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Technical Aspects and Benefits of Small Scale Hydrolasing Compared to Conventional Decontamination Methods

Pat Fisher

TMR Associates, LLC, 11575 West 13th Avenue, Lakewood, CO 80215, pfisher@tmrassociates.org

Joel Kohler

Washington Group International, 7800 East Union Avenue, Denver, CO 80237, jkohler173@aol.com

Abstract *– Conventional hydrolasing (water blasting at high pressure) has been employed throughout the decommissioning and decontamination industry to decontaminate radioactive surfaces for a number of years. It has traditionally been viewed as a technology reserved for difficult, labor-intense projects that could not be accomplished by other technology.*

Perhaps one of the most significant drawbacks to conventional hydrolasing has been that it traditionally generated large quantities of wastewater, which required expensive secondary waste handling.

Dry decontamination methods, such as shaving and scabbling, can be simple, effective methods of decontamination for concrete floors, but they meet with limited success in vertical and overhead applications.

Other methods, such as chemical peeling, can work well on steel surfaces, but meet with limited success on porous surfaces, such as concrete.

It has now been demonstrated, through a real-world application, that small-scale hydrolasing can be effectively deployed for structural decontamination projects of only a few thousand square feet. Additionally, it is far superior for decontaminating vertical and overhead surfaces. By incorporating a proven small-scale water recycling system with the proprietary hydrolasing and waste recovery technology developed by TMR Associates, L.L.C., small-scale hydrolasing is a better alternative than baseline technologies.

I. INTRODUCTION

I.A. Small-Scale Hydrolasing is Safe and Effective

TMR Associates, L.L.C., (TMR) has designed and implemented a small-scale hydrolasing application that effectively decontaminates horizontal, vertical, overhead, and irregularly-shaped surfaces to free release standards. It works well for thin and thick coatings, on a variety of surfaces.

The application further improves the effectiveness of hydrolasing by joining it with waste recovery and separation, along with wastewater treatment and recycling.

I.B. Baseline Technologies Lack Versatility

Decontaminating vertical and overhead surfaces is very difficult. Dry technologies, such as scabbling and shaving, can be effective methods of decontamination for open concrete floor areas, but they meet with limited success in vertical and overhead applications.

Chemical peeling can work well on steel surfaces but meets with limited success on porous surfaces.

Conventional hydrolasing equipment, including handheld lances and walk-behind floor machines, also meets with limited success when applied to vertical and overhead surfaces. Handheld lances might be used, but not easily. A handheld lance generates over 265 N (60 pounds) of back thrust when operating at 250 MPa (36,000 psi), and offers no vacuum recovery of the waste stream. Even in the hands of the most capable worker, such a tool is physically demanding to use, and therefore has limited production capabilities. Walk-behind floor machines are effective and less labor intense, but like dry floor shaver systems, they are limited to open floor areas.

Perhaps the greatest obstacle to utilizing conventional hydrolasing as a decontamination technology can be summed up in one word: wastewater. Hydrolasing systems blast targeted surfaces with water at pressures up to 275 MPa (40,000 psi) and generally use between 15 and 45 liters (4 and 12 gallons) of water per minute. The volume of radioactively contaminated wastewater generated can prove both difficult and expensive to handle. Additionally, many sites do not have adequate fresh water supplies available to support hydrolasing, requiring that a supply of water be trucked in, adding more cost and complexity to the project. Because of these complications, hydrolasing is often viewed as a technology of last resort, reserved for large projects that cannot be decontaminated using more conventional means.

However, the VAC TRAX® system is a fully integrated small-scale hydrolasing system. The remainder of this document will address the application of various other decontamination methods, discuss how a fully integrated small-scale hydrolasing system worked in its most recent application, and describe the results of that application.

II. OVERVIEW OF OTHER DECONTAMINATION TECHNOLOGIES

The typical room to be decontaminated presents the decommissioning manager with a variety of surface conditions:

- Open floor areas
- Vertical surfaces – walls and columns
- High overhead surfaces – various ceiling and beam configurations
- Corners and edges
- Surfaces coated with various thicknesses of paint, fixative, or fire-retardant coatings

Traditionally, a variety of technologies have been required for a single project.

