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U.S. DEPARTMENT OF ENERGY (DOE), OAK RIDGE K-25 SITE TECHNOLOG LOGIC DIAGRAM, DOE-OAK RIDGE OPERATIONS OFFICE, OAK RIDGE, TN - (USED AS A REFERENCE IN OU3 RI/FS/PP MAIN REFERENCE AND APPENDIX D)

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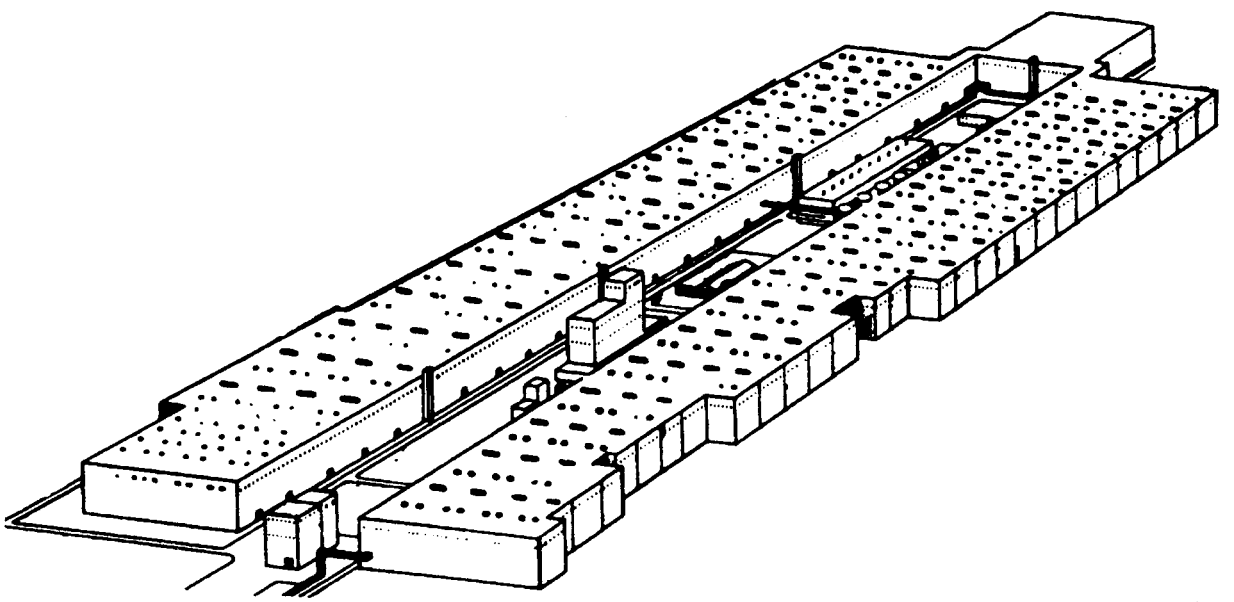
OAK RIDGE K-25 SITE TECHNOLOGY LOGIC DIAGRAM

Prepared for the Office of Technology Development
U.S. Department of Energy



TECHNOLOGY EVALUATION DATA SHEETS VOLUME 3A

Part A Characterization • Decontamination • Dismantlement

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Oak Ridge K–25 Site
Technology Logic Diagram

Volume 3
Technology Evaluation Data Sheets

Part A
Characterization • Decontamination • Dismantlement

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Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Electron Spectroscopy for Chemical Analysis (ESCA)—A surface technique that operates on photo-electric effect. Electrons are ejected from the core of the atom with kinetic energies specific to the element. Chemical shifts in energy add information about the chemical state of the element.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

February 26, 1993

Additional Comments:
Amount of waste produced—None, approximately a 5-mg sample is required
Overall cost—High capital costs, approximately $200–$600 per sample
Efficacy/strengths—Elemental and chemical state information from the outermost surface material (<10 nm) provide contaminant attachment and bonding mechanism information. This is a mature technology.

Science/Technology Needs: Model studies are needed to identify binding energies for standard compounds of Tc and U for suspected matrices.

Implementation Needs: Instrumentation and personnel currently exist at K-25.

Author: D.P. Hoffmann/(615)574-3896

References:
F. J. Gruthaner, *MRS Bulletin*, **12**(6), 60–63 (1987).

AUGER ELECTRON SPECTROSCOPY (AES) CHAR-2-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Auger Electron Spectroscopy (AES)—A technique of speciation of analyte atoms by detection of characteristic gamma radiation caused by intershell electron transitions induced by X-ray excitation.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

Additional Comments:
Amount of waste produced—Approximately 5 mg of sample is required. Sample preparation varies from none to extensive.
Overall cost—High capital costs. High costs per sample, approximately 3–8 h/sample.
Efficacy/strengths—Elemental, spatial, and depth profiling information is obtained from the surface region (<10 nm) of the sample. It is applicable to monitoring contaminant interaction with the host matrix and identifying complexation, location, and binding sites of the contamination. This is a mature technology.

Science/Technology Needs: Mature, model studies are needed to probe the host/contaminant effects for accurate depth profiling.

Implementation Needs: Instrumentation and personnel exist within the three plants.

Author: D.P. Hoffmann/(615)574-3896

References: C.C. Chang, *MRS Bulletin*, **12**(6), 70–74 (1987).

SECONDARY ION MASS SPECTROSCOPY (SIMS) CHAR-3-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Secondary Ion Mass Spectroscopy (SIMS)—Ionized gas impinges on sample to eject secondary ions that are subsequently mass analyzed.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—Approximately 5 mg of sample is required. Minimal sample preparation is required.
Overall Cost—High capital costs; moderate to expensive for analysis (~0.5–4.0 h/sample).
Efficacy/Strengths—Elemental and compound identification from the sample surface, spatially resolved information, and depth profiling are possible. Enrichment information is also possible.

Science/Technology Needs: This is a mature technology. Model studies are needed to calibrate for depth profiling studies.

Implementation Needs: Instrumentation and personnel exist at the three plants.

Author: D. P. Hoffmann/(615)574-3896

References: W. Katz, J .G. Newman, *MRS Bulletin*, **12**(6), 40–47 (1987).

LASER IONIZATION MASS SPECTROSCOPY (LIMS, LAMMA, LIMMA)

CHAR-4-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Laser Ionization Mass Spectrometry (LIMS)—A technique for mass spectrometric analysis of solids that uses a pulsed, laser-energy source to vaporize and ionize the analyte.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—Approximately 1-5 mg of sample is required. Minimum sample preparation is needed.
Overall Cost—High capital costs; low to moderate cost per sample (approximately 1 hour)
Efficacy/Strengths—Mass spectroscopy identification of elements and compounds on a surface with high spatial resolution. Enrichment information is possible.

Science/Technology Needs: This is a mature technology. Model studies are needed to optimize results interpretation.

Implementation Needs: Prototype instrumentation and research instrumentation exists. More equipment would be required. The necessary personnel are available.

Author: D. P. Hoffmann/(615)574-3896

References: Hercules et al., *Journal of Analytical Chemistry*, **54**, 280A (1982).

PORTABLE VOLATILE ORGANIC COMPOUNDS (VOC) DETECTORS

CHAR-5-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings; soils

Problem Area/Constituents: Gas-phase analysis

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Portable volatile organic compounds (VOC) detectors

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment
Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications
Driver Evaluation:	Regulatory Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—Low capital costs; very low cost per analysis (approximately $1).
Efficacy/Strengths—These portable units allow real-time field monitoring for organic vapors. Some units are specifically calibrated for certain gases. Others allow a wide range of gas

detection. There are various sizes ranging from pocket size to briefcase size, with a variety of data logging and sample collection options. Detection limits can be as low as the ppb range.

Science/Technology Needs: This is a mature technology. We must ensure that radiation and the complex mixtures that may be present do not hamper the detection efficiency.

Implementation Needs: We must adapt this maturing technology to allow detection of specific gases of interest that may not be currently available, and we must adapt our collection capabilities to allow for large area and limited access sampling.

Author: D. P. Hoffmann/(615)574-3896

References: Vendor literature (MSA, Sensidyne, MDA, Andersen, Sentex, and Foxboro)

FIELD PORTABLE X-RAY FLUORESCENCE (FPXRF) CHAR-6-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum
Liquids			

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Field Portable X-Ray Fluorescence (FPXRF)—Fluorescence from the decay of elements excited by X-rays is used to obtain quantitative and qualitative elemental analyses of samples.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications
Driver Evaluation:	Regulatory Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—The cost is approximately $50K per unit and pennies per sample.
Efficacy/Strengths—It is portable, logs data, and has an elemental range of Al to U. ppm levels are accepted by the EPA for Level I site assessment. It is a quick procedure (approximately 1 to 2 minutes per sample).

Science/Technology Needs: This is a mature technology.

Implementation Needs: This technology is mature for manual applications. It is an excellent candidate technology for automated or robotic deployment systems.

Author: D. P. Hoffmann/(615)574-3896

References: Vendor literature (Outokompu, HP)

SECONDARY NEUTRAL MASS SPECTROMETRY (SNMS) CHAR-7-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Secondary neutral mass spectrometry (SNMS)

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Regulatory Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—$100–$500/sample
Efficacy/Strengths—A wide variety of post-ionization schemes are currently in use to increase the ion yield. This method of solid-state mass spectroscopy has improved quantitative capabilities and would allow accurate uranium-enrichment studies to be performed.

Science/Technology Needs: System development and model studies for calibration of enrichment measurements for small particles of uranium.

Implementation Needs: Capital equipment costs $500K and development costs $200K.

Author: D. P. Hoffmann/(615)574-3896

References:

FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR) CHAR-8-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum
Liquids			

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Fourier Transform Infrared Spectroscopy (FTIR)—A spectroscopic technique used for identifying and quantitating inorganic and organic materials by measuring the absorbance spectrum of the material in the infrared spectral region. Fourier transform methodology speeds the measurement by allowing simultaneous, rather than the slower, sequential scanning of the entire absorbance spectrum.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance Obstructed/Limited Access to Host
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications
Driver Evaluation:	Regulatory Risk Assessment Technical Assessment

February 26, 1993

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)
Organic (Oil, PCBs, VOCs, TCE)

Additional Comments:
Amount of Waste Produced—None to a few ml per sample
Overall Cost—$50–$500 per sample
Efficacy/Strengths—A multitude of detector and sampling devices exist to allow gas, liquid, solid and microanalysis to be performed. Mature technique with a host of applications to any environmental restoration/waste management program.

Science/Technology Needs: Data base for rapid materials identification and model studies materials interaction is needed.

Implementation Needs: Hardware costs range from $25K to $500K. Development costs are <$200K.

Author: D. P. Hoffmann/(615)574-3896

References:

ULTRAVIOLET/VISIBLE (UV-VIS) SPECTROSCOPY CHAR-9-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum
Liquids			

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Ultraviolet/Visible (UV-VIS) Spectroscopy

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance Obstructed/Limited Access to Host
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

Additional Comments:
Amount of Waste Produced—None to a few ml per sample
Overall Cost—$50–$200 per sample
Efficacy/Strengths—This mature technology can be used in a variety of field and laboratory procedures for the identification of materials. It can provide rapid screening capabilities for sample selection.

Science/Technology Needs: Model studies and application design.

Implementation Needs: Hardware costs are <$200K; development costs are <$100K.

Author: D. P. Hoffmann/(615)574-3896

References:

ELECTROCHEMICAL METHODS CHAR-10-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum
Liquids	Gases		

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Electrochemical Methods—Oxidizable or reducible species, excited by a voltage or current function in an electrical circuit, yield qualitative information about species of interest.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Liquid Host Disturbance Obstructed/Limited Access to Host
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, Cr04, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

February 26, 1993

Additional Comments:
Amount of waste produced—5–100 mL per sample
Overall cost—Widely variable (>$50)
Efficacy/strengths—There are a wide variety of electrochemical techniques (e.g., electrogravimetry, polarography, coulometry, voltametry) that can provide chemical and materials interaction information. These techniques could be useful in waste treatment and interaction studies as well as identifying species present in waste streams.

Science/Technology Needs: Adaptation and protocols for model studies to be performed on complex systems are needed.

Implementation Needs: Hardware costs range from $50K–$250K; development costs are $250K.

Author: D.P. Hoffmann/(615)574-3896

References:

NUCLEAR MAGNETIC RESONANCE (NMR) CHAR-11-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings; soils

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum
Liquids	Gases		

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Nuclear magnetic resonance (NMR)—A method for identification and quantitation of molecules by detecting absorption of radio frequency power that excites nuclear spin resonances of various nuclei (H, ^{13}C) contained in the molecule.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—None to a few ml per sample
Overall Cost—$200-$500 per sample
Efficacy/Strengths—This mature technology can be applied to both liquid and solid sample (MAS) and can provide imaging information. This technology is very useful for identifying materials as well as for studying materials interactions.

Science/Technology Needs: Model studies and protocols for adaptation and application of technology.

Implementation Needs: Hardware costs range from $200K—$2M; development costs range from $200K—$500K.

Author: D.P. Hoffmann/(615)574-3896

References:

SURFACE ACOUSTIC WAVE (SAW) SENSORS CHAR-14-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings; soils

Problem Area/Constituents: Gases

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Surface acoustic wave (SAW) sensors—A SAW device is a sensor that detects specific gases or compounds in solution. Adsorption of analyte on its surface alters the speed, frequency, or phase of a traveling surface acoustic wave.

Status:

Status Evaluation:	Accepted Demonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications
Driver Evaluation:	Regulatory Risk Assessment Technical Assessment

Applicable Contaminant Evaluation:Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of waste produced—None
Overall cost—The cost per unit is low ($2–10K), and the cost per sample is also low ($1–10).
Efficacy/strengths—It has a fast response time and provides a direct measure of organic vapors. Various sampling scenarios are possible. Detection levels of ppm are possible. It can be tailored to a specific gas or to a family of gases. Higher temperature and small probe unit devices need to be optimized. Laser/thermal desorption sampling capabilities and on-line process monitoring also need to exist for large scale D&D efforts. These will allow more direct monitoring of D&D processes and minimize restrictions as to their application.

Science/Technology Needs: Coatings need to be developed to allow detection of gases of specific interest that are currently not available. Higher temperature and small probe unit devices need to be optimized. Laser/thermal desorption sampling capabilities and on-line process monitoring also need to exist for large scale D&D efforts. These will allow more direct monitoring of D&D processes and minimize restrictions as to their application.

Implementation Needs: Normal

Author: D. P. Hoffmann/(615)574-3896

References:
C. G. Fox, J. F. Alder, *Analyst*, 1989, 114, page 997

LASER PHOTO ACOUSTIC SPECTROSCOPY (LPAS, PAS) CHAR-15-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment Process Buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum
Liquids	Gases		

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Laser photo acoustic spectroscopy (LPAS, PAS)

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance Obstructed/Limited Access to Host
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Regulatory Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE, ...) Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

February 26, 1993

Additional Comments:
Amount of waste produced—Little to no waste is produced.
Overall cost—Moderate capital costs are involved, and the cost per sample is low.
Efficacy/strengths—It has high sensitivity, large dynamic range, simple experimental procedures, and can be used on gases or solids. It can be portable, and it allows in situ measurements. ppb levels of detection are possible.

Science/Technology Needs: Laser detection combinations that are applicable for specific D&D waste or monitoring scenarios are needed.

Implementation Needs: Development or enhancement of portable and in situ capabilities is needed.

Author: D.P. Hoffmann/(615)574-3896

References:
P.L. Meyer and M.W. Sigrist, *Rev. Sci. Instrum.*, 1990, 61(7), p. 1779.

ANNULAR DENUDERS

CHAR-16-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: Airborne particulates/dust

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Annular denuders

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Regulatory Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE, ...) Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Radioactive (α, β, γ)

Additional Comments:
Amount of waste produced—Low to no waste is produced (mg per sample).
Overall cost—The cost is low using either disposable or reusable tubes.
Efficacy/strengths—It can be tailored for a wide variety of gas and particulate pollutants.

Science/Technology Needs: Detection tubes for enhanced radiological analysis are needed.

February 26, 1993

Implementation Needs: Automated and field applications are needed.

Author: D.P. Hoffmann/(615)574-3896

References:

F.W. Liberti, A. Febo, and M. Possanzini, *NATO ASI Ser.*, 1988, 252, p. 465.

PARTICLE-INDUCED X-RAY EMISSION (PIXE) CHAR-17-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Particle-induced X-ray emission (PIXE)—The generic technique of particle-induced X-ray emission spectroscopy. The particles may be protons, photons, or other particles usually obtained with energies available in particle accelerators (protons in the range of 2-4 MEV). Used with an energy-dispersive detector, it is a multielement detection method with sensitivities in the ppm range. Microprobes have been developed for obtaining spatial distribution of elements in a sample. A photon microprobe is under development.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment

February 26, 1993

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

Additional Comments:
Amount of waste produced—No waste is produced.
Overall cost—This is a high capital item, and it takes about 0.5 hour per sample.
Efficacy/strengths—It enables trace elemental analysis over a wide elemental range. It has micro and mapping capabilities, and it has high performance.

Science/Technology Needs: This is a mature technology.

Implementation Needs: The instrumentation is not available on site. Analysis is available at outside laboratories. Sampling scenarios could be designed to identify and use the strengths of the technique.

Author: D.P. Hoffmann/(615)574-3896

References:
W. Maenhaut, *Nucl. Instrum. Meth. Phys. Res.*, 1990, B49, p. 518.

INFRARED SPECTROSCOPY (LP-FTIR) CHAR-18-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings; soils

Problem Area/Constituents: Gases

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Fourier transform infrared spectroscopy (LP-FTIR)—A spectroscopic technique used for identifying and quantitating airborne substances over long paths (up to kilometers) by measuring the absorbance spectrum of the atmosphere in the infrared region. Fourier transform methodology speeds the measurement by allowing simultaneous measurement, rather than the slower sequential method of the entire absorbance spectrum.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Organic (oil, PCBs, VOCs, TCE)

Additional Comments:
Amount of waste produced—No waste is produced.
Overall cost—Capital costs are moderate.
Efficacy/strengths—It has a long path range that allows averaging of emissions over a large

area. Remote sensing is easily performed, real-time results, simultaneous multiple species identification.

Science/Technology Needs: No units currently exist on site. Several vendors are marketing equipment. Software development would enhance site-specific applications.

Implementation Needs: Centralized mounting areas with robotically controlled unit would allow multiple site areas to be monitored with one unit.

Author: D.P. Hoffmann/(615)574-3896

References:

R. H. Kagann, O.A. DeSimone, and W.F. Herget, Proc. EPA/A&WMA Int. Symposium on Toxic and Related Air Pollutants, 1989.

MICROWAVE DIGESTION

CHAR-19-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings; soils

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum
Liquids	Sludges		

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Sampling

Technology: Microwave digestion—Radiation in the microwave region is used to excite polar molecules to speed sample dissolution in closed systems.

Status:

Status Evaluation:	Accepted Demonstrated
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Radioactive (α,β,γ)

Additional Comments:
Amount of waste produced—Very low to none
Overall cost—Low capital cost

Efficacy/strengths—It has the ability to digest and extract trace elements from soils and complex matrices before analysis. This is an emerging technology.

Science/Technology Needs: This is an emerging technology that shows much promise in reducing the amount of waste produced in analyzing samples as well as increasing the quality of the data obtained.

Implementation Needs: Instrumentation is needed as well as optimizing the digestion of concrete and soil matrices.

Author: D.P. Hoffmann/(615)574-3896

References:

W.R. Kammin and M.J. Brandt, *Spectroscopy*, 1989, 4(3), p. 49.

ULTRASONIC EXTRACTION CHAR-20-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Sampling

Technology: Ultrasonic extraction

Status:

Status Evaluation:	Demonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Radioactive (α, β, γ) Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of waste—The amount produced is dependent on the sampling scenario (>5 mL).

Overall cost—Low, approximately $1K–$4K per unit
Efficacy/strengths—It utilizes low temperature, high energy, solvent extraction for removal of materials from porous media.

Science/Technology Needs: Ultrasonic units exist for a variety of purposes on site. Testing needs to be performed to establish the enhancement of material retrieval from porous media. Various solvents, acids, and bases need to be tested for extraction efficiency.

Implementation Needs: Inverse heads need to be designed for sampling from the floors and other horizontal (top side) applications.

Author: D.P. Hoffmann/(615)574-3896

References:
Personal experience and interaction with various vendors for possible applications.

CHEMOMETRIC-ASSISTED DATA ANALYSIS CHAR-21-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: Data evaluation from any characterization method

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Statistics/modeling/data assessment

Technology: Chemometric-assisted data analysis—Application of mathematical models to assist in the design of sampling and analysis procedures and in the implementation of the resulting analytical data.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Regulatory Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Radioactive (α, β, γ) Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of waste produced—N/A
Overall cost—Low, approximately $1K and up
Efficacy/strengths—It allows the full potential of data to be realized. This expanding field of data analysis has many tools to allow trends and components from multivariate data to be realized. This is a mature and growing field of data analysis.

Science/Technology Needs: Chemometric models need to be set up to handle the vast amount of data to be generated. Historic data needs to be analyzed to determine if any trends can be detected with the limited data sets that exist.

Implementation Needs: Availability of data input and interaction from robotic units are needed. Chemometric systems need to be implemented to allow data-assisted sampling and experimentation to be performed in real time.

Author: D.P. Hoffmann/(615)574-3896

References:

S.D. Brown, R.S. Bear, Jr., and T.B. Blank, *Journal of Analytical Chemistry*, 64(12), 1992, p. 23R.

ARTIFICIAL INTELLIGENCE/NEURAL NETWORKS CHAR-22-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: Data and instrument manipulation

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Statistics/modeling/data assessment

Technology: Artificial intelligence/neural networks

Status:

Status Evaluation:	Accepted Demonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Radioactive (α, β, γ) Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of waste produced—N/A
Overall cost—Approximately $1K and up
Efficacy/strengths—It allows control of instrumentation, data analysis, and interpretative analysis based upon human logic with the processing power and repetitive capabilities of computerized systems.

Science/Technology Needs: The are many areas in which artificial intelligence could enhance not only the quality of the work performed but also allow the work being performed to be optimized on a more real-time basis.

Implementation Needs: Software and model development will allow this powerful tool to be applied to the desired system.

Author: D.P. Hoffmann/(615)574-3896

References:

S.D. Brown, R.S. Bear, Jr., and T.B. Blank, *Journal of Analytical Chemistry*, 64(12), 1992, p. 41R.

IMMUNOASSAY DETECTION CHAR-23-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum
Soils	Liquids		

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Immunoassay detection

Status: Status Evaluation: Accepted

Support/Application Evaluation: Mechanical Host Disturbance
Thermal Host Disturbance
Liquid Host Disturbance
High-Energy Host Disturbance
Gas-Phase Host Disturbance
Obstructed/Limited Access to Host

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications
Automated Applications
Robotic Applications

Driver Evaluation: Regulatory
Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Organic (Oil, PCBs, VOCs, TCE, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—Low, approximately 5 ml per sample
Overall Cost—A few dollars per sample
Efficacy/Strengths—It is field portable; test kits are specifically designed for target contaminant and are easy to use. Detection limits are in ppb range.

Science/Technology Needs: This is a mature and emerging technology. Kits are designed to perform in specialized waste streams.

Implementation Needs: Automated sampling and reading systems for quick on-line processing of waste streams. We need to train on and utilize commercially-available test kits to reduce analysis costs.

Author: D. P. Hoffmann/(615)574-3896

References:
1. Vendor information (J.T. Baker, 1-800-JTBAKER)
2. K. R. Carter, *Environmental Protection*, 1992, 3(5), page 43

COLD VAPOR (MERCURY) ANALYSIS CHAR-24-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum
Liquids			

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Cold vapor (mercury) analysis—the absorption by ground-state mercury atoms when excited by a mercury-line source results in a decrease in the detected excitation energy and is related logarithmically to the number of mercury atoms in the light path.

Status: Status Evaluation: Accepted

Support/Application Evaluation:
Mechanical Host Disturbance
Thermal Host Disturbance
Liquid Host Disturbance
High-Energy Host Disturbance
Gas-Phase Host Disturbance

Temporal Areas of Evaluation:
Pretreatment
During Treatment
Posttreatment

Deployment Evaluation:
Manual Applications
Automated Applications

Driver Evaluation:
Regulatory
Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Inorganic (Hg)

February 26, 1993

Additional Comments:
Amount of Waste Produced —Approximately 5 ml per sample
Overall Cost —Approximately $15K per unit
Efficacy/Strengths —It is automated, a mature technology, EPA approved, and ppt levels.

Science/Technology Needs: This is a mature technology.

Implementation Needs: This is a mature technology.

Author: D. P. Hoffmann/(615)574-3896

References:
Vendor information (LDC Analytical, 1-800-532-4752)

FIBER-OPTIC CHEMICAL SENSORS CHAR-25-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum
Liquids	Solids		

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Fiber-optic chemical sensors

Status: Status Evaluation:	Accepted Demonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance Obstructed/Limited Access to Host
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications
Driver Evaluation:	Risk Assessment Technical Assessment

February 26, 1993

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)
Organic (Oils, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—The cost is variable, approximately $3K and up.
Efficacy/Strengths—The waveguides allow a variety of spectroscopic probes to be delivered to remote regions and to limited access areas. This technology allows remote sensing in hazardous environments and can be robotically placed within remote locations. Although this can be a "sampling" attachment for many spectroscopies, it can also be used in conjunction with a variety of physical measurements.

Science/Technology Needs: We need a combination of waveguides and spectroscopic techniques that have been matched not only for each other but also for specific monitoring scenarios.

Implementation Needs: We need waveguides that can withstand the harsh chemical environment that may be present in some of the cascade equipment scenarios.

Author: D. P. Hoffmann/(615)574-3896

References:
R. E. Dessey, *Journal of Analytical Chemistry*, 1989, 61(19), page 1079R

February 26, 1993

PARTICLE SIZE ANALYSIS CHAR-26-OG

EM Problem: Decommissioning

K-25 Site Problem:

Problem Area/Constituents: Dust and particulates

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Particle size analysis—photographic, photometric, and electrometric techniques produce size measurement and distribution data for particulates in samples of powders and slurries.

Status: Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Radioactive (α, β, γ) Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

Additional Comments:
Amount of Waste Produced—None to very little
Overall Cost—Approximately $10K and up
Efficacy/Strengths—There are a variety of particle-size determinations on the market. This is a mature technology that can collect samples for particle-size distribution, and then allow

further analysis to be performed on the collected material. There are several in situ, real-time monitoring devices, and the lower limit of detection is constantly being pushed back.

Science/Technology Needs: None, this is a mature technology.

Implementation needs: In situ devices need to be implemented for more aggressive IH/HP protection of personnel and to ensure the control (spread) of radioactive contamination.

Author: D. P. Hoffmann/(615)574-3896

References:
Vendor literature

DIFFERENTIAL OPTICAL ABSORPTION SPECTROSCOPY (DOAS) CHAR-27-OG

EM Problem: Decommissioning

K-25 Site Problem:

Problem Area/Constituents: Gases

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Differential Optical Absorption Spectroscopy (DOAS)

Status: Status Evaluation:	Accepted Demonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—
Efficacy/Strengths—It has fast response time, stable spectral emission, ppm to ppb level of detection, and it is best suited for strong ultraviolent absorbers.

February 26, 1993

DIFFERENTIAL OPTICAL ABSORPTION SPECTROSCOPY (DOAS) CHAR-27-OG

Science/Technology Needs: None

Implementation Needs: It can be implemented for direct site/scenario needs.

Author: D. P. Hoffmann/(615)574-3896

References:

Edner, et al., *Appl. Opt.*, 1986, 25, page 403

February 26, 1993

HADAMARD MASKING FOR SPATIAL RESOLUTION CHAR-28-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Hadamard masking for spatial resolution

Status: Status Evaluation:	Demonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications
Driver Evaluation:	Regulatory Risk Assessment Technical Assessment

February 26, 1993

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)
Organic (Oils, PCBs, VOCs, TCE, ...)
Radioactive (α, β, γ)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—Approximately $1K and up
Efficacy/Strengths—It allows spatial resolution or multiplexing measurements to be made with a single-channel detector. This masking technology can allow a wide variety of techniques to obtain spatially resolved information with a higher signal-to-noise ratio than a standard single-point, limiting mask.

Science/Technology Needs: Mask designs and collimator for specific applications are needed. We need to understand the scattering effects of using masks for radiation measurements.

Implementation Needs: We need masks for adaptation of radiological counters for large area analysis.

Author: D. P. Hoffmann/(615)574-3896

References:
D. P. Hoffmann; A. Proctor; and D. M. Hercules; 1989, *Appl. Spec.*, 43(6), pp. 899-907

AUTOCORRELATION AND AUTOCONVOLUTION OPTIMIZED MULTIVARIATE ANALYSIS

CHAR-29-OG

EM Problem: Decommissioning

K-25 Site Problem:

Problem Area/Constituents: Data assessment

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Statistics/modeling/data assessment

Technology: Autocorrelation and autoconvolution optimized multivariate analysis—mathematical models that enhance the information content of data by optimizing data collection and processing.

Status: Status Evaluation:	Demonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oils, PCBs, VOCs, TCE, ...) Radioactive (α, β, γ)

Additional Comments:
Amount of Waste Produced—N/A
Overall Cost—$1K and up
Efficacy/Strengths—It allows spectroscopic data to be analyzed and interpreted with minimum impact from noise. It allows the multivariate information to be fully analyzed. It increases computer searching abilities when comparing spectra with a large variation in spectral quality

February 26, 1993

AUTOCORRELATION AND AUTOCONVOLUTION OPTIMIZED MULTIVARIATE ANALYSIS

CHAR-29-OG

Science/Technology Needs: We need to establish a data base of spectroscopic responses in support of D&D efforts.

Implementation Needs: The software exists on site. We can tailor the software for direct programmatic applications.

Author: D. P. Hoffmann/(615)574-3896

References:

D. P. Hoffmann, A. Proctor, and D. M. Hercules; 1989, *Anal. Chem.*, 61(8), pp. 898-904

February 26, 1993

EXTENDED X-RAY ABSORPTION FINE STRUCTURE (EXAFS) CHAR-30-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Extended X-Ray Absorption Fine Structure (EXAFS)—A diffraction technique for crystalline materials using synchrotron radiation as a source and an C-ray spectrometer as a detector. A Fourier transform of internal oscillation frequency gives spatial information.

Status: Status Evaluation: Accepted

Support/Application Evaluation:
Mechanical Host Disturbance
Thermal Host Disturbance
Liquid Host Disturbance
High-Energy Host Disturbance
Gas-Phase Host Disturbance

Temporal Areas of Evaluation:
Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation:
Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—Varies ($500 per sample and up)
Efficacy/Strengths—It gives bonding structure and nearest neighbor interactions for non-crystalline materials. It has a wide range of elemental applications. Absorption edge and radial profiles can give insight into the amount of material present and identity of nearest neighbors.

Note: This technique would be available only at Synchrotron Centers.

Science/Technology Needs: Model studies are needed for the specific elements/matrix combinations of interest.

Implementation Needs: Access to SR at BNL-NSLS. Software and personnel exist for interpretation and experimental design.

Author: D. P. Hoffmann/(615)574-3896

References:
M. J. Fay, A. Proctor, D. P. Hoffmann, and D. M. Hercules; 1988, *Analytical Chemistry*, 60(21), pp. 1225A-1243A

POWDER X-RAY DIFFRACTION (XRD) CHAR-31-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Powder X-Ray Diffraction (XRD)

Status: Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oils, PCBs, VOCs, TCE, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—None to 5 ml per sample
Overall Cost—High capital costs for equipment, $100 and up per sample
Efficacy/Strengths—Phase identification of crystalline phases in solid samples. Approximately 1 wt% lower limit of detection. It can supply quantitative, stress/strain, and particle size information.

Science/Technology Needs: This is a mature technology. Model studies of the complex mixtures of interest are needed if quantitative analysis is desired.

Implementation Needs: None

Author: D. P. Hoffmann/(615)574-3896
(615) 576-2820 (Fax)

References:

Materials Science Department, MMES, K-25 Site, Oak Ridge, TN, 37381-7272

February 26, 1993

OPTICAL MICROSOCOPY CHAR-32-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum
Particulates		Liquids	Sludges

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Optical microscopy

Status: Status Evaluation:	Accepted Demonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—None to 1 ml per sample
Overall Cost—Approximately $5K and up
Efficacy/Strengths—This is a mature technology. A variety of optical parameters and techniques can be used to identify, document, measure, and quantify samples.

Science/Technology Needs: A particle atlas of site-specific materials is needed to allow rapid identification.

Implementation Needs: A centralized image collection system is needed to establish a site-specific database.

Author: D. P. Hoffmann/(615)574-3896

References:
Materials Science Department, MMES, K-25 Site, Oak Ridge, TN, 37381-7272

SCANNING ELECTRON MICROSCOPY (SEM) CHAR-33-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Scanning Electron Microscopy (SEM)—A focussed, high-energy beam of electrons produces secondary and back-scattered electrons when it impinges on a sample in high vacuum. Because of its high-resolution spacial characteristics, the technique is suitable for texture analysis, mapping, and corrosion studies. It is frequently coupled with X-ray excitation to extract elemental information.

Status: Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—None to 5 ml per sample
Overall Cost—High capital equipment costs
Efficacy/Strengths—It allows the documentation and analysis of very small particles. It allows sample preparation and collection to minimize the waste generated. It can magnify a sample in the range of 10x to 800,000x. It is most powerful when used in conjunction with analytical attachments (EDS, WDS, image analysis) and differing electron imaging modes.

Science/Technology Needs: This is a mature technology.

Implementation Needs: This is a mature technology.

Author: D. P. Hoffmann/(615)574-3896

References:
Materials Science Department, MMES, K-25 Site, Oak Ridge, TN, 37381-7272

TRANSMISSION ELECTRON MICROSCOPY (TEM) CHAR-34-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Transmission Electron Microscopy (TEM)—A beam of high-energy electrons is focussed onto a sample in vacuum. Resolution of less than 1 micrometer permits determination of microstructure approaching atomic dimensions, particle sizing, and microanalysis. Often coupled with X-ray techniques, this technique can be used to obtain elemental analyses.

Status: Status Evaluation: Accepted

Support/Application Evaluation:
Mechanical Host Disturbance
Thermal Host Disturbance
Liquid Host Disturbance
High-Energy Host Disturbance
Gas-Phase Host Disturbance

Temporal Areas of Evaluation:
Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation:
Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—None to 5 ml per sample
Overall Cost—High capital equipment costs
Efficacy/Strengths—It has ultrahigh resolution (down to .75 Angstrom). It is an accepted method for certain applications (e.g., asbestos, ceramics), and it has a wide range of technical applications. It is most powerful when used in conjunction with its analytical capabilities (EDS, image analysis, electron diffraction)

Science/Technology Needs: This is a mature technology.

Implementation Needs: This is a mature technology.

Author: D. P. Hoffmann/(615)574-3896

References:
Materials Science Department, MMES, K-25 Site, Oak Ridge, TN, 37381-7272

ENERGY DISPERSIVE X-RAY SPECTROSCOPY (EDS, EDX, EDAX)

CHAR-35-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Energy Dispersive X-Ray Spectroscopy (EDS, EDX, EDAX)

Status: Status Evaluation: Accepted

Support/Application Evaluation:
Mechanical Host Disturbance
Thermal Host Disturbance
Liquid Host Disturbance
High-Energy Host Disturbance
Gas-Phase Host Disturbance

Temporal Areas of Evaluation:
Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation:
Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—None to 5 ml per sample
Overall Cost—High capital equipment costs
Efficacy/Strengths—It allows rapid elemental analysis (Be and up) and quantitative analysis of solid samples. It is typically used in conjunction with electron microscopy. Although the detection limit is roughly 1 wt%, that is the detection limit of the area of the sample that is being probed. Thus, it is possible to analyze the individual materials that are present in the ppm range and lower.

Science/Technology Needs: None

Implementation Needs: None

Author: D. P. Hoffmann/(615)574-3896

References:
Materials Science Department, MMES, K-25 Site, Oak Ridge, TN, 37381-7272

WAVELENGTH DISPERSIVE X-RAY SPECTROSCOPY (WDS, WDX) CHAR-36-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Wavelength Dispersive X-Ray Spectroscopy (WDS, WDX)—

Status: Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

February 26, 1993

WAVELENGTH DISPERSIVE X-RAY SPECTROSCOPY (WDS, WDX) CHAR-36-OG

Additional Comments:
Amount of Waste Produced—None to 5 ml per sample
Overall Cost—High capital equipment costs
Efficacy/Strengths—It allows rapid elemental analysis (Be and up) and quantitative analysis of solid samples. It is typically used in conjunction with electron microscopy. Although the detection limit is roughly 1 wt%, that is the detection limit of the area of the sample that is being probed. Thus, it is possible to analyze the individual materials that are present in the ppm range and lower.

Science/Technology Needs: None

Implementation Needs: None

Author: D. P. Hoffmann/(615)574-3896

References:
Materials Science Department, MMES, K-25 Site, Oak Ridge, TN, 37381-7272

February 26, 1993

ELECTRON DIFFRACTION (ED, SAED, LEED) CHAR-37-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Electron Diffraction (ED, SAED, LEED)—

Status: Status Evaluation: Accepted

Support/Application Evaluation:
Mechanical Host Disturbance
Thermal Host Disturbance
Liquid Host Disturbance
High-Energy Host Disturbance
Gas-Phase Host Disturbance
Obstructed/Limited Access to Host

Temporal Areas of Evaluation:
Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation:
Risk Assessment
Technical Assessment
Regulatory

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—None to 1 ml per sample
Overall Cost—High capital equipment costs
Efficacy/Strengths—When used in conjunction with transmission electron microscopy, it can provide phase identification of submicron particulates and impurities in a host matrix. It allows asbestos identification.

Science/Technology Needs: None

Implementation Needs: None

Author: D. P. Hoffmann/(615)574-3896

References:
Materials Science Department, MMES, K-25 Site, Oak Ridge, TN, 37381-7272

NONDESTRUCTIVE TESTING (NDT) FOR CONCRETE — CHAR-38-OG

EM Problem: Decommissioning

K-25 Site Problem: Process structures

Problem Area/Constituents: Concrete

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Nondestructive Testing (NDT) for Concrete—

Status: Status Evaluation:	Accepted Demonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance Obstructed/Limited Access to Host
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Manual Applications Robotic Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—Variable
Efficacy/Strengths—It has the ability to predict the strength and capabilities of concrete without imparting any physical damage to the existing structure.

February 26, 1993

NONDESTRUCTIVE TESTING (NDT) FOR CONCRETE CHAR-38-OG

Science/Technology Needs: Testing protocols for evaluating and characterizing large concrete structures.

Implementation Needs: Testing plan for Site buildings. Field testing kit for Site-wide deployment.

Author: D. P. Hoffmann/(615)574-3896

References:
J. R. Clifton; Dialog File No. 265/266, ID No. 62266

February 26, 1993

000086

INORGANIC CEMENTITOUS MATRIX COMPOSITES CHAR-39-OG

EM Problem: Decommissioning

K-25 Site Problem: Process structures

Problem Area/Constituents: Concrete

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Statistics/modeling/data assessment

Technology: Inorganic cementitous matrix composites

Status: Status Evaluation:	Demonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Radioactive (α, β, γ)

Additional Comments:
Amount of Waste Produced—N/A
Overall Cost—
Efficacy/Strengths—It determines the structural properties of cementitous materials and how they evolve and interact with other materials. This will lead to a better understanding of concrete/contaminant interactions and should allow optimization of various sampling and decontamination protocols.

Science/Technology Needs: Characterization of the variations in the cement for the various structures of interest is needed; and matrix/contaminant interaction studies need to be performed.

Implementation Needs: Collaboration with BNL researchers is recommended.

Author: D. P. Hoffmann/(615)574-3896

References:
T. Sugama; Dialog File No. 265/266; ID No. 55022; AS-253-EECD

RADIOGRAPHIC IMAGING CHAR-40-OG

EM Problem: Decommissioning

K-25 Site Problem: Process structures, process systems

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Radiographic imaging

Status: Status Evaluation: Accepted

Support/Application Evaluation:
Mechanical Host Disturbance
Thermal Host Disturbance
Liquid Host Disturbance
High-Energy Host Disturbance
Gas-Phase Host Disturbance

Temporal Areas of Evaluation:
Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation:
Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Radioactive (α, β, γ)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—Medium to high capital equipment cost
Efficacy/Strengths—Digital radiography can be used to determine the status of low-level nuclear waste forms. Classical radiography can be used to provide spatial distribution information for radiological contaminants.

Science/Technology Needs: Scattering and attenuation factors that the host matrix has on the radiograph need to be better understood.

Implementation Needs: A laboratory dedicated to radiography imaging would greatly facilitate the application of this technology.

Author: D. P. Hoffmann/(615)574-3896

References:
R. T. Bernardi; Dialog File No. 265/266; ID No. 54711

COMPUTER TOMOGRAPHY (CT) CHAR-41-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Computer Tomography (CT)

Status: Status Evaluation: Accepted

Support/Application Evaluation:
Mechanical Host Disturbance
Thermal Host Disturbance
Liquid Host Disturbance
High-Energy Host Disturbance
Gas-Phase Host Disturbance
Obstructed/Limited Access to Host

Temporal Areas of Evaluation:
Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation:
Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—High capital equipment costs
Efficacy/Strengths—This is a nondestructive imaging technique that can characterize low-level nuclear waste for water content.

Science/Technology Needs: Technology is being developed and may be applicable to many scenarios.

Implementation Needs: Implementation needs are uncertain at this time.

Author: D. P. Hoffmann/(615)574-3896

References:
R. T. Bernardi; Dialog File No. 265/266; ID No. 54711

RADIATION-INDUCED SEGREGATION (RIS) CHAR-42-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Structural Steel	Porous Nickel	Sheet Metal
Pipes	Copper Wiring	Cylinders
Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper
Aluminum		

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Statistics/modeling/data assessment

Technology: Radiation-Induced Segregation (RIS)

Status: Status Evaluation:	Demonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Radioactive (α,β,γ)

Additional Comments:
Amount of Waste Produced—N/A

February 26, 1993

Overall Cost—
Efficacy/Strengths—This model can lead to a better understanding of the migration of contaminants and the creation of defect sites in materials due to radiation effects.

Science/Technology Needs: Models need to be used to determine if, in the highly-enriched cascade equipment, the enrichment and temperature combinations allow for an enhancement of defect sites, which may cause a variability in decontamination or dismantlement.

Implementation Needs: Same as above.

Author: D. P. Hoffmann/(615)574-3896

References:
L. E. Rehn; Dialog File No. 265/266, ID No. 795; 58403

RADIATION-ENHANCED DIFFUSION (RED) CHAR-43-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Porous Nickel
Sheet Metal	Pipes	Copper Wiring
Cylinders	Metal Equipment	Instruments
Nickel-Lined Steel	Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)
Copper	Aluminum	

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Statistics/modeling/data assessment

Technology: Radiation-Enhanced Diffusion (RED)

Status: Status Evaluation:	Demonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Radioactive (α, β, γ)

February 26, 1993

Additional Comments:
Amount of Waste Produced—N/A
Overall Cost—
Efficacy/Strengths—This model can lead to a better understanding of the migration of contaminants and the creation of defect sites in materials due to radiation effects.

Science/Technology Needs: Models need to be used to determine if, in the highly-enriched cascade equipment, the enrichment and temperature combinations will allow for an enhancement of defect sites, which may cause a variability in decontamination or dismantlement.

Implementation Needs: Same as above.

Author: D. P. Hoffmann/(615)574-3896

References:
L. E. Rehn; Dialog File No. 265/266, ID No. 795; 58403

CRITICALITY INDICES (CI) CHAR-44-OG

EM Problem: Decommissioning

K-25 Site Problem: Process structures, process systems

Problem Area/Constituents: Fissionable materials

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Statistics/modeling/data assessment

Technology: Criticality Indices (CI)

Status: Status Evaluation:	Accepted
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Regulatory Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Radioactive (α, β, γ)

Additional Comments:
Amount of Waste Produced—N/A
Overall Cost—
Efficacy/Strengths—It allows one to quickly identify the criticality needs of D&D efforts as the enrichment level of the contaminant waste stream varies.

Science/Technology Needs: The program must be implemented to specifically address the D&D technologies to be implemented and suggest the modifications that are needed for low- versus high-enrichment materials.

Implementation Needs: Same as above.

Author: D. P. Hoffmann/(615)574-3896

References:
B. L. Broadhead; Dialog File No. 265/266; ID No. 66669

SUBSURFACE COMPLEXATION CHAR-45-OG

EM Problem: Decommissioning

K-25 Site Problem: Soils and groundwater

Problem Area/Constituents: Concrete, soils, porous media

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Statistics/modeling/data assessment

Technology: Subsurface complexation

Status: Status Evaluation:	Demonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Radioactive (α, β, γ) Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—N/A
Overall Cost—
Efficacy/Strengths—This modeling and our understanding of it will allow a more logical choice of decontamination technologies and an understanding of where contaminants may be located during environmental restoration activities.

Science/Technology Needs: Models need to implemented that take into account the geological formations that exist within the Oak Ridge Reservation.

February 26, 1993

Implementation Needs: Same as above.

Author: D. P. Hoffmann/(615)574-3896

References:
D. L. Perry; Dialog File No. 265/266; ID No. 51826, ESD-60

HOLOGRAPHIC IMAGING CHAR-46-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Holographic imaging

Status: Status Evaluation: Accepted

Support/Application Evaluation:
Mechanical Host Disturbance
Thermal Host Disturbance
Liquid Host Disturbance
High-Energy Host Disturbance
Gas-Phase Host Disturbance

Temporal Areas of Evaluation:
Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation:
Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: N/A

February 26, 1993

Additional Comments:
Amount of Waste Produced—None
Overall Cost—
Efficacy/Strengths—It allows in situ measurements to be made of the stress/strain distribution over large areas. This will be extremely useful in understanding the risks in removing large pieces of equipment and in the application of high-pressure or high-energy decontamination techniques to equipment.

Science/Technology Needs: This is a mature technology.

Implementation Needs: We need a holographic imaging laboratory with field-portable units to allow holographic imaging of permanently-mounted components.

Author: D. P. Hoffmann/(615)574-3896

References:
MMES staff members

MOSSBAUER SPECTROSCOPY CHAR-47-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Mossbauer spectroscopy

Status: Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance Obstructed/Limited Access to Host
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—None
Overall Cost—Medium capital equipment costs
Efficacy/Strengths—It is ultrahigh resolution spectroscopy, although it is limited to isotope pairs that have overlapping excitation lines. The use of synchrotron radiation is growing as a means to broaden the use of this technique.

Science/Technology Needs: This is a mature technology.

Implementation Needs: None

Author: D. P. Hoffmann/(615)574-3896

References:
MMES staff members

ISOTOPIC DILUTION MASS SPECTROSCOPY (IDMS) CHAR-48-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Isotope Dilution Mass Spectrometry (IDMS)—A method for quantitative determination of concentrations of elemental species by incorporation in the sample of a standard that contains one or more isotopes of the element of interest.

Status: Status Evaluation: Accepted

Support/Application Evaluation:
- Mechanical Host Disturbance
- Thermal Host Disturbance
- Liquid Host Disturbance
- High-Energy Host Disturbance
- Gas-Phase Host Disturbance

Temporal Areas of Evaluation:
- Pretreatment
- During Treatment
- Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation:
- Risk Assessment
- Technical Assessment

Applicable Contaminant Evaluation:
- Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)
- Organic (Oil, PCBs, VOCs, TCE, ...)
- Radioactive (α,β,γ)

February 26, 1993

Additional Comments:
Amount of Waste Produced—None to approximately 5 ml per sample
Overall Cost—High capital equipment costs
Efficacy/Strengths—It is able to measure the natural levels of long-lived fission products (Tc, I) and neutron-capture product (Pu) as low as 10^7 atoms.

Science/Technology Needs: Model studies are needed to enable quick analysis of U and Tc ratios to determine the extent of Tc that may be expected for various stages of the cascade equipment.

Implementation Needs: Equipment is needed, as well as the model studies mentioned above.

Author: D. P. Hoffmann/(615)574-3896

References:
D. B. Curtis; Dialog File No. 265/266; ID No. 25825; ERWE552C

Tc GEOCHEMISTRY CHAR-49-OG

EM Problem: Decommissioning

K-25 Site Problem: Soils and groundwater

Problem Area/Constituents: Soil, groundwater

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Statistics/modeling/data assessment

Technology: Tc geochemistry

Status: Status Evaluation:	Demonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Radioactive (α, β, γ)

Additional Comments:
Amount of Waste—None
Overall Cost—
Efficacy/Strengths—It allows a better understanding of the associations of Tc with other uranium ores and geological structures. This information will assist in both understanding how to contain Tc and how to best perform decontamination and restoration activities.

Science/Technology Needs: A better understanding of the association of Tc and its environmental matrices is needed.

February 26, 1993

Implementation Needs: Same as above.

Author: D. P. Hoffmann/(615)574-3896

References:
D. B. Curtis; Dialog File No. 265/266; ID No. 25825; ERWE552C

ION CHROMATOGRAPHY (IC) CHAR-50-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum
Liquids			

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Ion Chromatography (IC)

Status: Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications
Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—None to 100 ml per sample
Overall Cost—Low capital equipment costs
Efficacy/Strengths—It has the ability to separate and quantify ions in solution (ppm to ppb detection limits depending upon the matrix effects). It can be automated and can perform in some on-line process applications.

Science/Technology Needs: A detector system that is optimized for the expected waste streams that will be generated needs to be determined. This type of system can be used for process control of waste generation.

Implementation Needs: We have systems available for process control of D&D efforts.

Author: D. P. Hoffmann/(615)574-3896

References:
P. R. Haddad; Dialog File No. 265/266; ID No. 25460

IN SITU MEASUREMENT OF NATURAL GAMMA EMITTERS CHAR-51-OG

EM Problem: Decommissioning

K-25 Site Problem:

Problem Area/Constituents: Concrete, wood, tile, soils

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: In situ measurement of natural gamma emitters

Status: Status Evaluation:	Demonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Radioactive (α, β, γ)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—Medium to high capital equipment costs
Efficacy/Strengths—It gives the ability to obtain an accurate measure of gamma emitters to determine background levels and can also be used to monitor for small changes in the gamma emitters concentration around a D&D site, which is very important.

Science/Technology Needs: This is a mature technology.

February 26, 1993

Implementation Needs: Modification to existing equipment is needed, and calibration facilities to allow in situ measurements of low-level components must be provided.

Author: D. P. Hoffmann/(615)574-3896

References:

B. L. Dickson; Dialog File No. 265/266; ID No. 24670

ADVANCED METHODS OF PERSONNEL MONITORING CHAR-52-OG

EM Problem: Decommissioning

K-25 Site Problem:

Problem Area/Constituents: Personnel clothing, personnel

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Statistics/modeling/data assessment

Technology: Advanced methods of personnel monitoring

Status: Status Evaluation:	Demonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Regulatory Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Radioactive (α, β, γ) Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—Variable (none to approximately <100 ml per sample)
Overall Cost—Variable
Efficacy/Strengths—It defines quantitative measurements of uranium in human components (hair, blood, nails) that can be used to verify exposure, both past and present. This benchmarking will not only allow best health monitoring of workers but will also limit future liabilities.

February 26, 1993

Science/Technology Needs: Model studies are needed to correlate exposure and quantitative analysis from various human factors.

Implementation Needs: We need a detailed monitoring program for personnel protection.

Author: D. P. Hoffmann/(615)574-3896

References:
University of Sidney, Dialog File No. 265/266; ID No. 24317

MIGRATION OF VOCs IN POROUS MATERIALS CHAR-53-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Roofing Materials	Tile
Wood	Transite	Asbestos Insulation
Gaskets	Soils	

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Statistics/modeling/data assessment

Technology: Migration of VOCs in porous materials

Status: Status Evaluation: Demonstration

Support/Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—N/A
Overall Cost—
Efficacy/Strengths—A better understanding of the migration of VOCs in porous materials will allow better predictions as to the extent of remediation or decontamination that is required for their disposal. This understanding will also allow a more intelligent application of solvent decontamination technologies for use on porous media.

February 26, 1993

MIGRATION OF VOCs IN POROUS MATERIALS CHAR-53-OG

Science/Technology Needs: Models need to be developed that are applicable to Site-specific scenarios.

Implementation Needs: Software and hardware are needed to implement the modeling systems.

Author: D. P. Hoffmann/(615)574-3896

References:

R. B. Wallace; Dialog File No. 265/266; ID No. 2P42ES04911-04 0004

February 26, 1993

MEMBRANE TECHNOLOGY FOR SAMPLE COLLECTION AND CONCENTRATION

CHAR-55-OG

EM Problem: Decommissioning

K-25 Site Problem:

Problem Area/Constituents: Liquids and gases

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Sampling

Technology: Membrane technology for sample collection and concentration—membranes permeable predominantly to selected components in mixtures separate for accumulation or to facilitate analysis/detection.

Status: Status Evaluation:	Accepted Demonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications
Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...) Radioactive (α, β, γ)

February 26, 1993

Additional Comments:
Amount of Waste Produced—None
Overall Cost—Low
Efficacy/Strengths—The use of membrane technology can assist in a large number of characterization and decontamination scenarios. The ability to utilize membranes for the selective separation and concentration of contaminant allows the contaminant to be identified by cheaper, less-sensitive (typically), field-portable instrumentation.

Science/Technology Needs: System development or adaptation for specific applications; validation.

Implementation Needs: Sample collection systems for Site-specific applications.

Author: D. P. Hoffmann/(615)574-3896

References:
J. M. Radovich; Dialog File No. 265/266; ID No. 008194

GLOW DISCHARGE IONIZATION MASS SPECTROSCOPY

CHAR-56-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum
Liquids			

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Glow discharge ionization mass spectroscopy

Status: Status Evaluation: Accepted

Support/Application Evaluation:
Mechanical Host Disturbance
Thermal Host Disturbance
Liquid Host Disturbance
High-Energy Host Disturbance
Gas-Phase Host Disturbance

Temporal Areas of Evaluation:
Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation:
Risk Assessment
Technical Assessment
Regulatory

Applicable Contaminant Evaluation:
Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)
Organic (Oil, PCBs, VOCs, TCE, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—None to approximately 5 ml per sample
Overall Cost—High capital costs
Efficacy/Strengths—It allows on-site monitoring of organic compounds in a variety of host matrices. Quantitation down to the ppb level is possible. It is rugged and portable.

Science/Technology Needs: Model studies are needed of host interactions and interference for quantitative analysis.

Implementation Needs: Some instrumental and development needs still exist.

Author: D. P. Hoffmann/(615)574-3896

References:
C. P. McGinnis; Dialog File No. 265/266; ID No. 30296

ENVIRONMENTAL DYNAMICS OF ORGANIC COMPOUNDS CHAR-57-OG

EM Problem: Decommissioning

K-25 Site Problem:

Problem Area/Constituents: Soils, groundwater

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Statistics/modeling/data assessment

Technology: Environmental dymanics of organic compounds

Status: Status Evaluation:	Demonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—N/A
Overall Cost—
Efficacy/Strengths—A better understanding of the interactions of organic compounds of interest and their environmental hosts will allow a better understanding of not only how to characterize them but also decontaminate them.

