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ENGINEERING COMPUTER OPTECNOMICS, INC.

ROAD TRANSPORTABLE ANALYTICAL
LABORATORY (RTAL) SYSTEM

QUARTERLY TECHNICAL REPORT
DECEMBER 1992 - FEBRUARY 1993

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U.S. DEPARTMENT OF ENERGY
MORGANTOWN ENERGY TECHNOLOGY CENTER
ATTN: CONTRACTOR REPORTS RECEIPT COORDINATOR
M/S F07, P.O. BOX 880
3610 COLLINS FERRY ROAD
MORGANTOWN, WEST VIRGINIA 26507-0880

FOR:

U.S. DEPARTMENT OF ENERGY
MORGANTOWN ENERGY TECHNOLOGY CENTER
P.O. BOX 880
MORGANTOWN, WEST VIRGINIA 26507-0880

BY:

ENGINEERING COMPUTER OPTECNOMICS, INC. (ECO)
1356 CAPE ST. CLAIRE CENTER
ANNAPOLIS, MARYLAND 21401

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

036 Cape St. Claire Center, Annapolis, Md. 21401 Tel: (301) 757-3245

TABLE OF CONTENTS

	<u>Page</u>
Contract Objective	1
Background	1
Approach	3
Progress During Quarter	3
Task 2 - Performance Requirements	5
Task 3 - Development of Conceptual Design	19
Plans for Next Quarter	24
Overall Status Assessment	24

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CONTRACT OBJECTIVE

The goal of this contractual effort is the development and demonstration of a Road Transportable Analytical Laboratory (RTAL) system to meet the unique needs of the Department of Energy (DOE) for rapid, accurate analysis of a wide variety of hazardous and radioactive contaminants in soil, groundwater, and surface waters. This laboratory system will be designed to provide the field and laboratory analytical equipment necessary to detect and quantify radionuclides, organics, heavy metals and other inorganics, and explosive materials. The planned laboratory system will consist of a set of individual laboratory modules deployable independently or as an interconnected group to meet each DOE site's specific needs. Modules considered for inclusion in the system are:

- Radiochemistry Laboratory
- Chemical Analysis Laboratory
- Biomonitoring Laboratory
- Field Analytical Instrument Laboratory
- Robotic Sampler/Monitor Base Station
- Decontamination Trailer
- Operations Control Center
- Protected Living Quarters

Each module will provide full protection for operators against radioactive particulates and conventional environmental contaminants.

The use of a road transportable, fully independent, highly reliable laboratory system will save the DOE significant time and money by eliminating costly, paper-intensive, and time-consuming shipment of samples to central laboratories. The goal of the integrated laboratory system is to provide a full range of analyses within 16 hours (after sample preparation) with high accuracy and quality assurance. At the same time, the system will provide full protection for the operating personnel and the sensitive analytical equipment against the environmental extremes and hazards encountered at DOE sites.

BACKGROUND

The DOE facilities around the country have, over the years, become contaminated with radionuclides and a range of organic and inorganic wastes. The major types of contamination found at the various sites have been summarized in the "Environmental Restoration and Management Five Year Plan" and, except for radionuclides (at most locations) and high explosives (at a few locations), are representative of the types of wastes found at many manufacturing facilities.

The DOE faces additional unique challenges in cleaning up this

contamination. Many of the DOE sites encompass large land areas and were originally sited in relatively unpopulated regions of the country to minimize risk to surrounding populations. In addition, many times wastes were stored underground at the sites in 55-gallon drums, wood boxes or other containers until final disposal methods could be determined. Over the years, these containers have degraded, releasing contaminants into the surrounding environment. This contamination has spread, in some cases polluting extensive areas.

Remediation of these sites requires extensive sampling to determine the extent of the contamination, to monitor cleanup and remediation progress, and for post-closure monitoring of facilities. The Environmental Protection Agency (EPA) has found that shipping samples to a central laboratory for analysis is a slow and expensive process. The EPA is emphasizing the use of field instrumentation and transportable laboratories to provide critical analytical data (which form the basis for remediation decisions) faster and at lower cost. The use of field systems can cut several weeks to months off the turnaround time for analytical information.

The DOE's problems in getting samples analyzed is further compounded by the likely presence of radionuclides in the samples. DOE's samples require wipe tests for surface contamination before shipment and after receipt, specialized transportation containers and procedures (depending on the level of radioactivity), and a substantial amount of additional paperwork. It can be very difficult to ship samples off-site from DOE facilities because of requirements established to ensure against inadvertent release of radioactive materials.

Thus, the DOE would benefit greatly if it had reliable road transportable, fully independent laboratory systems that could perform the full range of analyses required on-site. Such systems could accelerate the remediation effort by providing critical analytical data more rapidly, and save significant sums of money by eliminating transportation costs and manpower costs associated with sample shipments.

The current effort addresses the unique requirements of the DOE for a Road Transportable Analytical Laboratory system capable of screening for a wide variety of hazardous and radioactive contaminants in soil, groundwater, and surface waters. This laboratory is being designed to provide the field and laboratory analytical equipment necessary to detect and quantify radionuclides, organics, heavy metals and other inorganics, and explosive materials.

