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ISIS: An Interactive System for Instruction and Sampling

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D. E. Fields

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
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Health and Safety Research Division

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ABSTRACT

This computer interactive system for instruction and sampling is designed to introduce sampling of a contaminated site or field sampling to persons new to the activity. Through a series of questions, the program determines the extent of field sampling experience the novice has previously obtained. Based on answers given to these questions, the program provides the novice information about what should be done to prepare for and initiate correct field sampling procedures. Information on the types of radioactive emissions (alpha, beta, and gamma) for which the novice will be searching is also available.

Detailed instructions are presented by the program for the detection and measurement of alpha, beta, and gamma radiation. Procedures for operating the alpha counter, Geiger-Müller counter, and scintillation counter are presented in clear and precise steps so that very few errors, if any, are expected.

INTRODUCTION

Since many new personnel at Oak Ridge National Laboratory have little or no experience with field sampling techniques and procedures, the Interactive System for Instruction and Sampling (ISIS) may prove to be a beneficial program. These novices need training, and ISIS may be used to assist in this activity.

ISIS is a computer program designed to introduce field sampling to novices in this subject by asking them a series of questions and giving help and instructions according to their answers. ISIS was implemented using the VP-Expert system because of the availability and quantity of documentation on this system (Sawyer 1988).

ISIS queries the user about the forms of radiation that he is familiar with and what he is seeking, and, based on the user's answers, describes the forms of radiation and how to use the equipment to detect these forms. The program also asks if the user has checked the equipment and if the user knows how to operate it. Additional information is then given by the program if a need is ascertained.

As described in this report, this expert system is a tutorial interaction program. It provides field sampling procedures based on the user's level of expertise as compared to information necessary to perform an effective survey.

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APPLICATIONS FOR EXPERT SYSTEMS

Expert systems have many applications. Many jobs that involve decision-making can be adapted to an expert system. Although expert systems won't completely replace an expert, they may aid both the expert and the novice. Expert systems can be used to interpret, predict, diagnose, design, plan, monitor, debug, repair, instruct, and control (Miller 1989).

The following are examples of expert systems currently in operation:

ExperTAX (Martorelli, 1988) -- gives advice about tax planning and guides accountants through the process.

Mass Storage advisor (Martorelli, 1988) -- diagnoses errors in old mass storage systems.

PREDICT (SN 1989) -- interprets phenomena and symptoms to suggest possible types of pest infestations of red pines.

ISIS is an expert system knowledge base constructed from research through field sampling work. ISIS is a program in which field sampling was applied to field sampling.

CONSIDERATIONS OF FIELD SAMPLING METHODS

Certain decisions must be made when writing an expert system program for field sampling. These include considerations of proper procedures for health and safety, equipment usage, surveying, mapping, and sampling. To acquire information for these considerations, one of the authors (Buckley) went into the field and learned the techniques and procedures.

One important field procedure is checking radiation equipment for accuracy by comparing previous log readings using a known source with present readings using the same source. This procedure is used at the start of every field sampling day.

Taking into account different forms of radiation and how to detect them is also important for field sampling work because one must know what type of radiation one is looking for in order to know what equipment to use. The expert system program describes three different forms of radiation alpha, beta, and gamma -- and tells the user what equipment is appropriate.

Yet another necessary field procedure is checking clothing and equipment for contamination. Potentially contaminated material needs to be scanned with radiation detection equipment for alpha, beta, and gamma contamination. An alpha and a Geiger-Müller counter should used to check boots and gloves before entering any vehicle.

The procedure for sampling soil and water also needs to be considered. The expert system program tells the user what procedure might be useful.

ADVANTAGES OF AN EXPERT SYSTEM SHELL

Expert system shells can have many uses, one of which is that expert knowledge can be put into it and acted upon. Also, someone who is not a computer programmer can codify their knowledge on a particular subject in a computer program. The expert system program can be duplicated as many times as needed in order to give help to nonexperts in many places. The expert system shell is cost effective because with its use, experienced personnel are required to spend less of their time for training new personnel for field work. Unlike a human, the expert system functions the same way every day regardless of what is happening. The expert system documents information so it won't forget possible important facts for a task. Over all, the expert system has many advantages.

