bags to collapse slightly. These reverse airbags have sewn-in rigid rings that allow them to flex but not collapse completely or “pancake” during the cleaning cycle. Due to the off-line cleaning requirement, this type of reverse air baghouse must be oversized to account for a portion of it during cleaning, making this style less cost-effective than a pulse jet

6.3 What do Baghouse Filters Remove

Baghouse dust collectors are regarded as highly effective systems that are capable of achieving up to 99.9% efficiency. Depending on the design and fabric filter, baghouse filters remove and can withstand or capture abrasive particles, acid gasses, filter explosive dust, mists, fumes, and fine powders. They can collect difficult-to-capture air pollutants and airborne toxic materials found in dust and welding fumes, and particulate residue.

Given the high efficiency, the systems are well regarded and widely used across many different industrial sectors—food processing and agricultural plants, asphalt and cement plants, coal

processing plants, quarries, steel and iron foundries, chemical and paint manufacturing plants, utilities, power generation, and energy plants, and so on.

6.4 Advantages and Disadvantages of the Principal Baghouse Designs

That said, baghouse designs do differ. Three principal designs are the shaker baghouse, the reverse air filter baghouse, and the pulse jet baghouse. The primary difference between the designs is how the bags are cleaned.

A shaker baghouse is a mechanical system. As the name suggests, shaker systems work by shaking accumulated dust cakes from the filter bag. The bags are hung from the top of the unit and are attached to a tube sheet at the bottom of the baghouse. There, the dirty air enters, and, as it is pulled up, the filter collects dust and particulates inside the bag, and clean air exits through the top.

Its primary advantage is its low initial investment costs, fundamental design, and simple operation. As the units are generally compartmentalized into sections, the entire system does not have to be shut down when cleaned. Nonetheless, the units take up space, are not well-suited for high-temperature contaminants, and are more energy and time-intensive than other cleaning methods. Also, collection efficiency can be reduced when even small amounts of positive pressure are inside the bag. With reverse air filter baghouse designs, airflow is reversed through the filter bags via an exhaust fan rotating over the bag module. In reverse air systems, dust and particulates collect outside the bags, where dust cakes accumulate. The cleaning process requires reverse air blown through the bag to release the particulates and dust.

A reverse air baghouse system is a cost-effective method that generates lower pressure than the pulse jet baghouse system, which utilizes compressed air. Because they consist of multi-compartment, sections can be cleaned without shutting the whole system down. The gentle cleaning cycle is ideal for high-temperature collection and allows for a longer bag life. On the downside, cleaning must be done often, there are no effective means to remove residual dust buildup, which requires more maintenance than other types of baghouse systems.

Pulse jet baghouse systems utilize bursts of compressed air that are directed through the clean side of a filter bag to remove the dust cakes from the surface of the filter media. The bags are hung from the tube sheet and supported by metal cages during cleaning—pulses of air push through the bag to dislodge solids where they are collected in a hopper below. The clear advantage of a pulse jet system is the baghouses are to be cleaned as the system continues online. It also cleans better than shaker or reverse air baghouse systems, is space-efficient and, as a result, requires fewer bags. The main disadvantages are its use of dry compressed air, which adds to energy costs. It also requires special types of fabrics to filter higher temperature contaminants. Finally, pulse jets cannot tolerate high moisture levels or be used where humidity is generated from high moisture gasses or content.



Overall, baghouse systems are versatile and efficient. Capable of capturing small micron particle dust with a removal efficiency of over 99%. Systems can manage from millions of cubic meters per hour to

hundreds of thousands of cubic meters. The basic design structure is simple, stable, reliable, and less of an investment than other air pollution control units. However, some system designs can require large power consumption. Those systems are easily maintained, but they do require ongoing maintenance to function at peak efficiency. Finally, though there are exceptions depending on the filter media design, baghouse systems are best suited for operation in relatively dry environments. They are not recommended for collecting sticky dust-like contaminants or gasses.

7 Managing Byproducts from the HDG Process

The surface preparation of steel prior to immersion in molten zinc is important for producing hot-dip galvanized coatings. Each pre-treatment chemical solution requires rebalancing as iron and contaminants increase in concentration. When these chemical solutions are no longer effective, they will need to be disposed, recycled, or reused. The materials removed from the process that hold value in other processes or markets may be transferred as beneficial reuse or sold. These materials should be tracked from your facility to its final destination to ensure safe handling for human health and the environment. It is the galvanizer's legal responsibility to make sure the material leaving the facility is handled, treated, and stored properly.

