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Explosive Detection Security System (EDSS) Test and Evaluation

By CPAD Holdings

Submitted by Transport Canada

TECHNICAL REPORT

April 1992

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Un sommaire en français de ce rapport est inclus avant la Table des matières.

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16. Abstract

A series of tests and evaluation procedures were conducted to ascertain the performance of the Explosives Detection Security System (EDSS™) in both laboratory and airport security gate environments.

The laboratory experiments were broken down into four parts: analytical performance tests, operational performance tests, longevity and stability tests and controlled line voltage variation tests. The airport security gate experiments included all operational field trials. Throughout the testing period the EDSS™ system performed satisfactorily, meeting or surpassing the test procedure requirements in 95 percent of the tests performed. It was found that the performance of the EDSS™ is slightly impaired by low voltage levels.

The overall test results have shown that the EDSS™ system is an effective and reliable explosives detection device, demonstrating high sensitivity to low-level explosive compounds and rapid execution of sampling and analysis cycles. The ease of installation, operation and maintenance of the system made it an acceptable tool for airport security procedures. In addition, the scanning techniques used have posed virtually no inconvenience to boarding passengers.

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16. Résumé

Une série de procédures de test et d'évaluation a été effectuée pour évaluer le fonctionnement du système de sécurité pour la détection des explosifs (EDSS^MC) dans un environnement de laboratoire et de poste de sécurité aérienne.

Les expériences en laboratoire furent de quatre types: des tests de performance analytique, de performance d'opérations, des tests de longévité et de stabilité, et des tests de variation controllée de voltage de ligne. Les expériences au poste de sécurité aérienne comprenaient des essais d'opérations sur le champ. Pendant la période de test, le fonctionnement du système EDSS^MC a été satisfaisant, répondant ou dépassant les exigences des procédures de test dans 95 pour cent des expériences exécutées. Il a été constaté que la performance du système EDSS^MC diminue légèrement à une basse tension.

En général, les résultats de test ont démontré que le système EDSS^MC est un détecteur d'explosifs efficace et fiable, démontrant une sensibilité accrue pour des composés explosifs à bas niveau, ainsi qu'une exécution rapide des cycles d'échantillonnage et d'analyse. La facilité d'installation, des opérations et du maintien du système en font un outil adéquat pour les procédures de sécurité aérienne. De plus, les techniques d'examen utilisées n'ont posé aucun inconvénient aux passagers.

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Their cooperation and enthusiasm during the EDSS™ field trials contributed greatly to the successful completion of this project.

SUMMARY

This report documents the results of a test and evaluation program devised to assess the capability, efficiency and reliability of the Explosives Detection Security System (EDSS™) developed by CPAD Holdings Ltd. of Nepean, Ontario. It also comments on the human resource, maintenance and environmental requirements of the system.

The EDSS™ system is designed to sample, detect and identify a broad range of explosive compounds, including untagged plastics, in essentially real time. Its patented analytical system is based on proprietary sample collectors and preconcentrators, which prepare and inject samples into gas chromatographic and ion mobility spectrometer detection subsystems. Its intended applications include the scanning of passengers and luggage in airport security gates, as well as the inspection of baggage rooms, vehicles, buildings, mail and other environments where explosives screening may be required.

Test results have indicated that:

1. The EDSS™ system reliably detects and identifies all explosive compounds tested;
2. The system is sensitive to very low levels of explosive materials (less than 25 ng);
3. Explosive detection and accompanying alarm signal are executed within 10 seconds from the initial sampling time;
4. The capabilities of the system are consistent over the long term;
5. The system performs equally well in laboratory and field environments.

Furthermore, the Ottawa airport field trials have demonstrated that:

6. The system is easily monitored and maintained by security personnel;
7. The scanning techniques used are inoffensive to the public.

These results point to a satisfactory functioning of the EDSS™ system throughout the test and evaluation stage. The system met or surpassed the test procedure requirements in 95 percent of the tests performed. The only performance difficulty encountered was during the line voltage variation tests, where it was found that the performance of the EDSS™ is slightly impaired by low voltage levels. This, however, was easily taken care of by the installation of voltage stabilizers.

A recurrent problem during the testing stage was the lack of standard test procedures. Some procedures required one or more modifications to ensure adequate testing of the EDSS™, indicating that the requirements for this kind of device are not properly established. The present document could be used as a basis for the eventual development of a standard requirements specification.

SOMMAIRE

Ce rapport documente les résultats d'un programme de test et d'évaluation formulé pour déterminer les capacités, l'efficacité et la fiabilité du système de sécurité pour la détection des explosifs (EDSS^{MC}) développé par CPAD Holdings ltée. de Nepean, Ontario. De plus, il fait mention des exigences au niveau des ressources humaines, du maintien et de l'environnement du système.

Le système EDSS^{MC} a été conçu pour l'échantillonnage, la détection et l'identification d'une vaste gamme d'explosifs, incluant des plastics non-identifiés, essentiellement en temps réel. Son système analytique breveté est basé sur des préleveurs d'échantillons et des préconcentrateurs propriétaires, qui préparent et injectent des échantillons dans des sous-systèmes de détection à chromatographie en phase gazeuse et à spectromètre à ions mobiles. Ses applications projetées comprennent l'examen des passagers et des bagages aux barrières de sécurité aérienne, aussi bien que l'inspection des salles de bagages, des véhicules, des immeubles, du courrier, et dans d'autres environnements où la détection des explosifs serait requise.

Les résultats de test indiquent que:

1. Le système EDSS^{MC} détecte et identifie fidèlement tous les composés explosifs éprouvés;
2. Le système possède une grande sensitivité (moins de 25 ng de matières explosives);
3. La détection d'un explosif et le signal d'alarme sont exécutés en moins de 10 secondes à partir du temps d'échantillonage initial;
4. Les capacités du système sont constantes à long terme;
5. Le système fonctionne aussi bien en application réelle qu'en laboratoire.

En outre, les essais à l'aéroport d'Ottawa démontrent que:

6. Le système est facilement contrôlé et maintenu par le personnel de sécurité;
7. Les techniques d'examen sont inoffensives pour le public.

Ces résultats révèlent un fonctionnement satisfaisant du système EDSS^{MC} pendant la phase complète de test et évaluation. Le système a répondu ou surpassé les exigences des procédures de test dans 95 pour cent des expériences exécutées. La seule difficulté au niveau de la performance a été constaté pendant les tests de variation controllée de voltage de ligne, où la performance du système EDSS^{MC} a diminué légèrement à une basse tension. Ce problème a été facilement corrigé par l'installation des stabilisateurs de tension.

Un problème périodique pendant la phase de test était le manque d'un standard pour les procédures de test. Quelques procédures devaient être modifiées une ou plusieurs fois pour assurer des tests adéquats, ce qui indique que les exigences ne sont pas bien établies pour ce genre de système. Ce document pourrait être utilisé à l'avenir aux fins de l'établissement d'une spécification des exigences standard pour les systèmes de détection des explosifs.

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ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used in the text of this report or its appendices:

amp	-	amperes
cm	-	centimetres
DMNB	-	Dimethyl-dinitrobutane
DNT	-	Dinitrotoluene
ECD	-	Electron Capture Detector
EDSS	-	Explosives Detection Security Systems
EDSU	-	Explosives Detection Sampling Unit
EGDN	-	Ethylene Glycol Dinitrate
egu	-	EDSS™ GC units (signal value)
eiu	-	EDSS™ IMS units (signal value)
ft	-	feet
g	-	grams
GC	-	Gas Chromatograph
hr	-	hours
ICAO	-	International Civil Aviation Organization
IMS	-	Ion Mobility Spectrometer
kg	-	kilograms

lb - pounds

m - metres

M - megabytes, Maximum (bar height)

mg - milligrams

N - Name (of compound)

ng - nanograms

NG - Nitroglycerine

NRC - National Research Council

O-MNT - Ortho-mononitrotoluene

ORU - Operator's Remote Unit

PCAD - Particle Collector and Detector

PETN - Pentaerythritol Tetranitrate

pg - picograms

P-MNT - Para-mononitrotoluene

ppb - parts per billion

ppt - parts per trillion

RCMP - Royal Canadian Mounted Police

RDX - Cyclotrimethylene Trinitramine

RFU - Remote Fan Unit

SCU - Sample Collector Unit

s, sec - seconds

SYS - System

T	-	Threshold
TC	-	Transport Canada
TDC	-	Transportation Development Centre
TNT	-	Trinitrotoluene
VAC	-	Volts Alternating Current
VCAD	-	Vapour Collector and Detector
WSU	-	Walk-thru Sampling Unit

DEFINITIONS

Two non-standard units of measure are used on the EDSS™ equipment:

egu - EDSS™ GC units. This unit of measure derives from a proprietary formula developed by CPAD for calculating the relative signal strength obtained by the EDSS™ on analyses of vapour explosives. The egu values are a function of the number of kilohertz measured on the Electron Capture Detector (ECD) of the Gas Chromatograph (GC) per span of milliseconds corresponding to the sampling rate.

eiu - EDSS™ IMS units. This unit of measure derives from a proprietary formula developed by CPAD for calculating the relative signal strength obtained by the EDSS™ on analyses of plastic explosives. The eiu values are the number of volts detected on the Ion Mobility Spectrometer (IMS) per span of microseconds corresponding to the sampling rate.

Both formulas for determining signal values are, in essence, a means of measuring the area under a peak on the EDSS™ analog display.

1. INTRODUCTION

The present report documents the results of a test and evaluation program for the Explosives Detection Security System (EDSS™) designed by CPAD Holdings Ltd. of Nepean, Ontario.

1.1 Purpose

The test and evaluation procedures were designed to ascertain the capabilities of the EDSS™ system. These capabilities include:

1. The ability of the EDSS™ to detect and accurately identify a specific range of explosive compounds;

2. High sensitivity to low levels of explosive materials;

3. Efficiency of sampling and analysis cycles, that is, the rapidity with which explosive detection and alarm are carried out;

4. Stable and reliable operation over the long term;

5. The ability of the EDSS™ to function reliably under controlled interference conditions and controlled line voltage variation;

6. Satisfactory performance in an actual airport security scenario.

Throughout the airport testing phase, a second and related area of study was to determine the usability and maintainability of the equipment, including how easily it could be operated by regular airport security staff, and how well the product was received by the public.

The purpose of this report is to clearly and objectively describe the direct results of the test and evaluation program, to comment on the observed maintenance and operational requirements of the EDSS™ system, and to present an analysis and discussion of the results.

1.2 Objective

The objective of this project was to evaluate the performance and reliability of the EDSS™ General Purpose Scanner and the EDSS™ Walk-thru Personnel Scanner for detecting concealed explosives. This project was also designed to characterize the equipment in terms of its impact on traffic flow and ergonomic factors, and provide estimates of operation and maintenance costs.

The modal objective from which this project emanates concerns the need to develop expertise, techniques and equipment in support of security requirements for the improvement of air traveller safety in the Canadian air transportation environment. A sub-objective of this involves Transport Canada's research of innovative systems for detecting goods that present a threat to the safety of air travellers.

1.3 Scope

This study was carried out between September 16th, 1991 and March 17th, 1992. A breakdown of the various testing activities along with their dates, performing organizations and locations is given in Table 1.1. The test and evaluation program is described in Chapter 3 of this report, and the original *Test and Evaluation Procedures* are presented as Appendix A.

Table 1.1 Breakdown of Testing Activities

TEST	FROM	TO	PERFORMING ORGANIZATION	LOCATION
Analytical Performance	91/09/16 92/02/25	91/12/09 91/02/27	NRC and CPAD Holdings CPAD Holdings (with NRC)	NRC / CPAD CPAD plant
Operational Performance	92/02/25	91/02/27	CPAD Holdings (with NRC)	CPAD plant
Longevity and Stability	91/11/27	91/12/09	TC and CPAD Holdings	NRC / CPAD
Line Voltage Variation	91/12/09	91/12/09	TC and CPAD Holdings	CPAD plant
Operational Field Trials	91/12/09	92/03/17	CPAD Holdings	Ottawa Airport

The scope of this document is defined largely by the requirements of the *Test and Evaluation Procedures*, in that it responds to each of the sections and subsections of that program. In addition, this report covers the following topics:

1. Usability factors, including the level of expertise required to operate the equipment and its impact on human resources;

2. Maintenance requirements, including a regular maintenance schedule and estimate of ongoing operations and maintenance costs;

3. Ergonomic factors, including the ideal location relative to metal detectors and X-ray equipment, adaptability of the equipment to existing airport security installations and impact on airport passenger traffic.

1.4 Background Material

CPAD Holdings Ltd. is a high technology company located in Nepean, Ontario, adjacent to Ottawa, Canada. It was established in 1986 and has become a centre of excellence in the field of trace compound detection. Its research and development team includes physical chemists, physicists, engineers and highly skilled technicians. Their efforts over a five-year period were devoted totally towards the development of a bomb detection system to counter terrorist activities.

The result has been the invention of the Explosives Detection Security System (EDSS™) and development of the EDSS™ Walk-thru Personnel Scanner and the EDSS™ General Purpose Scanner, sometimes referred to as the Baggage/Parcel Scanner. These systems are patented on a worldwide basis. They are designed to detect concealed explosives on a person or in baggage in a non-intrusive manner and to do so quickly without interruption to traffic flow. EDSS™ is a state-of-the-art defence against terrorist attacks, and is specifically intended to secure transportation systems.

In September, 1991, CPAD entered into a contract with the Transportation Development Centre of Transport Canada wherein the EDSS™ Walk-thru Personnel Scanner and the EDSS™ General Purpose Scanner would be evaluated with respect to its performance and reliability. They would also be characterized in terms of their impact on traffic flow and their ergonomic factors, and estimates of operation and maintenance costs would be determined. Test and evaluation activities would be carried out in accordance with approved test and evaluation procedures and involve Transport Canada, the National Research Council and CPAD Holdings Ltd.

1.5 Procedures Used

The test and evaluation procedures are identified and described in Chapter 3 of this document. For a more detailed description of procedures which may be unfamiliar to the reader, please refer to Appendix A, *Test and Evaluation Procedures*.

Due to the lack of a standard requirements specification several sections of the *Test and Evaluation Procedures* were revised to more adequately test the capacities of the EDSS™ system. Full descriptions of these modifications are incorporated in Chapter 3 under the various test type headings.

1.6 Problems Encountered

During the course of the test and evaluation phase, it became apparent that some parts of the *Test and Evaluation Procedures* could not be performed exactly as described in that document. In particular:

1. There is no documented method for measuring the quantity of pentaerythritol tetranitrate (PETN) transferred by hand from explosives such as DM12 to various materials to be tested;

2. The NRC did not consider its laboratory qualified to carry out the longevity and stability tests;

3. The NRC felt that the prescribed controlled line voltage variation tests were not within their area of expertise.

During a meeting between NRC and CPAD held November 8th, 1991, it was agreed that a new particle calibration source procedure should be established. An alternative procedure was drawn up by CPAD and approved by Transport Canada on February 25th, 1992. In addition, it was agreed that CPAD Holdings Ltd. would request approval from Transport Canada to carry out the longevity and stability tests at the NRC facilities, and the controlled line voltage variation tests at the CPAD laboratory. Approval for this modification was granted by Transport Canada on November 26th, 1991.

Another area where problems were encountered involved a low main power supply at the Ottawa airport during the operational field trials. To counter the consistently low voltage levels, voltage stabilizers were installed in February 1992, on both the walk-thru unit and the baggage scanner.

On the second day of the longevity and stability tests an electronic failure occurred on the Ion Mobility Spectrometer (IMS), resulting from a hot spot near the IMS. This problem was resolved by installing an additional cooling system in the cabinet.

1.7 Report Structure

The various sections of this report are organized as follows:

Chapter 2: Product Overview

A general description of the EDSS™ system, including the General Purpose Scanner, the Walk-thru Personnel Scanner, the Central Control and Display and the Walk-thru Remote Control and Display. Equipment operating procedures are also covered.

Chapter 3: Test Program

A brief summary of the major requirements of the test and evaluation program, including test types, general procedures and evaluation methods used. This section is included to facilitate the reader's understanding of the test results, and is not intended to replace the *Test and Evaluation Procedures*, Appendix A, where full details of the test plans and procedures are documented.

Chapter 4: Analytical Performance Tests

A description of the results of laboratory testing to ascertain the analytical performance of the EDSS™ system. These tests may be referred to elsewhere in TDC documentation as the *development tests* of the system. They include the vapour detection evaluation (Section A) performed by NRC and CPAD, the plastic explosives detection evaluation (Section B) performed by CPAD and the interference tests (Section C) performed by NRC and CPAD.[1]

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[1] These section names refer to distinctions set out in the *Test and Evaluation Procedures*, and not to the section numbering of the present report.