PROTOTYPE EXPERT SYSTEM OPERATION

The VP-Expert system is a program designed to reason using stored data to suggest decisions that an expert would make. The field sampling knowledge based program for the expert system shell acquires information from the user to determine what additional information the user needs to know. Then the program tells the user exactly what to do based on this information. The program is basically a tutorial interactive program.

To load the field sampling knowledge base, put a system disk in drive A and load the Disk Operating System into memory by typing Ctrl-Alt-Del. Remove the disk and put the expert system disk into drive A. Type VPX FIELD at the A> prompt to use the field sampling program. Once the program is loaded, a message will appear briefly describing what the field sampling knowledge base program does. After the user presses a key, the program asks some of the following questions (what questions are asked is determined by answers to prior questions):

(1) About which forms of radiation are you knowledgeable?

(2) Do you know how to use radiation detection equipment?

(3) Have you checked your equipment?

(4) Have you surveyed a site with your equipment?

(5) What type of radiation emissions will you be looking for?

Based on these and other questions, the computer gives knowledge on field sampling procedures and techniques. The following are two examples of knowledge on field sampling procedures and techniques:

> "At the start of every day use the following procedure to check your equipment: First, get the counts per minute of normal background radiation for your instrument. Second, get the

counts per minute of a known radioactive source. Record these readings in a log book, then check to see if these are the normal readings for the counter by checking previous log entries. If not, the equipment may need to be calibrated."

"With a sodium iodide scintillation counter it is possible to detect gamma radiation only. Find hot-spot areas with the scintillation counter by slowly swinging the probe of the counter back and forth a few inches above the ground until the needle of your counter shows an increased reading and/or you audibly detect an increase in radiation."

We believe that this knowledge base will prove a valuable tool for novices interested in field sampling. In constructing the knowledge base, emphasis was also put on procedures for quality assurance/quality control. This is to minimize chances of an accident occurring with a new person on the job.

EXPERT SYSTEM OPERATION

To load the expert system program, put in a system disk into drive A. Load in the disk operating system by pressing Ctrl-Alt-Del. Take the system disk out of drive A. Put in the expert system disk into drive A and put the sample files disk into drive B. Type VPX at the A> prompt. Shortly afterwards, a menu will come into view consisting of Help, Induce, Edit, Consult, Tree, Filename, Path, and Quit.

To use the Help section of the expert system, press 1 or H for help and press ENTER at the prompt. Help for the main menu should appear. To get out of that Help screen and to acquire help for something else, hit the ESCAPE key. A list of words will appear on screen. Press the first letter of the word that is being sought or use the arrow keys to move the cursor to it on the screen. Press RETURN and help will be displayed on the word that was picked. Use the arrow keys, PgUp or PgDn keys, to browse through the help information. Press the ESCAPE key twice to get out of the Help section.

To use the Induction section, press 2 or I and press ENTER at the prompt. An induction table is sometimes used to create a knowledge base, although a knowledge base can be created without it. With the induction section, a knowledge base can be created with a work sheet or database file. Do this by typing W or D, the name of the database or work sheet file, and the name of the new knowledge base file the induced information will comprise. Messages that indicate the induction process is occurring will appear. Create is for creating a text induction table. Press C and type in the name of the induction table to create or the old one to edit. After the table is made, press T to convert the text induction table into a working knowledge base. Type in the name of the induction table text file and the name of the new knowledge base which will be created. The Induction section is a means to create a knowledge base with a text, database, or work sheet file. Press the ESCAPE, Q, or 5 key to return to the Main Menu.

To edit a knowledge base press 3 or E. If you decide to edit an old knowledge base on the sample files disk, change the path to B:\. While holding down the Ctrl key, note that the legend at the bottom of the screen changes. The numbers on the bottom of the screen represent function keys. Holding down the Ctrl key and pressing function keys allows the user to manipulate blocks of text. Holding down the shift key and pressing function keys allows for search and replacement of text. Holding down the Alt key and pressing function keys allows for the control and access of the disk operating system through the VP-Expert system program.

To consult a knowledge base, press 4 or C. Use the arrow keys to choose which base you want to consult. Once the knowledge base is loaded, a menu may appear depending on the program that is being loaded. Press 2 or G to use the knowledge base. The rest of the menu is used for debugging. Press 3 or W to see the results of a variable change. Press 4 or V to see the value of a variable. Press 5 or R to see a rule in the knowledge base. Press 6 or S to get to another menu. This menu contains Trace, Fast, Slow, and Windows. Trace produces a trace file on the disk of the decisions made during the consultation. Fast makes the information in the windows move quickly while Slow makes it move slowly. Windows allows the user to manipulate the location and size of the windows and save the window's characteristics permanently. The Q or ESCAPE keys always allow the user to go backward in the menus.