The following materials are used or produced in the galvanizing process and either recycled or reused back in the galvanizing process or sold to another industry as a raw material ingredient.

- Metal Scrap – Chain/Wire/Steel (fixtures)
- Process Rinse Waters – caustic, acid, quench
- Ferrous sulfate heptahydrate
- Ferrous chloride solution
- Hot-dip galvanizing skimmings
- Hot-dip galvanizing dross



7.1 Recycling and Reuse of Materials

When materials meet the below listed criteria per USEPA, they may be exempt from the definition of “solid waste” (40 CFR 261.2) and therefore cannot be hazardous wastes. Materials are not a solid waste when recycled by being:

- Used or reused as ingredients in an industrial process to make a product, provided the materials are not being reclaimed; or
- Used or reused as effective substitutes for commercial chemical products; or
- Returned to the original process from which they are generated without first being reclaimed or land disposed. The material must be returned as a substitute for feedstock materials. In cases where the original process to which the material is returned is a secondary process, the materials must be managed such that there is no placement on land...per Resource Conservation and Recovery Act (RCRA) 40 CFR 261.2(e)(1)(i-iii).¹

Some of the hot-dip galvanizing facilities have processes that manufacture a secondary material that may be handled as a commercial chemical product. The systems removing

iron from acid produce ferrous chloride solution or ferrous sulfate heptahydrate crystals that are often sold for commercial use and components of animal feed, fertilizer, and water treatment chemicals. Hot-dip galvanizing facilities with kettles produce hot-dip galvanizing skimmings when zinc ammonium chloride flux burns off pretreated steel. These skimmings contain zinc, zinc oxides, and zinc chlorides and are collected for sale to zinc brokers and zinc producers. The hot-dip galvanizing bottom dross contains a combination of zinc/iron intermetallic alloys and free zinc and is removed from the kettle and sold to zinc brokers and zinc producers. Both materials are typically used as a feedstock material for zinc metal production and are excluded from the RCRA definition when recycled or reused.

Some facilities have a Metallurgical Zinc Recovery (MZR) unit to recover the zinc metal and metal alloys from the hot-dip galvanizing skimmings and floor sweepings. The MZR is a thermo-mechanical device that separates the free zinc from the process and the skimmings. Facilities using MZR units to recover the metal content from the skimmings typically either sell the solid material or discard remaining material as nonhazardous solid waste. The recovered melted zinc metal can be reintroduced directly into the galvanizing kettle.

Ferrous chloride and caustic solutions are not considered wastes when sold to be used or reused as effective substitutes for commercial chemical products. These solutions are often shipped as hazardous material commercial products for use in wastewater treatment, zinc manufacturing, oil cracking processes, or other chemical processes.

Water quench solutions after the galvanizing kettle are typically not disposed. Water is added to replace the evaporated amount. Solids (dirt, oils, iron, and chemical precipitate) gradually accumulate at the bottom of process solution tanks. When the solid material is removed from the water quench solution, it is typically shipped offsite for reuse in zinc production or disposed offsite as a nonhazardous or hazardous waste. Facilities with chromate or water quench solutions accumulate zinc which settles to the bottom. This zinc may continue to be used in the plant for galvanizing, shipped offsite for use by the zinc producers, or disposed as a solid waste. This material may be a hazardous waste that is corrosive and/or toxic. All solids leaving the process as waste should be analyzed for RCRA metals by TCLP and characterized before shipment.

7.1.1 Difference between Recycling and Reuse

The correct terminology when referring to how materials, such as wastes or commercial products, are handled after leaving a hot-dip galvanizing facility is important. Understanding the difference between recycle and reuse can determine how the material is reported to regulatory authorities. Regulatory authorities have clarified the definitions of recycling, reuse, and reclamation to prevent sham recycling of hazardous materials. "Sham recycling may include situations when a secondary material is ineffective or marginally effective for the claimed use; used in excess of the amount necessary; or handled in a manner inconsistent with its use as a raw material or commercial product substitute." Secondary materials include spent materials, listed and characteristic sludges, listed and characteristic byproducts, commercial chemical products, and scrap metal.

According to USEPA, there are four legitimate recycling factors versus sham recycling.