The use of a road transportable, fully independent, highly reliable laboratory system, the RTAL, will save the DOE significant time and money by eliminating costly, paperwork-intensive and time-

consuming shipment of samples to central laboratories. The integrated RTAL system will be able to provide a full range of accurate analyses on-site. At the same time, the RTAL system will provide full protection for the operating and the sensitive analytical equipment against the environmental extremes and the hazards encountered at DOE sites.

APPROACH

The development of the Road Transportable Analytical Laboratory system will be conducted in two phases. Phase I, encompassing work at Maturity Level 4, is for the evaluation of an optimized design of the RTAL system to most effectively meet the needs of the DOE. This phase will incorporate development of detailed performance requirements (based on documented data and meetings with potential DOE users of the RTAL system), development and evaluation of alternative system designs, and optimization of the final design. The phase I results will include a quantitative analysis of the cost and time savings to be provided by the RTAL system compared to current procedures for off-site sample analyses.

Phase II of this effort represents a transition to Maturity Level 5, Full-Scale Demonstration. A full-scale, fully operational prototype RTAL system will be constructed. This system will be tested at an appropriate DOE site or sites to demonstrate the performance of the system and further quantify the cost and time savings it provides.

Upon completion of Phase II, ECO, Inc. will enter into commercial production of the Road Transportable Analytical Laboratory system, providing full warranties and guarantees for the product. The RTAL system will be integrated into ECO's existing line of TERMMTM and Superfund TERMMTM modular transportable analytical laboratory and operational control systems.

PROGRESS DURING QUARTER

This report documents the progress achieved on the development of the Road Transportable Analytical Laboratory system during the second quarterly period of the Phase I development, from December 1, 1992 through February 28, 1993. The Phase I effort under this contract is divided into six tasks:

- Task 1 - Information Required for NEPA
- Task 2 - Performance Requirements
- Task 3 - Development of Conceptual Design
- Task 4 - NQA1 Compliance Analysis
- Task 5 - Final Design
- Task 6 - Phase 1 Topical Report

The schedule for the performance of these tasks is provided in Figure 1. In accordance with this schedule, Task 1 was completed during the first quarterly period. Work was performed on Tasks 2 and 3 during the second quarterly period just completed. The progress achieved for these two tasks is discussed below.

Task 2 - Performance Requirements

The DOE's Office of Environmental Restoration and Waste Management is conducting a study of projected analytical needs across the DOE Complex. The study concentrates on the DOE's nine largest facilities in terms of analytical requirements and extrapolates these data to the entire Complex. The preliminary results of this study (as of September 1992) were obtained and reviewed. The final version of the study is expected to be published during the 2nd quarter of FY 1993 but is not yet available.

The study projects that, across the DOE Complex, some 1.2 million sample analyses were performed on 60,000 samples during FY 1991. This demand is projected to grow to 3.3 million analyses on 130,000 samples in FY 1994. The study indicates a slow drop in demand after FY 1994, but this may be an artifact due to the relative scarcity of remediation project definition in the out-years.

Most of the samples that will be taken and analyzed are for operable unit characterization and for low level/mixed waste disposal. The types of analyses that will have to be performed are:

- Volatile Organics by GC/MS
- Semi-Volatile Organics by GC/MS
- Pesticides/PCB's by GC
- Toxicity Characteristic Leach Procedure (TCLP)
- Metals by ICP-AES
- Metals by AA
- Anions
- Gross Alpha or Beta
- Gamma Spectroscopy
- Nuclide-Specific Analysis

The DOE study also investigated the radioactivity of the samples to be collected. The study defines four levels of sample radioactivity:

R1 - radiation low enough for bench-top analysis	<10 mR/h,
<10 nCi/g alpha
R2 - sample handling must be performed in a hood	10-200 mR/h,
<10 nCi/g alpha

MONTHS AFTER CONTRACT AWARD

TASK

PHASE I

1. Information Required for NEPA
2. Performance Requirements
3. Development of Conceptual Design
4. NQA1 Compliance Analysis
5. Final Design
6. Phase I Topical Report

MONTHS AFTER PHASE II AWARD

TASK

PHASE II

7. NEPA Documentation
8. Construction Drawings
9. Prototype System Construction
10. On-site Prototype Sys. Evaluation
11. Final Report

KEY	
◇	= Start
0	= Completion

Figure 1. Performance Schedule

R3 - sample handling must be performed in a hot cell	>200 mR/h
R4 - sample handling must be performed in a glove box	<200 mR/h, >10 nCi/g alpha

The vast majority (84%) of the samples projected to be collected are expected to fall into the R1 category, suitable for bench-top handling. Samples falling into the R2 category (handling in a hood) represent 14% of the total. Samples in the R3 and R4 categories (handling in a glove box or hot cell) represent a combined total of only 2% of the samples to be collected. These results clearly indicate that the RTAL system design should emphasize handling of samples on benches and in hoods, with an occasional sample requiring handling in a glove box or hot cell.