Science/Technology Needs: Site-specific models are needed.

February 26, 1993

Implementation Needs: Same as above.

Author: D. P. Hoffmann/(615)574-3896

References:
C. T. Chiou; Dialog File No. 265/266; ID No. CR-83-283

MAGNETIC RESONANCE IMAGING (MRI, NMRI) CHAR-58-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Magnetic Resonance Imaging (MRI, NMRI)

Status: Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...) Radioactive (α, β, γ)

February 26, 1993

Additional Comments:
Amount of Waste Produced—None
Overall Cost—High capital equipment costs
Efficacy/Strengths—This mature, yet growing, technology has the potential of allowing nondestructive inspection of internal structure of materials and evaluating for system integrity. This type of technology may provide very useful information not only for identifying how to dismantle an unknown but also for verifying the status of waste form integrity.

Science/Technology Needs: Model studies are needed for waste forms and various equipment parts.

Implementation Needs: Instrumentation is needed.

Author: D. P. Hoffmann/(615)574-3896

References:
M. P. Andre; Dialog File No. 265/266; ID No. 0004; 83381; 664

CONTINUOUS AIR MONITORING (CAM) CHAR-59-OG

EM Problem: Decommissioning

K-25 Site Problem:

Problem Area/Constituents: Dust, particulates

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives:
Sampling
In situ characterization/monitoring

Technology: Continuous Air Monitoring (CAM)—Apparatus designed to provide continuous sampling of air uses a variety of detection methods to identify and quantify components in the air stream.

Status: Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications
Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Radioactive (α, β, γ) Organic (Oil, PCBs, VOCs, TCE, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—None to very little
Overall Cost—Low
Efficacy/Strengths—Optimizing the methods used for large-area or large-scale air monitoring will better allow characterization and monitoring studies to be performed. These studies will provide insight into the spread of contamination and how to best monitor for it.

Science/Technology Needs: This is a mature sampling technology.

Implementation Needs: This is a mature technology.

Author: D. P. Hoffmann/(615)574-3896

References:
M. D. Hoover; Dialog File No. 265/266; ID No. 62466

TOMOGRAPHIC SEISMIC MONITORING (TSI) CHAR-60-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Tomographic Seismic Monitoring (TSI)

Status: Status Evaluation: Accepted

Support/Application Evaluation: Mechanical Host Disturbance
Thermal Host Disturbance
Liquid Host Disturbance
High-Energy Host Disturbance
Gas-Phase Host Disturbance

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—None
Overall Cost—
Efficacy/Strengths—This imaging toll can allow the quantitation of the interaction between soil type and transport properties of toxic wastes. This information will have great potential of allowing better sampling locations to be determined, leading to better characterization, as well as allowing a better determination of the area to be characterized.

Science/Technology Needs:

Implementation Needs:

Author: D. P. Hoffmann/(615)574-3896

References:
MMES staff members

CORRELATION OF HOST MATRIX POROSITY WITH COLLECTION EFFICIENCY: STANDARDIZED METHODS

CHAR-61-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Roofing Materials	Tile
Wood	Transite	Asbestos Insulation
Gaskets	Soil	

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Sampling

Technology: Correlation of host matrix porosity with collection efficiency: standardized methods

Status:

Status Evaluation:	Evolving Technology (Conceptual)
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Radioactive (α, β, γ) Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—N/A
Overall Cost—
Efficacy/Strengths—This method would use chemometric-based data analysis to compare

collection of contaminant during sampling as a function of the host matrix porosity and collection method.

Science/Technology Needs: An experimental design and models need to be established.

Implementation Needs: A study needs to be performed.

Author: D. P. Hoffmann/(615)574-3896

References:
D. P. Hoffmann, K-25 Site

VACUUM-ASSISTED, REVERSE FLOW, SOLVENT EXTRACTION METHODS

CHAR-62-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Roofing Materials	Tile
Wood	Porous Nickel	Transite
Asbestos Insulation	Gaskets	Porous Aluminum
Soil		

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Sampling

Technology: Vacuum-assisted, reverse flow, solvent extraction methods

Status:

Status Evaluation:	Evolving Technology (Conceptual)
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Radioactive (α, β, γ) Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—5-100 ml per sample
Overall Cost—Low

February 26, 1993

VACUUM-ASSISTED, REVERSE FLOW, SOLVENT EXTRACTION METHODS

CHAR-62-OG

Efficacy/Strengths—In this method, sampling is obtained by low-angle drilling through the host matrix to a point that is within the diffusion boundary of the porous media; feeding a solvent into the drill hole; and using a vacuum device to pull the solvent through the contaminated matrix and collect the contaminant and solvent.

Science/Technology Needs: Model studies are needed.

Implementation Needs: Model studies are needed.

Author: D. P. Hoffmann/(615)574-3896

References:

D.P. Hoffmann, K-25 Site

February 26, 1993

SCREENING METHODS FOR CLASSIFIED MATERIALS CHAR-63-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum
Liquids	Gases		

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Screening methods for classified materials

Status:

Status Evaluation:	Accepted Demonstration Evolving Technology (Conceptual)
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Radioactive (α, β, γ) Organic (Oil, PCBs, VOCs, TCE, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—Variable
Overall Cost—
Efficacy/Strengths—Quick screening and characterization methods for classified material can lead to safer and more efficient use of manpower and storage resources when working (D&D or ER) in a suspect classified material area.

Science/Technology Needs: Technique development is needed.

Implementation Needs: Model studies are needed.

Author: D. P. Hoffmann/(615)574-3896

References:
D.P. Hoffmann, K-25 Site

MULTIANGLE DRILLING FOR DEPTH PROFILING OF CONTAMINANTS

CHAR-64-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum
Soils			

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Sampling

Technology: Multiangle drilling for depth profiling of contaminants

Status:

Status Evaluation:	Demonstration Evolving Technology (Conceptual)
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Manual Applications Robotic Applications
Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Radioactive (α, β, γ) Organic (Oil, PCBs, VOCs, TCE, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—Variable
Overall Cost—Low
Efficacy/Strengths—Although core drilling is a preferred technique to removal of a sample that remains spatially resolved, it is not always possible to do so. Multiangle drilling should allow a summation of depth artifacts to be determined through analysis of each sample collected. This system can utilize standard drilling equipment.

Science/Technology Needs: Model studies need to be performed

Implementation Needs: Model studies need to be performed.

Author: D. P. Hoffmann/(615)574-3896

References:
D.P. Hoffmann, K-25 Site

SMALL LONG-RANGE ALPHA DETECTOR (LRAD) CHAR-65-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified. DOE Order 5400.5, ANSI N13.12, and NRC 5

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Small Long-Range Alpha Detector (LRAD)

Status:

Status Evaluation:	Demonstration
Support/Application Evaluation:	Mechanical Host Disturbance Obstructed/Limited Access to Host
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications
Driver Evaluation:	Regulatory Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Radioactive (α, β, γ)

Additional Comments:
Amount of Waste Produced—None

February 26, 1993

Overall Cost—$10K per device
Efficacy/Strengths—It actively detects surfaces/objects contaminated at or below release limits. It measures ionized air drawn from a container holding a contaminated object, irrespective of shape.

Science/Technology Needs: All types of D&D characterizations and cleanup certifications are needed.

Implementation Needs: Suitable niche applications (viz-a-viz other passive alpha monitoring devices such as alpha track detectors and electrets) need to be identified.

Author: Richard Gammage/(615)574-6256
References:
Los Alamos publication, LA-12199-MS

GAS CHROMATOGRAPHY-FOURIER TRANSFORM INFRARED SPECTROSCOPY (GC-FTIR) CHAR-66-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum
Collected Air Samples			

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory Characterization and Analysis

Technology: Gas Chromatography-Fourier Transform Infrared Spectroscopy (GC-FTIR)—

Status:

Status Evaluation:	Demonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE, ...)

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Additional Comments:
Amount of Waste Produced—<1 ml per day (not including standard preparation)
Overall Cost:—Approximately $200K for instrumentation
Efficacy/Strengths—GC-FTIR combines the separation capabilities of gas chromatography with the structural identification capabilities of Fourier transform infrared spectroscopy. The technique is complementary to gas chromatography—mass spectroscopy.

Science/Technology Needs: Specific methods for targeted analytes and general methods for unknown identification need to be developed. Software for data interpretation needs to be developed, and different commercial interface configurations for desired characteristics (sensitivity, reproducibility, etc.) need to be evaluated.

Implementation Needs: Normal

Author: G.B.H.

References:
Review articles:
C. L. Putzig et al., *Analytical Chemistry*, 1992, 64, 270R-302R (especially pp. 288-9)
G. A. Eiceman, et al., *Analytical Chemistry*, 1992, 64, 170R-180R (especially p. 175R)

GC-FTIR manufacturers:
Biorad/Digilab, Cambridge, MA, (617) 499-4519
Mattson, Madison, WI, (608) 831-5515
Nicolet, Madison, WI, (800) 346-7288

METALLOGRAPHIC SECTIONING AND PREPARATION CHAR-67-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment Process Buildings

Problem Area/Constituents

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Aluminum	Copper

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Sampling

Technology: Metallographic sectioning and preparation

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications
Driver Evalutation:	Risk Assessment Technical Assessment

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Applicable Contaminant Evaluation: Radioactive
Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

Additional Comments:
Amount of Waste Produced—~1 liter liquid and spent abrasive per 1-6 samples
Overall Cost—<$500
Efficacy/Strengths—Provides representative sample showing contaminant depth distribution.

Science/Technology Needs: Procedure development for specific applications are needed; then protocols for standardized preparation should be developed.

Implementation Needs: None. Facilities available (See also core drilling).

Author: G. C. Marsh

References:
Technique is used routinely for preparation of metallic, ceramic, and geological materials.

CONVENTIONAL LEAK DETECTION METHODS USING GAS DETECTION EQUIPMENT BEFORE INDUCTION OF TREATMENT GAS INTO PROCESS SYSTEMS

CHAR-68-OG

EM Problem: Decommissioning

K-25 Site Problem: Process structures, process systems

Problem Area/Constituents: Pipes, cylinders, and piping sections composed of interstage cell components, including cylinders

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Conventional leak detection methods using gas detection equipment before induction of treatment gas into process systems

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment
Deployment Evaluation:	N/A
Driver Evaluation:	N/A
Applicable Contaminant Evaluation:	N/A

Additional Comments:
Amount of Waste Produced—None
Overall Cost—It is relatively inexpensive, and the equipment exists in-plant.
Efficacy/Strengths—It allows detection of all sizes of leaks in process piping system before treatment.

Science/Technology Needs: The technology is well established.

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CONVENTIONAL LEAK DETECTION METHODS USING GAS DETECTION EQUIPMENT BEFORE INDUCTION OF TREATMENT GAS INTO PROCESS SYSTEMS

CHAR-68-OG

Implementation Needs: None

Author: H. E. Philpot

References:
MMES staff members

February 26, 1993

ACOUSTIC EMISSION CHAR-69-OG

EM Problem: Decommissioning

K-25 Site Problem: Process structures, process systems

Problem Area/Constituents: Pipes, cylinders, and cylinders containing material that would produce a "noise" signal due to pressure-driven leaks or internal gas reactivity

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Acoustic emission

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	N/A
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—It will be relatively inexpensive using existing in-house equipment
Efficacy/Strengths—It can detect pressure-driven "noise" or gas reactivity "noise" during all treatment phases. It is primarily a pretreatment for pressure-driven leak detection. It could be used to detect areas of high energy gas reactivity during treatment/posttreatment.

Science/Technology Needs: This technology is well established.

February 26, 1993

Implementation Needs: None

Author: H. E. Philpot

References:
MMES staff members

February 26, 1993

ULTRASONIC LEAK DETECTION CHAR-70-OG

EM Problem: Decommissioning

K-25 Site Problem: Process structures, process systems

Problem Area/Constituents: Pipes, cylinders, and pipe sections composed of interstage cell components (including cylinders)

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Ultrasonic leak detection

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment
Deployment Evaluation:	N/A
Driver Evaluation:	N/A
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—It is relatively inexpensive. Equipment exists in-plant.
Efficacy/Strengths—It allows detection of gross pressure-driven leaks in the process system before treatment.

Science/Technology Needs:

Implementation Needs:

Author: H. E. Philpot

References: MMES staff members

February 26, 1993

OPTIMIZATION OF SAMPLING DESIGNS CHAR-71-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment Process Buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Sampling

Technology: Optimization Of Sampling Designs—Research and development into the statistical aspects of sampling such diverse, extensive media.

Status:

Status Evaluation:	Demonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications
Driver Evaluation:	Regulatory Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Radioactive (α, β, γ) Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

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Additional Comments:

Efficacy/Strengths—Appropriate sampling designs can prevent obtaining too little information when sampling is complete or spending too much money on a more than adequate number of samples.

Science/Technology Needs: Literary searches for finding useful sampling designs from investigations in other fields. New statistical methods for sampling design.

Implementation Needs: Normal

Author: J. L. Bock

References: K-25 Site Statistical Services

DATA BASE MANAGEMENT FOR LARGE QUANTITIES OF DATA CHAR-72-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Data management

Technology: Data base Management for Large Quantities of Data—Brings together data base management procedures and software that will effectively manage the data produced from a full-scale D&D effort.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Radioactive (α, β, γ) Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

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Additional Comments:

Efficacy/Strengths—Generating large amounts of data is useless unless the data are reliable and there are ways to readily make use of it.

Science/Technology Needs: Data management procedures and techniques need to be found or developed that will readily allow for statistical manipulation and visual display of large quantities of data. Procedures will need to be developed to ensure the integrity of the data. This is extremely important when modifications and additions to the database could come from many different sources.

Implementation Needs: Normal

Author: J. L. Bock

References: Geodata Group, MMES Engineering, K-25 Statistical Services

VISUAL DISPLAY OF STATISTICAL INFORMATION CHAR-73-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: N/A

Technology: Visual Display Of Statistical Information—Incorporation of currently available and soon-to-be available visualization software with the D&D database.

Technology Status:

Status Evaluation:	Demonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Radioactive (α, β, γ) Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

Science/Technology Needs: We need integration of statistics software and a database system with graphic display capabilities. Currently, a Geographic Information System (GIS)

comes the closest to meeting this need. New techniques for graphic data display may need to be developed to aid scientists and regulators in their understanding of complex contamination scenarios.

Implementation Needs: Normal

Author: J. L. Bock

References: K-25 Site Statistical Services

STATISTICAL METHODS FOR MULTIVARIATE DATA — CHAR-74-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: N/A

Technology: Statistical Methods For Multivariate Data—Research and development in the field of multivariate statistics

Status:

Status Evaluation:	Demonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Radioactive (α, β, γ) Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

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STATISTICAL METHODS FOR MULTIVARIATE DATA CHAR-74-OG

Science/Technology Needs: Due to the complex nature of contamination from many different sources, new methods will need to be found or developed that will further our understanding of multiconstituent contamination.

Implementation Needs: Normal

Author: J. L. Bock

References: K-25 Site Statistical Services

February 26, 1993

STATISTICAL METHODS FOR SPATIALLY CORRELATED DATA CHAR-75-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Statistics/Modeling/Data assessment

Technology: Statistical Methods For Spatially Correlated Data—Research and development of geostatistical techniques and methods in the D&D arena.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Manual Applications Automatic Applications Robotic Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Radioactive (α, β, γ) Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

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Additional Comments:

Efficacy/Strengths—The use of spatial statistics and kriging (geostatistics) has been demonstrated successfully for a number of years in the mining and petroleum industries.

Science/Technology Needs: Easy-to-use kriging software will need to be found or developed.

Implementation Needs: Normal

Author: Normal

References: K-25 Site Statistical Services

ATOMIC SPECTROSCOPY (AA, AE) CHAR-76-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Note: It can be used for trace analysis for metals in all the above materials.

Soil	Airborne Particulates	Water

Reference Requirements: EPA regulations, ASTM methods. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Atomic spectroscopy (AA, AE)

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications
Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—Very small quantities (<10 ml) of aqueous waste
Overall Cost—$25-$50 per metal determined
Efficacy/Strengths—It is a standard, well-accepted methodology for highly-sensitive and selective determination of single metals.

Science/Technology Needs: The technology is well-developed and applicable as is.

Implementation Needs: Technology is available at the K-25 Site.

Author: J. R. Stokely

References: EPA regulations; Office of Solid Waste (SW-846), EPA CLP SOW 88, ASTM methods.

INDUCTIVELY COUPLED PLASMA SPECTROSCOPY (ICP) CHAR-77-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Note: It can be used for trace analysis for metals in all the above materials.

Soil	Airborne Particulates	Water

Reference Requirements: EPA regulations, ASTM methods. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Inductively coupled plasma spectroscopy (icp)

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications
Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—Small quantities (<10 ml) of aqueous waste
Overall Cost—$100-$150 per multielement analysis of metals
Efficacy/Strengths—It is a standard, well-accepted methodology. It allows multielement analyses (up to 50 elements).

Science/Technology Needs: It is applicable as is. This is a well-developed technology.

Implementation Needs: It is available at K-25 Site.

Author: J. R. Stokely

References: EPA regulations, Office of Solid Waste (SW 846), EPA CLP SOW 88, ASTM Methods Manuals

INDUCTIVELY COUPLED PLASMA—MASS SPECTROSCOPY (ICP-MS)

CHAR-78-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Note: It can be used for trace analysis for metals in all the above materials.

Reference Requirements: This is a new technology with little formal acceptance by regulatory and standards organizations. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Inductively coupled plasma—Mass spectroscopy (ICP-MS)

Status:

Status Evaluation:	Demonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

Additional Comments:
Amount of Waste Produced—Small quantities (<10 ml) of aqueous waste
Overall Cost—$100–$200 per multielement analysis for metals
Efficacy/Strengths—It has multielement capability. It is more selective than ICP/AES. It can perform isotopic analysis.

Science/Technology Needs: It is applicable as is for multielement analysis of aqueous solutions. Development is in progress to use the technology for surface analysis using laser ablation techniques.

Implementation Needs: It is now or soon will be available at the K-25 Site. It is available at ORNL.

Author: J. R. Stokely

References: In-house methods, literature publications

SAMPLING AND MIXING METHODS CHAR-81-OG

EM Problem: Decommissioning

K-25 Site Problem: Contaminated soil

Problem Area/Constituents: Soil

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Sampling

Technology: Sampling and mixing methods

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Manual Application
Driver Evaluation:	Technical Assessment/Risk
Applicable Contaminant Evaluation:	Radioactive (α, β, γ) Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)
Additional Comments:	Amount of waste produced—none

Science/Technology Needs:

Implementation Needs:

Author: J. S. Watson

References:

February 26, 1993

PUNCH CORES

CHAR-82-OG

EM Problem: Decommissioning

K-25 Site Problem: Soils and groundwater

Problem Area/Constituents: Soil

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement(s): Characterization

Alternatives: Sampling

Technology: Punch cores

Status:

Status Evaluation:	Demonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment
Deployment Evaluation:	Manual Application
Driver Evaluation:	Technical Assessment Risk Assessment
Applicable Contaminant Evaluation:	Radioactive (α, B, γ) Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—None
Efficacy/Strengths—Faster and cheaper

Science/Technology Needs:

Implementation Needs:

Author: J. S. Watson

References: Arid Site Identification

February 26, 1993

WELLS AND PUNCH SOURCES CHAR-83-OG

EM Problem: Decommissioning

K-25 Site Problem: Soils and groundwater

Problem Area/Constituents: Groundwater

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Sampling

Technology: Wells and punch sources

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment
Deployment Evaluation:	Manual Application
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Radioactive (α, β, γ) Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)
Additional Comments:	Amount of Waste Produced—Minimum

Science/Technology Needs:

Implementation Needs:

Author: J. S. Watson

References:

February 26, 1993

LASER-BASED RAMAN SCATTERING CHAR-84-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Laser-Based Raman Scattering—The identification and quantitation of molecular species is based on the principle that the energy of excitation is altered by specific interactions.

Status:

Status Evaluation:	Evolving Technology Conceptual
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During treatment Posttreatment
Deployment Evaluation:	Manual applications
Driver Evaluation:	N/A
Applicable Contaminant Evaluation:	N/A

Additional Comments:
Amount of Waste Produced—None
Overall Cost—Expensive

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Efficacy/Strengths—Can be diagnostic of compound identification but typically very insensitive; for gross contamination. Other methods probably better with respect to sensitivity.

Science/Technology Needs: Need portable equipment, laser, etc., for in-situ use.

Implementation Needs: Down-sizing needed. Enhancements in sensitivity needed.

Author: M. R. Cates

References:

INFRARED ABSORPTION (LASER-BASED) CHAR-85-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Note: But some surfaces (wood, etc.) may present problem with background.

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In Situ Characterization and Monitoring

Technology: Infrared Absorption (Laser-Based)—

Status:

Status Evaluation:	Accepted (for commercial units) Evolving Technology (for laser-based)
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During treatment Posttreatment
Deployment Evaluation:	Manual applications
Driver Evaluation:	N/A
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—Inexpensive (but moderate to expensive with laser)
Efficacy/Strengths—Can be diagnostic for detection of organics. Typical detection limits in ppm range; could go lower with lasers perhaps.

Science/Technology Needs: Laser source would enhance sensitivity, but cost and size would increase appreciably.

Implementation Needs: Inexpensive commercial units can be purchased, detection limits ppm-ppt. Laser-based systems need to be developed.

Author: M. R. Cates

References:

LASER ABLATION FOR DIAGNOSING METALS AND RADIONUCLIDES

CHAR-86-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Laser ablation for diagnosing metals and radionuclides

Status:

Status Evaluation:	N/A
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	N/A
Deployment Evaluation:	N/A
Driver Evaluation:	N/A
Applicable Contaminant Evaluation:	N/A

Additional Comments:
Amount of Waste Produced—
Overall Cost—$200K
Efficacy/Strengths—Technique could be used to sample and analyze solid materials by ablating away the surface, followed by analysis of the removed material.

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LASER ABLATION FOR DIAGNOSING METALS AND RADIONUCLIDES

CHAR-86-OG

Science/Technology Needs: Technology for laser ablation is just now becoming available, and a program would be needed to develop the technique for practice of application of the analysis.

Implementation Needs:

Author: M. R. Cates

References:

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LASER/FLASHLAMP HEATING TO RELEASE OR DESORB SURFACE AND SUBSURFACE CONTAMINANTS

CHAR-87-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: N/A

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Laser/flashlamp heating to release or desorb surface and subsurface contaminants

Status:

Status Evaluation:	Predemonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance Obstructed/Limited Access to Host
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Manual Applications Robotic Applications
Driver Evaluation:	Technical Assessment
Applicable Contaminant Evaluation:	Radioactive Inorganic (U, Tc, Cr, Cr04, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

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Additional Comments:

Efficacy/Strengths—Surface and subsurface characterization. Potential speed.

Science/Technology Needs: Depth profiling and surface area sampled must be determined for each material. Means of sampling the plume must be developed for each analyte.

Implementation Needs: To be determined for specific applications.

Author: M. R. Cates

References:

GAS CHROMATOGRAPHY—MASS SPECTROMETRY (GC-MS) CHAR-88-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Note: Extracts of the above—airborne particulate matter, organics

Reference Requirements: EPA regulations, OSHA-accepted technology. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Gas Chromatography—Mass Spectrometry (GC-MS)—Utilizing the separation characteristics of various chromatographic columns, qualitative and quantitative data are obtained by correlating masses detected with the elution times.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications
Driver Evaluation:	Regulatory Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE, ...)

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Additional Comments:
Amount of Waste Produced—Near zero for volatiles; approximately 10 ml per sample organic extract
Overall Cost—$200–$400 per sample for volatiles; $400–$800 per sample for semivolatiles; $200–$600 for PCBs
Efficacy/Strengths—Standard EPA-accepted methods exist. It is useful for chemical identification and confident quantitation.

Science/Technology Needs: Technology is applicable as is. Benefit would be derived from faster chromatography to shorten analysis time.

Implementation Needs: Technology is available at the K-25 Site.

Author: M. R. Guerin

References: EPA regulations; the Office of Solid Waste (SW-846) Methods Compendium.

LIQUID CHROMATOGRAPHY—MASS SPECTROMETRY (LC-MS) CHAR-89-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Note: Extracts of the above—Essential small "washes" of surfaces

Reference Requirements: EPA regulations. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Liquid chromatography—mass spectrometry

Status:

Status Evaluation:	Demonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Regulatory Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE, ...)

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Additional Comments:
Amount of Waste Produced—20 ml of organic solvent (total) from liquid chromatography and from extract per sample
Overall Cost—$500 per sample
Efficacy/Strengths—It is primarily for organic pollutants that cannot be gas chromatographed (polar, thermally labeled).

Science/Technology Needs: Case-by-case development and demonstration for specific applications is needed. Technology is not currently in routine use.

Implementation Needs: Normal

Author: M. R. Guerin

References: There are a limited number of EPA Office of Solid Waste procedures.

DIRECT SAMPLING ION TRAP MASS SPECTROMETRY (DSITMS) CHAR-90-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Note: Extracts of the above—Continuous air monitoring

Reference Requirements: OSHA. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Direct sampling ion trap mass spectrometry

Status:

Status Evaluation:	Predemonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance Obstructed/Limited Access to Host
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE, ...)

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Additional Comments:
Amount of Waste Produced—None
Overall Cost—It is application-specific.
Efficacy/Strengths—It allows rapid (<5 min) determination of organics, continuous air monitoring, and possible real-time surface analysis.
This technology is under development at ORNL. It was exported to the Savannah River Laboratory, and it is being considered for Hanford and MMES deployment.

Science/Technology Needs: Methods need to be developed for specific applications.

Implementation Needs: Hardware ($100K) and personnel are needed for development, training, and implementation.

Author: M. R. Guerin

References:

SOLID SORBENT SAMPLING CHAR-91-OG

EM Problem: Decommissioning

K-25 Site Problem:

Problem Area/Constituents: Air

Reference Requirements: OSHA. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Sampling

Technology: solid sorbent sampling

Status:

Status Evaluation:	Demonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance Obstructed/Limited Access to Host
Temporal Areas of Evaluation:	During Treatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment

Applicable Contaminant Evaluation: Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—$50 per sampling tube
Efficacy/Strengths—It allows collection and concentration of vapor-phase, organic chemicals for subsequent analysis.

Science/Technology Needs: Methods need to be developed for specific applications.

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Implementation Needs: Normal

Author: M. R. Guerin

References:

FLUORESCENCE DETECTION CHAR-92-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Fluorescence detection

Status:

Status Evaluation:	Predemonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	N/A
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—Moderate (<$100 per sample)
Efficacy/Strengths—It can be tuned to monitor specific classes of compounds. Note: We can do this without a laser for in situ monitoring. The laser system needs further development.

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Science/Technology Needs: The technology is somewhat established, but specific compounds to be detected must be tested with another method before deployment, which is not routine.

Implementation Needs: Hardware needs to be procurred and conditions established for the specific compounds of interest.

Author: M. V. Buchanan

References:

LASER ABLATION ORGANIC MASS SPECTROMETRY CHAR-93-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Laser ablation organic mass spectrometry

Status:

Status Evaluation:	Predemonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	N/A
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—Moderate (<$500 per sample)
Efficacy/Strengths—It can characterize nonvolatile, polar compounds that cannot be detected by other mass spectrometry techniques.

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Science/Technology Needs: We need to develop a sampling methodology (perhaps using a wipe of the surface) and test it on target compounds.

Implementation Needs: We need to procure equipment and other normal implementation needs.

Author: M. V. Buchanan

References: MMES staff members

February 26, 1993

GAS CHROMATOGRAPHY USING A MULTITUDE OF DETECTORS CHAR-94-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Roofing Materials	Tile
Wood	Pipes	Transite
Gaskets	Gases	Liquids, especially organic liquids

Reference Requirements: No regulatory requirements need to be met to implement this technology. Some gas chromatography detectors need to be vented to prevent worker exposure to toxic pollutants. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Alternatives: Laboratory characterization and analysis

Technology: Gas chromatography using a multitude of detectors, including flame ionization, electron capture, thermal conductivity, photoionization, flame photometric, and thermionic

Status:

Status Evaluation: Accepted

Support/Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications
Automated Applications

Driver Evaluation: Risk Assessment
Technical Assessment
Regulatory

Applicable Contaminant Evaluation: Organic (Oil, PCBs, VOCs, TCE, ...)

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Additional Comments:
Amount of Waste Produced—Minimal. It is only necessary to vent gas chromatographs using nondestructive detectors
Overall Cost—$5K–$25K per instrument, depending on needs, plus miscellaneous supplies (carrier goods, etc.)
Efficacy/Strengths—It has high efficacy for a very wide variety of organic species, both volatile and semivolatile organics. It is good for a variety of species, and the analysis time is 10–60 min.

Science/Technology Needs: Technology needs are minimal. While improvements can be made, in general, the technology is ready to use.

Implementation Needs: A variety of gas chromatography equipment exists already at the K-25 Site and may be useful for many needs. The status of portable or transportable systems at the K-25 Site is not known. The greatest need is for experienced operators, especially with field systems.

Author: R. A. Jenkins

References: There is a tremendous amount of open literature on the use of gas chromatography for determination of organic contaminants associated with D&D activities.

ELECTRET PASSIVE SURFACE ALPHA MONITOR CHAR-95-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: U, Np, Th on the following:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Technical Requirements—DOE Order 5400.5, ANSI N13.12, NRC 5, and NUREG 1.86. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring
Note: More expensive and imperfect

Technology: Electret passive surface alpha monitor—The device performs as a passive ion chamber when placed on a contaminated surface; positive ions produced by alpha particles are drawn to a negatively charged Teflon electret screwed into the roof of the chamber. The electret voltage is gradually drained. The voltage is read on a simple hand-held voltmeter before and after exposure. The voltage drop is converted to an equivalent surface contamination (dpm/100 cm^2) or soil contamination (pCi/g). Sensitivity is sufficient to quantify alpha contamination after a few hours of exposure even at the most stringent DOE release limit of 100 dpm/100 cm^2.

Status:

Status Evaluation:	Demonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance High-Energy Host Disturbance Obstructed/Limited Access to Host
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications

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ELECTRET PASSIVE SURFACE ALPHA MONITOR CHAR-95-OG

Driver Evaluation: Risk Assessment
Technical Assessment
Regulatory

Applicable Contaminant Evaluation: Radioactive (α)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—$15 per electret unit, and is reusable. The voltage reader is $300.
Efficacy/Strengths—Monitor is sensitive (100 min. exposure for quantification) and has on-the-spot readout capability. It is a simple technology to use, can be used in large numbers, and allows verification of cleanup to strictest limits. The plastic is completely insensitive to β, γ radiation and, hence, ideal for use in discriminating α in mixed α, 6, γ fields.

Science/Technology Needs: The technology is commercialized for radon monitoring and is easily adapted for monitoring surface α contamination. It needs evaluation and validation for niche applications.

Implementation Needs: The limits of α monitoring in mixed radiation fields needs to be defined. Niche applications in Decommissioning and Decontamination using health physics technicians. Algorithms for multidevice deployment should be developed and tested to give a high confidence level of not missing contamination on large area surfaces.

Author: R. B. Gammage/(615)574-6256

References: Pilot tests were completed and the data presented at 1992 Health Physics Society Annual Meeting.

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ALPHA TRACK ETCH DETECTORS FOR SURFACE ALPHA CONTAMINATION

CHAR-96-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: U, Np, Th on the following:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Technical Requirements—DOE Order 5400.5, ANSI N13.12, NRC 5, and NUREG 1.86. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: More expensive laboratory characterization and analysis. No alternative is available for in-situ detection of contamination in restricted spaces such as cracks, crevices or under furnishings.

Technology: The Alpha Track Detectors (ATDs)—Alpha-sensitive plastics cut to a size appropriate for specific applications, e.g., to fit inside pipes or in narrow crevices. After exposure, the plastic is developed chemically to visualize damage tracks produced by alpha emitting contamination. The track density is measured optically and converted to an equivalent dpm/unit area. The technology has been proven commercially in the application of indoor radon monitoring with a million detectors having been sold. Deployment is simple and detectors can be used by unskilled workers. Chemical etching and track reading are highly automated with proven, developed quality assurance/quality control.

Status:

Status Evaluation:	Demonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications

February 26, 1993

ALPHA TRACK ETCH DETECTORS FOR SURFACE ALPHA CONTAMINATION

CHAR-96-OG

Driver Evaluation: Risk Assessment
Technical Assessment
Regulatory

Applicable Contaminant Evaluation: Radioactive (α)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—A few dollars each
Efficacy/Strengths—The detector has high sensitivity (100 min. exposure for quantification at 220 dpm/100 cm^2) and provides a permanent record of the radiation field. It is deployable on irregular and difficult to access surfaces, and it is small in size. It can be used in large numbers to sample large surface areas with a high level of confidence of not missing significant contamination. Contamination is mapped with submillimeter resolution and small "hot" particles are identifiable.

Science/Technology Needs: It is fully commercialized for radon monitoring and directly applicable for surface monitoring. It allows for initial surface characterization and verification in release for unrestricted use and permanent recording of cleanup.

Implementation Needs: Plastic monitors of differing sizes and flexibilities need to be tailored and fabricated for specific tasks to be identified in pilot testing on-site. Deployment of detectors in large numbers will require establishment of on-site chemical etching and track reading capabilities. Methods need developing to count tracks appearing in tight spray-like clusters produced by "hot" particles with conversion to a corresponding dpm/unit area.

Author: R. B. Gammage/(615)574-6256

References: Pilot test results are available. A manuscript is in press, *Health Physics Journal*. A copy of the Health Physics Society talk is available.

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SELECT ALPHA RADIONUCLIDE ANALYSIS BY PERALS — CHAR-97-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: U, Np, Th on the following:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Technical Requirements—DOE Order 5400.5, ANSI N13.12, NRC 5, and NUREG 1.86. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Select Alpha Radionuclide Analysis by Photon Electron Rejecting Alpha Liquid Scintillation (PERALS)—A very sensitive (pCi/g) technique for measuring alpha-emitting isotopes in soil, water, and airborne dust.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications
Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
Applicable Contaminant Evaluation:	Radioactive (α)

February 26, 1993

Additional Comments:
Amount of Waste Produced—Spent acid and organic scintillants (1.5 ml/sample).
Overall Cost—Approximately $20K for setup of analytical equipment and about $50/sample.
Efficacy/Strengths—It is a very sensitive, isotopically-selective method that is capable of detecting 1 pCi/g of individual isotopes in soil or water. It is ideal for uranium analysis and is adaptable for Tc-99, a beta emitter. It is a commercially available reader and scintillant cocktails specific to each alpha emitter. It has the lowest detection limits of rapid analytical techniques.

Science/Technology Needs: Cost effective, timely analysis of select alpha emitting radionuclides in large numbers of samples is needed to verify nonviolation of cleanup standards.

Implementation Needs: A PERALS laboratory is already set up at the ORNL DOSAR facility. It can be adapted for rapid "on-line" monitoring of both airborne and loose contamination.

Author: R. B. Gammage/(615)574-6256

References: It was used to evaluate uranium resuspension factors during cleanup and demolition at Weldon Springs (FUSRAP). Refer to the PERALS method evaluation for transuranic contaminants, Report EGG/WTD—9412, March 1991. Contact Dr. Richard Gammage or Dr. Charles Dudney, HASRD/ORNL, at 4-6256 or 6-2712.

X-RAY FLUORESCENCE FOR IN SITU MONITORING OF TOXIC HEAVY METALS

CHAR-98-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Toxicity Characteristic Maximum Concentrations, 40 CFR 261.24

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: X-ray fluorescence for in situ monitoring of toxic heavy metals

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—$15K per XRF
Efficacy/Strengths—This technology is already in use in HUD and EPA programs to detect Pb paints. Measuring devices are commercially available for analyzing homogenized samples for heavy elements or detecting heavy metals in situ on surfaces. It was evaluated in the EPA Site Program.

February 26, 1993

X-RAY FLUORESCENCE FOR IN SITU MONITORING OF TOXIC HEAVY METALS

CHAR-98-OG

Science/Technology Needs: There are a variety of situations involving surfaces contaminated with heavy metals.

Implementation Needs: We need to evaluate substrate effects from different surfaces for magnitude and prevalence of false positives and negatives. Both room temperature or liquid nitrogen cooled XRF monitors are available commercially for testing and matching to K-25.

Author: R. B. Gammage/(615)574-6256

References: Many publications and user courses are available. HASRD (ORNL) is implementing XRF in HUD lead in paint programs. Contact Richard Gammage or David Wilson, HASRD/ORNL, at 4-6256 or 6-7607.

February 26, 1993

PCB IMMUNOASSAY KIT CHAR-99-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: There are numerous PCB spills, leaks, and soakings involving:

Concrete	Tile	Wood
Pipes	Transite	Asbestos Insulation
Gaskets	Metal Equipment	

Reference Requirements: EPA cleanup standard; the most stringent is 10 ppm PCBs by weight. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: PCB immunoassay kit

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—Small amount of reagents
Overall Cost—$80 per test ($35 per kit; 20-30 tests per person per day)
Efficacy/Strengths—It was thoroughly evaluated in DOE site restoration to minimize false negatives with the commercially-available test kit. It is very sensitive (5 ppm).

February 26, 1993

Science/Technology Needs:

Implementation Needs: The technology is ready to apply and should be used for routine analyses at the K-25 Site.

Author: R. B. Gammage/(615)574-6256

References: It was evaluated in DOE Analytical Field Screening Program. Contact Dr. Roger Jenkins at ACD-ORNL.

February 26, 1993

PORTABLE GAS CHROMATOGRAPH/ECD FOR ANALYZING PCBs IN SOIL/DUST

CHAR-100-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: Polychlorinated biphenyls (PCBs) on:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: 10 ppb PCBs in soil is the strictest EPA limit. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Portable Gas Chromatograph/electron capture detector (ECD) for Analyzing PCBs in Soil/Dust—PCBs are extracted with solvent from soil using a simple, two-step procedure. The extract is then injected into a field gas chromatograph that separates the sample components and selectively detects halogenated species, including PCBs. Arachlors (PCB mixtures) are identified by their separation pattern and can be quantified using specific chromatographic peaks.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment Regulatory

February 26, 1993

PORTABLE GAS CHROMATOGRAPH/ECD FOR ANALYZING PCBs IN SOIL/DUST

CHAR-100-OG

Applicable Contaminant Evaluation: Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—Small amounts of methanol/hexane extractant
Overall Cost—A few dollars per analysis; the gas chromatograph costs $15K
Efficacy/Strengths—It was developed and verified by the EPA. One technician can conduct tens of analyses per day. One manager at a Superfund site estimated on-site data during removal saved $500K (360 analyses in 8 days). The method is accurate to below 10ppb.

Science/Technology Needs:

Implementation Needs: We need to order GC/ECD devices (approximately $15K each).

Author: R. B. Gammage/(615)574-6256

References: Dr. Tom Spittler, EPA Region I Director, is the contact. Method descriptor is available. User courses are given regularly.

February 26, 1993

SYNCHRONOUS FLUORESCENCE SCREENING FOR POLYCYCLIC AROMATIC HYDROCARBONS (PAHs) CHAR-101-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: Polycyclic Aromatic Hydrocarbons (PAHs) on:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: 10 ppb for general PAHs. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Synchronous Fluorescence Screening for PAHs—When light of a specific wavelength is directed onto a sample, certain organic compounds (such as PAHs), absorb and reemit that light (fluoresce) at a higher wavelength. Analytes can be differentiated because they absorb and fluoresce at different wavelengths. Fluorescence intensity is quantitatively proportional to analyte concentration.

Status:

Status Evaluation:	Demonstration Predemonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE, ...)

February 26, 1993

SYNCHRONOUS FLUORESCENCE SCREENING FOR POLYCYCLIC AROMATIC HYDROCARBONS (PAHs) CHAR-101-OG

Additional Comments:
Amount of Waste Produced—Solvent in ml quantities
Overall Cost—A few dollars per analysis; $25K for the reader. A spectrofluorimeter costs $25K.
Efficacy/Strengths—An easy concentration step allows detection at drinking water standards. It takes a few minutes per analysis.

Science/Technology Needs: Technology needs to be validated in the EPA program. Numerous situations involved used oils and lubricants.

Implementation Needs: Normal

Author: R. B. Gammage/(615)574-6256

References: It is being implemented for groundwater analyses at Y-12. A paper was published. Contact Dr. John Haas, HASRD/ORNL, at 4-5042.

IN SITU PASSIVE MONITORS FOR SURFACE CONTAMINATION BY WEAK BETA RADIONUCLIDES

CHAR-102-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: Tc on:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: DOE Order 5400.5, ANSI N13.12, NRC 5, and NUREG 1.86. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives:

Technology: In Situ Passive Monitors For Surface Contamination By Weak Beta Radionuclides—The exoelectron technique is the weakly penetrating radiation analog to thermoluminescence, which is the standard for passive, solid-state dosimetry for strongly penetrating radiations. The exposed exoelectron dosimeter is heated to liberate low-energy electrons from a thin surface layer. The thin exoactive layer is especially sensitive to low-energy, beta radiations such as those from ^{3}H, ^{14}C or ^{99}Tc. The exoelectrons expelled during heating are counted in a Geiger or proportional counter, and the reading converted to an equivalent dpm/unit area.

Status:

Status Evaluation:	Predemonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance High-Energy Host Disturbance Obstructed/Limited Access to Host
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications

February 26, 1993

IN SITU PASSIVE MONITORS FOR SURFACE CONTAMINATION BY WEAK BETA RADIONUCLIDES

CHAR-102-OG

Driver Evaluation: Risk Assessment
Technical Assessment
Regulatory

Applicable Contaminant Evaluation: Radioactive (ß)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—A few dollars per detector; it can be deployed in large numbers
Efficacy/Strengths—It has a reusable, TLD-like chip with a signal-to-noise ratio of 10 after 100 min exposure for a mCi/cm^2 of tritium. Small size detectors are available for monitoring difficult-to-access locations. It is highly sensitive to weak beta emitters such as tritium, C-14, and Tc-99. Other survey meters have low sensitivity and cannot access tight spaces.

Science/Technology Needs: A thorough evaluation of this technology is needed for differentiating Tc-99 from other radionuclides in mixed surface contaminations. Pairs of detectors, one with a beta absorber on its surface, will be needed to discriminate weak beta from more penetrating radiations.

Implementation Needs: A commercial exoelectron reader is available at the K-25 Site. Different types of ceramic exoelectron materials should be tested to select the most suitable type.

Author: R. B. Gammage/(615)574-6256

References: "Measuring Tritium With Exoelectron Dosimeters," R. B. Gammage, *Nucl. Inst. Methods 127*, pp. 279-284 (1975).

February 26, 1993

THIN TWO-DIMENSIONAL TLD ARRAY FOR SPATIAL CHARACTERIZATION OF SURFACE ALPHA CONTAMINATION CHAR-103-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: U, Np, Th on:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: DOE Order 5400.5, ANSI N13.12, NRC 5. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Thin Two-Dimensional TLD Array for Spatial Characteriztion of Surface Alpha Contamination—A flexible sheet contains a fine grid of miniature thermoluminescence dosimeter elements that have a preferential sensitivity to alpha rays. Exposed sheets are scanned with a laser beam to heat the individual chips and produce a readable thermoluminescence that is converted into a three-dimensional map. The laser scanning bleaches the dosimeter and readies the sheet for reuse.

Status:

Status Evaluation:	Demonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
Applicable Contaminant Evaluation:	Radioactive (α)

February 26, 1993

THIN TWO-DIMENSIONAL TLD ARRAY FOR SPATIAL CHARACTERIZATION OF SURFACE ALPHA CONTAMINATION CHAR-103-OG

Additional Comments:
Amount of Waste Produced—None
Overall Cost—A laser reader costs $60K; a reusable detector sheet (30 x 30 cm) is $225.
Efficacy/Strengths—The detector sheet contains 10,000 pixels. The limit of detection is 20 alpha rays on a pixel. It maps primary contamination fields, while discriminating alpha "hot spots."

Science/Technology Needs: It is commercially available from International Sensor Technologies, Model PSR 100. It will need to be adapted to specific D&D needs. Size and shape of detector sheets needs tailoring to specific geometrics. Discriminating ability in mixed radiation fields needs further definition.

Implementation Needs: Normal

Author: R. B. Gammage/(615)574-6256

References: International Sensor Technologies, specification brochure for Model PSR 100 and final progress report (Phase II) of SBIR National Cancer Institute Grant No. 5 R44 CA 44242-0. The local contact is Dr. Richard Gammage, ORNL, at 4-6256.

PASSIVE NEUTRON DETECTION CHAR-104-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment Process Buildings

Problem Area/Constituents: Uranium on:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Passive Neutron Detection Requires (α,η) on Fluorine—Instrument detects neutrons emitted from UO_2F_2 deposits.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	All
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Robotic Applications
Driver Evaluation:	Regulatory Risk Assessment
Applicable Contaminant Evaluation:	Radioactive (α, β, γ) for uranium determination

February 26, 1993

Additional Comments:
Amount of Waste Produced—
Overall Cost—$20K per unit
Efficacy/Strengths—It should match the standard matrix for the sample to be useful for all matrixes. This method can measure in place, or a large sample can be brought to the neutron detector. It is used for uranium determination if fluorine is present in the compound. It is presently used to measure uranium holdup. Practical detection limit is 50g of uranium in the form of UO_2F_2 for a 1-hour count.

Science/Technology Needs: None

Implementation Needs: None

Author: R. C. Hagenhauer/(615)574-8835

References: K/ITP-237, *Nondestructive Assay Measurements of Gaseous Diffusion Process Equipment.*

NaI FLOOR SCANNER CHAR-105-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: Gamma emitters (U) on:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: NaI Floor Scanner—System detects gamma rays emitted from ^{235}U and ^{238}U contamination.

Status:

Status Evaluation:	Predemonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Regulatory
Applicable Contaminant Evaluation:	Radioactive (γ)

Additional Comments:
Amount of Waste Produced—
Overall Cost—$7K per unit, including shielding
Efficacy/Strengths—It is good for detection of activity below the surface, but it is not as sensitive, however, as an alpha, beta floor scanner. Its approximate sensitivity is 1000 dpm/U/cm^2.

February 26, 1993

Science/Technology Needs: We need a simple cart to move the detector a fixed distance above the surface.

Implementation Needs: Cart holder needed for detector.

Author: R. C. Hagenhauer/(615)574-8835

References: MMES Staff Members

February 26, 1993

NaI-Ge GAMMA SPECTROSCOPY CHAR-106-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: Uranium on:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Sampling; In situ characterization and monitoring

Technology: NaI-Ge Gamma-Spectroscopy—The NaI detector is used to quantify ^{235}U and ^{238}U in items that allow the gamma to penetrate. The Ge detector is used to complete the attenuation correction factors for the NaI data.

Status:

Status Evaluation:	Accepted Demonstration
Support/Application Evaluation:	All
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Robotic Applications
Driver Evaluation:	Technical Assessment Risk Assessment Regulatory
Applicable Contaminant Evaluation:	Radioactive (α, β, γ)

February 26, 1993

Additional Comments:
Amount of Waste Produced—
Overall Cost—$40K per combination NaI and Ge detectors
Efficacy/Strengths—The technology is useful for ^{235}U and ^{238}U detection. The system can measure radioactivity below the surface. It is relatively inexpensive. A high-resolution Ge detector may be needed to determine correction factors for attenuation. Sensitivity = 10g ^{235}U; 500g ^{238}U.

Science/Technology Needs: Correction factor methodology needs to be published.

Implementation Needs: None

Author: R. C. Hagenhauer/(615)574-8835

References: K/ITP-237, *Nondestructive Assay Measurements of Gaseous Diffusion Process Equipment.*

NEUTRON ACTIVATION (^{252}Cf SHUFFLER OR DIFFERENTIAL DIE-AWAY SYSTEM) CHAR-107-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: ^{235}U on:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Sampling; laboratory characterization and analysis

Technology: Neutron Activation (^{252}Cf Shuffler Or Differential Die-Away System)—Neutrons generated by the instrument interact with ^{235}U to cause fission. The fission neutrons are then detected to quantify the ^{235}U.

Status:

Status Evaluation:	Demonstration
Support/Application Evaluation:	All
Temporal Areas of Evaluation:	Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Regulatory
Applicable Contaminant Evaluation:	Inorganic (U)

Additional Comments:

Efficacy/Strengths—It is generally used for low-level determinations of uranium in almost anything. It is specific for ^{235}U and useful in most any matrix. The equipment is expensive

($0.5—1.5 million). This is the most sensitive unit on the market for the nondestructive assay of uranium. Sensitivity is ~10 mg ^{235}U/55-gallon drum.

Science/Technology Needs: Development is needed for containers that are larger than 55-gal drums. Separate calibration standards are needed for each matrix.

Implementation Needs: Normal

Author: R. C. Hagenhauer/(615)574-8835

References: *Capability and Limitation Study of the DOT Passive-Active Neutron Waste Assay Instrument*, LA-12237-MS.

PROPORTIONAL COUNTER FOR ALPHA, BETA ACTIVITY CHAR-108-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: U, Np, Th, Tc on:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Proportional Counter for Alpha, Beta Activity—Alpha and beta radiation emitted from the surface contamination is detected and counted.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	All
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Robotic Applications
Driver Evaluation:	Regulatory
Applicable Contaminant Evaluation:	Radioactive (α, β, γ)

Additional Comments:

Efficacy/Strengths—It has sensitivity to 100 dpm/cm^2. Relatively inexpensive probes are available for wide areas or measurements, or it can be made small to measure inside pipes. It may be able to distinguish Tc activity from uranium.

February 26, 1993

PROPORTIONAL COUNTER FOR ALPHA, BETA ACTIVITY CHAR-108-OG

Science/Technology Needs: This is a well-established technology. Some minor development may be needed to distinguish Tc activity from uranium. Probes for measuring vertical or overhead items are needed.

Implementation Needs: Normal

Author: R. C. Hagenhauer/(615)574-8835

References: MMES staff members

February 26, 1993

WASTE CURIE MONITOR (BAG OR BARREL COUNTER FOR LOW-LEVEL RADIOACTIVITY) CHAR-109-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: Uranium on roofing materials, tile, wood

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Sampling

Technology: Waste Curie Monitor (Bag or Barrel Counter for Low-Level Radioactivity)—Gamma rays are emitted by the contaminated samples that are detected by the large plastic scintillators surrounding the 55-gallon drums.

Status:

Status Evaluation:	Accepted
Support/Application Evaluation:	All
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Regulatory Risk Assessment
Applicable Contaminant Evaluation:	Radioactive (γ)

Additional Comments:

Amount of Waste Produced—None
Efficacy/Strengths—It is good for measuring scrap lumber for low levels of activity (below 32 PCi/g). It must be used in conjunction with a high-resolution gamma spectroscopy systems to determine atomic abundance. It is presently used for low-level measurements of combustible waste. Sensitivity for ^{235}U=10 mg for ^{238}U=200 mg.

February 26, 1993

WASTE CURIE MONITOR (BAG OR BARREL COUNTER FOR LOW-LEVEL RADIOACTIVITY) CHAR-109-OG

Science/Technology Needs: Development may be necessary for containers larger than 55-gallon drums.

Implementation Needs: Normal

Author: R. C. Hagenhauer/(615)574-8835

References: MMES Staff Members

February 26, 1993

FLUORESCENCE DIAGNOSIS OF CONTAMINATED SURFACES AND AIRBORNE CONSTITUENTS

CHAR-110-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: Contaminants such as UO_2F_B, UF_4, PCBs, carcinogenic agents, and any others characterized by a detectable fluorescence signature on:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Sampling; in situ characterization and monitoring

Technology: Fluorescence diagnosis of contaminated surfaces and airborne constituents

Status:

Status Evaluation:	Predemonstration
Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance Obstructed/Limited Access to Host
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications

February 26, 1993

FLUORESCENCE DIAGNOSIS OF CONTAMINATED SURFACES AND AIRBORNE CONSTITUENTS

CHAR-110-OG

Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
Applicable Contaminant Evaluation:	Fluorescence of UF_6, U, UO_2F_2, etc. Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...) Organic (Oil, PCBs, VOCs, TCE, ...)

Additional Comments:
Amount of Waste Produced—None
Overall Cost—It is dependent on the specific application. Equipment, assembly, and testing will comprise the costs.
Efficacy/Strengths—It may be used in situ, with or without automation, and with or without fiber optics for limited access areas. It can certify when the surface/area is cleaned/decontaminated, which eliminates extra processing. It may eliminate expensive laboratory characterization, some degree of heavy equipment transport, and dismantling. It can monitor the status of processing in real time. Fluorescence is, in general, sensitive to ppm for airborne situations.

Science/Technology Needs: There will be a modicum of fluorescence spectroscopy work required for some contaminants to fill in the gaps of published fluorescence data. Technology requirements may be fulfilled by off-the-shelf lasers, detectors, and associated support equipment.

Implementation Needs: The required equipment such as laser (light source), optics, detectors, personal computers (for data acquisition), and interfaces must be purchased. Staff with extensive experience on-site in laser applications and optical design, field testing, and other appropriate technologies are available. On-site laboratory storage, assembly, and staging are available on-site. The procedures must be written.

Author: S. W. Allison/(615)576-2725

References: There is much literature that supports the efficacy of fluorescence-based analytical instrumentation for in situ sampling, measurement, and characterization. Of particular note are the following:

1. S. W. Allison et al., "Use of Fiber Optics and Laser-Induced Fluorescence for Remote Measurements in Strong Rotation", K/TS-11, 018, MMES, Oak Ridge Gaseous Diffusion Plant (June 1983) [Also published in *Proc. Fifth Workshop on Gases in Strong Rotation*, (Univ. of Virginia, June 5-9, 1983)].
2. S. W. Allison, G. T. Gillies, M. R. Cates, B. W. Noel, "Fiber Optic Pulsed Laser Delivery for Remote Measurements," *Optical Engineering*, June 1987, Vol. 26, No. 6, pp. 538-546.

LASER ABLATION; INDUCTIVELY COUPLED PLASMA; ATOMIC EMISSION SPECTROSCOPY

CHAR-111-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: Concrete

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Laser ablation; inductively coupled plasma; atomic emission spectroscopy

Status:	Demonstration
Support/Application Evaluation:	High-Energy Host Disturbance
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Robotic Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)

Additional Comments:
Efficacy/Strengths—It will be accepted by end of this year after the Fernald demonstration. It allows multiple elemental analyses.

Science/Technology Needs: We need to improve the robotic process for site-specific conditions (e.g., floor, wall, ceiling).

Implementation Needs: Normal

Author: S. Y. Lee/(615)574-6316

References: Contact Marvin Anderson, Ames Laboratory, Ames, IA 50010-6739; at x(515) 294-4580.

February 26, 1993

PORTABLE GAMMA-RAY SPECTROMETRY CHAR-112-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents: Concrete

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ characterization and monitoring

Technology: Portable Gamma-Ray Spectrometry—Characterization and monitoring technologies are available but need to be put together for in situ implementation. Application of sensor technology for in situ characterization and monitoring requires robotic technology and remote control technology.