1. A hazardous secondary material that provides a useful contribution to the recycling process or to a product or intermediate of the recycling process.
2. The recycling process must produce a valuable product or intermediate.
3. The generator and the recycler must manage the hazardous secondary material as a valuable commodity when it is under their control.
4. The product of the recycling process must be comparable to a legitimate product or intermediate.²

There are distinctions between materials that are recycled by being used/reused without reclamation and those that must be reclaimed before use. A material is reclaimed if it is processed to recover a usable product, or it is regenerated. In USEPA's Toxics Release Inventory (TRI) and Canada's National Pollutant Release Inventory (NPRI), the distinction between recycling and reuse determines whether the material is reportable on the forms. The definitions of recycle and reuse for reporting on the TRI and NPRI are below.

Recycle

According to USEPA, for a material to be recycled there are intervening reclamation or recovery steps performed before being reused. Recycling includes a variety of methods where the material can be recovered, such as solvent recovery and metals recovery. The material must undergo a recovery step prior to being used again, such as removing impurities. Intervening reclamation or recovery steps would include, but are not necessarily limited to:

- Reclaiming the metal from material that has entered a treatment or pollution control device or a process where removal of certain constituents in the material occurs
- Removing toxic chemicals using a pollution control device
- Removing contaminants from the material after it has been used and the material can no longer be reused for its intended purpose without reclamation or recovery.³

Reuse

For a material to be directly used or reused there can be no intervening reclamation or recovery steps in the metal recovery. Simple phase changing of the material, such as simply remelting the metal before further use, would not be considered a reclamation or recovery step.³ Hot-dip galvanizing skimmings and dross are often sold to be directly used as a raw material for another process. An example would be the direct use of skimmings as a feedstock for mineral supplements to animals. Another example is the direct addition of the hot-dip galvanizing skimmings and dross to a process to make zinc oxide where no recovery steps are performed.

Summary

Hot-dip galvanizers incorporate waste minimization practices at their facilities to reduce the amount of both raw material use (i.e. acid, water, ammonium chloride, etc.) and byproducts that needs to be disposed by implementing reuse practices as well as finding other industries that can use these materials. Some materials are directly reused in the hot-dip galvanizing process such as using rinse solutions as make-up water in the process tanks. Other materials are often sold to other industries that can use the material as part of their process. Hot-dip galvanizing skimmings and bottom dross should not be considered as wastes but material that can be sold and directly used as a feedstock in another process. Understanding the difference between reuse and recycling is important in identifying materials and classifying them for regulatory agencies.

8 Arlington Proposed Project

Seattle Galvanizing Company, Inc. is proposing to repurpose the existing building into a spin-line galvanizing facility. This facility will have all the latest environmental technologies and automation processes in place. The address of the proposed facility is:

18520 67th Ave NE
Arlington, WA 98223

8.1 Boundaries

8.1.1 Outside

Figure 1 shows the boundaries of the proposed facility:

- No galvanized steel will be stored outside the new facility. Unless absolutely necessary to do so.
- Bare steel will enter the facility through the overhead doors.
- Bare steel may occasionally be stored outside.