To see information on a trace file press 5 or T. A menu will appear with Text and Graphics. Press T, 1, G, or 2 to cause a list of trace files on the disk to appear if a filename hasn't already been entered. Use the arrow keys or manually type in the file name to pick the file. Press T or 1 to edit text of the trace file. Press G or 2 to view a graphic display of a trace file.

SUMMARY

In this project, a program called ISIS was developed to assist novices in doing field sampling work. This tutorial interactive knowledge based program was written under the VP-Expert system program shell. ISIS interviews a novice using questions pertaining to field sampling. Afterwards, it displays text in accordance with the questions answered by the user.

ISIS may be expanded or improved upon through the following modifications: First, gamma to beta ratio questions or other radionuclide-specific questions may be asked to try to determine what type of radionuclides are present in the contaminated soil and/or water. Second, a list of other possible strategies for field sampling may be added and presented in the field sampling program. Third, information may be displayed on calibration of the equipment after checking it. Fourth, a list of laboratories and procedures may be presented to determine how many liters of water are needed for a water sample.

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APPENDIX A

Sample Run of the Program

```
:\>vpx field
```

V P - E X P E R T
Version 2.02

Published by Paperback Software International

This expert system advises you on how to field sample during your stay at ORNL. It asks a few qestions and gives some advice.

Press any key to begin the consultation.

```
Do you know how to use radiation detection equipment?
 NO ◄                        YES


About which forms of radiation are you knowledgeable?
 ALPHA ◄                     BETA                       GAMMA
 NONE

Have you surveyed a site with your equipment?
 NO ◄                        YES

What type of radiation emissions will you be looking for?
 ALPHA                       BETA                       GAMMA
```

↓ → Enter to select END to complete /Q to Quit ? for Unknown

```
Do you know how to use radiation detection equipment?
 NO ◄                        YES


About which forms of radiation are you knowledgeable?
 ALPHA ◄                     BETA                       GAMMA
 NONE

Have you surveyed a site with your equipment?
 NO ◄                        YES

What type of radiation emissions will you be looking for?
 ALPHA ◄                     BETA                       GAMMA
```

↓ → Enter to select END to complete /Q to Quit ? for Unknown

ɔu know how to use radiation detection equipment?
◂ YES

: which forms of radiation are you knowledgeable?
IA ◂ BETA GAMMA
Ξ

you surveyed a site with your equipment?
◂ YES

type of radiation emissions will you be looking for?
IA ◂ BETA GAMMA

you mapped out the site you surveyed?
◂ YES

you taken soil and/or water samples from the site?
YES

Enter to select END to complete /Q to Quit ? for Unknown

MAKING A MAP OF A SURVEYED AREA

Press any key to continue.

SAMPLING AT A SURVEYED SITE

An area to be sampled is identified by a flag. Check the radiation level for an area that is to be sampled and record it in a notebook. Take a sample approximately two inches deep and record the radiation level two inches down in the soil. Take samples 2-6 inches deep with a shallow sampling tool. Take a sample approximately two inches deep and record the radiation level two inches down in the soil. Then take a sample six inches down into the soil. Use a post-hole digger to take samples 6-12 inches deep. Record the radiation level six inches down into the soil. Take a sample that goes twelve inches down intothe soil. Record the radiation level twelve inches deep. If the contaminated site has any bodies of water take a water sample making sure that the amount of water needed for the lab that it is being sent to is taken.

Press any key to continue.

which forms of radiation are you knowledgeable?
A ◄ BETA GAMMA

you surveyed a site with your equipment?
YES

type of radiation emissions will you be looking for?
A ◄ BETA GAMMA

you mapped out the site you surveyed?
YES

you taken soil and/or water samples from the site?
YES

you checked your clothing and equipment for contamination?
YES

Enter to select END to complete /Q to Quit ? for Unknown

BETA EMISSIONS

Beta particles consist of negatively charged electrons. Beta particles can travel a few feet through the air and can be stopped by a piece of aluminium an eighth of an inch thick.

