

Molten Wax As A Dust Control Agent - 8334

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ABSTRACT

Molten wax shows considerable promise as a fixative and dust control agent in demolition of radioactively contaminated facilities. Sticky molten wax, modified with special surfactants and wetting agents, is capable of not only coating materials but also penetrating into friable or dusty materials and making them incapable of becoming airborne during demolition. Wax also shows significant promise for stabilization of waste residuals that may be contained in buildings undergoing demolition. Some of the building materials that have been tested to date include concrete, wood, sheetrock, fiber insulation, lime, rock, and paper. Protective clothing, clay, sand, sulfur, and bentonite clay have been tested as surrogates for certain waste materials that may be encountered during building demolition. The paper describes several potential applications of molten wax for dust control in demolition of radioactive contaminated facilities.

As a case-study, this paper describes a research test performed for a pipeline closure project being completed by the Idaho Cleanup Project at the Idaho National Laboratory. The project plans to excavate and remove a section of buried Duriron drain piping containing highly radioactive and friable and 'flighty' waste residuals. A full-scale pipeline mockup containing simulated waste was buried in sand to simulate the direct-buried subsurface condition of the subject piping. The pipeline was pre-heated by drawing hot air through the line with a HEPA vacuum blower unit. Molten wax was pumped into the line and allowed to cool. The line was then broken apart in various places to evaluate the permeation performance of the wax. The wax fully permeated all the surrogate materials rendering them non-friable with a consistency similar to modeling clay. Based on the performance during the mockup, it is anticipated that the wax will be highly effective in controlling the spread of radiological contamination during pipe demolition activities. A larger test was completed this year to simulate the work in more realistic conditions.

INTRODUCTION

In cleanup and removal of radioactive contaminated facilities work is slowed by the threat of airborne dispersal of minute particles of radioactive material that can originate from building debris and even the settled dust within such facilities. Concrete that may have alpha contamination hidden inside the first millimeter of surface is also an issue. Potentially contaminated materials are sometimes as much of a problem as materials that are known to be contaminated. The presence of friable asbestos fibers found in many buildings undergoing demolition is also a concern. Traditional techniques, such as spraying these materials down with water or fog is somewhat effective, but temporary. The water becomes contaminated and mobile. Water creates other hazards and still requires special handling because all of the water used is potentially contaminated. There are a number of spray-on coatings available but these do not have the ability to permeate inside the construction materials. When the building materials are broken up during demolition contaminated dust or friable asbestos fibers may still be released.

Molten Waxfix wax technology was originally designed for underground grouting work in radioactive contaminated burial sites but may have numerous applications in demolition of contaminated facilities. Due to the unusual surfactant properties of the special wax, it tends to penetrate into building materials and exposed surfaces. Pre-heating the materials can enhance this penetration effect. While the wax remains molten, it penetrates surfaces much like a cleaning solvent or gasoline. However once the wax cools, all the permeated material becomes a waterproof solid and contamination contacted by the wax becomes fixed and non-dusty. Generally the wax can permeate through any material that would adsorb water or gasoline. This includes all fibrous materials such as wood but excludes metal, plastic and glass. The Waxfix molten wax used in this work is not brittle but malleable and slightly sticky at ambient temperature and has surfactant properties that allow it to displace water. Typical melting point of the non-flammable wax is about 51.6 Celsius (125F).

Sealing Surfaces With Wax Vapor

Molten wax tends to give off vapor that can cement particles of sand together in the ground. It has also been noted that lab areas adjacent to vats of molten wax may be coated with a thin film of wax that appears to be vapor deposited. It may be possible that the interior of buildings can be fogged with vapor phase wax to fix dust in inaccessible locations such as roof trusses and piping and wiring. This application has not been tested but seems feasible. Molten wax could be applied as a vapor to air duct systems to fix contaminants in place without damaging the system.

Waxfix 145 has a melting point of 63C, (145F) and a flash point of over 260C, (500F). A forced air heating system designed to deliver air at a controlled temperature of 121C, (250F) is proposed for dispersing the wax vapor. The unit would have a tank holding the molten wax at a liquid temperature and injecting it through an atomization spray nozzle into the airflow. The temperature of the airflow would be precisely controlled to prevent creating an explosive. The vapor might be combustible and may have similar hazard levels as spraying paint. The hot vapor system would be directed inside a duct system to coat all surfaces with a thin layer of the wax.

