Final Report

Sacramento County Sanitation District No. 1

Generation of Toxicants from the Manufacture, Use, and Disposal of Piping Materials

Vitrified Clay Pipe (VCP) and Polyvinyl Chloride (PVC):

A Comparison

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Introduction

The Sacramento County Sanitation District No. 1 (CSD-1) is considering revising the engineering design standards in its new trunk sewer design manual to include allowed use of polyvinyl chloride (PVC) sewer pipes. Historically, CSD-1 has specified exclusive use of vitrified clay pipe (VCP) for small diameter sewer piping applications. Inclusion of PVC pipe is being considered to allow designer selection of the piping material best suited for each application and to limit market restrictions that can be caused by reliance on one type of piping material.

Prior to including a new piping material into its infrastructure design standards, CSD-1 staff felt it prudent to investigate issues related to PVC piping manufacture and use. Those issues are:

1. Engineering sustainability of PVC pipe in sanitary sewer applications.
2. Comparison of energy requirements to manufacture VCP and PVC pipe.
3. Generation of toxicants in the manufacture, use, and destruction of VCP and PVC pipe.

CSD-1 staff contracted with the Office of Water Programs, California State University, Sacramento to conduct an independent literature study of the three issues listed above. The report describing the results of the study of the generation of toxicants from the manufacture, use, and disposal of VCP and PVC sewer piping follows.

Background

The creation, use, and disposal of all manufactured products impacts the environment in some manner. Through the years, we have learned to identify processes that have significant negative environmental and health impacts and have endeavored to modify those processes to minimize the impacts or have developed substitute products. Societal pressures often influence the efforts to reduce environmental and health risks associated with manufactured products. One of the ways society exerts pressure is through selective purchasing policies toward "environmentally friendly" products and away from products determined to have negative health and environmental impacts. It is in this spirit that CSD-1 requested evaluation of a literature study of toxicant generation caused by the manufacture, use, and disposal of VCP and PVC sewer pipe.

Evaluation of Literature

Working with the trade organizations for piping materials manufacturers, CSD-1 staff identified the need to study the generation of toxicants resulting from the manufacture, use, and disposal of both VCP and PVC pipe. Specifically, the toxicants of concern are dioxins and furans associated with PVC and crystalline silica associated with VCP. This report is a summary and analysis of information in published literature about the risks associated with exposure to dioxins, furans, and crystalline silica and about the risk of releasing those toxicants through use of VCP and PVC piping products.

Silica - Silica is composed of silicon and oxygen, the two most abundant elements in the Earth's crust (Burgess, 1998). As expected, silica is a very common, naturally occurring material. Undisturbed, silica presents no human health hazard. However, when crushed, silica particles become airborne. Airborne silica presents a significant inhalation health hazard, one that is responsible for hundreds of deaths per year (Krizan, 2000).

Silica is commonly crushed during mining and earthwork processes and during the manufacture of products using earthen materials, including vitrified clay pipe. Raw material clay for VCP manufacture is mined and transported to factories. At the factories the material is crushed, ground and graded prior to being hydrated and formed into piping products. The "green" pipes are next fired in high temperature kilns to vitrify the exposed pipe surfaces, which gives the piping strength and durability. All of the described manufacturing-related processes have the potential for release of silica to the environment (Burgess, 1998).

Finished pipe is transported to job sites where it is installed underground. Although the potential for silica release from finished pipe is extremely low, job site cutting of VCP releases silica to the environment (Krizan, 2000). At the end of a pipe's useful life, the potential exists for it to be excavated from the ground and broken and crushed as part of removal and disposal operations. Pipe breaking and crushing creates the potential for silica release.

The greatest health risk associated with airborne silica is contraction of silicosis, a scarring of the lungs, which creates a barrier to oxygen transfer from the lungs to the bloodstream (Heivilin et al., 1996). Silicosis is caused by inhalation of crystalline silica. Heart disease is a companion health problem associated with silicosis. Heart disease can result when silicosis destroys pulmonary blood vessels, creating backpressure on the right ventricle of the heart (Krizan, 2000).

Some in the health field also attribute cancer to silicosis. In 1996, the International Agency for Research on Cancer concluded there was sufficient evidence that certain types of silica act as carcinogens (Heivilin et al., 1996). That decision and the question of whether silica is a carcinogen are controversial in the medical and industrial health fields. However, the link between silica inhalation and contraction of silicosis is well documented and widely accepted.

Dioxin and Furan – Dioxins and furans are organic molecules associated with chlorinated organic materials, including PVC. Resins used in the manufacture of PVC are produced by chlorinating heated organic chemical mixtures. Further chlorination of the resins is used to form the polyvinyl chloride used to manufacture PVC pipes. Dioxins and furans can be inadvertently produced during the production of PVC.