Press any key to continue.

GAMMA EMISSIONS

Gamma radiation consists of photons or packets of energy. Gamma radiation is more penetrating than alpha or beta and can be stopped by thick layers of lead and concrete.

Press any key to continue.

USING RADIATION DETECTION EQUIPMENT

First set the counter on the highest range, and switch down into the lower ranges until you have a noticeable reading on the counter. When this occurs, find hotspot areas using the probe of your counter appropriately. Equipment usage is described by other parts of this expert system program.

Press any key to continue.

DETECTING ALPHA EMMISIONS

You will need an alpha detector which must make physical contact with the potentially contaminated material. For many alpha counters about three counts per minute is normal background radiation for alpha emmissions. Getting a higher reading may mean the material is contaminated.

Press any key to continue.

SURVEYING A POTENTIAL SITE

It is important to know what type of radioactive material is present in the potential site to know what instrument to use. Once this is known, flags are put into areas of soil which have high radioactive levels or hotspots, and the counts per minute of radiation is marked on the flag. Recording the range of radioactive levels is also important. It is also good to check on both sides of a stream for contamination, because often a stream contains contamination for either upstrean or from the bank of the stream.

Press any key to continue.

CHECKING CLOTHING AND EQUIPMENT FOR CONTAMINATION

Check clothing and equipment with the alpha counter and the Geiger-Muler counter. Make sure the alpha counter and Geiger-Muler counter make physical contact with the pontentially contaminated material. Also, to get an accurate reading, don't check your clothing and equipment on site because this can lead to detecting radiation from the site and not clothing or equipment. Before entering the van, truck, or car to leave the site, check your boots and gloves for contamination.

Press any key to continue.

DO YOU WANT TO SEE THIS DEMONSTRATION AGAIN?

YES NO

↑ ↓ → Enter to select END to complete /Q to Quit ? for Unknown

APPENDIX B

Listing of Rules and Frames

APPENDIX B

The following is a listing of the rules and is the forward chaining section of the program:

RULE 1

IF CONTAM<>UNKNOWN THEN SW=1;

RULE 2

IF USE=NO THEN EQUIP=YES;

RULE 3

IF SURVEY=YES THEN RAD=NONE MAP=YES;

The following is a listing of the frames and is part of the backward chaining section of the program:

WHENEVER CONTAM

IF SW=1 AND CONTAM=NO THEN CLS LOCATE 1,13

DISPLAY CHECKING CLOTHING AND EQUIPMENT FOR CONTAMINATION

Check clothing and equipment with the alpha counter and the Geiger-Muller counter. Make sure the alpha counter and Geiger-Muller counter make physical contact with the potentially contaminated material. Also, to get an accurate reading, don't check your clothing and equipment on site because this can lead to detecting radiation from the site and not clothing or equipment. Before entering the van, truck, or car to leave the site, check your boots and gloves for contamination.

LOCATE 19,26 DISPLAY Press any key to continue.

WHENEVER CONTAM IF SW=1 AND SAMPLE=NO THEN CLS LOCATE 1,27

DISPLAY SAMPLING AT A SURVEYED SITE

An area to be sampled is identified by a flag. Check the radiation level for an area that is to be sampled and record it in a notebook. Take a sample approximately two inches deep and record the radiation level two inches down in the soil. Take samples 2-6 inches deep with a shallow sampling tool.

DISPLAY

Take a sample approximately two inches deep and record the radiation level two inches down in the soil. Then take a sample six inches down into the soil. Use a post-hole digger to take samples 6-12 inches deep.Record the radiation level six inches down. Take a sample that goes twelve inches down into the soil. Record the radiation level twelve inches deep. If the contaminated site has any bodies of water take a water sample making sure that the amount of water needed for the lab that it is being sent to is taken.

LOCATE 19,26 DISPLAY Press any key to continue.

WHENEVER CONTAM
IF SW=1 AND MAP=NO THEN CLS LOCATE 1,22
DISPLAY MAKING A MAP OF A SURVEYED AREA

This section needs to be added to later.

LOCATE 19,26 DISPLAY Press any key to continue.