Chapter 5: Operational Performance Tests

A description of the results of controlled operations testing designed to determine the operational performance of the EDSS™ system. These tests include the vapour detection evaluation (Section A) performed by NRC and CPAD, and the plastic explosives detection evaluation (Section B) performed by CPAD.[1]

Chapter 6: Longevity and Stability Tests

The results of testing the performance of the EDSS™ system over a continuous operational period of 7 days, including an evaluation of the Walk-thru Personnel Scanner and General Purpose Scanner, and a description of equipment inspection results.

Chapter 7: Controlled Line Voltage Variation Tests

An account of the results of testing the performance of the EDSS™ Walk-thru Personnel Scanner and General Purpose Scanner over a range of static line voltage levels.

Chapter 8: Operational Field Trials

A description of extended testing of the EDSS™ at one of the security gates of the Ottawa airport. These trials were designed to determine the ability of the scanners to detect concealed explosives in a real-life scenario and operate reliably in an airport environment.

Chapter 9: Analysis and Discussion of Results

The results of all test and evaluation procedures are summarized and their implications as to the success of the testing phase are outlined.

Chapter 10: Conclusions

Conclusions and recommendations regarding the test and evaluation of the EDSS™ system are presented, based objectively upon the overall test results.

Appendix A: Test and Evaluation Procedures

The procedures drawn up by CPAD Holdings Ltd. and approved of by the Transportation Development Centre to test and evaluate a broad range of performance criteria of the EDSS™ system. These procedures also appear as Appendix II of TDC contract T8200-1-1511/01-XSD.

Appendix B: Operations Manual

Instructions for installing, operating and maintaining the EDSS™ system. This document has been developed by CPAD for the use of security personnel and their supervisors. It is annexed here to provide the reader with a more detailed description of how the EDSS™ is used and maintained.

Appendix C: Sample Graphic Displays

Examples of the bar graph and analog graph readings for various levels of explosive compounds detected by the EDSS™, as well as example troubleshooting displays. These examples have been chosen for their instructional nature, and are not intended to represent average or typical readings.

2. PRODUCT OVERVIEW

2.1 General

The EDSS™ is an explosives detection system proposed for use at airport security gates and baggage rooms, as well as for vehicle, building and mail inspection. It operates in essentially real time, providing effective and non-invasive detection of a full range of explosives, taggants and untagged plastics. The various components of the system have been designed for easy installation in existing security areas, without interference to normal passenger traffic or baggage handling procedures.

The EDSS™ patented analytical system uses proprietary sample collectors and preconcentrators to prepare and inject samples into gas chromatographic and ion mobility spectrometer detection subsystems. Separate but cross-referenced and integrated analytical subsystems provide for redundancy in the processing of each sample. The result is a highly sensitive and accurate explosives detection device.

2.2 Technical Description

The EDSS™ system includes two primary scanning units: the transportable General Purpose Scanner and the stationary Walk-thru Personnel Scanner. Each of these is equipped with a monitoring system, the Central Control and Display. In addition, the Walk-thru Personnel Scanner is connected to a remote monitor, the Walk-thru Remote Control and Display.

The two scanning units and their monitors are described in the following sections. For further details, the reader may also examine the EDSS™ Operations Manual, included here as Appendix B.

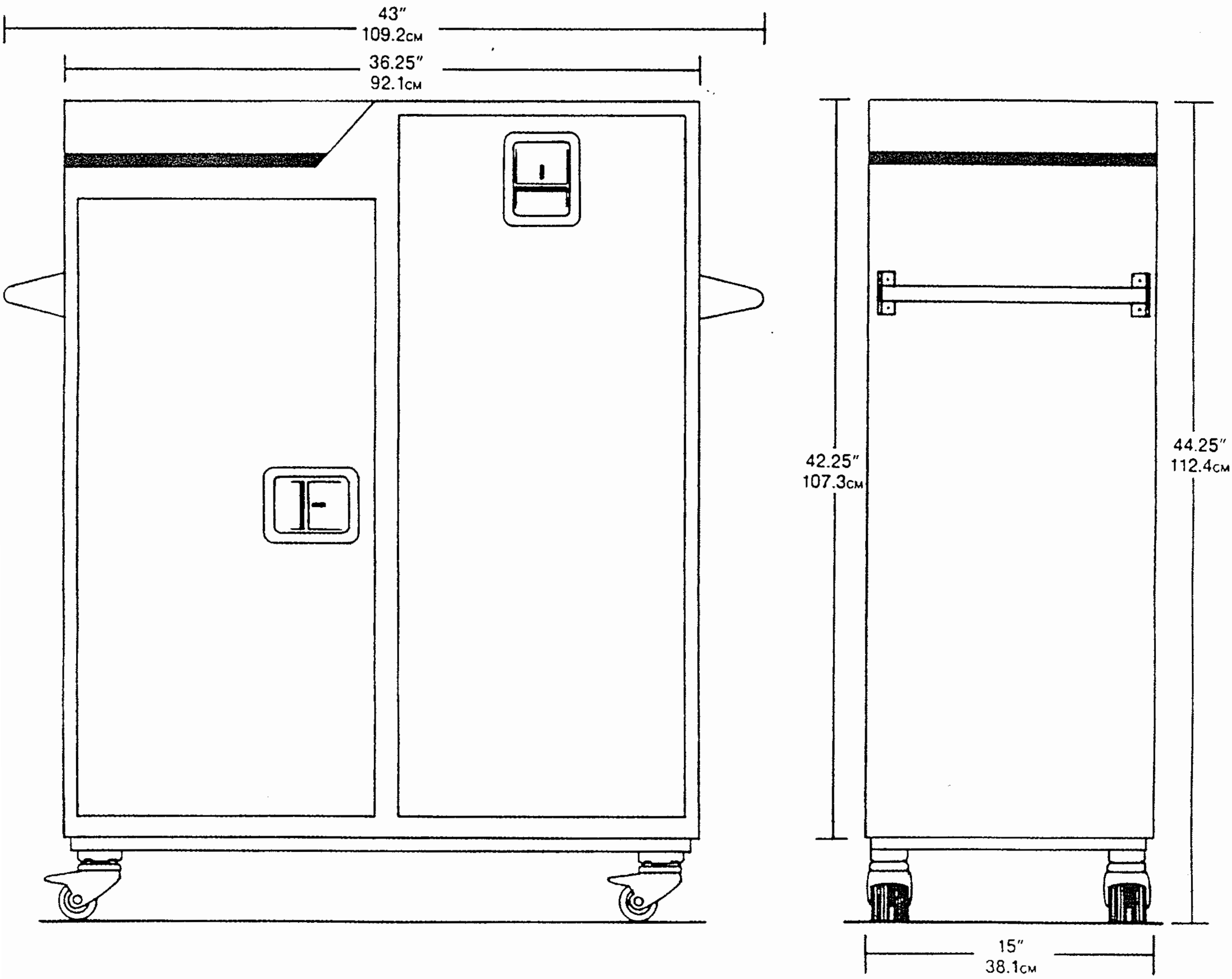

Figure 2.2 General Purpose Scanner Physical Dimensions

2.2.2 Walk-thru Personnel Scanner

The EDSS™ Walk-thru Personnel Scanner is a stationary unit intended mainly for use at airport security gate entrances. It has been designed to scan individuals and their hand-held luggage as they pass through the scanning portal. The portal has been designed for free, uninterrupted passage of all individuals, including disabled persons. Its modular panels may be arranged and coloured to suit the local architecture. Figure 2.3 illustrates the Walk-thru Personnel Scanner.

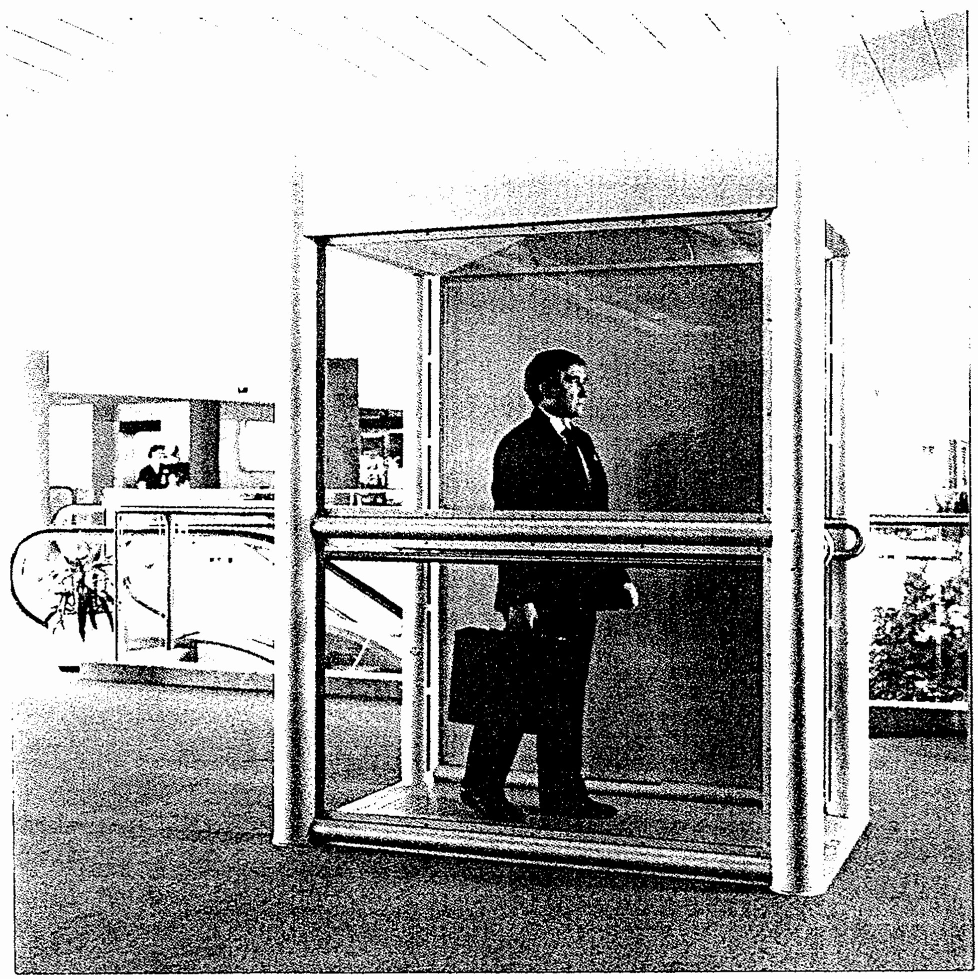

Figure 2.3 The EDSS™ Walk-thru Personnel Scanner

Sampling is accomplished by non-invasive automatic collection while the individual is inside the portal. As with the General Purpose Scanner, the Walk-thru Personnel Sampler utilizes a high-volume sampling technique coupled with a patented analytical system which includes unique sample collectors and preconcentrators to prepare and inject samples into both gas chromatography and ion mobility spectrometer analytical subsystems.

If an explosive compound is detected, visual and audible alarms are set off, a central control monitor displays the type and quantity of explosive detected, and a remote monitor displays a picture of the suspect or suspects associated with the alarm.

The Walk-thru Personnel Scanner has the following components:

1. A walk-through portal;
2. One analytical module cabinet, similar in function and form to the cabinet of the General Purpose Scanner described in paragraph 2.2.1;
3. Two 15 amp power lines for connection to two separate conventional 15 amp outlets;
4. One remote vacuum and muffler unit;
5. One Central Control and Display monitor, installed beneath the top cover of the cabinet (see paragraph 2.2.3 for details and specifications);
6. One Walk-thru Remote Control and Display centre, installed at a remote location for surveillance by security personnel (see paragraph 2.2.4 for details and specifications).

The operational specifications of the Walk-thru Personnel Scanner are given in Table 2.2. Its physical dimensions are represented in Figure 2.4.

Table 2.2 Walk-thru Personnel Scanner Operational Specifications[2]

MATERIALS DETECTED:	DMNB, DNT, EGDN, NG, O-MNT, PETN, P-MNT, RDX, TNT
PROCESSING TIME:	1000 persons per hour
ALARMS:	Central Control: red flashing ALARM light, audible signal, visual signal, graphic identification of explosive type and quantity Remote Monitor: red flashing light, audible signal, display of suspect's picture
CONSUMABLES:	Power Supply: 120 VAC ± 8% or 240 VAC ± 8% Compressed Gas: Ultra-high purity nitrogen

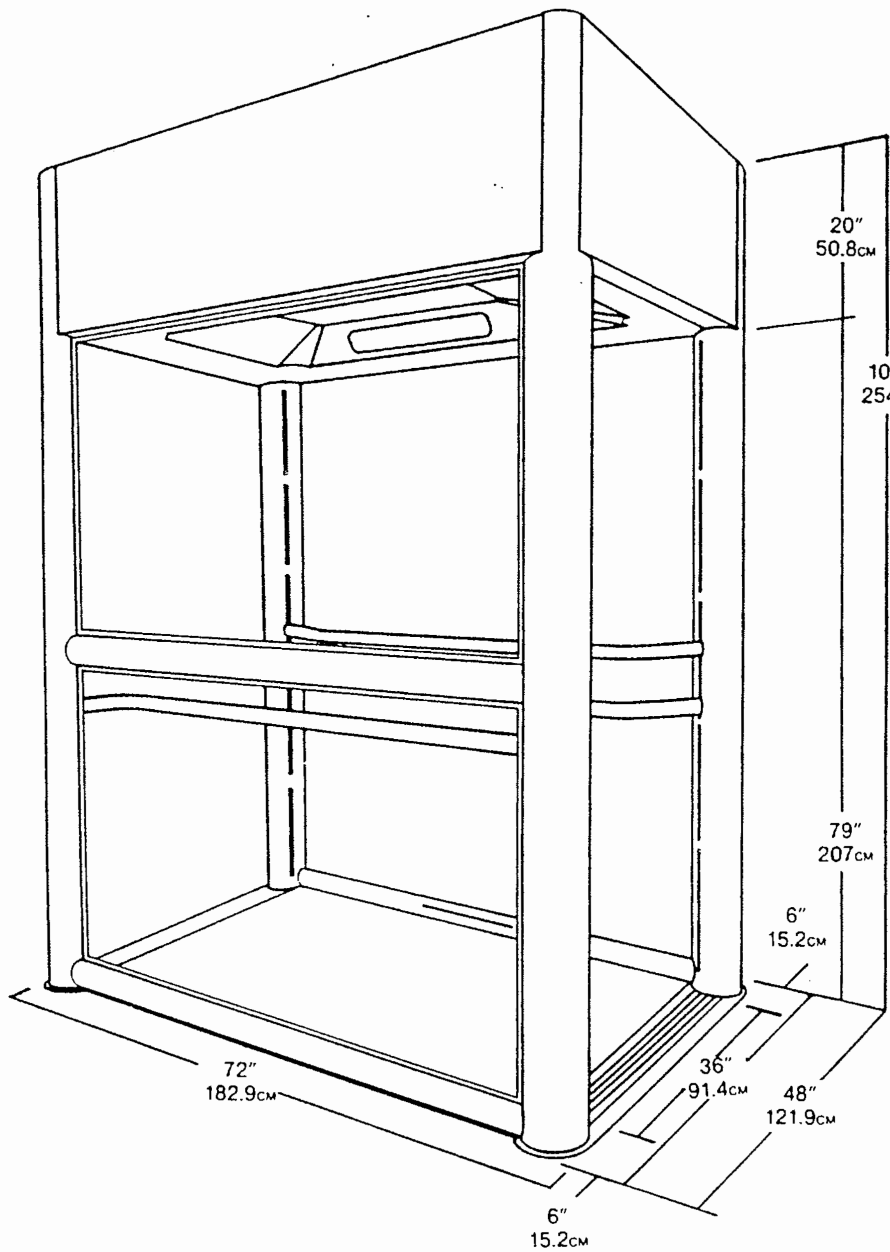

Figure 2.4 Walk-thru Personnel Scanner Physical Dimensions

2.2.3 Central Control and Display

The Central Control and Display is a subsystem mounted beneath the top cover of the analytical cabinet for both the General Purpose Scanner and Walk-thru Personnel Scanner. It includes a set of operator controls similar to those on the hand-held wand, as well as a monitor and keyboard for operator viewing and input. The Central Control and Display is accessed by unlocking the top cover and raising it to a vertical position. It is illustrated in Figure 2.5.