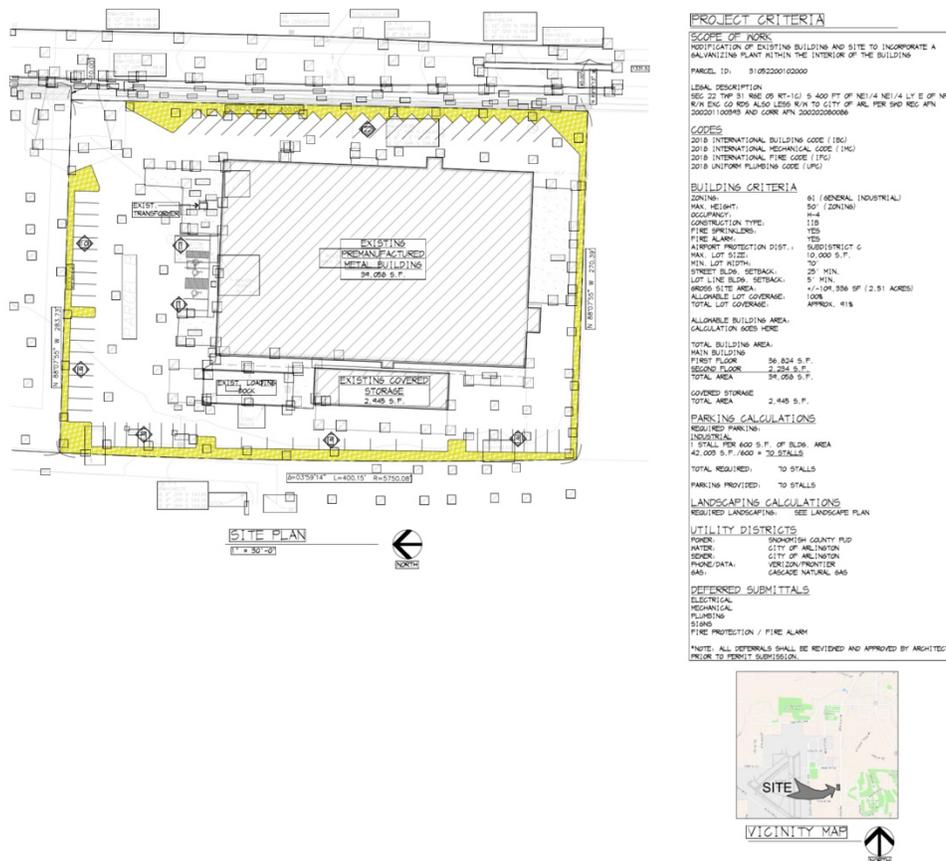
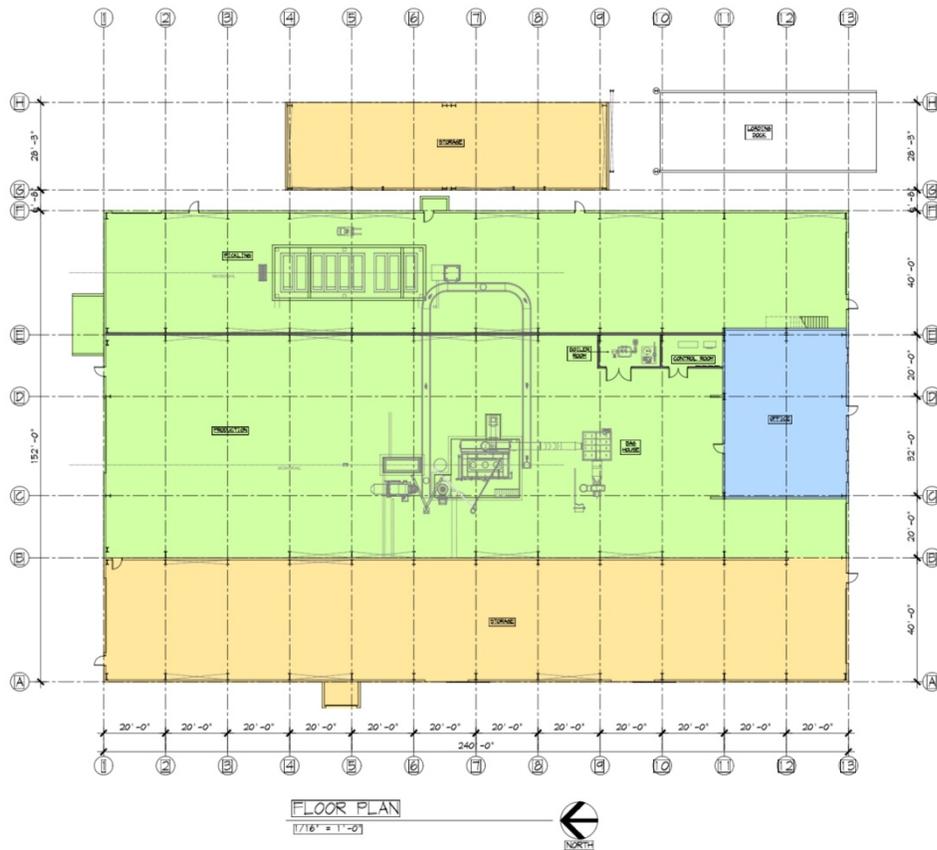


Figure 1

8.1.2 Inside

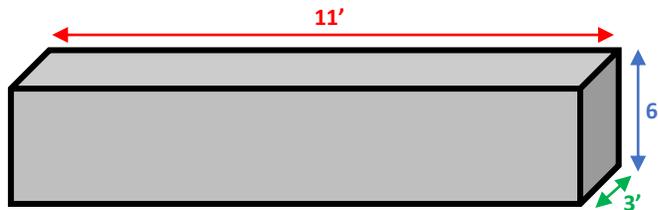
Figure 2 shows the activities and layout of what will occur inside the facility:

- East side of the facility will be dedicated to the storage and receiving of the bare steel and where the pickling tanks will be located.
- East side of the facility will be dedicated to where the galvanizing will occur.
- West side of the facility will be used to store the finished galvanized steel, packaged, and shipped.