The wax would condense on all surfaces. A heating system could be operated for a period of time prior to the treatment to warm up the duct if deep penetration is desired.

The preferred manner of applying wax to a building interior or exterior is with a heavy stream of liquid molten wax. The relatively high volumes of wax directed as a stream rather than a spray avoid heat loss to the air and allow the wax to heat surfaces and therefore penetrate into those surfaces more effectively. Building interiors can be pre-heated with radiant or forced air heating systems to achieve a high ambient temperature before treatment. For temporary buildings erected for excavation of contaminated soil, a molten wax may be spray applied to the interior before operations begin. After the work is complete a second spray application of wax will bond the contaminants into the layers of wax to facilitate dust-free demolition.

Molten wax may be sprayed on the buildings as they are being demolished using substantially the same procedures as are used with water. However the wax need not be used sparingly as is done with water because the wax cannot migrate more than a few inches into the ground and it will not evaporate and release airborne contaminants as water can.

Permeating Building Materials

Tests have shown that the wax is able to permeate into concrete much as wax travels up the wick of a candle. The wax is not simply on the surface but in the microscopic pores of the material. Concrete floors and walls often have contamination that has entered into the surface of the concrete within the first quarter inch from the surface. Molten wax can permeate the first 6 millimeters, (0.25 inches) of concrete and tie up this contamination so that it is not released when the concrete is broken up. If the treated portion of concrete is crushed, no contaminated dust will be generated. Since contamination is often limited to the first few millimeters of a concrete surface, wax may be attractive as a pre-demolition agent.

The depth of penetration of the wax into concrete is a function of the relative temperatures and total mass heat capacity of the concrete compared to that of the wax pored on the concrete. The wax continues to flow until it cools enough to solidify. For example if a very thin layer of molten wax is simply sprayed onto a room temperature concrete slab in a thin film, the wax will not penetrate the concrete significantly because it is rapidly cooled by the greater thermal mass of the concrete. However if the slab is pre-heated to a temperature above the melting point of the wax by heat lamps and a 6 millimeter, (0.25 inch) deep pool of molten wax is applied over a large area at a high temperature, the wax could easily penetrate 24 millimeters, (1inch) into the concrete depending on the permeability of that concrete. Ceiling and wall slabs may be permeated effectively by pre-heating the surface and spraying the wax through a fire hose nozzle. Penetration will always be limited by permeability of the concrete or covering materials. If an intact epoxy coating covers the concrete floor the permeation would be greatly impeded, but it will still penetrate in the area of any scratches in the coating.



Fig. 1. Waxfix permeation and wicking action in shale rock

Materials with a low heat capacity such as ceiling tile, insulation and wood may not require pre-heating if deep penetration is not required, because the molten wax itself can carry enough heat to warm these materials to above the melting point of the wax. Asbestos in wallboard, insulation and ceiling tiles could be sprayed with sticky molten wax and then demolished immediately without release of airborne fibers. Disposal of the treated asbestos material may be completed more easily since the fibers are no longer dispersible.

Sealing Of Ground Surface Over Tank Farms

Some tank farms such as those at the Hanford site have suffered ground contamination from liquid spills. Rain drives this contamination further downward toward the water table. Placing an impermeable cover over the bermed site is complicated by the myriad of pipes, wires, sensors and equipment that is buried in the gravel cover. The area over each tank is typically a gravel-covered area. A tanker truck of molten wax may supply molten wax through and instant heater that heats the wax to 149°C, (300°F) as it is sprayed out onto the gravel through a large hose. If the area is inaccessible to workers on foot the molten wax may be distributed through a concrete pumping boom. The wax will pass through the gravel, encapsulating potentially dusty contamination and will soak into the underlying soil and form a waterproof barrier layer.

Contaminated Liquids Disposal

Molten wax can also aid in contaminated liquids disposal. Liquids that have been taken up by polymer or clay absorbents and placed in drums can be post treated by saturating them with molten wax to produce a more secure disposal waste form. Liquids disposal can be difficult and costly. Polymer beads are commercially available from several manufacturers in various type

that can that can absorb either organic or water based liquids. A partially full drum of liquid may be solidified in just a few minutes by simply pouring a quantity of these beads into the drum. However the polymer beads remain wet to the touch and the liquids can still evaporate or leach. The sorbed beads can be mixed with cement but there remains some potential for release. The beads can be incinerated or processed into glass but this is very costly.