In some cases, decontamination was deemed too complicated or expensive, and simply not performed. Whole buildings were then disposed of as contaminated waste.

II.A. Dry Decontamination Technologies

Shavers and scabblers are the core dry decontamination technologies. There are advantages and disadvantages to each.

Shavers are used primarily in open floor areas. They will effectively remove a uniform layer of surface by milling it. Typically, the shaver is an electrically powered tool that employs a rotating drum and a series of blades that are spaced closely to remove a consistent layer of material. A vacuum recovery system can be integrated, to collect the shaving debris and control dust.

The advantages of shaving technology are that it leaves behind a relatively smooth and uniform surface, while creating a minimal volume of waste.

Some disadvantages of shaving technology are demonstrated when thick coatings or deeper layers of contamination are involved. Shavers remove more surface material by making repeated passes over the same area, effectively multiplying the time necessary to complete the work. Some coatings, such as thick epoxies and certain fixatives, become gummy when heated by the rotating shaver blades. The coatings then stick to the blades and drum, causing equipment failure.

The shaver is self-propelled and operated by a worker, who walks behind the machine to guide it. The worker must take care to avoid protrusions in the floor's surface that can damage the blades, and to avoid damage to the machine's 460 VAC electric power supply.

The technology is most effective for smooth surfaces, and thin coatings.

For the perimeter of the floor, smaller scabbling machines can be used. Scabbling technology is based on a series of impact heads that literally beat the target surface, breaking it up and chipping it away. Some scabbling tools also work in conjunction with vacuum recovery systems, to control dust and debris.

Generally, floor scabblers are slower than shavers, and remove less depth of surface material. They are operated similar to shavers and may be powered by compressed air or electricity.

Recently, a wall shaving system was developed that will shave flat wall surfaces in square or rectangular configurations within a few feet of floor level. However, it cannot be deployed on overhead or angular surfaces, such as columns and beams.

The most common dry method for decontaminating walls, overhead areas, and angular surfaces (such as columns, beams, and ledges) is for workers deployed from scaffolding, man-lifts, and ladders to use handheld shavers and scabblers.

Such handheld equipment can be very useful for decontaminating random spots of just a few square feet. For example, during final survey these technologies are a convenient way to decontaminate small areas that fail to meet the predetermined decontamination parameters. They can be deployed quickly, and the area can immediately be resurveyed.

However for larger areas, such technologies are very labor intense, and present a number of health and safety concerns, such as working from elevated platforms, repetitive motion stress injuries, and possible damage to electric power sources.

With few exceptions, dry technology does not offer remote operation capabilities, making it less desirable for decontamination of highly contaminated areas.

II.B. Chemical Peel Technology

In recent years a number of chemical processes have been developed to remove contamination from surfaces. Most are multiple-step processes that involve spraying or painting the chemicals over the target surface, then allowing them to cure for varying lengths of time, ranging from a few hours to several days. Once the solution has cured, it is stripped from the surface by peeling, scraping, or washing. The target surface can then be surveyed, and the process repeated as needed.

This technology has met with significant success in the decontamination of metal surfaces, such as equipment and glove boxes. To date it has worked less successfully on porous surfaces, such as concrete, where contamination may have penetrated beyond the surface layer.

The most significant advantage to chemical peel technology is that, by successfully decontaminating equipment or glove boxes, the items do not require size reduction for disposal.

The greatest drawback is that it may fail to remove the contamination.

II.C. Conventional Hydrolasing

Conventional hydrolasing has traditionally been reserved for difficult projects. These projects are not only floors, but also high walls, ceilings, columns, and any variety of irregularly shaped surfaces, that have required decontamination. The high-pressure lance can access difficult areas more quickly and more effectively than other technologies.

The drawbacks to high-pressure lance or open-wand hydrolasing are similar to those encountered with handheld dry technologies. It is very labor intense, requiring workers to be deployed from elevated surfaces, and having a high risk of repetitive motion stress injuries. Although high voltage electricity is not used and is therefore not a safety factor, there are risks of high-pressure water injuries.

The greatest disadvantage of conventional hydrolasing is the large quantity of secondary waste created by the water used. The disposal of wastewater is expensive. It first must be collected, by vacuuming the water and debris into containers. Next, it may be filtered, allowing the solids to be further processed, and dried or solidified for disposal. The remaining water can then be treated or solidified for disposal. Alternately, the waste stream is not filtered, and the water is allowed to evaporate before packaging the debris for disposal.