The report, "Analytical Laboratory Study Report for Pit 9 Remediation Activities," prepared for EG&G Idaho by Dames & Moore in July 1992 projects analytical requirements for the remediation of this waste pit at the Idaho National Engineering Laboratory (INEL). Analyses required include:

- Volatile Organics
- Semi-Volatile Organics
- Polychlorinated Biphenyls (PCB's)
- Metals (including mercury)
- TCLP
- Gross Alpha/Beta
- Gross Gamma
- Pu^{239,240}
- Am²⁴¹
- U^{234,235,238}
- Th²³⁴
- Co⁶⁰
- Cs¹³⁷/Ba¹³⁷
- Sr^{89,90}/Y⁹⁰

The report concludes that a transportable analytical laboratory able to process 20 samples per day would accelerate the Pit 9 remediation. Remediation efforts at Pit 9 are scheduled to last for three years.

In addition to Pit 9, the INEL also has remediation efforts underway or planned for other sites at the facility. For example, the INEL Test Area North (TAN) has groundwater contamination problems that would also benefit from the availability of the prototype RTAL. Thus, the INEL appears to be an excellent location for the planned demonstration of the prototype RTAL, based on their need and desire for such a system.

To meet the goals cited above while retaining the flexibility to meet the requirements of individual sites, the RTAL is being

designed as a series of individual modules that can be deployed as an integrated group or individually. Each module is being designed with the following features:

- Shock and vibration protected for road transport
- Easily prepared for transport
- Shielded against low levels of radioactivity
- Controlled underpressurization
- Filtration of incoming and exiting air through HEPA filters
- Integral electrical generator and motor
- Integral heating, ventilation and air conditioning (HVAC) system capable of handling wide range of outside temperatures and humidities
- Controlled air flow from "clean" to "dirty" areas
- Insulation in walls, floor and roof
- Integral fuel tanks
- Integral tanks for water and wastewater
- Rugged, redundant design for maximum availability
- Hardened equipment for maximum reliability
- Designed for long life
- Designed for minimum acquisition and maintenance costs
- Designed for ease of repair and maintenance
- Designed for ease of exterior decontamination
- Innocuous appearance to minimize public apprehension during transport and deployment

The interior layout of each module will be determined by its function and the equipment it carries. The design and layout of the laboratories, in particular, is based on a top-down approach. The chemical analysis laboratories, for example, are designed to efficiently allow for the analysis of the analytes listed above. Table 1 summarizes the analysis of equipment needs for organic analyses. The standard method or methods for each organic analyte were evaluated to determine the sample preparation and analytical measurement equipment required for each analyte. A quality assurance/quality control (QA/QC) Level of III was assumed for all analytes. This provides full validation of all data via a series of standards, replicates and other QA/QC tests. This table demonstrates the extensive equipment that will be required for the analysis of organic contaminants.

Table 2 summarizes the analysis of equipment needs for the inorganic analytes. All the heavy metals but mercury are detectable by Inductively Coupled Plasma (ICP) Spectroscopy. Mercury analysis requires the use of an Atomic Absorption (AA) Spectrometer. The preferred analytical method for the other metals is ICP. Since most sites do not appear to have significant mercury contamination, the best arrangement of the inorganic analysis laboratory may be to include an ICP Spectrometer and leave space for installation of an AA Spectrometer when needed. This minimizes costs to the DOE while still providing full flexibility to meet

TABLE 1

<u>ORGANIC LABORATORY</u>				
<u>PARAMETER</u>	<u>SAMPLE SIZE</u>	<u>EPA METHOD</u>	<u>QA/QC LEVEL</u>	<u>MAJOR EQUIPMENT</u>
VOA	40ML (Liquid) 10g (Solid)	Sample Prep & Analysis 8240A	III	<ul style="list-style-type: none"> • GC/MS, packed column • Purge & trap device • Mass spec requirement: 35-260 AMU every 3 seconds or less • Data system • Recirc chiller • Carrier gases: H₂ or He • Analytical balance • Screening: head space sampler (method 38/0) with GC (PID & HECD detectors)
				or
				extraction with hexadecane & analysis on GC with FID and/or ECD
SEMI-VOA	1L (Liquid) 50g (Solid)	Sample Prep 3520A (Liquids)	III	<ul style="list-style-type: none"> • Continuous liquid-liquid extractors • Kuderna-danish concentrators • Water bath • Recirc chillers • Solvent storage
		3550A (Solids)	III	<ul style="list-style-type: none"> • Ultrasonic extractors • Sound enclosures • Vacuum pump • Kuderna danish extractors • Water bath • Analytical balance • Solvent storage
		or Supercritical Fluid Extraction		<ul style="list-style-type: none"> • Supercritical fluid extraction • Carbon dioxide source
		3640 (sample cleanup)	III	<ul style="list-style-type: none"> • Gel permeation chromatography system
				HPLC with GPC column UV detector Recorder

TABLE 1

ORGANIC LABORATORY (CONT'D)

<u>PARAMETER</u>	<u>SAMPLE SIZE</u>	<u>EPA METHOD</u>	<u>QA/QC LEVEL</u>	<u>MAJOR EQUIPMENT</u>
SEMI-VOA		Analysis 8270A	III	<ul style="list-style-type: none"> • GC/MS, fused silica capillary column • MS requirements: 35-500 AMU every 1 second or less • Data system • Carrier gas: H₂ or He
PCB's	1L (Liquid) 50g (Solid)	Sample prep 3520A (Liquids)	III	<ul style="list-style-type: none"> • Continuous liquid-liquid extractors • Kuderna-danish concentrators • Water bath • Recirc chillers • Solvent storage
		3550A (Solids)	III	<ul style="list-style-type: none"> • Ultrasonic extractors • Sound enclosures • Vacuum pump • Kuderna-danish extractors • Water bath • Analytical balance • Solvent storage
		or Supercritical fluid extraction		<ul style="list-style-type: none"> • Supercritical fluid extractor • Carbon dioxide source
		3640	III	<ul style="list-style-type: none"> • Gel permeation chromatography system • HPLC with GPC column • UV detector • Recorder
		Analysis 8080A	III	<ul style="list-style-type: none"> • CG with ECD/HECD detector • Data system • Analytical balances