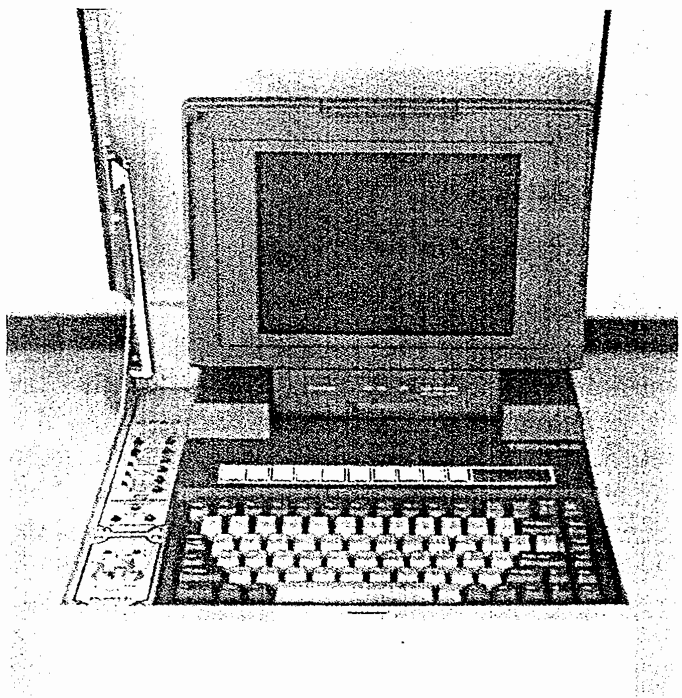

Figure 2.5 The EDSS™ Central Control and Display

The Central Control and Display has the following components:

1. A portable computer, including a lift-top monitor, standard keyboard and 1.4 megabyte diskette drive. This computer contains the software governing startup and cleaning procedures, graphic and diagnostic displays, online help, and the fine-tuning of alarm level thresholds and analog graph settings;

2. A system status and control panel, located to the left of the computer. This panel includes luminous indicators for the following: gas status, system ready, system standby, pause mode, continuous cycle mode, single cycle mode, sampling active, alarm detection and normal reading. It also has a system ON/OFF switch and a fan ON/OFF switch. The function of these indicators and switches is outlined in paragraph 2.3 of this document, with details given in the Operations Manual, Appendix B.

The operational specifications of the Central Control and Display are subsumed under Tables 2.1 and 2.2, above.

2.2.4 Walk-thru Remote Control and Display

The Walk-thru Remote Control and Display is a unit connected to the cabinet of the Walk-thru Personnel Scanner by means of four cables, sheathed as a single line, which carry audio and video signals from the Walk-thru to the Remote unit. The cables can be as long as 30.5 m (100 ft), permitting installation of the Remote Control and Display at a distant location convenient for supervision by security personnel. In addition, the Remote Control and Display is mounted on wheels to permit easy relocation. This flexibility of installation permits operation of the Walk-thru unit without direct local monitoring. Furthermore, a modem connection to the Remote Display allows for off-site analysis of data by CPAD specialists. The Remote Control and Display is illustrated in Figure 2.6.

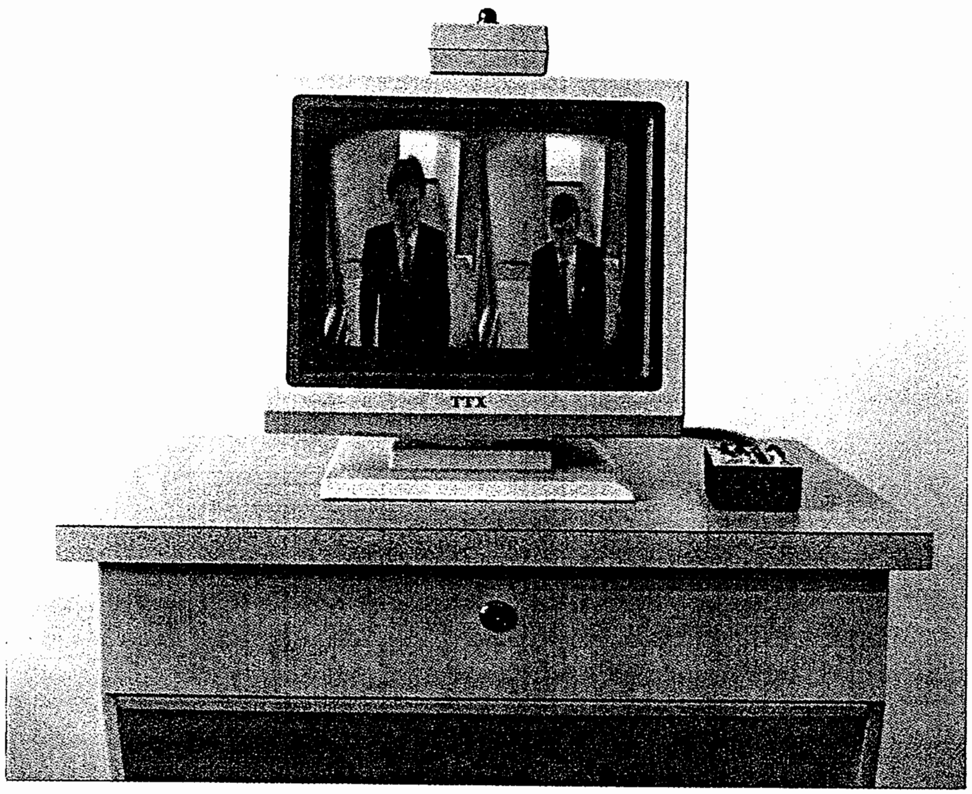

Figure 2.6 The EDSS™ Walk-thru Remote Control and Display

The Walk-thru Remote Control and Display has the following components:

1. A single-drawer table equipped with casters;

2. A PC-type computer, including monitor and standard keyboard. This computer contains the software governing the video display of photographs taken during a system alarm, as well as the same analytical software found in the Central Control and Display (paragraph 2.2.3);

3. A system status and control panel, located to the right of the computer, similar in construction to the operator controls and signal display mounted on the hand-held wand of the General Purpose Scanner;

4. A red luminous alarm indicator affixed to the top of the computer monitor.

The operational specifications of the Walk-thru Remote Control and Display are subsumed under Table 2.2 on page 15. Its physical dimensions are represented in Figure 2.7.

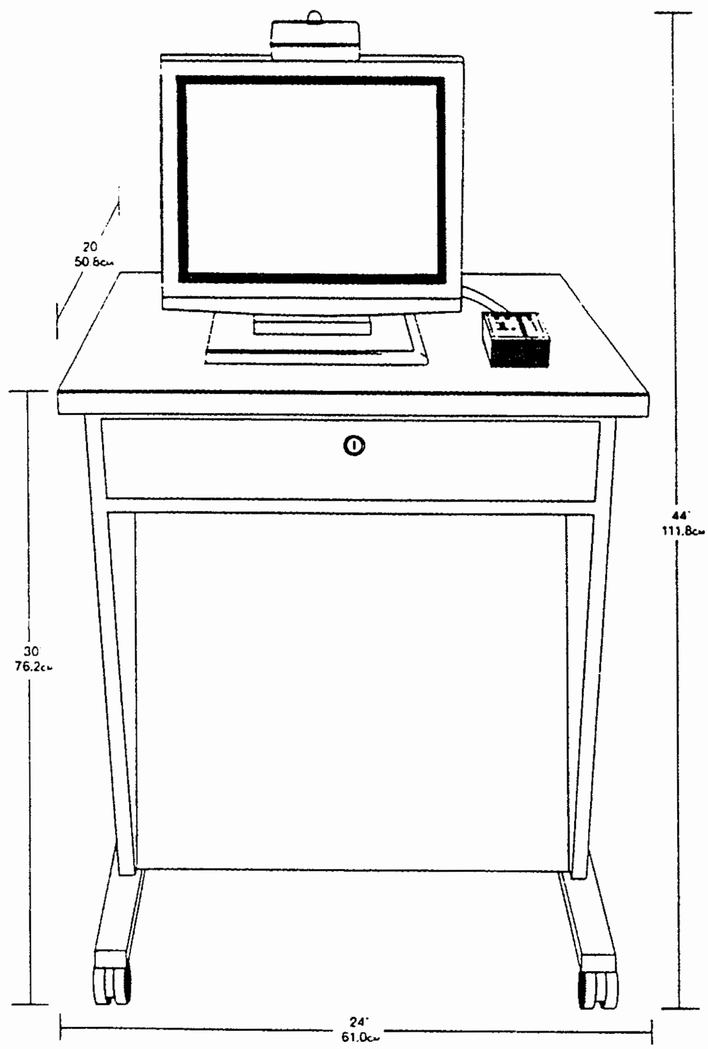

Figure 2.7 Walk-thru Remote Control and Display Physical Dimensions

2.3 Operating Procedures

The following is a brief summary of the operating procedures for the EDSS™ General Purpose Scanner and Walk-thru Personnel Scanner under normal conditions and in alarm situations. For full details regarding operating procedures, refer to the *Operations Manual*, which appears here as Appendix B. The reader is also invited to examine the sample graphic displays presented as Appendix C.

2.3.1 Equipment Startup

Starting up the scanner for operation involves the following steps:

1. Turn on the nitrogen gas supply by slowly opening the two green Nupro valves located above the gas tanks inside the cabinet;

2. Check that the gas supply is adequate, that is, more than 500 psi. If less than this, top up the tanks from an external supply tank;

3. Make sure the scanner power cables are connected to two separate 15 amp circuit outlets;

4. Connect a sampling hose to the unit by plugging in the electrical cable for the hose, and connecting the vacuum hose to the hose coupling at the rear of the scanner cabinet;

5. Unlock and lift up the top cover of the cabinet to access the computer, monitor and controls;

6. Turn the system ON/OFF and FAN switches, located at the bottom of the control panel, to the ON position.

   The computer monitor displays the message "Countdown to Start-up: 60 Minutes". The system then goes through an automatic preparation period of one hour;

7. When the automatic preparation period is complete, the READY-YES green light turns on, the STANDBY yellow light turns on, and the monitor displays the message "Ready".

   The EDSS™ system is now ready for immediate operation or system configuration.

2.3.2 System Configuration

Before beginning operations, it is recommended to check that all EDSS™ subsystems are operational, that the system is properly calibrated, and that the background thresholds are at an appropriate level for the ambient environment.

Procedure for Checking the Subsystems:

To check the subsystems, the operator uses the diagnostic display (Troubleshooting Display) to determine the status of key technical components.

1. Press <F8> on the computer keyboard to bring up the Troubleshooting Display on the monitor. The equipment executes a single cycle and carries out internal diagnostic tests. The results of these tests are displayed on the monitor.

   If a "Failure" or "Out of Range" value is given on the Troubleshooting Display, there may be a problem with the corresponding subsystem. Refer to the troubleshooting procedures at the end of the *Operations Manual*, which appears here as Appendix B;

2. Repeat step 1 two more times. Three diagnostic tests are required to check all three sample collectors.

Calibration Procedure:

The EDSS™ system must be calibrated on a regular basis to ensure that the signal indicators accurately reflect the chemical analyses for each of the compounds. It is recommended to calibrate the system on startup each morning, and at least one more time each day during low-traffic periods. The procedure for calibrating the system involves the use of calibration standard compounds.

1. Activate the Standby mode by pressing the STANDBY button on the control panel;

2. Press the <K> key on the computer keyboard. The monitor displays:

```
Calibrate Menu
Calibrate Compounds
Adjust Calibration
Add Calibration Peaks
CSP Calibration
```

Select *CSP Calibration* using the arrow keys, and press <Enter>.

3. Feed a standard sample to the EDSS™ analytical unit:

   i) Load a calibrated vapour generator with a standard sample of the compound for which you are calibrating the system,
   ii) Remove the wand hose from the EDSS™,
   iii) Turn the vapour generator on and hold it near the EDSS™ intake,
   iv) Press the SINGLE CYCLE button on the control panel.

   The EDSS™ system goes through a single cycle and samples the compound.

4. Press the <K> key on the keyboard for the list of calibration functions. Select *Calibrate Compounds* using the arrow keys, and press <Enter>. The monitor displays:

```
Select Compound
       1
       2
       3
       A
       4
       5
       6
       7
       B
       C
       D
```

5. Select the number that corresponds to the compound sampled and press <Enter>. The message *Peak found and calibrated* appears. The EDSS™ system is now calibrated for that compound.

Repeat this procedure for each compound, using the appropriate standard sample in the vapour generator. Note that a calibration for compound #6 (TNT) will also calibrate the system for compound #7 (RDX).

Procedure for Setting Background Thresholds:

The background thresholds determine what quantity of a particular compound must be detected before an alarm is raised. They permit the EDSS™ system to account for the presence of background contamination and continue to detect explosive compounds, which give signals above the set threshold levels. The thresholds must be set for each compound on a regular basis, preferably twice a day, to account for possible changes in the ambient atmosphere.

Alarm Level Thresholds may be set automatically or manually for each compound. Thresholds are set automatically during the 60-minute startup process (paragraph 2.3.1). Manual settings override automatic settings and establish minimum threshold levels below which the automatic settings cannot fall.

1. To set a threshold automatically:

   i) Press the <F4> key on the computer keyboard,
   ii) The message *Auto Threshold # to Change* appears on the monitor,
   iii) Enter the number of the bar on the Bar Chart for the compound threshold to be set, and press <Enter>;

2. To set a threshold manually:

   i) Press the <F5> key,
   ii) The message *Which threshold do you wish to change* appears on the monitor,
   iii) Enter the number of the bar on the Bar Chart for the compound threshold you want to set,
   iv) Erase the current value using the <Backspace> key,
   v) Enter the new threshold value and press the <Enter> key.

Repeat these procedures for each threshold you want to establish. The system's background thresholds can be set using both manual and automatic procedures on different compounds.

2.3.3 Operating Modes

When the READY YES green light is on, four operating modes are available: Single Cycle, Continuous Cycle, Pause and Standby. Each mode is briefly described below.

Single Cycle Mode:

The Single Cycle mode is recommended for periodic sampling. To execute a single cycle, press the SINGLE CYCLE button on the control panel. The PAUSE light goes out, and the SINGLE CYCLE light turns on.

In the Single Cycle mode the EDSS™ conducts one cycle of sampling, analysis and display, and then stops. The results of the analysis are displayed on the monitor as a bar chart and, using a special key sequence, an analog chart. The bar chart gives the current sample values and alarm thresholds, and a graphic display of any explosive materials detected. When an alarm occurs, the message "ALARM" appears in large capital letters down the left side of the screen, in addition to the audible signal and red ALARM light on the control panel.

If no alarm sounds, the operator can execute another single cycle, or move into Continuous Cycle, Pause or Standby mode. If an alarm sounds, only the Pause mode is available, described below.

Continuous Cycle Mode:

The Continuous Cycle mode is recommended for continuous operations, for example, when a steady stream of people are going through the Walk-thru unit, or when automatic operation is desired.

To execute continuous cycles, press the CONTINUOUS CYCLE button on the control panel. The PAUSE light goes out and the CONTINUOUS CYCLE light turns on.

In Continuous Cycle mode the EDSS™ conducts repeated cycles of sampling, analysis and display. The results of each analysis are displayed on the monitor in the same way as for Single Cycle mode, indicating the type of explosive detected, if any, and the strength of the signal.

The equipment operates continuously until an alarm sounds. On an alarm, the system processes the samples currently being collected and analyzed, and moves into Pause mode. The results of the sample that caused the alarm are immediately displayed on the monitor. To see the results of the two samples processed after the alarm sample, press the SINGLE CYCLE button once for each bar graph display.

Pause Mode:

The Pause mode occurs automatically after an alarm. To reactivate the system, press the PAUSE button or the <Q> key on the keyboard. If PAUSE is pressed, the EDSS™ goes through a short cleaning process before continuing with normal operations. With the <Q> key, the system bypasses the cleaning cycle and returns to normal operations immediately. A cleaning cycle is recommended after an alarm.

The operator can request a pause at any time by pressing the PAUSE button. This may be useful, for instance, when the operator wants to stop the Continuous Cycle mode briefly. It is recommended to put the system into Pause mode before entering the Standby mode.

If the EDSS™ is left in Pause mode for more than 10 minutes, it moves automatically into Standby mode.

Standby Mode:

The Standby mode occurs automatically after system startup and after 10 minutes in Pause mode. It can also be activated manually. Manual activation of the Standby mode is recommended if the system is to be left unused for some time, as the consumption of nitrogen gas is reduced in this mode.

To activate the Standby mode press the STANDBY button on the control panel. The STANDBY light turns on. No sampling activities are carried out while in Standby mode. The equipment can be immediately returned to normal operations by pressing the SINGLE CYCLE or CONTINUOUS CYCLE button.