III. SMALL SCALE HYDROLASING WITH WATER RECYCLING

In a project recently completed at the Rocky Flats Environmental Technology Site (RFETS), TMR addressed three key hydrolasing technology issues:

- Remote operation of hydrolasing equipment
- Collection and separation of the hydrolasing waste stream
- Treatment and recycling of the wastewater

III.A. Remote Operation of Hydrolasing Equipment

TMR first deployed remote operated hydrolasing technology in 1999. The most recent generation of VAC TRAX® technology includes a variety of hydrolasing heads that are deployed from several types of Mobile Access Platforms (MAPS). Together, they are used to remove coatings and layers of concrete from flat, vertical, overhead, and irregularly shaped surfaces.

The VAC TRAX® hydrolasing heads can be configured to spray wide patterns, up to 23 cm (9 inches) in diameter, to remove thin coatings or shallow layers of concrete. Other heads are used to concentrate the cleaning pattern to a smaller area, used for example in decontaminating the perimeter of a surface, or in concentrating waterpower when deep penetration of the surface is necessary to remove contamination.

MAP units move the hydrolasing head over the target surface. They are built to accommodate specific job conditions. For example, Figure 1 shows a column machine capable of deploying two hydrolasing heads, allowing two sides of the column to be decontaminated at the same time. To follow the surface contours, the arms are held by variable tension against the column.

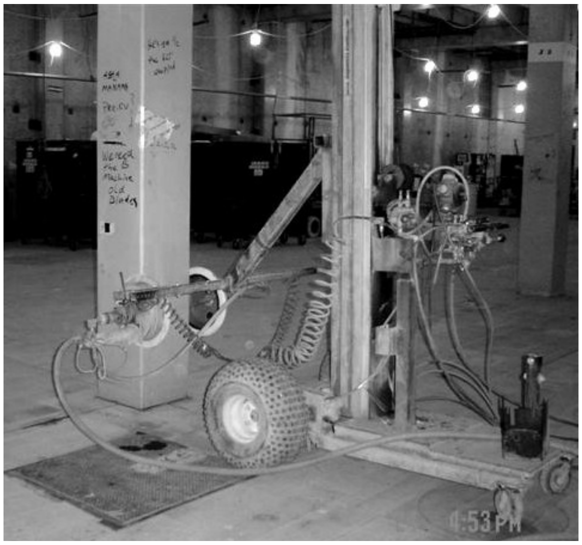

Figure 1. TMR Double-Headed Column Cleaner

Figure 2 shows a MAP deploying two hydrolasing heads, which decontaminate two surfaces of a ceiling and beam at the same time. The spray patterns of the hydrolasing heads overlap slightly, to offer maximum coverage of both surfaces.

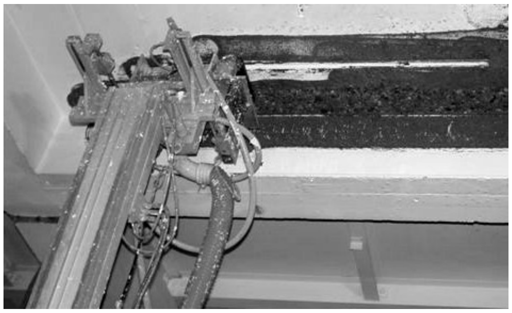

Figure 2. TMR Beam and Ceiling Cleaner

Other MAPS are used to convey hydrolasing heads over walls, floors, corners, edges and so on. All MAP units are powered and controlled pneumatically, with no high voltage electricity required. By allowing hydrolasing heads and MAP units to be configured in multiple ways, wide ranges of surface types are decontaminated. Since the equipment is pneumatic, and not electric, workers can easily change equipment to meet the needs of the job.

An operator riding on the MAP and controlling all functions from an onboard control panel can operate any of the MAPs locally. However, for many decontamination projects, contamination levels make it difficult or impossible for a worker to be in close proximity to the area for prolonged periods.

For areas of high contamination, all MAPs can be operated remotely. The control console can be located within visual range of the equipment, or by installing remote cameras the worker can control the equipment from another location.