Status:	Accepted
Support/Application Evaluation:	Mechanical Host Disturbance
Temporal Areas of Evaluation:	Pretreatment Posttreatment
Deployment Evaluation:	Robotic Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Radioactive (γ)

Additional Comments:
Efficacy/Strengths—It is only for uranium and other actinide isotopes.

Science/Technology Needs: We need robotic technology for remote control applications.

Implementation Needs: Technologies are available but need to be put together for implementation.

Author: S. Y. Lee/(615)574-6316

References: N. H. Cutshall, ORNL

February 26, 1993

CHEMICAL LEACHING TESTS FOR PROTOCOL DEVELOPMENT FOR EVALUATION OF CLEANING OPTIONS AND EFFECTIVENESS

CHAR-113-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: Chemical Leaching Tests for Protocol Development for Evaluation of Cleaning Options and Effectiveness—Laboratory characterization includes physical (hardness, density, etc.) and chemical (acid, base, chelate leaching, tests, etc.) tests for helping decontamination technology development.

Status:

Status Evaluation: Demonstration

Support/Application Evaluation: Liquid Host Disturbance

Temporal Areas of Evaluation: Pretreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Technical Assessment

Applicable Contaminant Evaluation: Radioactive (α, β, γ)
Inorganic (U, Tc, Cr, CrO4, Hg, Pb, ...)
Organic (Oil, PCBs, VOCs, TCE, ...)

February 26, 1993

CHEMICAL LEACHING TESTS FOR PROTOCOL DEVELOPMENT FOR EVALUATION OF CLEANING OPTIONS AND EFFECTIVENESS

CHAR-113-OG

Additional Comments:
Amount of Waste Produced—
Overall Cost—
Efficacy/Strengths—

Science/Technology Needs: This test will help waste minimization technology development (decontamination planning and technology evaluation).

Implementation Needs: We need decontamination technology development.

Author: S. Y. Lee/(615)574-6316

References: Refer to the Fernald Uranium ID Reports.

February 26, 1993

00002-24

ON-LINE SUPERCRITICAL FLUID EXTRACTION—MULTIDETECTOR GAS CHROMATOGRAPHY (SFE-GC)

CHAR-115-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings

Problem Area/Constituents:

Concrete	Structural Steel	Roofing Materials	Tile
Wood	Porous Nickel	Sheet Metal	Pipes
Transite	Asbestos Insulation	Gaskets	Copper Wiring
Cylinders	Metal Equipment	Instruments	Nickel-Lined Steel
Porous Aluminum	Monel (67Ni/30Cu/1.4Fe)	Copper	Aluminum

Other: It is especially useful for analysis of soil contaminants.

Reference Requirements: Regulations for total petroleum hydrocarbons and PCBs. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Laboratory characterization and analysis

Technology: On-Line Supercritical Fluid Extraction—Multidetector Gas Chromatography (SFE-GC)

Status:

Status Evaluation:	Predemonstration
Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Regulatory
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE, ...)

February 26, 1993

Additional Comments:
Amount of Waste Produced—None
Overall Cost—It could be 25% or even less than that of separate conventional analyses.
Efficacy/Strengths—Organic, solvent-contaminated wastes are not generated, as opposed to conventional organic analytical methods. There is also much faster sample turnaround than with conventional methods. One commercial instrument already is available for the rapid determination of total petroleum hydrocarbons in soil by on-line SFE-GC. The SFE of PCBs also has been demonstrated. It appears highly likely that the two methods can be combined to allow the rapid and simultaneous analysis of both contaminants in soil and other solids.

Science/Technology Needs: The technology requires optimization for the most efficient analysis of both total petroleum hydrocarbons and PCBs in a single operation.

Implementation Needs: Normal

Author: W. H. Griest

References:

ULTRASONIC RANGING AND DATA SYSTEM (USRADS) CHAR-123-OG

EM Problem: Soils, groundwater, and surface water (RA)

K-25 Site Problem: Soils, buried waste; hydrology

Problem Area/Constituents: General

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: Statistics, data collection

Technology: Ultrasonic Ranging and Data System (USRADS); transmits surveyor position by measuring the travel time of ultrasonic pulses from a backpack transmitter and associates the position with electronically transmitted data.

Status: Accepted and being used commercially.

Efficacy: Allows real-time determination of sampling frequency needed and greatly speeds sampling.

Science/Technology Needs: Adaptation to various data generation systems.

Implementation Needs: None. Currently in use.

Author: J.E. Nyquist/(615)574-4646

References:

1. J.E. Nyquist and M.S. Blair, *Geophysics*, Vol. 56, July 1991, pp. 1114–1121.

February 26, 1993

GROUND-PENETRATING RADAR CHAR-124-OG

EM Problem: Soils, groundwater, and surface water (RA)

K-25 Site Problem: Soils, buried waste, hydrology

Problem Area/Constituents: General

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ physical

Technology: Ground-penetrating radar. Extremely short electromagnetic pulse return interference by both metallic and nonmetallic objects.

Status: Accepted. Commercially available.

Science/Technology Needs: Improvements are needed in depth of penetration and signal-to-noise and signal processing, particularly antenna design. The technology could be developed to measure subsurface plumes.

Implementation Needs: The system would cost approximately $30K.

Author: J.E. Nyquist/(615)574-4646

References:

1. Workshop on Noninvasive Geophysical Site Characterization, LA-12311-C.

ELECTRICAL AND ELECTROMAGNETIC (EM) METHODS CHAR-125-OG

EM Problem: Soils, groundwater, and surface water (RA)

K-25 Site Problem: Soils, buried waste, hydrology

Problem Area/Constituents: General

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ physical

Technology: Electrical and electromagnetic (EM) methods, including measurements based on electrical conductivity and those which measure natural electrical potentials.

Status: Developed through accepted.

Efficacy: Useful for mapping site subsurface features which influence contaminant transport and which might be missed through drilling. Used airborne (Oak Ridge) and on the surface. Could be used in borehole applications. Might be developed for actual plume detection.

Science/Technology Needs: Development of site-specific techniques and data handling and imaging methods are needed. The Lawrence Livermore National Laboratory-developed borehole system could be adapted for use in Oak Ridge.

Implementation Needs: Development cost is estimated to be $200K; systems cost, $100K. Commercial rental equipment is available.

Author: J.E. Nyquist/(615)574-4646

References:

1. Workshop on Noninvasive Geophysical Site Characterization, LA-12311-C.

February 26, 1993

SEISMIC METHODS (REFRACTION, PROFILING, REFLECTION) CHAR-126-OG

EM Problem: Soils, groundwater, and surface water (RA)

K-25 Site Problem: Soils, buried waste, hydrology

Problem Area/Constituents: General

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ physical

Technology: Seismic methods (refraction, profiling, reflection). Seismic methods measure elastic and acoustic subsurface parameters.

Status: Developed through accepted. Refraction and deep reflection have been used successful for years; however, shallow (<30m) reflection capability is relatively recent.

Efficacy: Useful for identifying and mapping geological features which control contaminant migration.

Science/Technology Needs: Developed shallow sources should be tested. Techniques should be adapted and used for both vertical and horizontal boreholes.

Implementation Needs: Development cost is estimated at approximately $200K; systems cost, $50K. Commercial rental equipment is available.

Author: J.E. Nyquist/(615)574-4646

References:

1. Workshop on Noninvasive Geophysical Site Characterization, LA-12311-C.

February 26, 1993

MICROGRAVITY METHODS CHAR-127-OG

EM Problem: Soils, groundwater, and surface water (RA)

K-25 Site Problem: Soils, buried waste, hydrology

Problem Area/Constituents: General

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ physical

Technology: Microgravity methods. This technology involves measuring variations in the earth's gravitational field caused by differences in the densities of objects such as rocks, natural structures, and artifacts.

Status: Development.

Efficacy: Gravity methods have been successfully used in the mining and petroleum industries. Increased sensitivity is needed for accurate, unambiguous interpretation. Microgravity has been used at the K-25 Site.

Science/Technology Needs: Development of increased sensitivity for rapid, cost-effective subsurface detection and mapping is needed. Also, site-specific development is needed for detecting karst cavities and conduits.

Implementation Needs: Development is expected to cost $200K. Systems cost is expected to be $60K. Commercial rental equipment is available.

Author: J.E. Nyquist/(615)/574-4646

References:

1. Workshop on Noninvasive Geophysical Site Characterization, LA-12311-C.

February 26, 1993

MAGNETICS CHAR-128-OG

EM Problem: Soils, groundwater, and surface water (RA)

K-25 Site Problem: Soils, buried waste, hydrology

Problem Area/Constituents: General

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Characterization

Alternatives: In situ physical

Technology: Magnetics. This technology involves measurement of anomalies in the direction, gradient, or intensity of the earth's magnetic field.

Status: Accepted. An aerial survey has been completed in Oak Ridge.

Efficacy: Useful for detecting buried, ferrous metal objects.

Science/Technology Needs: Development of methods to minimize interference is needed.

Implementation Needs: Development is expected to cost $200K. Deployment is expected to cost $15K. Commercial rental equipment is available.

Author: J.E. Nyquist/(615)574-4646

References:

1. Workshop on Noninvasive Geophysical Site Characterization, LA-12311-C.

DECONTAMINATION

SOLVENT EXTRACTION DCON-1-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: PCBs on concrete, in asbestos, on metal

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternative: Bulk Decontamination Method

Technology: Solvent Extraction—Selective removal of organic contaminants by dissolution in a solvent.

Could be applied as a "factory style" process in either batch or continuous fashion. Contaminated materials fed into processing equipment and cleaned material exits. This would be applicable to concrete scabble, transite (asbestos-reinforced concrete) or metal shards for example. A countercurrent extractor, such as developed by the ORNL Fuel Recycle Division for fuel dissolution, would appear to be an appropriate contractor and availability of both lab and pilot-scale equipment should be pursued.

Could also be applied as a portable technology, the solvent being applied to a localized spot with a device patterned after a carpet cleaning machine.

Status: Solvent extraction is a mature technical field but specific extractants have not been identified for PCB extraction from concrete etc. An attractive solvent, triethylamine, has been evaluated for organic extraction from sludge (TTP OR-373-AH) and found to be a very effective solvent and one for which industrial processing equipment is available commercially.

Solvent recycle equipment and off-gas treatment equipment could be easily adapted for use here.

Science/Technology Needs: Technology development—(1) Survey and tests of specific extractants applicable to PCB-contaminated concrete, transite and metal are needed.
(2) A portable "spot" remover can be developed or adapted from commercial devices.

Technology demonstration—(3) Applicability of rotary contractor, solvent recycle and, if appropriate because of solvent selection, an off-gas treatment system.

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Implementation needs: Development cost—Less than ~$250K, $500K, and $1000K for 1, 2, and 3, respectively assuming availability of lab scale and pilot-scale extraction units from ORNL and industrial participation in demo.

Deployment—No unusual costs. Development (pilot-scale) equipment may be used in production.

Documentation—Professional judgement.

Author: R. L. Fellows

References: MMES staff members

February 26, 1993

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents:

Composite roofing (tar, tar paper, rock) with no contamination[1]
Composite roofing (tar, tar paper, rock) with U contamination[2]
Composite roofing (tar, tar paper, rock) with U and Tc contamination[1]

Reference Requirements:

- Resource Conservation and Recovery Act and the Hazardous and Solid Waste Amendments of 1984, 40 CFR 260–270
- NEPA, 40 CFR 1500–1508
- Clean Air Act, 40 CFR 60–65
- Clean Water Act, 40 CFR 110–146 and 400–471
- National Emissions Standards for Hazardous Air Pollutants, 40 CFR 61, Subpart H
- DOE Order 5480.11, "Radiation Protection for Occupational Workers" (draft)
- DOE Order 5480.12, "Prevention, Control, and Abatement of Environmental Pollution"

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Bulk Decontamination Methods

Technology: Incineration of Combustibles with Rad Contamination

Status: Accepted—The incineration of roofing materials is accepted by the Environmental Protection Agency.[3] The incineration of contaminated combustible building materials is common in the nuclear industry.[4]

Waste generated: This will depend on the design of the incinerator and the ash content of the waste being burned. During a test, the K-1435 incinerator generated 1.1 gal of wastewater and 27 lb of ash per 100 lb of waste fed.[5]

Cost: capital cost, $26M (1987 dollars); operating cost, $10/lb (1992 dollars).[5]

Science/Technology Needs: N/A

Implementation Needs: A new incinerator would be needed because the existing incinerator cannot accept waste with more than 5 ppm total uranium and enrichments higher than 1% ^{235}U.[6] The present incinerator requires the services of about 30 maintenance workers (maintenance mechanics, electricians, pipe fitters, welders, and instrument mechanics), their supervisors, 34 chemical operators, their supervisors, and 7 engineers.[7] About 8–10 years could be required for writing an environmental impact statement, holding public hearings, and obtaining the necessary permits—TSCA permit, RCRA permit, NESHAP permit, and Clean Air Act permits.[8]

Author: D. H. Bunch

References:

1. W. S. Lenihan et al., *Building Characterization Report, ORGDP Diffusion Facilities Permanent Shutdown, Building K-29*, KD-5750, April 29,1990, p. 25.

2. R. L. Farrar, Jr. "K-27 Roof Rocks," (letter to J. L. Gamble) (U) UCC-ND Jan 20, 1979, K-ET-124 (RPT:C-RD).

3. *Compilation of Air Pollutant Emission Factors*, Third Edition, U. S. Environmental Protection Agency, AP-42-ed-3.

4. R. Kohout, "Incineration," *Radioactive Waste Technology*, edited by A. Alan Moghissi, Herschel W. Godbee, and Sue A. Hobart, American Society of Mechanical Engineers and American Nuclear Society, 1986.

5. T. O. Rogers, telephone conversation with D. H. Bunch, May 28, 1992.

6. *Waste Acceptance Plan and Analytical Protocol for the Toxic Substances Control Act Incinerator*, K/HS-252/R2, November 1991.

7. Fidel Perez, telephone communication with D. H. Bunch, June 15, 1992.

8. L. V. Gibson, Jr., telephone conversation with D. H. Bunch, June 16, 1992.

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Concrete, composite roofing, wood. Constituents: U, Tc, actinides, oils

Reference Requirements:

- Federal Facility Compliance Agreement for Oak Ridge Site
- Federal Facility Compliance Agreement for PCBs
- Clean Air Act
- Toxic Substance Control Act
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Bulk Decontamination Methods

Technology: Biological

Status: Evolving Technology (preconceptual)—This technology is in the preconceptual stage. The knowledge base exists for biological treatment of various contaminants. However, there is no database for application of the technology for bulk decontamination purposes.

The technology should work for bulk decontamination of the above listed media. However, the different media should probably be reduced (by shredding, pulverizing, etc.) before biotreatment. This could present a problem in separation of the media and the biomass. In the case of oils, this may not be a problem because the oils are mineralized. In the case of the metals, though, separation of the contaminated biomass would be necessary. At this time, an estimate of the decontamination efficiency that might be expected cannot be made because of the preconceptual status of the technology. An estimate of the capital and operating cost of the technology cannot be made at this time because of its preconceptual status. The waste generated would be either the mixture of the particular media and biomass (in the case of oils decontamination) or the contaminated biomass that has been separated from the biomass (if separation is feasible). An estimate of the quantity of waste cannot be made at this time.

Science Technology Needs: A research project is needed to investigate the feasibility of using biological treatment for bulk decontamination of materials.

Author: R. D. Bundy

Implementation Needs: The cost of an R&D project on surface decontamination by biological treatment would probably range from $300K to $600K.

References: MMES staff members

February 26, 1993

DRY HEAT DCON-4-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Concrete, transite, and asbestos pipe insulation contaminated with oil or oil and PCBs

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site)
- FFCAs for PCBs
- Applicable federal and state laws and regulations (e.g., Clean Air Act and Toxic Substance Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Bulk Decontamination Methods

Technology: Dry Heat

Status: Conceptual—The effective application of dry heat to the above problem areas is uncertain and untried. A significant amount of bench-scale laboratory studies would be needed to define applicability of the process to the above problem areas.

Science/Technology Needs: The availability of engineered equipment is judged to be adequate providing that laboratory studies verify effective contamination removal by heat. Secondary waste treatment would need to be addressed. The ability to collect gas phase contaminants and separate them from the clean air needs to be developed. Following this is the requirement to convert the gas phase contaminant to a suitable form for long-term containment.

Implementation Needs:

Author: R. B. Alderfer

References: MMES staff members

February 26, 1993

CHEMICAL LEACHING DCON-5-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: PCBs on concrete, in asbestos, on metal

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Bulk Decontamination Methods

Technology: Chemical Leaching—Selective removal of contaminants. Could be applied as a "factory style" process in either batch or continuous fashion. Contaminated materials are fed into processing equipment, and cleaned materials exit. Could also be applied as a portable technology, the solvent being applied in some way to a localized spot.

Status: Demonstration—A wide variety of leaching agents are possible. Removal of PCBs would be most successful with an organic solvent. Many would be acceptable, but most are hazardous themselves. A successful solvent might be trimethylamine (TMA), an organic solvent used in the "BEST" process.

Efficacy: Leaching with TMA would be capable of leaving PCB residues lower than the Energy Systems limit of 2 ppm. Any residual TMA would rapidly evaporate or would be very rapidly degraded in the environment by biological organisms. The RCRA spill reporting limit for TMA is 5000 lb—a level which would allow large quantities of TMA to be left in the substrate.

Waste: Waste would be TMA contaminated with PCBs. This material could be fed to the TSCA Incinerator.

Science Technology Needs: Demonstration of cleanup levels for PCBs.

Implementation Needs: Development costs—$250K for a laboratory study to confirm efficacy and $250K for development of application tools (shop vac or carpet cleaner-style machine).

Author: R. L. Fellows

References: MMES staff members

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CATALYTIC EXTRACTION PROCESS (CEP) DCON-6-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Metals of all kinds and configurations with U, Tc, actinides, PCB, and oils. Oils, paper, wood, tiles, other combustibles contaminated with U, Tc, actinides, PCB, and oils.

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site)
- Applicable federal and state laws and regulations (e.g., Clean Air Act, RCRA, NEPA, and NESHAP)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternative: Bulk Decontamination Methods

Technology: Catalytic Extraction Process (CEP)—The catalytic extraction process uses an induction or electric arc furnace to form a molten metal bath. The catalytic extraction process uses the molten bath not only as a means for metal purification but also as a high temperature, high energy density medium for more effectively reducing hazardous waste materials, such as PCBs, hydrocarbons, and cyanide to nonhazardous material. The molten metal at about 3,000°F provides much more effective contact with the material in a smaller volume than possible with the hot gases in a conventional incinerator.[1]

Status: Predemonstration—CEP was developed by a commercial vendor to use standard "off-the-shelf" steel industry equipment.[1] It is unique concerning the use of a molten metal bath to more effectively disassociate hazardous materials with potential recovery of valuable or usable constituents. CEP reportedly will allow many hazardous wastes to be processed ten times more effectively than an incinerator, since the molten metal bath at 3,000°F provides much better thermal contact than hot gases. If the wastes being processed require oxygen, it is added as pure oxygen rather than air, and off-gases are one-fifth to one-fiftieth the volume of an incinerator for the same amount of material. Capital costs are estimated at one-half that of an incinerator and operating costs are estimated at one-third that of an incinerator's operating costs. The costs to incinerate mixed wastes in the TSCA incinerator at K-25 is estimated[2] at $6/lb if solids were fed with liquids. Thus the payback potential for

CEP is great. This process has not yet been used to incinerate or smelt scrap bearing radioactivity.[3] Experiments at Y-12 have shown that mild steel, stainless steel, nickel, copper, and monel can be purified by smelting to levels of 0.01 ppm to 4.0 ppm residual uranium. Aluminum was more difficult to purify with levels of residual uranium remaining at concentration's from 3 to 100 ppm. Tc reportedly was not removed.[4] Hesmatpour and Copeland[5] report better results for aluminum (1 to 2 ppm). Based on information contained in a report by Kellogg et al.[6], a cost of roughly $0.93/lb of metal smelted may be estimated, which includes capital and operating costs. Their estimate concludes that if a *de minimus* standard is obtained allowing the ingots to be sold, the value of the metal could totally pay for the project. The wastes would be in the form of radioactive slag and perhaps scrubber solution although wet scrubbers may be avoided in many applications.[1] Quantities are not available, but Kellogg et al.[6] estimated that ~50 lb of slag would be generated per ton of scrap metal processed by smelt purification.

Science/Technology Needs: Technology Development Needs—The report that Tc is not removed by the process may seriously damage the prospect of using this method for metal purification if a suitable fluxing agent cannot be demonstrated. Also, the poor results reported in removing aluminum must be further investigated. The use of CEP as a substitute for incineration of mixed waste has not been done on any scale at this point and must be developed.

Implementation Needs: The technology development will require further lab and pilot-scale evaluation. Detailed requirements for the CEP development of production phase could not be obtained, but are assumed to closely resemble those roughly estimated for smelt purification. The costs are briefly enumerated as follows: development cost, $3–5M; capital cost, one-half the amount of an incinerator of equal capacity (~$16 M); and operating cost, one-third the amount of an incinerator ($2–$3/lb for nonmetals, $0.93/lb for metals smelting)

The following requirements are based on that assumption. The development costs would include a small electric induction furnace, two full-time technical people (one with experience in metallurgy), analytical, maintenance, and other support personnel. The duration may be 24 months and the development costs are roughly estimated by the investigator at $2.0–$3.5 million. The following requirements for a smelt facility are listed by Kellogg et al.:[6] scrap handling and preparation, scrap transportation, scrap weighing and drying facility (the scrap must be heated prior to placing in the smelter to drive off oil and water), eight-ton capacity electric induction furnace with two crucibles, mold preparation and cooling, slag process refractory repair, flux storage and preparation, ingot dumping and storage, offices, laboratory and control room, maintenance areas, and personnel convenience stations. Capital and operating costs were not indicated, but as mentioned above, an overall cost of roughly $0.93/h can be estimated based on their conclusions that all costs could be recovered from the sell of 90,000 tons of metal presently in the DOE inventory (valved at $102 million in 1982 dollars) assuming a *de minimus* is established. (About 74% of the metal value is the nickel which amounts to only 11% by weight of the metals in the Kellogg study).

Most likely no existing facility at the K-25 Site will satisfy the operational requirements of this facility (the Kellogg study assumes new facilities are constructed). The design and

construction phase will require the support of many engineering disciplines: structural and site engineering, engineering mechanics, process design, electrical engineering, instrument engineering, safety engineering, and metallurgy. Numerous support services will be required: health physics, industrial hygiene, health, safety, environmental, and analytical services. Numerous construction and maintenance craftsmen will be required: welders, carpenters, electricians, mechanics, ETI personnel, and supervisors. These requirements cannot be quantified at present. The establishment of a *de minimus* standard is very critical for the success of this project since the resulting ingots cannot be sold without this legislation.

Author: E. B. Munday

References:

1. Jeffrey D. Smith, "Molten Metal Technology," *EI Digest*, Industrial and Hazardous Waste Management Environmental Information LTD, July 1991

2. Tom Rodgers, Martin Marietta Energy Systems, Inc., personal communication, June, 1992.

3. Victor Gatto, Molten Metal Technology, Inc., personal communication, June 1992.

4. Y-12 Plant data

5. B. Hesmatpour and G. L. Copeland, *The Effects of Slag Composition and Process Variable on Decontamination of Metallic Wastes by Melt Refining*, ORNL/TM-7501, Union Carbide Corporation, January 1981.

6. D. R. Kellogg et al., *Metal-Smelting Facility*, CONF-820418-13, DE-82 013539, Union Carbide Corporation Nuclear Division, 1992.

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Transite contaminated with the following:

- U
- oil
- U and oil
- U and Tc
- oil and PCBs
- U, oil, and PCBs
- U, Tc, and oil
- U, Tc and actinides
- U and PCBs
- U, Tc, oil, and PCBs
- U, Tc, actinides, oil and PCBs

Reference Requirements:

- Federal Facility Compliance Agreements (FFCAs), e.g., FFCA for Oak Ridge Site
- FFCAs for PCBs
- Applicable Federal and State laws and regulations, e.g., Clean Air Act and Toxic Substance Control Act
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternative: Bulk Decontamination Methods

Technology: Vacuum (Low Pressure)

Status: Accepted. Allied Signal has a proprietary, vacuum-based process for removing soluble Cr^{+6} from transite sheets. It has used a vacuum in conjunction with dilute acids to decrease Cr^{+6} from 7 ppm to below 4 ppm bulk decontamination residual concentration. The low separation efficiency makes this a doubtful process candidate and there is no experience of removing radiological contaminants. Any process for removing transite contaminants must begin at the problem definition stage.

Science Technology Needs: None

Implementation Needs: Large blower systems are needed to draw a vacuum on the building; sprayer systems are needed to spray acid on the material. Capital and operating costs are considered proprietary. Capital cost is roughly estimated at $1M–$10M and operating costs, at $2–$8/ft^2.

Author: R. B. Alderfer

Reference: J. Harrigan, International Dismantling and Machinery Corp., South River, NJ., personal communication to R. Alderfer, Martin Marietta Energy Systems, Inc., June 5, 1992.

CHEMICAL FOAMS DCON-8-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Used for in situ decontamination of vertical surfaces, large components, and internal surfaces of nickel-plated steel equipment or steel pipes. Contamination (smearable) can be uranium or other contaminants as dictated by foam constituents

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site)
- Applicable federal and state laws and regulations (e.g., Clean Water Act & Toxic Substance Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternative: Chemical Surface Cleaning (fixed and transferable contamination)

Technology: Chemical Foams—For removing smearable contamination from contacted surfaces. Foam is used as a carrier of chemical decontamination agents, such as detergents and wetting agents, not as the agent itself. It is sprayed onto component walls or the component is filled with the foam. For vertical surfaces, decontamination agents are suspended in a thick, dry foam that is applied to the surface to be cleaned. Ideally, a light, even coating (1–2 in. thick) is formed, with a resident time on vertical surfaces of at least several minutes. It can be sprayed on and wiped, rinsed, or vacuumed off. Repeated applications can give "several orders of magnitude reduction in surface contamination."[1] More recently, gels have been preferred for equipment exteriors, and foams are utilized for circulating in pipes and systems in situ.[2]

Status: Accepted. Widely used throughout the nuclear industry.

Waste: Small amount of contaminated sulfonated detergents, synthetic wetting agents, coupling agents, rinse water, and drying cloth.

Cost: The technology itself is inexpensive, but development and scale-up will probably require significant financial support.

Advantages: Good method for large components with complex shapes. Good method for internal in situ decontamination to eliminate smearable contamination prior to dismantlement. Low final waste volume. Remote application is easily done.[2]

Disadvantages: Fully controlled foaming times are needed. There is difficulty in keeping foam circulating while integrally filling large cavities. It is not appropriate for use on cracked surfaces or where there are deep or convoluted crevices.

Effectiveness: In one study, decontamination effectiveness using Turco was 63-92% (DF 2.7 to 12.5) on painted surfaces inside a hot cell.[1] On unpainted carbon steel, it was 75-90%. It does not remove oxides, but it removes lightly bonded contaminants. The contact time is too short to obtain DFs currently desired in a batch process (spraying or filling). One approach is to fill the component and then circulate the foam for as long as necessary.[2] Currently in use at Rockwell International, using a spray system developed by TURCO.

Science Technology Needs: Full control over the mean bubble dimensions and the volume swell factor are needed, indicating that some basic research will be necessary.

Implementation Needs: Scale-up/development of the process to a size appropriate for K-25 Site use. Estimated costs follow: development, $1M–$4M; capital cost, < $50K; operating cost, $0.50–$2/ft^2.

Author: D. E. Beck

References:

1. J. M. Harris, J. R. Miller, R. S. Frazier, J. H. Walter, "Foam Process for Application of Decontaminating Agents," from the *International Conference on Decontamination of Nuclear Facilities*, Niagara Falls, Canada, September 19, 1982.

2. J. R. Costes, J. P. Gouchon, M. Montjoie (Commissaruat a l'Energie Atomique, France) "Recent Developments in Gel and Foam Decontamination Processes Applied to Decommissioning," *Proceedings of the Nuclear and Hazardous Waste Management International Topical Meeting (Spectrum '88)*, Sept. 11–15, 1988, Pasco, Washington, Published by ANS, LaGrange Park, Ill. (September 1988), pp. 24–29.

CHEMICAL GELS DCON-9-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Exterior equipment surfaces, floors, and walls; reagents should be chosen according to substrate and contamination.

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site)
- Applicable federal and state laws and regulations (e.g., Clean Water Act & Toxic Substance Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternative: Chemical Surface Cleaning Methods

Technology: Chemical Gels—For removing smearable contamination from contacted surfaces. The use of Chemical gels is most suited to *in situ* decontamination of large surfaces.[1] Gel is used as a carrier of chemical decontamination agents, not as the agent itself. It is sprayed onto component walls; allowed to work; and then scrubbed, wiped, rinsed, or peeled off. Solutions with viscosities of 300–600 cps form a reasonably stable film on the contaminated surface. An airless compressor can be used for spraying the gel and, with a change in heads, for rinsing. Typical reagent combinations are a nitric-hydrofluoric-oxalic acid mixture and a nonionic detergent mixed with a carboxymethylcellulose gelling agent, with aluminum nitrate used as a fluoride chelating agent. Steps include scraping and vacuuming of solid waste material, preliminary hot water rinsing, and gel spraying throughout the cell.

Status: Demonstration.

Advantages: It is a good method for large component in situ removal of smearable contamination. Minimizes secondary waste volumes.[2] Remote application is easily done.

Disadvantages: It is a complex system that requires laboratory optimization for each change in variables. Costly and time-consuming for decommissioning but possibly worthwhile for maintenance and cleaning operations. Reagent action is limited by the solution viscosity,

which reduces the ion diffusion rate at the gel/surface interface. Amount of active reagents in gel film must be kept low (< 10 g/m^2).

Effectiveness: DFs can be as high as 100.[1] In some cases, as many as 3 gel applications have been required (e.g., 2 acid and 1 base applications).

Wastes: After spraying and rinsing the gel film two or three times, the volume of waste to be neutralized was four or five times less than that for decontamination of the same item by chemical solutions such as nitric acid. Treatment of the acidic and basic wastes can be by phosphate precipitation, sulfate precipitation, simple neutralization, or neutralization and addition of preformed nickel ferrocyanide precipitate.[1]

Science/Technology Needs: Complex gel formulation with a number of compounds may be required, depending on the objectives. Laboratory optimization will be necessary, with any change in variables.

Implementation Needs: N/A

Author: D. E. Beck

References:

1. J. R. Costes, J. P. Gouchon, M. Montjoie, "Recent Developments in Gel and Foam Decontamination Processes Applied to Decommissioning," *Proceedings of the Nuclear and Hazardous Waste Management International Topical Meeting (Spectrum '88)*, Sept. 11–15, 1988, Pasco, Washington, Published by ANS, La Grange Park, IL (Sept. 1988), pp. 24–29.

2. R. P. Allen, K. J. Schneider, G. J. Konzek, and R. I. Smith, "Decontamination Technology Assessment" from *Proceedings of the Nuclear and Hazardous Waste Management International Topical Meeting (Spectrum '88)*, Sept. 11–15, 1988, Pasco, Washington, Published by ANS, LaGrange Park, IL (Sept. 1988), pp. 511–513.

ORGANIC ACID TREATMENT/ BNFL CITRIC ACID DECONTAMINATION

DCON-10-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Metal equipment (exterior) contaminated with uranium and technetium, aluminum, copper, Monel, steel, nickel substrates with U, Tc, and actinide contamination

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site)
- Applicable Federal and State laws and regulations (e.g., Clean Water Act & Toxic Substances Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Chemical Surface Cleaning (fixed and transferable contamination)

Technology: Organic Acid Treatment/BNFL Citric Acid Decontamination

Status: Demonstrated—The technology is currently in use by BNFL at Capenhurst gaseous diffusion plant. BNFL uses citric and sulfuric acids in sequence for removal of U and Tc, respectively, from metal surfaces (mostly wrought aluminum). Citric acid portion is dilute ("soft"), with correspondingly low corrosion. The carboxylate ion is strongly complexing.

Effectiveness: BNFL process achieved surface DF of 300 for U alpha, and 40 for Tc beta[1]. Decontaminated to below British standards for release as scrap: 11.1 Bq/g alpha, and 0.4 Bq/g beta. The high-enrichment portion of Capenhurst decontamination was completed in 1985. Recycled to metals market were 1,000 tons aluminum, 1700 tons steel and 350 tons other metals[2]. The low-enrichment portion of the facility is now in the process of decontamination.

Limitations: If uranium recovery is required, citric acid may be inappropriate. Citric tends to prevent U precipitation. Although the BNFL process works well on wrought aluminum, it may have only limited success with cast Al.[3]

Advantages: Demonstrated effectiveness in decontamination of GDP facility. BNFL is willing to market the technology.

Wastes: Secondary wastes are (1) Citric acid containing metal ions, especially uranium, and (2) sulfuric acid containing metal ions, especially technetium and nickel. Citric acid is relatively benign to the environment, biodegradable, and treatable by ion exchange removal of radionuclide and other metal ions. Remaining effluent may be treatable at sewage treatment plant (POTW). Sulfuric acid is also treatable by ion exchange with possible recycle of cleaned acid. Tertiary wastes are depleted ion exchange resins. NOTE: SEG and possibly other companies compact and solidify IX resin wastes on contract or they will provide complete IX services.

Costs: Total net costs for the Capenhurst decontamination project are expected to be around one hundred million pounds. Four years ago, BNFL's operating cost was approximately $300 per metric ton. Ours would rate higher because of more sophisticated effluent treatment needs. Capital costs will include spray booth and tank installation with fluid recirculation systems but will not be significantly higher for the BNFL process than for any other proven acid dissolution decontamination system.

Science/Technology Needs: Technology development needs: Pilot plant development for waste treatments (ion exchange columns) to verify that we can meet our standards and regulations. More fundamental studies are needed in secondary waste disposal.[4]

Implementation Needs: Development—The financial resources necessary for purchase of technology, regulatory compliance, pilot-scale decontamination and waste treatment demonstrations. For personnel, a Ph.D. and/or an engineer to direct development. Cost: $400K–$1000K.

Implementation—the financial resources necessary for retrofit of facility, environmental compliance, and procedural requirements. The procedure should require no more personnel than the nitric acid process did in the Building K-1420 at the K-25 Site.

Hardware needs: K-1420 operations could be adapted for citric acid cleaning, but would require building additional spray booths with fluid recirculation for each (to adapt BNFL process). Portsmouth has had trial runs substituting citric acid for sodium carbonate and nitric acid in its spray booth operation (X-705 facility) with success[5] (this, along with BNFL's expertise, may reduce the amount of original research, paperwork, etc. necessary to begin implementation). In general, decontamination with BNFL's citric acid process should pose no undue difficulties or unusual resource needs. It may well be less costly to implement than the familiar nitric acid process would be due to the relative nontoxicity and ease of treating secondary waste stream. Capital costs would be $4M–$10M if new equipment is required; operating costs would be $300/2200 lb (BNFL estimate).

Author: D. E. Beck

February 26, 1993

References:

1. D. Leigh, BNFL, personal communication, July 20, 1992.

2. D. W. Clements and G. H. C. Begg, "Decommissioning Britain's Gaseous Diffusion Plant--With Special Reference to Volume Reduction Techniques," *Proc. Inst. Mech. Eng., IMechE Conference*, 1992, pp. 179–88.

3. John Barber, John Kennerly, and others of Martin Marietta Energy Systems, personal communications. May–June 1992.

4. G. D. Del Cul, P. E. Osborne, D. E. Beck, *Evaluation of Alternatives for Best Available Technology Treatment and Retreatment of Uranium-Contaminated Wastewater*, K/QT-394, Part 1, January 1991.

5. M. E. Holland, *Use of Citric Acid for Large Parts Decontamination*, GAT-2000 under contract DE-AC04-76ORO 0001 with the U.S. Department of Energy, Goodyear Atomic Corp., Piketon, Ohio, September 1979.

FLUOROBORIC ACID TREATMENTS DCON-11-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Concrete contaminated with U, Tc, actinides. Structural steel, metal equipment exteriors and interiors (steel, stainless steel, nickel alloys, aluminum), sheet metal, and pipes, contaminated with U, Tc, actinides.

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site)
- Applicable federal and state laws and regulations (e.g., Clean Water Act and Toxic Substances Control Act)
- DOE orders

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Subelement: Decontamination

Alternatives: Chemical Surface Cleaning Methods

Technology: Fluoroboric Acid Treatments—Decontamination and decommissioning using Fluoboric Acid (HBF_4) in dipping baths, loop systems, or by spraying.

Status: Demonstration—Technology was designed specifically for D&D.[1] Attacks nearly every metal surface and metallic oxide. Removes oxide and contaminated outer layer in controllable, uniform and efficient manner. Unrestricted use of materials should be possible after decontamination, due to high decontamination factor (DF); however, corrosion is high (DF is a function of the depth of metal removed).

Waste: Approximately 1 gram metallic waste generated per square meter per micron depth of base metal removal. The acid can be electrolytically regenerated and recycled, with the radioactive waste plated out at the cathode and solidified in cement. Final quantity of cement-solidified waste is 20–50 grams per meter^2 decontaminated metal. Other waste treatment options are neutralization and precipitation with solidification in cement (200–500 g of concrete/m^2 of surface cleaned) or treatment by ion exchange followed by solidification of the resin in cement (400–700 g of concrete/m^2 of surface cleaned).

The reaction is heterogeneous and proceeds as:

1. $nHBF_4 + Me = Me(BF_4)_n + n/2\ H_2$
2. $nHBF_4$ + metallic oxide = $Me(BF_4)_n$ + water

Fluoroboric (or fluorosilicic) acid can also scabble and clean cement and brickwork. If it is contaminated to a depth of only a few mm., concrete flooring and structures can be returned to unrestricted use.[1]

Science/Technology Needs: Depends to a certain extent on similarities between K-25 and Chernobyl operations.[2] Results of the technology usage at Chernobyl may answer many questions for us.

The fluoroboric acid technology generates a metal waste as a result of metal surface removal. The optimum material for solidification of this waste needs to be determined.

Implementation Needs:

Hardware (equipment): Fabrication of all key plant parts from polypropylene or from Halar-coated metal.

Resources (financial): Capital cost in 1990 to set up a plant for decontaminating 5 tons/day of steel was DM 1.3 million ($774K) excluding development, planning and buildings.[2] Operating costs will be relatively low; this is a very simple process. The plant can be manufactured in modular form[2] and installed in existing buildings.

NOTE: Fluoroboric acid exhibits low vapor pressure and requires only the standard precautions for acid or base work.

Author: D. E. Beck

References:

1. J. D. Hanulik and W. T. Rippin, "Chemical Decontamination for Decommissioning with Application of DECOHA Technology on Metal, Concrete, and Brickwork," from *Proceedings of the Institution of Mechanical Engineers Nuclear Decom '92, Decommissioning of Radioactive Facilities* International Conference, London, England. February 17–19, 1992.

2. H. W. Beaujean, J. Fiala-Goldiger, J. Hanulik, "DECOHA at Chernobyl," *Nuclear Engineering International*, April 30, 1991.

INORGANIC ACID TREATMENTS DCON-12-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Metal equipment (exterior) contaminated with U, Tc, actinides. Also structural steel, nickel-lined steel equipment (interior), piping.

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site)
- Applicable Federal and State laws and regulations (e.g., Clean Water Act & Toxic Substances Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Chemical Surface Cleaning (fixed and transferable contamination)

Technology: Inorganic Acid Treatments—Removal of tightly adherent contamination using *nitric acid* solutions in spray booth or dipping decontamination processes. Use of other inorganic acids.

Status: Accepted—Nitric acid decontamination has been the preferred method at K-25 for cleaning converters and other large items in K-1420 spray booth operations since the 1940s. Portsmouth's X-705 facility is the same as K-1420's, but has been modified to keep effluent and emissions within regulatory limits.[1] Both Portsmouth and K-25 decontaminate for maintenance but not for the release of the metal. Concentrated (pH<2) solution with concurrent corrosion; however, additives (1% urea) and modifications can greatly reduce corrosion. Decontamination factor (DF) for concentrated acid treatment is in the 100 range.[2]

Advantages/Effectiveness: Excellent DFs. One of the waste products, uranyl nitrate, is the first step in conversion of U to U_3O_4 (thus nitric acid is commonly used in uranium recovery processes). This ease of U recovery is the primary reason Portsmouth continues to use nitric acid decontamination.

Limitations: Secondary waste requires treatment and disposal as an RCRA waste.

Waste: Large quantities of corrosive nitrates produced. Difficult and expensive to treat by today's standards; however, Portsmouth has built a biodenitrification facility which meets NPDES outfall standards. In addition to and prior to biodenitrification, waste treatment will likely involve removal of uranium by liquid-liquid extraction, ^{99}Tc by ion exchange, other heavy metals by precipitation.[3] Uranium removal can also be effected by lime softening/iron coprecipitation.[4]

Cost: Nitric acid decontamination was used extensively at the gaseous diffusion plants, but data is not available regarding costs. Currently, Portsmouth plant is developing a data base to track costs,[3] but it will not contain historical data.

Although nitric acid is by far the most common, sulfuric acid has been used in decontamination—notably to dissolve nickel-plating prior to removal of technetium at the nickel-steel interface.[5] Other inorganic acids, such as hydrochloric, are rarely mentioned in the literature. The exception is fluoboric acid, for which a separate input sheet is written.

Science/Technology Needs:

Technology improvement needs: Adaptation of Portsmouth (or other) modifications to system (i.e., scrubbers, filters, treatment for nitrates and heavy metals) in order to meet regulatory requirements.[6] Possible development of HNO_3/HF decontamination methods, with or without ultrasonic agitation.[7,8]

Continuing research and development, waste treatment, and volume reduction. Possible research and development in control of base metal dissolution.

Implementation Needs: Nitrate treatment facility either on site or accessible to decontamination facility. Financial resources: probably less capital cost, at K-25 Site, for nitric acid decontamination than for any other wet decontamination technology. However, a treatment facility for corrosive nitrate wastes is required. Support personnel to sample, analyze, develop treatments, and ensure compliance with RCRA regulations will be necessary; thus, operating costs may be relatively high.

Author: D. E. Beck

References:

1. J. C. Bailey, J. Dykstra, and R. A. Joseph, *Review and Appraisal of K-1420 Decontamination--Uranium Recovery (U).*, K/D-5819, Engineering Division of Oak Ridge Gaseous Diffusion Plant. April 1989.

2. K. H. Miyamaru, H. Mizuno, and Y. Imai, *Cost Benefit Study of Chemical Decontamination*, presented at *Decontamination of Nuclear Facilities, International Joint Topical Meeting*, ANS-CNA, Niagara Falls, Canada. Sept. 19–22, 1982.

3. Personal communication, A. J. Saraceno, Portsmouth GDP. April 29, 1992.

4. G. D. Del Cul, P. E. Osborne, and D. E. Beck, *Evaluation of Alternatives for Best Available Technology Treatment and Treatment of Uranium-Contaminated Solutions*, K/QT-394, Oak Ridge K-25 Site. April 1991.

5. G. H. Goodall and B. E. Gillespie, *Decontamination of Surfaces*, (BNFL) Patent No. GB 2191329 A. December 1987.

6. Personal opinion, based on J. C. Bailey et al., *Review and Appraisal of K-1420 Decontamination--Uranium Recovery (U)*, K/D-5819, Engineering Division, Oak Ridge Gaseous Diffusion Plant. April 1989.

7. S. Buck and A. Colquhoun, "Decommissioning of a Mixed Oxide Fuel Fabrication Facility," (BNFL), eds. Pflugrad et al. *International Conference on Decommissioning of Nuclear Installations*, (Brussels, Oct. 24–27, 1989). Report No. CONF-891077-EUR-12690. Barking (UK) Elsevier Applied Science, 1990.

8. Allen, Schneider, Konzek, and Smith, "Decontamination Technology Assessment," *Proceedings of the International Topical Meeting for Nuclear and Hazardous Waste Management Spectrum '88*, ANS, La Grange Park, Ill. September 1988, pp. 511–513.

CAUSTIC TREATMENT DCON-13-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Structural steel; metal equipment (exterior); nickel-lined steel (interior); aluminum; all contaminated with U, Tc, and/or actinides; aluminum pipe contaminated with Cr.

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site)
- Applicable federal and state laws and regulations (e.g., Clean Water Act and Toxic Substance Control Act)
- DOE orders

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Subelement: Decontamination

Alternatives: Chemical Surface Cleaning

Technology: Caustic Treatment—The use of alkaline sodium carbonate, ammonium carbonate, sodium EDTA, sodium citrate, trisodium phosphate, other sequestering agents, and detergents for surface washing and removal of particulates; the use of alkaline permanganate to oxidize chromium in high-Cr oxides (preconditioning the oxide for further treatment).

Status: Accepted/demonstrated
Surface smearable decontamination with caustic chemicals (essentially soap and water scrubbing) is accepted technology at K-25.[2] Using alkaline potassium permanganate to dissolve high-chromium oxides by oxidizing the chrome content in PWRs (Pressurized Water Reactors) has been demonstrated.[3] The latter may or may not be relevant to K-25 needs; the need for dissolution of high-Cr oxides appears unique to PWRs in the commercial sector. The K-25 caustic hand-scrubbing process was applied to cleaning small items.

Waste: Moderate quantities of contaminated caustic solutions. Simple neutralization and precipitation has been the traditional treatment. The sludge produced could be solidified and the effluent sent to the Central Neutralization Facility.

Cost: Caustic decontamination was used extensively at the gaseous diffusion plants, in conjunction with nitric acid, but, at this time, cost information is not available.[1] Capital costs could be minimal, but scrubbing with caustic solutions is labor intensive.

Effectiveness: Decontamination factors (DFs) for removal of smearable contaminants are also not available; however, items cleaned with caustic chemicals can usually be green-tagged by Health Physics personnel (<300 dpm alpha).[1]

Science/Technology Needs: None for removal of smearable contamination with carbonates, soaps, etc.;[2] possibly some technology development and basic research to gather data and to determine usefulness of alkaline dissolution of surface fluoride films (as noted in the status section, little data was recorded or kept).

Implementation Needs: This is an established process that could be reimplemented at K-1420 with no major changes. Capital cost are estimated at <$10K; operating costs, at >$1/ft^2.

Author: D. E. Beck

References:

1. Personal communication, G. D. Conner, the K-25 facility, June 16, 1992, and J. M. Urik, the X-705 facility (Portsmouth), June 16, 1992.

2. SOP 1410.20, "Large Parts Decontamination ('C' Floor Plan)," July 1989, and SOP 1410.21, "Small Parts Decontamination ('A' Floor Plan)," July 1989, Martin Marietta Energy Systems, Inc., Oak Ridge Gaseous Diffusion Plant Standard Operating Procedures.

3. T. Swan, M. G. Segal, W. J. Williams, M. E. Pick, *LOMI Decontamination Reagents and Related Preoxidation Processes*, EPRI-NP-5522M, Research Project 1329-1. Prepared by Central Electricity Generating Board, Berkeley Nuclear Laboratories, UK, for the Electric Power Research Institute, Palo Alto, Calif. December 1987.

REDOX TREATMENTS DCON-14-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Steel pipe/chromates; aluminum pipe with chrome; Monel, copper, structural steels, nickel-lined steel equipment contaminated with uranium; aluminum valves with Chrome.

Reference Requirements:

- Federal Facility Agreements (e.g., FFCA for Oak Ridge Site)
- Applicable Federal and State laws and regulations (e.g., Clean Water Act & Toxic Substances Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Chemical surface cleaning methods.

Technology: Redox Treatments—Various "designer" combinations, including the following: (1) AP-Citrox—a two-step process using an alkaline permangante oxidizing step followed by a citric acid-oxalic acid reducing step, (2) LOMI—a one-step process using vanadous picolinate solution for reduction of ferric ion to ferrous (using vanadium ion) and subsequent chelation with picolinate, and (3) Ceric acid—solutions of cerium IV in inorganic acids (nitric, sulfuric, sulfamic, etc.); several different formulations, but all appear to work by oxidization with Ce followed by complex formation with an inorganic acid to keep metals in solution.

Status: Demonstrated for nuclear power plant decontamination; predemonstration for gaseous diffusion plant and fluoride films.

Citrox, a mixture of oxalic and citric acids (Turco 4521 is a Citrox reagent) has been used since the early 1980's to decon boiling water reactors (BWRs). Its DF ranged from 0.3 to 17 in a 1984 series of tests.[1] AP-Citrox (Citrox with pre-oxidation by alkaline permanganate) was developed for PWRs, oxides of which have a high percentage of chrome. The purpose of the AP step is to oxidize and remove chrome from the high-chromium (>20%) oxide film prior to complexation by citric and oxalic acids. Addition of pre-oxidation step to Citrox process increases the DF by a factor of 10 to 100, for high-chrome oxides.

Disadvantage: There can be intergranular attack and stress corrosion cracking on steel when oxalic acid is present in decontamination solution.

Waste: Produces largest quantity ion-exchange resin waste of the three technologies discussed.

Cost: Operating costs relating high, especially for two-step process.

LOMI (for low oxidation-state metal ion) is a noncorrosive process using vanadous picolinate solution to rapidly reduce iron-based oxides. LOMI was developed in response to the oxalic acid corrosion problems mentioned above, and has been used for decontamination of Boiling and Pressurized Water Reactors (BWR and PWR) since the mid-1980's. It is often combined with a preoxidation step making it a process of two or more steps using acidic or alkaline permanganate or both. Multi-step process may be NP-LOMI (nitric acid/permanganate), AP-LOMI (alkaline permanganate), or AP/NP/LOMI, depending on the substrate. Other LOMI combinations can be tailored, such as LOMI-NP-LOMI, etc., to obtain the optimum decontamination.[2]

Advantage: An advantage to LOMI is that it has proven to be unaffected by the incorporation of nickel in the oxide lattice, which can make dissolution of iron-based oxides by simple complexing acids difficult.[3]

Disadvantages: Possible storage problems; both permanagnate and LOMI solutions are thermodynamically unstable when exposed to water.

Tailoring is essential for efficient decontamination; not only from system to system, but sometimes within the system. For example, Cr content in the oxide can vary from location to location within a piece of equipment.

Effectiveness: Overall decontamination factor, DF, at Monticello recirculation system, was 22.9 (removal of 96% of the contamination), using LOMI. On high-chrome equipment, the DF was 3.6 (removal of 72%). LOMI was less effective than a Citrox process in decontaminating TMI-2 reactor cooling system.[4]

Waste: Volume of secondary waste generated is about one-half that of the Citrox process. It does contain relatively high metal concentrations which could be precipitated out before passing the remaining waste through ion-exchange columns. A cation resin from DOW and an anion resin from Rohm & Haas are effective in cleaning the waste stream. "Cleanup by ion-exchange is straightforward and very efficient."[5] However, disposal of IX resins is becoming a problem.

Cost: Both capital and operating costs are probably higher than for Citrox, but have collected no hard cost data.

Cerium solutions in acid (for example, cerium nitrate) are the most recent developments in REDOX decontamination. They produce a high DF, are excellent for use on complex

configurations, and produce a resolution rate higher than electropolishing.[6] Cerium oxidation is also called promising for TRU decontamination.[7] At least one of the ceric acid methods, using tetrasulfato ceric acid, is patented.[8]

Advantages: Ceric acid solutions eliminate the need for separate oxidizing and decontaminating solutions. Wide applicability to complex configurations. Dilute (soft) process and temperatures as low as 70 C help keep corrosion rates low.

Disadvantages: New technology, requiring more development. Must be tailored to substrate and oxide film.

Effectiveness: A solution of ceric acid and inorganic acid was found to remove more than 97% of contamination in a reactor cooling system.[9] For greater effectiveness, ceric acid cleaning may be followed by conventional decontamination (mixture of a chelate and an organic acid) and a final rinse with deionized water.

Waste: The spent ceric acid solution can be cleaned with a mixed anion-cation exchange resin and reused, or it can be neutralized, evaporated, and disposed of as solid waste. In order to recycle, the CeIII can be oxidized back to CeIV by oxidizing with ozone or peroxide. Subsequent passage through ion exchange columns will remove most radioactive metal ions.

Uranyl and plutonyl will pass through, and can then be recovered by solvent extraction or more ion exchange. Disposal of ion exchange resins or solidified wastes may present a problem. Another option is for electrolytic regeneration of the spent ceric acid solution.

Cost: Cerium solutions are nearly as effective as permanganate solutions, for oxidation. However, cerium solutions are more expensive. Research and development are necessary for application of the process to gaseous diffusion equipment.

Science/Technology Needs: All REDOX techniques will require demonstration to determine their usefulness to decontamination of gaseous diffusion operations and applicability to fluoride-based contaminant films. It is estimated that development costs could be greater that $1M to bring a REDOX decontamination development through bench-scale and demonstration phases.

Implementation Needs: N/A

Author:

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8. Murray, A. P., C. G. Slater, R. W. White, Ceric Acid Decontamination of Nuclear Reactors, U. S. Patent No. 4,880,559. November 1989.

9. Murray et al, "Ceric Acid Decontamination of Nuclear Reactors," U. S. Patent Number 4,880,559. Nov. 14, 1989.

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Contaminant metal ions on metal.

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternative: Chemical Surface Cleaning—Selective removal of contaminants using a combination of an electric current and an electrolyte fluid.

Technology: Electropolishing—This technology is a surface removal process which is traditionally applied to metallic (conductive) substrates. The electropolished area is defined by the path of the electric current (the path of lowest resistance) from electrode to substrate, hence a rough surface is smoothed because the "high" spots are closer to the electrode than are the low spots. Cracks or crevices will not be electropolished until the surrounding "high" areas are removed. Traditionally applied as a portable or "localized" technology on small areas, the solvent and electricity being applied in some way to a localized spot.

Could be applied as a "factory style" process in batch fashion to contaminated parts. Contaminated materials fed into processing equipment and cleaned material exits.

Status: Demonstration

Efficacy: Electropolishing is a surface removal technique and the amount of surface removed is proportional to factors such as current, time, and voltage. These factors can be increased so that the entire surface is removed. For smooth contaminated materials, the level of decontamination is dependent on transport of electropolishing products away from the cleaned surface and, in practice, levels of zero added contamination can be achieved.

Waste: A contaminated electrolyte solution is a product of this process.

Limitations: Electropolishing is essentially a "line of sight" process so cracks, crevices, areas out of sight of, or shadowed by, the electrode will not be decontaminated. Contaminated electrolyte must be removed for complete decontamination to be achieved. Electropolishing is difficult to apply to in situ equipment.

Science/Technology Needs: Primary and secondary waste treatment and solution recyle need to be developed. Cleanup principles (e.g., ion exchange and filtering) are well established, so that only design and demonstration are needed.

Implementation Needs: Development costs are estimated at $400K–$1000K; operating cost, at >$1/ft^2.

Authors: R. L. Fellows

Reference: MMES staff members

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GAS PHASE DCONTAMINATION DCON-16-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers. Deposit removal.

Problem Area/Constituents: Nickel-lined steel equipment, copper tubing, aluminum pipe, and steel cylinders contaminated with uranium.

