Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

File Blue 92

DATE: September 24, 1992
IN REPLY REFER TO: NMT-3:92-474
MAIL STOP: E511
TELEPHONE: (505) 667-2320

Steve please advise me

Mr. Ed Horst
NM Dept. of Hazardous and
Radioactive Waste
P. O. Box 26110
Santa Fe, NM 87502

Dear Mr. Horst:

You recently requested more information concerning magnetic separation from the Los Alamos National Laboratory publication Environmental Technologies. This letter is to respond to your request.

Enclosed please find additional information about our program. At Los Alamos a team of chemists, physicists and engineers is studying magnetic separation methods for various applications which include soil decontamination, plutonium, uranium, and precious metal chemical processing, and treatment of fission product waste. The soil decontamination work is the major element in a cooperative research and development agreement (CRADA) between Los Alamos and Lockheed Environmental Systems and Technology Company.

I hope this letter and the enclosed information give you a better understanding of our work. If you have questions or ideas for magnetic separation applications we would like to hear from you. Feel free to contact either myself at (505) 667-2320 or my colleagues Laura Worl (505) 665-7149 or Coyne Prenger (505) 665-0951.

Thank you for your interest in our work.

Sincerely,

Larry R. Avens

Request page #70 to be sent 11-19-92

Enclosure: a/s

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Opportunities for Magnetic Separation Applications in Complex 21

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The Magnetic Separation Process

Magnetic separation is a physical separation process that segregates materials on the basis of magnetic susceptibility. Because the process relies on physical properties, separations can be achieved while producing a minimum of secondary waste.

When a paramagnetic particle encounters a nonuniform magnetic field, the particle is urged in the direction in which the field gradient increases. Diamagnetic particles react in the opposite sense. When the field gradient is of sufficiently high intensity, paramagnetic particles can be physically captured and separated from extraneous material.

Because all actinide compounds are paramagnetic (Fig. 1), magnetic separation of actinide-containing mixtures is feasible. Magnetic separation on recycle plutonium chemical process residues has been demonstrated on an open gradient magnetic separator. The advent of reliable superconducting magnets makes magnetic separation of weakly paramagnetic species attractive.

L Radioactive elements w/atomic No. ≥ 89 & ≤ 103

Figure 1: Magnetic Susceptibility of selected compounds and elements

Compound/Element	Susceptibility, 10^{-6}
Paramagnetic	
FeO	+7200
Fe_2O_3	+3586
Cr_2O_3	+1960
UO_2	+2370
PuF_4	+1760
Am	+1000
PuO_2	+730
Ni_2O_3	+660
Pu	+610
U	+409
PuF_6	+173
Th	+134
CrO_3	+40
Ca	+40
Al	+16
Diamagnetic	
Si	-4
Graphite	-6
MgO	-10
CaO	-15
ThO_2	-16
MgF_2	-23
CaF_2	-28
SiO_2	-30
NaCl	-30
Al_2O_3	-37
KCl	-39
$CaCl_2$	-54
CaI_2	-109

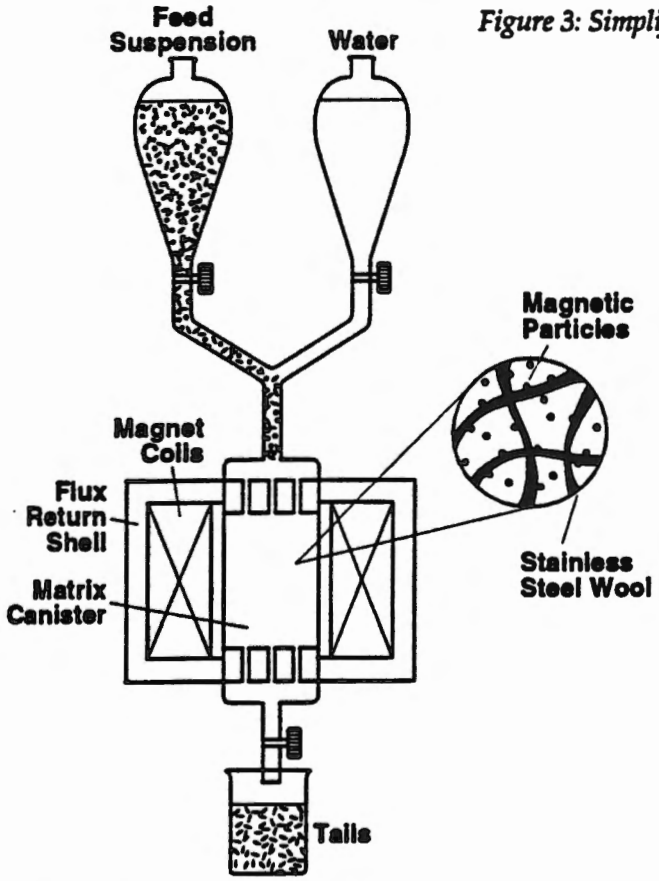


Figure 3: Simplified HGMS Diagram

fraction passes through the magnetized volume unaffected. The magnetic fraction is flushed from the matrix later when the magnetic field is reduced to zero or the matrix is removed from the magnetized volume.