2.3.4 Equipment Shutdown

The equipment may be put into Standby mode if the expected period of inactivity is less than two or three days. The scanner can be then reactivated without going through the one-hour startup procedure.

For longer periods of inactivity, a complete shutdown is recommended:

1. Activate the Standby mode, as described in paragraph 2.3.3;

2. Turn the system ON/OFF and FAN switches, located at the bottom of the control panel, to the OFF position;

3. Close and lock the top cover of the cabinet;

4. Turn off the nitrogen gas supply by closing the two green Nupro valves located above the gas tanks inside the cabinet. Close firmly by turning clockwise until hand-tight.

3. TEST PROGRAM

This section outlines the major requirements of the test and evaluation program, including a description of the various test types and the procedures and evaluation methods used. For details on the test program, the reader is invited to consult the *Test and Evaluation Procedures*, which appear in this document as Appendix A.

3.1 General

Five principal areas of testing have been defined:

1. **Analytical Performance Tests**

   Testing carried out to ascertain the analytical performance of the EDSS™ system. These tests may be referred to elsewhere in TDC documentation as the *development tests* of the system.

2. **Operational Performance Tests**

   Tests designed to determine the operational performance of the EDSS™ system.

3. **Longevity and Stability Tests**

   Testing of the EDSS™ system over a continuous long-term operational period.

4. **Controlled Line Voltage Variation Tests**

   Evaluation of the performance of the EDSS™ Walk-thru Personnel Scanner and General Purpose Scanner over a range of static line voltage levels.

5. **Operational Field Trials**

   Extended testing of the EDSS™ at one of the security gates of the Ottawa International Airport, to determine the competence of the system in an actual airport environment.

The following paragraphs discuss the test and evaluation procedures designed for each of the five areas of testing. All approved changes to the initial procedures drawn up in the October 15th, 1991 version of the *Test and Evaluation Procedures* are covered under the appropriate test headings.

3.2 Analytical Performance Tests

The *Test and Evaluation Procedures* call for laboratory tests of analytical performance to ascertain the following:

1. The range of explosives and taggants detected, that is, what types of explosive compounds can be identified by the EDSS™;

2. The limit of detection for each of the explosives determined in number 1;

3. Whether any interferents can be identified. An interferent is a non-explosive product that is detected and analyzed as an explosive compound.

The laboratory tests have been divided into two types: vapour detection and plastic explosives detection.

3.2.1 Vapour Detection Evaluation

Explosive Compounds To Be Tested:

Ethylene Glycol Dinitrate (EGDN),
Dinitrotoluene (DNT),
Nitroglycerine (NG),
Taggant Candidates: EGDN, ortho-mononitrotoluene (O-MNT), para-mononitrotoluene (P-MNT) and dimethyl-dinitrobutane (DMNB)

Establishing Lower Detectable Limits of Overall Detection System:

This test requires repeated sampling and analysis for 5-second and 10-second sampling periods. The lower detectable limit is taken as a signal emanating from an explosive sample which is beyond twice the background noise in the baseline of the unit with no sample present. The baseline is the average value established from a series of samples of the ambient atmosphere, taken on the same sample collector, for each compound under consideration. The background noise in the baseline is the average difference between the values established in determining the baseline.

For this procedure the equipment baseline is established, a sample introduced to the unit, the output recorded, and the baseline reading reestablished by the unit. These steps are repeated in series, with the sample size decreased until the signal is detectable within 2 to 3 standard deviation units of the background noise in the baseline.

Establishing Clear Down Time:

The clear down time is the time required to return to the approximate baseline value, that is, 2 to 3 times the original baseline values.

For this procedure the EDSS™ is subjected to high (5 to 50 ppb) and low (10 to 100 ppt) concentrations of EGDN. The time the system requires to return to baseline levels is recorded.

Vapour Detection Evaluation of the General Purpose Scanner:

Vapour detection is carried out using vapour generators which emit explosive vapours at a constant rate and dilution. A primary vapour generator (also referred to as a dog box) is placed at a reproducible position with respect to the sample orifice of the EDSS™ system.

For this procedure the equipment baseline is established, a sample introduced to the sample nozzle at the end of the sampling hose, the output recorded, and the baseline reestablished by the unit. These steps are repeated in series, with the sample size decreased until the signal is detectable within 2 to 3 standard deviations of the baseline noise.

Vapour Detection Evaluation of the Walk-thru Personnel Scanner:

Vapour detection is carried out using vapour generators which emit explosive vapours at a constant rate and dilution. A calibrated set of sample generators are used to calibrate all secondary generators. A sample cartridge containing a source of the particular explosive vapour is placed in a secondary generator. A test subject turns the generator on and takes it into the Walk-thru unit for a specified length of time.

The procedure for this test is similar to that for the General Purpose Scanner. The sample is introduced for a period of five seconds with the following variations:

1. While the equipment is in pause mode;

2. While the equipment is in non-pause mode, that is, any active mode;

3. At various locations inside the Walk-thru portal.

In addition to this test, the analytical subsystem of the Walk-thru unit is tested in the same way as for the General Purpose Scanner, using a primary vapour generator.

3.2.2 Plastic Explosives Detection Evaluation

Explosive Compounds To Be Tested:

Cyclotrimethylene trinitramine (RDX),
Pentaerythritol tetranitrate (PETN)

These compounds are found in C-4, DM12, Semtex-H, Deta Sheet and similar sheet explosives.

Establishing Lower Detectable Limits of Overall Detection System:

The lower detectable limit is taken as a signal emanating from an explosive sample which is beyond twice the background noise in the baseline with no sample present. The baseline is the average value established from a series of samples of the ambient atmosphere, taken on the same sample collector, for each compound under consideration. The background noise in the baseline is the average difference between the values established in determining the baseline.

For this procedure the equipment baseline is established, a metered volume of a standard solution of RDX or PETN injected onto a sample collector, the output recorded, and the baseline reading reestablished by the unit. These steps are repeated in series, with the volume of solution decreased until the RDX or PETN signal is detectable within 2 to 3 standard deviation units of the background noise in the baseline.

Particle Calibration Source:

A series of 6 to 10 test squares measuring 7.62 cm by 7.62 cm (3" by 3") are cut from a particular material. The squares of material are contaminated with a thumbprint of each plastic explosive tested. The test subject produces the thumbprints by first touching a sample of the explosive and then making a thumbprint on each of the test squares. The test materials include stainless steel, vinyl, cardboard, nylon, polyethylene, leather and canvas.

Alternate squares are analyzed in the laboratory by washing with solvent and injecting the solution on a gas chromatograph. The remaining squares are sampled by the EDSS™ General Purpose Scanner.

Modification of the Particle Calibration Source Procedure:

The NRC encountered a technical problem with the test procedure described above. There is no documented method for measuring the quantity of PETN transferred by hand from explosives such as DM12 to the various materials to be tested. The procedure proposed for the particle calibration source requires further development before it can be used at an appropriate level of confidence.

During a meeting between the NRC and CPAD on November 8th, 1991, it was agreed that a new procedure should be established. An alternative procedure was drawn up by CPAD and approved by Transport Canada on February 25th, 1992. In this procedure, thumbprints of DM12, C-4, Semtex-H and Deta Sheet are applied to stainless steel, cardboard, nylon, vinyl, polyethylene, leather, canvas and hard plastic.

The medium is sampled before the test to determine its cleanliness, that is, that no explosive signal is present. The explosive material is moulded into a small block by a handler, who then places a series of thumbprints on adjacent squares marked on the test surface material. The EDSS™ is operated through several cycles to ensure that no explosive signal is present. Beginning with the last thumbprint made, a single cycle sample of each thumbprint is taken and the results noted.

When a sample results in an alarm the EDSS™ is placed in a clean cycle, the sampling hose changed for a clean hose, and the scanner operated through several cycles to ensure that it is free of any residual signal. This procedure is repeated for each of the explosive compounds and surface materials to be tested.

3.2.3 Interference Tests

Potential interferent compounds include low smoke concentrations (such as smoke from a cigarette, cigar or pipe), car exhaust, perfumes, freons, chlorinated solvents, acetone and foodstuffs.

The procedure for identifying interferents involves sampling the potential interferent with the EDSS™ system and recording the results.

Modification of the Interference Tests Procedure:

A revised set of potential interferents was drawn up by CPAD and approved by Transport Canada on February 25th, 1992. The list of materials provided in the new test protocol includes freons, soap, musk perfumes, low-level smoke, car exhaust, chloroform, carbon tetrachloride and acetone. The procedure for identifying interferents remains unchanged.

3.3 Operational Performance Tests

The *Test and Evaluation Procedures* call for controlled operational tests to characterize the capability of the EDSS™ system to identify the presence of explosives on a person or in parcels or baggage.

For the operational performance tests the alarm thresholds on the EDSS™ are set at appropriate levels for the ambient environment. The unit's alarm signal is used as the indicator of the presence of the explosive being sampled. The results are thus based on a binary distinction: *Alarm* condition versus *No Alarm* condition.

The operational tests have been divided into two types: vapour detection and plastic explosives detection.

3.3.1 Vapour Detection Evaluation

Explosive Compounds To Be Tested:

EGDN,
DNT,
NG,
Taggant Candidates: EGDN, O-MNT, P-MNT and DMNB

Modification of Explosive Compounds to be Tested:

A revised procedure was drawn up by CPAD and approved by Transport Canada on February 25th, 1992. In this new procedure the following compounds are to be tested:

EGDN,
TNT,
NG,
Taggant Candidates: EGDN, O-MNT, P-MNT or DMNB

Vapour Detection Evaluation of the General Purpose Scanner:

The International Civil Aviation Organization (ICAO) has devised a procedure called the *ICAO Suitcase Test*, which is appropriate for testing the operational performance of the General Purpose Scanner's vapour detection.

The Suitcase Test requires that a mass of approximately 50 g of a marked explosive be placed inside a polyethylene bag which is then wrapped in cotton and surrounded by a layer of crumpled newspaper. The wrapped explosive is then placed inside a cardboard box measuring approximately 15.25 cm (6") by 40.64 cm (16") by 60.96 cm (24"), and all edges and openings of the box are sealed with tape.

A slit 10 cm long is cut at mid height along one side of the box with a sharp knife, and a vapour sample is taken. The box is then sealed and another sample taken. Thereafter, the box is sampled at specific time intervals.

Modification of the Procedure for Vapour Detection Evaluation of the General Purpose Scanner:

In the revised procedure drawn up by CPAD and approved by Transport Canada on February 25th, 1992, a more detailed ICAO Suitcase Test was proposed. The samples are prepared as follows:

EGDN and NG:

A sample mass of dynamite equivalent to 1/4 stick is sealed in a thin polyethylene bag and wrapped in two layers of simple unbleached cotton fabric.

Taggant Candidate:

A sample mass of approximately 50 g of moulding putty is marked with 0.1% of the selected taggant. The sample is structured so that it is approximately 6 cm by 5 cm in surface area. This sample is sealed in a thin polyethylene bag and wrapped in two layers of simple unbleached cotton fabric.

TNT:

A vapour generator emitting vapour equivalent to one 454 g (1 lb) block of TNT is sealed in a thin polyethylene bag and wrapped in two layers of simple unbleached cotton fabric.

Each wrapped sample is sealed in a corrugated cardboard box measuring approximately 15.25 cm X 40.6 cm X 61 cm (6" X 16" X 24") in the following manner:

1. The empty box is first sampled to ensure it is free of explosive vapours;

2. The sample is placed in the centre of the three-dimensional space, and the box filled with 500 g of crumpled newspaper in such a way that the sample remains suspended in the centre of the box;

3. The box is closed and all openings and edges are sealed with tape;

4. A 10 cm slit is made at mid height on one side of the box with a very sharp knife or razor.

To determine the elapsed time between packaging and sampling, a record is made of the time the packaging is completed. Air samples are taken from the slit on the side of the box. Samples are taken at 15-minute intervals for EGDN and NG, and at one-hour intervals for TNT and the taggant candidate. The results and time of each sample are recorded.

Vapour Detection Evaluation of the Walk-thru Personnel Scanner:

This test requires that a sample of the explosive material be carried on a person who walks through the Walk-thru portal.

A sample of the explosive is placed in a small cardboard box the size of a cigarette package. The box is located under garments worn by the person, and an initial soak time of at least 15 minutes is allowed to elapse. The person walks through the Walk-thru portal at a normal pace, and the results are recorded. The test is repeated over specific time intervals.

As an optional procedure, a hand-wand may be attached to the Walk-thru unit, and the person scanned with the wand. The results of this scan are also recorded.

Modification of the Procedure for Vapour Detection Evaluation of the Walk-thru Personnel Scanner:

In the revised procedure drawn up by CPAD and approved by Transport Canada on February 25th, 1992, a more detailed evaluation method was proposed. Approximately 50 g of moulding putty containing 0.1% of DMNB is place in a cigarette box. The cigarette box is then put in a shirt pocket under a suit jacket worn by the test subject.

An initial soak time of 15 minutes is allowed to elapse, after which the test subject walks through the portal at a normal pace. After passing through the Walk-thru the test subject is sampled with the hand wand, without it coming in contact with the test subject. The test is repeated at 15-minute intervals, and all results are recorded.

3.3.2 Plastic Explosives Detection Evaluation

Explosive Compounds To Be Tested:

RDX,
PETN

Modification of Explosive Compounds to be Tested:

A revised procedure was drawn up by CPAD and approved by Transport Canada on February 25th, 1992. In this procedure the following explosive materials are to be tested, all of which contain RDX and PETN:

C-4,
DM12,
Semtex-H,
Deta Sheet

Plastic Explosives Detection Evaluation of the General Purpose Scanner:

The operational performance of the General Purpose Scanner's plastic explosives detection is tested by sampling a suitcase or box at three levels of detection difficulty.

1. First level of difficulty:

   For the least difficult detection task, an explosive sample is handled in the following way: the handler kneads and shapes a plastic explosive into a bomb-like shape, places it inside an appropriate appliance and then places the appliance in a suitcase.

2. Second level of difficulty:

   The handler installs the bomb-shaped explosive sample in the appliance, and then gives the appliance to an accomplice. The accomplice packs the appliance in a suitcase.

3. Third level of difficulty:

   For the most difficult detection task, an explosive sample is handled in the following way: the handler shapes and installs the explosive in the appliance, places the appliance in a plastic bag and gives the wrapped appliance to the accomplice. The accomplice places the package in a suitcase.

For this procedure the exterior of the suitcase is sampled in the normal manner, and the results recorded. Then the suitcase is sampled using a wiping technique, and the results recorded. If the results in either case are negative, the suitcase is opened and sampled on the inside, and results recorded.

Modification of the Procedure for Plastic Explosives Detection Evaluation of the General Purpose Scanner:

In the revised procedure drawn up by CPAD and approved by Transport Canada on February 25th, 1992, a simpler and more statistically significant evaluation method was proposed. In this procedure two types of containers are used: plastic containers and glass jars, which simulate concealment of explosives in devices such as a plastic electronic instrument and a glass preserving jar. The samples are prepared to reflect two different scenarios, the first involving only the bomb handler and the second involving an accomplice.

1. First level of difficulty:

   For the least difficult detection task, the medium and the handler are first sampled to ensure that they are free of contaminants. The handler wearing rubber gloves opens the medium, places the explosive inside and kneads the explosive between the fingers. The medium is then closed by the handler.

2. Second level of difficulty:

   For the more difficult detection task, the medium and the handler are first sampled to ensure they are free of any contaminant. The medium is opened by a second person wearing rubber gloves. The handler, also wearing rubber gloves, places the explosive inside the medium and kneads it between the fingers. The medium is then closed by the second person.

The sampling procedure involves sampling the medium externally and recording the results. If the results are negative for either the first or second level of difficulty, the medium is opened and sampled internally, and the results recorded.

3.4 Longevity and Stability Tests

The *Test and Evaluation Procedures* call for laboratory tests to determine the longevity and stability of the explosives detection system through performance tests over a continuous long-term operational period.

Before and after each of the performance tests, the gas supply level, diagnostic displays and general condition of the sample collectors and filters are checked and noted. In addition, the system is checked for any abnormal conditions such as hot spots or mechanical wear points. Any such problems are reported.

3.4.1 Test Plan

For the EDSS™ system, an operational testing period of 7 days (168 hours) is proposed. During days 1 to 5, the EDSS™ units are operated in Continuous Cycle Mode for an 18-hour period commencing at 6:00 a.m. and ending at 12:00 (midnight). From midnight to 2:00 a.m. the units are set in Cleaning Mode. And from 2:00 a.m. until 6:00 a.m. they are in Standby Mode. Regular maintenance and operating procedures are followed, as described in the *Operations Manual*, Appendix B. During days 6 and 7 the EDSS™ units are in Standby Mode at all times.