Reference Requirements:

- Clean Air Act, NEPA, NESHAP, FFCAs
- Applicable federal and state laws and regulations
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Chemical Surface Cleaning (fixed and transferable contamination)

Technology: Gas Phase Decontamination—Gas phase decontamination uses a strong fluorinating gas (most likely chlorine trifluoride) to fully fluorinate uranium solid deposits contaminating the inside surfaces of gaseous diffusion equipment to uranium hexafluoride gas, which can be recovered and reused. The item requiring decontamination would be evacuated, leak tested, charged to subatmospheric pressure with fluorinating gas, sealed, and left for an extended period of time (possibly greater than 6 months), while proceeding to charge other items. Later the gases would be removed and the uranium hexafluoride recovered. The process would allow in-situ recovery of the uranium deposits with alleviation of criticality and health physics concern as well as possible cost avoidance.

Status: Predemonstration—Efforts to decontaminate gaseous diffusion process equipment, bearing uranium deposits as the principle contaminate, have been undertaken by personnel at the US/DOE gaseous diffusion plants at various times with varying degrees of success as reported by Bundy and Munday.[1] Ongoing lab-scale studies[2] indicate that chlorine trifluoride (ClF_3) is capable of reacting with uranium deposits at room temperature much faster than previously believed, which suggests a novel approach to decontaminating the equipment by sealing it, evacuating it, and then adding a subatmospheric, static charge of ClF_3 for an extended period. Recent lab studies have demonstrated the ability to remove uranium deposits from copper tubing removed from a cascade to below the detection level of an alpha meter following a three-month exposure to ClF_3 at subatmospheric pressure. The costs for handling the wastes is included in the operating cost estimates of $15K per item.

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Science/Technology Needs: The lab studies must continue to demonstrate feasibility of the process, and the full-scale demonstration should be done provided the lab results are favorable. A production-scale process will require development of a method to recycle excess chlorine trifluoride. The gas phase process will require handling of the off-gases which will generate liquid scrubber wastes and dry chemical trap wastes which will be contaminated with uranium and perhaps technetium and traces of other radionuclides.

Implementation Needs: The operating costs for processing equipment depends greatly upon the condition and configuration of the equipment. If a cascade cell is in good condition and can easily be sealed, the cell could be treated as a single equipment item and treated for about $20K in operating costs (this does not include any costs to seal the item). If a single "00" converter that weighs 28,800 lb is decontaminated by gas phase treatments for $15K, the cost per pound would be $0.52/ft^2. This cost would be reduced much more if an entire cell can be treated at once.[2] The capital costs for full-scale production equipment is estimated at $3M (most of this amount is already included in the $2.26M capital cost for the full-scale demonstration).

Further lab studies and a full-scale demonstration are expected to cost $4,950K: $345K for lab studies, $2,260K for capital costs, and $2,345K for operating costs. The demonstration is expected to require two full-time technical people (1 CHE and 1 Chemical Technologist), as well as analytical, maintenance, and other support personnel. The design and construction phase will require about $864K in support from the following disciplines of Energy Systems engineering staff: engineering mechanics, process design, electrical engineering, instrument engineering, and safety engineering. Most of the construction activities will be conducted by the construction supervisor. Support services will include: Health Physics, Industrial Hygiene, Health and Safety, Environmental and Analytical Services. The equipment needs will include an evacuation pump, gas manifolds and off-gas handling equipment including chemical traps, scrubber, and stack with isokinetic sampler. Gas analyzers will also be required for quantitative gas analysis. The equipment will be mounted on a trailer.[3]

The production equipment and requirements will be the same as that used for the full-scale demonstration except additional equipment must be constructed for UF_6 recovery and possibly off-gas recycling. These additions are expected to add about $685K to the capital costs. The operating costs, listed under "Status" above, are estimated at $15K per item. Full production operation is expected to require the following personnel assuming only one crew: 2 chemical operators and 1 supervisor plus support from technical division, analytical services, and health physics. Additional personnel would be needed for final material disposition.

Author: E. B. Munday

References: MMES personnel and the following:

1. Roy D. Bundy and Earl B. Munday, *Investigation of Gas-Phase Decontamination of Internally Radioactively Contaminated Gaseous Diffusion Process Equipment and Piping,*

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BIOLOGICAL SURFACE CLEANING DCON-17-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Concrete, structural steel, tile, metal equipment (exterior), Ni-lined steel equipment (interior), Monel, copper, aluminum, insulated copper wiring, sheet metal, steel pipe. Constituents: oils, U, Tc, actinides.

Reference Requirements:

- Federal Facility Compliance Agreement for Oak Ridge Site
- Federal Facility Compliance Agreement for PCBs
- Clean Air Act
- Toxic Substance Control Act
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Chemical Surface Cleaning Methods

Technology: Biological Surface Cleaning—Involves the use of liviing organisms to clean or mobilize surface contamination.

Status: Evolving technology (preconceptual)—This technology is in the preconceptual stage. The knowledge base exists for biological treatment of various contaminants. However, there is no database for application of the technology for surface decontamination purposes. The technology is likely to work if methods can be developed for applying a layer of microbes to surfaces to be decontaminated, supplying needed nutrients to the microbes, and finally removing the microbe layer from the decontaminated surface. The technology may possibly be applied in situations where other technologies cannot be used. For example, microbes could be transported by water to contaminated internal surfaces of equipment that are inaccessible to other technologies. At this time, an estimate of the decontamination efficiency that might be expected cannot be made. The waste generated would be the contaminated layer of microbes removed from the treated surface. An estimate of the quantity of waste cannot be made at this time.

Science/Technology Needs: A research project is needed to investigate the feasibility of using biological treatment for decontamination of surfaces.

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Implementation Needs: An estimate of the capital and operating cost of the technology cannot be made at this time because of its preconceptual status. The cost of an R&D project on surface decontamination by biological treatment would most likely range from $300K to $600K/year.

Author: J. H. Wilson

References: MMES staff members

LASER-ACTIVATED CHEMISTRY DCON-18-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers. Deposit removal.

Problem Area/Constituents:

- Structural steel, sheet metal, and metal equipment (exterior) contaminated with U; U and oil; U and Tc; U, oil, and PCB; U, Tc, and oil; U, Tc, oil, PCBs; U, Tc, and actinides; U and PCBs; or U, oil, Tc, PCBs, and actinides
- Nickel-plated steel equipment (interior), monel, copper, aluminum, and steel contaminated with U; U and Tc; or U, Tc, and actinides
- Insulated copper wiring contaminated with U or U and Tc - steel pipe contaminated with As, chromates, Ba, and dioxins
- Steel cylinders contaminated with UF_6 and Tc or UF_6, Tc, and actinides

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site, FFCA for PCBs)
- Applicable federal and state laws and regulations (e.g., Clean Air Act, Toxic Substance Control Act)
- DOE orders.

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Chemical Surface Cleaning Methods

Technology: Laser-Activated Chemistry—The conceptual basis for the technology exists; laser-activated chemistry is a proven technique for accelerating chemical reaction rates and for selecting reaction channels and chemical stoichiometries.

Status: A widely accepted technique with many industrial applications (there is even an international journal, Laser Chemistry, that publishes papers on new and emerging applications), the use of laser-activated chemistry for radiological decontamination is an evolving technology. Predemonstration laboratory testing of the technology has been planned and is waiting to be funded.

Decontamination with laser-activated chemistry will probably have two primary applications. First, the process can augment other decontamination processes that do not work in difficult-

to-access regions. For instance, the directional nature of laser beams allows the process to reach very small crevices and cracks that are missed by gross decontamination processes. Second, laser-activated chemical processes are capable in many cases of removing all traces of radiological contamination. This will be applicable to situations where a very high degree of decontamination is required.

Decontamination with laser-activated chemistry will likely produce small amounts of waste. In many cases it might be possible to chemically process the waste to separate the radiological contamination from the chemical agent, thereby recovering the radiological component and recycling the chemical agent.

Science/Technology Needs: Laser-activated chemistry for decontamination needs a considerable amount of laboratory research before a technology demonstration can be contemplated. Basically, the hardware and other material required for implementing the technique (e.g., lasers, optics, chemical agents, vacuum systems, filtration systems) already exists; what is needed is a concerted effort to bring all of these components together for the specific applications. Also, the functional requirements of the technology (e.g., where is the contamination located or what degree of decontamination is required?) are being defined as the problem areas are characterized. The development of the technique will need to be coordinated with these requirements.

Implementation Needs: The successful development of this technology will require a team of researchers dedicated to the task. There are many suitable laboratories and qualified researchers available. A best guess of the human resources required is that five person-years of effort over a period of two to three years will be sufficient to develop and demonstrate a prototype system. Most of the hardware needed will consist of off-the-shelf equipment items such as laboratory glove boxes, laser systems, and data acquisition systems. A rough estimate of the financial investment required for development and demonstration is several million dollars over a three-year period.

The successful deployment of the technology will require a transfer of the technology from the laboratory researchers to a commercial manufacturer. The prototype system would serve as the basis for larger-scale or mass production systems. In concept, a laser-activated chemical decontamination system should lend itself to a very high degree of automation, and a commercially available system should be capable of turn-key operation. One technician would be capable of overseeing the operation of multiple systems.

Author: D. B. Smith

References: MMES staff members

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents:

- Structural steel/U. Tc. oils, PCBs, actinides
- Metal equipment (exterior)/U. Tc. oils, PCBs, actinides
- Nickel-lined steel equipment (interior) U. Tc. actinides
- Monel/U. Tc
- Copper/U. Tc, actinides, lube oil
- Aluminum/U. Tc, actinides
- Steel/chromates
- Sheet metal/U. Tc, oils, PCBs
- Steel Pipe/As, chromates, Ba, dioxins, asbestos
- Steel Cylinders/UF6, Tc, actinides

Reference Requirements:

- Federal Facility Compliance Agreements (e. g., FFCA for Oak Ridge Site)
- Applicable federal and state laws and regulations (e. g., Clean Water Act and Toxic Substance Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Chemical Surface Cleaning Methods

Technology: Ultraviolet (UV)Light/Ozone—Ultraviolet light is absorbed by oxygen molecules to form ozone which dissociates to form atomic oxygen. Furthermore, the contaminant molecules are excited and/or dissociated by the absorption of UV. The excited contaminant molecules and the free radicals produced by dissociation of contaminant molecules react with atomic oxygen to form simpler, volatile molecules, such as CO_2, H_2O, and N_2O.

Status: Predemonstration—In the semiconductor industry the UV/ozone surface-cleaning method is an effective method of removing a variety of contaminants from surfaces. Representative contaminants include various oils such as human skin oils, cutting oil, and vacuum pump oil; solder fluxes; greases; and cleaning solvent residues such as acetone,

ethanol, methanol, isopropyl alcohol, trichloroethane, and trichlorotrifluoethane. In most instances UV/ozone surface-cleaning is a simple-to-use process which is inexpensive to set up and operate; cleaning systems are available commercially primarily for the semiconductor industry. The method can produce clean surfaces in air or in a controlled atmosphere, at ambient to slightly elevated temperatures.

However, there are limitations to this cleaning method. Only those contaminants that will dissociate and react with atomic oxygen to form simpler, volatile molecules, such as CO_2, H_2O, and N_2 are effectively removed. There are safety issues involved with the use of UV, the presence of mercury in the UV lamps, and the generation of ozone. Distance of the surface from the UV source has to be minimized for best cleaning results. And because inorganic contaminants such as dust, salts, and solid oxides cannot be removed by this method, precleaning is necessary.

The specific application to decontamination is in the problem definition stage in that UV/ozone cleaning technology exists and may have some applicability to cleaning tasks. The efficacy of this technology to the particular target areas/problem constituents is unknown at this time.

Science/Technology Needs: Alone, the potential of the UV/ozone surface cleaning method for reducing organic contaminants to rather innocuous byproducts warrants further development. Especially, development of a safe, portable, efficient system is desirable. Techniques of combining this method and other efficient plasma methods for removing contaminant metals, oxides, etc., would be particularly advantageous and justifies further investigation. However, its efficacy in removing the specific organic and radioactive contaminants is not demonstrated. Using a commercial UV/ozone hardware, laboratory scale experiments could be conducted to establish a data base of cleaning rates on removing organic contaminants from different substrates and to develop necessary techniques to handle the waste generated. Subsequently, the equipment should be developed with a capability of performing robotic, remote, and automatic operation with computer control.

Implementation Needs: Development activities: to address science needs, the approximate cost of equipment and staff time is $1M (capital equipment, $200K; staff, $800K). For the above activities, the staff are required to be highly trained in the fields of plasma technology and chemistry: one-half would be scientists at the masters and/or the Ph D level, and one-half is highly trained technicians at the BS level.

Demonstration activities: to perform a bench-scale demonstration, the approximate cost of robotic equipment, and staff time is $2M (capital equipment, $500K; staff, $1.5M). For this phase of work, approximately 20% of the staff will be comprised of highly trained staff as mentioned above. The remaining 80% of the staff will have high school training complemented with one to two months of on the job training. After the demonstration phase the majority of the effort can be implemented by technicians that are trained (1–2 months) for this specific work.

Author: W. L. Gardner

February 26, 1993

Reference: J. R. Vig, "UV/Ozone Cleaning of Surfaces, Semiconductor Cleaning Technology/1989," in *Electrochemical Society Proceedings*, **90-9**, 105–113 (1990).

ELECTROMIGRATION DCON-20-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Contaminant metal ions on/in concrete.

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Chemical Surface Cleaning

Technology: Electromigration—Removal of contaminants using electric potential to cause ion migration. This process will leave the concrete surface intact and usable.

Status: Predemonstration—Electromigration is being investigated and developed on a laboratory scale. The phenomenon has been demonstrated on concrete and a patent application has been made by the K-25 developers (Bostick et al.).

May be applied as a portable or "localized" technology on select areas, the solvent and electricity being applied to a localized spot. Significant (90+%) contamination reductions have been demonstrated during the demonstration of the phenomenon. Parametric studies have not been successful because a reliable test system to evaluate the migration on concrete remains to be developed.

Enough information is available from the demo to suggest this process is very likely to be developed to the point that concrete decontaminated via this route will meet safety guidelines for nonradiological areas.

Waste generated by electromigration if solvent recycle is adapted may typically be loaded ion exchange resin for example.

Science/Technology Needs: Science—Several aspects require fundamental evaluation. Selection of the best characteristics for a working fluid (electrolyte) remains to be evaluated to cause migration of all contaminants to the surface. Concrete imbibing studies need to be done to evaluate the flow or migration mechanism. A reliable test system has not yet been developed to allow parametric studies.

Technology development—Electromigration has been demonstrated in concrete but no process optimization has occurred. Electromigration solvents for use on horizontal surfaces,

gels for vertical surfaces, ceilings etc. still remain to be developed as do the specific large-scale containment structures for solutions. Cheap electrode materials need to be identified and recycle of the solutions must be designed.

Implementation Needs: Implementation needs may be quite modest. Since the process is intended to be an in-situ technology, only development facilities are necessary. Process equipment will consist of power supplies, electrodes etc., the sizes of which will be determined by the surface area to be decontaminated.

Development cost—About 4 MY or $1000K which should be considered the effective value of the buildings that are recovered for beneficial use.

Deployment cost—Modest with little equipment or labor.

Documentation—Consultation with the developer.

Author: R. D. Fellows

References: MMES staff members

SMELT PURIFICATION DCON-31-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Metal equipment, nickel-lined steel equipment, porous nickel, nickel ingots, porous aluminum, aluminum, structural steel, sheet metal, steep pipe, steel cylinders, monel, and copper contaminated with U, Tc, actinides, and oils.

Reference Requirements:

- Clean Air Act, Clean Water Act, RCRA, NEPA, and NESHAP
- Federal Facility Compliance Agreements (FFCAs)
- Applicable federal and state laws and regulations
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Metal Refining

Technology: Smelt Purification—Purifies metals by adding to the scrap suitable fluxes that will react with the impurities when the metal is melted. The impurities are then removed in the slag that separates from the molten metal and floats to the top. The items requiring smelting must be cut to suitable size for addition to the smelter.

Status: Demonstration—Smelt purification of radioactive metals has been performed by a large number of investigators on a lab-scale and by some investigators on a large-scale. The metals include mild steel, stainless steel, nickel, copper, monel, aluminum, and others. Metal purification has been demonstrated to levels of 0.01 ppm to 4.0 ppm residual uranium, except aluminum smelting was not as successful (3 to 100 ppm). Heshmatpour and Copeland[1] report better results for aluminum (1 to 2 ppm). Tc reportedly[1] is not removed by smelt purification. Scientific Ecology Group (SEG) personnel estimate[2] the costs (operating and capital combined) of metal smelting at $0.65 to $2.00/lb depending on the type metal and configuration of the metal. Steel will probably cost $0.65 to $0.95/lb to process. Kellogg et al. estimated[3] that the capital and operating costs of smelting the 90,000 tons of DOE scrap metal presently on hand could be recovered through sale of the metal if a de minimus residual were established. Based on their conclusion, a cost of roughly $0.93/lb of metal can be estimated in 1992 dollars. They assumed construction of a new facility with an 8 ton capacity, electric induction furnace capable of handling 4-6 ton/h ferrous or 1.6/h non-

ferrous metals. They also estimated that about 50 lb of slag would be generated per ton of metal smelted. No figures for off gas treatment are available.

Science/Technology Needs: The report that Tc is not removed by the process may seriously damage the prospect of using this method if a suitable fluxing agent cannot be demonstrated. The poor results reported in removing aluminum must be further investigated.

Implementation Needs: The technology development needs will require further lab and pilot-scale evaluation. The development costs would include a small electric induction furnace, two full-time technical people (one with experience in metallurgy), analytical, maintenance, and other support personnel. The duration may be 24 months and the development costs are roughly estimated by the investigator at $3M to $5M.

The following requirements for a smelt facility are listed by Kellogg et al.:[3] scrap handling and preparation, scrap transportation, scrap weighing and drying facility (the scrap must be heated prior to placing in the smelter to drive off oil and water), eight ton capacity electric induction furnace with two crucibles, mold preparation and cooling, slag processing, refractory repair, flux storage and preparation, ingot dumping and storage, offices, laboratory and control room, maintenance areas, and personnel convenience stations. Capital and operating costs were not indicated, but as mentioned above, an overall cost of roughly $0.93/h can be estimated based on their conclusions that all costs could be recovered from the sale of 90,000 tons of metal presently in the DOE inventory (valued at $102M in 1982 dollars) assuming a de minimus is established. (About 74 percent of the metal value is the nickel which amounts to only 11 percent by weight of the metals in the Kellogg[3] study). Most likely no existing facility at the K-25 Site will satisfy the operational requirements of this facility (the Kellogg study[3] assumes new facilities are constructed). The design and construction phase will require the support of numerous engineering disciplines: structural and site engineering, engineering mechanics, process design, electrical engineering, instrument engineering, safety engineering, and metallurgy. Numerous support services will be required: health physics, industrial hygiene, health, safety, environmental, and analytical services. Numerous construction and maintenance craftsmen will be required: welders, carpenters, electricians, mechanics, ETI personnel, and supervisors. These requirements cannot be quantified at present. The establishment of a de minimus standard is very critical for the success of this project since the resulting ingots cannot be sold without this legislation.

Author: E. B. Munday

References:

1. B.Heshmatpour and G. L. Copeland, "The Effects of Slag Composition and Process Variables on Decontamination of Metallic Wastes by Melt Refining," Union Carbide Corporation, January 1981.

2. Douglas Jamesian, Scientific Ecology Group, personal communication to E. B. Munday, Martin Marietta Energy systems, Inc., June, 1992.

3. D. R. Kellogg et al., Metal-Smelting Facility, CONF-820418-13, DE82 013539, Union Carbide Corporation Nuclear Division, 1982.

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Porous nickel and nickel ingots contaminated with U, Tc, and actinides

Reference Requirements:

- Clean Water Act, NEPA, and RCRA
- Federal Facility Compliance Agreements (FFCAs)
- Applicable federal and state laws and regulations
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Metal Refining

Technology: Electrorefining—Uses an electrolysis cell that contains a flat anode made from the impure nickel and a flat cathode made of pure nickel. The pure nickel used for the cathode is stripped off of a stainless steel blank, which was briefly used as a cathode. An electrolytic solution provides a conductive medium for the voltage applied between the anode and cathode that causes the impure nickel to ionize into positive nickel ions in the solution and that causes nickel ions at the cathode to plate out. The anode and cathode compartments are separated by a porous diaphragm. Impurities in the nickel anode that are lower than nickel in the electromotive series will usually drop out as a sludge beneath the anode. Impurities higher than nickel in the electromotive series will travel with the nickel ions. The anode solution is therefore continuously circulated by pump from the anode compartment to a purification train to the cathode compartment where the pure nickel is plated out on the cathode. The direction of the solution flow through the diaphragm is from cathode to anode. Electrorefining would require the scrap nickel to first be smelted and poured into suitable anode molds.[1] Leach/electrowinning avoids the need to smelt the scrap nickel into anodes by substituting a process to leach the nickel into an electrolytic solution.

Status: Predemonstration—Electrorefining is a well-established commercial technology. However, this technology cannot be considered mature concerning its use for decontaminating radioactive metal because this application is much less established. Electrowinning, a method very similar to electrorefining, has been successfully conducted on

a bench-scale to produce nickel containing <1 bq/g of Tc-99 (the accepted European standard).[2] Uranium is easier to remove than technetium, which means this method will likely allow favorable decontamination factors. The cost of an operating facility with a 10-million-pound/year capacity is estimated at $2M capital and $6/lb operating costs. The operating costs exceed the present value of nickel ($3.60/lb) because commercial nickel companies operate on a much larger scale.[3] The development costs are estimated at $3M. Recycle of the electrolytic solutions is assumed with resulting mixed solid waste bearing nickel, uranium, technetium, and other compounds amounting to roughly 2% by weight of the nickel processed.[4]

Science/Technology Needs: Pilot-scale testing of this method is needed with special attention to decontamination efficiency and recycle of the electrolytic solutions.

Implementation Needs: The electrorefining plant will also require a smelting and anode forming facility to form the impure nickel into anodes of proper configuration. A tank house containing the electrolytic cells and an electrical capacity of roughly 1 kwhr/lb nickel refined are required. The capital costs altogether are estimated at $200M, and the operating costs are estimated at $6/lb of nickel.[3] The development costs are roughly estimated at $3 million. Estimates of the numbers of personnel are not yet available. The design will require the support of virtually all engineering disciplines. Facility operation will require process engineers, electrical engineers, supervisors with at least 2 years technical background, chemical operators, electricians, mechanics, and general shop crafts. Metallurgical and analytical chemistry support is also required. To allow sale of the resulting purified nickel, either a *de minimus* level must be established in the USA or permission must be obtained to sell the metal in Europe where a *de minimus* exists.

Author: E. B. Munday

References:

1. J. R. Boldt, Jr., *The Winning of Nickel*, D. Van Nostrand Company, Inc., Princeton, NJ, 1967.

2. Dr. T. Snyder, Scientific Ecology Group, Inc., personal communication to E. B. Munday, Martin Marietta Energy Systems, Inc., July 1992.

3. L. G. Guglielmin, INCO Exploration and Technical Services, Inc., personal communication to E. B. Munday, Martin Marietta Energy Systems, Inc., July 1992.

4. Rough estimate by E. B. Munday, Martin Marietta Energy Systems, Inc., July 1992.

NICKEL CARBONYL PROCESS OF Ni PURIFICATION DCON-33-OG

EM Problems: Decommissioning

K-25 Site Problem: Deposit Removal

Problem Area/Constituents: U, Tc, Actinides and other inorganic contaminants on Ni metal and Ni-plated steel.

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Metal Refining Method (Also Bulk Decontamination Method)

Technology: Nickel Carbonyl Process of Ni Purification—The formation of volatile $Ni(CO)_4$ is used as the basis of a process to separate Ni from all other contaminants.

Status: Accepted technology—Fundamental technology has been industrial practice for decades.

It is applied as a "factory style" process in either batch or continuous reactors. Contaminated metal fed directly into processing equipment. Ultimately the volatile, decontaminated $Ni(CO)_4$ is decomposed into Ni metal and the CO is recycled.

Efficacy: The process is a very selective decontamination process for Ni. A test of this process at a commercial production facility with contaminated Ni barrier tube was performed in the 1950's by K-25 personnel. The Ni metal product contained 3 ppm (3 μg/g) uranium contamination, equivalent to 1.0 Pci/g natural uranium. Tc and other radioactive contamination was not measured. Source: internal report.

Waste: Contaminants are left in the original reactor as unreacted "ash." A catalyst or sensitizer (sulfide) is required to speed the conversion of raw Ni to the carbonyl, but waste volumes will be of the order of the contamination itself and may be fluoride, oxide or sulfide.

Limitations: The process is used by the world's largest commercial producer of Ni metal. It is recognized that the process gas, $Ni(CO)_4$, is highly hazardous (Industrial Hygiene Threshold Limit Values in air, 0.05 ppm or 0.12 mg/m^3, OSHA Permissible Exposure Limit of 0.001 ppm in air, but may be increased to 0.05 ppm); there is conflicting information on whether Ni compounds are carcinogenic to humans and some Ni compounds have been demonstrated to be carcinogenic to animals, while some have been exonerated. The process gas containment systems are not fail-safe. $Ni(CO)_4$ liquifies below 43 C (109°F). It appears to be a slight detonation hazard, which has been controlled through equipment and process design.

February 26, 1993

Science/Technology Needs:

Development—Confirmation that decontamination is achieved from Tc and other radioactive materials indigenous to diffusion plant operations.

Technology Improvement—Evaluation of technologies to reduce hazards due to gas leaks.

Implementation Needs: For 10-million-lb/year (5000-ton/year) plant, low estimates of capital cost ~$60 Canadian/annual lb or $600M. Operating cost is estimated to be $6 Canadian/lb. Estimates provided verbally by sources at leading Ni metal producer.

Author: R. L. Fellows

References: MMES staff members

February 26, 1993

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Porous nickel and nickel ingots contaminated with U, Tc, and actinides

Reference Requirements:

- NEPA, RCRA, and Clean Water Acts
- Federal Facility Compliance Agreements (FFCAs)
- Applicable federal and state laws and regulations
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Metal Refining Methods

Technology: Leach/Electrowinning—This process would begin by pulverizing the impure nickel and leaching (dissolving) the nickel into an electrolytic solution. International Nickel Company (INCO) has proposed that the contaminated nickel could be leached into a solution containing dissolved chorine gas and copper ions. The copper acts as a chlorine exchange agent for the nickel to form soluble nickel chloride from the nickel metal. The required chlorine gas is generated as a by-product during the electrowinning of the nickel from the solution. The copper is recycled except for small amounts. Uranium in the leach solution is removed by solvent extraction, stripped with a weak aqueous chlorine solution, and recovered by precipitation with sodium hydroxide as sodium diuranate. The electrolytic solution containing the nickel is plated onto the cathode.[1] Leach/electrowinning avoids smelting anodes as required in the electrorefining method, but requires a leaching step that was not needed in the electrorefining method.

Status: Predemonstration—Leach/Electrowinning is a well-established commercial method for producing nickel from nickel ore, but is not used commercially to refine impure nickel metal. Scientific Ecology Group, Inc. (SEG), has conducted bench-scale evaluations that purified nickel contaminated with technetium to less than .1 bq/g (the European release standard). The method used to get the nickel into solution and the purification train are proprietary information of SEG.[2] Uranium is easier to remove than technetium, which means this method will likely allow favorable decontamination factors. The costs of an operating

facility with a 10-million-pound-per-year capacity are estimated by INCO at $200M capital and $3.80/lb operating costs. The operating costs exceed the present value of nickel ($3.60/lb) because commercial nickel companies operate on a much larger scale.[1] The development costs are estimated by INCO at ~$440K if the work were done at their facilities. Recycle of the electrolytic solutions is assumed with resulting mixed solid waste bearing nickel, uranium, technetium, and other compounds amounting to roughly 2% by weight of the nickel processed.[3] These cost figures compare closely to the electrorefining process because of the similarity of the processes and because both estimates are very approximate. Personnel at INCO prefer leach/electrowinning to electrorefining because they believe the leach/electrowinning will give a purer product and think leaching will have operational advantages to smelting anodes.[1]

Science/Technology Needs: Pilot-scale testing of this method is needed with special attention to the leaching process, decontamination efficiency, and recycle of the electrolytic solutions. The development work by SEG may satisfy some of this requirement.

Implementation Needs: The leach/electrowinning plant will require a size-reduction facility, a leaching facility, and a tankhouse for the electrolytic cells. Electrical capacity to supply roughly 1 kwhr/lb. nickel refined is required.[3] The capital costs altogether are estimated at $200 million, and the operating costs are estimated at $3.80/lb of nickel.[1] The development costs are estimated by INCO in two phases: Phase 1 would be a bench scale, batch operating requiring $170K and Phase 2 would be a continuous small-scale process with recycle of solutions and would cost an additional $270K.[1] These estimates assume the development activities are done at INCO's facility. Estimates of the numbers of personnel are not yet available. The design will require the support of virtually all engineering disciplines. Facility operation will require process engineers, electrical engineers, supervisors with at least 2 years technical background, chemical operators, electricians, mechanics, and general shop crafts. Metallurgical and analytical chemistry support is also required. To allow sale of the resulting purified nickel, either a *de minimus* level must be established for the USA or permission must be obtained to sell the metal in Europe where a *de minimus* standard exists.

Author: E. B. Munday
(615) 576-5806.

References:

1. L. G. Guglielmin, INCO Exploration and Technical Services, Inc., personnel communication to E. B. Munday, Martin Marietta Energy Systems, Inc., July 1992.

2. Dr. T. Snyder, Scientific Ecology Group, Inc., personal communication to E. B. Munday, Martin Marietta Energy Systems, Inc., July 1992.

3. Rough estimate by E. B. Munday, Martin Marietta Energy Systems, Inc., July 1992.

ULTRA-HIGH-PRESSURE WATER (UHPW) DCON-35-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Concrete, structural steel, tile, epoxy, metal equipment (exterior), Ni-lined steel equipment (interior)
After disassembly: Monel, copper, aluminum, sheet metal, steel pipe, aluminum pipe
The media tabulated above may be treated by the subject technology for removal of all the listed contaminants.

Reference Requirements:

- Federal Facility Compliance Agreement for Oak Ridge Site
- Federal Facility Compliance Agreement for PCBs
- Clean Air Act
- Clean Water Act
- Toxic Substance Control Act
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Mechanical Abrasive Methods

Technology: Ultra-High-Pressure Water (UHPW)—In the UHPW decontamination process, an ultra-high-pressure intensifier pump pressurizes water up to 55,000 psi and forces it through small-diameter nozzles, generating high velocity waterjets at speeds up to 3,000 ft/s. The nozzles may be mounted in various types of cleaning heads for contaminated surfaces. The waterjets thoroughly penetrate and remove surface contaminants. Care must be taken so as to not damage the substrate. In the use of the UHPW decontamination technology, the UHPW cleaning head, attached to a lance, may be manually moved about on the surfaces being decontaminated. The decontamination efficiency depends on the applicator translation speed. Remote operation of the UHPW cleaning head would be desirable. Also, in some applications (such as decontamination of hot cells), remote operation will be required. Consequently, the adaptation of the equipment to a robotics control system would be necessary.

Status: Accepted by industry. The UHPW decontamination technology is available and has been used by industry. The addition of abrasives is also available for industrial cutting and

milling. Before acceptance at K-25 and other DOE sites, the issues of criticality, wastewater treatment, and prevention of spread of contamination must be addressed). The technology can produce high levels of decontamination. Removal of a galvanized layer from sheet metal has been demonstrated. Waste generated is contaminated water from the cleaning operation. In cleaning concrete, for example, a typical flow rate for one cleaning head would be 3–5 gal/min at a surface treatment rate of about 1 ft^2/min.

Science/Technology Needs: The existing vacuum systems, which recover water from the cleaning (or power) head of the unit, need to be developed. To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be recycled and reused in the UHPW cleaning operation. The system must be capable of treating the contaminants specific to the site and reducing their concentrations to allowable levels for water recycle. Remote operation will necessitate the adaptation of the ultra-high-pressure cleaning heads and the vacuum collection systems to a robotic control system. A data base on UHPW cleanup experience is desirable. This could be developed through communication with the Water Jet Technology Association. The data would be useful in optimization of cleaning parameters in future UHPW decontamination activities. Nozzle configuration, water pressure and flow rate, distance of the cleaning head to the substrate, and the geometric complexities of the substrate are all parameters that need to be evaluated.

Implementation Needs: Development costs: For development and demonstration of a water recycle system, in combination with UHPW decontamination, an estimate of funding requirements is $1.2M. Personnel requirements are estimated to be $1.7M (approximately 50% engineer and 50% technician time) and 4.1 FTEs (approximately 10% P&E, 45% engineer, and 45% technician time) for FY 93 and FY 94, respectively. The cost of a robotic control system is estimated at $250K.

Deployment costs: FLOW International supplies ultra-high-pressure power units with intensifier pumps rated at pressures of 40,000 to 55,000 psi are supplied at costs up to $200K. Several ultra-high-pressure tools are available for use with the power unit. Operating costs for a UHPW unit would primarily involve labor costs. Assuming a minimum two-person operation (at a labor rate of $40K/year/person) of a UHPW unit during the day shift, operating costs would be approximately $350/day. These costs do not include either the disposal cost of the wastewater that is generated or the capital and operating costs of a system to treat the wastewater and recycle it to the UHPW unit. Development of an acceptable water recycle system is needed to establish estimates for the latter costs. Personnel training for supervisors and for operators will be needed for operation of the UHPW unit and recycle system. Facilities for performing prototype cleaning operations for each decontamination project would be beneficial. Capital costs: UHPW system, >$500K with vacuum system; glove box, >$50K; and work room, ~$250K. Operating cost is estimated at >$2/$ft^2$.

Author: J. H. Wilson

References: MMES staff members, especially C. E. Benson

February 26, 1993

000269

SHOT BLASTING DCON-36-OG

EM Problem: Decommissioning

K-25 Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers. Deposit removal.

Problem Area/Constituents: Capable of removing a wide variety of contaminants including U, Tc, Actinides, PCBs, Oils, etc., from exterior surfaces including concrete, structural steel, metal equipment, monel, copper, and aluminum.

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site)
- Applicable Federal and State laws and regulations (e. g., Clean Water Act & Toxic Substance Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Mechanical Surface Substrate Removal Methods

Technology: Shot Blasting—This technology uses iron shot (pellets) which are accelerated mechanically. After the shot hits the surface to be cleaned, it is recovered by a magnetic system and recirculated.

Status: Accepted—Commercial units are available[1] that have been used to prepare large areas of concrete floors in one step for painting, for cleaning rust and marine growth form ship hulls, and for cleaning structural steel elements. A Wheelbrator Blastrac is being used to decontaminate floors at the K-25 site. Cleaning rates for floors are quoted as being faster than acid etching, sandblasting, and scarifying by factors of 1.7, 1.3, and 2.0, respectively.[2] Portable machines with design rates of 2,500 ft^2/h are available.[3] The method is considered advantageous because it is commercially available and has considerable cleaning experience on various surfaces.[4] Shot blasting differs from sand blasting in that it can be controlled to give more accurate results.[5] Decontamination factors on the order of 10-100 and costs on the order of $\$10/m^2$ are reported for similar technologies.[4] Shot is recycled many times during cleaning, but ultimately erodes and becomes part of the waste stream at the rate of approximately 0.1 lb/m^2.

Science/Technology Needs: Technology improvement is needed in areas of waste minimization related to blast media erosion and disposal, containment of waste, and

demonstration of specific blast-media substrate/contaminant capabilities, including determination of decontamination factors and process automation. Development of a medium level demonstration facility to evaluate these factors will require ~4PY technical staff, plus ~4PY technicians, and will cost on the order of $1,500K.

Implementation Needs: This technology, while developed and commercially available, will require a system for processing the waste that will result. For instance, use of the device will generate contaminated dust, gases, and/or fluids. This will require a system to separate and package the contaminant. An integrated pilot facility will cost on the order of $4000K. Design, fabrication and operation will require ~20 PY effort, of which about 30% will be technical staff.

Author: H. H. Haselton

References:

1. Blastrac Division the Wheelbrator Corp., 27 Amlajack Blvd., Shenandoah, GA 30265.

2. "The Original Blastrac Portable Shot Blast Cleaning Systems the Preferred Way to Prepare Floor Surfaces," Wheelbrator B218.00A.

3. "The Original Blastrac Portable Shot Blast Cleaning Systems Specifications," Wheelbrator B219.00B CC/2-90.

4. IAEA Technical Report 300, "Cleanup of Large Areas Contaminated as a Result of a Nuclear Accident," 1989.

5. *Metals Handbook, Vol. 5, Surface Cleaning, Finishing and Coating*, Ninth Edition, 1978.

SCABBLERS/SCARIFIERS DCON-37-OG

EM Problem: Decommissioning

K-25 Site Problem: Deposit removal. Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Concrete—The concrete may be treated by the subject technology for removal of all the listed contaminants.

Reference Requirements:

- Federal Facility Compliance Agreement for Oak Ridge Site
- Federal Facility Compliance Agreement for PCBs
- Clean Air Act and Toxic Substance Control Act
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Mechanical Abrasive Methods

Technology: Scabblers/Scarifiers—This technology decontaminates a concrete substrate by using mechanical impact methods to remove the contaminated surface. Many vendors market units that use high-speed reciprocating tungsten-carbide tipped pistons to pulverize protective coatings, laitance, and concrete substrate in a single-step process. Other types of units use a shrouded needle scaler to remove concrete from outside edges and inside corners, as well as from wall surfaces. These units are also used for removing lead-based coatings and contamination from steel surfaces. The solid debris produced by mechanical scabbling is removed and collected by a vacuum system. Mechanical scabblers usually are operated manually. If desired in order to generate more uniform removal rates or are required (i.e., high levels of radioactivity), the units could be adapted for remote-controlled operation).

Status: Accepted—The technology has been used for decontamination purposes in numerous applications involving hazardous and/or radioactive contaminants. Because the technology involves removal of contaminated surfaces, the decontamination efficiency should be 95% or higher. The waste generated is the pulverized surface layer that is collected by a vacuum system. The amount of waste generated depends upon the depth of the surface layer that needs to be removed to achieve decontamination. For example, two different commercial units provide removal of concrete at rates of 3–4.5 in.^{3}/min (8–12 lb/h) and 60 in.^{3}/min (160 lb/h), respectively, at a removal depth of 1/16 in.

Science/Technology Needs: Remote operation will require the adaptation of the scabbler to a robotic control system.

Implementation Needs: Development costs—The cost of a robotic control system is estimated at $250K. Deployment costs—The capital costs of the two different commercial units mentioned above are $10K and $110K, respectively. Operating costs for a scabbler would primarily involve labor costs. Assuming a minimum two-person operation (at a labor rate of $40K/year/person) of a scabbler during the day shift, operating costs would be approximately $350/day. Training of personnel to operate mechanical scabblers will be needed.

Author: J. H. Wilson

References: MMES staff members

GRIT BLASTING DCON-38-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers. Deposit removal.

Problem Area/Constituents: Capable of removing a wide variety of contaminants, including U, Tc, actinides, PCBs, oils, etc., from exterior surfaces, such as concrete, structural steel, metal equipment, Monel, copper, and aluminum.

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site)
- Applicable Federal and State laws and regulations (e.g., Clean Water Act and Toxic Substance Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Mechanical Surface Substrate Removal Methods

Technology: Grit Blasting—Commonly known as sand blasting, this pneumatic cleaning process can use a wide variety of grits.

Status: Accepted by industry—Grit blasting has been used on a large number of occasions in the nuclear industry in applications ranging from heavily contaminated pipework with the contamination fixed in the oxide to lightly contaminated surfaces. Commercial units are readily available.[1] Typical abrasives include sand, glass beads, metallic beads, and soft materials such as nut shells and rice hulls. Grit blasting has been shown to be an efficient cleaning method, with unlimited decontamination factors being obtained.[2] Grit blasting is widely used in industry for removing all classes of scale and rust from a wide range of metal products.[3] Waste production rates depend on the media/surface combination. Highly abrasive grits will clean more effectively and faster than soft grits but will ultimately become part of the waste stream. Waste production rates, including grit plus filters, could range from 0.005 to 0.1 lb/ft^2.

Science/Technology Needs: Technology improvement is needed in areas of waste minimization related to blast media erosion and disposal, containment of waste and vacuum systems, and demonstration of specific blast-media substrate/contaminant capabilities,

including determination of decontamination factors and process automation. Cost of a medium scale facility to evaluate these factors is estimated to be $1,500K.

Implementation Needs: This technology, while developed and commercially available, will require a system for processing the waste. For instance, use of the device will generate contaminated dust, gases, and/or fluids. This will require a system to separate and to package the contaminants. Cost of a pilot demonstration is estimated to be $4,000K. Application of this technology requires staff with technician training.

Author:

References:

1. Progressive Blasting Systems, 4201 Patterson, S. E., Grand Rapids, MI 49508.

2. *Metals Handbook*, 9th Ed., Vol. 5, "Surface Cleaning, Finishing and Coating," 1978.

3. IAEA Technical Report 300, "Cleanup of Large Areas Contaminated as a Result of a Nuclear Accident," 1989.

CENTRIFUGE CRYOGENIC CO_2 PELLET BLASTING DCON-39-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers. Deposit removal.

Problem Area/Constituents: All contaminants on concrete, metal equipment (exterior), nickel-lined steel equipment (interior), porous nickel, structural steel, copper, aluminum, sheet metal, steel pipe, porous aluminum, steel cylinders, Monel

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site)
- Applicable Federal and State laws and regulations (e.g., Clean Water Act and Toxic Substance Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Mechanical Surface Substrate Removal

Technology: Centrifuge CO_2 Pellet Blasting—Similar to the compressed air/CO_2 pellet blasting technology. It uses a high-speed rotating wheel to accelerate the CO_2 pellets. In comparison to the compressed air technology, the centrifuge system can achieve much higher pellet speeds and efficiencies that allow applications of both high-rate cleaning and etching on most surfaces.

Status: Predemonstration—The technology of CO_2 pellet blasting using compressed air to accelerate the pellets is a demonstrated and effective technology for decontaminating equipment at nuclear reactor sites producing minimal secondary wastes.[1,2] The use of centrifuge pellet acceleration has been established in the DOE Fusion Energy Program to form and accelerate pellets of frozen deuterium and tritium for fueling fusion reactors.[3] This technology includes accelerating pellets of argon and CO_2 for the purpose of cleaning heavy oxidation deposits from uranium surfaces as part of the DOE Y-12 waste minimization program.[4] Cleaning uranium was not feasible using the commercially available cryoblasting hardware because the pellet speeds in these machines are limited to a level at which little or no etching of the oxide layers occurs. With the higher speeds available, the centrifuge technology enables removal of hard oxide layers from steel, thereby removing both zinc coatings from galvanized steel/sheet metal and nickel plating from brass screws. A brief program with the Air Force Warner Robins Air Logistics Center demonstrated the removal of

the urethane and epoxy paint surfaces from F-15 aircraft at a rate of 120 ft^2/h for a 15-HP accelerator. Because the pellets evaporate to gaseous CO_2 upon impact, the secondary waste stream is limited to the materials removed from the surface. The contaminants are released during the blast to the surrounding air. A vacuum shroud surrounding the blast nozzle and covering the impact area could be used to produce a negative pressure and collect the airborne contaminants in a conventional HEPA filtering system. The secondary waste stream would thereby be limited to the HEPA filters. The capital cost of a 30-HP centrifuge blaster capable of accelerating 1 ton/h of CO_2 at speeds up to 400m/s would be $200K. The unit would be remotely manipulated by an operator and would be capable of cleaning rates of 200 to 2,000 ft^2/h depending on the nature of the surface to be cleaned.

CO_2 costs—$50/h
Electricity costs 30 kW @ $.06/h—$1.80/h
Labor one person @ $100/h—$100/h
Total Cost—$151.80/h
Cost/ft^2—$0.75/$ft^2$ @ 200 ft^2/h or $0.075/$ft^2$ @ 2000 ft^2/h

Because the removal or etching rate of the surface varies dramatically with the specific application, data on specific decontamination efficiencies need to be obtained to obtain accurate cost estimates. However, decontamination factors for compressed air systems have range from 3 to >5000 for various materials.[5] Due to the higher speed capability and the increased throughput capabilities, the costs will be one-fifth or less than that of present compressed air systems.

Science/Technology Needs: In comparison to ultra high pressure water blasting, the centrifuge CO_2 system can produce comparable or more aggressive etching, comparable or increased efficiencies, and comparable capital equipment costs. The difference is that the CO_2 method is dry. This makes the CO_2 blasting technology compatible with use in enriched uranium and eliminates the need for a water decontamination system. The centrifuge system is 25 times more efficient and can attain much higher pellet speeds. For example, with the centrifuge, a 4-HP electric motor replaces a 100-HP air compressor system and can strip paint at a rate five times that of the commercial system due to its increased speed capability. This increased capability will allow cleaning and etching at greatly increased rates.

Implementation Needs:

- Compliance specifications need to be set for each K-25 site problem; 1PY $200K.
- An advanced prototype CO_2 blaster needs to be made available for field demonstration; 2PY $400K.
- Methodology for collection of waste contaminants requires design effort; 1PY $200K.
- A nonradiation demonstration laboratory needs to be assembled; 3PY $500K.
- A multiteam effort is required to integrate the best staff in the organization; 1PY $200K.
- A radiation demonstration laboratory needs to be assembled; 2PY $400K (in addition to 4 above).
- A full demonstration model needs to be available for definite performance evaluation; 6PY $1500K.

- Staff requirements: Development—20% for M.S. or Ph.D. staff, 80% for technicians. Demonstration—5% for M.S. or Ph.D. staff, 95% for technicians.

Author: C. A. Foster

References:

1. Alpheus Cleaning Technologies, 9105 Milliken Ave., Rancho Cucamonga, CA 91730.

2. Cold Jet, 455 Wards Corner Rd., Loveland, OH 45140.

3. C. A. Foster, "Solid Deuterium Centrifuge Pellet Injector," *J. Vac. Sci. Tech.*, **A1**(2), 952–958, 1983.

4. C. A. Foster, "Surface Impact Cleaning by High-Speed Cryogenic Pellets," *Second International Workshop on Solvent Substitution*, Phoenix, Ariz., December 10–13, 1991.

5. R. J. Dabolt, "Evaluation of Pelletized Carbon Dioxide as a Fluidized Abrasive Agent for Removal of Radioactive Contamination," Document No. ER-89-002 (1989), Chem-Nuclear Systems, 220 Stoneridge Dr., Columbia, SC 29210.

ICE BLASTING DCON-40-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Concrete, structural steel, tile, epoxy, metal equipment (exterior), Ni-lined steel equipment (interior)

After disassembly—monel, copper, aluminum, sheet metal, steel pipe, aluminum pipe.
The media tabulated above may be treated by the subject technology for removal of all the listed contaminants.

Reference Requirements:

- Federal Facility Compliance Agreement for Oak Ridge Site
- Federal Facility Compliance Agreement for PCBs
- Clean Air Act
- Clean Water Act
- Toxic Substance Control Act
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Mechanical Surface Substrate Removal

Technology: Ice Blasting—Similar to other decontamination technologies that direct a high velocity stream of fine particles, such as shot, grit, cryogenic pellets, or plastic pellets, onto a surface to remove contamination. The contaminated wastewater that is generated by the melting ice particles is the controlling medium for the displaced contamination. The water must then be treated for discharge by processing in commercially available evaporators. When using the ice blasting decontamination technology, the ice blasting cleaning head may be manually moved about on the surfaces being decontaminated. Decontamination efficiency depends on the applicator translation speed, cleaning head distance from substrate, operating pressure, and geometric complexities of the substrate. Remote controlled operation of the cleaning head would be desirable. Also, in some applications (such as decontamination of hot cells), remote operation will be required. Consequently, the adaptation of the equipment to a robotics control system would be necessary.

Status: Accepted—The ice blasting technology has been used recently for decontamination at the Oconee nuclear power plant in Seneca, South Carolina, decontamination testing was performed at the Oak Ridge X-10 site.

Ice blasting will remove coatings and some fixed surface contamination, but it will not take off concrete to a significant depth. The waste produced is contaminated wastewater. The amount of wastewater generated depends upon the ice blasting rate. For example, a unit recently demonstrated at the Oak Ridge X-10 site operated at 11 gal/h.

Science/Technology Needs: A commercially available evaporator will be required. Because of the low volume of water generated during operation, evaporation—and not recycle—will likely be more cost-effective. Capital costs of an evaporator would be $60K to $90K. Remote operation will require the adaptation of the ice blasting and water collection systems to a robotics control system.

Implementation Needs: Development Costs—The cost of a robotics control system is estimated at $250K (personal communication with C. E. Benson). Deployment Costs—The capital cost of an ice blasting machine such as that used at a nuclear power plant, as mentioned above, would be $155K. Operating costs for an ice blasting unit would primarily involve labor costs. Assuming a minimum two-person operation (at a labor rate of $40K/year/person) of an ice blasting unit during the day shift, operating costs would be ~$350/day. Training of personnel to operate the ice blasting equipment and the wastewater treatment system will be needed.

Author: J. H. Wilson

References: C. E. Benson

SUPERCRITICAL CO_2 DCON-41-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers. Deposit removal.

Problem Area/Constituents: Concrete, structural steel, tile, epoxy, metal equipment (exterior), Monel, copper, aluminum, sheet metal, steel pipe, aluminum pipe. These media may be treated by the subject technology for removal of all the listed contaminants.

Reference Requirements:

- Federal Facility Compliance Agreement for Oak Ridge Site
- Federal Facility Compliance Agreement for PCBs
- Clean Air Act
- Toxic Substance Control Act
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Mechanical Surface Removal Methods

Technology: Supercritical CO_2 Blasting—Supercritical CO_2 (above its critical temperature of 87.8°F and at high pressure) is pressurized by an ultra high pressure intensifier pump up to 55,000 psi and forced through nozzles, generating high velocity CO_2 jets at speeds up to 3,000 ft/s. The nozzles may be mounted in various types of cleaning heads for contaminated surfaces. The CO_2 jets thoroughly penetrate and remove surface contaminants without damaging the healthy substrate. The removed contaminants, any of the substrate surface layer that may be removed, and the CO_2 are captured by a vacuum recovery system. In the recovery system, the substrate surface layer, if removed, and the contaminants are collected by a cyclone separator and a HEPA filter. The CO_2, now in the gaseous state, is discharged to the atmosphere or recovered and recycled to the supercritical cleaning step.

Status: Predemonstration—This technology is being developed by a private company. Similar to the UHPW process, which has been demonstrated to remove the galvanized layer from sheet metal, the supercritical CO_2 technology should produce high levels of decontamination. The waste generated is the removed contaminants and the substrate surface layer collected in the vacuum recovery system. The CO_2 is either discharged to the atmosphere or recycled to the supercritical cleaning operation.

Science/Technology Needs: Evaluation of the effect of operating parameters (e.g., pressure, distance between nozzle and substrate, traversing speed of cleaning head) on the removal of various contaminants from different substrates.

Implementation Needs: Development costs—The cost of a development program for the supercritical CO_2 blasting technology is estimated to be from $250K to $1M (Dave Monserud). Deployment costs—The capital cost of a commercial supercritical CO_2 cleaning unit is estimated to be $150K (Dave Monserud of FLOW International). Operating costs for a supercritical CO_2 unit would primarily involve labor costs and cost of CO_2. Assuming a minimum two-person operation (at a labor rate of $40K/year/person) of a CO_2 blasting unit during the day shift, labor costs would be approximately $350/day. The cost of CO_2 will depend upon the blasting rate, which would be determined during the development phase of the technology. Other implementation needs include personnel training for operation of the supercritical CO_2 decontamination unit and vacuum recovery system and facilities for performing prototype cleaning operations for each decontamination project (personal communication with C. E. Benson).

Author: J. H. Wilson

References:

1. MMES staff members, especially C. E. Benson.

2. Dave Monserud, FLOW International Corporation, Seattle, Wash.

PLASTIC PELLET BLASTING DCON-42-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers. Deposit removal.

Problem Area/Constituents: Capable of removing a wide variety of contaminants, including U, Tc, actinides, PCBs, oils, etc., from exterior surfaces of concrete, structural steel, metal equipment, Monel, copper, and aluminum.

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site)
- Applicable Federal and State laws and regulations (e.g., Clean Water Act and Toxic Substance Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Mechanical Surface Substrate Removal

Technology: Plastic Pellet Blasting—A cleaning process similar to sand blasting but which uses less abrasive plastic pellets.

Status: Demonstrated—Plastic pellet blasting is a widely used alternative to sand blasting for applications in which it is desired to remove surface contamination or contaminated coatings while imparting minimal damage to the substrate.[1,2] Cost of the media is high ($1 to $2/lb) and pellet erosion can also be a factor, but cyclone systems are capable of recycling pellets up to thirty times for reuse. Cleaning rates of up to 4 ft^2/min are quoted for a 1/2 in. nozzle at 30 psi with operating costs in the range of $0.20–$2.15/ft^2 or $45–$65/h using skilled labor.[3] Plastic media has some advantages over grits, like sand and metal shot, in that it can more easily be separated from eroded metallic substrate and that it can be disposed of by incineration, thus potentially significantly reducing waste disposal costs.

Science/Technology Needs: Technology improvement is needed in areas of waste minimization related to blast media erosion and disposal, containment of waste, demonstration of specific blast-media substrate/contaminant capabilities, including determination of decontamination factors and process automation. Cost of a medium level demonstration facility involving about 6–8 PY will be about $1,500K.

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Implementation Needs: This technology, while developed and commercially available, will require a system for processing the waste. The device will generate contaminated dust, gases, and/or fluids. This will require a system to separate and to package the contaminants. Cost of a pilot facility will be about $4,000K. Application of the technology requires staff with technician training.

Author:

References:

1. Stripping Technologies, 2949 E. Elvira Rd., Tucson, Ariz. 85706.

2. Progressive Blasting Systems, 4201 Patterson, SE, Grand Rapids, Mich. 49508.

3. K. E. Abott, "Plastic Media Blasting—The Maturing of the Technology," 27th Annual Aerospace/Airline Plating & Metals Finishing Forum & Exposition, San Antonio, Tex., March 26–28, 1991.

HAND GRINDING, HONING, SCRAPING DCON-43-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers. Deposit removal.

Problem Area/Constituents:

- Concrete with U contamination;[1] U and Tc contamination;[2] and U, Tc, and actinide contamination[2]
- Structural steel with U contamination;[3] U and Tc contamination; and U, Tc, and actinide contamination
- Metal equipment (exterior) with U contamination;[4] U and Tc contamination; and U, Tc, and actinide contamination
- Monel with U contamination;[5] U and Tc contamination;[5] and U, Tc, and actinide contamination[5]
- Copper with U contamination;[5] U and Tc contamination;[5] and U, Tc, and actinide contamination[5]
- Aluminum with U contamination;[5] U and Tc contamination;[5] and U, Tc, and actinide contamination[5]
- Sheet metal with U contamination;[6] U and Tc contamination;[6] and U, Tc, and actinide contamination[6]

Reference Requirements:

- NEPA, 40 CFR 1500–1508
- DOE Order 5480.11, "Radiation Protection for Occupational Workers" (draft)
- DOE Order 5480.12, "Prevention, Control, and Abatement of Environmental Pollution"

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Mechanical Surface Removal Methods

Technology: Hand Grinding, Honing, Scraping—Power-driven grinding equipment is used to remove the surface from the contaminated object.