Figure 3. TMR Locally Operated Ceiling Unit

AT RFETS, the VAC TRAX® MAP technology allowed workers to decontaminate walls and ceilings from the floor, without scaffolding or man-lifts. Figure 3 shows a locally operated VAC TRAX® decontaminating a 5.5 meter (18-foot) high ceiling. Figure 4 shows a remotely operated VAC TRAX® with an articulating hydrolasing head as it reaches in to clean an otherwise inaccessible ledge.

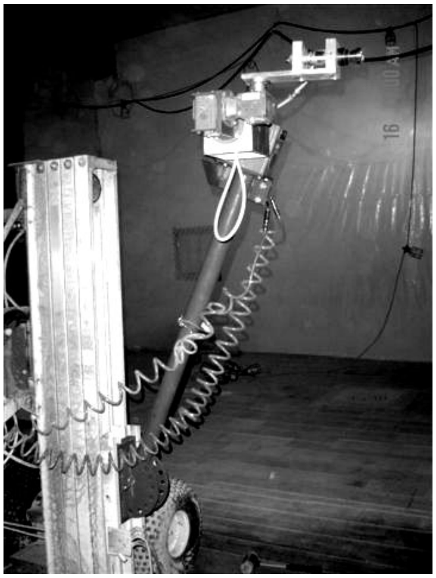

Figure 4. Remote Operated VAC TRAX® with Articulating Head

III.B. Collection and Separation of the Hydrolasing Waste Stream

TMR has upgraded its earlier waste collection and separation technology to the patent-pending Waste Stream Separator (WSS) system. The WSS, as seen in Figure 5, is a multiple part system. A pneumatically operated Venturi provides the vacuum source to draw the hydrolasing wastewater and debris into specially fitted dual waste drums. Previous generations of the WSS employed electric vacuum sources that posed significant safety risks. By eliminating high voltage electricity from the system, the WSS became safer and easier to maintain.

The solid waste is drawn into one of two 208-liter (55-gallon) drums, where it is further separated from the wastewater by a patent-pending liner. When the drum is full of solids, it is removed and replaced. The full drum can then be set aside, to allow remaining liquid to settle out. The drum is then re-pumped, and drying agent is added to ensure that no free liquids remain. The client’s waste inspectors then inspect, survey, and test the drum to verify that no free liquids remain, and that it meets all shipping criteria. Over the life of the project, 30 drums of waste were generated while hydrolasing about 4,100 square meters (44,000 square feet) of surface. No drums required repacking and no drums failed to meet waste disposal or shipping criteria.

All wastewater is then sent to the water recycling system.

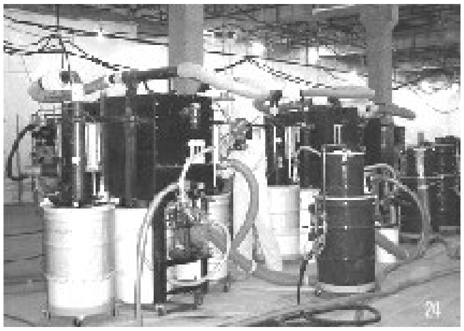

Figure 5. WSS Systems at RFETS

III.C. Treatment and Recycling of Wastewater

The disposal of wastewater has traditionally been one of the greatest challenges faced by users of conventional hydrolasing technology. Recycling of the wastewater is a relatively new phenomenon, thought to require large, complex water treatment systems that would be impractical for small projects. For the project at RFETS, TMR used small-scale, readily available components to maintain a supply of clean water for hydrolasing. The system shown in Figure 6 proved to be more than adequate, and very cost effective. By using a series of settling tanks, filters, resin beds, and limited use of a small Reverse Osmosis (RO) unit, TMR was able to maintain a consistent supply of clean water.

Figure 6. Wastewater Treatment System

III.D. Integrating the Component Technologies

The major components of the hydrolasing system used for the RFETS project are summarized in Table 1.

The ultra-high pressure (UHP) water pumps used were of two capacities. The smaller pump produced water flow of 23 liters per minute (lpm) (6 gallons per minute (gpm)) at up to 250 MPa (36,000 psi). The larger also worked at pressures up to 250 MPa (36,000 psi), and produced water flow of 46 lpm (12 gpm). Both pumps maintain relatively constant flow rates while allowing the operator to vary the pressure as needed. Generally, water pressures between 195 MPa (28,000 psi) and 220 MPa (32,000 psi) were used. The pumps were staged outside the contamination area, for ease of maintenance, and to ensure they would be free released at the end of the project.