Much higher electromagnetic fields are routinely available with today's superconducting magnet technology. Higher fields offer the possibility of a broader range of HGMS applications than is afforded by conventional electromagnets, which are limited by the saturation of iron.

For our HGMS work at Los Alamos, we have a laboratory-scale one-inch-bore cross-field, conventional magnet and a larger, warm-bore superconducting magnet. The maximum field intensity of the conventional coil magnet is 20,000 gauss (2 tesla), while that of the superconducting magnet is 80,000 gauss (8 tesla). At the time of this writing, the 1-inch magnet is undergoing cold testing while the superconducting magnet is scheduled for delivery in a few weeks.

Magnetic Separation Applications in Complex 21

Several applications of magnetic separation will be examined for Complex-21: 1) concentration of recycled-plutonium, chemical processing residues, 2) extraction of actinides from liquid wastes, and 3) development of reusable magnetic gas filters.

We have shown that chemical process residues, such as reduction slags, crucibles, graphite, and silica, can be segregated into a plutonium-rich and a plutonium-lean fraction. The plutonium content of the lean fraction from these demonstration experiments is sufficiently low in plutonium that it is uneconomical to recover the plutonium value. Therefore, the plutonium lean fraction can be discarded directly in grout. Processing of dry residues is important not only for Complex-21 processing but also for volume reduction of the current DOE backlog.

Opportunities for Magnetic Separation Applications in Complex 21 (continued)

HGMS might also be useful as a selective filter for fluid waste generated during actinide chemical processing. Our magnetic separation model predicts that HGMS can reduce the actinide concentration in liquid waste streams by several orders of magnitude.

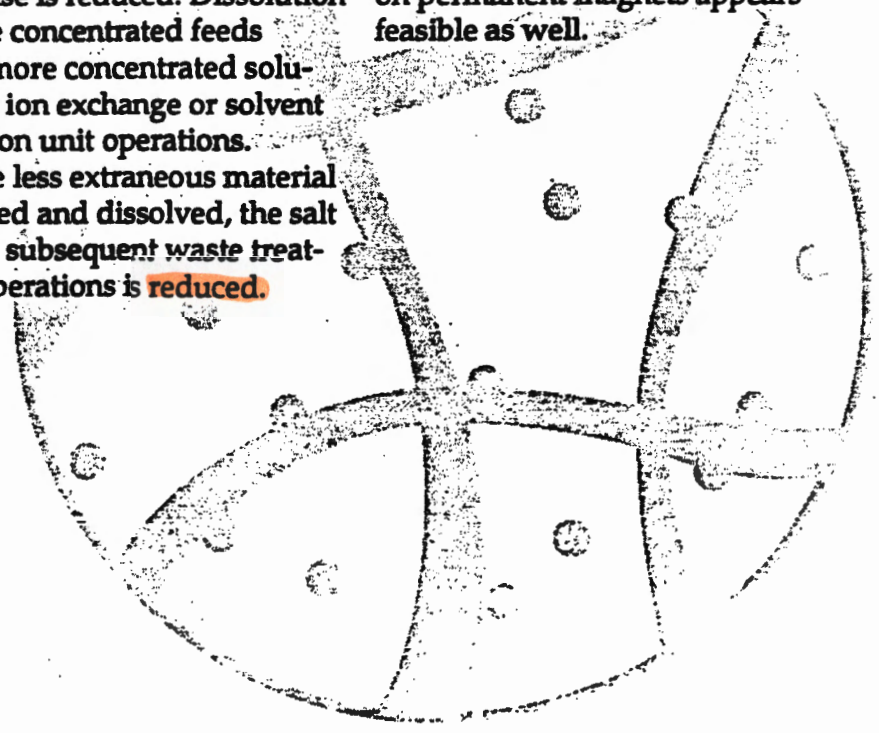
An identified need in uranium and plutonium operations is the reusable filter for glovebox and hood exhaust. A reusable high-efficiency magnetic filter for paramagnetic particulates appears feasible, but only a small amount of work has been conducted in this area.