Status: Accepted—Grinding has been successfully used for small-scale decontamination at K-25. There are no references or experience with remote operation of grinding equipment at K-25. This grinding was done with hand-held power grinders.[8] Operating cost varies with the shape of item being decontaminated and on the location (whether it is difficult to reach the

contaminated item, if there is enough room for the worker to move around in, if the working environment is hot, etc.). A representative operating cost may be 24 worker-hours per 8" G-17 valves. The inside and outside of these valves were decontaminated.[9] The heat generated by the grinding operation causes organic compounds to vaporize and decompose.[10] Grinding has been accepted in the past because the generation of these vapors was overlooked. The technology needed to control these vapors has not been identified.

Science/Technology Needs: If possible, a remotely operated system should be developed to reduce workers' radiation exposure. An off-gas containment and treatment system needs to be developed.

Implementation Needs: Capital cost—$150 ($50 to $500K with vacuum system);[7] operating cost—about $0.50/ft^2; development cost—of gas containment and treatment system, $1,000K.

Author: D. H. Bunch

References:

1. *Decontamination and Decommissioning Integrated Demonstration Strategy* (Draft for Review), November 1991, pp. 2–9.

2. T. Shapiro et al., *K-25 Building Characterization Report*, KD-5748, March 10, 1988, p. 64.

3. C. D. Phillips, personal conversation with D. H. Bunch, June 4, 1992.

4. T. Shapiro et al., p. 24.

5. *Decontamination and Decommissioning of the Oak Ridge Gaseous Diffusion Plant* (Draft), K/SS-523.

6. J. M. Chiang, *Building Characterization Report, ORGDP Diffusion Facilities Permanent Shutdown, Building K-33*, KD-5752, April 6, 1988, p. 14.

7. M. H. Randolph, Jr., telephone conversation with D. H. Bunch, June 16, 1992.

8. M. O. Beeler, telephone conversation with D. H. Bunch, June 4, 1992.

9. J. Boudreaux, facsimile communication to D. H. Bunch, June 15, 1992.

10. John Googin, written comments on draft of Wiring Diagram, November 1992.

AUTOMATED GRINDING DCON-44-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents:

- Concrete with U contamination;[1] U and Tc contamination;[2] and U, Tc, and actinide contamination[2]
- Structural steel with U contamination;[3] U and Tc contamination; and U, Tc, and actinide contamination
- Metal equipment (exterior) with U contamination;[4] U and Tc contamination; and U, Tc, and actinide contamination
- Monel with U contamination;[5] U and Tc contamination;[5] and U, Tc, and actinide contamination[5]
- Copper with U contamination;[5] U and Tc contamination;[5] and U, Tc, and actinide contamination[5]
- Aluminum with U contamination;[5] U and Tc contamination;[5] and U, Tc, and actinide contamination[5]
- Sheet metal with U contamination;[6] U and Tc contamination;[6] and U, Tc, and actinide contamination[6]

Reference Requirements:

- NEPA, 40 CFR 1500–1508
- DOE Order 5480.11, "Radiation Protection for Occupational Workers" (draft)
- DOE Order 5480.12, "Prevention, Control, and Abatement of Environmental Pollution"

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Mechanical Surface and Substrate Removal

Technology: Automated Grinding—Remotely-operated, power-driven grinding equipment with a manipulator for turning and moving the contaminated item is used to remove the top layer of the contaminated object.

Status: Conceptual—Grinding has been successfully used for small-scale decontamination at K-25. There is no experience with remote operation of grinding equipment at K-25. This grinding was done with hand-held power grinders.[8] Remotely operated grinding equipment

is available,[9] but no references to its use for decontamination has been found. The heat generated by the grinding operation causes organic compounds to vaporize and decompose.[10] Grinding has been accepted in the past because the generation of these vapors was overlooked. The technology needed to control these vapors has not been identified.

Science/Technology Needs: The applicability of this technology to contaminated items at K-25 should be demonstrated. A system to contain and treat the off gas needs to be developed.

Implementation Needs: Trained equipment operators and maintenance people. Equipment cost is estimated at $250K (1992 dollars);[7] development cost, at $1,000K. As regards operating cost, an operator should be able to decontaminate about 900 ft^2/h.[7]

Author: D. H. Bunch

References:

1. *Decontamination and Decommissioning Integrated Demonstration Strategy* (Draft for Review), November 1991, pp. 2–9.

2. T. Shapiro et al., *K-25 Building Characterization Report*, KD-5748, March 10, 1988, p. 64.

3. C. D. Phillips, personal conversation with D. H. Bunch, June 4, 1992.

4. T. Shapiro et al., p. 24.

5. *Decontamination and Decommissioning of the Oak Ridge Gaseous Diffusion Plant* (Draft), K/SS-523.

6. J. M. Chiang, *Building Characterization Report, ORGDP Diffusion Facilities Permanent Shutdown, Building K-33*, KD-5752, April 6, 1988, p. 14.

7. Don Noll, Harry G. Movat Company, telephone conversation with D. H. Bunch, June 15, 1992.

8. M. O. Beeler, telephone conversation with D. H. Bunch, June 4, 1992.

9. Don Noll, Harry G. Movat Company, telephone conversation with D. H. Bunch, June 15, 1992.

10. John Googin, written comments on draft of Wiring Diagram, November 1992.

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents:

- Structural steel with U contamination;[1] U and Tc contamination; U, Tc, and actinide contamination
- Metal equipment (exterior) with U contamination;[2] U and Tc contamination;[2] U, Tc, and actinide contamination[2]
- Monel with U contamination;[3] U and Tc contamination;[2] U, Tc, and actinide contamination[2]
- Copper with U contamination;[4] U and Tc contamination;[4] U, Tc, and actinide contamination[4]
- Aluminum with U contamination;[4] U and Tc contamination;[4] U, Tc, and actinide contamination[4]
- Sheet metal with U contamination;[5] U and Tc contamination;[5] U, Tc, and actinide contamination[5]

Reference Requirements:

- NEPA, 40 CFR 1500–1508
- DOE Order 5480.11, "Radiation Protection for Occupational Workers" (draft)
- DOE Order 5480.12, "Prevention, Control, and Abatement of Environmental Pollution"

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Mechanical Surface Removal

Technology: Metal Milling—Machine shaves off a layer of metal.

Status: Accepted. Milling has been used to decontaminate individual metal items at K-25.[7] This method is most suitable only when there is a large number of similar items to be decontaminated because there is a 1/2- to 3/4-h set-up time required between differently shaped items.[8] After the equipment is set up and loaded, about 2.5 ft^2 per hour can be milled.[9]

Waste generated: The top (up to 1/8 in.) of the metal would be chipped off.[7]

Science/Technology Needs: N/A

Implementation Needs: Machinists must operate this equipment.[7] Capital cost—There are several pieces of milling equipment already at K-25. If these are not operable when the decontamination is done, $100K (1983 dollars)[6] per milling machine will be required. Operating cost—about $17.50/ft^2.

Author: D. H. Bunch

References:

1. C. D. Phillips, personal conversation with D. H. Bunch, June 4, 1992.

2. T. Shapiro et al., *Building Characterization Report, ORGDP Diffusion Facilities Permanent Shutdown, Building K-25*, KD-5748, March 10, 1988, p. 64.

3. T. Shapiro et al., ibid., p. 24.

4. *Decontamination and Decommissioning Plan for the Oak Ridge Gaseous Diffusion Plant* (Draft), K/SS-523, pp. 2–35.

5. J. M. Chiang et al., *Building Characterization Report, ORGDP Facilities Permanent Shutdown, Building K-33*, KD-5752, April 6, 1988, p. 14.

6. "Machine Tool Financing," *Iron Age*, **226**(22), August 19, 1983.

7. M. A. Trisel, telephone conversation with D. H. Bunch, June 5, 1992.

8. N. F. Kuneman and M. A. Trisel, personal communication to D. H. Bunch, June 12, 1992.

9. M. A. Trisel, personal communication to D. H. Bunch, June 17, 1992.

CONCRETE MILLING DCON-47-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Concrete with U contamination;[1] U and Tc contamination;[2] and U, Tc, and actinide contamination.[2]

Reference Requirements:

- NEPA, 40 CFR 1500–1508
- DOE Order 5480.11, "Radiation Protection for Occupational Workers" (draft)
- DOE Order 5480.12, "Prevention, Control, and Abatement of Environmental Pollution"

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Mechanical Surface Removal Methods

Technology: Concrete Milling—Machine removes the top layer of the concrete.

Status: Conceptual

Waste generation—The top 6–25 mm of the pavement are removed.[3]

Costs: All costs are 1980 dollars.[3] These costs do not include the capital and operating costs for trucks to haul away the debris. Capital cost: $50K to $363K for commercial equipment, plus $200K to modify for remote operation. Operating cost: $500K to $1.6M per square mile.

The equipment is commercially available[3], but no references to its use for decontamination has been found.[4] The equipment, which consists of large vehicles used by paving contractors,[3] is primarily suitable for use on large-area horizontal surfaces.

Science/Technology Needs: The technology to remotely operate the equipment needs to be developed and demonstrated.

Implementation Needs: Development Cost—about $3M

Author: D. H. Bunch

February 26, 1993

References:

1. *Decontamination and Decommissioning Integrated Demonstration Strategy* (Draft for Review), November 1991, pp. 2–9.

2. T. Shapiro et al., *Building Characterization Report, ORGDP Diffusion Facilities Permanent Shutdown, Building K-25*, KD-5748, March 10,1988, p. 64.

3. M. M. Barbier and C. V. Chester, "Decontamination of Large Horizontal Concrete Surfaces Outdoors," *Proceedings of the Concrete Decontamination Workshop*, Richland, Wash., September 1980.

4. C. V. Chester, telephone conversation with D. H. Bunch, June 4, 1992.

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Concrete with U contamination;[1] U and Tc contamination;[2] and U, Tc, and actinide contamination[2]

Reference Requirements:

- NEPA, 40 CFR 1500–1508
- DOE Order 5480.11, "Radiation Protection for Occupational Workers" (draft)
- DOE Order 5480.12, "Prevention, Control, and Abatement of Environmental Pollution"

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Mechanical Surface Removal

Technology: Explosive—The top 3 or 4 in. of the concrete are removed by detonating carefully placed and timed explosive charges.

Status: Demonstration

Waste generated: The top 3 or 4 in. of concrete are reduced to contaminated rubble.[3]

Estimated costs: capital, <$50K; operating, ~$5/ft^2; and development, $1M–$4M.

Blasting has been used at nuclear reactors,[4] but it has not been demonstrated on the buildings at K-25 site.

Science/Technology Needs: Safety concerns need to be resolved; care must be taken to contain the dust and to prevent structural damage to both the building being decontaminated and the surrounding structures.[4] Improvements in the methods of applying explosives and in the uniformity of the detonation are needed.[5] The explosion will generate toxic organic vapors.[6] The technology to control these vapors must be developed and demonstrated.

Implementation Needs: A certified blasting technician will be needed,[6] as will covers to both contain the dust and to protect the air evacuation and treatment systems.[4]

Author:

References:

1. *Decontamination and Decommissioning Integrated Demonstration Strategy* (Draft for Review), November 1991, pp. 2–9.

2. T. Shapiro et al., *Building Characterization Report, ORGDP Diffusion Facilities Permanent Shutdown, Building K-25*, KD-5748, March 10,1988, p. 64.

3. K. G. Anderson, "Experiences in Removing Surfaces with Explosives," *Proceedings of the Concrete Decontamination Workshop*, Richland, Wash., September 1980.

4. T. S. Laguardia, "Concrete Decontamination and Demolition Methods," Nuclear Energy Services, Inc., Danbury, Connecticut, *Proceedings of the Concrete Decontamination Workshop*, Pacific Northwest Laboratory, September 1980.

5. *Decontamination and Decommissioning Integrated Demonstration Strategy* (Draft for Review), November 1991, pp. 2–38.

6. John Googin, written comments on draft of The Wiring Diagram, November 1992.

COMPRESSED-AIR CRYOGENIC CO_2 PELLET BLASTING DCON-51-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers. Deposit removal.

Problem Area/Constituents: Concrete, metal equipment (exterior), nickel-lined steel equipment (interior), porous nickel, structural steel, copper, aluminum, sheet metal, steel pipe, porous aluminum, steel cylinders, monel.

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for the Oak Ridge Site)
- Applicable federal and state laws and regulations
- Clean Water Acts and Toxic Substance Control Act
- DOE orders.

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternative: Surface Cleaning (transferable contamination)

Technology: Compressed-Air Cryogenic CO_2 Pellet Blasting—Similar to traditional sandblasting except that pellets made of solid CO_2 (dry ice) are used instead of sand. Depending on the pellet impact velocity and the substrate material, the pellets clean by removing surface contamination or removing/etching of the substrate. As in sandblasting, the surfaces to be decontaminated must be accessible to the blast nozzle.

Status: Demonstration—This technology is commercially available.[1,2] It has been used at nuclear reactor sites to decontaminate hand tools and some equipment.[3-6] With a person operating the "gun," it requires a few minutes to decontaminate a hand tool. The operation of the device is tiring to the operator so that either a remote manipulator or frequent rest periods would be required for large tasks or continuous use.

Since the dry ice pellets evaporate on contact, the secondary waste stream is minimized. The contamination "blasted" from the surface is collected via vacuum/HEPA filtration system, which is either a closely coupled shroud over the surface or a specially designed room air filtration system. The secondary wastes generated would be limited to the HEPA and rough filters. The technology is known to be effective at removing smearable contamination. The removal of fixed contamination depends on the nature of the bonding. The technology, for example, can remove paint and loose rust, but it is not aggressive enough to etch steel or

remove black oxide from steel. Tests using a CO_2 system for decontamination are limited, but a fixed contamination reduction ratio of 3 : 1 was reported for concrete at a rate of 90 ft^2/h and 5000 : 1 for angle iron at 10 ft^2/h.[3]

Science/Technology Needs: Since the cleaning rate is a dominant factor in the cost, and it is highly variable, depending on the nature of the specific contaminant and surface material, more extensive tests need to be done to produce accurate cost estimates.

Implementation Needs: For waste handling, we need design and construction of equipment to handle the waste stream. Application of this technology requires staff with technician training.

The operating cost of a typical unit is approximately $160K. For a 100kW unit at $.06 kw/h, energy costs would be $6/h. Labor costs for a manually operated system would require two operators, alternating, at $200/h. A remotely manipulated/robotics system could reduce labor costs by allowing multiple guns to be operated by one person. Manual operation would be $216/h @ 100 ft^2/h = $2.0/$ft^2$; 10 ft^2/h = $20/$ft^2$. A remote manipulator system with one operator and four guns would be $164/h @ 400 ft^2/h = $0.41/$ft^2$; @ 40 ft^2/h = $4.10/$ft^2$.

Author: C. A. Foster

References:

1. Alpheus Cleaning Technologies, 9105 Milliken Ave., Rancho Cucamonga, Calif. 91730.

2. Cold Jet, 455 Wards Corner Rd. Loveland, Ohio 45140.

3. Chem Nuclear Systems, *Evaluation of Pelletized Carbon Dioxides a Fluidized Abrasive Agent for Removal of Radioactive Contamination*, April 1989.

4. Power Reactor and Nuclear Fuel Development Corporation,"Overview and Strategy for Managing TRU Waste," PNC/DOE/PNC Specialist Meeting, October 17–18, 1989.

5. Environmental Alternatives: Summary and Analysis for a Carbon Dioxide Blasting Demonstration at Georgia Power Company, Hatch Station.

6. TTI Engineering, "Report on Nondestructive Cleaning Decontamination Facility at Surry Power Station," November 1990, Seminar viewgraphs from seminar held March 22, 1991.

HIGH-PRESSURE WATER DCON-52-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Concrete, structural steel, tile, epoxy, metal equipment (exterior), Ni-lined steel equipment (interior)—after disassembly, monel, copper, aluminum, sheet metal, steel pipe, aluminum pipe. These media may be treated by the subject technology for removal of all the listed contaminants.

Reference Requirements:

- Federal Facility Compliance Agreement for Oak Ridge Site
- Federal Facility Compliance Agreement for PCBs
- Clean Air Act
- Clean Water Act
- Toxic Substance Control Act
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Surface Cleaning (transferable contamination)

Technology: High-Pressure Water (5,000–20,000 psig)—Blasting of surfaces with high pressure water will remove difficult deposits that are tightly adherent to substrate materials. Water pressure at the nozzle of commercially available high-pressure blasting systems is typically 5,000 to 20,000 psig. Flow rates vary from 4 to >100 gpm. When used with chemical additives, this technique can be effective for decontaminating piping trays, overhead surfaces, upper regions of walls, gratings, pumps, and similar items. However, splashing from blast operations can be extensive and result in recontamination if precautions are not taken. In the use of this decontamination technology, the high-pressure-water cleaning head may be manually moved about on the surfaces being decontaminated. Because the decontamination efficiency depends on the applicator translation speed, as well as on other operating parameters, remote operation of the high-pressure-water cleaning head would be desirable. Also, in some applications (such as decontamination of hot cells), remote operation will be required. Consequently, the adaptation of the equipment to a robotics control system would be necessary.

Status: Accepted—High-pressure-water blasting has been used very successfully to decontaminate various large and complex surfaces at nuclear power plants. These include coolant pump impellers and cavities, fuel storage racks and handling equipment, floor drains and sumps, reactor cavity walls, pipes, and valves. When used as a preliminary step to wiping or scrubbing activities, DFs in the range of 50 are commonly achieved for loosely deposited and loosely adherent contamination. Experience has demonstrated that blasting effectiveness becomes negligible when the cleaning nozzle tip is more than 10–12 in. away from the surface being cleaned. However, before acceptance at K-25 and other DOE sites, the issues of wastewater treatment and prevention of spread of contamination must be addressed. The waste generated is the contaminated water from the cleaning operation. The waste production rate is essentially the same as the water rate in the cleaning step, which can range from 4 to >100 gpm.

Science/Technology Needs: To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be recycled and reused in the high-pressure-water cleaning operation. Remote operation will necessitate the adaptation of the mobile high-pressure-water and vacuum collection systems to a robotics control system.

Implementation Needs: Development costs—For development and demonstration of a water recycle system, in combination with high-pressure-water decontamination, an estimate of funding requirements is $1.2M. Personnel requirements are estimated to be $1.7M (approximately 50% engineer and 50% technician time) and 4.1 FTEs (approximately 10% P&E, 45% engineer, and 45% technician time) for FY 93 and FY 94, respectively. The cost of a robotics control system is estimated at $250K. This is based on the cost of a system that is available from the Remotek Company. Estimated cost of a glove box is <$50K and of a work room, >$250K. Operating cost would be $.06–$2/ft^2.

Deployment costs—The capital cost of a high-pressure-water cleaning unit will be in the $50K–$75K range. Operating costs for a high-pressure-water cleaning unit would primarily involve labor costs. Assuming a minimum two-person operation (at a labor rate of $40K/year/person) during the day shift, operating costs would be approximately $350/day. Personnel training for operation of a high-pressure-water unit and a water treatment and recycle system would be required.

Author: J. H. Wilson

References: MMES staff members

February 26, 1993

SUPERHEATED WATER DCON-53-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Concrete (may drive contaminates deeper into unfinished concreate), structural steel, tile, epoxy, metal equipment (exterior), Ni-lined steel equipment (interior)—after disassembly, monel, copper, aluminum, sheet metal, steel pipe, aluminum pipe. The media tabulated above may be treated by the subject technology for removal of all the listed contaminants.

Reference Requirements:

- Federal Facility Compliance Agreement for Oak Ridge Site
- Federal Facility Compliance Agreement for PCBs
- Clean Air Act
- Clean Water Act
- Toxic Substance Control Act
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Surface Cleaning (transferable contamination)

Technology: Superheated Water (e.g., at conditions of 300 psi and 300°F)—Directed as a high velocity stream on a surface to remove contamination. The contaminated wastewater that is generated must then be treated for discharge or for recycle to the superheated water decontamination operation. In the use of this decontamination technology, the superheated water cleaning head may be manually moved about on the surfaces being decontaminated. Also, a hand-held wand may be more conveniently used for vertical surfaces, equipment surfaces, etc. Because the decontamination efficiency depends on the applicator translation speed, as well as on other operating parameters, remote operation of the superheated water cleaning head would be desirable. Also, in some applications (such as decontamination of hot cells), remote operation will be required. Consequently, the adaptation of the equipment to a robotic control system would be necessary.

Status: Accepted—Technology is available and has been used by industry. However, before acceptance at K-25 and other DOE sites, the issues of wastewater treatment and prevention of spread of contamination must be addressed. Because of the relatively low operating

pressures [as compared to, for example, ultra high pressure water (UHPW) at 30,000–50,000 psi], superheated water will only remove surface contamination that is soluble or loosely bound to the surface. In these cases, the decontamination efficiency should be high. However, for tightly bound or imbedded surface contamination, removal may be insignificant. The waste generated is the contaminated water from the cleaning operation. The wastewater generation rate for a typical commercial unit ranges from 0.4 to 2 gpm.

Science/Technology Needs: To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be recycled and reused in the superheated water cleaning operation. Remote operation will necessitate the adaptation of the mobile cleaning and vacuum collection system to a robotic control system.

Implementation Needs: Development costs—For development and demonstration of a water recycle system, in combination with superheated water decontamination, an estimate of funding requirements is $1.2M. Personnel requirements are estimated to be $1.7M (approximately 50% engineer and 50% technician time) and 4.1 FTEs (approximately 10% P&E, 45% engineer, and 45% technician time) for FY 93 and FY 94, respectively. The cost of a robotic control system is estimated at $250K. This is based on the cost of a system that is available from a private company.

Deployment costs—The capital cost of a basic unit (spray-vacuum cleaning system) is $175K. Various attachments are available for specialty cleaning. Operating costs for a superheated water cleaning unit would primarily involve labor costs. Assuming a minimum two-person operation (at a labor rate of $40K/year/person) of a cleaning unit during the day shift, operating costs would be approximately $350/day. Training of personnel for operation of the superheated water cleaning unit and the wastewater treatment system will be needed. Other capital costs include <$50K for a glove box and >$250K for a work room. Operating cost would be $0.05–$2/ft^2.

Author: J. H. Wilson

References: MMES staff members

HOT WATER DCON-54-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Concrete (may drive contaminants deeper into unfinished concrete), structural steel, tile, epoxy, metal equipment (exterior), Ni-lined steel equipment (interior)—after disassembly, monel, copper, aluminum, sheet metal, steel pipe, aluminum pipe. The media tabulated above may be treated by the subject technology for removal of all the listed contaminants.

Reference Requirements:

- Federal Facility Compliance Agreement for Oak Ridge Site
- Federal Facility Compliance Agreement for PCBs
- Clean Air Act
- Clean Water Act
- Toxic Substance Control Act
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Surface Cleaning (transferable contamination)

Technology: Hot Water (at low pressure)—Used to flush areas to dissolve readily soluble contaminants or to flush loosely deposited particles to a central area for collection.

Status: Accepted—Flushing with hot water is often used following scrubbing, especially on floors. The effectiveness of flushing is enhanced by the use of squeegees to force the water and contaminants to collection or drain areas. The technique is not effective on fixed, nonsoluble contamination but should be effective for exterior (transferable) contamination. The waste generated is the contaminated water from the flushing operation.

Science/Technology Needs: To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be recycled and reused in the hot water cleaning operation.

Implementation Needs: Development costs—For development and demonstration of a water recycle system, in combination with hot water flushing, an estimate of funding requirements

is $1.2M. Personnel requirements are estimated to be $1.7M (approximately 50% engineer and 50% technician time) and 4.1 FTEs (approximately 10% P&E, 45% engineer, and 45% technician time) for FY 1993 and FY 1994, respectively.

Deployment costs—Capital costs for hot water cleaning will be <$5K. Operating costs for a hot water cleaning unit would primarily involve labor costs. Assuming a minimum two-person operation (at a labor rate of $40K/year/person) during the day shift, operating costs would be approximately $350/day or less than <$1/ft^2.

Authors: J. H. Wilson

References: MMES staff members

STEAM CLEANING DCON-55-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Concrete, structural steel, tile, epoxy, metal equipment (exterior), Ni-lined steel equipment (interior)—after disassembly, monel, copper, aluminum, sheet metal, steel pipe, aluminum pipe. The media tabulated above may be treated by the subject technology for removal of all the listed contaminants.

Reference Requirements:

- Federal Facility Compliance Agreement for Oak Ridge Site
- Federal Facility Compliance Agreement for PCBs
- Clean Air Act
- Clean Water Act
- Toxic Substance Control Act
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Surface Cleaning (transferable contamination)

Technology: Steam Cleaning—Combines the solvent action of water with the kinetic energy effect of blasting. At the relatively high temperatures, the solvent action is increased and the water volume requirements are reduced compared to water blasting. In the use of this decontamination technology, the steam cleaning head may be manually moved about on the surfaces being decontaminated. Also, a hand-held wand may be more conveniently used for vertical surfaces, equipment surfaces, etc. Because the decontamination efficiency depends on the applicator translation speed, as well as on other operating parameters, remote operation of the steam cleaning head would be desirable. Some applications (such as decontamination of hot cells), will require remote operation. Consequently, the adaptation of the equipment to a robotics control system would be necessary.

Status: Accepted—The technique has proven useful, especially on complex shapes and large surfaces. Good results can be obtained for surface decontamination with minimum radwaste volumes. Steam cleaning is quite effective for encrusted salt formations where leakage of chemically treated water has occurred. However, before acceptance at K-25 and other DOE sites, the issues of wastewater treatment and prevention of spread of contamination must be

addressed. The waste generated is the contaminated condensed steam from the cleaning operation.

Efficacy: Not expected to be effective for removing fixed contamination on equipment interiors. Effectiveness for transferable contamination must be demonstrated.

Science/Technology Needs: To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be recycled and reused in the steam cleaning operation. Remote operation will require the adaptation of the mobile heating and vacuum collection systems to a robotics control system.

Implementation Needs: Development costs—For development and demonstration of a water recycle system, in combination with steam decontamination, an estimate of funding requirements is $1.2M. Personnel requirements are estimated to be $1.7M (approximately 50% engineer and 50% technician time) and 4.1 FTEs (approximately 10% P&E, 45% engineer, and 45% technician time) for FY 1993 and FY 1994, respectively. The cost of a robotics control system is estimated at $250K. This is based on the cost of a system that is available from the Remotek Company.

Deployment costs—The capital cost of a steam cleaning unit will be in the $50K—$75K range. Operating costs for a steam cleaning unit would primarily involve labor costs. Assuming a minimum two-person operation (at a labor rate of $40K/year/person) of a steam cleaning unit during the day shift, operating costs would be approximately $350/day or $0.05–$2/ft^2. Personnel training for operation of a steam cleaning unit and water recycle system will be needed. Capital cost: <$50K for glove box and ~$250K for work room.

Author: J. H. Wilson

References: MMES staff members, especially C. E. Benson

HAND BRUSHING USED TO REMOVE SURFACE CONTAMINATION

DCON-56-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers. Deposit removal.

Problem Area/Constituents:

- Concrete with U contamination[1]
- Concrete with U, Tc contamination[1]
- Concrete with U, Tc, and actinide contamination[2]
- Structural steel with U contamination[2]
- Structural steel with U and Tc contamination
- Structural steel with U, Tc, and actinide contamination
- Metal equipment (exterior) with U contamination[3]
- Metal equipment (exterior) with U and Tc contamination
- Metal equipment (exterior) with U, Tc, and actinide contamination
- Nickel-lined steel equipment (interior) with U contamination[4]
- Nickel-lined steel equipment (interior) with U and Tc contamination[4]
- Nickel-lined steel equipment (interior) with U, Tc, and actinide contamination[4]
- Monel with U contamination[4]
- Monel with U and Tc contamination[4]
- Monel with U, Tc, and actinide contamination[4]
- Copper with U contamination[2]
- Copper with U and Tc contamination[5]
- Copper with U, Tc, and actinide contamination[5]
- Aluminum with U contamination[5]
- Aluminum with U and Tc contamination[5]
- Aluminum with U, Tc, and actinide contamination[5]
- Sheet metal with U contamination[6]
- Sheet metal with U and Tc contamination[6]
- Sheet metal with U, Tc, and actinide contamination[6]

Reference Requirements:

- NEPA, 40 CFR 1500–1508
- DOE Order 5480.11, "Radiation Protection for Occupational Workers" (draft)
- DOE Order 5480.12, "Prevention, Control, and Abatement of Environmental Pollution"

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

February 26, 1993

HAND BRUSHING USED TO REMOVE SURFACE CONTAMINATION

DCON-56-OG

Subelement: Decontamination

Alternatives: Surface Cleaning (transferable contamination)

Technology: Hand Brushing Used to Remove Surface Contamination

Status: Accepted

Capital cost—$258;[8] operating cost—$1/ft^2 (15–20 employee hours per sq yd)[7]

Waste generated—The HEPA filters on the vacuum cleaner used to pick up the particles of contamination and substrate removed by the brushing.

Effectiveness—Brushing is effective for removing smearable contamination, and less effective for fixed contamination.[9] Brushing has been used for decontamination at K-25.[2]

Science/Technology Needs: This technology has been demonstrated on plutonium deposits.[7] A test to demonstrate that this material will work on the uranium deposits at K-25 should be made before a large capital investment is made.

Implementation Needs: Workers require a few hours of special training to operate this equipment.[7]

Author: D. H. Bunch

References:

1. *Decontamination and Decommissioning Integrated Demonstration Strategy* (Draft for Review), November 1991, pp. 2–9.

2. T. Shapiro et al., *Building Characterization Report, ORGDP Diffusion Facilities Permanent Shutdown, Building K-25*, KD-5748, March 10, 1988, p. 64.

3. C. D. Phillips, personal conversation with D. H. Bunch, June 4, 1992.

4. T. Shapiro et al., ibid., p. 24.

5. *Decontamination and Decommissioning Plant for the Oak Ridge Gaseous Diffusion Plant* (Draft), K/SS-523, pp. 2–35.

6. J. M. Chiang et al., *Building Characterization Report, ORGDP Diffusion Facilities Permanent Report, Building K-33*, KD-5752, April 6, 1988, p. 14.

7. P. Osborne, telephone conversation with D. H. Bunch, August 10, 1992.

8. *VWR Scientific Apparatus Catalog 92/93*, VWR Scientific, 1991.

9. R. P. Allen, "Overview of Nonchemical Decontamination Techniques," *American Nuclear Society Executive Conference on Decontamination Techniques*, CONF-840956, September 1984.

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(615) - 576 - 0201 D. H. Bunch.

AUTOMATED BRUSHING TO REMOVE SURFACE CONTAMINATION

DCON-57-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents:

- Concrete with U contamination[1]
- Concrete with U, Tc contamination[1]
- Concrete with U, Tc, and actinide contamination[2]
- Structural steel with U contamination[1]
- Structural steel with U and Tc contamination
- Structural steel with U, Tc, and actinide contamination
- Metal equipment (exterior) with U contamination[3]
- Metal equipment (exterior) with U and Tc contamination
- Metal equipment (exterior) with U, Tc, and actinide contamination
- Nickel-lined steel equipment (interior) with U contamination[4]
- Nickel-lined steel equipment (interior) with U and Tc contamination[4]
- Nickel-lined steel equipment (interior) with U, Tc, and actinide contamination[4]
- Monel with U contamination[4]
- Monel with U and Tc contamination[4]
- Monel with U, Tc, and actinide contamination[4]
- Copper with U contamination[5]
- Copper with U and Tc contamination[5]
- Copper with U, Tc, and actinide contamination[5]
- Aluminum with U contamination[5]
- Aluminum with U and Tc contamination[5]
- Aluminum with U, Tc, and actinide contamination[5]
- Sheet metal with U contamination[6]
- Sheet metal with U and Tc contamination[6]
- Sheet metal with U, Tc, and actinide contamination[6]

Reference Requirements:

- NEPA, 40 CFR 1500–1508
- DOE Order 5480.11, "Radiation Protection for Occupational Workers" (draft)
- DOE Order 5480.12, "Prevention, Control, and Abatement of Environmental Pollution"

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

February 26, 1993

AUTOMATED BRUSHING TO REMOVE SURFACE CONTAMINATION

DCON-57-OG

Alternative: Surface Cleaning (transferable contamination)

Technology: Automated Brushing to Remove Surface Contamination

Status: Demonstration

Costs—For the cleaning of pipe interiors at Rocky Flats, costs were $12,000/ft, including costs for remote operation, containment, and remote viewing.[7] Capital cost is estimated at about $50–$250K; operating costs, at >$1 ft^2; development cost, at $200–$1000K;

Waste Generated—The HEPA filters on the vacuum cleaner used to pick up the particles of contamination and substrate removed by the brushing.

Effectiveness—Brushing is effective for removing smearable contamination, and less effective for fixed contamination.[1] Brushing has been used to clean the interior of plutonium-contaminated pipe at Rocky Flats.[1] The piping at Rocky Flats was cleaned to shiny metal.[7]

Science/Technology Needs: This technology has been demonstrated on plutonium deposits.[7] A test to demonstrate that this material will work on the uranium deposits at K-25 should be made before a large capital investment is made.

Implementation Needs: Workers require a few hours of special training to operate this equipment.[7]

Author: D. H. Bunch

References:

1. *Decontamination and Decommissioning Integrated Demonstration Study* (Draft for Review), November 1991, pp. 2–9.

2. T. Shapiro et al., *Building Characterization Report, ORGDP Diffusion Facilities Permanent Shutdown, Building K-25*, KD-5748, March 10, 1988, p. 64.

3. C. D. Phillips, personal conversation with D. H. Bunch, June 4, 1992.

4. T. Shapiro et al., ibid., p. 24.

5. *Decontamination and Decommissioning Plan for the Oak Ridge Gaseous Diffusion Plant* (Draft), K/SS-523, pp. 2–35.

6. J. M. Chiang et al., *Building Characterization Report, ORGDP Diffusion Facilities Permanent Report, Building K-33*, KD-5752, April 6, 1988, p. 14.

7. D. Knutson, Rocky Flats, telephone conversation with D. H. Bunch, May 28, 1992.

February 26, 1993

8. R. P. Allen, "Overview of Nonchemical Decontamination Techniques," *American Nuclear Society Executive Conference on Decontamination Techniques*, CONF-840956, September 1984.

SPONGE BLASTING DCON-58-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers. Deposit removal.

Problem Area/Constituents: Concrete, structural steel, tile, plastic, metal equipment (exterior), Monel, copper, aluminum, sheet metal, insulated copper wiring. These media may be treated by the subject technology for removal of all the listed contaminants.

Reference Requirements:

- Federal Facility Compliance Agreement for Oak Ridge Site
- Federal Facility Compliance Agreement for PCBs
- Clean Air Act
- Clean Water Act
- Toxic Substance Control Act
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Surface Cleaning (transferable contamination)

Technology: Sponge Blasting—The Sponge-Jet system decontaminates by blasting surfaces with various grades of patented water-based urethane foam cleaning media using 110 psig as the propellant. The foam may be used either dry or wetted for a variety of surface contaminants such as oils, greases, lead compounds, chemicals, and radionuclides. The following two types of foam cleaning media are used: (1) a nonaggressive grade that is used for surface cleaning on sensitive or otherwise critical surfaces and (2) aggressive grades that are impregnated with abrasives that can remove tough materials such as paints, protective coatings, and rust (it can also roughen concrete and metallic surfaces if desired). The cleaning heads of the Sponge-Jet unit are similar to those of other blasting technologies and could be readily adapted to a robotic control system. Robotic control is required in applications where workers could be exposed to unacceptable levels of contamination.

Status: Accepted—The technology is relatively new. It is currently being used by a company in Tennessee that produces projectiles containing uranium and by a nuclear power plant in Pennsylvania. Extensive data on decontamination factors are not available. Foam blasting media are recyclable in a closed-cycle wash unit that centrifugally launders the cleaning media. The media typically can be recycled eight to ten times. On the first time through, the

sponge blasting unit uses 6–8 ft^3 or media per hour at a surface cleaning rate of about 1 ft^2/min. Thus, the solid waste produced (foam media with the absorbed contaminants) is approximately 0.01 ft^3/ft^2 of surface cleaned. For waste minimization purposes, the contaminated wash water from the wash unit can be treated and recycled.

Science/Technology Needs: To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be recycled and reused in the sponge blasting operation. The system must be capable of treating the contaminants specific to the site and reducing their concentrations to allowable levels for water recycle. Remote operation will require the adaptation of the cleaning heads to a robotic control system.

Implementation Needs: Development costs—The cost of a robotic control system is estimated at $250K Remotek Company (personal communication with C. E. Benson). For development and demonstration of a water recycle system in combination with sponge blasting, an estimate of funding requirements is $1.2M. Personnel requirements are estimated to be $1.7M (approximately 50% engineer and 50% technician time) and 41 FTEs (approximately 10% P&E, 45% engineer, and 45% technician time) for FY93 and FY94, respectively.

Deployment Costs—Operating costs for a sponge blasting unit would primarily involve labor and material costs. Assuming a minimum two-person operation (at a labor rate of $40K/year/person) of a blasting unit during the day shift, labor costs would be approximately $350/day. A conservative estimate of blasting media material costs is $70 per hour. Based on an 8-h day with about 75% operating time, operating costs would be approximately $2/$ft^2$ of surface cleaned. The capital cost of a standard sponge blasting unit is $13K. A sifter unit, used to separate the used blasting media from debris such as paint flakes, rust particles, etc., costs $6K. The blasting media wash unit is not standard and is designed for each specific application.

Author:

References: Information on the Sponge-Jet system was provided by J. R. Cavallo, Sponge-Jet, Inc., 10 Grove St., P.O. Box 206, Dover, N.C, 03820 (Phone: 603-742-8350).

HOT AIR STRIPPING DCON-59-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents:

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site and FFCA for PCBs)
- Applicable federal and state laws and regulations (e.g., Clean Air Act and Toxic Substance Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Surface Cleaning (transferable contamination)

Technology: Hot Air Stripping

Status: None of the K-25 surface cleaning problems seem directly applicable to thermal treatment by hot air. Oil and PCBs could conceivably be removed from surfaces; however, the large-scale containment, separation, condensation, and ultimate disposal present insurmountable obstacles at present for planning realistic evaluations. There is no known or proposed use of the hot air stripping process to directly treat any of the K-25 D&D substrate/contaminants. The basic air-stripping technology is well known for volatiles in liquids and many commercial designs are readily available if secondary treatment of effluent is required.

Science/Technology Needs: Specific needs depend on specific secondary treatment requirements.

Implementation Needs: These would depend on the concentration and condition of the secondary decontamination wastes.

Author: R. B. Alderfer

References: MMES staff members

February 26, 1993

DRY HEAT ROASTING

DCON-60-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Structural steel, sheet metal, and metal equipment (exterior) contaminated with oil or oil and PCBs and copper contaminated with oil.

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site and FFCA for PCBs)
- Applicable federal and state laws and regulations (e.g., Clean Air Act and Toxic Substance Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Surface Cleaning Methods

Technology: Dry Heat Roasting

Status: The technology of dry heat roasting (i.e, calcination and other modes of generation) is well developed and accepted by industry particularly for liquid waste treatment. It is in operation at enrichment plants for decontamination solution treatment. This technology is not appropriate at this time because none of the K-25 problem substrates that need treatment are applicable to dry heat roasting decontamination. Only secondary decontamination solutions are applicable.

Science/Technology Needs: Technology improvement needs would include pilot studies of specific solutions needing treatment and comparison to other alternatives.

Implementation Needs: Nothing unusual

Author: R. B. Alderfer

References: MMES staff members

February 26, 1993

SOLVENT WASHING DCON-61-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Concrete with U contamination[1]

- Concrete with U, Tc contamination[1]
- Concrete with U, Tc, and actinide contamination[2]
- Structural steel with U contamination[2]
- Structural steel with U and Tc contamination
- Structural steel with U, Tc, and actinide contamination
- Metal equipment (exterior) with U contamination[3]
- Metal equipment (exterior) with U and Tc contamination
- Metal equipment (exterior) with U, Tc, and actinide contamination
- Nickel-lined steel equipment (interior) with U contamination[4]
- Nickel-lined steel equipment (interior) with U and Tc contamination[4]
- Nickel-lined steel equipment (interior) with U, Tc, and actinide contamination[4]
- Monel with U contamination[4]
- Monel with U and Tc contamination[4]
- Monel with U, Tc, and actinide contamination[4]
- Copper with U contamination[2]
- Copper with U and Tc contamination[5]
- Copper with U, Tc, and actinide contamination[5]
- Aluminum with U contamination[5]
- Aluminum with U and Tc contamination[5]
- Aluminum with U, Tc, and actinide contamination[5]
- Sheet metal with U contamination[6]
- Sheet metal with U and Tc contamination[6]
- Sheet metal with U, Tc, and actinide contamination[6]

Reference Requirements:

- Toxic Substances Control Act, 40 CFR 761
- Resource Conservation and Recovery Act and the Hazardous and Solid Waste Amendments of 1984, 40 CFR 260–270
- NEPA, 40 CFR 1500–1508
- The Clean Air Act, 40 CFR 60–65
- The Clean Water Act, 40 CFR 110–146 and 400–471
- DOE Order 5480.11, "Radiation Protection for Occupational Workers" (draft)
- DOE Order 5480.12, "Prevention, Control, and Abatement of Environmental Pollution"

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific

characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Surface Cleaning Methods (transferable contamination)

Technology: Solvent Washing—Contaminated items are washed in solvent. An automated system is used to spray and recover the solvent.

Status: Conceptual

Cost—$300K (1980 dollars); development cost—$1M to $4.5M; labor cost—an average of 7.5 minutes per item was required when decontamination small items such as pipe wrenches, vise grips, lard cans[12].

Demonstration cost—$1M to identify and demonstrate the replacement solvent. Plutonium-contaminated items at Richland, Washington were rinsed with Freon.[7] Solvents that are less damaging to the environment need to be identified and demonstrated.[8] The vendor who supplied the equipment for Richland ten years ago no longer sells it.[9]

This technique is mainly applicable to smearable contamination.[10]

Waste generated—Only the surface material removed.[11]

Science/Technology Needs: Solvents that are less damaging to the environment need to be identified and demonstrated.[6]

Implementation Needs: Nothing unusual

Author: D. H. Bunch

References:

1. *Decontamination and Decommissioning Integrated Demonstration Strategy* (Draft for Review), November 1991, pp. 2–9.

2. T. Shapiro et al., *Building Characterization Report, ORGDP Diffusion Facilities Permanent Shutdown, Building K-25*, KD-5748, March 10, 1988, p. 64.

3. C. D. Phillips, personal conversation with D. H. Bunch, June 4, 1992.

4. T. Shapiro et al., ibid., p. 24.

5. *Decontamination and Decommissioning Plant for the Oak Ridge Gaseous Diffusion Plant* (Draft), K/SS-523, pp. 2–35.

6. J. M. Chiang et al., *Building Characterization Report, ORGDP Diffusion Facilities Permanent Report, Building K-33*, KD-5752, April 6, 1988, p. 14.

7. R. P. Allen, telephone conversation with D. H. Bunch, June 17, 1992.

8. *Decontamination and Decommissioning Integrated Demonstration Strategy* (Draft for Review), November 1991.

9. D. E. Fowler, telephone conversation with D. H. Bunch, June 5, 1992.

10. R. P. Allen, *"Overview of Nonchemical Decontamination Techniques,"* PNL-SA-12562, September 1984, p. 7.

11. Richard P. Allen, H. W. Arrowsmith, and M. W. McCoy, "New Contamination Technologies for Environmental Applications," *Environmental Decontamination, Proceedings of the workshop, December 4–5, 1979, Oak Ridge, Tenn.*, CONF-791234, February 1981.

12. C. E. Wilson, "High Pressure Freon Decontamination of Remote Equipment," *Proceedings of the International Topical Meeting on Remote Systems and Robotics in Hostile Environments*, American Nuclear Society, 1987.

13. *Decontamination and Decommissioning Integrated Demonstration Strategy (Draft for Review)*, November 1991.

SOLVENT WASHING TO REMOVE ORGANICS DCON-62-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents:

- Concrete contaminated with oils and PCBs[1]
- Copper contaminated with lube oils
- Gasket material with no contamination
- Gasket material contaminated with PCBs[2]
- Sheet metal contaminated with PCBs and oils[1]

Reference Requirements:

- Toxic Substances Control Act, 40 CFR 761
- Resource Conservation and Recovery Act and the Hazardous and Solid Waste Amendments of 1984, 40 CFR 260–270
- NEPA 40 CFR 1500–1508
- The Clean Air Act 40 CFR 60–65
- The Clean Water Act 40 CFR 110–146 and 400–471
- DOE Order 5480.11,"Radiation Protection for Occupational Workers" (draft)
- DOE Order 5480.12, "Prevention, Control, and Abatement of Environmental Pollution"

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Solvent Washing

Technology: Solvent Washing to Remove Organics

Status: Conceptual—Solvent degreasing was used successfully at K-25, but its use was stopped to avoid exposing the workers and the environment to the hazardous solvents. Other solvents might be available, but their effectiveness would have to be demonstrated.[3]

Cost—$400K (1992 dollars) for a 4,000-lb capacity unit. Labor Cost—One operator for one hour to load, clean, and unload 4,000 lb of metal.[4]

This equipment is produced by a number of manufacturers[5] and its use for removing organic surface contamination is common in a variety of industries.[3]

Science/Technology Needs: Solvents that are less damaging to the environment need to be identified and demonstrated.[6]

Implementation Needs: Maintenance mechanics operated degreasing equipment at K-25.[3]

Author: D. H. Bunch

References:

1. J. M. Chiang et. al., *Building Characterization Report, ORGDP Facilities Permanent Shutdown, Building K-22, Rev. 0*, K/D 5752, April 6, 1988, p. 20.

2. *Decontamination and Decommissioning Plan for the Oak Ridge Gaseous Diffusion Plant (Draft)*, K/SS-523, pp. 2–9.

3. Bruce Walker, personal communication to D. H. Bunch, June 5, 1992.

4. David West, Durr Corp., phone conversation with D. H. Bunch, June 8, 1992.

5. *Thomas Register of American Manufacturers*, Thomas Publishing Company, NY, 1992, pp. 7651–7663.

6. *Decontamination and Decommissioning Integrated Demonstration Strategy*, Draft for Review, November 1991.

STRIPPABLE COATINGS DCON-63-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Structural steel, tile, epoxy, metal equipment (exterior), Ni-lined steel equipment (interior), Monel, copper, aluminum, insulated copper wiring, instruments, sheet metal, steel pipe, aluminum pipe. The media tabulated above may be treated by the subject technology for removal of all the listed contaminants.

Reference Requirements:

- Federal Facility Compliance Agreement for Oak Ridge Site
- Federal Facility Compliance Agreement for PCBs
- Clean Air Act
- Toxic Substance Control Act
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Surface Cleaning (transferable contamination)

Technology: Strippable Coatings—A coating, such as a water-based organic polymer, is applied to a contaminated surface by methods such as spraying, brushing, and rolling (as may be used for paint). When the coating dries, it is either manually stripped from the surface or, in the case of "auto-release" coatings, it is collected by vacuuming. The surface contamination is removed with the coating, producing a dry, hard, nonairborne waste product. Water-based strippable coatings are intended for use in decontaminating smooth and semirough porous surfaces, including steel, concrete, aluminum, wood, and painted surfaces.

Status: Accepted—The technology has been used for decontamination purposes in applications involving hazardous and/or radioactive contaminants. The waste product is the solid polymer that contains the removed contaminants. Typical coverages would be 50 ft^2 per gallon of polymer. Strippable coatings are very effective. However, the application and removal times are relatively long in some instances, the cost of materials is high, and the radioactive waste aspects for disposal must be carefully considered. Most commercial strippable coatings may be incinerated.

Science/Technology Needs: A potential area of improvement for strippable coatings is the reduction of material costs.

Implementation Needs: Development costs—The technology needs listed above for strippable coatings are rather general. The costs of such improvements to the companies supplying the coatings would be difficult to estimate.

Deployment costs—The cost of a spray unit for applying strippable coatings is <$10k. The cost of the polymer is $50–$70/gal. At the coverage stated above, the cost of materials per unit area of contaminated surface would be $1–$1.4/ft^2.

Author: J. H. Wilson

References: MMES staff members

VACUUMING (LOW PRESSURE) DCON-64-OG

EM Problem: Decommissioning

K-25 Site Problem:

Problem Area/Constituents: Concrete, sheet metal, structural steel, process equipment both interior and exterior. All potentially contaminated areas with loose materials.

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site and FFCA for PCBs).
- Applicable federal and state laws and regulations (e.g., Clean Air Act and Toxic Substance Control Act)
- DOE orders

Subelement: Decontamination

Alternatives: Surface Decontamination Methods

Technology: Vacuuming (Low Pressure)—Use of a vacuum cleaner to remove, by air entrainment, loosely adhering contamination.

Status: It is widely accepted widely by industry for removing loose solid contaminants. When a significant amount of solids are present but not loose, they may be broken free by hand scraping or more automated means and then vacuumed by a HEPA filtration vacuum systems. Dust-laden areas are also good candidates where the possibility of contamination exists.

Science/Technology Needs: Development—Cleanable, reusable pre-filters and HEPA filters should be developed to minimize wastes.

Implementation Needs: Resources are minimal, available, readily applicable.

Author: R. B. Alderfer

References: MMES staff members

ULTRASONIC CLEANING DCON-65-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents:
- Metal Equipment (exterior) U, Oils, PCB
- Sheet Metal (small pieces less than 3 × 4 ft)—PCB, Oils, U, Tc, Actinides
- Copper
- Solid depleted uranium—oil

Reference Requirements:
- FFCA for K-25 Site
- RCRA and TSCA regulations as applied to solvents used in washing and organic contaminants on the metal surfaces (oils, PCB, etc.)
- NRC NUREG 1.86 as applied to release standards for radioactive surface contamination

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternative: Surface Cleaning (transferable contamination)

Technology: Ultrasonic Cleaning—Utilizes the scrubbing action of liquid excited by ultrasonic frequencies to remove surface deposits of oils, organic, and loosely bound solids from metals, plastic, glass, and other solids. It produces no abrasion, distortion, or changes in most solids and is ideally suited for delicate or valuable parts and materials that are to be reused.

Status: Accepted—The cost of application is high compared to other decontamination methods. The cost is greater than $\$2/ft^2$, and it may exceed $\$10/ft^2$.

Ultrasonic cleaning has been used for many years in the private sector and in government installations for removing surface contamination from relatively small metal parts that can fit into an ultrasonic bath. This technology has been demonstrated on a plant scale at Y-12 for the past 4 years as a substitute for solvent washing. Initial funding was provided by HAZWRAP and DOE-ALO. Ultrasonic Cleaning is not used at the K-25 Site on a large scale. The technology will work well for loosely bound surface deposits such as dust, dirt, organic, oils, PCBs, etc., on metal equipment, sheet metal, and solid depleted uranium. The technique is not practical for large items that would require size reduction. It is ineffective for tightly bound materials such as paints, varnishes, and other materials that are difficult to remove.

The technique may generate secondary wastes which are expensive to manage (such as solvent and detergent solutions requiring processing). The technique is intended for valuable parts which could be recycled "as is" after cleaning. The technique is also good for removing deposits in difficult-to-access places, and it may be useful for electronic parts and electric motors.

Science/Technology Needs: Technology development needs to include definition of acceptable cleaning liquids that (1) are not hazardous, (2) can be separated from the contaminants, and (3) can be reused to minimize secondary wastes. Technology improvements should include more aggressive cleaning action.

Implementation Needs:
The technology is sufficiently mature to be used in most D&D applications without the need for additional personnel and educational investments. Investment in means to produce a more aggressive cleaning action may be cost effective and could likely be accomplished on a pilot scale for about $1M. If the needs for more aggressive cleaning within the DOE D&D were great enough, private sector suppliers of ultrasonic equipment would likely bear the cost of its development.

Author: J. M. Kennerly

References:

1. L. M. Thompson, R. F. Samandl, and H. L. Richards, "Solutions for the Chlorinated Solvent Debacle, " YDB 904, Rev. 1.

2. L. M. Thompson and R. F. Samandl, "Ultrasonic Aqueous Cleaning as a replacement for Chlorinated Solvent Cleaning," report in preparation.

MICROWAVE SCABBLING DCON-71-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers.

Problem Area/Constituents: Concrete—May be treated by the subject technology for removal of all the listed contaminants.

Reference Requirements:

- Federal Facility Compliance Agreement for Oak Ridge Site
- Federal Facility Compliance Agreement for PCBs
- Clean Air Act
- Toxic Substance Control Act
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Thermal Surface Substrate Removal

Technology: Microwave Scabbling—This technology directs microwave energy at a concrete surface using a specialized waveguide applicator and heats the concrete and the free water present in the concrete matrix. Continued heating produces thermal- and steam-pressure-induced mechanical stresses that cause the concrete surface to burst. The concrete particles from this steam explosion are small enough to be removed by a vacuum system, yet less than 1% of the debris is small enough to pose an airborne contamination hazard. The process is fast, dry, generates little dust, and avoids mechanical impacts. In the use of the microwave scabbling technology, the microwave applicator head may be manually moved about on the concrete surfaces being decontaminated. Because the rate and depth of surface removal depend on the applicator translation speed, remote operation of the mobile microwave equipment would be desirable. Also, in some applications (such as decontamination of hot cells), remote operation will be required. Consequently, the adaptation of the equipment to a robotics control system would be necessary.

Status: Predemonstration—In fiscal year 1991, Oak Ridge National Laboratory (ORNL) demonstrated[1] reliable removal of noncontaminated concrete surfaces using microwave energy. At microwave frequencies of 2.45 GHz and 10.6 GHz, continuous concrete removal rates of 1.1 cm^3/s at 5.2 kW and 2.1 cm^3/s at 3.6 kW, respectively, were obtained. Removal rate and removal depth are controlled by choosing the proper frequency and varying the

power and translation speed of the applicator on the concrete surface. Higher frequencies preferentially remove surface contamination. A mobile prototype microwave concrete removal machine is being built at ORNL during FY 1992–FY 1993. A rugged, compact, and electrically efficient microwave applicator that is better integrated with the required concrete debris collection system is being developed.[2] In 1987, a group from Japan reported on a mobile microwave decontaminator that could perform removal at a rate of 11 cm^3/s.[3] This removal rate was equal to that of the fastest commercial mechanical concrete breaking machines. It is anticipated that, with an upgrade of power and improvements to the applicator design to spread out the microwave power in a larger area, concrete removal rates comparable to or exceeding those obtained with conventional concrete removal equipment can be achieved.[4] The microwave technique is a dry process that generates little dust and avoids the need to work when the concrete surfaces are wet. Because microwave scabbling removes the contaminated concrete surface, the decontamination efficiency should be 100% if there is no recontamination from the removed scabble. The waste generated is concrete rubble that has particle diameters lying primarily in the range of 1 to 10 mm. The quantity of waste generated depends upon the translation speed of the microwave applicator and the depth of the concrete surface layer that is removed. For example, for a removal depth of 10 mm and a surface area treatment rate of one square foot per minute, 150 lb/h of concrete waste would be generated.