The pressurized water was fed to the hydrolasing tools inside the contamination area through a combination of stainless steel tubing and UHP hoses.

A variety of hydrolasing tools were deployed, as previously described. Most VAC TRAX® are enclosed, or shrouded, and include vacuum recovery. However some of the smaller hydrolasing heads are not enclosed, such as the articulating ledge cleaner in Figure 4. In this case, or when it was necessary to use an open lance, the waste stream was instead vacuumed from the floor surface.

Table I. Hydrolasing Equipment

Component	**Description**	**Rating**	**Power Source**
Pump	Ultra high-pressure tri-plex pump	250 MPa, (36,000 psi) 23 or 46 lpm (6 or 12 gpm)	460 VAC electric, 139 or 279 amps
VAC TRAX	Hydrolasing head, MAP, control console	N/A	Pneumatic, 860 kPa (125 psi), 2.8 m^3/min (100 cfm)
WSS	Includes Venturi vacuum source and waste separation system	Vacuum 0.35 m^3/s (750 cfm) flow @ 27 kPa (8” Hg) vacuum	Pneumatic, 860 kPa (125 psi), 2.8 m^3/min (100 cfm)
Water Recycling	Holding tanks, filters, resin beds, RO	17,000 liter (4,500 gallons) capacity, 5,700 liters (1,500 gallons) per day	110 VAC electric; pneumatic, 2.8 m^3/min (100 cfm)

The debris and wastewater was retrieved through a 7.6 cm (3 inch) vacuum hose attached directly to the WSS. The redesigned WSS, with two receiving drums, was able to alternate waste separation activities from one drum to the other. This allowed work to continue by filling the second drum while the first drum was serviced or replaced. The WSS drums provided gross filtration of the wastewater to 800 microns. The remaining wastewater was then sent to the water treatment system for further processing and recycling.

The first step in the wastewater recycling system was to pump it from the WSS to settling tanks, where it remained undisturbed for up to 24 hours. The clear water was then pumped off and sent through a series of cartridge filters, and ion exchange resin beds. The water was then sent to a holding tank where it was tested by client personnel. To be reused, the water could not have any detectable levels of plutonium (Pu). It also had to be of neutral pH, have total dissolved solids (TDS) of less than 25 parts per million, and conductivity of less than 25 micro mho. No batches were rejected. Had any batch failed it could have been reprocessed or further polished in the RO unit. The clean water was then sent to a holding tank that fed the UHP pumps. Due to evaporation, and small quantities of water remaining in the waste drums and settling tanks, it was periodically necessary to add additional water to maintain sufficient operating quantities. Toward the end of the project, make up water was not added, thus decreasing the volume of water that remained upon completion.

III.E. Manpower Requirements

While the changes TMR made in each of the three technology areas were significant, the first key to better job performance was the *integration* of the technologies.

The second key was a properly trained workforce.

It is very popular today to refer to a work crew as a “team,” and to encourage “teamwork.” For a hydrolasing project to be successful, it is imperative that the crewmembers really do work as a close-knit team. Each person is responsible for a link in the hydrolasing system chain, and if one link fails the whole chain fails. TMR now mandates 40 hours of classroom training before an operator is allowed to work on a crew as an Operator I. Classroom training includes coursework in UHP water safety, equipment design, operation, and maintenance, hydrolasing procedures, radio communications and protocol, and hands-on equipment training. The operator then receives additional on-the-job training to become a fully qualified Operator II in each area of hydrolasing operations.

A single crew is composed of 5 people:

- Pump operator
- VAC TRAX® operator
- WSS operator
- Water treatment system operator
- Relief operator or helper

When multiple hydrolasing units are in use simultaneously, a single pump operator can monitor up to four pumps. A single WSS operator can monitor two WSS units. One water treatment system operator can control the water supply for four hydrolasers.

For the recently completed RFETS project, normal staffing for two teams on two shifts was sixteen crewmembers, including working foremen, a craft superintendent, and a maintenance mechanic.