Transportation of finished PVC pipe and installation processes at the job site present no potential for dioxin release, unless the PVC is burned in a fire. It is the burning of PVC that presents the greatest potential for dioxin and furan release to the environment (Meharg et al., 1997). Therefore, safe disposal options must be considered when PVC pipe reaches the end of its useful life. Whereas crushing and landfilling present no dioxin or furan release risk, incineration has the potential for significant dioxin and furan release.

Discussion

It is clear that toxicants are associated with both VCP and PVC pipe products. The toxicants present health risks for those exposed. In evaluating the risk associated with specifying the use of each product, it is necessary to assess the probability of exposure to the respective toxicants. Three activities will be assessed: manufacturing, use, and disposal.

Manufacturing - Clay pipe manufacturing has been practiced in the U.S. for over 100 years. Industrial health risk to workers exposed to airborne crystalline silica associated with clay mining and pipe manufacturing are well documented (Burgess, 1998). Risk minimization for these workers is the responsibility of OSHA and the clay pipe manufacturers because the risk occurs in industrial workplaces. Significant improvements have been made through the years to reduce worker risk through administrative and engineering controls of silica dust and through use of improved personal respirator devices. Risk to the general public from the pipe manufacturing process is minimal because of remote siting of manufacturing facilities relative to where people work, play, and live. The risk of silica exposure to the public from occasional travel past clay mining and clay pipe manufacturing facilities is comparable to occasional travel past road construction, excavation, or mining operations, all of which generate airborne silica.

In an extensive study of three chlorinated organic material manufacturing industries in North America, including PVC, Carroll et al. (1998) determined that significantly less that one percent of the estimated dioxin releases in the U.S. result from the studied industries and none from PVC manufacture. The study included all 28 manufacturing facilities in Canada and the U.S. that produce the studied chlorinated organic materials.

Because dioxin is a suspected carcinogen, environmental regulations prohibit its release to the environment. Manufacturers have installed controls to eliminate dioxin releases in response to the requirements.

<u>Use</u> – Transportation to the jobsite, installation of the pipe, and pipe utilization for conveying sewage constitute the use category for this report. For both VCP and PVC pipe, transportation to the jobsite presents no risk for exposure to toxicants, unless a traffic accident occurs involving the vehicle transporting the pipe materials. For VCP, an accident could result in pipe breakage and silica dust generation. For PVC, an accident involving a fire where the pipe burned could produce dioxin release. Both scenarios have an extremely low probability and present a much lower risk than exposure to other materials that are transported on our highway and rail systems every day.

There is no dioxin exposure risk associated with installation of PVC pipe, but a risk of silica exposure can occur when installing clay pipe. Pipe cutting is a common jobsite activity during pipe installation. Cutting clay pipe using a dry sawing method generates dust, which includes crystalline silica. Trends in the industry are toward use of wet sawing techniques to minimize dust generation, but dry sawing still occurs. Cutting PVC pipe presents no dioxin release potential.

Pipe utilization constitutes, by far, the longest duration activity of all those evaluated and discussed in this report. The piping materials are expected to remain serviceable for 50 to 100 years. During this activity, neither pipe material is expected to release toxicants to the environment. Both materials are highly resistant to physical or chemical breakdown and are physically isolated underground.

<u>Disposal</u> – Sewer pipes are expected to remain serviceable for 50 to 100 years. At the end of their expected service life, pipes must be replaced to continue providing sewer service to customers. Historically, replacement meant digging up old pipes and replacing them with new, which required disposal of the old pipes. Current trends are to rehabilitate old pipes in place by slip lining or using trenchless technology replacement techniques, which leaves old pipes in place. Although current trends point toward reduced pipe disposal requirements, it is prudent to assume that some pipe disposal will always be required.

Disposal of clay pipe presents the opportunity for release of silica if old pipe is broken and crushed during the removal and disposal processes. Care will have to be exercised to minimize silica dust generation. Disposal of PVC pipe presents no dioxin problem, unless the pipe is incinerated. Incineration can cause significant generation of dioxins and furans (Meharg, et al., 1997) and must therefore be avoided.

Conclusions

1. Crystalline silica presents a significant inhalation health hazard. It can cause silicosis, a debilitating and sometimes fatal lung disease. Crystalline silica is generated in the raw material acquisition and pipe manufacturing processes of vitrified clay pipe. It can also be generated by cutting clay pipe using dry saw techniques and by breakage and crushing during transportation and disposal.
2. Dioxins and furans are suspected human carcinogens. Dioxin and furan generation can occur when PVC pipe is burned. Therefore, incineration is not an option for disposal of PVC pipe.
3. Both pipe materials, vitrified clay and PVC, have the potential to produce toxicants. The risk of these toxicants causing health problems in people outside of the pipe manufacturing industries is remote. The risk associated with specifying and using either pipe product is low and should not present an impediment to specification of either pipe product for use in sewage collection service.

References

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