TABLE 1

<u>ORGANIC LABORATORY (CONT'D)</u>			
<u>PARAMETER</u>	<u>SAMPLE SIZE</u>	<u>EPA METHOD</u>	<u>QA/QC LEVEL</u>
TCLP*		1311	III
• VOA	40ml (Liquid) 120g (solid)		
• SEMI VOA	1L (Liquid) 120g (solid)		

MAJOR EQUIPMENT

- End over end agitation
- Extractors
- Filtration devices
- Vacuum or N₂ source
- Analytical balance

• TCLP requirements are the same for both VOA's and SEMI-VOA's

TABLE 2

INORGANIC LABORATORY

<u>PARAMETER</u>	<u>SAMPLE SIZE</u>	<u>EPA METHOD</u>	<u>QA/QC LEVEL</u>	<u>MAJOR EQUIPMENT</u>
Metals	100ml (Liquid) 10g (solid)	Sample prep 3010A (aqueous)	III	<ul style="list-style-type: none"> • No major equipment for standard method • Possible automated systems including microwave digestion to speed through-put
		3050A (sludges, soils & sediments)	III	<ul style="list-style-type: none"> • Analytical balance • Possible automated systems including microwave digestion to speed through-put
		Analysis 7470A/7471A	III	<ul style="list-style-type: none"> • Cold trap atomic absorption spectrophotometer
		6010A		<ul style="list-style-type: none"> • Inductively Coupled Argon Plasma emission spectrometer
Anions			III	<ul style="list-style-type: none"> • Ion chromatography system • Data system • Eluent storage
TCLP	100ml (Liquid) 120g (solid)	1311	III	<ul style="list-style-type: none"> • End over end agitation • Extractors • Filtration • Vacuum or N₂ source • Analytical balance

each site's individual needs.

The amount of equipment required for sample preparation and analysis of both the organic and inorganic analytes is quite extensive. Based on the lists in Tables 1 and 2, separate modules for the organic and inorganic analysis laboratories will be required to accommodate all the equipment that must be installed. The only overlap between the two laboratories is the extraction component of the Toxicity Characteristic Leachate Procedure (TCLP). Thus, the division of the Chemical Analysis Module into two modules - Organic Chemical Analysis and Inorganic Chemical Analysis - should prove to be very workable and efficient.

A similar analysis of analytical needs has been performed for the Radiochemistry Module. This analysis is summarized in Table 3, which lists the analytes, the analytical methods, and the equipment required to perform these methods. The list of required equipment is extensive, requiring the use of a separate module for this laboratory.

Specific construction requirements for the RTAL modules are based on DOE Order 6430.1A of 4/6/89, "United States Department of Energy General Design Criteria," and documents referenced in this manual. This comprehensive design manual provides guidance on a wide range of construction requirements. The following requirements reference the corresponding sections in this DOE Order.

Light Gauge Steel (Section 0512-2)

Light gauge steel shall comply with American Iron and Steel Institute (AISI) Specifications for the Design of Cold-Formed Steel Structural Members.

Steel Joists (Section 0521)

Steel joist floor and roof construction shall comply with the Steel Joist Institute (SJI) Standard Specifications Load Tables and Weight Tables for Steel Joists and Joist Girders.

Metal Fastening (Section 0532)

Structural connections for buildings and other structures shall comply with the requirements of the Uniform Building Code (UBC) and American Institute of Steel Construction (AISC) M011. Welding of structures shall comply with the American Welding Society (AWS) D1.1, D1.2, D1.3, and D5.2.

Fuel Storage Tanks (Section 0512-6)

Fuel storage tanks shall comply with American Petroleum Institute (API) 650.

Insulation (Section 0720)

Insulation shall comply with UBC Chapter 17. The thermal resistance of insulation and the degradation of thermal resistance

TABLE 3

RADIOCHEMISTRY LABORATORY

PARAMETER	SAMPLE SIZE	EPA METHOD	QA/QC LEVEL	MAJOR EQUIPMENT
Gross Alpha & Gross Beta Radioactivity	100g	900.0	III	Gas-flow proportional counting systems or Scintillation detector systems Stainless steel planchets Drying oven Analytical balance Drying lamps Electric hot plates
Gamma Emitting Radionuclides	100 g	901.1	III	Large volume (>50 cm ³) Ge (li) detectors or 4" x 4" NaI (TI) detectors
Radioactive Strontium	100g	905	III	Gamma-ray spectrometers Data processing equipment Low background beta counting system Centrifuge Drying oven Hot water baths Electric hot plates Analytical balance pH meter Dessicators Stainless steel planchets Drying lamps

TABLE 3

RADIOCHEMISTRY LABORATORY (CONT'D)

PARAMETER	SAMPLE SIZE	EPA METHOD	QA/QC LEVEL	MAJOR EQUIPMENT
Actinide elements	100g	907	III	Alpha particle counters Stainless steel planchets Filtering apparatus Alpha sensitive phosphors Centrifuge Silica columns Reagent storage Vacuum source Other Major Equipments Fume hoods Microwave digestors

over time shall be considered as a part of the energy conservation analysis and the design of mechanical systems. Thermal insulation used between the exterior and interior shall be moisture resistant. The space between outside window frames and adjoining walls, and between exterior door frames and adjoining walls, shall be insulated.