IV. EVALUATION

The project described in this document was the structural decontamination of Building 707 at RFETS.

The hydrolasing work performed included removing paint and epoxy from:

- Over 650 square meters (7,000 square feet) of walls, 4.25–5.5 meters (14-18 feet) high.
- Over 3,250 square meters (35,000 square feet) of ceiling. The ceiling was twin-tee concrete with 0.5 meter (18 inch) webbing every 1.2 meters (4 feet).
- 35 concrete columns, as shown in Figure 7.
- Other miscellaneous structures, such as the pit in Figure 8 and the ledge in Figure 4, were also hydrolased.

Figure 7. Hydrolased Concrete Columns

IV.A. Decontamination and Waste Generation

Before hydrolasing, contamination levels were as much as 5,000 dpm/100 cm^2. The free release requirements were 20 dpm/100 cm^2 loose and 100 dpm/100 cm^2 fixed. All hydrolased areas were free released.

The 30 208-liter (55-gallon) drums of solid waste generated were sent to the Nevada Test Site for burial. The shipping required that the drums could contain no free liquids, under SCO 1.

The recycling system worked with total water volume of 17,000 liters (4,500 gallons). Over the course of the job, about 220,000 liters (58,000 gallons) of water were recycled to hydrolase about 4,100 square meters (44,000 square feet) of surface area. At the end of the project the 11,300 liters (3,000 gallons) of water remaining were sent through the RO unit, before returning to the client for disposal.

The 11,300 liters (3,000 gallons) of water that remained in the water treatment system at the end of the project could have been used for dust suppression. However for reasons not related to water quality, they were sent to the on-site water treatment facility that was authorized to accept water with less than 50 Pico curies of Pu per liter.

IV.B. Other Problems Encountered

It is not always possible to know how deep the surface coating is, or what lies beneath it. Hard surfaces, such as epoxy paint, require high water pressure and narrowly focused hydrolasing heads to penetrate through the outer surface. However, if the structural materials underneath are inconsistent, the hydrolasing tool can easily remove too much material from a soft area. For example, if a pipe was removed from a concrete wall, the resulting hole might be filled in with grout, and then painted over with epoxy paint. When the surface is hydrolased the hydrolaser will remove the paint and only a small amount of concrete wall; but when the hydrolyser passes over the grouted surface it can remove 5 cm (2 inches) or more of the softer material.

Extra care must be exercised when hydrolasing concrete block walls, to avoid removing excessive amounts of grout from between the blocks. By changing the angle of the water jets in the hydrolasing head, TMR was able to successfully remove the contaminated surface of concrete block walls while leaving most of the grout in place.

IV.C. Safety

TMR experienced no significant safety problems during the life of the project.

Hydrolasing can be one of the most dangerous activities on a job site. Ultra-high pressure water injuries can be fatal. By using VAC TRAX® technology the workers were kept at a safe distance from the hydrolasing heads. By operating VAC TRAX® from remote or onboard control consoles, and eliminating as much open-lance hydrolasing as possible, the risks of repetitive motion stress injury and heat stress were reduced. By upgrading the vacuum system in the WSS from a 460 VAC blower unit to an air operated Venturi unit, and eliminating the potentially deadly combination of high voltage electricity and water, a significant job hazard was eliminated. By providing extensive pre-job training and establishing clear communications protocols, workers became more confident. As workers became more confident in their abilities, and more clearly understood their roles and responsibilities, the benefits to the project were clear. With fewer mistakes made, there was less broken equipment, less down time, and a safer workplace. When considered all together, the same circumstances that create a safe working environment also provide a more productive work environment.

Figure 8. Hydrolased Pit

V. CONCLUSION

Small-scale hydrolasing, combined with a proven small-scale water recycling system, successfully decontaminated walls, ceilings, beams, columns, and other irregularly shaped surfaces to meet free release requirements. The solid waste was separated into ready-to-ship 208-liter (55-gallon) drums. The liquid waste was recycled through an efficient, reliable recycling system. TMR’s hydrolasing technology worked safely, without creating large volumes of secondary waste.

Small-scale hydrolasing has proven to be a practical and effective method of decontamination. This technology also provides decommissioning managers with a highly compact, portable, single solution for a variety of decontamination problems.