Benefits of Magnetic Separation in Complex 21

The benefits of interjecting magnetic separation as a head end unit operation include the generation of only a very small volume of secondary waste. The ability to concentrate the actinides from extraneous materials before processing begins yields a more efficient recovery operation. This is true because reagent (acid) use is reduced. Dissolution of more concentrated feeds yields more concentrated solutions to ion exchange or solvent extraction unit operations. Because less extraneous material is leached and dissolved, the salt load on subsequent waste treatment operations is reduced.

Magnetic filtration of fluid waste may be a method to cut TRU effluents from DOE facilities to near zero. This would greatly reduce waste treatment cost.

Magnetic gas filters on glovebox process exhaust would also greatly reduce the frequency that conventional high-efficiency particulate air filters must be changed. A reusable filter based on permanent magnets appears feasible as well.



"A cooperative research and development agreement was recently signed with AWC/Lockheed to examine paramagnetic separation for soil decontamination."

Project Status

As of this writing, cold testing of the roll separator has been completed and it has been installed in a glovebox. Soon, process-demonstration will begin. The roll separator represents a pilot-scale demonstration for this technology. Data obtained from this unit can be used, in collaboration with the vendor, to design and fabricate a full-scale processing unit with virtually any number of separation stages and processing rates.

The conventional HGMS unit at Los Alamos is currently being used in cold testing. Through the use of

1) various nonradioactive surrogate materials with different magnetic susceptibilities,
2) different surrogate particle sizes,
3) parameter variation such as flow rate, solids loading in the slurry, fluid viscosity, etc.
4) magnetic matrix parameters, and
5) magnetic field strength,

a performance based HGMS model is being developed. The hope here is that given a separation problem, we will have the ability to select the processing criteria set that will achieve a necessary performance level. Currently, numerous experiments must be conducted to determine optimum performance.

The superconducting HGMS is due in Los Alamos very soon. After cold testing and model development, one of the HGMS separators will be relocated for plutonium residue processing tests.

There are other important aspects of magnetic separation work at Los Alamos that do not strictly involve Complex 21. A cooperative research and development agreement was recently signed with AWC/Lockheed to examine paramagnetic separation for soil decontamination. In addition, a soil decontamination study with Rocky Flats is anticipated. Use of HGMS to segregate underground storage tank waste, a problem at the Hanford site, is also being studied. ♦

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Special Reprint

Los Alamos, Lockheed Back Attractive Cleanup Technology

BY DENNIS WAMSTED

LOS ALAMOS, N.M.—Hoping to prove that there is nothing new under the sun, researchers at Los Alamos National Laboratory here are studying the possibility of adapting a technology now used to purify clay for papermaking for use in the cleanup of the nation's severely contaminated nuclear weapons facilities.

The technology—high gradient magnetic separation (HGMS)—has looked extremely promising in tests using non-radioactive surrogate materials, says Larry Avens, with the labs's Nuclear Materials Technology Division. And Avens is hopeful that the technology will prove equally capable of removing radioactive material. If it works, HGMS could become a key component of the Department of Energy's cleanup effort and give the U.S. an advantage in the international environmental technology market, says Avens, who has been working on the technology since 1988.

Already used commercially in Georgia's kaolin industry to remove impurities from the clay—which is used in the publishing industry to coat paper—the principle behind HGMS is relatively simple: magnets can be used to remove ferromagnetic and paramagnetic substances from gases and liquids.

The specifics are somewhat more complex, as outlined in a paper written by Avens and several other Los Alamos researchers. "Most commonly," Avens and his colleagues wrote, "the feed is slurried with water and passed through a magnetized volume. Field gradients are produced in the magnetized volume by a ferromagnetic matrix material. The matrix can be steel wool, steel balls, nickel foam, etc. Ferromagnetic and paramagnetic particles are extracted from the slurry while the diamagnetic fraction passes through the magnetized volume unaffected. The magnetized fraction is flushed from the matrix later when the magnetic field is reduced to zero or the matrix is removed from the magnetized volume." (See diagram for details.)

The beauty of this technology, says Avens, is that all actinide compounds are paramagnetic and, potentially, can be removed from mixtures, either in dry form or in a slurry, through magnetic separation. Actinides are radioactive elements with increasing atomic numbers, beginning with number 89 or 90 and continuing to 103.

What has been missing from the mix are magnets powerful enough to attract elements that are only weakly magnetic, such as plutonium and uranium. But all that has changed with the development of reliable superconducting magnets, says Avens.

Earlier this month, Los Alamos received a superconducting magnet, built by Cryomagnetics in Oak Ridge, Tenn., that is four times more powerful than the conventional coil magnet that researchers at the lab have been using. Specifically, Avens says, the new superconducting magnet, which should be ready for testing this week, has a maximum field intensity of 80,000 gauss (eight tesla). In contrast, the lab's conventional coil magnet has a maximum field intensity of 20,000 gauss (two tesla).