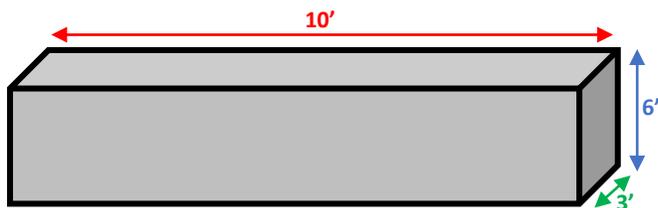


8.2 Kettle and Tank Dimensions

1. All cleaning, degreasing, and rinse tanks are:



2. Kettle (Zinc Bath) is:



8.3 Baghouse Specification

The baghouse being used for the operation is designed by Western Technologies and built by Donaldson Filtration Solutions.

Western Technologies - World renowned design and manufacturers of high quality, durable, and energy-efficient equipment for the hot-dip galvanizing industry.

Donaldson Filtration – Global leaders in the filtration industry who use the latest, innovative technologies and solutions.

8.3.1 Spin Line Pollution Control



12th January 2022

Seattle Galvanizers Spin Plant Pollution Control

1. The galvanizing fume extraction system for fume generated on the surface of the molten zinc is in the form of elevated peripheral (lip) fume extraction. The moth of the fume extraction slot has evolved of decades to efficient capture fume and the mouth of the slot is designed for optimal extraction velocity.

The rate of extraction has also evolved over decades of design. The only standard for peripheral fume extraction from galvanizing kettle is a German standard VDV 2579 and this standard requires an extraction rate of 3,500 m³/m²/hr. of kettle surface area. This equates to an extraction rate of approximately 5,800 C.F.M. From years of experience we have determined that 1,000 C.F.M. per foot of kettle length for kettles under 5'-0" wide to be more efficacious. We have proposed an extraction rate of 10,000 C.F.M.

2. Seattle Galv to supply information for chemicals used in the process.
3. There are no solvent cleaners used in the process to the best of our knowledge.
4. The only fuel burning piece of equipment in the plant is a galvanizing furnace. The furnace is a 2-burner high velocity furnace reference 3366. It has a thermal input of 2,000,000 BTU/hr. and uses natural gas.
5. The bag house manufacturer is to be determined.
6. Seattle Galv to supply information.

***Manufacturers of the Most Advanced Galvanizing
Equipment Available in the World Today!***

Western Technologies recommended using a 10,000 C.F.M motor, however, per the study above, a 6,000 C.F.M motor would have been more than sufficient. Seattle Galvanizing Company decided to go the extra mile and purchase a 15,900 C.F.M motor to ensure the capture of a higher percentage of emissions. This will exceed the professional required standards.

The manufacturer of the baghouse motor and specifications:

New York Blower
Model: C05024-100

27 SWSI Class 4 Fan
 ACF Wheel
 Arrangement 1 Belt Drive
 15,900 C.F.M
 16" WC 2,639 rpm
 50.4 BHp
 70 F 0.075#/ft3

8.3.2 Fume Analysis Pre Filter



DATA SHEET

Typical Galvanizing Fume Analysis

Size Range 30% < 1µm
 70% < 2µm
 90% < 4µm

Particulate Weight Range 20 to 70 mg/m³

Typical Composition (Dry Galvanizing):

ZnCl ₂	3.6%
ZnO	15.8%
Zn	4.9%
NH ₄ Cl	68.0%
NH ₃	1.0%
Oil	1.4% (dependent upon efficiency of degrease)
Carbon	2.8%

The weight of particulate removed by the bag filter will vary greatly depending upon the flux used and the surface area of work being galvanized. However a general guide used in the U.S., assuming 6% zinc usage would be 150g/tonne of steel galvanized. General composition as follows:

Ammonium Chloride	68.0%
Zinc Oxide	16.0%
Zinc	5.0%
Zinc Chloride	3.5%
Carbon, Water, Oil and Ammonia (combined)	7.5%

8.3.3 Fume Analysis Post Filter



Typical Fume Analysis After Filter

< 1 g/m³

Occasional 2 to 3 g/m³

30% Zn CL by weight

2% Fe CL

Remainder NH₃CL (ammonium chloride)