Louvers and Vents (Section 1020)

Louvers and vents located in potentially corrosive environments shall be corrosion-resistant or protected against corrosion.

Grills and Screens (Section 1024)

Grills and screens located in potentially corrosive environments shall be corrosion-resistant or protected against corrosion.

Doors and Windows - General (Section 0800)

Doors and windows located in potentially corrosive environments shall be corrosion-resistant or protected against corrosion. Glazing methods and materials shall comply with the Flat Glass Marketing Association (FGMA) Glazing Manual and the FGMA Sealant manual.

Windows - General (Section 0800-2.1)

Where double or triple glazing is required, insulating glass units shall be used, not multiple glazing. Windows and curtain walls shall be designed for wind loads in accordance with the UBC. Windows shall offer substantial resistance to unauthorized entry but need not be more resistant to penetration than adjoining walls, ceilings, and floors.

Windows - Maintenance and Repair (Section 0800-2.4)

Operating mechanisms, parts, and equipment in operable windows shall have a history of reliability and readily available replacement parts, and shall not be made of zinc.

Aluminum Windows (Section 0850-2)

Aluminum windows shall comply with American Architectural Manufacturers Association (AAMA) 101.

Hardware (Section 0870)

Door and window hardware shall comply with the American National Standards Institute (ANSI) A156 series. The preparation of doors and frames for the installation of bolts, closers, latches, locks, pivots, and strikes shall comply with the ANSI A115 series. Zinc hardware shall not be used. The locks on at least one door of any room shall be equipped to prevent personnel from being locked inside, except as otherwise required to satisfy DOE safeguards and security standards. Where primary reliance is placed on doors or windows as physical security barriers, heavy duty builders' hardware shall be used, and all screws, nuts, bolts,

hasps, clamps, bars, wire mesh, hinges, and hinge pins shall be fastened securely to preclude surreptitious removal and assure visual evidence of tampering. Hardware accessible from outside the area shall be peened, brazed, or spot welded to preclude removal or be otherwise secured by hardware that is inaccessible to unauthorized tampering. Where primary reliance is placed on doors as physical security barriers, key locksets shall meet the requirements of the ANSI A156 series.

Lockers (Section 1050)

Where significant moisture is normally present (such as in shower rooms), lockers shall not use hardboard facings, unimpregnated paper honeycomb cores, or paper honeycomb cores with foam plastic fill or vermiculite fill.

Hygiene Facilities (Section 0710-1)

Waterproofing shall be used at walls, floors, and other building elements to prevent water leakage from showers, areas using water wash-down, and other types of water basins. Where water is to be contained, waterproofing shall extend up walls above the expected high water level. Where water washdown is used, waterproofing shall extend to fully cover the expected wall areas to be washed. Wall, floor, and other building element waterproofing shall meet base course and through-the-wall flashings, and shall make a bond with these flashings.

Furniture (Section 1260-2)

Furniture shall comply with National Fire Protection Association (NFPA) 101, Chapter 31 (sections concerning furnishings, decorations, and treated finishes), and UBC Chapter 17 for folding, portable, and movable partitions.

Furniture Systems (Section 1260-3)

Furniture systems shall comply with NFPA 101, Chapter 31 (sections concerning furnishings, decorations, and treated finishes), and UBC Chapter 17 for folding, portable, and movable partitions.

Interior Lighting (Section 1655)

Interior lighting systems shall comply with the Illumination Engineering Society (IES) Lighting Handbook. Non-uniform lighting practices shall comply with 41 CFR 101-20.116-2 and with Section 1694, Energy Conservation. Lighting power budget shall be determined in conformance with the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 90. Exit and emergency lighting systems shall comply with NFPA 101 and NFPA 110. Maximum use shall be made of fluorescent and High Intensity Discharge (HID) lamps. Where HID lamps are used, a standby lighting system shall be provided to meet emergency lighting requirements during HID lamp restrike periods. When using HID lighting indoors, careful consideration of the required color rendition shall be made from visual and health safety perspectives.

Adequate light levels are necessary to ensure optimum performance in all work areas. Glare and shadowing shall be avoided. Lighting design shall consider environmental degradation effects (such as dust) to ensure adequate lighting intensities can be provided on a long-term basis. Emergency lighting systems shall be provided as required by NFPA 101.

Decontamination (Section 1300-11.1)

Design of the areas in a facility that may become contaminated with radioactive or other hazardous materials under normal or abnormal operating conditions shall incorporate measures to simplify future decontamination. Such items as service piping, conduits, and ductwork shall be kept to a minimum in these areas and shall be arranged to facilitate decontamination. Filters shall be positioned in ventilation systems in locations that minimize contamination of ductwork. Walls, ceilings, and floors shall be finished with washable or strippable coverings. If necessary, all cracks, crevices, and joints shall be caulked or sealed and finished smooth to prevent contaminated material accumulation in inaccessible areas.