Science/Technology Needs: The development and testing of a mobile prototype microwave concrete removal machine needs to be completed (TTP No. OR-3DAA; DOE No. OR-1012-04). Significant improvements in concrete removal rates and efficiencies can be achieved by modeling the microwave scabbling process as an unsteady, three-dimensional, finite-element, nonlinear, thermal and mechanical stress problem. Because the microwave absorption properties of concrete are critically dependent on temperature and frequency, the frequency and temperature dependent dielectric properties of concrete are being measured and the data will be used in a one-dimensional model developed at Florida International University to characterize the stresses generated in the concrete under the conditions of rapid microwave heating.[5,6] Extensions of this work to three dimensions will follow. Remote operation will necessitate the adaptation of the mobile microwave and vacuum collection systems to a robotics control system. In addition, the development of real-time monitoring sensors for measuring the progress of the decontamination process is needed so that only the contaminated portion of the concrete is removed, thus minimizing the amount of waste produced.

Implementation Needs: Development costs: The cost for development and testing of a mobile prototype microwave concrete removal machine is estimated to be $2.5M for FY 1993-1995.[2] The personnel requirements are 2.5 FTEs per year (50% technical, 50% support personnel). The cost of a robotics control system is estimated at $250K. This is based on the cost of a system that is available from the Remotek Company (personal communication with C. E. Benson).

Deployment costs—A credible estimate of capital cost for a microwave scabbler unit cannot be made until a prototype unit has been developed and demonstrated. Operating costs for a scabbler would primarily include power and labor costs. Assuming a two-person (at a labor

rate of $40K/year/person) operation of a 100kW unit at 75% usage during the day shift, operating costs would be approximately $350/day. Training personnel to operate the microwave scabbler at DOE sites will be needed. Also, this training will need to be included in any technology transfer activities.

Author: J. H. Wilson

References:

1. T. L. White, R. G. Grubb, L. P. Pugh, D. Foster, Jr., and W. D. Box, "Removal of Contaminated Concrete Surfaces by Microwave Heating-Phase I Results," to be published in the proceedings of the 18th American Nuclear Society Symposium on Waste Management, Waste Management '92, Tucson, Ariz., March 1–5, 1992.

2. TTP No. OR-3DAA (DOE No. OR-1012-04).

3. H. Yasunaka et al., "Microwave Decontaminator for Concrete Surface Decontamination in JPDR," *Proc. Int. Decommissioning Symp.*, Oct. 4–8, 1987, pp. 109–115.

4. T. L. White, private communication.

5. W. Li et al., "Heat Transfer with a Radiation Contaminated Slab Applying a Microwave Heating Technique," in press, ASME Trans., *J. of Heat Transfer*, 1992, ASME National Heat Transfer Conference, Aug. 8–11, 1992, San Diego, Calif.

6. W. Li et al., "Heat and Mass Transfer in a Contaminated, Porous Concrete Slab Subjected to Microwave Heating," to be published, 1992 Annual Winter Meeting of ASME, Anaheim, Calif., Nov. 25–Dec. 2, 1992.

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers. Deposit removal.

Problem Area/Constituents:

- Concrete with U, Tc, oils, PCBs, actinides, chromate
- Structural steel with U, Tc, oils, PCBs, actinides
- Metal equipment (exterior) with U, Tc, oils, PCBs, actinides
- Nickel-lined steel equipment (interior) with U, Tc, actinides
- Monel with U, Tc
- Copper with U, Tc, actinides, lube oil
- Aluminum with U, Tc, actinides
- Steel with chromates
- Sheet metal with U, Tc, oils, PCBs
- Steel pipe with As, chromates, Ba, dioxins, asbestos
- Steel cylinders with UF_6, Tc, actinides

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site)
- Applicable federal and state laws and regulations (e.g., Clean Water Act and Toxic Substance Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Thermal Surface and Substrate Removal

Technology: Plasma torch—Uses an inert gas passing through a high-power DC or RF arc discharge to produce a very-high-temperature gas stream that is capable of melting nearly all uncooled materials. Such torches are used in plasma synthesis and decomposition of materials.

Status: Potential uses in decontamination of materials include breaking down oils and PCBs into less harmful or harmless substances, rapid spalling of concrete, and using the difference in coefficient of thermal expansion to delaminate contaminants from underlying substrates. The torch's inert gas is recyclable and creates no additional waste stream of its own compared to the CO_2 and NO_x product created by a combustion torch. Plasma torches exist

commercially to weld and cut materials that either have a very high melting temperature or require an inert atmosphere to prevent oxidation.

Science Technology Needs: While plasma torch technology exists, its efficacy in removing various organic and radioactive contaminants has not been demonstrated. Elevation to the predemonstration stage involves laboratory-scale experiments, which will be designed by using experimental results obtained from on-going development activities associated with plasma cleaning and fluorination technologies. The laboratory equipment will be constructed and operated for generating high-temperature thermal plasmas to destroy organic contaminants and to vaporize and encapsulate heavy metals. A database of decontamination rates of plasma torch techniques will be established. The equipment required for plasma torch cleaning of large surface areas that are contaminated will be developed to accommodate robotics, remote, and automatic operations with computer control. Also, computer modeling of plasma-surface interactions will be used to provide significant improvements in the removal rate and efficiencies of plasma torch methods. Standard filters can be used to clean the working gas.

Implementation Needs: Development costs—To address science needs, the approximate cost of equipment and staff time is about $1M (capital equipment, $200K; staff, $800K). For these activities, the personnel must be highly trained in the fields of plasma technology and chemistry. One-half are scientists with masters or doctoral degrees, and one-half are highly trained technicians with bachelor of science degrees.

Demonstration costs—To perform a bench-scale demonstration, the approximate cost of laboratory preparation, equipment, and staff time is about $2M (capital equipment, $500K; staff, $1.5M). For this phase of work, approximately 20% of the staff will be comprised of highly trained staff as mentioned above. The remaining 80% of the staff will have high school training complemented with 1–2 months of on-the-job training. After the demonstration phase, the majority of the effort can be implemented by technicians that are trained (1–2 months) for this specific work.

Author: W. L. Gardner

References: J. R. Hollis, *Environ. Progress*, **2**, 7, 1983.

EM Problem: Decommissioning

K-25 Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers. Deposit removal.

Problem Area/Constituents:

Structural steel, sheet metal, and metal equipment (exterior) contaminated with the following:
- U
- U and oil
- U and Tc
- U, oil, and PCB
- U, Tc, and oil
- U, Tc, oil, and PCBs
- U, Tc, and actinides
- U and PCBs
- U, oil, Tc, PCBs, and actinides

Nickel-plated steel equipment (interior), monel, copper, aluminum, and steel contaminated with the following:
- U
- U and Tc
- U, Tc, and actinides
- Insulated copper wiring contaminated with U or U and Tc
- Steel pipe contaminated with As, chromates, Ba, and dioxins
- Steel cylinders contaminated with UF_6 and Tc or UF_6, Tc, and actinides

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site, FFCA for PCBs)
- Applicable federal and state laws and regulations (e.g., Clean Air Act and Toxic Substance Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Thermal Surface and Substrate Removal

Technology: Laser Heating

Status: Laser-based photothermal heating is currently being considered by the Air Force as a method for removing organic coatings (e.g., polyurethane paint) from metal and composite surfaces. A prototype paint-removal system was built by BDM International and is now being tested by the Air Force. This system removes a 2-mil-thick coating of paint at a rate of about 2.5 ft^2/min. Ames Laboratory is conducting laboratory tests of methods for laser-based decontamination of metal surfaces. The goal is to remove radionuclides from contaminated metal and to accomplish an isotopic separation of the nuclides after removal. Hanford-Westinghouse is waiting for funding to begin laboratory tests of their approach to laser-based decontamination of metal surfaces. The primary application for laser-based photothermal heating is when large surface areas need a high degree of decontamination with the absolute minimum amount of waste generation. The technology produces as waste only the material that is removed from the surface (all the vaporized material is collected in a filtration system).

Science/Technology Needs: The existing laser-based photothermal heating systems can be evaluated for possible use on decontamination problem areas. Other systems using lasers with different operational parameters (e.g., wavelengths, pulse durations) should also be considered for application on decontamination problem areas.

Implementation Needs: The successful development of this technology will require that commercial vendors of laser-based photothermal heaters be encouraged to adapt their existing systems to meet the requirements of specific problem areas. Commercially available systems should be capable of turn-key operation by trained technicians. The Air Force paid BDM International about $1 million to develop the prototype system that they are testing, but it is not unrealistic to estimate that future systems will have a cost on the order of several hundred thousand dollars.

Development costs are estimated to be over $2M; capital costs, $500K–$1000K; and operating costs, $1/$ft^2$.

Author: D. B. Smith

References: MMES staff members

February 26, 1993

LASER ETCHING AND ABLATION DCON-74-OG

EM Problem: Decommissioning

K-25 Site Problem: Deposit Removal

Problem Area/Constituents:

Structural steel, sheet metal, and metal equipment (exterior) contaminated with the following:
- U
- U and oil
- U and Tc
- U, oil, and PCBs
- U, Tc, and oil
- U, Tc, oil, and PCBs
- U, Tc, and actinides
- U and PCBs
- U, oil, Tc, PCBs, and actinides

Nickel-plated steel equipment (interior), monel, copper, aluminum, and steel contaminated with the following:
- U
- U and Tc
- U, Tc, and actinides
- Insulated copper wiring contaminated with U or U and Tc
- Steel pipe contaminated with As, chromates, Ba, and dioxins
- Steel cylinders contaminated with UF_6 and Tc or UF_6, Tc, and actinides

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site, FFCA for PCBs)
- Applicable federal and state laws and regulations (e.g., Clean Air Act, Toxic Substance Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Thermal Surface and Substrate Removal

Technology: Laser Etching and Ablation—The use of laser etching and ablation is an evolving technology.

Status: The conceptual basis for the technology exists, and a similar technique is used to clean optical surfaces and microelectronics substrate materials to ultrahigh levels. Predemonstration laboratory testing of an application of the technology to decontamination has been planned and is waiting to be funded.

Decontamination with laser etching and ablation chemistry will probably have two primary applications. First, the process can augment other decontamination processes that do not work in difficult-to-access regions. For instance, the directional nature of laser beams allows the process to reach very small crevices and cracks that are missed by gross decontamination processes. Second, etching and ablation is capable in many cases of removing all traces of radiological contamination. This will be applicable to situations where a very high degree of decontamination is required.

Decontamination with laser etching and ablation generates the absolute minimum amount of waste. The technology produces as waste only the material that is removed from the surface (all the vaporized material is collected in a filtration system).

Science/Technology Needs: Laser etching and ablation for decontamination needs a considerable amount of laboratory research before a technology demonstration can be contemplated. The hardware and other materials required for implementing the technique (e.g., lasers, optics, vacuum and filtration systems) already exist; what is needed is a concerted effort to bring all of the components together for the specific applications. Furthermore, the functional requirements for the technology (e.g., where is the contamination located, or what degree of decontamination is required?) are being defined as the problem areas are characterized. The development of the technique will need to be coordinated with these requirements.

Implementation Needs: The successful development of laser etching and ablation decontamination will require a team of researchers directed toward its development. There are several laboratories and many qualified researchers available. A best guess of the human resources required is five man-years of effort over 2–3 years will be sufficient to develop and demonstrate a prototype system. Most of the hardware needed will consist of off-the-shelf equipment such as laboratory glove boxes, laser systems, and data acquisition systems. A rough estimate of the financial investment required for development and demonstration is several million dollars over a 3-year period.

The successful deployment of the technology will require a transfer of the technology from the laboratory researchers to a commercial manufacturer. The prototype system would serve as the basis for larger-scale or mass production systems. In concept, a laser-based decontamination system should lend itself to a very high degree of automation, and a commercially available system should be capable of turn-key operation. One technician would be capable of overseeing the operation of multiple systems.

Development costs are estimated to be >\$2M; capital costs, \$500K–\$1000K; and operating costs, ~\$1/ft^2.

LASER ETCHING AND ABLATION

DCON-74-OG

Author: D. B. Smith

References: MMES staff members

February 26, 1993

PLASMA SURFACE CLEANING DCON-75-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers. Deposit removal.

Problem Area/Constituents: U-, Oil-, and PCB-contaminated metal equipment (Exterior) U-, Oil-, and PCB-contaminated sheet metal

Reference Requirements: Documents

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site, FFCA for PCBs)
- Applicable federal and state laws and regulations (e.g., Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Thermal Surface and Substrate Removal

Technology: Plasma Surface Cleaning—With a reactive plasma, chemically reactive species clean contaminated surfaces by the processes of chemisorption, reaction and desorption, or gasification. For example, in an oxygen plasma cleaning, oxygen atom and ozone and UV photons are the reactive species to convert hydrocarbon contaminants into volatile products. This plasma cleaning technology is being developed for the DOE's waste minimization program. The plasma cleaning technology can be developed for decontamination for oil- and PCB-contaminated metal process equipment.

Status: Predemonstration—Plasma surface cleaning methods by glow discharges are commonly and effectively used for cleaning high-bonding-energy contaminants from surfaces of metals, metal oxides, and glasses.[1] Plasma cleaning is done in vacuum chambers for accelerators and magnetic fusion devices.[2] Recently tritium contaminated hardware has been plasma cleaned with a decontamination factor of 1000.[3] Plasma processes of etching and deposition are also used in material processing and microelectronic manufacturing in industry.[4-7] Extrapolating these plasma cleaning techniques for decomposing and destroying oil and PCB contaminants in metal process equipment is feasible. Based on known plasma assisted etching rates, decontamination rates by reactive plasmas are expected to be higher than that by gas phase decontamination methods. Moreover, the plasma cleaning process provides a means of separating and recovering uranium from the mixed uranium contaminants, recycling the process equipment, reducing the volume of generated secondary wastes, and helping to minimize the final waste deposition cost. Though additional radio frequency or microwave power is required the plasma cleaning techniques will be

approximately a factor of ten cheaper and faster than the gas cleaning techniques. Together with a scrubber, the supporting equipment used for the gas phase decontamination system, including thermal management system, vacuum system, computer control and monitors can be used for the waste generated in plasma cleaning methods. It is the author's opinion that a savings of a factor of ten could be realized in a production environment.

Science Technology Needs: A plasma decontamination method should be developed to fulfill certain science and technology needs, even though plasma discharges have been used in laboratories and industry for cleaning and etching of many materials. Prototype equipment needs to be constructed and operated for generating reactive plasmas to clean oil and PCB contaminants. A database of decontamination rate on oil cleaning and PCB destruction needs to be established. The capability of plasma generation and cleaning on internal surfaces of contaminated equipment that have large surface areas needs to be established. Also, computer modeling of plasma-surface interactions will be used for providing significant improvement in the removal rate and efficiencies of plasma methods. The modeling will provide guidance on key technical issues associated with geometrical configuration, size, time dependent, and nonlinear plasma chemical reactions. Collection systems for vaporized contaminants should be demonstrated.

Implementation Needs: Development costs—To address science needs, the approximate cost of equipment and staff time is $1.5M (capital equipment, $500K; staff, $1M). For these activities, the staff are required to be highly trained in the fields of plasma technology and chemistry. One-half will be scientists with masters and/or doctoral degrees, and one-half will be highly trained technicians with bachelor of science degrees.

Demonstration costs—To perform a bench-scale demonstration, the approximate cost of laboratory preparation, equipment, and staff time is $2.5M (rad laboratory capital equipment, $800K; staff, $1.7M). For this phase of work, approximately 20% of the staff will be comprised of highly trained staff as mentioned above. The remaining 80% of the staff will have high school training complemented with 1–2 months of on-the-job training. After the demonstration phase, the majority of the effort can be implemented by technicians that are trained (1–2 months) for this specific work.

Author: C. C. Tsai

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February 26, 1993

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5. D. L. Flamm, "Plasma Chemistry in Etching," *Proc. of the NATO Advanced Study Institute on Plasma-Surface Interactions and Processing of Materials*, Alicante, Spain, September 4–6, 1988, pp. 35–55.

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7. In the draft document of the DOE Environmental Management D&D Workshop, Held in Knoxville, Tennessee on August 12–16, 1991.

PLASMA ETCHING/FLUORINATION DCON-76-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers. Deposit removal.

Problem Area/Constituents: U-contaminated nickel-lined steel equipment (Interior); U-contaminated monel, aluminum

Reference Requirements: Documents. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternative: Thermal Surface Removal

Technology: Plasma Etching/Fluorination—Using a fluorine plasma discharge, volatile fluorides are produced along with chemically reactive fluorine atoms that promoting rapid etching. The contaminated metal surfaces are exposed to energetic ions, electrons, and photons. The decontamination rate is greatly enhanced. The plasma etching and fluorination technology can be developed for in situ decontamination of DOE process equipment.

Status: Predemonstration—Plasma surface cleaning methods by glow discharges are commonly and effectively utilized for cleaning high-bonding energy contaminants from surfaces of metals, metal oxides, and glasses. Plasma cleaning is done in vacuum chambers for accelerators and magnetic fusion devices. Recently, tritium-contaminated hardware has been plasma cleaned with a decontamination factor of 1000. Plasma processes of etching and deposition are also used in material processing and microelectronic manufacturing in industry. The plasma cleaning and etching is a predemonstration technology. Extrapolating these plasma cleaning techniques for gasifying and recovering uranium deposits in uranium process equipment is feasible. Based on plasma-assisted etching rates, decontamination rates by reactive plasmas will be higher than that by gas phase decontamination methods. Moreover, the plasma cleaning process provides a means of separating and recovering uranium from the mixed uranium contaminants, recycling the process equipment, reducing the volume of generated secondary wastes, and helping to minimize the final waste deposition cost.

Although requiring additional radio frequency or microwave power, the plasma cleaning and fluorination techniques could be cheaper and faster than the gas cleaning techniques. The supporting equipment used for the gas phase decontamination system, including gas handling system for trapping uranium hexafluoride, thermal management system, vacuum system, computer control and monitors, can be used for the waste generated in plasma cleaning and fluorination methods. Thus, since the plasma surface cleaning methods are

expected to be much faster than the gas phase decontamination method, it will save—in conjunction with the gas phase system—potentially tens of millions of dollars for the decontamination and decommissioning (D&D) of gas diffusion plants. Approximately $10M development costs and $2M capital equipment costs will be required.

If successfully developed, the prototype plasma fluorination hardware could decontaminate a 10 m^3 tank in 1 month and cost $0.25M (or $0.75M per stage). It is the author's opinion that a savings of a factor of ten could be realized in a production environment. Wastes would be vaporized contaminants plus filters and HEPA filters from the collection system.

Science/Technology Needs: Science—Data on cleaning rates for contaminants and substrates of interest are needed.

Development—The capability of plasma etching on deposits in complex equipment with large surface areas needs to be established.

Implementation Needs: A collection system with appropriate filters for the vaporized deposits would be needed to use this technology. An electric power supply would be needed. Development cost is estimated at ~$10M; capital cost, at ~$2M; and operating cost, at $0.01–$0.30/ft^2.

Author: C. C. Tsai

References: MMES staff members

FLASHLAMP CLEANING DCON-77-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process building, process support building, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities, and cooling towers. Deposit removal.

Problem Area/Constituents:

Structural steel, sheet metal, and metal equipment (exterior) contaminated with the following:
- U
- U and oil
- U and Tc
- U, oil, and PCBs
- U, Tc, and oil
- U, Tc, oil, and PCBs
- U, Tc, and actinides
- U and PCBs
- U, oil, Tc, PCBs, and actinides

Nickel-plated steel equipment (interior), monel, copper, aluminum, and steel contaminated with the following:
- U
- U and Tc
- U, Tc, and actinides
- Insulated copper wiring contaminated with U or U and Tc
- Steel pipe contaminated with As, chromates, Ba, and dioxins
- Steel cylinders contaminated with UF_6 and Tc or UF_6, Tc, and actinides

Reference Requirements:

- Federal Facility Compliance Agreements (e.g., FFCA for Oak Ridge Site, FFCA for PCBs)
- Applicable federal and state laws and regulations (e.g., Clean Air Act and Toxic Substance Control Act)
- DOE orders

Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Decontamination

Alternatives: Thermal Surface and Substrate Removal

Technology: Flashlamp Cleaning

February 26, 1993

Status: Radiological decontamination using high-energy xenon flashlamps is an emerging technology. Flashlamp systems are being used to clean organic contamination from valuable objects such as artwork, ship hulls, and precious metals. Several flashlamp-based systems are in use in locations around the world. Hanford-Westinghouse is conducting laboratory tests of xenon flashlamp systems for removing radionuclide contamination from the surfaces inside metal storage vessels (personal communication with Dana J. Flesher, Hanford-Westinghouse, July 7, 1992).

The primary application for flashlamp cleaning is when large surface areas need a high degree of decontamination with the absolute minimum amount of waste generation. The technology produces as waste only the material that is removed from the surface (all the vaporized material is collected in a filtration system).

Science/Technology Needs: The commercially available flashlamp systems can be evaluated for possible use on decontamination problem areas.

Implementation Needs: The successful development of this technology will require that commercial vendors of xenon flashlamp systems be encouraged to adapt their systems to meet the requirements of specific problem areas. Commercially available systems should be capable of turn-key operation by trained technicians. Currently available systems cost $50K to $100K. Development cost is estimated at $1.4M; and operating cost, at $0.50–$2/ft^2.

Author: D. B. Smith

References: MMES staff members

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DISMANTLEMENT

000353

HIGH-PRESSURE ABRASIVE WATER JET DISM-11-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Massive concrete contaminated with uranium, oil, PCBs, and lead-based paint.

Reference Requirements: DOE, EPA, NRC, OSHA, etc. Regulations to be furnished by "Regulatory Team." Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Concrete cutting

Technology: High-pressure abrasive water jet

Generic. Scarfing—Robotic manipulated high-pressure water jet machine that systematically scarfs the contaminated floor, walls, columns, and overhead. Vacuum recovery system that would collect contaminated slurry and recycle the water and possibly the abrasives if used. Cutting—Robotic manipulated high-pressure water jet machine. The machine will be track-mounted and can move in two directions over the rough scarfed surface. The concrete will have been decontaminated by scarfing and will be moved to a crusher and be used as fill.

Specific. Pressure abrasive water jet: Abrasive water jet scarfing is ultra-high-pressure water with and without abrasive that is forced through a small diameter nozzle that creates a spray that cuts away the surface of concrete. The contaminated surface removed by scarfing will be handled as nuclear waste with the contaminated abrasives and water to be recycled. The remainder of the decontaminated building above ground level to be cut up by water jet cutting or other methods, crushed, and reused locally as fill, etc. The technology has been demonstrated at MMES in Oak Ridge, but not at the K-25 Site.

Status: Demonstration. Abrasive water jet cutting uses ultra-high-pressure water with abrasives that is forced through a small diameter nozzle creating a stream that cuts through up to 3-ft-thick reinforced concrete with one pass. This method would be used to cut reinforced concrete that is above ground level into sections to be taken to a crusher.

A 100,000-ft^2 Mississippi River Bridge was scarfed using a high-pressure water jet in less than 4 months—this task would have taken 10 to 15 men, working 5 days a week, approximately 2 years using conventional jack hammers.

This technology has been demonstrated but not at K-25 Site. DOE-sponsored development. Programmable robotic manipulators have been developed. Water can be recycled. Concepts for abrasive recycling with 95% spoils recoverable. Battelle Pacific Northwest Laboratory has successfully demonstrated scarification and cutting of steel-reinforced concrete; successfully demonstrated at West Valley Nuclear Services, New York. Scarfing is used by the Tennessee Department of Transportation (TN DOT) on bridges and is illustrated on video as it is being used on the Mississippi River Bridge. (See Flow, Inc., video).

High maintenance items: nozzles, hoses, and pumps when abrasives are used.

A high-efficiency recovery system a must for scarfing to keep contaminated runoff to a minimum. Cracks in concrete will be a problem because contamination will still be present and will have to be addressed, but no one system will be ideal for every situation.

A high-pressure water jet cutting recovery system will need to be on both sides of the section being cut because of blowthrough. The recovery system opposite the machine will have to withstand the pressure of blowthrough.

After removing the contaminated surfaces; which will be microwave dried, stored in containers, shipped, and buried; the remainder of the decontaminated building can be crushed and used locally as fill. This process will save \$17.00/ft^3 for disposal. The mass of debris accumulated from demolishing concrete structures is estimated to be approximately 15% of the cubic dimension of the structure.

Cost payback. Based on scarfing a 3-ft-thick, 6-ft-square section of concrete and assuming that 3 in. are to be removed, top and bottom, decontamination would create 18 ft^3 of contaminated debris with no void. The remaining decontaminated material would create 90 ft^3 of locally usable material after crushing. This process would save \$1800 in storage alone, excluding reuse of the crushed material.

The cutting rate on 24-in.-thick reinforced concrete would be 1 in./min. Thicker reinforced concrete requires more power, etc.

Demonstrations for the scarfing and cutting need to be completed before cost payback can be evaluated. The lower pressure systems that require less water and simplify the recovery system would be best suited for contaminated concrete. The low-pressure system works at a slower rate, but the simpler recovery system would justify its use.

Microwave drying being developed at ORNL could be used to consolidate and immobilize liquid radioactive wastes inside containers for ultimate waste disposal but would require demonstrations.

Science/Technology Needs: A recovery system with recyclable abrasives needs to be demonstrated. This will require a portable facility, if available, or pools with the equipment necessary to separate and possibly decontaminate the water and abrasive for reuse.

Development of this equipment—manipulators for positioning on the floor, columns, and overhead, and cleaning pools for demonstration—would cost $3.5M. Demonstration cost includes characterizing walls and floor, identifying grid patterns of reinforcing steel if cutting concrete, building portable containment enclosure, personnel protection, clothing and container storage but not transportation and burial charges.

Implementation Needs: Need to view videos available from other nuclear facilities and possibly visit sites and evaluate recovery systems without on-site demonstration. Determine what robotics have been developed with in-house seminars from vendors on latest and future technology. Robotic manipulators with recovery system needs to be able to move around on floor, up and around concrete columns, and overhead (the underside of the floor above). Methods of addressing cracks in concrete; blow through when cutting; containerization of contaminated material, water, and possibly abrasives will have to be found.

Give dollar value estimate for a given amount of this technique so that by extrapolation a given building or site could be estimated/evaluated.

Author: T. Barnes

References:

1. Consultation with MMES staff members.

February 26, 1993

DIAMOND WIRE CUTTING DISM-12-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Massive concrete contaminated with uranium, oil, and PCBs.

Reference Requirements: All regulations required by OSHA, NRC, DOE, EPA, etc., to be provided by "Regulatory Team." Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Concrete cutting

Technology: Diamond wire cutting

Generic. Diamond wire cutting of decontaminated concrete into sections to be taken to a crusher for reduction in size to be used locally as fill, etc.

Specific. Diamond wire cutting of concrete to dismantle concrete structures. Diamond wire consists of a continuous cable with replaceable diamond impregnated sleeves the full length of the cable. Holes are cut through the reinforced concrete usually by core drilling. The wire is threaded through the holes and around a series of powered and idler sheaves. The drive sheave mechanism is mounted on a track which maintains tension.

Status: Demonstration. Diamond wire cutting can be used to cut concrete at other nuclear facilities except at ground level floors (see Dimas video). Diamond wire cutting is an industry-accepted method, but with heavy reinforced concrete it will be a high maintenance item (diamond-impregnated sleeves, cable, and sheaves) and requires water coolant for the cable.

The waste generated will be a slurry which would make the vacuum and recovery system less expensive than when debris has to be handled. The slurry would be low level contamination or possibly no contamination at all because the concrete would already be decontaminated by scrabbling. The area would be clean and relatively clear, but positioning the core drilling equipment and the diamond wire cutting machine will be more difficult because there will probably be exposed reinforcing bar.

Cracks in the concrete will probably still contain some contamination but because it will be mixed with a large amount of non-contaminated concrete it will probably still meet the criteria so it can be used locally as fill, etc. A method for removing the cracks from the sections of concrete should be developed.

Cost information:

- Required 12 h to cut a 4-ft × 10-ft opening through a 4-ft-thick concrete wall,
- Required 10 h to cut a 4-ft^2 opening through a 53-in.-thick concrete wall,
- Required 2 h to saw off a 3-ft × 5-ft solid concrete machine base,
- Required 16 h to saw off a 42-in. × 36-ft-long solid concrete machine base.

By crushing the decontaminated building and the material used as fill, the disposal cost of $17/$ft_3$ will be saved. The mass of debris from demolishing concrete structures is estimated to be 15% of the cubic dimension of the structure.

The demonstrations will need to be completed before a true evaluation of the cost payback can be made.

Science/Technology Needs: Track system for maneuvering core drilling machine and diamond wire cutting machine may be required.

Exposed reinforcing bar will have to be manually cut in areas where cored holes are to be located to lower maintenance on saw.

Development and installation of the track system and recovery system for demonstration will be $1.5M.

Demonstration costs include personnel protection, clothing, and storage but not transportation and burial charges.

Demonstrations will have to be completed before a cost payback can be evaluated.

Implementation Needs: Determine what robotics have been developed using in-house seminars from vendors on the latest and future technology and determine robotic needs.

Track needs to be developed for demonstrations. Manipulators with vacuum systems need to be able to move in two directions. Vacuum systems will be needed on both sides of the floor being cut.

Author: T. Barnes

References:

1. Consultation with MMES staff.

February 26, 1993

CONVENTIONAL (JACKHAMMER, HEADACHE BALL) DISM-21-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Massive concrete contaminated with uranium, oil, and PCBs.

Reference Requirements: All regulations required by OSHA, NRC, DOE, EPA, etc., to be provided by "Regulatory Team." Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Demolition

Technology: Jackhammer, headache ball

Generic. Roboticly manipulated single- or multiple-head, hydraulic- or pneumatic-actuated hammers to scrabble contaminated concrete. These hammers will be equipped with a vacuum system to handle the dust and take the debris to a crusher for a reduction in size.

The same type of hammers with vacuum described above could be used to break up concrete structures into sections that can be taken to a crusher for reduction in size so that they can be used as fill, etc., locally.

Specific. Conventional (jackhammer, headache ball). Massive concrete demolition using wrecking balls, hydraulic or pneumatic hammers. A wrecking ball is a large-diameter steel ball suspended by a cable from a crane. The ball is dropped or swung and strikes the wall or floor to burst the concrete.

Hydraulic or pneumatic hammers. A single head is a hammer with a single, pulsating, wedged-shaped head that can be manually or remotely operated. It can be used to create holes in concrete and to scrabble or break concrete into sections for removal. This equipment has been used to chisel away the outside shell of some reactors.

A multiple head is a machine that has a series of pulsating, wedged-shaped heads that can be manually or remotely operated. Originally, this machine was designed to prepare concrete floors for resurfacing, but it has been adapted for scrabbling concrete.

Status: Demonstrated. This technology has been demonstrated, and the wrecking ball is a demolition-industry-accepted method but is not recommended for contaminated concrete such as exists in most DOE facilities. It is not practical to contain the dust, and the reinforcing bar has to be cut by other means.

Hydraulic or pneumatic hammer. The single-head hammer is an industry-accepted method for creating holes, scrabbling, and demolishing concrete, but it is not practical to use on a massive scale to scrabble or demolish large areas—it could be used in corners, etc., where multiple head machines would be unlikely to access.

The multiple-head hammer is an industry-accepted method for light scrabbling concrete surfaces. Vacuum systems exist to contain dust. Machines come in different lengths and capacities.

The dust from the single-head and multiple-head hammers would require a vacuum system with dust filters. The debris would need to be removed by vacuum and taken to a crusher for reduction in size. To contain the dust may require starting with a wet floor.

Concrete reinforcing bar will have to be cut by other means when using multiple-head hammer machines.

Mechanical hammers can drive the contamination further down into the concrete.

Having removed the contaminated surface, and assuming that the remainder of the decontaminated building can be crushed and used as fill, $\$17/ft^3$ for disposal could be saved. The mass of debris from demolishing concrete structures is estimated to be 15% of the cubic dimension of the structure.

Demonstrations are needed before cost payback can be evaluated.

Science/Technology Needs: Vacuum systems to handle dust and small-to-medium pieces of concrete need to be demonstrated. Crusher to downsize concrete pieces needs to be demonstrated. The development and installation of the robotic and vacuum systems to handle both dust and pieces of concrete and a crusher for demonstration would cost $1.5M. Demonstration cost would include personnel clothing and protection but not transportation and storage charges. Crushed decontaminated material to be stored on-site until local use can be determined.

Implementation Needs: Need to view videos available from other nuclear facilities and possibly visit other sites to evaluate multiple head hammer machines without on-site demonstrations. Determine what robotics have been developed with in-house seminars from vendors on latest and future technology. Robotic manipulators with recovery systems need to be able to move around the floor, up and around concrete columns, and overhead.

CONVENTIONAL (JACKHAMMER, HEADACHE BALL) DISM-21-OG

Demonstrations need to show how the corners and hard-to-get areas will be handled.

Before disturbing the walls that are underground or the ground level floor, a core sampling by a soil engineer is needed to determine the water level of wet-weather springs. This determination is to make sure the dam created by the existing underground walls does not break, creating a pool or stream running through contaminated debris or across contaminated soil (not ever exposed before) underneath the floor. Some foundations go all the way to bedrock, and some were built on fill over wet-weather springs. If necessary, the soil underneath the floor will have to be decontaminated or stored.

Author: T. Barnes

References:

1. Consultation with MMES staff.

February 26, 1993

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Massive concrete contaminated with uranium, oil, and PCBs.

Reference Requirements: All regulations required by OSHA, NRC, DOE, EPA, etc., to be provided by "Regulatory Team." Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Demolition

Technology: Blasting

Generic. Demolition

Specific. Delayed firing of explosives to demolish decontaminated concrete structures. This method reduces vibrations on surrounding structures, controls direction of material movement, and limits the amount of dust created. All the concrete structure remaining after decontaminating will be taken to the crusher to be used locally as fill, etc.

Controlled blasting is a series of blasts set off in a predetermined sequence that reduces vibrations and controls the direction of material movement. Blasting mats can be used to hold down debris and dust. Water may be required to hold down dust.

Assuming that the decontaminated building can be used as fill, $\$17/ft^3$ for disposal could be saved. The mass of debris from demolishing concrete structures is estimated to be 15% of the cubic dimension of the structure.

Status: Demonstrated. This technology has been demonstrated and used by the demolition industry for years. Reinforcing bar has to be cut after blasting. Contaminated concrete will have to be removed by scarfing or scrabbling. All walls and floors below ground level should not be disturbed until all debris has been removed and water level tests are complete.

Locate a noncontaminated structure that will not have to be decontaminated and demolish it with controlled blasting monitoring vibrations so that the system can be evaluated before

actually being put into use. This demonstration on a nondecontaminated structure will cost $200K and includes personnel clothing and protection but not transportation.

Science/Technology Needs: Crane system for handling large sections of decontaminated concrete to crusher. Remote method of cutting reinforcing bar in large amounts of debris. Create method for installing lift rings for crane handling of large sections of debris or other methods of moving debris to crusher.

Major components needed would be crane, remote reinforcing bar cutting technique, front end loader, and crusher. Crushed decontaminated material would be stored on-site until local use is determined.

Implementation Needs: Possibly watch and record an actual site being demolished by controlled blasting. View videos from demolition companies and explosive manufacturers to see what method industry uses to cut reinforcing bar and remove large amounts of debris.

Before disturbing the structures that are to come down and any near it, the walls that are underground, or the ground-level floor, a core sampling by a soil engineer is needed to determine the water levels of wet weather springs. This determination is to ensure that the dam created by the existing underground walls and floor does not break, creating a pool or stream running through contaminated debris or across contaminated soil (never exposed before) beneath the floor. Some foundations go all the way to bedrock, and some were built on fill over wet-weather springs. If necessary the soil underneath the floor will have to be decontaminated or stored.

Author: T. Barnes

References:

1. Consultation with MMES staff.

DEMOLITION COMPOUNDS (EXPANSIVE GROUT) DISM-23-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Massive concrete contaminated with uranium, oil, PCBs.

Reference Requirements: All regulations required by OSHA, NRC, DOE, EPA, etc., to be provided by "Regulatory Team." Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Demolition

Technology: Demolition compounds (expansive grout)

Generic. Demolition

Specific. Holes are created in a predetermined pattern in walls and floor, and an expansive grout is inserted. The grout expands creating cracks in the concrete, allowing the section to be removed. The concrete structure will have been decontaminated by scarfing or scrabbling. The section removed will be taken to a crusher by reduction in size and used locally as fill, etc.

For demolition of decontaminated concrete structures using expansive grout, holes are created in concrete by other means and the expansive grout is inserted. The grout expands, creating cracks in a predetermined pattern which creates cracks, so that the section can be easily removed.

Assuming that the decontaminated building can be crushed and used as fill, $17/ft^3 for disposal could be saved. The mass of debris accumulated from demolishing concrete structures is approximately 15% of the cubic dimensions of the structure.

Status: Demonstrated. It is effective on nonreinforced or lightly reinforced concrete. Any reinforcing bar will have to be cut by other means. The compound is not considered dangerous. Contamination control would not be a problem, because the contamination will have already been removed by scarfing or scrabbling. The demonstration would cost $500K.

This demonstration cost includes personnel clothing and protection but not transportation and storage.

Science/Technology Needs: Using a lightly or noncontaminated building, a demonstration can be made without scrabbling being required. The building would need to be lightly or non-reinforced concrete. The crushed decontaminated material could be stored on-site until local use could be determined.

Size, depth, and pattern of holes would need to be determined. The method of cutting any reinforcing bar must established. Fractured concrete would be removed with a pavement breaker, backhoe, or bucket loader. The dirt beneath the floor will have to be moved, if necessary, and decontaminated or stored.

Implementation Needs: Pattern, size, depth, and location of the reinforcing bar need to be established. The means for cutting the reinforcing bar and removing the fractured section of concrete needs to be established. Crane facility and crusher to reduce concrete section to eliminate any voids in storage. Before disturbing the walls that are underground or on the ground-level floor, core sampling by a soil engineer is needed to determine the water level of wet weather springs to ensure that the dam created by the existing underground walls does not break, creating a pool or stream running through contaminated rubble or across contaminated soil (never exposed before) beneath the floor. Some foundations go all the way to bedrock, and some were built on fill over wet weather springs. If necessary, the dirt beneath the floor will have to be decontaminated or stored.

Author: T. Barnes

References:

1. Consultation with MMES staff.

February 26, 1993

MICROWAVE SCABBLING DISM-31-OG

EM Problem: Decommissioning

K-25 Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Massive concrete contaminated with uranium, oil, PCBs

Reference Requirements: All regulations required by OSHA, NRC, DOE, EPA, etc., to be provided by "Regulatory Team." Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Surface removal

Technology: Microwave scabbling

Generic. Surface removal

Specific. A roboticly manipulated microwave machine that systematically scabbles the floor, columns, walls, and overhead to remove the contaminated surface. A vacuum system will take the contaminated material to a crusher to be reduced in size for storage. The microwave scabbling system allows starting with, working with, and ending up with a dry surface.

In massive concrete scabbling using roboticly controlled and manipulated microwave machines, the microwave energy is directed at the concrete surface and heats the concrete and free water present in the concrete (virtually all concrete, old and new, has some water content). Continued heating produces steam-pressure-induced mechanical stresses that cause the concrete surface to burst. The amount of concrete removed in a single pass can be controlled by choosing the frequency, power, and speed of the microwave system. Assuming that the decontaminated building can be used as fill, $17/ft^3 for disposal could be saved. The mass of debris from demolishing concrete structures is approximately 15% of the cubic dimension of the structure.

Status: Demonstrated. Microwave scabbling of concrete is in the final stage of Phase 2 (see Concrete Spalling Test 23 video). Note: What appears on the video as dust is actually the steam of a Phase 4 program at ORNL. Phase 3 is scheduled for completion in mid-1994. It will develop improved mobility, remote video control, vacuum waste collection, and remote controlled capabilities. Phase 4 will involve the design of vertical and overhead scabbling as

well as optimization of the proper methods and configurations for cleaning the off-gas discharged by the vacuum system. All ANSI and OSHA standards will be met or exceeded.

Microwave scabbling was demonstrated by JAERI in 1987 with as much as 3 cm removed in one pass, but the amount of microwave energy released was not reported.

The waste generated will be handled by a vacuum system that transfers the material to a crusher for reduction in size. The crusher may require water to hold down dust but the material can be dried by other microwave systems outlined under "Implementation Needs."

The location relative to the surface and grid pattern of the reinforcing bars affects the microwave system, but this is being addressed.

Less than 1% of the debris is less than 1 mm in diameter; therefore, most of the debris should not pose an airborne contamination hazard.

Cracks in the floor that may release microwave energy will require shielding.

Cost payback will have to be addressed after Phase 3 and possibly Phase 4 have been completed on microwave scabbling.

Science/Technology Needs: The development has already been funded (see TTP No. OR-3DAA). Installation and demonstration of the Phase 3 advanced-stage microwave machine, robotics, and vacuum system will be $3M.

Demonstration costs include characterizing walls and floor, identifying the reinforcing steel grid pattern, building portable containment enclosures, personnel protection, clothing, and container storage but not transportation and burial charges.

Development and installation of the Phase 4 system for demonstration will be $5M.

Implementation Needs: Create a demonstration program for the most advanced system of so a true comparison can be made.

A track system, if needed, should be developed for demonstration. Manipulators with vacuum systems need to be able to move along the floor, around columns, up walls, and overhead.

Microwave drying being developed at ORNL could be used to consolidate and immobilize liquid radioactive waste inside containers for ultimate safe disposal, but the technique needs demonstration.

Author: T. Barnes

February 26, 1993

References:

1. Consultation with MMES staff.

February 26, 1993

QUALITATIVE IR THERMOGRAPHY (STRUCTURAL INTEGRITY) DISM-32-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Structural steel in walls, beams, and roofs contaminated with small amounts of uranium, oil, and PCBs

Reference Requirements: (To be provided by "Regulatory Team") Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Inspection or support to be subsequent to dismantlement.

Alternative: Disassembly

Technology: Qualitative IR thermography to detect cracks in steel beams, unrecorded variations in wall construction, beam/wall discontinuities, or soaked roofing subsurface.

Status: Predemonstration.

Advantages:
- Inexpensive, portable, noninvasive, passive measure.
- Real-time or VCR/still imaging.
- Reasonable compact apparatus (roughly 6 ft^3).
- Excellent, initial gross detection method.

Disadvantages:
- Image often requires trained interpretation.
- Emissivity differences and/or local spurious infrared sources may complicate image analysis.
- Generation of spent inert nitrogen gas may complicate operation in tight, confined space.
- Outdoor measures may be weather dependent.

Competitive technologies:
- Other thermal measures. Thermocouples (cheap, point measures); "crayons" (cheap, very rough manual measure); thermal resistive devices (cheap, slow measures); IR arrays or single IR transistors (moderately priced, point measures).
- Techniques based on other phenomena, such as nuclear radiation, electromagnetic

radiation, emitted light or sound, ultrasound, strain, etc. Perhaps most immediate competitor is visible light solid-state camera; generally cheaper, simpler operation than IR camera when both are available.

Cost:

- AGA-750/AGA-782: ATD offers system and operator at roughly $70/hr, plus applicable overheads. ATD can provide liquid N_2 coolant; the sponsor may have to provide power. Additionally, the sponsor is responsible for logistical support including travel, decontamination, and a site guide. ATD does not offer system-only use.
- AGA-900: A more advanced system, such as the AGA-900, could cost over $100K. However, the AGA-900 is quantitative and links to PC software for image analysis. ATD does not carry an AGA-900 but can provide operator support tailored to a sponsor's needs.

Use of existing AGA-750/782 ATD systems can provide immediate payback with little up-front cost. Purchase of a dedicated system, such as the AGA-900, can provide enhanced performance with substantial capital investment; such a purchase might be justified by a need for extensive quantitative data to support engineering analysis and/or long-term project use.

Transport generally takes two man-trips. Setup for a portable AGA-750 typically takes 10 min but requires no interface to outlets or building equipment. Setup for a semiportable AGA-782 (color, real-time image record) takes up to 1 h and requires external power. One trained operator can run the AGA-750 for 2–4 h; the AGA-782 has no battery-recharge limit on operation. Assorted lenses provide varied fields of view and zoom.

Example: Wall suspected of separation from abutting I-beam. Method: Heat I-beam with Briskeat strip heaters and look for delays in transverse heat conduction into wall. Estimate in work-hours: transport (0.5), setup (0.5), transient Briskeat strip heating (3), time-lapse front-angle thermal transient heating viewing and VCR record (3), system tear-down (0.5), transport (0.5), support (2-way travel, oral report, VCR review, recharge, liquid N_2 refo). (3). Total time: 11 work-hours. Total cost: $770 plus applicable overhead.

Assumptions: No donning, doffing, or contamination, safety or health procedures required by environment; guided, unobstructed access and transport over distance under 100 yd; AGA-782 system used; view uncomplicated by complex thermal environment, obstructions, or elevation, etc. Violation of aforementioned assumptions generally add to cost.

Generation of spent inert nitrogen gas may complicate operation in a tight, confined space.

Science/Technology Needs: Requires natural or applied transient or steady-state heating. The method works best with an IR-flat background.

QUALITATIVE IR THERMOGRAPHY (STRUCTURAL INTEGRITY) DISM-32-OG

Implementation Needs: ATD's 2 AGA systems require liquid nitrogen and should not be used in a high shock or vibratory environment. Only a few hours of sampling time are possible per battery charge, although AC power also is available. Robotics are generally locally operated. Remote operation and robot-arm type mounting are both possible but will likely require development for particular application.

Author: F. L. Paulauskas

References:

1. MMES staff assessment.
2. AGEMA Infrared Systems, Inc., product literature.

February 26, 1993

CONVENTIONAL DISASSEMBLY (MECHANICAL) DISM-33-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Disassembly of metallic nuclear installation components contaminated with small amounts of uranium, oil, and PCBs.

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Disassembly

Technology: Conventional disassembly

Generic. Disassembly.

Specific. Conventional disassembly (mechanical) includes sawing with tooth or abrasive blades and dismantling by removing nuts and bolts. Dismantling by removing fasteners creates no extra waste, and, if the dismantled pieces are clean, they can often be reused. However, dismantling by removing fasteners is slow and labor-intensive. Unlike the thermal sawing processes, sawing with tooth or abrasive blades will not cause contaminants to melt into the work piece. Also, little danger exists of electrical shock compared to the arc processes. Cutting can be done in air or under a liquid using power or hand tools. Very soft and very hard materials are most difficult to cut—very soft material sticks on the saw blade, and the teeth or abrasive on the blade must be harder than the work piece or no cutting will occur.

Status: Accepted technology. Cost depends on the equipment chosen for the job, but most equipment is inexpensive.

Science/Technology Needs: Depends on the particular method chosen. Most mechanical cutting systems are portable, allowing cuts to be made in place.

Implementation Needs: Depends on the particular method chosen. Conventional sawing and dismantling tends to be simple technology that can be performed roboticly using the proper manipulators.

Author: J. W. Koger, A. L. Demint

References:

1. MMES staff members.

February 26, 1993

Nd: YAG AND CO_2 LASER CUTTING (STRUCTURAL STEEL) DISM-34-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Structural steel in walls, beams, and roofs contaminated with small amounts of uranium, oil, and PCBs

Reference Requirements: Document (to be provided by "Regulatory Team"). Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting

Technology: Nd: YAG or CO_2 laser cutting (removal of major components from the cascade)

Status: Predemonstration. Technology exists in the predemonstration stage at the Penn State Applied Research Laboratory (ARL). The U.S. Navy has funded feasibility demonstration of the technology for dismantlement of submarine hulls. The technology is very likely to work, because laser cutting is common in industry. The following are seen as potential benefits and limitations of laser cutting technology using existing laser technology (e.g. Nd: YAG and CO_2).

Advantages/benefits:

- Minimization of bulk contaminated waste, mixed waste, etc., relative to other cutting techniques.
- Cost savings of $800M to $1.2B in reduction of labor and protective clothing.
- A laser generator that remains remote to the contaminated equipment, possibly outside the building, thus avoiding being contaminated.
- Potential exists for the localized destruction of organic contaminants, such as oils and PCBs, thus eliminating them from any waste generated.

Potential limitations:

- A small amount of bulk contamination will result (small, relative to what was introduced in past equipment removal and reassembly by oxyacetylene cutting).
- A fiber-optic or other waveguide delivery system is preferred and has been demonstrated for Nd: YAG lasers, but appropriate wave guides have not been demonstrated for CO_2 lasers.

- Laser safety issues such as beam containment need to be addressed to minimize restrictions to collateral activities.

Science/Technology Needs: Laser cutting using a laser carried through a fiber-optic cable or waveguide requires field demonstration. Further laboratory development is needed. Better optical fibers are needed if using CO_2 lasers.

Implementation Needs: Tooling to interface the laser cutting head with the automated delivery platform needs to be designed and demonstrated, and a demonstration is required on simulated equipment for the K-25-type facility and the K-33-type facility. Projected cost: $5M.

Author: W. S. Key

References:

1. MMES Photonics R&D Staff.
2. Denny, P.E., Applied Research Lab. (Penn State University), Personal Communication, August 1992.
3. Ibid., Technology Briefing, April 15, 1992.
4. Ibid., Personal Communication, January 4, 1993.
5. ANSI standard §136.1-1992.

ABRASIVE WATER JET DISM-35-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Disassembly of metallic nuclear installation components contaminated with small amounts of uranium, oil, and PCBs

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting

Technology: Abrasive water jet cutting

Generic. Cutting

Specific. The abrasive water jet consists of a jet of abrasive-loaded water at pressures exceeding 50,000 psi which is directed at the workpiece. Ferritic and austenitic steel up to 9-in.-thick can be cut; other metals can also be cut. An intensifier is used to generate the high pressures required; the intensifier requires periodic rebuilding (every 500 hrs) and constitutes a noise hazard when operating (100 to 110 dB).

Status: Demonstrated. Abrasive water jet cutting is an accepted technology. Airborne and gaseous contamination generated is low. The system can also be remotely operated. Cutting speed for 2.5-in.-thick carbon steel is 3 to 4 in./min. Abrasive consumption (usually garnet) is 1.5 to 2 lb/min. Approximately 1.4 gal/min of liquid is also generated. In 1989 dollars, cost of an abrasive water jet system was $150K. Nozzles and orifices, as well as abrasives, are consumable. Nozzles were $10 each, orifices $16, and garnet abrasive was $0.32/lb.

Science/Technology Needs: Technology needs recovery system for the water (which will probably be contaminated) and recyclable abrasives.

Implementation Needs: The ability to separate contamination from the water slurry would have to be demonstrated. This system can be operated remotely.

Author: J. W. Koger, A. L. Demint

February 26, 1993

References:

1. *Alternative Reactor Vessel Cutting Technologies for the Experimental Boiling Water Reactor*, NL-89/31, Argonne National Laboratory.
2. *Abrasive Water Jet Cutting of Uranium*, FMPC-2118.
3. *CNC Water-Jet Machining and Cutting Center*, KCP-613-4397.

PLASMA ARC CUTTING DISM-36-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Disassembly of metallic nuclear installation components contaminated with small amounts of uranium, oil, and PCBs

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting

Technology: Plasma arc cutting

Generic. Cutting

Specific. Plasma arc cutting uses a high-velocity, high-temperature ionized gas torch to cut conductive materials. An arc is established between a tungsten electrode and the work piece in either nitrogen or a mixture of argon and hydrogen. The gas and arc are constricted as they leave the torch nozzle, causing very-high-current densities and temperatures; this causes the work piece to melt and the molten metal to be blown out through the cut being made. Jets of water may be used to further constrict the plasma arc and cool the nozzle, thus prolonging the nozzle's life.

Status: Demonstrated. This is an accepted technology. Typical cutting speed is 13 in./min, and the maximum in-air depth of cut in carbon steel is 7 in. Almost any metal can be cut, because of the high plasma temperature. Metals resistant to oxy-fuel cutting, such as copper, nickel, magnesium, and titanium, can be cut by plasma arc. Stainless steels require use of a flux to be cut with oxy-fuel, but a flux is not needed with plasma arc. Aluminum is also easily cut by plasma arc. Hearing protection normally is required—noise levels are over 100 dB near the torch. Airborne contamination will be generated (smoke and particulates) but can be reduced when water jets are used. Torch life is 1–2 h but is prolonged when water jets are used. Uranium contamination may be alloyed with the structural members being removed, making decontamination nearly impossible when this or any thermal cutting method is used. Complex geometries and layered structures that are not tightly bonded are difficult to cut using plasma arc technology. In 1989 dollars, a plasma arc system costs $40K;

nozzle tips are consumable and cost $1K each. Gas and electric power also are required as well as electrodes ($100 each).

Science/Technology Needs: Research has been done in Germany whereby the torches have been mounted on a large blade (600 mm diam), but the process is discontinuous, requiring the rotation of the blade to be stopped to ignite the torches. The Germans cite the need to make their process continuous and to make the process computer-aided (1989). Cutting under 20 m of water was demonstrated.

Implementation Needs: The particulate generation rate has been determined to be 4–6 lb/hr, requiring a HEPA-filtered exhaust system and a contained area in which to cut. If water jets are used, 0.5 gal/hr is required. Robotics: The plasma-arc torch is operated remotely, but frequent maintenance of the system is necessary, requiring entry to the cutting area.

Author: J. W. Koger, A. L. Demint

References:

1. *An Evaluation of Alternative Reactor Vessel Cutting Technologies for the Experimental Boiling Water Reactor at Argonne National Laboratory*, ANL-89/31.
2. *Final Report from the Technical University of Hannover to the Department of Research and Technology*, INIS-MF-12032, German Government.

ARC SAW CUTTING

DISM-37-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Structural steel in walls, beams, and roofs contaminated with small amounts of uranium, oil, and PCBs

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting

Technology: Arc saw cutting. The arc saw consists of a circular, toothless blade through which current is passed, causing an arc between the blade and work piece (which must be conductive). The arc melts the work piece, while the rotating blade spins away the molten metal. The arc saw is generally used underwater. When cutting in air, the blade must be water-cooled (5–20 gpm). Cutting underwater is preferred because it reduces noise, smoke, and blade wear. The depth of the cut depends only on the blade diameter. The arc saw cuts metal significantly faster than other contemporary techniques, but it does not work well on carbon steels because of the generation of a magnetic field that slows the cutting rate to about half of that for other metals. For deep cuts, side arcing is a problem, and several passes must be made.

Status: Demonstrated. This technology is accepted. An arc saw for cutting uranium metal is being installed at the Y-12 Plant. In 1989 dollars, arc saws cost $160K to $280K; saw blades are consumable and cost $1200 each. Average wear ratios are about 5 in.^{2} of material cut per in.^{2} of blade.

Science/Technology Needs:

Implementation Needs: The arc saw requires ventilation; the extent of the ventilation depends on whether the saw is run underwater. Robotics: The arc saw can be operated remotely, because the blade does not make contact with the work piece.

