Local Exhaust Ventilation in Large Confined Spaces

Chessor E
School of Occupational and Environmental Hygiene, University of British Columbia, Vancouver, BC, Canada

Introduction

In North America, there is an ongoing effort to repair the effects of corrosion in large boilers and pressure vessels. In recent years this work has been done from scaffolds erected in the boiler or vessel. The largest pressure vessels in British Columbia are known as Kamyr Digesters, and are found in Kraft pulp mills. The boilers are found in pulp mills across Canada and the USA, and in thermal power plants in east of the Rocky Mountains in Canada and across the USA.

The scaffold structures are made up from 50 mm diameter steel columns and struts that are assembled with steel wedges. The length of these components and their fitting dimensions are standardized across North America. All the scaffold components can be moved into the space through a 500 mm diameter manhole, and assembled without mechanical aids.

The processes involved in corrosion repair work include abrasive blasting, air-carbon arc gouging, grinding, welding and metal spraying. All these processes generate substantial quantities of toxic air pollution. Typically workers have been protected from the air contaminants by air supplied respirators and general ventilation.

Ventilation System Development

The Kamyr digesters in BC range from 4 to 8.5 meters (13 to 27) feet in diameter, and 45 to 60 meters (150 to 200 feet) in height. They are made of stainless steel 100 to 130 mm thick. In a Kamyr digester the openings available for ventilation and access may be limited to two manholes each 500 mm or 20 inches in diameter. Some digesters have manholes at the top and bottom, and one near the middle. There are bolted flanges at the top and bottom which are about 1.5 meters in diameter. These may also be opened to allow mechanical repairs, and to improve access and ventilation.

When relying on general ventilation, workers often experience concentrations of metal fume and dust that limit visibility to 2 or 3 meters. This smog increases the incidence of injury, and slows the work. Workers' clothing gets very dirty from the settling particulate. People involved with this repair work have realized for many years that there would be significant advantages to controlling air pollutants at source. In 1991, a welder who had some experience with source control ventilation in a shipyard was working in a Kamyr digester. He got into a discussion about the smog with another welder, and described the ventilation system in the shipyard. The other welder was Keith Ferlin, and the conversation inspired him. Why not, he thought, build a source control ventilation system for Kamyr digesters. He began discussing the possibility with friends and potential clients. Long time friend and welder Morris Kemps became a business partner.

The engineers who organized repair work in digesters set out the specifications for a source control ventilation system. It would need to control fume from any point on the inside wall of the vessel. Installation and removal would need to be accomplished in a few hours each. It should be powered by compressed air. The cost would need to be offset by production gains, so the system would need to control fume from at least a dozen welders, to reduce downtime.

Design and Testing

Starting from that, and what they had learned about the shipyard system, they sketched up a system of ducts and hoods. They realized they would need some engineering assistance, and went hunting. They ended up in the engineering section of the Workers' Compensation Board, in Richmond, BC. Most of the dimensions on their sketches were changed, and details were added. Around this time they connected with a long-time friend who had recently completed a computer aided drafting course. They put him to work drawing a digester with a full height scaffold in it.

Keith and Morris worked out detailed hood designs, and invested some of their own dollars in having them built. At the same time, they worked out the details of a duct system that could be moved into a digester through the manholes and assembled in a few hours. It could provide up to 600 cfm of air flow from hoods located anywhere on the walls of a vessel, and a total air flow of 10,000 cfm.

The next step was to test the hoods with an air-arc gouger. The results were very encouraging, and they were ready to show their prototype to prospective investors. They targeted scaffold rental companies, because they had designed a duct system that would mount quickly and easily on the scaffold systems used in digesters. A deal was struck with a firm in Prince George, and they arranged to have a complete duct and hood system built. By May 1996 they had a complete system stretched out across the ground, and a compressor connected to the air movers. A hood was installed on a large steel plate, and a welder went to work with a gouger. Several staff from local pulp mills watched the demonstration, and were suitably impressed.

System Deployment

Some of the observers at that demonstration were from Northwood Pulp, and had been considering the use of local exhaust in their digesters for over a year. The "B" digester at Northwood was shut down the following week, and the ventilation system was installed with the scaffold. Relatively small amounts of gouging and welding work were done, but the ventilation system was seen to control fume well. Later that year the ventilation system was used in a digester at Mackenzie BC, and in the "A" digester at Northwood.

Still and video pictures of the demonstrations went to the 1996 annual meeting of the Boilermakers Union.

The partnership between the inventors and the first scaffold company ended in 1997, and a licensing agreement was reached with a larger scaffold company in 1998. They have promoted the system across North America. It has been used successfully in a lead smelter furnace and several coal fired utility plant boilers. Those projects involved abrasive blasting, and the system was used to contain the dust from that. This was achieved by constructing plywood enclosures to isolate the area, and exhausting 8000 cfm or more to an air cleaning device. The enclosures were kept small, so the ventilation system was able to change the air in less than a minute. Thick clouds of dust developed in the enclosures, but they were cleared in a few minutes. After abrasive blasting, the boiler walls had new metal applied by overlay welding or metal spraying. The ventilation system prevented any buildup of visible fume cloud from those processes.

Both scaffold companies continue to serve pulp mills in BC. The first is no longer using air powered air movers. Several pulp mills in BC have installed centrifugal fans with electric motors at the top of their digesters, and connect the local exhaust system duct to them. The scaffold company has a centrifugal fan they take with them to other mills.
This eliminates the need for air powered air movers, and the cost of renting and operating a compressor for the ventilation system.