Decontamination of Personnel (Section 1300-6.6)

Design shall provide for personnel decontamination facilities close to areas that represent sources of potential contamination. After the decontamination process has been completed, the individual must pass a decontaminant test to assure the person is free from any contaminants before proceeding to a change room.

Change Rooms (Section 1306.8)

Men's and women's change rooms shall be provided for changing into and from protective clothing. These areas shall be adjacent to shower facilities. Change rooms shall be designed to ensure that clean clothing and protective clothing are segregated. The change room exhaust air shall be High Efficiency Particulate Air (HEPA) filtered if dispersible radionuclides are handled in the process areas it serves.

General Selection Procedures for Heating, Ventilation and Air Conditioning (HVAC) Systems (Section 1550-1.1)

The design professional shall evaluate building HVAC systems and sub-systems and select major HVAC equipment components based on a consideration of health and safety requirements, initial costs, operating costs, and maintenance costs according to the procedures listed in Section 0110-12.7, Building Design Analysis. HVAC equipment shall be sized to satisfy the building heating and cooling load requirements and to meet all general equipment design and selection criteria contained in the ASHRAE Fundamentals Handbook, ASHRAE Equipment Handbook, ASHRAE Systems Handbook, ASHRAE Applications Handbook, and ASHRAE Refrigeration Handbook. Calculations and equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and appropriate chapters of the ASHRAE Fundamentals Handbook.

Heating and Air Conditioning Equipment Sizing and Performance (Section 1550-1.3)

The capacity of central heating, refrigeration, and ventilation equipment shall be sized for the peak building or maximum simultaneous zone heating and cooling design loads in accordance with the ASHRAE Fundamentals Handbook. Individual zone equipment shall be sized according to the peak zone load. The requirements of ASHRAE Standard 62 concerning minimum outside air requirements shall also be considered during the sizing process. All HVAC equipment shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6.

Ventilation Exhaust Systems Design Requirements (Section 1550-1.5)

The design professional shall select ventilation exhaust systems for the effective removal of noxious odors, hazardous gases, vapors, fumes, dusts, mists, and excessive heat and for the provision of fresh air to occupants.

Personnel Ventilation Air Requirements (Section 1550-1.5.3)

Outdoor air shall be provided in the quantities indicated for conditioned offices and other occupied spaces in ASHRAE Standard 62. Outdoor air in addition to the quantities required by ASHRAE Standard 62 shall be provided when required to balance a building's or space's exhaust air rate or to maintain the building or space under a positive pressure.

Recirculation (Section 1550-1.5.4)

When air is supplied to a space, the portion of the total supply air that exceeds the required outdoor air quantity shall be recirculated through the ventilation system except from areas in which recirculation is specifically prohibited. If the indoor air quality does not meet or exceed the limits given in ASHRAE Standard 62, the recirculated air must be treated and monitored. Areas from which air shall not be recirculated include areas that produce or emit dust particles, heat, odors, fumes, spray, gases, smoke, or other contaminants that cannot be sufficiently treated and could be potentially injurious to health and safety of personnel or are potentially damaging to equipment. These areas shall be 100% exhausted. Rest rooms and other malodorous spaces shall be exhausted at a rate of not less than 2 cubic feet per minute (cfm) per square foot or as specified in ASHRAE Standard 62, whichever is more stringent, regardless of any other calculated ventilation requirements. Space ventilation air from adjacent spaces should be used as the ventilation supply air for the 100% exhausted spaces as long as ventilation by this method does not violate any requirements of NFPA 90A, NFPA 101, or special space pressurization requirements; and the air supplied is not potentially more hazardous than the air from the space exhausted.

Equipment Room Ventilation (Section 1550-1.5.7)

Mechanical and electrical equipment rooms shall be exhausted

so that room temperature does not exceed National Electrical Manufacturers Association (NEMA) equipment ratings.

Air Handling and Air Distribution Systems (Section 1550-2.5)

The design professional shall consider and design air handling equipment and air distribution systems sized to optimize both initial cost and air handling system operating and maintenance costs. The design professional shall provide all air handling equipment (fans, terminal units, air handling units, etc.) with vibration isolators and flexible ductwork connectors to minimize transmission of vibration and noise. Systems shall satisfy the noise criteria levels recommended for various types of spaces and vibration criteria as listed in the ASHRAE handbooks. Airflow velocities shall be designed to minimize settling of entrained particles as outlined in the American Conference of Governmental Industrial Hygienists (ACGIH) Industrial Ventilation Manual. Air handling and air distribution systems shall meet the energy conservation requirements for transport energy in ASHRAE Standard 90. Supply and outdoor air intakes shall be located a minimum of 10 feet from any exhaust opening.

