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EPA **Project Summary**

Assessment of Techniques for *In Situ* Repair of Flexible Membrane Liners: Final Report

H. E. Haxo, Jr.

The feasibility of using either patching or plugging to make *in situ* repairs of damaged areas in in-service flexible membrane liners (FMLs) was investigated. Applying the basic criteria used in assessing and testing liners and seams in FMLs that are being installed, it appears highly questionable that conditions required for preparation of adequate seams and permanent repairs can be met with FMLs exposed below wastes. Exposed liners, however, can be repaired if the proper conditions of cleanliness and dryness are met. Repairing with formed-in-place plugs holds some promise for short-term use; however, the compatibility of the plugging material with the waste liquid should be assessed.

Experimental studies relating to preparation of high density polyethylene (HDPE) seams made with a heat gun indicate the importance of surface preparation in achieving adhesion between the two pieces of liner being seamed. Cleanliness and fresh surfaces are necessary. Compatibility tests of six different potential plugging materials (five epoxies and one cement) in five simulated test media show the importance of the medium on the ability of the material to set and with long-term integrity of the cured materials.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The use of flexible membrane liners in liner systems for waste storage and disposal facilities has been increasing over the past decade. The principal basis for this application of FMLs is their low permeability to liquid flow and their ability to minimize the escape of waste constituents and subsequent contamination of surface or groundwater. While these liners can be quite effective in reducing environmental contamination, the potentially low permeability of the liner can be compromised by membrane defects during manufacture, by seam defects, by excessive swelling, or by damage occurring accidentally during

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installation or as a result of wear and tear during service.

In view of the desirability of being able to repair damaged in-place FMLs without having to remove large quantities of waste from above them, the original project was undertaken to assess the feasibility of making permanent *in situ* repairs of in-place membrane and admix liner systems.

The full report of this study discusses the technical requirements and conditions for *in situ* repairs of FMLs at various times during installation and service. The results of searching the existing technical literature on seaming polymeric sheeting and the results of discussing the general industry practice with technical experts are presented, along with laboratory results using different repair techniques. Laboratory test procedures used in assessing repair methods are described and test results are presented.

Summary of Work

The open technical literature was searched for information on the repair of FMLs. The search included literature on adhesion, adhesives, and various methods of seaming coated fabrics, membranes, and FMLs. However, outside of work either performed by Matrecon under previous EPA contracts or observed by Matrecon personnel, little information was found relating to the repair of FMLs in the field or under simulated field conditions.

The general concept of repairing liners was investigated with particular reference to potential problems that might occur during the different phases in the life of a liner. Also investigated was the concept of temporary versus permanent repair.

Criteria for repairing liners in the field were scrutinized. It was felt that the basic requirement for a permanent repair should be that it meet the same criteria that the liner and seam must meet at the time of liner installation. If a patch is used, its adhesion to the liner should equal that of the original seams. On the other hand, if a formed-in-place plug is used to repair a hole in a liner, chemical adhesion to the liner may not be required if a sufficiently high mechanical bond is formed between the liner and the plug.

The consensus of a panel of experts in this field was that work should be concentrated on investigating the repair of damage to HDPE FMLs and possibly the use of plugs for repairing damage to FMLs below ground level. The following tasks were recommended by the panel and were undertaken:

1. Assess methods of seaming polyethylene with a Leister gun and by spin-welding.

2. Assess the compatibility of polyethylene seams in contact with a series of five test media. These test media included deionized water, 10% HCl, 10% NaOH, a 5% solution of mineral oil in xylene, and a mixed solvent containing equal volumes of chloroform, methyl ethyl ketone, and cyclohexane.

3. Assess the compatibility of six potential plugging materials in contact with the same series of five test media. These potential plugging materials were all hardenable liquid compositions and included five epoxies and one hydraulic cement. In one study, the ability of the plugging materials to harden in the presence of the test media was determined and, if they did harden, whether they maintained their properties in continued exposure. A second study was performed in which these plugging materials were cured in air and then immersed in the test media.

Conclusions

The long-term integrity of seams made in a repair operation is questionable. Repairing a damaged FML by patching the liner with pieces of the same type of membrane material of essentially the same composition can only be performed if the liner is clean and dry and has a

fresh surface. These conditions are prerequisites for achieving good adhesion between materials in general and are very difficult to achieve in the environment of waste disposal facilities, except perhaps on slopes and in areas of the FML not exposed to the weather or to the waste.

The difficulties involved in making quality repairs that meet the criteria imposed on a newly installed liner make it even more important to emphasize quality control and quality assurance during the construction of a disposal facility and the installation of a liner so as to minimize the possibility of liner failure. It appears that, if there is inaccessible damage below the waste in an in-place liner, the damage is nonrepairable and it may be necessary to close the disposal unit.

Plugging holes in a liner with hardenable liquids, such as the epoxies, may be feasible (1) if good mechanical bonds can be made between the plug and the liner, (2) if the liquid is deliverable to the location of the damage, and (3) if the plugging material is compatible with the waste liquid during cure and subsequent exposure.

Because of uncertainty about the adequacy of liner repairs *in situ* below solid waste levels, backup systems are essential. Double liner systems may provide that backup assurance necessary to protect the groundwater system.

Recommendations

At the present state of liner technology and given the difficulties involved with repairing in-service FMLs and with closing an impoundment unit once there is damage to the liner, it is recommended that large impoundment units be avoided and that smaller units be used which can be monitored individually. Small units can be cleaned out or closed without moving massive quantities of waste, thus reducing the risk of groundwater contamination.

Information is lacking in the open technical literature on the durability of FML seams, failures of in-service FMLs, and the repair of in-service FMLs. To fill this need, field verification studies should be undertaken to assess the types of failures that occur. An effort should be made to locate and assess field repairs of liners made during installation and performance testing.

Increased emphasis should be placed on the development of seaming techniques, including the development of new techniques. Also, increased emphasis should be placed on seam testing to ensure that seams with long-term integrity and durability are prepared and accepted during installation.

Samples of seams should be included in the compatibility testing of the FMLs during the liner selection and design process. Quality assurance tests of seams should be performed during liner construction. In addition, seam samples cut from the actual liner should be exposed and routinely tested during service to monitor any changes in seam quality.

Henry E. Haxo, Jr., is with Matrecon, Inc., Alameda, CA 94501.
***Robert P. Hartley** is the EPA Project Officer (see below).*
The complete report entitled "Assessment of Techniques for In Situ *Repair of Flexible Membrane Liners," (Order No. PB 87-191 813/AS; Cost: $13.95, subject to change) will be available only from:*
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Hazardous Waste Engineering Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268