WHENEVER CONTAM
IF SW=1 AND SURVEY=NO THEN CLS LOCATE 1,26
DISPLAY SURVEYING A POTENTIAL SITE

It is important to know what type of radioactive material is present in the potential site to know what instrument to use. Once this is known, flags are put into areas of soil which have high radioactive levels or hot spots, and the counts per minute of radiation is marked on the flag. Recording the range of radioactive levels is also important. It is also good to check on both sides of a stream for contamination, because often a stream contains contamination for either upstream or from the bank of the stream.

LOCATE 19,26 DISPLAY Press any key to continue.

WHENEVER CONTAM
IF SW=1 AND RAD=GAMMA THEN CLS LOCATE 1,26
DISPLAY DETECTING GAMMA EMISSIONS

With a sodium iodide scintillation counter it is possible to detect gamma radiation only. Find hot-spot areas with the scintillation counter by swinging the probe of the counter back and forth across the ground until the needle of your counter shows an increased reading and/or you audibly detect an increase in radiation.

LOCATE 19,26 DISPLAY Press any key to continue.

WHENEVER CONTAM
IF SW=1 AND RAD=BETA THEN CLS LOCATE 1,26
DISPLAY DETECTING BETA EMISSIONS

Use the following procedure with a Geiger-Muller counter to detect beta. First, get a beta and gamma count with an open sliding shield geiger counter. Next, take the reading with the sliding shield closed to obtain a gamma reading. The difference between the first reading and the second gives the beta count.

LOCATE 19,26 DISPLAY Press any key to continue.

WHENEVER CONTAM
IF SW=1 AND RAD=ALPHA THEN CLS LOCATE 1,26
DISPLAY DETECTING ALPHA EMISSIONS

You will need an alpha detector which must make physical contact with the potentially contaminated material. For many alpha counters about three counts per minute is normal background radiation for alpha emissions. Getting a higher reading may mean the material is contaminated.

LOCATE 19,26 DISPLAY Press any key to continue.

WHENEVER CONTAM
IF SW=1 AND USE=NO THEN CLS LOCATE 1,22
DISPLAY USING RADIATION DETECTION EQUIPMENT

First set the counter on the highest range, and switch down into the lower ranges until you have a noticeable reading on the counter. When this occurs, find hot-spot areas using the probe of your counter appropriately. Equipment usage is described by other parts of this expert system program.

LOCATE 19,26 DISPLAY Press any key to continue.

WHENEVER CONTAM
IF SW=1 AND EQUIP=NO THEN CLS LOCATE 1,18
DISPLAY CHECKING THE RADIATION DETECTION EQUIPMENT

At the start of every day use the following procedure to check your equipment. First, get the counts per minute of normal background radiation for your instrument. Second, get the counts per minute of a known radioactive source. Record these readings in a log book, then check to see if these are the normal readings for the counter by checking previous log entries. If not, the equipment may need to be calibrated.

LOCATE 19,26 DISPLAY Press any key to continue.

WHENEVER CONTAM
IF SW=1 AND KNOW<>GAMMA THEN CLS LOCATE 1,30
DISPLAY GAMMA EMISSIONS

Gamma radiation consists of photons or packets of energy. Gamma radiation is more penetrating than alpha or beta and can be stopped by thick layers of lead and concrete.

LOCATE 19,26 DISPLAY Press any key to continue.

WHENEVER CONTAM
IF SW=1 AND KNOW<>BETA THEN CLS LOCATE 1,31
DISPLAY BETA EMISSIONS

Beta particles consist of negatively charged electrons. Beta particles can travel a few feet through the air and can be stopped by a piece of aluminum an eighth of an inch thick.

LOCATE 19,26 DISPLAY Press any key to continue.

WHENEVER CONTAM
IF SW=1 AND KNOW<>ALPHA THEN CLS LOCATE 1,32
DISPLAY ALPHA EMISSIONS

An alpha particle consists of a positively charged helium nucleus which is 2 protons and 2 neutrons. Alpha particles travel only a few inches through the air and can be stopped by a sheet of paper.

LOCATE 19,26 DISPLAY Press any key to continue.

WHENEVER CONTAM
IF SW=1 AND SAMPLE=YES AND MAP=YES AND SURVEY=YES AND EQUIP=YES AND CONTAM=YES AND USE=YES THEN LOCATE 10,1
DISPLAY YOU ALREADY KNOW BASICALLY HOW TO FIELD SAMPLE

LOCATE 19,26 DISPLAY Press any key to continue.

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