On day 1 the system is started up in the usual manner. Eleven sets of tests are performed during the 7 days of operation, with a twelfth set performed on the morning of day 8. The overall test plan, including daily schedule and elapsed time, is detailed in the *Test and Evaluation Procedures*, Appendix A.

3.4.2 Test of the General Purpose Scanner

Before each test, the scanner is checked to ensure that all systems are normal. A sample cartridge containing a source of DMNB vapour is placed in a calibrated vapour generator. The generator is turned on, the vapour collected by the General Purpose Scanner, and the results recorded.

To test the results for plastic explosives, a prepared calibration source of RDX in liquid phase is injected into the equipment using a syringe, and the results recorded. Each test for DMNB and RDX is repeated five times.

3.4.3 Test of the Walk-thru Personnel Scanner

Before each test, the scanner is checked to ensure all systems are normal. A sample cartridge containing a source of DMNB vapour is placed in a calibrated vapour generator. A test subject turns the generator on using a fixed emission rate of approximately 1 mg per minute, and takes the generator through the Walk-thru unit at waist height. The generator is on for the total travel time through the portal. The results are recorded, and the test repeated five times.

3.5 Controlled Line Voltage Variation Tests

The *Test and Evaluation Procedures* call for testing the EDSS™ over a static line voltage range of from 102 VAC to 132 VAC. The purpose of this test is to evaluate the performance of the EDSS™ system at less than ideal voltage levels, the ideal level being 120 VAC.

Before testing, the equipment is inspected and parts replaced, if required. The overall system calibration is checked and adjusted. The voltage level is set and the equipment tested using a prepared explosive sample, in the following sequence:

1. 120 VAC (normal voltage level)
2. 126 VAC
3. 114 VAC
4. 132 VAC (maximum voltage level)
5. 108 VAC
6. 102 VAC (minimum voltage level)

3.5.1 Test of the General Purpose Scanner

A sample is taken before the test with no explosive compound present, and the results recorded. The line voltage is set at the first test level (120 VAC) 15 minutes before testing. Samples of RDX on the particle calibration source are then collected by the General Purpose Scanner using the normal sample collection method, and the results recorded. The test is repeated five times. Then the line voltage is set to the next test level for another series of tests.

At the end of the line voltage variation test, the scanner's after-test values are checked and reported.

3.5.2 Test of the Walk-thru Personnel Scanner

A sample is taken before the test with no explosive compound present, and the results recorded. The line voltage is set at the first test level (120 VAC) 15 minutes before testing. A sample cartridge containing a source of DMNB vapour is placed in a calibrated vapour generator. A test subject turns the generator on and takes it through the Walk-thru unit at shoulder height. The generator is on for the total travel time through the portal. The results are recorded, and the test repeated five times. Then the line voltage level is set to the next test level for another series of tests.

At the end of the line voltage variation test, the scanner's after-test values are checked and reported.

3.6 Operational Field Trials

The *Test and Evaluation Procedures* call for operational field trials to determine the following:

1. Identification of the most effective and efficient location of equipment:

    i. for scanning checked baggage and persons with hand-held luggage,
    ii. for placement relative to metal detectors and X-ray units;

2. Evaluation of the effectiveness of the EDSS™ in terms of:

    i. detecting concealed explosives,
    ii. the impact on traffic flow,
    iii. the operation of the scanners as elements of an integrated security gate involving metal detectors and X-ray units;

3. Any alterations or modifications to the EDSS™ configuration that are proposed for enhancement of:

    i. performance and reliability,
    ii. ergonomic factors,
    iii. integration with existing airport architecture at security gates and other desirable locations;

4. Projected operation and maintenance costs;

5. The impact on human resources, including:

   i. the level of expertise required to operate the equipment,
   ii. person-year requirements per system;

6. An estimate of first and second-level maintenance tasks.

3.6.1 Equipment Location

For the operational field trials, it was proposed to locate the EDSS^{TM} equipment in a low traffic area at first, building up to a full-impact situation gradually. It was also proposed to locate the equipment such that passengers could pass through the Walk-thru unit before going through the X-ray area.

A General Purpose Scanner was to be located next to the X-ray equipment to scan baggage as it comes off the X-ray. A second General Purpose Scanner was to be located either at the check-in counter or in the baggage room, for scanning checked baggage. In fact, a second baggage scanner was not purchased under the contract for the scanning of checked baggage, and this requirement was later dropped.

3.6.2 Scanning Protocol

It was determined in the test procedures that a detailed scanning protocol for operators should be established. This protocol would include procedures to follow when the equipment detects an explosive compound or residue, as well as a low, medium and high-threat scenario. For the different scenarios, the equipment sensitivity and scanning techniques would be set to reflect the threat situation.

During the operational field trials the test supervisor and assistants operate the equipment and maintain a detailed log describing the various factors of interest to the trials.

3.6.3 Operational Tests

To evaluate the ability of the EDSS™ to detect explosives under the different threat scenarios described above, controlled tests are scheduled during the general scanning of passengers and baggage, as well as during standby periods.

These tests involve a range of explosives scanned under three methods: non-intrusive scanning, intrusive scanning and a statistically significant sampling procedure involving both non-intrusive and intrusive scanning.

Test of the General Purpose Scanner:

The procedure proposed is similar to the longevity and stability test for the General Purpose Scanner (section 3.4), using a range of explosive materials, containers and threat scenarios. The equipment is calibrated taking into account the threat scenario under which it will operate.

The non-intrusive sampling method, whereby the sample case is scanned on its external surfaces only, is used under the low-threat scenario. The statistically significant sampling method is used under the medium-threat scenario. Here, a preset number of cases is opened and sampled internally, while the other cases are sampled externally. Under the high-threat scenario, all cases are opened and sampled internally.

For each scenario the results, either an *Alarm* or *No Alarm* situation, are recorded and related to the sampling method used. A statistically significant number of tests are to be performed.

Modification of the Test of the General Purpose Scanner:

A revised procedure was drawn up by NRC on February 26th, 1992, to more accurately determine General Purpose Scanner's ability to detect concealed explosives and operate reliably in an airport environment. As a general condition, each EDSS™ unit is to be fitted with a remote muffler and software to record data significant to the evaluation, if these features are not already installed. The units are to be set up at a security screening point and located in conjunction with other security equipment.

Detection Types:

A positive detection occurs if the EDSS™ system correctly identifies an explosive and/or detection agent present in the test bag or on the test subject. A missed detection occurs when neither the explosive nor the detection agent are detected, or when they are incorrectly identified by the system. A false alarm occurs when the system indicates the presence of an explosive or detection agent, when neither are present.

Pre-Test Activities:

An appropriate equipment location should be determined, following the requirements described in paragraph 3.6.1. To ensure that neither the test subjects nor the test bags are contaminated, blank samples are taken prior to testing. If an alarm is recorded, no further tests are conducted until the signal levels return to normal values.

Scanning Protocol:

For both opened and unopened bags the scanning protocol used is that which has been established through field trials by the manufacturer.

Test Scenarios:

Three levels of difficulty are defined. For the first level of difficulty (the least difficult detection task) person A assembles and arms a bomb. Arming the bomb involves placing batteries into the selected test bomb object. Person A then opens the test bag and loads the bomb into the bag. Loading the bomb into the bag requires that the bomb be placed in the centre of the bag between layers of a mixture of wool, cotton and polyester clothing. Person A then closes the bag and carries it to the General Purpose Scanner for sampling.

For the second level of difficulty, person A assembles the bomb and passes it to person B, who arms the bomb, opens the test bag, loads the bomb into the bag, closes the bag and carries it to the General Purpose Scanner for sampling.

For the third level of difficulty (the most difficult detection task) person A assembles the bomb and passes it to person B, who arms the bomb and loads it into an open test bag. After the bomb is loaded, person C closes the bag and carries it to the General Purpose Scanner for sampling.

Compounds to be Tested:

The tests involve some or all of the following:

C-4 with detection agent DMNB,
Semtex-H with detection agent EGDN,
Semtex-A with detection agent EGDN,
Optionally: EGDN-based explosives

In cases where real explosives are not permitted, appropriate simulants will be used. If the presence of a detection agent interferes with particle detection, unmarked explosives may be used.

Test Procedure:

In addition to the test bags containing explosive substances, a random number of test bags which do not contain explosives are also submitted for sampling. The operator first scans the test bags externally. The *Alarm* or *No Alarm* results are recorded and the data saved. All test bags which do not cause an alarm are returned for a second scan in which the bags are opened by the operator and scanned internally. Once again, the results are recorded and the data saved.

Test of the Walk-thru Personnel Scanner:

This test proposed in the October 15th version of the *Test and Evaluation Procedures* is similar to the vapour detection evaluation of the Walk-thru unit for the operational performance tests (paragraph 3.3.1). It requires that a sample of the explosive material be carried on a person who walks through the Walk-thru portal.

The equipment is calibrated taking into account the threat scenario under which it will operate. A sample of the explosive is packaged and strapped to the test subject's body. An initial soak time of 30 minutes is allowed to elapse.

For the non-intrusive sampling method, the subject walks through the Walk-thru portal at a normal pace, and the results are recorded. Under the statistically significant sampling method, a preset number of subjects are given additional scanning with the hand-held wand, without the wand coming in contact with the person. For the intrusive sampling method, all subjects are scanned with the hand wand attached to the Walk-thru unit.

For each scenario the results, either an *Alarm* or *No Alarm* situation, are recorded and related to the sampling method used. A statistically significant number of tests are to be performed.

Modification of the Test of the Walk-thru Personnel Scanner:

The revised procedure drawn up by NRC on February 26th, 1992, includes a more detailed procedure for testing the Walk-thru Personnel Scanner. The general conditions, detection types, pre-test activities and scanning protocol are the same as those described for the *Modification of the Test of the General Purpose Scanner*, above.

Compounds to be Tested:

The tests involve DMNB and/or EGDN.

Test Procedure:

The alarm thresholds are set at the levels used during routine scanning of passengers. In the first phase of the procedure, a vapour generator emitting DMNB and/or EGDN is held at various heights and locations in the Walk-thru portal, and the results recorded. This is to confirm the results previously obtained at the NRC premises during the analytical performance tests (paragraph 3.2.1).

In the second phase a test subject walks through the Walk-thru portal carrying the packaged explosive in a shirt breast pocket, or may at random walk through the portal without carrying an explosive. Test packages are prepared at least 24 hours prior to testing. When an explosive is used, the test subject walks through the Walk-thru immediately after receiving the test package, and thereafter at 15, 30, 45 and 60-minute intervals. All *Alarm* or *No Alarm* results are recorded and the data saved.

4. ANALYTICAL PERFORMANCE TESTS

This section describes the results of analytical performance testing carried out on the EDSS™ system to ascertain the range of explosives detected, the limit of detection for each explosive, and any identifiable interferents. These tests may be referred to elsewhere in TDC documentation as the *development tests* of the system.

An outline of the procedures for the analytical performance tests is given in paragraph 3.2 and its subparagraphs. Refer also to Appendix A, *Test and Evaluation Procedures*, for details. For ease of reference, the test results are documented here under the same headings as those of paragraph 3.2. Differences between the prescribed procedures and the actual procedures carried out are covered here under the appropriate test headings. Modifications made to the EDSS™ equipment during the analytical performance tests are described at the end of this section (paragraph 4.4).

4.1 Vapour Detection Evaluation

The vapour detection tests were carried out on the premises of the National Research Council (NRC). The tests began on September 16th, 1991, and were terminated on December 9th, 1991. The testing team included NRC scientists, with a CPAD explosives specialist in attendance.

All test results and informal notes were documented by the NRC's testing team. These results and comments will be published by the NRC as a separate report. The results documented here are compiled from notes taken during a meeting between CPAD Holdings, Ltd. and the NRC on November 26th, 1991.

4.1.1 Explosive Compounds Tested

All of the explosive compounds proposed for the vapour detection evaluation were tested. These compounds are DMNB, EGDN, P-MNT, O-MNT, NG and DNT.

4.1.2 Lower Detectable Limits of Overall Detection System

This test was carried out using the procedure described in paragraph 3.2.1. Evaluation of the General Purpose Scanner involved sampling explosive vapours emitted from a calibrated vapour generator placed at the sample orifice of the hand-held wand. For evaluation of the Walk-thru Personnel Scanner, a test subject carried a calibrated vapour generator emitting explosive vapours through the Walk-thru unit. For each repetition of the test, the equipment baseline was established before and after submitting the scanner to a sampling of explosive vapours.

The results of this test are summarized in Table 4.1. The figures given are the combined results from tests of the General Purpose Scanner and the Walk-thru Personnel Scanner's analytical component, rounded off to the nearest first-place decimal point. For a discussion of these results see Chapter 9, *Analysis and Discussion of Results.*

Table 4.1 Results of Vapour Detection Evaluation: Lower Detectable Limits

EXPLOSIVE COMPOUND	MINIMUM DETECTABLE CONCENTRATION (ppt)	MINIMUM MASS FLOW (ng/sec)
DMNB	1.9	0.2
EGDN	21.0	1.8
P-MNT	161.0	12.8
O-MNT	120.0	9.7
NG	51.0	5.4
DNT	98.0	10.3

4.1.3 Clear Down Time

The results of testing to establish the clear down time will be released by the NRC as a separate report. The NRC scientists informally commented to CPAD's project manager that the equipment recovers well, with some variations in recovery time apparently due to varying quantities of explosive material tested.

From independent testing carried out by CPAD Holdings, Ltd., the time required by the EDSS™ to return to the approximate baseline value after being subjected to concentrations of EGDN has been established as:

After high concentrations (5 to 50 ppb): the time to execute a clean cycle,
After low concentrations (10 to 100 ppt): immediately, that is, by the next sample.

4.1.4 Vapour Detection Evaluation of the General Purpose Scanner

Extensive evaluation tests of the General Purpose Scanner were carried out to determine its vapour detection capabilities. The results given in Table 4.1 may be consulted for an evaluation of the capacities of this unit.

4.1.5 Vapour Detection Evaluation of the Walk-thru Personnel Scanner

The evaluation procedure used differs somewhat from that described in the *Test and Evaluation Procedures* and outlined in paragraph 3.2.1. The aim of this procedure was to determine an attenuation factor which could be applied to the analyzer unit's sensitivity, so as to reflect the Walk-thru unit's overall sensitivity in collecting and analyzing samples. However, the proposed attenuation factors could not conclusively determine the efficiency of sample collection and analysis of explosive substances carried through the Walk-thru portal. The tests of the analytical subsystem of the Walk-thru, similar to those for the General Purpose Scanner, were considered more reliable.

Extensive evaluation tests of the analytical subsystem of the Walk-thru unit were carried out to determine its vapour detection capabilities. The results given in Table 4.1 may be consulted for an evaluation of the capacities of this unit.

4.2 Plastic Explosives Detection Evaluation

Initial plastic explosives detection tests were carried out at the NRC facilities between September 16th, 1991, and December 9th, 1991. The NRC provided the testing team for these tests.

All test results and informal notes were documented by the NRC's testing team. These results and comments will be published by the NRC as a separate report. The results given in paragraph 4.2.2 are from notes taken during a meeting between CPAD Holdings, Ltd. and the NRC on November 26th, 1991.

As mentioned in Chapter 3, the NRC team encountered a technical problem with the test procedures for the particle calibration source tests. CPAD developed a new procedure for testing the particle calibration source, with reproducible and measurable test parameters. The new procedure was approved by Transport Canada on February 25th, 1992, and is outlined in the *Modifications* section of paragraph 3.2.2. The test results reported below for the particle calibration source (paragraph 4.2.3) are the results of this new procedure, carried out between February 25th and 27th, 1992.

4.2.1 Explosive Compounds Tested

Both of the explosive compounds proposed for the plastic explosives detection evaluation were tested. These compounds are RDX and PETN. The detection capabilities for these compounds were tested using Semtex-H, Deta Sheet, DM12 and C-4.

4.2.2 Lower Detectable Limits of Overall Detection System

This test was carried out using the procedure described in paragraph 3.2.2. Evaluation of both the General Purpose Scanner and the analytical component of the Walk-thru Personnel Scanner involved injecting a metered volume of a standard solution of the explosive compound onto a sample collector on the unit. For each repetition of the test, the equipment baseline was established before and after submitting the scanner to a sample of the explosive.