Instead of making glass, drums of the sorbed polymer material can be microencapsulated using molten wax at a nominal cost. The drum is placed in a warming room to raise the temperature of the material to above the melting point of the wax. (130 F. to 170F melt point available) Then molten wax is introduced into the drum to displace all of the air out of the drum and fill the void space between the absorbent beads. The wax will also permeate into the surface of the beads forming a waterproof and air-tight seal around each one. The drum may then be topped off with wax, sealed and removed to ambient temperature. During cooling, a head of molten wax will be maintained on the drum to eliminate formation of any headspace in the drum. The lack of headspace will reduce the potential for development of gas pressure from radioactive decay, as any gas evolved will remain distributed and trapped in the sticky wax.

Case study: Wax as a penetrating fixative for sediment in buried pipes

As part of a remediation project being conducted by the Idaho Cleanup Project at the Idaho National Laboratory, a buried drain line that runs between a hot cell facility and a tank system will be excavated, sectioned, removed, and packaged for disposal. The line is constructed of four inch Duriron bell and spigot pipe and contains up to 38 millimeters, (1.5 inches) of highly radioactive dry, friable, crusty sediment. Duriron Pipe is a high silicon cast iron that is corrosion resistant but so hard and brittle that it cannot be cut with a saw but must be broken with a snap-cutter tool. The line is buried between up to 3 meters, (10 feet) deep and is approximately 45 meters, (150 feet) long.

The pipe material construction necessitates a snap cut, and the direct radiation fields associated with the pipe necessitate remote operations. It is desirable to employ an effective fixative to the interior surfaces of the pipe and the residuals contained in the pipe to eliminate the potential for contamination spread during the remote pipe snap-cutting, retrieval, and packaging. The project has previously investigated a variety of commercially available fixative materials to fill and stabilize the pipe before sectioning. Previous tests indicated that though the tested fixatives filled the void space they did not penetrate into the sediment, thus the dry unconsolidated sediment could still pose a contamination control problem during piping removal operations. Project management and engineering personnel decided to perform tests using an innovative penetrating grout made from molten wax. In theory, the molten wax would coat the interior surfaces of the pipe and saturate the sediment in the pipe and convert it into a malleable and non-dusty material before the pipe is broken.

A near full-scale test was conducted under contract to CH2M-WG IDAHO to verify that the Waxfix fixative process could meet project requirements while also meeting site safety and operational requirements. A test loop of 6 Duriron pipe segments, 2 half segments and 6 bends was prepared for the full-scale mockup test. Pairs of 2 pipes each were arranged in 3 parallel rows on the shop floor connected by U bends. Another 90-degree bend and a vertical riser of

Duriron pipe was installed on each end about 4 feet high. The test setup utilized about 16.8 meters, (55 feet) of 101.6 millimeter, (4 inch) Inside diameter Duriron pipe set up in a loop on blocks in a bed of sand and covered with a foot of soil to simulate burial. Temperature probes were attached to the outside of each joint of pipe. Prior to assembly of the pipe loop, each joint of pipe was partially filled with a different waste surrogate. The chemical composition of the sediment in the real pipe was unknown but a video camera inspection had shown it to be a hard and crusty deposit with the potential to be dusty when broken. Surrogates used were:

- Dry Bentonite Clay with a coating of hard cement grout
- High strength concrete made with cement, sand and bentonite.
- Dry Portland Cement with a hard cap formed by sodium silicate
- Dry hydrated Lime with a hard cap formed by sodium silicate
- Dry mixture of cement, sulfur, plaster and flyash with a hard cap formed by sodium silicate
- A Dry mixture of Portland cement, ground blast furnace slag, and bentonite clay with a hard cap formed by sodium silicate

The last four materials have sodium silicate sprayed on the top surface to simulate the hard crusty surface seen in the video inspection. Sodium silicate reacts with cement or lime to form a hard impermeable surface. The surrogate materials are intended to represent a range of permeability and to be dusty when broken. The surrogate material was loaded into each Duriron pipe using a half-section of 4" PVC pipe. The Duriron pipe was then rolled over to place a uniform layer of surrogate on the "floor" of the pipe. The thickness of the surrogate varied from 38 millimeters, (1-1/2 inch) thick to 63 millimeters, (2-1/2 inches) thick. The thicker areas are intended to simulate partial blockages that may possibly exist in the un-inspected areas of subject piping.