Ductwork Systems (Section 1550-2.5.6)

Ductwork systems shall be designed for efficient distribution of air to and from the conditioned spaces with consideration of noise, available space, maintenance, air quality and quantity, and an optimum balance between expenditure of fan energy (annual operating cost) and duct size (initial investment). Ductwork, accessories, and support systems shall be designed to comply with the ASHRAE Fundamentals Handbook, the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) HVAC Duct Construction Standards - Metal and Flexible, the SMACNA Fibrous Glass Duct Construction Standards, the SMACNA Round Industrial Duct Construction Standards, the SMACNA HVAC Duct Design Manual, the ACGIH Industrial Ventilation Manual, NFPA 45, and Energy Research and Development Administration (ERDA) 76-21. Exhaust ductwork shall comply with NFPA 91. Ductwork shall be designed to resist corrosive contaminants if present. Ductwork that handles air exhausted from shower rooms or other areas causing condensation on the duct interior shall be of aluminum construction, have welded joints and seams, and have drainage at low points. Ductwork thermal insulation shall comply with ASHRAE Standard 90. Ductwork shall be acoustically insulated to meet acceptable noise criteria.

Environmental Considerations - Temperature and Humidity (Section 1300-12.4.3)

An effective climate control system shall maintain temperature and humidity at an acceptable level. Temperature and humidity tolerance limits for recommended comfort zones are provided in Nuclear Regulatory Commission document NUREG 0700 Section 6.1, and University of California Research Laboratory (UCRL) 15673 Section 3.2.4.5.

Inside Design Temperature and Relative Humidities (Section 1550-1.2.2)

The design professional shall verify that the recommended design values are within the criteria bounds of ASHRAE Standard 55 and that the values are within energy conservation guidelines as stated in Section 0110-12, Energy Conservation. When space cooling is required, the inside design temperature to maintain personnel comfort shall be 78°F dry bulb unless otherwise indicated by project criteria. The design relative humidity shall be 50%. Summer humidification shall not be provided for personnel comfort. Cooling systems shall be designed to maintain space relative humidity conditions through the normal cooling process and should not have controls to limit the maximum relative humidity unless project specific criteria dictate.

Emergency Power Systems (Section 1660-2)

Emergency power systems shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and Institute of Electrical and Electronic Engineers (IEEE) 446. Where emergency generators are required for loads 25 kVA and smaller, gasoline or Liquefied Petroleum Gas (LPG) engines may be used. For loads greater than 25 kVA, diesel engines shall generally be used. Application of diesel engines shall comply with Federal Construction Council (FCC) Technical Report No. 69.

Task 3 - Development of Conceptual Design

A multi-modular system is required to provide the extensive instrumentation and support equipment necessary to accommodate the wide variety of analytes listed above. Accordingly, the Road Transportable Analytical Laboratory will consist of a set of individual laboratory modules, deployable independently or as an interconnected group to meet each DOE site's specific needs. This will provide the maximum flexibility to meet site's particular needs while being able to accommodate even the most demanding situations.

The original proposal for the RTAL suggested that the modules could be arranged in a circle around an interconnecting carousel with walkways to each module, as shown in Figure 2. This arrangement provides relatively easy access to each module. However alternative arrangements were also evaluated after studying the DOE's needs and visiting DOE sites. One arrangement, in particular, offers significant advantages over the arrangement originally proposed. This arrangement of the modular laboratories, shown in Figure 3, closely follows the steps the samples and operating personnel will take. The two modules closest to the contaminated area are the Radiochemistry Module and the Decontamination Module. Personnel, in appropriate protective ensembles, would bring samples to a sample pass-through located on

FIGURE 2

Road Transportable Analytical Laboratory System Concept

the side of the Radiochemistry Module closest to the contaminated area. They would pass the samples directly into a hot cell inside the Radiochemistry Module for preliminary analysis of radiation level. The operator inside the Radiochemistry Module would determine the sample's radiation level category, R1 through R4 (as defined above). This initial analysis would be conducted within a hot cell located in a separate room within the Radiochemistry Module. The room would be constructed and air flow maintained so that the sample in the hot cell would be in a triple barrier enclosure. The hot cell would also be used to subdivide samples for the multiple analyses to follow.

The vast majority of the samples that fit within the low radiation categories would be immediately passed from the hot cell through an interconnecting chamber into a hood in an adjacent room within the Radiochemistry Module. The samples would undergo the full range of analyses, as required for the operations at that site.

The Decontamination Module is also located closest to the contaminated area. When ready to stop work in the area of contamination, personnel would be checked for surface contamination. If radioactivity was detected, the personnel would take a decontamination shower to remove the radioactive particles. After exiting the shower, they would be re-checked for contamination. Once clean, they would remove their protective ensemble and change into street clothes. We are also considering the installation of a personal shower in this module for the comfort of the personnel. Dual changing facilities (for males and females) will be provided within this module. Personnel would exit the Decontamination Module via a separate door on the side of the unit away from the contaminated area.

These two modules are located closest to the work area to facilitate the movement of samples and personnel into and through them. Subsequent operations would be conducted in the modules located farther back from the contaminated area. This lowers the risk of contamination to personnel working in these modules, consistent with the principle of As Low As Reasonably Achievable (ALARA), while still effectively supporting the operations being conducted.

The modules for chemical analysis, field instrumentation, robotics, and aquatic biomonitoring would be in the next grouping. Samples from the Radiochemistry Module would be passed back to the appropriate laboratories in this group. Interconnecting walkways would connect all the modules so an operator could easily walk among the modules, as needed.

The investigation of chemical analysis equipment, discussed earlier as part of Task 2, revealed that an extensive array of analytical and sample preparation equipment will be required.