The NRC's conclusions as to the results of this test are summarized in Table 4.2. The figures given are the combined results from tests of the General Purpose Scanner and the Walk-thru Personnel Scanner's analytical component. For a discussion of these results see Chapter 9, *Analysis and Discussion of Results.*

Table 4.2 Results of Plastic Explosives Detection Evaluation: Lower Detectable Limits

EXPLOSIVE COMPOUND	MINIMUM DETECTABLE CONCENTRATION
RDX PETN	600 - 800 pg 2 - 2.5 ng

4.2.3 Particle Calibration Source

The original test procedures for determining the particle calibration source were considered incomplete by the NRC. The modified procedure described in paragraph 3.2.2 involved applying a series of thumbprints of Semtex-H, Deta Sheet, DM12 and C-4 onto stainless steel, cardboard, nylon, vinyl, polyethylene, leather, canvas and hard plastic. The thumbprints were sampled by the EDSS™ General Purpose Scanner starting from the last print made.

These tests were carried out between February 25th and 27th, 1992 at the CPAD plant, and were witnessed by members of Transport Canada, NRC, the RCMP and CPAD. The before-test background levels were recorded and verified as normal. All test results were recorded on ET-GPS-2/FP forms. They are summarized in Table 4.3.

Table 4.3 Results of Particle Calibration Source Evaluation

	SEMTEX-H		DETA SHEET		DM12		C-4	
SURFACE MATERIAL	Alarm on #	Total Prints	Alarm on #	Total Prints	Alarm on #	Total Prints	Alarm on #	Total Prints
St. Steel	24	24	None	24	24	24	None[3]	14
Cardboard	11	11	12	12	11	11	11	11
Nylon	11	11	12	12	12	12	11	11
Vinyl	12	12	None	12	12	12	12	12
Polyethyl.	12	12	None	12	12	12	12	12
Leather	12	12	12	12	12	12	4	12
Canvas	12	12	12	12	12	12	12	12
Hd. Plast.	14	14	12	14	14	14	11	14

[3] For C-4 on stainless steel, four separate tests were carried out. The compound was detected on only one of the four tests, at thumbprint number 14 on a grid of 14 prints. "None" appears in this table as an indication of the more common result.

The "Alarm on #" columns give the number of the thumbprint for which the first alarm was detected. Since sampling started from the last thumbprint made, this represents the weakest print detected by the equipment, but not necessarily the limit of detection. The "Total Prints" columns give the total number of thumbprints made on the surface material. The two figures can be compared to determine the relative strength of thumbprint required for detection of the explosive. For a discussion of these results see Chapter 9, *Analysis and Discussion of Results.*

4.3 Interference Tests

During the test and evaluation of the EDSS™ system at the NRC laboratory, a significant amount of interference testing was completed. These tests involved sampling the potential interferents and recording the results. The test results will be disclosed by the NRC as a separate report.

CPAD carried out independent interference testing at its plant on February 26th, 1992, using the General Purpose Scanner. These tests were witnessed by members of Transport Canada, NRC, the RCMP and CPAD, and official results were recorded on ET-GPS-2/IF forms. The products tested were: freon 22 and R-113, soap, musk perfume, musk oil, low-level smoke, car exhaust, chloroform, carbon tetrachloride and acetone.

Car exhaust initially caused an alarm as DMNB, but the peak was observed to be to the right of the DMNB peak position. That is, the car exhaust peak was not in the window. On experimental software both chloroform and carbon tetrachloride caused an alarm. The standard software, however, accurately analyzed these products as non-explosives. The significance of these results is discussed in Chapter 9, *Analysis and Discussion of Results.*

4.4 Equipment Modifications During the Analytical Performance Tests

Several equipment modifications were carried out to enhance the user friendliness of the EDSS™ and overcome minor mechanical problems.

1. Software:

   It became apparent that someone unfamiliar with the EDSS™ may have difficulty setting the thresholds to account for ambient background factors. To this end, software development was carried out to automate the default threshold settings. The new software was installed in the EDSS™ equipment being tested.

2. Preconcentrator O-rings:

   Difficulties with respect to background signals on the Ion Mobility Spectrometer (IMS) were traced to a shedding of material from the O-rings in the preconcentrators. At the suggestion of the NRC, new O-rings made of rulon were manufactured and installed on the equipment. The new material proved to be an effective solution to the problem.

3. Cooling Fans:

   CPAD's general experience with the EDSS™ equipment identified a need to install additional cooling in the cabinet of the General Purpose Scanner to overcome a hot spot which was causing a recurring electronic problem on the IMS. Both units at the NRC facilities as well as all CPAD units were retrofitted with cooling fans in the scanner cabinets.

4. Equipment Exchange:

   The General Purpose Scanner located at the NRC facilities was fitted with a more sensitive version of the IMS.[4] To provide uninterrupted availability of a General Purpose Scanner during the NRC tests, the originally delivered scanner was exchanged for another scanner equipped with the new IMS.

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[4] The Walk-thru unit at the NRC had already been fitted with the advanced IMS before testing.

5. OPERATIONAL PERFORMANCE TESTS

This section describes the results of controlled operational performance testing to characterize the capability of the EDSS™ system to identify the presence of explosives on a person or in parcels or baggage.

An outline of the procedures for the operational performance tests is given in paragraph 3.3 and its subparagraphs. For ease of reference, the test results are documented here under the same headings as those of paragraph 3.3. Differences between the prescribed procedures approved on February 25th, 1992, and the actual procedures carried out are covered here under the appropriate test headings. A note regarding modifications to the EDSS™ equipment during the operational performance tests appears at the end of this section (paragraph 5.3).

5.1 Vapour Detection Evaluation

The vapour detection tests were carried out at the CPAD plant from February 25th to 27th, 1992. The tests were performed by a team of CPAD scientists, and were witnessed by representatives from Transport Canada, NRC and the RCMP. All test results and informal notes were recorded on ET-GPS-2 and ET-WT-2 forms.

5.1.1 Explosive Compounds Tested

All of the explosive compounds proposed for the vapour detection evaluation were tested: NG, EGDN, TNT and the taggant candidate DMNB.

5.1.2 Vapour Detection Evaluation of the General Purpose Scanner

These tests used the ICAO Suitcase Test procedure prescribed by the *Test and Evaluation Procedures* and modified according to paragraph 3.3.1. Before testing, the background levels were verified and recorded as being at normal levels. Each explosive was enclosed in a polyethylene bag, wrapped with two layers of cotton fabric, packed between crumpled paper and enclosed in a cardboard box. The box was sealed with tape and a slit was made in one side of the box. The slit was sampled immediately after packing, and at regular intervals thereafter.

NG and EGDN were tested together, with 1/4 stick of dynamite sealed in the prescribed manner inside a cardboard box. The box was packed at 9:37 a.m. on February 25th, 1992, and tested immediately. Samples were taken every 5 minutes for the first half hour of the test, and then every 15 minutes. The first alarm was raised on the 7th sample at 10:48 a.m. on the same day, after a total elapsed time of 1 hour and 11 minutes.

DMNB was tested on a sample mass of moulding putty marked with 0.1% of the taggant. The box was packed at 9:56 a.m. on February 25th, 1992, and first sampled at that time. For the first hour and a half of the test, samples were taken every 15 minutes, and then once every hour. The first alarm was raised on the 12th sample at 4:00 p.m. on the same day, after a total elapsed time of 6 hours and 4 minutes. The test was repeated on February 26th, with the box packed at 9:40 a.m. and first sampled at 9:42 a.m. Samples were taken every half hour until noon, and then once an hour. On the 10th sample the slit was reopened by cutting through the original slit with a knife. The 11th sample was taken immediately afterwards and a clear alarm signal was raised at 3:30 p.m., after a total elapsed time of 5 hours and 50 minutes. The level of DMNB detected on the 11th sample was far above the alarm level, which lead the testing team to suspect that the slit was closing due to earlier sampling.

TNT was tested using a vapour generator that was turned on and sealed inside a cardboard box. The box was packed at 10:30 a.m. on February 25th, 1992, and tested immediately. Samples were taken approximately once every hour on February 25th, 26th and 27th. Due to interference caused by other operational performance tests being performed at the same time, testing was discontinued for several hours each day. The period of testing was thus not continuous over the three days, although the box remained sealed with the vapour generator inside during the entire time. On February 27th the alarm threshold for TNT was set to automatic. The first alarm was raised at 1:45 p.m. that day on the 12th sample of the box, after a total elapsed time of 51 hours and 15 minutes. This sample was taken from a second slit made on the opposite side of the box. Subsequent samples from the second slit also gave a clear alarm signal.

For a discussion of these results see Chapter 9, *Analysis and Discussion of Results*.

5.1.3 Vapour Detection Evaluation of the Walk-thru Personnel Scanner

The test for the Walk-thru Personnel Scanner described in paragraph 3.3.1 was executed by CPAD on February 25th and 26th, 1992, with witnesses from Transport Canada, NRC and the RCMP. The test subject carried a cigarette box containing 50 g of moulding putty marked with 0.1% DMNB in a shirt pocket underneath his jacket. He walked through the unit at a normal pace at time intervals of approximately 10 minutes. On the second day of tests, the hand-wand was also used to scan the subject after walking through, without the nozzle touching the subject.

The first set of tests began at 12:05 on February 25th, 1992. The before-test background levels were at normal values for all sample collectors. The first alarm was raised on the 7th sample at 1:05 p.m. All samples after that time confirmed the DMNB alarm signal.

The second set of tests began at 10:20 on February 26th. Background levels were once again at normal values before sampling began. The second sample taken at 10:24 identified DMNB on the subject. This alarm was confirmed with additional samples from both the Walk-thru portal and the hand-held wand. It was noted that the strength of the alarm signal from the hand-wand was three times that from the Walk-thru portal: an average of 37 egu versus 12 egu from the portal. For a discussion of these results see Chapter 9, *Analysis and Discussion of Results*.

5.2 Plastic Explosives Detection Evaluation

The procedure for plastic explosives detection evaluation described in paragraph 3.3.2 was carried out at the CPAD plant on February 26th, 1992. Members of Transport Canada, NRC and the RCMP also witnessed the tests. Before each test, the medium and the handler were sampled to verify that they were free of contaminants. For each of Semtex-H, DM12 and C-4 a sample was placed in a glass jar and another in a plastic container. The sample was kneaded by the handler, replaced in the jar or container, and then the jar or container was closed. Two levels of difficulty were tested: the first involving the handler only, and the second involving the handler who manipulated the explosive, and an accomplice who manipulated the jar or plastic container.

The jar or container was first sampled on the outside and, if no alarm was raised, on the inside. The results are given in Table 5.1, and discussed in Chapter 9, *Analysis and Discussion of Results*. Note that for DM12 and C-4, it was felt that if an alarm was raised for the second, more difficult detection task, it could be assumed that the equipment would also detect the explosive under the first level of difficulty.

Table 5.1 Results of Plastic Explosives Detection Evaluation

MEDIUM AND LEVEL OF DIFFICULTY	SEMTEX-H		DM12		C-4	
	Outside	Inside	Outside	Inside	Outside	Inside
Glass Jar, 1st Level	Alarm	not required	not required	not required	not required	not required
Glass Jar, 2nd Level	No Alarm	Alarm	Alarm	not required	Alarm	not required
Plastic Cont. 1st Level	No Alarm	Alarm	not required	not required	No Alarm	Alarm
Plastic Cont. 2nd Level	Alarm	not required	Alarm	not required	No Alarm	not recorded

5.3 Equipment Modifications During the Operational Performance Tests

No modifications to the General Purpose Scanner or the Walk-thru Personnel Scanner were required during these tests.

6. LONGEVITY AND STABILITY TESTS

This section describes the results of laboratory testing to determine the longevity and stability of the EDSS™ through performance tests over a continuous long-term operational period.

An outline of the procedures for the longevity and stability tests is given in paragraph 3.4 and its subparagraphs. Refer also to Appendix A, *Test and Evaluation Procedures*, for details. For ease of reference, the test results are documented here under the same headings as those of paragraph 3.4. Differences between the prescribed procedures and the actual procedures carried out are covered here under the appropriate test headings. Modifications made to the EDSS™ equipment during the longevity and stability tests are described under the *Equipment Inspection* subsections of paragraphs 6.3 and 6.4.

6.1 Change of Test Site

Early on in the testing phase, the NRC decided that its laboratory was not qualified to carry out the longevity and stability tests. CPAD requested approval from Transport Canada to supervise execution of these tests at the NRC facilities. The tests were performed there from November 27th, 1991, to December 6th, 1991, by a combined team of NRC and CPAD technical personnel. On December 6th, the General Purpose Scanner was moved to the CPAD plant for continuation of the tests until December 9th, 1991.

It should be noted that the test site at the NRC location was one with a very harsh environment for testing sensitive chemical analytical instrumentation. Both EDSS™ units were located in a machine shop adjacent to an overhead shipping door. The equipment was subjected to fumes from cutting oil as well as dust and other pollutants in the ambient atmosphere. It was also subjected to extremes of temperature due to its proximity to the outside loading door.

The results given in the following paragraphs have been taken from the official report forms ET-GPS.1, designed for the General Purpose Scanner results, ET-WT.1, for the Walk-thru Personnel Scanner results and ET-LS, designed for the equipment inspection records during the longevity and stability tests. These forms were filled out by the CPAD testing team at the time of the tests. In addition, CPAD has provided notes on equipment consumables.

6.2 Test Plan Execution

Following the recommended test plan, both the General Purpose Scanner and the Walk-thru Personnel Scanner underwent an operational testing period of 7 days (168 hours). For each scanner, 12 sets of tests were performed over the 7-day period.

Tests on the Walk-thru unit commenced November 27th, 1991, and were completed December 4th, 1991. The Walk-thru personnel scanner remained in Standby mode on days 4 and 5, rather than the projected days 6 and 7, to more easily accommodate a lighter employee workload during weekend hours. On days 1 to 3 and 6 to 7, the equipment operated in Continuous Cycle mode from 6:00 a.m. to 12:00 (midnight), in Cleaning mode from midnight to 2:00 a.m., and in Standby mode from 2:00 a.m. to 6:00 a.m.

Testing of the General Purpose Scanner began December 2nd, 1991, and ended on December 9th, 1991. The proposed time schedule for the various operational modes on days 1 through 7 was maintained. That is, the equipment was in Standby mode full time on days 6 and 7.

6.3 Test of the General Purpose Scanner

These tests were carried out using the general procedure described in paragraph 3.4.2. The tests were performed on DMNB using a calibrated vapour generator emitting a constant rate of DMNB vapour. The explosive was sampled from the sampling hose on every fourth sampling cycle, with the EDSS™ in Continuous Cycle mode.

Given that the nature of the longevity and stability tests is to determine whether equipment failures may occur under long-term operating conditions, it was felt that the tests using DMNB would be sufficient to indicate whether the system was functioning properly. The tests were therefore not repeated for RDX.

On the last two days of testing the equipment was moved to the CPAD plant, under approval by TDC, for the transitional phase of installation at the Ottawa International Airport. The equipment was left on during this period, but no recorded tests were carried out. Thus 10 sets of tests were performed and recorded for the General Purpose Scanner, rather than 12.

6.3.1 Test Results

The results of the longevity and stability tests for the General Purpose Scanner are given in Table 6.1. These figures have been averaged for each test performed, that is, the table presents the average before-test background level of all three sample collectors, the average DMNB sampling value over 5 samples, and the average non-explosive sampling value over 13 to 16 samples. For each group of three sampling cycles where no explosive was present, the values generally decreased to the before-test background level by the third cycle. For a discussion of these results see Chapter 9, *Analysis and Discussion of Results*.

Table 6.1 Results of Longevity and Stability Tests of the General Purpose Scanner[5]

TEST NO.	DATE	TIME	BEFORE-TEST BACKGROUND	DMNB SAMPLING AVERAGE VALUE	NON-EXPLOSIVE AVERAGE VALUE
1	91/12/02	09:50	12	111	12
2	91/12/02	15:55	0	647	104
3	91/12/03	09:25	25	765	159
4	91/12/03	15:40	0	742	38
5	91/12/04	09:00	19	486	116
6	91/12/04	15:40	10	653	95
7	91/12/05	09:00	10	532	115
8	91/12/05	15:00	0	551	87
9	91/12/06	08:50	10	583	111
10	91/12/06	15:15	12	586	105

[5] All before-test background values and sampling values are given in egu. Refer to the *Definitions* section of this report, on page xx of the front matter.

6.3.2 Equipment Inspection

The equipment inspection records and notes written during the General Purpose Scanner longevity and stability tests indicate the following:

1. Consumables:

   The consumption of ultra-high purity nitrogen during the 7 days totalled 47.0 kg. During the 16 hours per day of Continuous Cycle operation, gas consumption averaged 6.5 kg, or approximately 410 g per hour. In Standby mode, gas consumption averaged 117 g per hour.