Over the next six months, lab researchers will be using both the superconducting and conventional magnets to test the technology, says Avens. By the end of that period, he adds, the researchers should have a good idea of what the separation technology can, and cannot, do. Still, Avens is optimistic, since preliminary results at the lab using non-radioactive surrogate materials have shown the capability to remove over 99 percent of the paramagnetic compounds from mixtures.

Among the possible uses for the technology are:

- concentrating recycled plutonium and chemical processing residues;
- extracting actinides from liquid wastes; and
- filtering gases released during actinide chemical processing.

Concentrating the actinides in waste throughout DOE's weapons complex is a particularly promising application of magnetic separation, according to Avens, since it would make the treatment process much more efficient. The magnetic separation process itself also promises to generate only a small amount of secondary waste, he says.

Another possible application of the technology is in the cleanup of contaminated soil. Indeed, this application looks so promising that Los Alamos and AWC/Lockheed, a wholly owned subsidiary of Lockheed Corporation, signed a cooperative research and development agreement (CRADA) in March of this year to study the technology.

The goal of the two-year accord is to see if Los Alamos' magnetic separation technology can be linked to AWC/Lockheed's existing gravimetric separation technology. This technology, marketed under the trade name TruClean, works well, but only on particles of greater than 100 microns in size. In contrast, Los Alamos' magnetic separation technology promises to work on particles smaller than 100 microns.

If the combined tech-

(Continued on next page)

Lab Eyes New Uses For Magnets

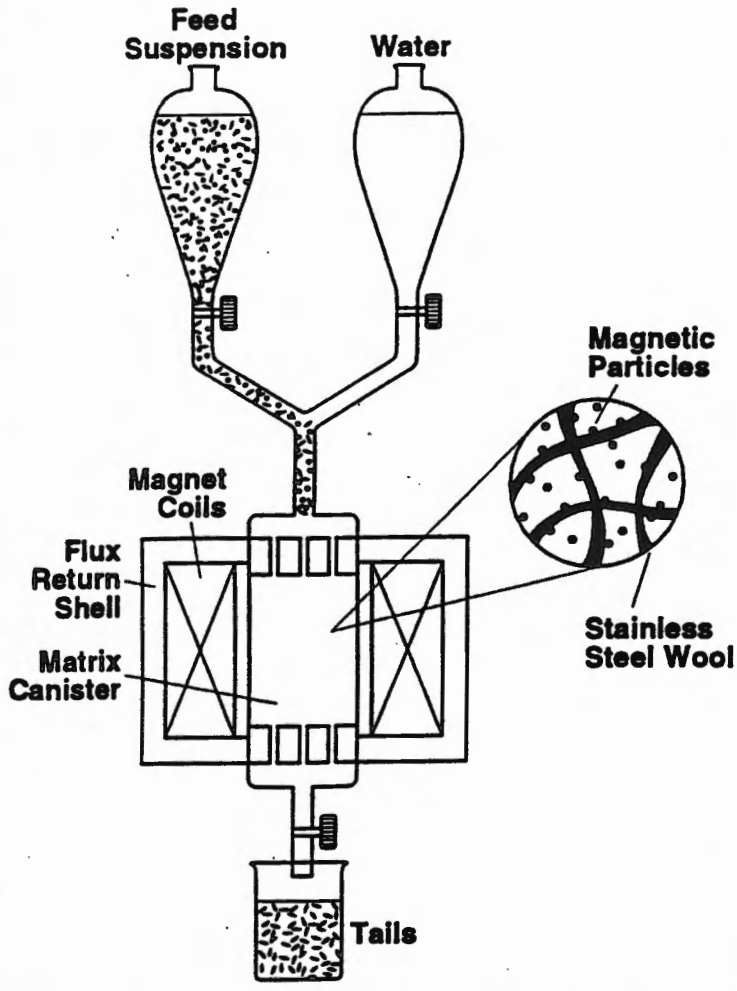
(From page one)

nology works as hoped, it could significantly reduce the cost of treating contaminated soil throughout the DOE weapons complex by enabling cleanup companies to concentrate the contamination. According to one lab estimate, the combination technology could concentrate the volume in less than 10 percent of the original volume of the waste. In other words, this would avoid the necessity of transporting, treating and disposing of 90 percent of the waste, which could save billions of dollars in cleanup costs, the lab estimates.

All told, about $1 million is being spent to research and develop the magnetic separation technology, according to Avens. This is split roughly in half between the CRADA-related research with Lockheed and funds Los Alamos has earmarked for its internal R&D program.

Further down the road, the technology may be applicable to treat wastewater, separate heavy metals and process precious metals.

Simplified HGMS Diagram



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