Author: J. W. Koger, A. L. Demint

February 26, 1993

References:

1. *An Evaluation of Alternative Reactor Vessel Cutting Technologies for the Experimental Boiling Water Reactor at Argonne National Laboratory*, ANL-89/31.

OXYGEN CUTTING DISM-38-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Disassembly of metallic nuclear installation components contaminated with small amounts of uranium, oil, and PCBs

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting

Technology: Oxygen cutting

Generic. Oxygen cutting.

Specific. Oxyacetylene torch cutting. Oxygen and acetylene are run through a torch and ignited; this flame causes rapid exothermic oxidation of the metal. In general, this process is only useful for cutting carbon steels. Highly alloyed steels and nonferrous metals tend to form refractory oxides; these oxides insulate the work piece from further melting. When cutting carbon steel clad with stainless steel, the stainless steel can be "gouged" using an electric arc to expose the carbon steel layer beneath. Fluxes also can be used to keep stainless steel from forming oxides. Introducing iron powder into the flame increases the flame temperature to aid in cutting alloyed steel. Propane or hydrogen can be used as fuel gases instead of acetylene; use of hydrogen allows cuts to be made underwater (metal powder flame-enhancers cannot be used underwater).

Status: Accepted: Electric arc gouging and the introduction of iron powder into the flame allow a wider range of materials to be cut than just mild steel. In 1989 dollars, a torch setup costs about $1700; oxygen was $0.08/ft^3, and acetylene was $0.43/ft^3.

Science/Technology Needs: Oxyacetylene cutting is a well-developed technology needing no further work.

Implementation Needs: Flame-cutting methods create smoke and metal fumes, so exhaust ventilation is required for personnel in the area. Robotics: Flame cutting is conducive to

mechanization, which tends to produce a neater, more even cut than cutting by hand. Mechanized cutting speeds of 18–30/min are attainable in 3- to 6-in.-thick mild steel.

Author: J. W. Koger, A. L. Demint

References:

1. *An Evaluation of Alternative Reactor Vessel Cutting Technologies for the Experimental Boiling Water Reactor at Argonne National Laboratory*, ANL 39-21.

PLASMA ARC SAW (STRUCTURAL STEEL) DISM-40-OG

EM Problem: Decomissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Structural steel in walls, beams, and roofs contaminated with small amounts of uranium, oil, and PCBs

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting

Technology: Plasma arc saw. This new technological development allows thermal cutting of steel (with wall thickness up to 300 mm), tubes, banks of tubes, and geometrically complicated components. Also, this technology can be used underwater up to a depth of 20 m. With a normal plasma torch, cutting is impossible or at least extremely difficult.

Status: Demonstration. Plasma arc saw technology enables thermal cutting of steel plates/walls independent of thickness in a water depth up to 20 m. This technology was demonstrated in cutting plates up to a thickness of 300 mm. The maximal permissible metallic wall thickness to be cut depends only on the diameter of the plasma arc saw blade. The emission of dust and aerosol during the process only depends on the melted material. This process is controlled by computers.

Science/Technology Needs: For large steel wall thickness (0.100 mm), requires development of the large saw and preruns in the process.

Implementation Needs: Requires transfer from development stages (prototype, 1990) to broad industrial application. Technology is available on a commercial basis. Robotics: Because of the intrinsic condition of cutting operations, a computer-controlled process is required. A remote control operation can be implemented without difficulty, making this technology very suitable for operations underwater.

All costs are related to a maximum part-wall-thickness cutting of 6.5 in. (stainless steel). Partial information was provided by the L-TEC Corporation in South Carolina (803-664-4397).

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The electric arc cutting system features a standard cutting head
- Plasma—approximately $50K
- Electric arc—approximately $25K

X, Y, Z table (to be placed in a determined location and not for transportation to field operations).
- Plasma—approximately till $150K (depending on sophistication)
- Electric arc—approximately till $150K (depending on sophistication)

Water table
- Plasma—approximately $60K-$80K
- Electric arc—approximately $60K-$80K (This arc cutting device with carbon electrode is not recommended for underwater operations.)

Air treatment system. This system features a filter device, hoods, snorkels device, etc., to be applied in atmospheric and underwater operations.
- Plasma—approximately $20K-$50K (depending on sophistication)
- Electric arc—approximately $20K-$50K (depending upon sophistication)

If cutting equipment will be made "transportable" to field operation directly on the installation. for plasma cutting devices:
- Cutting head—approximately $50K
- Portable "rig," "carrier", approximately $20K-$50K
- Hydraulic arm, moveable, displaceable up to approximately 10–12 ft high: approximately $40K-$60K

For an arc with a carbon electrode, this "transportable" system will not be recommended because of the multiple passes required to perform a metallic cut. In general, when field operations are desired, the cutting operation should be as simple and as fast as possible, especially when physical obstructions are present in the specific area of cutting. The cutting-deep (directly in the cutting kerf) is approximately 3/8 in. to 5/8 in. for the "first pass."

In general, two persons are required to operate these systems, especially during set-up of the system. Labor rate: $70/h each.
- A steel pipe should be cut.
- External diameter: 10 in.
- Wall-thickness: 1 in.
- The pipe has already been placed in or brought to the cutting head.
- Cutting speeds are 30–60 in./min.
- Necessary time to cut the pipe: approximately 1 min.

PLASMA ARC SAW (STRUCTURAL STEEL) DISM-40-OG

Electric arc or plasma arc cutting of metals generates dust, aerosol, and particles. Therefore, an air filter system is necessary (for atmospheric and underwater operations). These particles will clog the filter very often.

Author: F. L. Paulauskas

References:

1. *Final Report from the Technical University of Hannover to the Department of Research and Technology*, INIS-MF-12032, German Government.

February 26, 1993

THERMAL ARC WATER-JET CUTTING DISM-41-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Structural steel in walls, beams, and roofs contaminated with small amounts of uranium, oil, and PCBs

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting

Technology: Thermal arc water jet. With this device, steels up to a wall thickness of 100 mm can be cut underwater up to 20 m. The cutting process involves creation of an electric arc between the wire electrode and the metal sheet which melts the metal in the work piece. The water jet around the wire is used to "wash-away" melted material from the cutting kerf. The wire is consumed because of the high current. The wire has to be fed so that the process can work continuously.

Status: Demonstrated. In general, these devices are directed by a computer numeric controller. With additional tooling support, cutting in several axes of operations will be possible. Hole piercing up to a wall thickness of 30 mm also can be done. Cutting in vertical and horizontal motions, pipes, bank of pipes, and geometrically complicated components is possible.

In Y-12 Building 9201-5 (exclusion area), a prototype (experimental stage) of an arc saw with a water table is available. Although the construction of this prototype arc saw is not totally completed, this device can still be used for experimental trials. This arc saw can be operated underwater up to 15 ft. Deeper underwater operations also are possible, but they will require some design and construction changes. The diameter of the "saw" in this device will determine the maximal possible part wall thickness to cut.

In general, for these units, a water pool or water table is fixed in one location (not moveable or portable). The piece to be worked is brought to the machine for processing.

Science/Technology Needs: No additional basic development is necessary.

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Implementation Needs: Possible preruns may be required to accommodate the arc water-jet cutter to possible room/space shortages in the working area. In general, no major changes to the cutter device are needed. This is commercially available technology. Robotics: In general, the process is controlled by a numerical control device (computer). The process can be adapted to a machine with more axes for diversity of operation. A remote control operation also can be implemented, allowing this process to be very acceptable for underwater operation.

The approximate cost of this unit is $1M–$1.2M. Two operators are required to operate this unit ($70/hr each).

For dismantlement operations directly on the actual installation, inside of buildings, and in atmospheric operations (air), strict precautions must be taken for the generated dust and particles. The size of these particles ranges from approximately 1/16-in. to submicroscopic. If a suction-air filter system is used to purify/clean the air, the filter should be checked and changed as needed.

Costs include the following:
- Equipment for arc and plasma cutting technology (approximate values):
- All costs are related to a maximal part-wall-thickness cutting of 6.5 in. of stainless steel.
- Partial information was provided by the L-TEC Corp. in South Carolina (803-664-4397).
- The electric arc cutting system features a carbon electrode.

Standard cutting head
- Plasma: approximately $50K.
- Electric arc: approximately $25K.

X, Y, Z table (to be placed in a determined location and not for transportation to field operations).
- Plasma: approximately $150K (depending on sophistication).
- Electric arc: approximately $150K (depending on sophistication).

Water table
- Plasma: approximately $60K–80K (This arc cutting device with carbon electrode is not recommended for operations underwater).

Air treatment system—This system features a filter device, hoods, snorkel device, etc., to be applied in atmospheric and underwater operations.
- Plasma: approximately $20K–50K (depending on sophistication)
- Electric arc: approximately $20K–50K (depending on sophistication)

If the cutting equipment will be made "transportable" to field operation directly on the installation, for plasma cutting devices:

- Cutting head—approximately $50K
- Portable "rig carrier"—approximately $20K–50K
- Hydraulic arm, moveable, displaceable tup approximately 10- to 12-ft-high—approximately $40K–60K (pressed)

For an arc with carbon electrode, this "transportable" system will not be recommended. The reasons are multiple—passes required to reform a metallic cut. In general, when field operations are desired, that the cutting operation should be as simple and as fast as possible, especially when physical obstructions are present in the specific area of cutting. The cutting-deep (directly in the cutting kerf) is approximately 3/8 in to 5/8 in. for the "first pass."

In general, two persons are required to operate these systems, especially during the set-up of the system. Labor rate: $70/hr each.

Plasma cutting assumptions:

- A steel pipe should be cut,
- External diameter: 10 in.,
- Wall thickness: 1 in.,
- The pipe has already been placed in, or brought to, the cutting head
- Cutting speeds are 30–70 per/min.
- Time needed to cut the pipe—approximately 1 min.

The cutting of metals through electric arc or plasma generates dust, aerosol, and particles. Therefore, an air-filter system is necessary (for atmospheric and underwater operations).

Author: J. W. Koger, A. L. Demint

References:

1. *Final Report from the Technical University Hannover to the Department of Research and Technology*, INIS-MF-12019, German Government.

February 26, 1993

ADVANCED LASERS FOR CUTTING (DIFFUSION EQUIPMENT) DISM-42-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Structural steel in walls, beams, and roofs contaminated with small amounts of uranium, oil, and PCBs

Reference Requirements: Document (to be provided by "Regulatory Team"). Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting

Technology: Advanced lasers for cutting: Diode-pumped YAG, diode arrays, microwave pumped CO_2 etc.

Status: Predemonstration. Nd: YAG and CO_2 laser cutting technology exists in the predemonstration stage at the Penn State Applied Research Laboratory (ARL). The U.S. Navy has funded a feasibility demonstration of the technology for dismantlement of submarine hulls. The technology is very likely to work, because laser cutting is common in industry. New laser technologies becoming available in the 1993–1998 timeframe will provide the same advantages as current laser cutting but can provide additional advantages to laser use as a means of precise thermal cutting. Advantages of smaller units, smaller power requirements, easier deployment, and greater efficiency are expected. The following are seen as potential benefits and limitations of advanced laser cutting technology.

Advantages/benefits:

- Minimization of bulk contaminated waste, mixed waste, etc., relative to other cutting techniques. Essentially zero waste is created during cutting and no precut surface preparation is needed.
- Cost savings of $800M–$1.2B in reduction of labor and protective clothing.
- The laser generator remains remote to the contaminated equipment, possibly outside the building, thus avoiding being contaminated.
- Potential exists for the localized destruction of organic contaminants such as oils and PCBs, thus eliminating their removal from any waste generated.

- Laser beam delivery systems using existing fiber-optic technology will provide an economical and safe means for control and distribution of laser beam(s) for integration with automated systems.
- Operating and waste disposal costs relative to other systems are potentially very low.

Potential limitations:
- A small amount of bulk contamination will result.
- Laser safety issues such as beam containment need to be addressed to minimize restrictions to collateral activities.
- System capital cost is high relative to other cutting methods.

Science/Technology Needs:

Scaling of laser powers to required levels is needed.

A prototype integrated delivery system needs to be developed. Fiber optic delivery systems currently are not viable for some laser types.

Implementation Needs: Development: A prototype demonstration using a less-than-full-scale system to show feasibility and to surface all deployment issues is needed ($400K–$600K). Cost including the full-scale prototype system is $800K–$1M. Tooling to interface the laser cutting head with the automated delivery platform needs to be designed and demonstrated. A demonstration is required on simulated structures for the K-25 type facility and the K-33 type facility. Projected cost: $5M. A demonstration of system economics is needed.

Author: W. S. Key

References:
1. MMES Photonics R&D staff.
2. *R&D Magazine*, May 1992.
3. P. E. Denny, Penn State.

February 26, 1993

GRABBLER (SAW) MASSIVE SHEARING DISM-43-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Disassembly of metallic nuclear installation components contaminated with small amounts of uranium, oil, and PCBs.

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Demolition

Technology: Grabbler for remotely cutting metals (massive shearing). The excavator-mounted shear uses the hydraulic power of an excavator to operate a shear on the excavator arm. The shear can cut steel beams and concrete. Like the shear is the excavator-mounted grapple, which can be used to handle scrap and tear and pull to help demolish buildings. The operator is protected inside the cab of the excavator, 30–50 ft from the shearing site.

Status: Demonstration. The shear is an accepted technology. A "medium shear" which can cut up to 16-in. steel beams, costs roughly $100K (excavator excluded). The head of this shear rotates to allow shearing at different angles.

Science/Technology Needs: The excavator-mounted shear is a commercially available technology.

Implementation Needs: The excavator-mounted shear can only be used in areas large enough to accommodate the excavator. Spread of contamination when cutting contaminated metals would be minimal because the shearing takes place in the ambient temperatures, and no shavings or swart is generated. However, working in a contaminated area might contaminate the excavator. Robotics: The excavator can be modified to operate remotely, removing the operator from the work area.

Author: J. W. Koger, A.L. Demint

February 26, 1993

References:

1. Telephone conversation with Stan Salmi, LaBounty Mfg., Inc.

February 26, 1993

EXPLOSIVE CUTTING DISM-44-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Disassembly of metallic nuclear installation components contaminated with small amounts of uranium, oil, and PCBs

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Demolition

Technology: Explosive cutting. An explosive cutter consists of an explosive core contained in a metal or hard-plastic casing. The cutter is chevron-shaped so it can be directed at the work piece. This technique can be used either in air or underwater; immersion in water helps to dampen the sound of the explosion. This technique typically is used only where two or more cuts must be made simultaneously, or where cutting by other means is impractical. Cutting speed is a function of how fast the charges can be placed; this process can cut metals up to roughly 6-in. thick.

Status: Demonstrated. This technology is accepted as a means of gross cutting. Capital cost of this system, in 1989 dollars, was $100. Charges and cutters are consumable; charges cost $150/ft and cutters $8K each.

Science/Technology Needs: A means of buffering the shock wave and its associated noise is needed.

Implementation Needs: This process is not recommended for contaminated metals, because it would be extremely difficult to control the spread of airborne contaminants. Robotics: Charges can be placed remotely.

Author: J. W. Koger, A. L. Demint

References:

1. *An Evaluation of Alternative Reactor Vessel Cutting Technologies for the Experimental Boiling Water Reactor at Argonne National Laboratory*, ANL-89/31.

February 26, 1993

THERMITE CUTTING DISM-45-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Disassembly of metallic nuclear installation components contaminated with small amounts of uranium, oil, and PCBs

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Demolition

Technology: Thermite cutting. When iron, aluminum, and magnesium are ignited together, they react ("thermite reaction") to produce temperatures up to 10,000°F. Oxygen is forced through a lance (consisting of an iron pipe packed with aluminum, magnesium, and steel wires); the oxygen and wires then can be lit and the torch directed by the operator. The amount of oxygen controls the flame; the torch is extinguished by closing the oxygen valve. The system is portable but requires an operator to be close to the cutting. The torch can be used underwater.

Status: Predemonstration. The thermite reaction is well-known and understood, but the thermite lance (an accepted technology) is a gross cutting tool unsuitable to toxic materials. Hazards include spattering of hot metal, noise, metal fumes, and dust. In 1989 dollars, capital cost for the system was $555. Lances cost $5 each; oxygen cost also must be added.

Science/Technology Needs: The thermite reaction needs to be incorporated into a process that can be remotely controlled to be useful in contaminated environments.

Implementation Needs: Exhaust ventilation is required with this system as well as enhanced safety awareness because of the fire hazard created by the system. Robotics: The current technology is not amenable to robotics, because the lance is consumable and the rate of reaction depends on the oxygen flow, which is operator-controlled. The lance also must be placed on the work piece so as to continuously wash the molten metal down, out of the cut.

Author: A. L. Demint

February 26, 1993

References:

1. *An Evaluation of Alternative Reactor Vessel Cutting Technologies for the Experimental Boiling Water Reactor at Argonne National Laboratory*, NL-89/31.

CONVENTIONAL/AUTOMATED VACUUM SYSTEM DISM-46-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Asbestos removal

Reference Requirements: DOE, EPA, NRC, OSHA, etc. Regulations to be furnished by "Regulatory Team." Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Stripping involving manual removal of asbestos with the aid of a high-volume vacuum system. The vacuum system will be remote and will draw asbestos from inside the building to a mobile vacuum system outside the building. At this point, the asbestos will be bagged and disposed of.

Technology: Vacuum system. The conventional/automated vacuum system is self-contained and mounted on a towable trailer. The system includes a hopper, bagging port, HEPA filter, self-powered vacuum system, and large-diameter suction hose. The hose is routed to the asbestos removal area and transports asbestos to the hopper outside for bagging. The distance from the hopper to the removal point can be up to 1000 ft.

Status: Accepted. The technology is currently available and is in use at the Y-12 Plant in Oak Ridge, Tennessee. This system would save approximately 250% in the cost of materials and labor over the conventional removal and glove-bag operation. An example of cost-saving is that an area requiring 11 laborers and 4000 bags using the conventional method would require 4 laborers and 1500 bags using the proposed automated method.

Science/Technology Needs: None. However, this process could be integrated with alternative, highly automated systems, in which case it would require additional engineering design support.

Implementation Needs: Operator training is required on system setup and operation.

Author: C. Strange

February 26, 1993

References:

1. Stripping Vacuum System, Vacuum Engineering Corp., Milwaukee, Wi. (414) 444-4010.

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CO_2 BLASTING DISM-47-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Asbestos removal

Reference Requirements: DOE, EPA, NRC, OSHA, etc. Regulations to be furnished by "Regulatory Team." Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Stripping

Technology: CO_2 blasting. The system involves a roboticly manipulated CO_2 blasting machine that systematically removes exterior asbestos from the overhead pipes and walls. This system would encircle the pipe using a clamshell mechanism inside a shroud, with a vacuum recovery system that would collect contaminated debris. Pipe hangers, elbows, valves, and pipes located near walls must be addressed differently. All piping shall be free of exterior radioactive contaminants before removal.

Asbestos-covered walls are cleaned using a directional nozzle mounted on a robotic manipulator with a vacuum recovery system. The robot is operated remotely using optics to direct the CO_2 blast. Asbestos is removed down to the bare concrete or block wall, and the vacuum system recovers the asbestos after removal.

High-pressure CO_2 blasting: Ultra-high-pressure CO_2 forced through a small diameter nozzle which creates a spray to cut away the surface of material. Contaminated surface removed will be handled as waste. The remaining pipe then can be cut up by other methods and recycled, reused or disposed of locally. The technology is currently available but has not been demonstrated at the Oak Ridge K-25 Site.

Status: Demonstration. DOE-sponsored development: Programmable robotic manipulators have been developed. High-maintenance items include nozzles, hoses, and pumps. CO_2 blasting has been demonstrated but not at the K-25 Site.

By removing the contaminated surfaces (which will be bagged and disposed of), the remainder

of the decontaminated pipe can be recycled or reused. This process will save disposal cost of $\$17/ft^3$.

Demonstrations of removal need to be completed before cost payback can be evaluated. The CO_2 systems that require no water and simplify the recovery system would be well-suited for contaminated piping.

Science/Technology Needs: A vacuum recovery system linked to a robot-controlled CO_2 blaster needs to be demonstrated. Development of this equipment, which includes manipulators for tracking pipe during removal, remotely operated robotic manipulators, and an integrated vacuum system for demonstration, would cost $3.5M. Demonstration cost includes personnel protection, clothing, and container storage but not transportation and burial charges.

Implementation Needs: Need to view videos available from other nuclear facilities and possibly visit sites to evaluate recovery systems without an on-site demonstration. Determine what robotics have been developed using in-house seminars from vendors on the latest and future technology. Robotic manipulators with a recovery system need to be able to move around on the floor, up and around concrete columns, and overhead (the underside of the floor above). Methods of addressing removal of asbestos from valves in piping, piping elbows, and piping very near walls will have to be considered.

Author: C. Strange

References:

1. CO_2 Blasting, Alpheus Cleaning Tech Corp., Rancho Cucamonga, Ca., (714) 944-0055.
Dodge Guhan. Application Engineer.

February 26, 1993

GLASSIFICATION DISM-48-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Asbestos removal

Reference Requirements: DOE, EPA, NRC, OSHA, etc. Regulations to be furnished by "Regulatory Team." Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternatives: Stripping. A sealing-grinder, shredder, cutter, or accumulator linked to a machine that can bundle asbestos materials into a shape or size suitable for a machine that could encapsulate the asbestos with glass, thus alleviating the problem of suspended asbestos particles during shipping or disposal.

Technology: Glassification. Glassification is accomplished by taking a predetermined size of material and encasing it in glass. The size of the refuse can be linked to a machine that can reduce larger pieces of asbestos refuse so that they can be run through the glassification process. Once the asbestos has gone through the glassification stage, it can easily be handled for disposal. After glassification, the asbestos fibers would be encased. This could virtually eliminate airborne particles of asbestos during shipping.

Status: Demonstration. Technology is currently available; however, it has not been tested at the K-25 Site. Cost payback: Elimination of bagging or wrapping, multiple handling, and man interface could save $50M to $100M during displacement operations. The system could be useful in encasing other hazardous materials such as PCBs, volatile organic compounds, etc.

Science/Technology Needs: Need feasibility and design engineering to interface with a confined-environment machine equipped with a vacuum recovery system to process large pieces of asbestos into workable configurations. A study will need to be done to determine if this would create any new, unrecognized waste control or disposal problems.

Development of this equipment—cutter, shredder, or grinder—for demonstration would cost $3.5M. Demonstration cost includes building a portable containment enclosure and providing

personnel protection, clothing, and container storage but not transportation and burial charges.

Implementation Needs: Need to view videos available from other nuclear facilities and possibly visit sites to evaluate recovery systems without an on-site demonstration. Need to determine what robotics have been developed using in-house seminars from vendors on the latest and future technology.

Author: C. Strange

References:

1. Encapsulation, Vitrifix Of North America, Alexandria, Va., (703) 684-1090.

LASER CUTTING DISM-49-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Asbestos removal

Reference Requirements: DOE, EPA, NRC, OSHA, etc. Regulations to be furnished by "Regulatory Team." Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting. Involves a roboticly manipulated laser cutting machine that systematically holds and cuts the transite asbestos walls around diffusion equipment and outer building walls and stacks them on a transfer cart for removal and disposal.

Technology: Laser cutting (advanced laser for cutting asbestos materials). Laser cutting is accomplished using a laser beam which thermally sears through the asbestos and cuts it into pieces easily handled for disposal. This method would be used to cut the transite panels from around diffusion equipment. A laser manipulator could include either grippers or suction cups to safely remove and stack pieces during and after they have been cut.

Status: Predemonstration (DOE-sponsored development). Programmable robotic manipulators have been developed. Laser cutting of asbestos has had laboratory feasibility demonstration. Preliminary results indicate that cutting of material results in essentially no dispersement of fibers and leaves the asbestos-cut interface cauterized, thus helping to seal the surface and prevent dispersement of fibers during handling. An Nd: YAG-type lasers should have sufficient power and can be coupled with a fiber-optic delivery systems for ease of adaption to automated systems and for improved safety.

Cost payback: Elimination of waste, surface preparation, and man interface could save $50M–$100M during displacement operations. The system may be useful in cutting other hazardous materials such as PCBs, volatile organic compounds, etc.

Science/Technology Needs: Need confirmation of negligible asbestos dispersement and cut cauterization. Beam containment, laser safety, optics protection from flaming, etc., are issues to be addressed during development. The key issue is to substantiate that fusion of fibers

occurs and that the process does not create any new, unrecognized waste control or disposal problems.

Development of this equipment—a manipulator track for laser and grippers or holding devices for cut material for demonstration—would cost $3.5M. Demonstration cost includes building a portable containment enclosure and providing personnel protection, clothing, and container storage but not transportation and burial charges.

Implementation Needs: Need to view videos available from other nuclear facilities and possibly visit sites to evaluate recovery systems without an on-site demonstration. Determine what robotics have been developed using in-house seminars from vendors on the latest and future technology. Robotic manipulators with recovery system need to be able to move around on the floor, up and around concrete columns, and overhead (the underside of the floor above). Methods of addressing cracks in concrete; blow-through when cutting; containerization of contaminated material, water, and possibly abrasives; and removal of asbestos from valves in piping, piping elbows, and piping very near walls will have to be developed.

Cost Data:
- Development cost, approximately $800K to $1000K for a fieldable prototype system
- 12–18 months for issue resolution and field demonstration
- Cost per unit (not including automation) is approximately $150K–$250K

Author: C. Strange

References:
1. Laser Cutting, Laser Materials Processing, Manufacturing Science Dept., Penn State University, Henry E. Watson, (814) 865-6345.

ABRASIVE JET (HIGH PRESSURE) DISM-50-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Asbestos removal

Reference Requirements: DOE, EPA, NRC, OSHA, etc. Regulations to be furnished by "Regulatory Team." Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternatives: Cutting/removal. Involves a roboticly manipulated high-pressure water-jet machine that systematically removes the exterior asbestos of the pipe overhead. This system would encircle the pipe using a clamshell mechanism inside a shroud, with a vacuum recovery system that would collect contaminated slurry and recycle the water and possibly the abrasives, if used. Pipe hangers, elbows, valves, and pipes located near walls must be addressed differently. All piping shall be free of exterior radioactive contaminants before removal.

A roboticly manipulated, high-pressure water-jet machine will be used for cutting. The machine will be mounted, and manipulators will grip two ends of the pipe to support it inside the cutting area. After cutting, the manipulators will lower the section of pipe and load it onto a pallet so that the cut sections can be cycled through a remote water-jet system that can strip the asbestos from the exterior using a feed system which rotates the pipe as it travels through a series of water jets positioned at different angles around the diameter of the pipe. All piping shall be free of exterior and interior radioactive contaminants before removal.

Technology: High-pressure abrasive water-jet cutting. Abrasive water-jet removal is ultra-high-pressure water with and without abrasive that is forced through a small-diameter nozzle which creates a spray to cut away the surface of material. The contaminated surface removed will be handled as waste, with the contaminated abrasives and water to be recycled. The remaining pipe then can be cut by water-jet cutting or other methods and recycled, reused, or disposed of locally. The technology is currently available but has not been demonstrated at the Oak Ridge K-25 Site.

Abrasive water-jet cutting is ultra-high-pressure water with abrasive that is forced through a small diameter nozzle creating a stream that cuts through steel piping with one pass. This

method would be used to cut process piping after asbestos has been removed, or with asbestos covering still intact, into sections, either for disposal or remote removal of the asbestos.

Status: Predemonstration (DOE-sponsored development). Programmable robotic manipulators have been developed; water can be recycled. Concepts for abrasive recycling with 95% spoils recoverable; high-maintenance items include nozzles, hoses, and pumps, when abrasives are used. Metal cutting with high-pressure water jets has been demonstrated but not at the K-25 Site.

A high-efficiency recovery system is necessary to keep contaminated runoff to a minimum. Cracks in concrete will be a problem, because contamination will still be present and will have to be addressed, but no one system will be ideal for every situation.

A high-pressure water-jet-cutting recovery system will need to be present on both sides of the section being cut because of blowthrough. The recovery system opposite the machine will have to withstand the pressure of blowthrough.

By removing the contaminated surfaces which will be microwave dried and disposed of, the remainder of the decontaminated pipe can be recycled or reused. This will save a disposal cost of $\$17/ft^3$.

Demonstrations for removing and cutting need to be completed before cost payback can be evaluated. The lower pressure systems that require less water and simplify the recovery system would be best suited for contaminated piping. The low-pressure system works at a slower rate, but the simpler recovery system would justify it.

Microwave drying being developed at ORNL could be used to consolidate and immobilize liquid wastes inside containers or bags for ultimate waste disposal but would require demonstrations.

Science/Technology Needs: A recovery system with recyclable water and abrasives needs to be demonstrated. This system will require a portable facility, if available, or pools with the equipment necessary to separate and possibly decontaminate the water and abrasive for reuse.

Development of this equipment—manipulators for tracking pipe during removal, for holding pipe during cutting, for lowering pipe after cutting, and for cleaning pools for demonstrations—would cost $3.5M. Demonstration cost includes building a portable containment enclosure and providing personnel protection, clothing, and container storage but not transportation and burial charges.

ABRASIVE JET (HIGH PRESSURE) DISM-50-OG

Implementation Needs: Need to view videos available from other nuclear facilities and possibly visit sites to evaluate recovery systems without an on-site demonstration. Determine what robotics have been developed using in-house seminars from vendors on the latest and future technology. The recovery system's robotic manipulators need to be able to move around on the floor, up and around concrete columns, and overhead (the underside of the floor above). Methods of addressing cracks in concrete; blowthrough when cutting; containerization of contaminated material, water, and possibly abrasives; and removal of asbestos from valves in piping, piping elbows, and piping very near walls will have to be developed.

Author: C. Strange

References:

1. Abrasive Water Jet, Quest Integrated Inc., Kent Washington (206) 872-9500.

February 26, 1993

Nd: YAG AND CO_2 LASER CUTTING (MAJOR DISMANTLEMENT) DISM-51-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Major dismantlement; diffusion equipment contaminated with small amounts of uranium, oil, PCBs

Reference Requirements: Document (to be provided by "Regulatory Team"). Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting, advanced

Technology: Nd: YAG and CO_2 laser cutting (removal of major components from the cascade)

Status: Predemonstration. Technology exists in the predemonstration stage at the Penn State Applied Research Laboratory (ARL). The U.S. Navy has funded feasibility demonstration of the technology for dismantlement of submarine hulls. The technology is very likely to work, because laser cutting is common in industry. The following are seen as potential benefits and limitations of laser-cutting technology using existing laser technology (e.g. Nd: YAG and CO_2).

Advantages:

- Minimization of bulk contaminated waste, mixed waste, etc., relative to other cutting techniques.
- Cost savings of $800M–$1.2B in reduction of labor and protective clothing.
- A laser generator that remains remote to the contaminated equipment, possibly outside the building, thus avoiding being contaminated.
- Potential exists for the localized destruction of organic contaminates such as oils and PCBs, thus eliminating their removal from any waste generated.

Potential limitations

- A small amount of bulk contamination will result—small, relative to what was introduced in past equipment removal and reassembly by oxyacetylene cutting.
- A fiber-optic or other waveguide delivery system is preferred and has been demonstrated for Nd: YAG lasers, but appropriate wave guides have not been demonstrated for CO_2 lasers.

- Laser safety issues such as beam containment need to be addressed to minimize restrictions to collateral activities.

Science/Technology Needs: Laser cutting using a laser carried through a fiber-optic cable or waveguide requires field demonstration. Current fiber-optic cables cannot efficiently transmit the wavelengths generated by a CO_2 laser.

Implementation Needs: Tooling to interface the laser cutting head with the automated/robotic delivery platform needs to be designed and demonstrated. Also, a demonstration is required on simulated equipment for the K-25 type facility and the K-33 type facility. Projected cost: $5M.

Author: W. S. Key

References:

1. MMES Photonics R&D staff.
2. Denny, P.E., Penn State Applied Research Laboratory, technology briefing, April 15, 1992.
3. Ibid., Personal Communication, August 1992.
4. Ibid., Personal Communication, January 1993.
5. ANSI standard §136.1-1992.

HIGH-PRESSURE, ABRASIVE WATER-JET CUTTING DISM-52-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Major dismantlement

Reference Requirements: DOE, EPA, NRC, OSHA, etc. Regulations to be furnished by "Regulatory Team." Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting, advanced. Involves a roboticly manipulated, video controlled, high-pressure water-jet machine that systematically maneuvers around equipment cutting mounting hardware, piping, etc., attached to the equipment for removal by other means.

Technology: High-pressure, abrasive water jet. Abrasive water-jet cutting, with or without abrasives, is ultra-high-pressure water that is forced through a small diameter nozzle which creates a stream to cut through metal. The contaminated parent material that is removed will be separated and handled as nuclear waste with the contaminated abrasives and water to be recycled.

Blowthrough will have to be contained by shrouds attached to a high-efficiency vacuum system with any other overspray, etc., contained in a pool. The shrouds will have to be designed for specific application, with the containment pools being portable.

Status: Demonstrated. Abrasive water-jet cutting development was sponsored by DOE. Programmable robotic manipulators have been developed. Water and abrasives can be recycled with 95% spoils recoverable. Any recyclable material accumulated will save $\$20/ft^3$ on disposal.

Science/Technology Needs: Abrasive water-jet cutting technology exists, but high-efficiency vacuum recovery and mobile containment system will need to be further developed, with the shrouds, etc., designed for a specific application for a demonstration.

A state-of-the-art demonstration would cost $3.5M and would not include transportation or burial charges. The results of July 1992 estimate show that 58K tons of structural steel are in the K-25 "U" building alone. More than 3M lb of barriers are in K-33. More than 5M lb of

of copper are in the K-33 motors alone. Most of this material may be recycled with state-of-the-art disassembly and decontamination techniques.

Implementation Needs: Develop state-of-the-art system for demonstration on specific equipment. Develop market for massive amounts of recyclable steel, copper, etc.

Author: W. S. Key

References: MMES staff members.

February 26, 1993

ADVANCED LASERS FOR CUTTING DISM-53-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Major dismantlement

Reference Requirements: Document (to be provided by "Regulatory Team"). Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting, advanced

Technology: Advanced lasers for cutting. Involves diode-pumped YAG, diode arrays, microwave pumped CO_2 etc., (removal of major components from the cascade).

Status: Predemonstration. CO_2 laser cutting technology exists in the predemonstration stage at the Penn State Applied Research Laboratory (ARL). The U.S. Navy has funded a feasibility demonstration of the technology for dismantlement of submarine hulls. The technology is very likely to work, because laser cutting is common in industry. New laser technologies becoming available in the 1993 to 1998 timeframe will provide the same advantages as current laser cutting but can provide additional advantages to laser use as a means of precise thermal cutting. Advantages of smaller units, smaller power requirements, easier deployment, and greater efficiency are expected.

Advantages/benefits:

- Minimization of bulk contaminated waste, mixed waste, etc., relative to other cutting techniques. Essentially zero waste created during cutting and no precut surface preparation needed.
- Cost savings of $800M to $1.2B in reduction of labor and protective clothing.
- A laser generator that remains remote to the contaminated equipment, possibly outside the building, thus avoiding being contaminated.
- Potential exists for the localized destruction of organic contaminants such as oils and PCBs, thus eliminating their removal from any waste generated.
- Laser beam delivery systems using existing fiber-optic technology will provide an economical and safe means for control and distribution of laser beam(s) for integration with automated systems.

- Operating and waste disposal costs relative to other systems are potentially very low.

Potential limitations:

- A small amount of bulk contamination will result—small, relative to what was introduced in past equipment removal and reassembly by oxyacetylene cutting.
- Laser safety issues such as beam containment need to be addressed to minimize restrictions to collateral activities.
- System capital cost is high relative to other cutting methods.

Science/Technology Needs: Document. Scaling of laser powers to required levels is needed. A prototype integrated delivery system needs to be developed. A fiber-optic delivery system currently is not viable for some laser types.

Implementation Needs: Document/development. A prototype demonstration using a less-than-full-scale system to show feasibility and to surface all deployment issues is needed ($400K to $600K). Cost, including full-scale prototype system, is $800K–$1000K. Tooling to interface the laser cutting head with the automated delivery platform needs to be designed and demonstrated. A demonstration is required on simulated equipment for the K-25-type facility and the K-33-type facility. Projected cost: $5M. Demonstration of system economics is needed.

Author: W. S. Key

References:

1. MMES photonics R&D staff.
2. *R&D Magazine*, May 1992.

BAR-CODE/LASER TOOLING LOCATION DISM-54-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Major dismantlement

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Equipment location

Technology: Positioning of equipment using laser/bar codes

Status: Demonstration. Technology exists to precisely locate tooling using a laser/bar-code system. The Caterpillar Company has used this technology in warehouse/inventory systems to position stacker cranes to store and retrieve products in manufacturing facilities. The bar code can store site-specific operations and "next move" data. The stacker crane would contain the laser source and receiver. Bar codes are located on columns or other building features.

This technology definitely has application in removing the operator from contaminated areas and is likely to work with very little "prove-in." No waste will be generated by this technology.

Cost savings would depend on the degree of automation selected in the eventual philosophy of operation of the D&D effort. Full application of automatic positioning of tooling probably will not be justifiable. The optimum approach (author opinion) will be to do initial set-up with manual positioning for a dismantlement zone. The tooling then would reposition itself for the repetitive steps. Cost savings could be as much as $3.5M per major facility (K-25, K-33, K-31, K-29, K-27). These savings would result primarily from the reduction of labor for most tooling set-ups required. Assuming similar savings per facility, this technology could save $18M at the K-25 Site alone.

Science/Technology Needs: No new science or technology needs have been identified.

Implementation Needs: A demonstration within a diffusion facility is needed. This demonstration must address both types of diffusion equipment, the axial flow equipment (newer and larger), and the older type built during World War II.

The demonstration must indicate the required instrumentation interfacing with the control computers and interfacing with the robotics delivery platform and man-machine control area.

A demonstration of this technology could be a part of any other integrated demonstration of diffusion dismantlement but, if addressed as a single entity, would require $5M–$7M to design, procure, and install.

If this demonstration were part of the demonstration of an automated tooling delivery system, the cost of demonstration would be minor, because mechanical equipment would represent the bulk of the cost.

Author: W.S. Key

References: MMES staff members.

ZONING FOR CONTAINMENT (3 ZONES) DISM-55-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Major dismantlement

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternatives: Equipment location

Technology: Zoning for containment (three zones)

Status: Accepted. Containment to prevent the spread of exposed contamination to less contaminated areas has been demonstrated by ongoing D&D to be an effective cost-reduction tool. At the Mound Laboratory facility, a technique involving three zones, "cold, buffer, and hot," is being used to isolate contamination. Temporary containment using stud partitions and 0.003- to 0.005-mil plastic sheet to form a "buffer" area around equipment to be opened has been shown to prevent increasing contamination in the surrounding building when removing glove boxes. This technology will be necessary during dismantlement, and it will allow an estimated 80–90% of the materials to be removed to be treated as low-level waste.

Commercial suppliers are available that build standard sections of enclosures typically used to construct clean rooms and hoods. These same suppliers could be asked to supply panels that could be used and reused to enclose dismantlement activities within facilities. A portable air supply system would be used in conjunction with any temporary enclosures.

Cost savings would result from a reduction of disposal cost for 80–90% of the material in the diffusion facilities. Low-level waste can be disposed at $\$20/ft^3$. Material exceeding the limits for low-level cost approximately $\$100/ft^3$ to dispose of. Assuming that all building materials can be disposed of as low-level waste, the savings would be \$1B–\$2B for the older buildings (K-25 and K-27). Please note that recycling cost would be influenced in similar ways, but factors here are unknown. Spreading of contamination may prevent any practical recycling.

Science/Technology Needs: Lighter weight materials, such as those with honeycomb construction, may make panels easier to handle and cheaper. Inflatable panels may apply.

Implementation Needs: A demonstration of how a temporary barrier would be constructed in K-25 and K-33 is needed. Bracing to allow proper negative pressures to be developed in the dismantlement zone need to be conceptually engineered. Optimization for standardization of panels needs to be engineered to allow reuse of panels in the next dismantlement zone. A design for enhanced fire protection is needed. Flammable materials should be prohibited.

Author: L. C. Hensley

References:

1. MMES staff members.

OXYACETYLENE CUTTING TO REMOVE MAJOR COMPONENTS FROM CASCADE

DISM-56-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Major dismantlement

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Conventional

Technology: Use of existing features. Involves oxyacetylene cutting to remove major components from the cascade.

Status: Accepted. Technology exists in each of the diffusion plants that permits the removal of major components without new equipment. The methods and equipment have been proven and have been in use (and improved upon from time to time) for more than 40 years.

The cost to reactivate this equipment would be insignificant compared to any other technology.

Science/Technology Needs: The equipment used to remove gaseous diffusion equipment from the cascades would require removal from storage. When this group of jigs and fixtures have lost parts or are missing, the existing design drawings would be required to fabricate and replace needed components.

Implementation Needs: All jigs and fixtures would have to be located and, if necessary, retrofitted to restore them to their proper working condition. Existing jig and fixture fabrication drawings would need to be recalled from archives, where necessary.

Author: J. W. Smith

References:

1. MMES staff members.

February 26, 1993

ADVANCED AUTOMATIC FIXTURES, BUG-O, ETC. (MAJOR DISMANTLEMENT) DISM-57-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Major dismantlement

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternatives: Conventional

Technology: Advanced automatic fixtures, Bug-O, etc. (major dismantlement)

Status: Accepted. The Cascade Improvement Program, completed in the early 1980s for the diffusion facilities, used automated positioning tooling for cutting and welding to modify steel components including converter shells. This same tool concept can be adapted to cutting in the cascade, assuming the appropriate delivery system (efficacy).

The technology is a certainty to work for cutting round piping such as diffusion cascade piping. Careful attention will need to be paid to shrouding the area where the cut is occurring to avoid the spread of airborne contamination. The technology can achieve increased efficiency of manpower and safety.

Cost savings of 50–70% could be achieved over the 15–20 work-hours per cut on 30-in. piping. This cost reduction would translate to a savings of up to $20M for one major facility (K-33) alone, assuming 10 cuts per stage of major dismantlement. Safety of operators would be enhanced over manual methods. Waste would be minimized, when integrated with laser cutting techniques discussed in other data sheets. No waste specific to this technology would be generated, although a significant reduction of waste in the form of disposed safety clothing would be realized over manual techniques.

Science/Technology Needs: No science or development needs. A significant demonstration of a prototype will be required in the actual environment of the diffusion cascade. The demonstration would need to define the best way to power and control the tooling in a remote

operating mode. Integration with a robotic delivery platform would significantly compound the total benefit. Savings of 5 to 10 times those cited under "Status" could be realized.

This estimate is for gross savings and does not address the cost of robotics.

Implementation Needs: Approximately 1 work-year of design would be required to design a prototype ($90K). Total hardware cost would be approximately $100K in 1992 dollars. No significant software is required, although interlocking with any robotics would be necessary and may require approximately 0.5 work-years to design.

No facilities are needed over those existing in Oak Ridge. Reactivation of one crane bay in K-33 would be beneficial in that actual testing on diffusion piping could occur.

The total cost of a prototype demonstration would be about $1.5M. The tooling would then be duplicated. Approximately 20 different sizes would be required, resulting in a total procurement cost of $500K for the three larger facilities (K-29, K-31, K-33), assuming that each size costs $25,000. The older facilities would require approximately 30 different sizes at a total cost of $450K for K-25 and K-27, assuming that each size costs $15K.

Author: L. C. Hensley

References:
1. MMES staff members.

February 26, 1993

GRABBLER/GROSS SHEARING AND LIFTING DISM-58-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Major dismantlement

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Demolition

Technology: Grabbler/gross shearing and lifting

Status: Demonstrated. Commercially available technology exists to adapt large, hydraulic, excavator-mounted shearing jaws and grabbing devices to readily available earth-moving equipment. This technique has been used at the Apollo, Pennsylvania D&D project to remove structural steel from the former NUMEC fuel fabrication plant.

Benefits of such a system include the following:

- Few special tools would be needed, essentially, one size fits all.
- The same excavator device could be used to remove piping, equipment, asbestos, etc.
- The operator is isolated from the actual work area by the reach of the arm.
- Cost savings would be in the range of 75% saving on labor to disassemble the diffusion piping. (Estimated $15.4M per major building such as K-33).

Problems include the following:

- Much design effort will be required to assure that no airborne contamination leaves the work area.
- The resulting cut of pipe or equipment will be irregular and therefore difficult to close.
- Additional work will be required in the component disassembly area to recover from any mangling of components during major dismantlement.

Science/Technology Needs: No new science is needed.

Implementation Needs: A major demonstration of this technology will be required to determine the extent of airborne contamination generated for a typical cut into the diffusion piping. (If in situ decontamination is successful, this problem will be much reduced). Cost of such a demonstration will be $2M–$3M. Cost may be shared with a demonstration for asbestos, structural steel, massive concrete. The cost to implement the concept would be $300K–$500K, if the demonstration is successful. Robotics will be useful, if the excavator arm were to be operated remotely, either teleoperated or umbilical.

Author: L. C. Hensley

References: MMES staff members.

HIGH-PRESSURE, ABRASIVE WATER-JET CUTTING OF STEEL DISM-59-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Disassembly of major components

Reference Requirements: DOE, EPA, NRC, OSHA, etc. (regulations to be furnished by "Regulatory Team") Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting, advanced

Technology: High-pressure, abrasive water-jet cutting of steel. Involves a roboticly manipulated, video controlled, high-pressure water-jet machine that systematically maneuvers around equipment, cutting outside cover and exposing the inside which can be cut away, segregated, decontaminated, and recycled or shredded for disposal. The contaminated parent material that is removed will be segregated and handled as nuclear waste with the contaminated abrasives and water to be recycled.

Blowthrough will have to be contained by shrouds attached to a high-efficiency vacuum system, with any other overspray, etc., contained in a pool. The shrouds will have to be designed for specific application, with the containment pools being portable.

Status: Demonstration. Abrasive water-jet cutting development was DOE-sponsored. Programmable robotic manipulators have been developed. Water and abrasives can be recycled with 95% spoils recoverable. Any recyclable material accumulated will save disposal cost of $\$20/ft^3$.

Science Technology Needs: Abrasive water-jet cutting technology exists, but a high-efficiency vacuum recovery and mobile containment system will need to be further developed with the shrouds, etc., designed for a specific application for a demonstration. A state-of-the-art demonstration would cost $3.5M and would not include transportation or burial charges.

Implementation Needs: Develop a state-of-the-art system for demonstration of specific equipment. Develop a market for massive amounts of recyclable steel, copper, etc.

HIGH-PRESSURE, ABRASIVE WATER-JET CUTTING OF STEEL DISM-59-OG

Author: T. Barnes, M. Carroll

References:

1. Machine Kinetics Corporation, Knoxville, Tennessee.

February 26, 1993

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HIGH-PRESSURE WATER JET DISM-60-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Dismantlement of the process and mechanical gaseous diffusion equipment contaminated with uranium and uranium isotopes.

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting, advanced

Technology: High-pressure water jet. Previously used to disassemble converters in the late 1970s and early 1980s. Capabilities already exist.

Status: Accepted. (Capabilities, implementation/test media, problem areas, etc.) High-pressure water jets have been fully developed. Some equipment may still be available at the site.

Demonstration: justify.

Science Technology Needs: None.

Implementation Needs: Modifications may exist for current regulatory concerns. Schematic layout and representation need to be addressed.

Author: L. L. Oakes

References:
1. MMES staff members.

February 26, 1993

THERMAL ARC WATER-JET CUTTING DISM-61-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Disassembly of major components

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting, advanced

Technology: Thermal arc water-jet cutting. With this thermal arc water-jet cutting device, it is possible to cut steels up to a wall thickness of 100 mm underwater up to 20 m. The cutting process involves an electric arc between the wire electrode and the metal sheet, thus melting the metal in the workpiece. The water jet around the wire is used to "wash-away" the melted material from the cutting kerf. The wire is consumed because of the high current. The wire has to be fed so that the process can work continuously.

Status: Demonstration. Demonstrated technology of cut metallic parts/walls up to 100-mm-thick and up to 20 m underwater. These thermal arc water-jet cuts are, in general, directed by computer numeric controller. With additional tooling support, cutting in several axes of operations will be possible. Hole-piercing up to a wall thickness of 30 mm also could be done. Cutting in a vertical and horizontal motion, pipes, bank of pipes, and geometrically complicated components is possible. Robotics: In general, the arc water-jet cutting process is controlled by a numerical control device (computer). The process can be adapted to a machine with more axes for diversity of operation. A remote-control operation also can be implemented, allowing this process to be very acceptable for underwater operations.

In Y-12 Building 9201-5 (exclusion area), a prototype (experimental stage) of an arc saw with a water table is available. Although the construction of this prototype arc saw is not totally complete, this device can still be used for experimental trials. This arc saw can be operated underwater up to 15 ft. Deeper underwater operations also are possible, but they will require some design and construction changes.

The diameter of the "saw" in this device will determine the maximum possible part-wall-thickness to cut.

In general, these units (a water pool or water table) are fixed in one location (not moveable or portable). The piece to be worked is brought to the machine for processing.

The approximate cost of this unit is $1M–$1.2M. Two operators are required to operate this unit ($70/hr each).

For dismantlement operations directly on the actual installation, inside of buildings, in atmospheric operations (air), strict precaution has to be taken for the generated dust and particles. The size of these particles ranges from approximately 1/16 in. to submicroscopic. If a suction-air filter system is used to purify/clean the air, the filter should be checked and changed as needed.

All costs are related to a maximum part-wall-thickness cutting of 6.5 in. of stainless steel. Partial information was provided by the L-TEC Corporation in South Carolina (803-664-4397). The electric arc cutting system features a carbon electrode. Approximate costs for equipment for arc and plasma cutting technology follow:

Standard Cutting Head:
- Plasma—approximately $50K
- Electric arc—approximately $25K

X, Y, Z table (to be placed in a determined location and not for transportation to field operations).

Water table
- Plasma—approximately $60K–80K
- Electric arc—approximately $60K–$80K (This arc cutting device with carbon electrode is not recommended for operations underwater).

Air treatment system (This system features a filter device, hoods, snorkels device, etc., to be applied in atmospheric and under water operations.):
- Plasma—approximately $20K–$50K (depending on sophistication)
- Electric arc—approximately $20K–$50K (depending on sophistication)

If cutting equipment will be made "transportable" to field operation directly on the installation, for plasma cutting devices:
- Cutting head—approximately $50K
- Portable "rig," "carrier"—approximately $20K–$50K
- Hydraulic arm, moveable, displaceable up to approximately 10–12 ft high—approximately $40K–$60K (pressed).

For an arc with a carbon electrode, this "transportable" system will not be recommended, because multiple passes are required to reform a metallic cut. In general, when field

operations are desired, the cutting operation should be as simple and as fast as possible, especially when physical obstructions are present in the specific area of cutting. The cutting-deep (directly in the cutting kerf) is approximately 3/8 in. to 5/8 in. for the "first pass."

In general, two persons are required to operate these systems, especially during the set-up of the system. Labor rate: $70/hr each.

Plasma cutting assumptions:

- A steel pipe should be cut, external diameter: 10 in., wall thickness: 1 ft.
- The pipe has been already placed in or brought to the cutting head.
- Cutting speeds are 30 to 70 per min.
- Necessary time to cut the pipe—approximately 1 min.

The cutting of metals through electric arc or plasma generate dust, aerosol, and particles. For this reason, an air filter system is necessary (for atmospheric operations).

Science Technology Needs: No additional basic development is necessary.

Implementation Needs: Required possible pre-runs to accommodate the arc water-jet cutter to possible room/space shortages in the working area. In general, no major changes on the cutter device are needed. This is commercially available technology, at least in Germany.

Author: F. L. Paulauskas

References:

1. *Final Report from the Technical University Hannover to the Department of Research and Technology*, INIS-MF-12019, German Government.

February 26, 1993

PLASMA ARC SAW (DISASSEMBLY OF MAJOR COMPONENTS) DISM-62-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Disassembly of major components

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting, advanced

Technology:

Generic. Cutting, advanced

Specific. Plasma arc saw. This new technological development allows thermal cutting of steel with wall thickness up to 300 mm, tubes, bank of tubes, and geometrically complicated components. Also, this technology can be used underwater up to a depth of 20 m. With a normal plasma torch, it is impossible or at least extremely difficult.

Status: Demonstrated. Plasma arc saw technology enables thermal cutting of steel plates/walls independent of its thickness in a water depth up to 20 m. This technology was demonstrated in cutting plates up to a thickness of 300 mm. The maximal permissible metallic wall thickness to be cut depends only on the diameter of the saw (plasma arc) blade. The emission of dust and aerosol during the process, only depends on the melted material. This process is controlled by computers. Robotics: Because of the intrinsic condition cutting operations, a computer-controlled process is required in this plasma arc saw technology. A remote-control operation can be implemented without difficulty, making this technology very suitable for operation underwater.

Costs:

Equipment for arc and plasma cutting technology (approximate values):

- All costs are related to maximum part-wall-thickness cutting of 6.5 in. (stainless steel).

- Partial information was provided by the L-TEC Corporation in South Carolina (803-664-4397).
- The electric arc cutting system features a carbon electrode.

Standard cutting head:
- Plasma—approximately $50K
- Electric arc—approximately $25K

X, Y, Z table (to be placed in a determined location and not for transportation to field operations).
- Plasma—approximately $150K (depending on sophistication)
- Electric arc—approximately $150K (depending on sophistication)

Water table:
- Plasma—approximately $60K–$80K
- Electric arc—approximately $60K–$80K (This arc cutting device with carbon electrode is not recommended for operations underwater).

Air treatment system (This system features a filter device, hoods, snorkels device, etc., to be applied in atmospheric and underwater operations.):
- Plasma—approximately $20K–$50K (depending on sophistication)
- Electric arc—approximately $20K–$50K (depending on sophistication)

If the cutting equipment will be made "transportable" to field operation directly on the installation, for plasma cutting devices:
- Cutting head—approximately $50K
- Portable "rig," "carrier"—approximately $20K–$50K
- Hydraulic arm, moveable, displaceable up to about 10- to 12-ft high—approximately $40K–$60K (estimated).

For an arc with a carbon electrode, this "transportable" system will not be recommended. The reasons are the multiple-passes required to perform a metallic cut. In general, when field operations are desired, the cutting operation should be as simple and as fast as possible, especially when physical obstructions are present in the specific area of cutting. The cutting-deep (directly in the cutting kerf) is approximately 3/8 in. to 5/8 in. for the "first pass."

In general, two persons are required to operate these systems, especially during the setup of the system. Labor rate: $70/h each.

PLASMA ARC SAW (DISASSEMBLY OF MAJOR COMPONENTS) DISM-62-OG

Assumptions:

- A steel pipe should be cut; external diameter: 10 in.; wall thickness: 1 in.
- The pipe has been already placed in or brought to the cutting head
- Cutting speeds are 30 to 60 in./min
- Time required to cut the pipe: approximately 1 min

The cutting of metals through electric arc or plasma generate dust, aerosol and particles. For this reason, an air filter system is necessary (for atmospheric operations). These particles will clog the filter very often.