Procedure

An 8.8-kilowatt (30,000 BTU) x 8.5 cubic meter, (300 CFM) forced air propane heater was fitted to the pipe riser on one end of the mockup. This heater, with a 178-millimeter, (7-inch) diameter tubular body and a continuous ignition system was able to heat the entire pipe to over 82 Celsius, (180 degrees F) in less than 4 hours. The simulated waste in the Duriron pipe left an airflow path as small as 19 square centimeters, (3 square inches) in places so achieving the desired high airflow rate could not be done by the small fan of the heater alone. An industrial 6.5 horsepower shop vacuum with HEPA filter was connected to the discharge end of the line to increase the airflow rate and maintain the pipe at negative pressure. A simple heat exchanger made of aluminum air ducting was used to reduce the inlet temperature to the shop vacuum. This method produced a robust airflow estimated at 8.5 cubic meter, (300 CFM) that proved very effective at heating the Duriron pipe.

After heating the pipe for 4 hours, all areas were at least 82 Celsius, (180 degrees F). A hand pump was used to transfer molten Waxfix grout from a heated drum into the test pipe. Transfer was ended when the standpipe on both ends of the test loop filled to near the top. Additional

molten wax was added every hour to maintain the system full as the wax permeated into the surrogate material. The pipe remained hot above the 51.6 Celsius, (125 degree F) melting point of the wax for about 6 hours.

The next day all the soil was removed (See Fig 2) and the pipe was broken with a snap-cutter in over 20 places to evaluate the effectiveness of the treatment. (See Fig 3) The molten wax completely permeated all of the surrogate materials. The dusty material became non-dusty and slightly sticky. Some other places were broken with a large hammer to demonstrate that the surrogate materials had been completely permeated and rendered non-friable and non-dusty. (See Fig 4)



Fig. 2. Pipe test loop after wax treatment and removal of soil



Fig. 3. Top left to right pipe 6, 5, and 4 and bottom left to right pipe 3, 1, and 2



Fig. 4. Pipe 1, Dry bentonite surrogate with cement grout cap, broken with hammer

Mockup testing indicates that the wax fixative appears to be highly effective as a stabilization media for use in buried piping containing waste residuals in situations in which contamination control is critical. The molten wax coats the interior of the piping and completely permeates all tested waste surrogates. This allows sectioning of the piping while mitigating the potential for dry, dusty, friable waste residuals to become airborne. This is of particular importance with remote operations, with cutting techniques such as snap cutting in which significant energy is imparted to the pipe being cut and with highly 'flighty' radiologically contaminated material.

The most critical aspect of the use of molten wax as demonstrated in the mockup is the pre-heating of the piping and waste residuals. While pre-heating of the pipe is not strictly necessary with a relatively short pipe, it serves to increase the degree of permeation with unknown sediment materials. The hot airflow method of heating was selected because it could be performed at negative pressure and it provides a slow and predictable temperature rise. The concurrent heating of the soil around the pipe will allow molten wax encapsulation of adjacent soil if historical leakage has occurred.

As a result of the excellent results observed during the mockup, additional full scale verification testing was performed in 2007 and the process is currently set to be used in the actual hot cell piping at the Idaho National Engineering Laboratory in mid 2008.

CONCLUSIONS

Molten wax has many potential applications for safe decommissioning and demolition of radioactively contaminated facilities. The process has demonstrated usefulness in hot cell piping demolition and is expected to see progressively wider use for difficult radioactive facility demolition problems. It can be used on wooden, metal, and concrete structures. It can be sprayed onto surfaces as a coating but it can also be applied as a penetrating fixative and waterproofing agent. Wax is likely to be especially useful for asbestos fiber materials. It can also be used to waterproof soil over a tank farm site. Molten wax is relatively low cost at about ten dollars per gallon and can be heated and applied from a steel drum that can be handled by commonly available equipment. In larger applications wax can be delivered to a site as a molten liquid in common carrier tanker trucks. Molten wax can also be useful as a low-tech method of treating radioactive liquid waste at a much lower cost than comparable methods.