ROAD TRANSPORTABLE ANALYTICAL LABORATORY INTEGRATED COMPLEX

Each module independently deployable
to meet individual site needs

Engineering Computer Optecnomics, Inc
1356 Cape St. Claire Center
Annapolis, MD 21401
Tel (410) 757-3245
Fax (410) 757-8265

FIGURE 3

Investigation of alternative designs revealed that the space required for these equipment would exceed that available in a single module. Thus, it will be necessary to divide the chemical analysis function into two modules - an Organic Chemical Analysis Laboratory and an Inorganic Chemical Analysis Laboratory. This division works well in terms of dividing the necessary equipment and in terms of the type of analyses to be performed. In particular, this arrangement allows for segregation of the hoods in each laboratory, i.e. the hood in the Organic Chemical Analysis Module would be used for organic chemicals only and the hood in the Inorganic Chemical Analysis Laboratory would be used for inorganic chemicals only. This segregation of the hoods for use with organic and inorganic chemicals is in keeping with standard laboratory safety practice.

From the second group of modules, the interconnecting walkways converge to the Operations Control Center. The entrance to the Operations Control Center contains a frisking station to ensure that all entering personnel are free of contamination. If contamination is found, a decontamination shower is located just inside the entrance. All personnel leaving the grouping of laboratory modules would have to go through the Operations Control Center, thus, this final frisking station and decontamination shower provides insurance against personnel contaminated with radioactive particles from leaving the compound. The Operations Control Center would also contain work stations for the system operators and a small meeting room with an appropriate conference table. Since many of the analyses can be automated and the modules' computers will be interconnected by a Local Area Network (LAN), the operators can often work within the Operations Control Center and still maintain oversight and control over the operations in the other modules. The Operations Control Center will also contain a restroom and a small kitchen area for the convenience of the operators. This is especially important when the RTAL is stationed far from support buildings.

The final module, located behind the Operations Control Center would be the Protected Living Quarters. This module would provide support for personnel who must be at the site for long periods. After visiting DOE sites and talking with personnel both at field activities and at headquarters, it became evident that the need for a Protected Living Quarters Module would be quite infrequent. Since it would not be included in most applications, it is shown with dashed lines in Figure 3. The RTAL system is being designed so that it can be included, however, it is recognized that in most cases it will not be needed.

Specific alternative designs for each module are being developed. These are being analyzed to determine the set which best meets the needs of the DOE field activities.

One alternative being investigated is the use of a separate

module for electrical generation. This module would be capable of generating sufficient electricity to meet the needs of all the modules. This alternative would eliminate the need to have electrical generating capability in each module. It would provide more available room in the other modules for other uses (an important consideration since each module is space-limited) and it would minimize shock and vibration mounting requirements in the laboratory modules. This could result in an overall cost reduction. However, it would limit the deployment flexibility of the RTAL since this module would have to be deployed whenever an independent source of power was needed. Intermediate alternatives are also being investigated. In these, some of the modules would have their own electrical generation system so they could be deployed independently while retaining the use of a central electrical generation module when the entire modular RTAL complex is deployed.

This task on the development of alternative designs for the integrated RTAL complex and for each of its modules is continuing in accordance with the schedule provided in Figure 1, presented earlier.

PLANS FOR NEXT QUARTER

The plans for the upcoming quarter, from March 1993 through May 1993, call for the continuation of Task 3 (Development of Conceptual Designs), as shown in Figure 1. However, discussions have been initiated by ECO, Inc. with the DOE Project Officer to possibly accelerate this contractual effort. This is being suggested to meet the critical needs of DOE facilities for on-site transportable laboratory systems, which can be met by the RTAL. Thus, it would be to the DOE's advantage to accelerate the Phase I effort. ECO, Inc. is not envisioning any increase in project cost as a result of this potential acceleration.

OVERALL STATUS ASSESSMENT

The development of the Road Transportable Analytical Laboratory system is on schedule, as shown in Figure 1. All contractual requirements to date have been met. Performance and construction requirements have been developed and alternative designs for the integrated RTAL complex and each individual module are being developed and analyzed to optimize system performance at minimum acquisition and operational cost to the DOE. The following modifications to the originally proposed RTAL concept are considered very likely:

- A reorganization of the modules to provide a more functional working arrangement and to lower the risk of personnel exposure to radioactive contaminants

- Division of the Chemical Analysis Module into two separate modules - Organic Chemical Analysis and Inorganic Chemical Analysis - to accommodate all the equipment required for these laboratories
- Using the Protected Living Quarters on an as-needed basis at sites requiring this unique support capability; delete it from the prototype RTAL as it would not be required at the demonstration sites currently being considered (it could be added at a future date if required)
- Providing space within the Inorganic Chemical Analysis Module for an AA Spectrometer for mercury analysis but not installing this equipment item in the prototype RTAL (it would be added at future sites, as needed)

These modifications would make the RTAL more effective while maintaining minimum development, acquisition, and operational costs for the DOE. If these modifications are adopted, the total number of modules in the RTAL prototype would remain the same (one additional chemical analysis module versus the deletion of the Protected Living Quarters). However, the additional chemical analysis module will be more complicated and contain more expensive equipment than the Protected Living Quarters. Data is being collected to assess costs associated with the promising design concepts.

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