2. Maintenance:

   Filter #1 on the Vapour Collector and Detector (VCAD) was changed on the afternoon of day 1, due to accumulated dirt on the filter. Filter #2 on the Particle Collector and Detector (PCAD) was changed on the morning of day 3, for the same reason. Neither the SCU lint filter (wand lint screen) nor any of the PCAD and VCAD sample collectors required maintenance during the test period.

3. Equipment Status:

   A bad air leak occurred in the morning of day 2, causing a very high reading on NG/PETN, with an alarm raised at 9:05. Other than this alarm, diagnostic displays were consistently good, and no other unusual incidents occurred.

4. Repairs:

   On day 4 the tension on the PCAD was loosened one half turn, as the tension was too high. In addition, the PCAD motor fan was found to be somewhat weak, but did not require repair.

6.4 Test of the Walk-thru Personnel Scanner

These tests were carried out using the procedure described in paragraph 3.4.3. The tests were performed on DMNB using a calibrated vapour generator emitting a constant rate of DMNB vapour. A test subject carried the vapour generator through the Walk-thru unit on every fourth sampling cycle, with the EDSS™ in Continuous Cycle mode.

6.4.1 Test Results

The results of these tests are given in Table 6.2. These figures have been averaged for each test performed, that is, the table presents the average before-test background level of all three sample collectors, the average DMNB sampling value over 5 samples, and the average non-explosive sampling value over 13 to 16 samples. For each group of three sampling cycles where no explosive was present, the values generally decreased to the before-test background level by the third cycle. For a discussion of these results see Chapter 9, *Analysis and Discussion of Results*.

Table 6.2 Results of Longevity and Stability Tests of the Walk-thru Personnel Scanner[6]

TEST NO.	DATE	TIME	BEFORE-TEST BACKGROUND	DMNB SAMPLING AVERAGE VALUE	NON-EXPLOSIVE AVERAGE VALUE
1	91/11/27	09:30	7	118	29
2	91/11/27	15:00	3	59	9
3	91/11/28	09:45	13	124	24
4	91/11/28	15:00	4	141	16
5	91/11/29	09:05	14	144	26
6	91/11/29	15:25	2	109	6
7	91/12/02	09:00	4	180	32
8	91/12/02	15:00	0	116	7
9	91/12/03	09:10	17	188	35
10	91/12/03	15:25	0	133	11
11	91/12/04	08:45	13	154	40
12	91/12/04	15:00	0	148	16

[6] Once again, all before-test background values and sampling values are given in egu. Refer to the *Definitions* section of this report, on page xx of the front matter.

6.4.2 Equipment Inspection

The equipment inspection records and notes written during the Walk-thru Personnel Scanner longevity and stability tests indicate the following:

1. Consumables:

   The consumption of ultra-high purity nitrogen during the 7 days totalled 81.1 kg. During the 16 hours per day of Continuous Cycle operation, gas consumption averaged 11.3 kg, or approximately 707 g per hour. In Standby mode, gas consumption averaged 202 g per hour.

2. Maintenance:

   All three sample collectors for the PCAD were changed on the first day of tests, due to the development of improved O-rings made of viton (see paragraph 4.4). The VCAD Filter #1 and PCAD Filter #2 were also changed on day 1, due to an accumulation of dirt and lint. On day 3 Filter #2 required replacement again. On day 6 both Filter #1 and #2 were changed. Filter #2 was changed once again on the last day of testing. Throughout the test period, the SCU lint filter (wand lint screen) remained clean.

3. Equipment Status:

   On the afternoon of day 1 the diagnostic display showed a straight line for the IMS, which was easily repaired by replacing an electrical contact. On days 2 and 3 a peak occurred outside window 7 of the IMS, caused by burning cutting oil from machinery being operated near the test location. The equipment was cleaned and the problem corrected. All other diagnostic displays during the test period indicated that the three diagnostic traces were good.

4. Repairs:

   On the second day of testing an electronic failure occurred on the IMS, due to a hot spot near the IMS. Additional cooling was installed in the cabinet, and no further difficulty was encountered. The overheating problem was found to be common to all EDSS™ units, and all units were fitted with the new cooling system.

7. CONTROLLED LINE VOLTAGE VARIATION TESTS

This section describes the results of testing the EDSS™ system over a static line voltage range, to evaluate the performance of the equipment at less than ideal voltage levels.

An outline of the procedures for the line voltage variation tests is given in paragraph 3.5 and its subparagraphs. Refer also to Appendix A, *Test and Evaluation Procedures*, for details. For ease of reference, the test results are documented here under the same headings as those of paragraph 3.5. Differences between the prescribed procedures and the actual procedures carried out are covered here under the appropriate test headings. A note regarding modifications to the EDSS™ equipment during the line voltage variation tests appears at the end of this section (paragraph 7.4).

7.1 Change of Test Site

Early on in the testing phase the NRC felt that the prescribed controlled line voltage variation tests were not within their area of expertise. CPAD requested and obtained approval from Transport Canada to carry out these tests at the CPAD facilities. The tests were performed on December 9th, 1991, by a team of CPAD and Transport Canada personnel.

The results given in the following paragraphs have been taken from the official report forms ET-LVV, designed for the purpose of documenting the line voltage variation test results. These forms were filled out by the CPAD/TC testing team at the time of the tests.

7.2 Test of the General Purpose Scanner

RDX was used as the explosive sampling material, as prescribed in the *Test and Evaluation Procedures*. Tests number 1, 4 and 6 were carried out. That is, repeated sampling of the RDX was executed at the normal voltage level (120 VAC), the maximum level (132 VAC) and the minimum level (102 VAC). The system was calibrated as shown in Table 7.1. The after-test values were not noted on the ET-LVV forms, but were reported as being at normal background levels.

The results of this test are summarized in Table 7.2. For a discussion of these results see Chapter 9, *Analysis and Discussion of Results*.

Note that in Tables 7.1 and 7.2 the sample values are given in EDSS™ GC units (egu) for the vapour explosives, and in EDSS™ IMS units (eiu) for the plastic explosives.

Table 7.1 Calibration of the EDSS™ Scanners for the Line Voltage Variation Tests

EXPLOSIVE COMPOUND	SAMPLE VALUE (egu)	THRESHOLD (egu)
EGDN	30	60
DMNB	2	15
P-MNT	0	25
DNT	22	44
	SAMPLE VALUE (eiu)	THRESHOLD (eiu)
NG/PETN	0	500
RDX	195	500

Table 7.2 Results of Line Voltage Variation Tests of the General Purpose Scanner

READING NO.	VALUE (eiu) AT 120 VAC	VALUE (eiu) AT 132 VAC	VALUE (eiu) AT 102 VAC
1	2555	2367	2016
2	2310	3289	1734
3	2275	2276	1605
4	3231	2508	1670
5	3206	3279	1925

7.3 Test of the Walk-thru Personnel Scanner

As prescribed in the *Test and Evaluation Procedures*, DMNB was used as the explosive compound for the test. A test subject carried a calibrated vapour generator emitting DMNB vapour through the Walk-thru portal.

Tests number 1, 4 and 6 were carried out. That is, repeated sampling of the DMNB vapour was executed at the normal voltage level (120 VAC), the maximum level (132 VAC) and the minimum level (102 VAC). The system was calibrated as shown in Table 7.1. The after-test values were not noted on the ET-LVV forms, but were reported as being at normal background levels.

The results of this test are summarized in Table 7.3. For a discussion of these results see Chapter 9, *Analysis and Discussion of Results*.

Table 7.3 Results of Line Voltage Variation Tests of the Walk-thru Personnel Scanner

READING NO.	VALUE (egu) AT 120 VAC	VALUE (egu) AT 132 VAC	VALUE (egu) AT 102 VAC
1	76	151	111
2	103	94	99
3	111	113	125
4	125	205	176
5	157	75	78

7.4 Equipment Modifications During the Line Voltage Variation Tests

No modifications to the equipment were required during these tests. However, the need for voltage stabilizers became evident during the operational field trials at the Ottawa airport, where voltage levels were less than ideal. See paragraph 8.4 for details.

8. OPERATIONAL FIELD TRIALS

This section describes the results of the operational field trials held at the Ottawa International Airport. These field trials were intended to identify the most effective and efficient location of the EDSS™ equipment, to determine the general effectiveness of the scanners in an airport environment, and to provide concrete suggestions as to desirable enhancements of the EDSS™ configuration. In addition, the trials were proposed as an ideal forum for examining projected operation and maintenance costs, the impact on human resources, and the first and second-level maintenance tasks required in a real-life scenario.

An outline of the procedures for the operational field trials is given in paragraph 3.6 and its subparagraphs. Refer also to Appendix A, *Test and Evaluation Procedures*, for details. For ease of reference, the test results are documented here under the same headings as those of paragraph 3.6. Differences between the prescribed procedures and the actual procedures carried out are covered here under the appropriate test headings. Modifications made to the EDSS™ equipment during the operational field trials are described in paragraph 8.4, and proposed modifications are discussed in paragraph 8.5.

8.1 Equipment Location

8.1.1 Initial Installation at the Ottawa Airport

The Walk-thru Personnel Scanner and the General Purpose Scanner were moved from the NRC facilities to the Ottawa International Airport on December 9, 1991 for the purposes of setting up the operational field trials. Following the rationale of the test procedures, the EDSS™ equipment was located in a low traffic area at first.

The Walk-thru was installed in front of security gate number 3, slightly to the left of the passageway. A General Purpose Scanner was located inside security gate number 3 at the output end of the X-ray equipment. The Remote Control and Display unit for the Walk-thru was set up inside the X-ray area, within view of the General Purpose Scanner location. A second General Purpose Scanner was not included under the contract for testing of a checked baggage area. Figure 8.1 shows the general location of the various pieces of equipment in relation to the X-ray screening point.

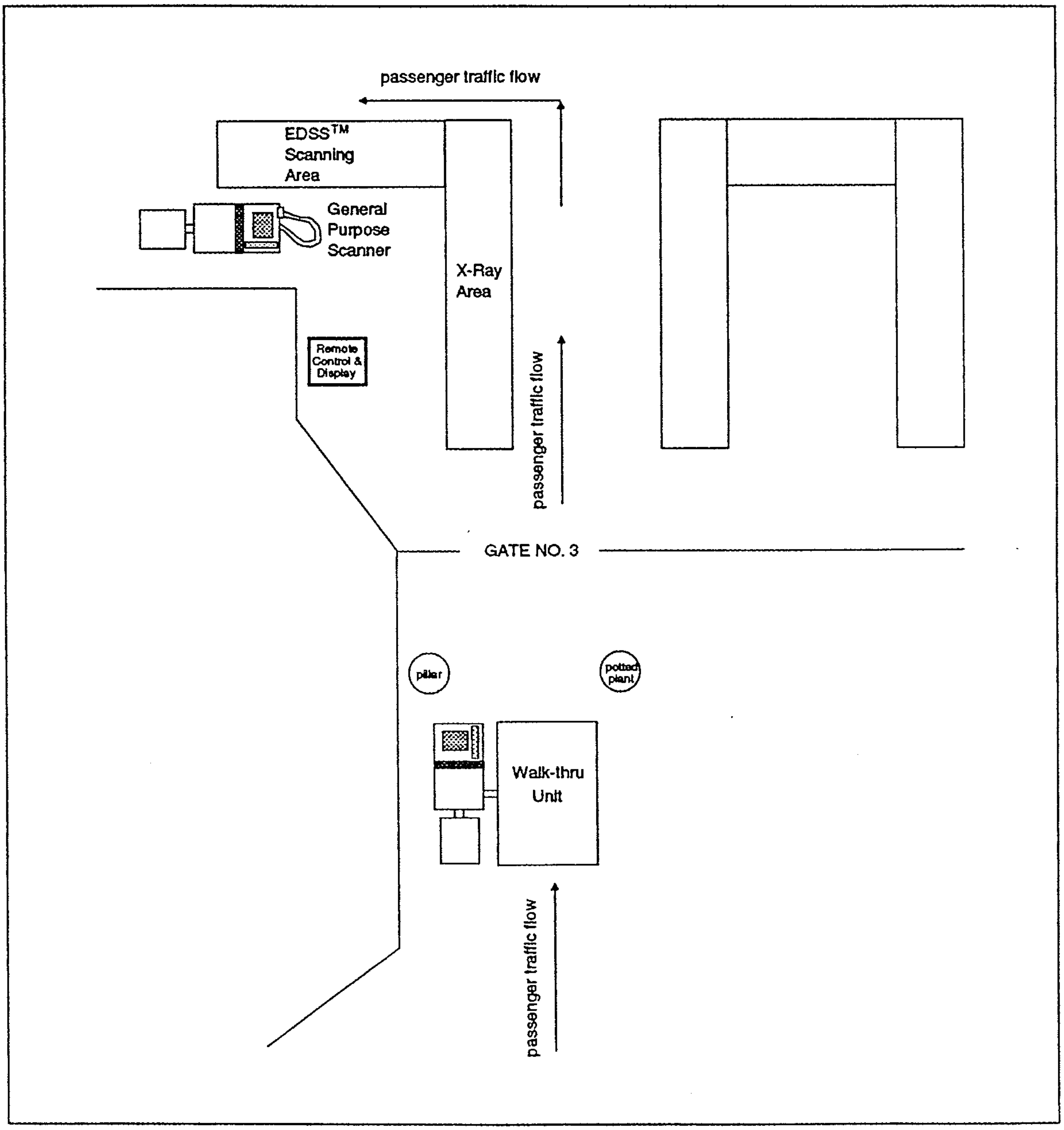

Figure 8.1 Floor Plan of the Ottawa Airport Installation

With this equipment configuration, passengers walked through the Walk-thru unit before reaching the X-ray area. The hand-held luggage was examined in the X-ray equipment and the passengers checked with metal detectors by regular Aeroguard Security personnel. The X-ray operator gave a statistically significant number of bags to the EDSS™ General Purpose Scanner operator for sampling. The scanner operator sampled each of these bags either intrusively using the round nozzle tip, or non-intrusively using the flat or round nozzle tip.

From the time of installation to December 27th, 1991, both scanners were operated in a non-alarm mode, to allow both security personnel and the general public to become accustomed to the EDSS™ equipment. The non-alarm mode also permitted the gathering of data on the ambient atmosphere before setting alarms to detection levels. On December 27th, the operating thresholds were adjusted to levels estimated to be appropriate levels of sensitivity for the Ottawa Airport environment. The operational tests began at this point (see paragraph 8.3 for results).

Scanning schedules were initially designed to cover peak periods only, using two senior EDSS™ operating technicians and two operators working on a full-time basis, with one operator working on a part-time basis. The operations took place on weekdays only, with two shifts of operators working each day. Initially, two persons operated the EDSS™ equipment installed at Gate 3. One was stationed at the Walk-thru, and the other at the General Purpose Scanner. The General Purpose Scanner was within view of the Remote Control and Display monitor, and the operator had easy access to its controls when required.

8.1.2 Revised Location of the Walk-thru Personnel Scanner

After two weeks of testing it was found that the initial location of the EDSS™ Walk-thru Personnel Scanner was not ideal, in that passengers would tend to walk around the portal, following a direct path toward security gate number 3. Maximum throughput was in the order of 200 persons per hour, rather than the potential throughput of 1000 persons per hour.

Since the *Test and Evaluation Procedures* called for a gradual buildup to a full-impact situation, it was decided to change the location of the Walk-thru unit on January 14th, 1992. From that time until the end of the testing period, the Walk-thru unit was located in front of security gate number 3 in the direct path of the gate, about two feet to the right of its original location. A portable guard rail was installed to the left of the portal and a large potted plant to the right of it, to further encourage the travelling public to enter the portal.

This change resulted in an observed increase in the number of persons passing through the Walk-thru portal. It should be emphasized that the public was at no time forced to enter the Walk-thru unit. A large sign was posted to the left of the portal explaining the purpose of the unit and the fact that compliance with testing was entirely voluntary. All EDSS™ operators were trained, if asked about the equipment, to inform the public of the voluntary nature of the tests.

The scanning schedule was increased during this period to include weekend operations. Scanning was carried out between 5:30 a.m. and 10:30 p.m. from Monday to Friday, and from 1:00 p.m. to 10:30 p.m. on Sundays. Sunday hours were cut back to 6:00 p.m. in mid-February. The two EDSS™ units were maintained in an ON status 24 hours per day. When not in operating mode the equipment was put on standby with a long cleaning cycle. Staffing of the two EDSS™ units was increased to four full-time and one part-time operators working under the direction of the test supervisor. Initially, two operators were stationed at the scanners at all times. Later on in the trials the Walk-thru station was phased out, and the General Purpose Scanner operator was able to supervise the Walk-thru entirely from the Remote Control.