Science Technology Needs: For large steel-wall thickness (>100 mm), requires the development of the large saw and pre-runs in the process.

Implementation Needs: Requires transfer from development stages (prototype, 1990) to broad industrial application. Technology is available in commercial basis.

Author: F. L. Paulauskas

References:

1. *Final Report from the Technical University of Hannover to the Department of Research and Technology*, INIS-MF-12032, German Government.

February 26, 1993

Nd: YAG AND CO_2 LASER CUTTING (MAJOR COMPONENTS) DISM-63-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Disassembly of major components

Reference Requirements: Document (to be provided by "Regulatory Team"). Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting, advanced

Technology: Nd: YAG and CO_2 laser cutting (removal of major components from the cascade)

Status: Predemonstration. Technology exists in the predemonstration stage at the Penn State Applied Research Laboratory (ARL). The U.S. Navy has funded a feasibility demonstration of the technology for dismantlement of submarine hulls. The technology is very likely to work, because laser cutting is common in industry.

Advantages/benefits:

- Minimization of bulk contaminated waste, mixed waste, etc., relative to other cutting techniques.
- Cost savings of $200M–$300M in reduction of labor and protective clothing.
- A laser generator that remains remote to the contaminated equipment, possibly outside the building, thus avoiding being contaminated.
- Potential exists for the localized destruction of organic contaminants such as oils and PCBs, thus eliminating their removal from any waste generated.

Potential limitations:

- A small amount of bulk contamination will result—small, relative to what was introduced in past equipment removal and reassembly by oxyacetylene cutting.
- A fiber-optic or other waveguide delivery system is preferred but has not been demonstrated.
- Laser safety issues such as beam containment need to be addressed to minimize

restrictions to collateral activities.

Science Technology Needs: Laser cutting using a laser carried through a fiber-optic cable or waveguide requires demonstration. Current fiber-optic cables cannot efficiently transmit the wavelengths generated by a CO_2 laser.

Implementation Needs: Tooling to interface the laser cutting head with the automated delivery platform needs to be designed and demonstrated.

A demonstration is required on simulated equipment for the K-25-type facility and the K-33 type facility. Projected cost: $5.0M.

Author: W. S. Key

References:

1. MMES Photonics R&D staff.
2. Denny, P.E., Penn State Applied Research Lab., Technology Briefing, April 15, 1992.
3. Ibid. Personal Communication, August 1992.
4. Ibid. Personal Communication, January 4, 1993.
5. ANSI standard §136.1-1992.

LIQUIFIED GAS CUTTING DISM-64-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Disassembly of major components

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Cutting, advanced

Technology:

Generic. Cutting, advanced

Specific. Liquified gas cutting. This technology is included in The Hanford Model (wiring diagram). Liquified gas would be used like water jet cutting. The advantage to such a system would be like CO_2 blasting in that removed or cut materials would be lifted from the surfaces involved by the evaporating gas with very little surface abrasion to trap contamination.

Status: Evolving technology. Another advantage may be achieved because of the low temperatures involved. Cutting below the embrittlement temperature for metals may be advantageous.

Cost advantages would be realized in cutting equipment where criticality safety is a major issue. This issue is in the 1940's vintage equipment. In this facility, any reduction in criticality safety considerations could mean major savings. This technique could save 20% of the cost of abrasive water jet cutting but would not save any cost of more conventional cutting techniques such as laser-cutting.

Science Technology Needs: A cooperative effort with commercial suppliers of jet cutting and blasting equipment must be initiated to investigate this technology. The Hanford wiring diagram states that "No known program" exists.

Implementation Needs: Full engineering and development is needed. The cost to implement this technology is estimated at $10M.

February 26, 1993

Author: L. C. Hensley

References:

1. *The Hanford Model: Environmental Cleanup Problems, Science and Technology Needs, Facility Managements*, September 1991.

February 26, 1993

SHREDDING, AUTOMATIC SORTING, AND/OR COMPACTION DISM-65-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Disassembly of major components

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Sorting, recycling

Technology:

Generic. Sorting for recycling

Specific. Shredding, automatic sorting, and/or compaction

Status: Predemonstration. Technology exists in commercial areas to shred and automatically sort materials, including sheet metal equipment (automobiles and appliances), for various purposes. These purposes include sorting raw materials from combustibles for recycling/power plants. The Saturn Manufacturing Company has supplied shredders to both ORNL and the Y-12 Plant in Oak Ridge for these purposes.

Application of this technology will require testing of large shredders capable of handling items with the structural integrity of an axial flow diffusion compressor. It is unlikely that such a machine can be procured in today's technological climate.

If whole components can be shredded and sorted by methods like magnetic separation (blades from rotors), then sorting for recycling becomes much less labor intensive and capital equipment cost will be greatly reduced. This technology could provide approximate savings of 20 h per component. For K-33 alone, this savings would be approximately $2.5M, assuming 20 h for each converter and compressor.

Science Technology Needs:

- New materials of construction are needed to allow large and thick steel cylinders to be processed in large shredders.
- Sorting techniques must be proven to separate various materials of a ductile nature; how much will be trapped in folds and bends.
- Cryogenic temperatures may embrittle the materials to enhance shredding. This feature needs to be investigated.
- A thorough inquiry of commercial vendors specializing in shredding and sorting must be conducted.

Cost of a demonstration to develop this system is estimated at $10M to $15M.

Implementation Needs: A thorough inquiry of commercial vendors specializing in shredding and sorting must be conducted. Cost of a demonstration to develop this system is estimated at $10–15M.

Author: L. C. Hensley

References:

1. MMES staff members.

February 26, 1993

USE OF EXISTING FIXTURES AND TOOLING DISM-66-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Disassembly of major components (diffusion equipment contaminated with small amounts of uranium, oil, PCBs). Includes major dismantlement of all process building equipment, transportation to the disassembly area, and disassembly of equipment. For the Oak Ridge diffusion equipment, the transporting distance is approximately 1 mile. The weights of transported equipment for major components are:

- 000 converter = 70K lb
- 000 compressor = 38K lb
- 2000-HP process motor = 21K lb
- 00 converter = 27K lb
- 00 compressor = 14K lb
- 850 P process motor = 7K lb
- 000 condensers = 21K lb
- 00 condensers = 18K lb
- various valves = 5K lb

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Conventional

Technology:

Generic. Conventional

Specific. Use of existing fixtures and tooling (oxyacetylene cutting to remove major components from the cascade). Oxyacetylene cutting and machine shearing to reduce the various components to a size compatible with remelting.

Status: Accepted. Technology exists in each of the diffusion plants that permits the removal of major components without new equipment. The methods and equipment have been proven and have been in use (and improved upon from time to time) for over 40 years.

USE OF EXISTING FIXTURES AND TOOLING DISM-66-OG

Science Technology Needs: An integration of advanced cutting techniques

Implementation Needs: All jigs and fixtures would have to be located and, if necessary, retrofitted to restore them to working condition. Existing jig and fixture fabrication drawings would need to be recalled from archives where necessary.

The estimated cost for the K-25 Site would be: Engineering to locate and supply new improved engineering tool designs, $500K. The estimated cost to locate, repair/build new tooling is $1.2M.

Author: J. W. Smith

References:

1. MMES staff members.

February 26, 1993

ADVANCED AUTOMATIC FIXTURES, BUG-O, ETC. (DISASSEMBLY OF MAJOR COMPONENTS) DISM-67-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Disassembly of major components

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Conventional

Technology: Advanced automatic fixtures, Bug-O, etc. (disassembly of major components)

Status: Accepted. The cascade improvement program completed in the early 1980's for the diffusion facilities used automated positioning tooling for cutting and welding to modify steel components including converter shells. This same tool concept can be adapted to cutting in the cascade assuming the appropriate delivery system.

The technology is a certainty to work for cutting round piping such as diffusion cascade piping. Careful attention will need to be paid to shrouding the area where the cut is occurring to avoid the spread of airborne contamination. The technology can achieve increased efficiency of manpower and safety.

Cost savings of 50%–75% could be achieved over the 15–20 work-hours per cut on 30-in. piping. This practice would translate to a savings of up to $20M for one major facility (K-33) alone, assuming 10 cuts per stage for major dismantlement. Safety of operators would be enhanced over manual methods. Waste would be minimized when integrated with laser cutting techniques discussed in other data sheets. No waste specific to this technology would be generated, although a significant reduction of waste in the form of disposed safety clothing would be realized over manual techniques.

Science/Technology Needs: No development or improvement needs. A significant demonstration of a prototype will be required in the actual environment of the diffusion cascade. The demonstration would need to define the best way to power and control the tooling in a remote operating mode. Integration with a robotic delivery platform would

significantly compound the total benefit. Savings of 5–10 times those cited under "Status" could be realized. (This is gross savings and does not address cost of robotics).

Implementation Needs: Approximately 1 work-year of design would be required to design a prototype ($90K). Total hardware cost would be approximately $100K in 1992 dollars. No significant software is required, although interlocking with any robotics would be necessary and may require approximately 0.5 work-years to design. No facilities are needed, other than those existing in Oak Ridge. Reactivation of one crane bay in K-33 would be beneficial in that actual testing on diffusion piping could occur.

Total cost of a prototype demonstration would be about $1.5M. The tooling then would be duplicated. Approximately 20 different sizes would be required, resulting in a total procurement cost of $500K for the three larger facilities (K-29, K-31, K-33), assuming that each costs $25K.

The older facilities would require approximately 30 different sizes at a total cost of $450K for K-25 and K-27, assuming that each costs $15K.

Author: L. C. Hensley, J. W. Smith

References:

1. MMES staff members.

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/constituents: Disassembly of major components (diffusion equipment contaminated with small amounts of uranium, oil, PCBs)

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Conventional

Technology:

Generic. Cutting, conventional

Specific. Saws (chain saws and abrasive wheels built into large fixtures for cutting the barrier out of the assembled bundles).

Status: Accepted. Technology exists in each of the diffusion plants to permit the removal of barriers from converter assembled bundles without new equipment. The methods and equipment have been proven and have been in use (and improved upon from time to time) for over 40 years.

The cost to reactivate this equipment would be insignificant compared to any other technology.

Science Technology Needs: Integration of advanced cutting techniques. The equipment that was used at the K-25 Site and is used at the Paducah and Portsmouth sites to disassemble gaseous diffusion converters would require removal from storage. If this group of devices were missing parts, the existing design drawings would be required to fabricate and replace needed components.

Implementation Needs: All equipment would have to be located and, if necessary, retrofitted to restore it to working condition. Existing equipment drawings would need to be recalled from archives where necessary.

Cost: $100K for Engineering to locate and supply new, improved engineering tool designs; $400K to repair and build new tooling. Approximate total cost: $500K.

Author: J. W. Smith

References:

1. MMES staff members.

February 26, 1993

USE OF EXISTING EQUIPMENT FOR DISASSEMBLY OF CENTRIFUGE MACHINES

DISM-69-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Disassembly of major components (gas centrifuge machines at K-25 Site and GCEP, Portsmouth, Ohio)

Reference Requirements: To be provided by "Regulatory Team." Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement. Disposal of contaminated and/or classified equipment from large buildings that could house existing or new projects.

Alternative: Conventional

Technology:

Generic. Conventional

Specific. Use of existing equipment for disassembly of centrifuge machines. The decontamination requirements for centrifuge cleanup are not unusual to other equipment decontamination. However, certain components would require special equipment (rotor-cutting device) and employ special techniques that allow them to be cleaned and stored in a more effective manner.

Status: Accepted. Robotics: Most of the equipment is remote-operated, and some robotics-type equipment is incorporated into the process. Some hands-on disassembly is required; however, more of the operation could be done by robotic-type machines.

Advantages:

- The equipment has been consolidated in K-1420, and installation and check-out has been completed.
- There are people on-site who have expertise in both machine disassembly and decontamination techniques using the specific equipment (T. R. Williams and L. D. Ladd, both of D&D, and the lead engineer for installation and check-out of the equipment, L. S. Hawk, ATD-ORNL).

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- A safety assessment for operation of the facility (KDSA 2122, Safety Assessment for D&D, K-1420) and operating procedures for the equipment (some are confidential) were out in draft form. L. S. Hawk has copies. Specific technical information is available but may be classified.

Disadvantages:
- Exact disposition of the hardware and materials after D&D was never determined.
- The equipment has been sitting for several years (since 1985 to 1990 timeframe) and may require maintenance before being useable.

Several other methods of cutting the materials are involved. However, a larger quantity of effluent would result from these alternate methods. The effluent would be contaminated and probably classified as RCRA waste. Some methods would create airborne dusts and need further containment.

Because most of the equipment needed for this task already exists, the cost of doing this work would be limited to the K-25 Site labor rates for working with contaminated equipment and the cost of the personal protective equipment used by the workers. The justification for doing this work now is that the equipment (capital expense) for doing the job already exists and the labor costs are as low now as they will probably ever be. Also, in the future, regulations will probably become more stringent, driving costs even higher.

This effort will save money in the future, because it will reduce the volume of contaminated materials being stored and free storage areas for other uses.

This project will generate a fairly large quantity of waste that can be consolidated in smaller areas than it now occupies. This project will generate a quantity of contaminated liquid that can be reduced and probably disposed of by the TSCA Incinerator. It will remove the majority of the transferable, loose contamination from the equipment, making the equipment safer to store until it can be disposed of later.

Science Technology Needs: Requires disposal of effluent and classified/contaminated hardware that meets the requirements of today's environmental standards.

Implementation Needs: Requires completion of the procedures and documentation necessary to start the facility. Equipment would require full check-out and operational testing.

Author: D. W. Brewer

February 26, 1993

USE OF EXISTING EQUIPMENT FOR DISASSEMBLY OF CENTRIFUGE MACHINES

DISM-69-OG

References:

1. MMES R&D staff.

(Declassification of specific elements is required for general application to D&D.)

February 26, 1993

COMPUTER-BASED D&D INFORMATION RETRIEVAL SYSTEM DISM-70-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Enabling technologies (network design for capacity and response performance of D&D information retrieval database)

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Configuration verification

Technology:

Generic. Configuration verification (high-speed servers with large-capacity volatile and nonvolatile memory storage and high-speed heterogeneous networks).

Specific. Computer-based D&D information retrieval system. Fiber-optic, high-speed networks with corresponding servers.

Status: Demonstration. Status exists with FDDI networks being the primary nominee for this purpose. An FDDI network exists within Energy Systems and is being evaluated through the Mathematics and Physics group and C&TD. The application of this technology initially only requires customization to meet the exact distribution requirements of the D&D program.

A central database and information retrieval system design with a "one area" location for all information has been planned for the D&D program. This database will have more graphics and visual information stored within it than has ever been planned before within Energy Systems. Data transmission rates and information database size will require proper planning in the design of the servers that access the database and the networking transmission media to make the volume of information accessible in a reasonable amount of time. The performance of the entire database system relies as heavily upon the performance of the networking hardware and software (and its capacity) as it does upon the design of the database and the query structure chosen.

It is intended that the database will be accessible to all program participants that require any D&D information. Everything from schedules and budgets to design-intent drawings, actual as-existing photographs, laser-mapping, three-dimensional (3-D) data, and final disposition of equipment and detailed procedures customized for every piece of equipment on the D&D list will be in the integrated database. The ability to access this information, to automatically produce a customized procedure or specification by merely inserting text and pointers in the database and having it produced as hardcopy or as mail and distributed with the inherent tracking systems to manage comments, etc., will require a massive amount of storage and server computational input/output capability.

Planning and implementation of this capability is a part of the systems approach necessary for the entire database function to approach a reasonable performance level. By addressing these requirements now, the implementation of a TQM approach will be better integrated into the entire program. Robotics:

Science Technology Needs: Specific programs, technology development needs, and technology improvement needs.

Implementation Needs: Cost of proof-of-principle, amount of resources, equipment, hardware, software, facility, and educational needs. Reference requirements needed to deploy the technology successfully.

Author: B. W. Van Hoy

References: MMES staff members.

February 26, 1993

AS-BUILT MASTER PLAN DATABASE DISM-71-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Enabling technologies

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Configuration verification

Technology:

Generic. Configuration verification

Specific. As-built master plan database

Status: Demonstration. This technology has been demonstrated at other sites on a smaller scale. Currently in Oak Ridge, the collection of as-built data is project-determined and satisfies a limited area of the plant, when it exists. When used for other applications, data most often require modifications because of the tailored characteristics related to specific projects.

Efficacy with D&D activities is high. If such a database existed, then location of dismantlement equipment would be a matter of programming the equipment to seek its precise work spot. Drawings of tooling applicable to specific tasks could be stored with the data for that task. The repetitive nature of diffusion facilities makes this technology even more attractive.

Cost benefits are related to the degree that robotics and automation are applied to dismantlement. Simulations visualizing the complete database could allow problem definition before removal of contaminated equipment. These simulations also could be used as a basis for analysis requirements such as project conceptual designs, detailed design of tooling design of development tests safety assessments, and QA plans. Savings of 20,000 work-hours could be realized during the start-up phase (3 years) of major dismantlement design efforts. In 1992 dollars, cost would be $1.6M.

As data are accumulated from many sources, these data would be archived as a part of the Master Plan Database and would allow immediate access through a well-designed man-machine interface to information such as the location of asbestos, PCBs, uranium deposits, stored waste, etc. Robotics:

Science/Technology Needs: Intelligent systems are needed that are capable of data translation and integration to common formats to interface with the as-built master database. These developments should be reflected in productions or transmissions of data throughout the system and to other databases.

A method allowing a computer system to convert electronic photographs into 3-D engineering information is needed (predemonstration level).

Holographic imaging may be a related development that is needed (predemonstration).

Technology is needed to enhance "manual drawing digitizing" to allow interpretation of the resulting file as a 3-D database (evolving technology).

Implementation Needs: Better interfacing with data generators is essential. The ability to communicate efficiently with personnel outside of engineering, who are at random locations throughout the plant areas, is needed. These individuals would communicate "red line changes" to the database across the network. The computerized system then would generate new graphic features or site attributes and accurately enter them into the system.

Author: J. H. Waggoner, L. C. Hensley

References:

1. MMES staff members.

GIF IMAGES TO ENHANCE AS-BUILT DOCUMENTATION DISM-72-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Enabling technologies (GIF imaging to enhance as-built documentation)

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Configuration verification

Technology:

Generic. Configuration verification (including personal computers, workstation computers, graphics software, digital scanners, NTSC baseband frame grabbers, high-resolution printers, vectorizing software).

Specific. GIF images to enhance as-built documentation. Specific technology exists in the image analysis and desktop publishing disciplines. The technology needs to be integrated into the design and as-built database requirements for its benefits to be realized.

Status: Predemonstration. Technology status is in the predemonstration to demonstration range of development. The concept is to take electronic images from digital cameras and camcorders as well as scanned images of common photographs and enter them into the computer. These images will be converted to GIF format for storage and viewing and will use graphics programs for contrast enhancement to obtain scale measurements and allow design personnel to evolve designs around complicated assemblies without having to routinely travel back to the contaminated site for observation. This will result in a large quality and time benefit. Robotics:

Science Technology Needs: Some technology development needs exist. Most of these stem from a systems integration set of requirements. Selection of the most advantageous suite of hardware and software that allow ease of use, high accuracy and definition, and the ability to select and view these images and display them in publications are the kind of needs that

should be addressed in a prototype system before initiation of a programwide set of GIF image specifications.

Implementation Needs: Presently, these are vague. This technology is one of the fastest evolving in the computer industry. Commercial products literally are being introduced every day. In addition, I&C at ORNL currently is doing many image storage and compression techniques for the Bureau of Engraving and Printing and the FBI which yield a 10 : 1 factor of file size with no discernable degradation in image quality. This type of industry-standard graphics manipulation to perform the job, state-of-the-art file compression to keep the database size manageable, and consideration of the response time of the computer network should allow the system to serve the entire program with an all-electronic graphics library of the design work and visual verification of the design.

Author: B.W. Van Hoy

References: MMES staff members.

February 26, 1993

ACCESS TO TECHNICAL RESOURCES DISM-73-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Enabling technologies

Reference Requirements: Refer to all data on this data sheet. Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Configuration verification

Technology:

Generic. Configuration verification

Specific. Technical resources database

Science Technology Needs: N/A

Implementation Needs: Note: This data sheet is to address the need to access current and progressive technical data referencing the technologies on hand to complete data sheets and the wiring diagram. A search was conducted of the many library capabilities and off-site databases which found the following resources to be most helpful:

- RAPIC (Remedial Action Information Center)—This is a comprehensive source of technical information pertinent to DOE's remedial action programs. This database contains scientific, technical, regulatory, and socioeconomic aspects of remediation for radioactively contaminated sites. The database has over 8500 references from both foreign and domestic reports, journals, conferences, books, theses, and patents relative to remediation. Approximately 4000 of these are related to D&D. Searches are free of charge to Energy Systems personnel. For search requests, contact Park Owen, K-1210, MS-7256, 6-0658.
- LION (Library Information On-line Network)—LION is a minicomputer system that supports on-line catalog and circulation services for books, journals, and reports for all of the Energy Systems technical libraries. Queries can be conducted by either subject or author, and all outputs locate the resource by library location.

This service can be accessed at any of the three major libraries at K-25, ORNL, or Y-12.

- ERA (Energy Research Abstracts)—ERAs are volumes published monthly that list all energy-related publications and reports. Many of these citations can be found with an ORNL database search (see Item 6 below).
- NTIS CD-ROM—Available at the ORNL Central Research Library are two CD-ROM disks which list all the documents published by the National Technical Information Service. All referenced articles are available in the microfiche files adjacent to the computer search area.
- OSTI (Office of Scientific and Technical Information)—Serves the DOE community by collecting, processing, and disseminating information resulting from DOE research as well as worldwide information on subjects of interest to DOE researchers. This information is provided to the public through the NTIS. General information: 576-4463; technical reports: 576-8401; databases: 576-1175.
- ORNL Central Research Library—This facility can conduct searches on your behalf on any technical subject, but the library has a charge for connecting to the various databases and a charge per printout of title and abstracts. Contact Robert Conrad, 574-2764, or Bill Myers, 574-6744. CD-ROMs are available for McGraw-Hill Science and Technical Reference Set, NTIS, Sce-Tech Reference Plus, and Science Citation Index, for personally conducted searches. Library staff have always been extremely helpful in locating source material.

Author: K. A. Ingle

References: MMES staff members.

February 26, 1993

ACOUSTICAL SCANNING OF DRUMS DISM-74-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Enabling technologies (vibration and acoustical scanning of drums and other closed vessels)

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Configuration verification

Technology:

Generic. Configuration verification. Requires industry-standard survey techniques for locating mass in drums and other containers that are closed and not easily opened for inspection.

Specific. Acoustical scanning of drums, including modal analysis by inputting different types of excitation energy (both vibration and acoustic) into the structure and monitoring the structure.

Status: Predemonstration. Drums, pipes runs, storage containers, process vessels, and other closed articles may or may not have large amounts of material deposited in them over time. By inputting energy into the structure, the response of the article in question is mandated by the formula F = MA. By measuring the force input and the acceleration of the response, the mass of the item can be derived. If this is significantly different from the design mass from the as-built drawings, then the discrepancy can be addressed. The frequency and magnitude of the response of the structure also will be altered as a result of contributions of the additional mass. This procedure will allow the determination of the actual level of the mass and also give a clue to the type of mass inside caused by density and damping of the additional components. Standard vibration and acoustic technology can be applied in this case, and very little customization will be necessary. This technique also lends itself well to performance by remote or robotic means, thereby not requiring any additional exposure, yet still validating the condition of the equipment in the pre-D&D state.

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This is an effort to determine the field condition of the site before the breach of structures that will occur in the D&D activities. Again, this is necessary to minimize the change for unforeseen events that have the potential to become occurrences.

This technology is in the demonstrated class. All the items are in commercial industry. They need to be applied to K-25's specific case for integration into the programmatic scheme.

Science Technology Needs: The application to K-25 may require some technology improvement needs that will require some software customization and optimization of excitation techniques to yield the best results in the least amount of testing and analysis time. The talent exists in-house to ultimately automate this type of testing and run it in a knowledge-based environment that would communicate its results directly into the integrated database of the D&D information retrieval system.

Implementation Needs: Implementation needs would require two or three modal testing engineers to baseline existing equipment and run a proof of concept tests with various excitation techniques on specific test articles. Integration and application to remote methods testing would require one test engineer to liaison with the design organization for the remote testing fixtures required for specific equipment and one engineer to specify and procure the required testing instrumentation and transducers. An instrumentation engineer and a controls programmer would have to interface with a knowledge-based programmer to design and program the knowledge-based analysis routine for each type of equipment tested (i.e., pipes, converters, valves, etc.), and these results then would be integrated into the appropriate areas of the D&D information retrieval database.

Today, approximately $500K worth of applicable instrumentation equipment exists for this effort. It is anticipated that a production system would require an additional $300K worth of testing instrumentation for evaluation of various signal processing and data acquisition techniques. Several computers also would be required for the knowledge-base effort and D&D retrieval system interface. Approximate cost is $300K.

Author: B. W. Van Hoy

References:

1. MMES staff members.

February 26, 1993

LASER TRIANGULAR MAPPING OF FACILITIES DISM-75-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Enabling technologies (laser mapping of facilities in 3-D)

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Configuration definition

Technology:

Generic. Configuration definition. Laser mapping has established distance coordinates to specific objects from a fixed reference source. This may apply to establishing exact coordinates and as-built data for disassembly.

Specific. Laser triangular mapping of facilities. The triangulation mapping with laser scanning of equipment in contaminated areas will establish an as-built database for the specific equipment immediately before D&D. This technology can confirm or deny the true as-built status and allows decisions to be made real-time on the status of disassembly for the specific equipment in question. Once D&D has been approved, this technology has established an exact relative set of dimensions for the robotic or remote manipulations necessary to achieve the task at hand.

This technology allows the coordinates for remote or robotic manipulation of the D&D to occur without any hands-on measurements and, as such, eliminates the opportunity for worker exposure to hazards. The measurements are also extremely accurate and, in the appropriate integrated database, can be used to verify the design intent before starting the D&D effort on any specific piece of equipment. This obviously gains several advantages to hands-on personnel doing D&D and running the potential to hazardous exposure as well as the speed of digital distance measurement and scanning. The instruments should scan and measure the entire compressor/pump area in approximately 30 min and relate these data to the design and graphics database.

In addition, the D&D effort can become extremely unwieldy, if an unanticipated component or event takes place well into the disassembly effort. The advantage of laser mapping and triangulation is that they anticipate these events before the existing structures are breached, avoiding the complications and potential occurrences that such an incident would beget.

Status: Predemonstration. Laser scanning and distance mapping have been applied in many different disciplines. Actual integration into a computer 3-D database for remote manipulation is probably in the predevelopment stages at commercial enterprises.

Science Technology Needs: Specific, detailed software that integrates 3-D mapping into an existing database for use in robotic or remote manipulation applications will be required. Manipulation of the database and adjustment/calibration of the sensors in a real-time field mode of operation will be necessary to achieve success of this program.

Implementation Needs: A development effort between Energy Systems and commercial systems developers will be required.

A resource of programmers, workstation computers, lasers, I&C coordinators, commercial firms, and best efforts contracts will be required to demonstrate this technology.

After a 1- to 2-year development effort with individuals skilled in robotics, mechanical design, electronics design, software design, and optics and optical mapping, a sufficient expertise should be available to initiate a design and procurement specification for procurement of multiple units to accomplish the optimum methods of D&D using either remote or robotic methods.

Author: B. W. Van Hoy

References:

1. MMES staff members.

February 26, 1993

QUALITATIVE IR THERMOGRAPHY (ENABLING TECHNOLOGIES) DISM-76-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Enabling technologies (surface and/or hidden/contained uranium, oil, or PCBs, contaminant detection and removal)

Reference Requirements: (To be provided by "Regulatory Team.") Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Configuration definition. Component inspection and/or contaminant detection through differences in thermal resistance and/or capacitance.

Technology: Qualitative IR thermography to detect piping flaws, piping contents, or effect of invasive thermal techniques (e.g., laser, torch cutting).

Status: Demonstrated

Advantages:
- Inexpensive, portable, noninvasive, passive measure.
- Real-time or VCR/still imaging.
- Reasonablly compact apparatus (approximately 75 lb and 6 ft^3).
- Excellent, initial gross detection method.

Disadvantages:
- Image often requires trained interpretation.
- Emissivity differences and/or local spurious infrared sources may complicate image analysis.

Competitive Technologies:
- Other thermal measures—Thermocouples (cheap, point measures), "crayons" (cheap, very rough manual measure), thermal resistive devices (cheap, slow measures), IR arrays or single IR transistors (moderately priced, point measures).
- Techniques based on other phenomena such as nuclear radiation, electromagnetic radiation, emitted light or sound, ultrasound, strain, etc. Perhaps most immediate

competitor is visible light solid-state camera; generally cheaper, simpler operation than IR camera when both are available.

- AGA-750/AGA-782: ATD offers system and operator at roughly $70/hr, plus applicable overheads. ATD can provide liquid N_2 coolant; sponsor may have to provide power. Sponsor is additionally responsible for logistical support including: travel, decontamination, and a site guide. ATD does not offer system-only use.
- AGA-900: A more advanced system such as the AGA-900 could cost over $110K. However, the AGA-900 is quantitative, and links to PC software for image analysis. ATD does not carry an AGA-900 but can provide operator support tailored to a sponsor's needs.

Use of existing AGA-750/782 ATD systems can provide immediate payback with little up-front cost. Purchase of a dedicated system, such as the AGA-900, can provide enhanced performance with substantial capital investment; such a purchase might be justified by a need for extensive quantitative data to support engineering analysis, and/or long-term project use.

Transport generally takes two man-trips. Set-up for portable AGA-750 typically takes 10 min but requires no interface to outlets or building equipment. Setup for semiportable AGA-782 (color, real-time image record) takes up to 1 hour and requires external power. One trained operator can run the AGA-750 for 2–4 h; the AGA-782 has no battery-recharge limit on operation. Assorted lenses provide varied fields of view and zoom.

Example: Piping with trap suspected to contain ^{235}U residue. Method: Provide transient heating and look for delayed surface temperature rise caused by high thermal capacitance ^{235}U mass. Estimate in work-hours: transport (0.5), setup (0.5), transient "blow dryer" heating (1), real-time varied-angle thermal decay viewing and B&W Polaroids snapshots for record (1.5), tear-down (0.5), transport (0.5), support [2-way travel, oral report, VCR review, recharge, liquid N_2 refill] (3). Total time: 6 work-hours. Total cost: $420

Assumptions: No donning, doffing, or contamination, safety or health procedures are required by the environment; guided, unobstructed access and transport over distance under 100 yd; AGA-750 system used; view uncomplicated by complex thermal environment, obstructions, or elevation, etc. Violation of aforementioned assumptions generally add to cost.

Generation of spent inert nitrogen gas may complicate operation in a tight, confined space. Robotics: Generally locally operated. Remote operation and robot-arm-type mounting are both possible, but will likely require development for particular application.

Science Technology Needs: Requires natural or applied transient or steady-state heating. The method work best with IR-flat background.

QUALITATIVE IR THERMOGRAPHY (ENABLING TECHNOLOGIES)

DISM-76-OG

Implementation Needs: ATD's 2 AGA systems require liquid nitrogen and should not be used in a high-shock or vibratory environment. Only a few hours of sampling time are possible per battery charge, although AC power is also available.

Author: F. L. Paulauskas

References:

1. MMES staff assessment.
2. AGEMA Infrared Systems, Product Literature.

February 26, 1993

VIDEO MAPPING DISM-77-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Enabling technologies

Reference Requirements: Document (to be provided by "Regulatory Team") Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Configuration definition

Technology:

Generic. Configuration definition

Specific. Video mapping, including video (or photographic) imaging for configuration mapping, evaluation, and control.

Status: Demonstration. Video images can be an effective means of establishing configuration layouts for planning and executing work. Digitizing video (photographic) images for establishing baseline layouts and for computer-automated comparison of different positions with a baseline to characterize and establish equipment differences would facilitate planning and work direction. Comparison of multiple-digitized images to highlight differences and conversion of images to line drawings is a well-established, demonstrated set of technologies.

Digitized imaging should be an important program tool, useful from project inception through completion. It also should be adaptable to facilitate dismantlement progress and to document completion. Cost for use would be small (<$200K over the course of a dismantlement project). This technology would not generate waste.

Science Technology Needs: Document. Technology development needs include the assembly of an imaging/computer system, software development, procedure development, and personnel training.

Implementation Needs: Document.

Resource requirements and development needs are as follows:
- Imaging, computer, and related hardware (approximately $40K–$60K)
- System integration and development (approximately $300K–$400K)
- Development personnel—image technologist, software specialist, project manager
- System functional testing
- 9–15 month development

Deployment Requirements:
- Procedure development and documentation ($30K–$50K)
- User training ($10K to $20K)
- System replication cost (if more than one system) ($60K to $80K)

Cost and schedule time were estimated by the contributor. Efficiency of the technology is based on a similar technology already demonstrated at ORNL.

Author: W. S. Key

References:
1. MMES staff assessment.

PHOTONIC REMOVAL OF CONTAMINANTS DISM-78-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Enabling technologies

Reference Requirements: Document (to be provided by "Regulatory Team.") Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Configuration definition

Technology:

Generic. Configuration definition

Specific. Photonic removal of contaminants by laser ablation, photolysis, etc. (In situ removal of small quantities of surface contaminants).

Status: Predemonstration. The technical approach to surface removal of materials and coatings by laser ablation, photo-induced thermal shock, photolysis, and other light-driven means is a well-demonstrated approach receiving greater current attention. It has the advantages of quickly removing materials at controlled rates and for which the depth of removal can be controlled. A specific technique from the area of photonics removal would facilitate the in situ removal of small levels of contaminants, thus allowing the immediate disposition of dismantled equipment for disposal. Thus, cost savings from lower material handling, avoidance of more complex and costly decontamination processes, and avoidance of mixed waste generation should be achievable. Such cost savings should be in excess of $200M.

Science Technology Needs: Predemonstration. The technology lies between the technology development and improvement state. It has been demonstrated and used outside the laboratory, but scale-up to major implementation has not been demonstrated. Complete development, including a fieldable prototype system, would cost an estimated $1M and would would take approximately 12–18 months.

February 26, 1993

Implementation Needs: To implement a system would cost between $150K and $250K, depending on desired removal rates, and additional requirements would be automation or semiautomation of the device for remote or limited man-interface during operation.

Author: W. S. Key

References:

1. MMES Photonics R&D staff assessment.

February 26, 1993

POINT AND DIRECT DISM-80-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Enabling technologies

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the Oak Ridge Reservation, radiation protection standards, DOE orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternative: Dismantlement support

Technology:

Generic. Dismantlement support

Specific. Point and direct. A semiautomated approach to directing the cutting, disassembly, and removal of equipment or materials. This approach would use an operator with a light wand to identify work paths for optically guided tools.

Status: Evolving technology (conceptual). The concept is in the preproof-of-principle state but relies on off-the-shelf components to implement. Thus, minimal development will be needed. Should be a good compromise where full automation or robotics are not achievable or impractical.

Science Technology Needs: Develop prototype and demonstrate efficacy. Requires integration of hardware and minimal software development. Cost to complete development is estimated to be $500K.

Implementation Needs: A prototype system should be field tested to evaluate and identify deployment needs. Testing could be done in conjunction with field demonstration of one of the dismantlement or decontamination technologies.

Author: L. C. Hensley, W. S. Key

February 26, 1993

References:

1. D. Farson, "Presentation of Point-and-Direct Robotic Welding," Penn State Applied Research Laboratory, April 15, 1992.

2. Farson, D. F., Penn State Applied Research Laboratory, personal communication, August, 1992.

IMPROVED PROTECTIVE CLOTHING AND EQUIPMENT DISM-81-OG

EM Problem: Decommissioning

K-25 Site Problem: Enrichment process buildings, process support buildings, cooling towers, electrical and electrical switch gear, pumping stations, laboratory facilities, special development facilities, administrative facilities

Problem Area/Constituents: Diffusion equipment contaminated with small amounts of uranium, oil, and PCBs

Reference Requirements: Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelement: Dismantlement

Alternatives: Generic technology; dismantlement support

Technology: Improved protective clothing and equipment

Status: Evolving technology. Because of the large amounts of protective clothing and equipment required to protect workers during the dismantlement of the massive diffusion plants, a very large sum of money has been included in the base case estimate. This estimate includes both the direct cost of equipment and indirect cost of lost worker efficiency caused by the limitations of working in the currently available equipment. A total cost of over $1 billion has been estimated. No known program currently exists to develop specific equipment of this nature for the diffusion plant dismantlement tasks.

Science/Technology Needs: Investigation of specific requirements for the dismantlement of a diffusion plant relative to criteria for this equipment must be conducted. Human engineering techniques must be used to model the doning and doffing routines and new techniques must be developed to speed this process as well as to specify newer materials more capable of recycling and/or safe disposal. The cost of such a program may be in the $3M–$5M range.

Studies must be made to plan the dismantlement sequence to permit design of enclosures, both mobile equipment cabs and portable containments, that better suit the repretitive nature of the diffusion facilties to be dismantled. The cost of this program would be in the $2M–$3M range.

Implementation Needs: Full engineering and development of the equipment is needed. Many commercial opportunities exist to work outside the government sphere to engineer and

develop such equipment. Most of the work would not be highly technical but would require a dedicated team with ergonomic skills. The cost of such a task would be in the $6M–$10M range. Payback potential relative to the $1 billion estimate within the diffusion plant tasks could be up to 50%.

Author: L.C. Hensley

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1. MMES staff members.

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Department of Energy

Adams, W. D.
DOE-OR
Assistant Mgr., ERWM

Bandy, Darrel H.
U. S. Department of Energy
P. O. Box 5400
Albuquerque, NM 87115

Bassi, Jo-Ann
DOE EM-351
c/o Ken Kuzio
Sandia Nat'l Lab
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2nd Floor, Rm. 211
Germantown, MD 20874

Cheng, Sam
US Department of Energy
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Clarke, Susanne
A6-55, US Department of Energy
P. O. Box 550
Richland, WA 99352

Duquella, Leon
ERWM, DOE-OR

Ellis, Nate
P. O. Box A
US Department of Energy
Solid Waste Division
Aiken, SC 29802

Frank, C. W.
Deputy Assistant Secretary,
EM-50,
Rm. 6B132, Forestal Bldg.
U. S. Department of Energy
Washington, DC 20585

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DOE-OR
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ER

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A5-19, US Department of Energy
825 Jadwin Ave.
Richland, WA 99352

Grace, Scott R.
US Department of Energy
Rocky Flats Office
DOE Bldg. 116
P. O. Box 928, Hwy 93
Golden, CO 80402-0928

Hain, K. E.
EM-55, Trevion II
U. S. Department of Energy
Washington, DC 20585

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DOE-OR
WMD, K-25

Hinschberger, Scott T.
785 DOE Place, MS-1219
Idaho Falls, ID 83401

Hyde, Jerry
US Department of Energy
EM-551, Trevion II Bldg.
Washington, DC 20585-0002

Johnson, Sherri V.
US Department of Energy
P. O. Box A, 703 A-B211
Aiken, SC 29802

Jugan, Mike
DOE-OR
ER, ORNL

Korynta, Rick
DOE-OR
WM

Lankford, Mac
DOE-HQ, EM55

Lankford, Sherry
DOE-OR
ER, Y-12

Lien, Steve
EM-54, Trevion II
U. S. Department of Energy
Washington, DC 20585

Lester, Brady
DOE-OR, ER

Lingle, Nelson
DOE-OR

McWilliam, Katie
US Department of Energy
Nevada Field Office
P. O. Box 98518
Las Vegas, NV 89193-8518

Mikkola, A. W.
US Department of Energy
Idaho Field Office
785 DOE Place
Idaho Falls, ID 83415

Moore, Johnny
US Department of Energy
DOE-OR
P. O. Box E
200 Administration Rd.
(Zip: 37830)
Oak Ridge, TN 37831

O'Rear, Michael
US Department of Energy
Savannah River Field Office
RFD #1, Bldg. 703A
Rm. E-208-N
P. O. Box A
Aiken, SC 29802

Powell, Jane
DOE-OR
ER, ORNL

Price, Les
DOE-OR
ER Enrichment

Radcliffe, Larry
DOE-OR
WMD

Riddle, Suzy
DOE-OR, ER

Roddye, Mac
DOE-OR
WMD, ORNL

Sager, Joy
DOE-OR
WMD, Y-12

Saxman, Pamela A.
US Department of Energy
RDDT&E
P. O. Box 5400
Albuquerque, NM 87115

Schneider, George
US Department of Energy
Idaho Field Office
785 DOE Place
Idaho Falls, ID 83402

000180

Schutte, W. C.
DOE-HQ, EM-551,
Trevion II
U. S. Department of Energy
Washington, DC 20585

Scott, Richard
US Department of Energy
San Francisco Field Office
1333 Broadway
Oakland, CA 94612

Shupe, Mel
DOE-HQ
EM-54

Sleeman, Bob
DOE-OR, ER Enrichment

Staats, Gary E.
US Department of Energy
Pittsburgh Energy Tech. Center
P. O. Box 10940
Receiving Dept. Bldg. 16
Cochran's Mill Road
Pittsburgh, PA 15236-0940

Stevenson, Karen
US Department of Energy
376 Hudson Street
New York, NY 10014-3621

Sweeney, John
DOE-OR
ER, ORNL

Tison, Tom
DOE-OR, K-25

Trader, Deborah E.
US Department of Energy
Richland Field Office
825 Jadwin Ave.
P. O. Box 550
Richland, WA 99352

Traglini, Mike
DOE-OR
ER, Y-12

Tyler, Reginald
US Department of Energy
Rocky Flats Office
DOE Bldg. 116
P. O. Box 928, Hwy 93
Golden, CO 80402-0928

Underwood, Doug
DOE-OR
WMD

Velezquez, Luis
DOE-OR

Voelker, Gary
EM-50, Trevion II
Washington, DC 20585

Wallin, Bruce W.
US Department of Energy
Rocky Flats Office
P. O. Box 928
Golden, CO 80402-0928

Walker, Bryan
Deputy AM for ERWM
DOE-OR

Webster, Steve
US Department of Energy
Chicago Field Office
9800 South Cass Ave.
Argonne, IL 60439

Whitehead, Rebecca
DOE-OR

Wolf, Stan
EM-54, Trevion II
U. S. Department of Energy
Washington, DC 20585

External

Allen, D.
Radian Corp.
Oak Ridge, TN

Austin, Bill
WSRC
P. O. Box 616
Aiken, SC 29808

Bain, J.
SAIC
Route 2
Kevil, KY 42053

Barber, David
Sandia National Laboratories
Organization 7023
P. O. Box 5800
Albuquerque, NM 87185

Barnes, T.
Machine Kinetics Corp.

BDM International/SAIC
12850 Middlebrook Rd.
Suite 300
Germantown, MD 20874

Bliss, Wayne
ES&H Div.
Reynolds Elec. & Engineer Co.
P. O. Box 98521
Las Vegas, NV 89193-8521

Boing, Larry
Argonne National Laboratory
9700 S. Cass Ave.
Argonne, IL 60439-4831

Benedetti, R. L.
EG&G Rocky Flats, Inc.
P.O. Box 464
Golden, CO 80402-0464

Berger, James
Office of Tech. Integration
Westinghouse Hanford Co.
P. O. Box 1970, MS L)-18
Richland, WA 99352

Berry, Dennis
Sandia Nat'l Laboratories
P. O. Box 5800, Dept. 6602
1515 Eubank S.E.
(Zip: 87123)
Albuquerque, NM 87185-5800

Brown, Craig
EPA, Region IV
Atlanta, GA

Buelt, Jim
Pacific Northwest Laboratory
P. O. Box 999, MSIN P7-41
Battelle Boulevard
Richland, WA 99352

Carlsen, B.W.
Westinghouse Idaho
Nuclear Co.
5108 P. O. Box 4000
Idaho Falls, ID 83415

Carroll, M. K.
Machine Kinetics Corp.
Knoxville, TN

Carter, Randy
Applied Radiological
Control, Inc
500 Chastain Center Blvd.,
Suite 545
Kennesaw, GA 30144-5559

000481

Christian, Jerry
Westinghouse Idaho Nuclear Co.
P. O. Box 4000
Idaho Falls, ID 83403

Coleman, J. Todd
WSRC, Bldg. 773-41A
Aiken, SC 29808

Colombo, Peter
Brookhaven National Lab
Bldg. 703-50 Rutherford
Upton, NY 11973

Conway, Sheila
Colorado Center for
Environmental Mgmt
1536 Cole Blvd, Bldg 4
Suite 180
Golden, CO 80401

Corones, James
AMES Laboratory
329 Wilhelm Hall
Iowa State University
Ames, Iowa 50011

Crockett, John
Oak Ridge Institute for Science
and Energy
P. O. Box 117
Oak Ridge, TN 37831

Dantz, John
SAIC
Germantown

Demmer, Rick
Westinghouse Idaho
Nuclear Co.
P. O. Box 4000, MS-5218
Idaho Falls, ID 83403

Denny, Paul
Penn State Applied
Research Laboratory
State College, PA

Deonigi, Duane
PNL, P. O. Box 999
Richland, WA 99352

Ditch, Ralph
Argonne National Laboratory
9700 S. Cass Ave.
Argonne, IL 60439

Dugger, H. A.
Kaiser Engineering
214 Pinetree
Richland, WA 99352

Eagan, Neal S.
Prgrm Development Div.
MSE Inc.
P. O. Box 3767
Butte, Montana 59702

Eaton, A.
SAIC, Rt. 2
Kevil, KY 42053

Emilia, Dave
Strategic Planning Dept.
Chem-Nuclear Geotech
P. O. Box 14000
2597B-3/4 Rd. (81503)
Grand Junction, CO 81502-2567

Erickson, M. D.
Argonne National Laboratory
9700 South Cass Ave. CMT/205
Argonne, IL 60439-4837

Ferguson, James F.
Westinghouse Idaho
Nuclear Corporation
P. O. Box 1625, MS-3970
Idaho Falls, ID 83415

Flores, Pedro
Smith, R. H.
Savannah River Site
P.O. Box 616, Bldg. 707-H
Aiken, SC 29806

Frazee, Brad
Westinghouse Idaho
Nuclear Co.
P. O. Box 4000
Idaho Falls, ID 83403

Fredette, Debbie
SAIC
P. O. Box 99
West Paducah, KY 42086

Gilchrist, Roger
Technology Demonstration
Programs
Westinghouse Hanford Co.
P. O. Box 1970, MS L5-63
Richland, WA 99352

Gillies, Bruce
ETEC, D/030, T038
P. O. Box 1449
Canoga Park, CA 91304

Goodell, Mark D.
WSRC, Bldg. 773-41A
Aiken, SC 29808

Gupta, Bimleshwar (Bim)
Manager, WM Programs
Nat'l Renewable Energy
Laboratory
1617 Cole Boulevard
Golden, CO 80401

Haas, Bill
AMES Laboratory
7 Spedding Hall
Iowa State University
AMES, Iowa 50011

Helt, James E., PhD
Director
Office of Waste Mgmt Prgms
9700 South Cass Ave.
Argonne, IL 60439-4837

Heine, William F.
B3-63, Westinghouse
Hanford Co.
P. O. Box 1970
Richland, WA 99352

Herman, Donald
Westinghouse Env.
Management Co.
of Ohio, Inc.
P. O. Box 398704
Cincinnati, OH
45239-8704

Heywood, Ann Cochran
P. O. Box 808
7000 East Avenue
MS L-207
Livermore, CA 94612

Hinds, Ron
SRTC, Bldg. 773A, Room B121
Aiken, SC 29802

Hottel, Robert E.
WSRC, P. O. Box 616
Aiken, SC 29808

Ison, Mike
Westinghouse Idaho Nuclear Co.
P. O. Box 4000, MS-5119
Idaho Falls, ID 83415

Jacobson, Roger, PhD
Desert Research Institute
P. O. Box 19040
Las Vegas, NV 89132-0040

Jaeger, Ralph
EG&G-Mound
One Mound Rd.
Miamisburg, OH 45343

000482

Jarrett, Jim
Pacific Northwest
Laboratories
P. O. Box 999, MS P7-43
Richland, WA 99352

Johnesee, Jim
Waste Policy Institute
12850 Middlebrook Rd.
Suite 108
Germantown, MD 20874

Jordan, David L.
Allied Signal Aerospace
Kansas City Plant
P. O. Box 419159,
D/272, FV43
2000 East 95th Street
Kansas City, MO 64141-6159

Kan, T.
AVLIS, LLNL
P. O. Box 94550
Livermore, CA

Karas, Theodore
EG&G, Bldg. T371 A
Rocky Flats Plant
P. O. Box 464
Golden, CO 80402-0464

Kelly, Vince
MSE, Inc.
P. O. Box 3767
Butte, Montana 59702

Koller, Ken
Waste Tech. Development
EG&G Idaho, Inc.
P. O. Box 1625
Idaho Falls, ID 83415-3940

Kostelnik, Lori
Westinghouse Idaho Nuclear Co.
Box 4000, MS-3205
Idaho Falls, ID 83415

Kuhl, Roger
AL/EQ
139 Barnes Dr., Bldg. 1117
Tyndall AFB, FL 32403-5319

Kuzio, Ken
Sandia Nat'l Lab
20201 Century Blvd.
2nd Floor, Rm. 211
Germantown, MD 20874

Larson, Scott
Princeton Plasma Physics Lab
P. O. Box 451
Princeton, NH 08543

Marske, Steve
Westinghouse Hanford Co.
P. O. Box 1970
Richland, WA 99352

McClure, Lloyd W.
Westinghouse Idaho Nuclear Co.
P. O. Box 4000
Idaho Falls, ID 83415-32111

McCoy, R. D.
Tennessee Department of
Environment &
Conservation
Emory Valley Road
Oak Ridge, TN 37830

McEvilly, Thomas
50E-111
Lawrence Berkeley Laboratory
1 Cyclotron Road
Berkeley, CA 94720

Mech, Steve
Westinghouse Hanford Co.
P. O. Box 1970,
MSIN L7-03
Richland, WA 99352

Merrill, Ken
EG&G Idaho, Inc.
P. O. Box 1625
Idaho Falls, ID 83415-3970

Meservey, Richard
D&D Program Manager, INEL
P. O. Box 1625, MS-1545
Idaho Falls, ID 83415

Meyer, Rod
Energy Technology
Engineering Center
P. O. Box 7930
Canoga Park, CA 93209-7930

Miller, R. L.
(H6-92), Westinghouse
Hanford Co.
P. O. Box 1970
Richland, WA 99352

Montoya, Gilbert
Los Alamos National Laboratory
P. O. Box 1663, MS #516
Los Alamos, NM 87545

Murphy, Hugh D.
ET-AET
Los Alamos Nat'l Lab
MS D446
Los Alamos, NM 87545

Neathery, A. P.
Kaiser Engineering -
Hanford
Richland, WA

Nelson, Jennifer
Sandia Nat'l Laboratories
P. O. Box 5800, Div. 6621
1515 Eubank S.E.,
(Zip 87123)
Albuquerque, NM 87185-5800

Newman, Christine
Westinghouse
Environmental
Management Co.
of Ohio, Inc.
P. O. Box 398704, MS 52
Cincinnati, OH
45239-8704

Nuhfer, Kimberly
Fernald Environmental
Management Co. of OH
P. O. Box 398704
Cincinnati, OH 45239-8704

O'Brien, Mike
EG&G
200 South Woodruff Ave.
Idaho Falls, ID 83415-3970

Olson, Herb
WSRC, P. O. Box 616
CCC Bldg. #4
Aiken, SC 29808

Peterson, Jerry L.
EG&G Rocky Flats, Inc.
Technology Department
P. O. Box 464
Golden, CO 80402-0464

Peterson, Mary
Pacific Northwest Laboratory
P. O. Box 999, MSIN P7-41
Battelle Boulevard
Richland, WA 99352

Petit, Paul J., PhD
FERMCO
6025 Dixie Hwy, Suite 250
Fairfield, OH 45014

Rankin, Nevyn
WSRC
P. O. Box 616
Aiken, SC 29808

Reynolds, Evan
Gilbert Commonwealth
1055 Commerce Park,
Suite 200
Oak Ridge, TN 37831

Robinson, Bill
Sandia Nat'l Laboratories
P. O. Box 969, Dept. 8240
7011 East Avenue (Zip: 94551)
Livermore, CA 94550

Rogers, Leo
EG&G Energy
Measurements, Inc.
P. O. Box 1912, MS RSL-11
Las Vegas, NV 89125

Rudin, M.
EM-54, Trevion II
U. S. Department of Energy
1000 Independence
Ave. SW
Washington, DC
20585-0002

Sampinato, Phil
Princeton Plasma Physics
Laboratory
Princeton, NJ

Sanford, Pete
KMI Services
4888 Pearl East Circle
Suite 103
Boulder, CO 80301

Sigg, R.
WSRC, P. O. Box 616
Bldg. 773A
Aiken, SC 29808

Slate, Steven C.
Pacific Northwest Laboratory
MSIN KI-19
Office of Environmental Tech.
P. O. Box 999
Richland, WA 99352

Smet, David
Westinghouse Hanford Company
P. O. Box 1970
MSIN X5-52
Richland, WA 99352

Snook, Jeff
75 DOE Place
Idaho Falls, ID
83401-1562

Spence, Scott
Kaiser Engineers - Hanford
P. O. Box 888, MISN #6-41
Richland, WA 99352

Steel, John L., P.E.
Waste Env. Remediation Prgms
Savannah River Tech. Center
Bldg. 773-41A
Aiken, SC 29802

Stein, Steve
Deputy General Manager
Environmental Mgmt Org.
Pacific Northwest Division
4000 N.E. 41st Street
Seattle, WA 98105

Stevens, Kenneth
WSRC
P. O. Box 616, Bldg.
992W-1
Aiken, SC 29808

Stewart, Irwin
Chem-Nuclear Geotech
P. O. Box 14000
Grand Junction,
CO 81506

Sturm, Harold F.
Savannah River Technology
Center
Savannah River Site
P. O. Box 616
Aiken, SC 29801

Swindle, Dave
Radian Corporation
Oak Ridge, TN

Walton, Russ
Princeton Plasma
Physic Lab.
P. O. Box 451
Princeton, NJ 08543

Waste Policy Institute
12850 Middlebrook Rd.
Suite 206
Germantown, MD 20874-5544

Waste Policy Institute
1872 Pratt Drive
Suite 1600
Blacksburg, VA 24060-6363

Wheelis, Ted
Sandia Nat'l Laboratories
Dept. 6623
1515 Eubank S.E.,
(Zip 87123)
Albuquerque, NM 87185

Wichlacz, Paul
INEL, EG&G
200 South Woodruff Ave.
Idaho Falls, ID 83415

Widrig, C.
Battelle—PNL
P. O. Box 999
Richland, WA 99352-K121

Wilks, D
SAIC, Rt. 2
Kevil, KY 42053

Woehr, C.
SAIC, Rt. 2
Kevil, KY 42053

Zeh, Charles
Morgantown Energy
Technology Center
3610 Collins Ferry Road
Morgantown, WV 26507-0880

000184