8.1.3 Impact on Traffic Flow

Neither the Walk-thru Personnel Scanner nor the General Purpose Scanner hampered the traffic flow at the Ottawa Airport. As there was an operator at each unit, passengers were able to ask questions about the new security equipment and decide whether or not to go through the Walk-thru unit. Those that did not go through had plenty of room to the right of the unit to make their way to the X-ray area. In fact, very few people decided to circumnavigate the Walk-thru. It was noted that physically disabled persons had no difficulty passing through the Walk-thru portal, as well.

Passenger traffic at the Ottawa Airport is generally quiet throughout the morning and early afternoon, increasing towards mid-afternoon, and trailing off again to a lighter traffic flow in the evening. The quieter periods posed no problem to passenger traffic, due to easy access to the Walk-thru and the sporadic nature of security procedures at these times.

During the heavier traffic periods, people would sometimes have to line up outside of security gate number 3, and at times the lineup carried right through the Walk-thru portal. No passengers expressed any discomfort, however. During these peak loading situations, the EDSS™ operator was easily able to keep up with the number of bags selected for scanning, as the capacity of the scanner is beyond the airport's current ability to process passengers through the security area. The slowdowns were thus not due to the EDSS™.

8.1.4 Integration with Existing Security Gate Procedures

From the time of initial installation until December 27th, 1991, the EDSS™ equipment was operated in non-alarm mode, in part to give the regular security personnel of the Ottawa Airport time to adjust to the presence of new security equipment. During the early days of operation, a few security employees verbally expressed their concern that their jobs might be changed or eliminated. These fears were quickly put to rest by the test supervisor and Aeroguard Security.

As time went on, security personnel at the X-ray units became accustomed to the new routine of passing a certain number of bags to the General Purpose Scanner operator. They developed a positive attitude toward the EDSS™ equipment, and supported the efforts of its operators. On several occasions during quiet traffic periods a security guard asked the EDSS™ operator how to use the equipment, and tried one or two scanning cycles. The reaction was once again positive, and Aeroguard Security personnel came to think of the EDSS™ as a practical machine that was easy to use.

The way the equipment was configured at the Ottawa Airport, passengers with their hand-held luggage first passed through the Walk-thru and, once inside the security gate, went through a metal detector and had their luggage checked by airport security personnel at the X-ray unit. These security people decided which bags would be scanned by the General Purpose Scanner. The EDSS™ operator then sampled each of the bags selected. On the few occasions when an alarm was sounded, the EDSS™ operator would notify a nearby security person of the situation. Given the close proximity of security personnel to the General Purpose Scanner, the audible signal was generally sufficient to bring an alarm situation to their attention.

This integration of security personnel and EDSS™ operator tasks worked well for the duration of the airport trials. The EDSS™ fit easily into the existing security equipment configuration at Gate 3. The equipment does not require much room and, since the General Purpose Scanner is on castors, can be located virtually anywhere. Vacuum hoses can be sized to fit the application, providing for even greater flexibility.

It remains unclear to Aeroguard Security just how the EDSS™ equipment should be integrated with the metal detectors and X-ray units on a permanent basis. One possibility is that the security person at the exit end of the X-ray area could use the General Purpose Scanner to scan selected bags. Further study to this end is desirable, and should include the participation of all interested parties.

8.2 Scanning Protocol

Three methods of scanning correspond to low, medium and high-threat scenarios. For the low-threat scenario, the non-intrusive scanning method is used. That is, all selected bags are scanned externally. In the medium-threat situation, a statistically significant number of bags are scanned internally as well as externally. And for a high-threat scenario all selected bags are opened and sampled internally.

For external sampling, the operator should pass the wand nozzle over all baggage handles, straps or clips that may have been handled by the person. For internal sampling, the bottom, walls and lid of the bag or case should be directly sampled by the wand nozzle, since they could camouflage a hidden layer of material.

The number of bags sampled also depends on the threat level of the situation. In a low-threat situation, the EDSS™ operator should sample any bags having questionable contents according to the results of the X-ray or other security equipment. The percentage of bags sampled should be increased in a medium-threat scenario. For a high-threat scenario, all bags should be sampled.

When the equipment detects an explosive compound or residue, the operator should notify an airport security officer following the procedures laid down by the airport security organization. For the Ottawa Airport trials it was agreed that the EDSS™ operators would scan only those bags they were invited to scan by security personnel. The security personnel were instructed to supply a statistically significant number of bags to the EDSS™ operator. The bags were to be opened and scanned internally in some cases, and in other cases scanned non-intrusively. In the case of an alarm, the EDSS™ operator was to inform the security personnel that an alarm had been sounded, and in their presence diplomatically request background information on the situation causing the alarm.

For a permanent airport installation the EDSS™ operator would ideally be fully qualified to take direct action in the case of an alarm, rather than having to notify a third party. However, the actual protocol of what to do when an alarm is sounded should be established by the organization responsible for security.

8.3 Operational Tests

The results given in the following paragraphs have been taken from four status reports produced by CPAD during the airport trials, dated January 13th, February 4th, February 26th and March 19th, 1992. Each report presented the frequency distribution of signal values on the two scanners for the reporting period. These frequency distributions were calculated from raw data saved by the EDSS™ computers during the trials, and transferred to 1.4M diskettes on a daily basis.

The *Equipment Inspection* subsections of the following paragraphs are taken from the daily log of the operational field trials. These forms were filled out each day by the CPAD test supervisor and his assistants for both the General Purpose Scanner and the Walk-thru Personnel Scanner.

The operational field trials began on December 27th, 1991. Initially, data collection by the on-board computers was sporadic. The equipment was brought up to its full functionality by January 8th, 1992. A second set of results for the trials was reported on February 4th, 1992, a third on February 26th, 1992, and the final test results calculated on March 19th, 1992. To give the reader a grasp of how the effectiveness of the EDSS™ equipment may have changed through time, these four evaluation periods have been set up as distinct reporting periods for the data.

During the operational field trials CPAD's laboratory engineers discovered that the EDSS™ detection subsystems were sensitive to trinitrotoluene (TNT) vapours. This facility was added to both EDSS™ units at the Ottawa Airport on January 22nd, 1992. Thus the intermediate reporting period includes some data on signal values taken for TNT. The final reporting period includes data for all detectable compounds, including TNT.

The ambient environment in the vicinity of the Ottawa Airport security gates is such that the alarm thresholds could be set relatively low, allowing for high sensitivity. This has permitted sensitive and accurate results. That is, the alarm thresholds were set so low that even tiny amounts of an explosive material could be detected.

Controlled operational tests were carried out according to the procedures described in paragraph 3.6.3. A test of the General Purpose Scanner involved 65 g of modelling clay marked with 0.1 percent DMNB. The test sample was placed in a cigarette box which was placed inside two zip-lock bags. This package was put in a brief case, which was sampled externally by non-intrusive sampling, and internally by intrusive sampling. The General Purpose Scanner sounded an alarm and identified the explosive as DMNB. Further controlled tests may be carried out at a later date. For a discussion of the results of the operational tests see Chapter 9, *Analysis and Discussion of Results.*

8.3.1 Test of the General Purpose Scanner

Table 8.1 gives the results of the first evaluation period. These results are the frequency distribution of chemical analyses performed by the General Purpose Scanner on all sampling cycles taken between December 27, 1991, and January 8th, 1992. Table 8.2 gives the results of the second evaluation period, from January 9th to February 4th, 1992. Table 8.3 gives the results of testing over the third evaluation period, from February 5th to February 26th, 1992. And Table 8.4 gives the results from the fourth evaluation period, from February 27th to March 17th, 1992. Due to the different signal value range for vapour detection versus plastic explosives detection, the two detection types are distinguished in these tables. For a discussion of these results see Chapter 9, *Analysis and Discussion of Results*.

Table 8.1 Results of the Operational Field Trials - First Evaluation for the General Purpose Scanner

I. VAPOUR DETECTION					
SIGNAL VALUES (egu)	EGDN	DMNB	P-MNT	O-MNT	DNT
< 50	2 847	2 820	2 852	2 853	2 853
51 to 75	2	25	0	0	1
76 to 100	2	3	0	0	0
> 100	3	6	2	1	0
TOTAL	2 854	2 854	2 854	2 854	2 854

II. PLASTIC EXPLOSIVES DETECTION		
SIGNAL VALUES (eiu)	NG/PETN	RDX
< 3000	2 846	2 854
3001 to 4000	2	0
> 4000	6	0
TOTAL	2 854	2 854

Table 8.2 Results of the Operational Field Trials - Second Evaluation for the General Purpose Scanner

I. VAPOUR DETECTION					
SIGNAL VALUES (egu)	EGDN	DMNB	P-MNT	O-MNT	DNT
< 50	4 839	4 814	4 842	4 834	4 843
51 to 75	1	27	1	9	0
76 to 100	1	2	0	0	0
> 100	2	0	0	0	0
TOTAL	4 843	4 843	4 843	4 843	4 843

II. PLASTIC EXPLOSIVES DETECTION			
SIGNAL VALUES (eiu)	NG/PETN	RDX	TNT
< 3000	4 824	4 837	1 939
3001 to 4000	3	4	0
> 4000	16	2	0
TOTAL	4 843	4 843	1 939

Table 8.3 Results of the Operational Field Trials - Third Evaluation for the General Purpose Scanner

I. VAPOUR DETECTION					
SIGNAL VALUES (egu)	EGDN	DMNB	P-MNT	O-MNT	DNT
< 50	4 101	3 932	4 058	4 090	4 103
51 to 75	3	170	5	13	2
76 to 100	0	3	23	0	0
> 100	1	0	19	2	0
TOTAL	4 105	4 105	4 105	4 105	4 105

II. PLASTIC EXPLOSIVES DETECTION			
SIGNAL VALUES (eiu)	NG/PETN	RDX	TNT
< 3000	4 101	4 104	4 100
3001 to 4000	1	1	4
> 4000	3	0	1
TOTAL	4 105	4 105	4 105

Table 8.4 Results of the Operational Field Trials - Fourth Evaluation for the General Purpose Scanner

I. VAPOUR DETECTION					
SIGNAL VALUES (egu)	EGDN	DMNB	P-MNT	O-MNT	DNT
< 50	2 705	2 685	2 705	2 685	2 705
51 to 75	0	16	0	16	0
76 to 100	0	3	0	3	0
> 100	0	1	0	1	0
TOTAL	2 705	2 705	2 705	2 705	2 705

II. PLASTIC EXPLOSIVES DETECTION			
SIGNAL VALUES (eiu)	NG/PETN	RDX	TNT
< 3000	2 693	2 703	2 703
3001 to 4000	6	1	1
> 4000	6	1	1
TOTAL	2 705	2 705	2 705

8.3.2 Test of the Walk-thru Personnel Scanner

Table 8.5 gives the results of the first evaluation period. These results are the frequency distribution of chemical analyses performed by the Walk-thru Personnel Scanner on all sampling cycles taken between December 27, 1991, and January 8th, 1992. Table 8.6 gives the results of the second evaluation period, from January 9th to February 4th, 1992. Table 8.7 gives the results of testing over the third evaluation period, from February 5th to February 26th, 1992. And Table 8.8 gives the results from the fourth evaluation period, from February 27th to March 17th, 1992. Due to the different signal value range for vapour detection versus plastic explosives detection, the two detection types are distinguished in these tables. For a discussion of these results see Chapter 9, *Analysis and Discussion of Results.*

Table 8.5 Results of the Operational Field Trials - First Evaluation for the Walk-thru Personnel Scanner

I. VAPOUR DETECTION					
SIGNAL VALUES (egu)	EGDN	DMNB	P-MNT	O-MNT	DNT
< 50	10 860	10 878	10 886	10 883	9 988
51 to 75	7	4	1	0	103
76 to 100	2	0	0	1	258
> 100	18	5	0	3	538
TOTAL	10 887	10 887	10 887	10 887	10 887

II. PLASTIC EXPLOSIVES DETECTION		
SIGNAL VALUES (eiu)	NG/PETN	RDX
< 3000	10 259	10 884
3001 to 4000	521	0
> 4000	107	3
TOTAL	10 887	10 887

Table 8.6 Results of the Operational Field Trials - Second Evaluation for the Walk-thru Personnel Scanner

I. VAPOUR DETECTION					
SIGNAL VALUES (egu)	EGDN	DMNB	P-MNT	O-MNT	DNT
< 50	38 597	38 601	38 601	38 589	16 268
51 to 75	1	1	2	1	4 470
76 to 100	2	0	0	1	5 868
> 100	3	1	0	12	11 997
TOTAL	38 603	38 603	38 603	38 603	38 603

II. PLASTIC EXPLOSIVES DETECTION			
SIGNAL VALUES (eiu)	NG/PETN	RDX	TNT
< 3000	38 224	38 601	11 817
3001 to 4000	378	1	1
> 4000	1	1	6
TOTAL	38 603	38 603	11 824

Table 8.7 Results of the Operational Field Trials - Third Evaluation for the Walk-thru Personnel Scanner

I. VAPOUR DETECTION					
SIGNAL VALUES (egu)	EGDN	DMNB	P-MNT	O-MNT	DNT
< 50	65 521	65 745	65 133	65 733	43 115
51 to 75	221	0	0	1	9 556
76 to 100	2	0	0	2	6 810
> 100	7	6	618	15	6 270
TOTAL	65 751	65 751	65 751	65 751	65 751

II. PLASTIC EXPLOSIVES DETECTION			
SIGNAL VALUES (eiu)	NG/PETN	RDX	TNT
< 3000	65 491	65 751	49 112
3001 to 4000	256	0	0
> 4000	4	0	0
TOTAL	65 751	65 751	49 112

NOTE: TNT was added during this period.

Table 8.8 Results of the Operational Field Trials - Fourth Evaluation for the Walk-thru Personnel Scanner

I. VAPOUR DETECTION					
SIGNAL VALUES (egu)	EGDN	DMNB	P-MNT	O-MNT	DNT
< 50	46 247	46 258	46 259	46 260	46 260
51 to 75	9	0	0	0	0
76 to 100	2	0	0	0	0
> 100	2	2	1	0	0
TOTAL	46 260	46 260	46 260	46 260	46 260

II. PLASTIC EXPLOSIVES DETECTION			
SIGNAL VALUES (eiu)	NG/PETN	RDX	TNT
< 3000	42 292	46 260	46 260
3001 to 4000	1 729*	0	0
> 4000	2 239*	0	0
TOTAL	46 260	46 260	46 260

* High readings here reflect an erroneous calibration which existed for a period of thirty-six hours.

8.4 Equipment Modifications During the Operational Field Trials

The following modifications were made to the EDSS™ equipment during the Ottawa Airport field trials:

1. Voltage Stabilizers:

   The main power supply at the Ottawa Airport was consistently low. Without the EDSS™ equipment operating it was in the range of 112 VAC to 114 VAC. With the equipment running it would drop as low as 104 VAC. It was felt that this low voltage could affect equipment operation, the ideal voltage level being 110 to 120 VAC. Voltage stabilizers were installed in February, 1992, on the electrical circuits for both the Walk-thru Personnel Scanner and the General Purpose Scanner.

2. New Drive Motors:

   There was a failure on one of the process control motors during the airport trials. It was decided to increase the margin of operational assurance by upgrading these drive motors. Both the Walk-thru unit and the General Purpose Scanner were retrofitted with the new motors in February. With these process control motors the EDSS™ is now able to accommodate a wider voltage variation, and the impact of fluctuating voltage is considerably lessened.

3. Wand Handle Design:

   The scanner operators at the Ottawa Airport suggested that the shape of the General Purpose Scanner wand nozzle be revised for easy insertion into baggage of all sizes. A new nozzle was designed that is lighter, easier to hold, and provides more convenient access to baggage.

4. PCAD Sample Collector Design:

   The PCAD sample collectors were redesigned for a better fit.

8.5 Proposed Modifications

In paragraph 8.1.4 on the integration of the EDSS™ equipment with existing security equipment it was mentioned that the security person at the exit end of the X-ray area could easily operate the scanner. To integrate the security equipment in this way, the EDSS™ General Purpose Scanner could be modified such that the sampling hose is suspended next to the X-ray operator from a sling attached to the ceiling or an overhead bar. In a peak traffic situation the operator could leave the scanner in Continuous Cycle mode, and pass baggage directly under the sampling wand when required. Actual manipulation of the scanner controls would be necessary in an alarm situation only, leaving the operator's hands free for baggage handling.

Other modifications suggested by the operators and the testing team are the following:

1. Install tie wraps for the sampling hose power cord on the General Purpose Scanner to keep the wires out of the way;

2. Tighten the hose connection to the wand;

3. Change the screen fitting for the nozzle to simplify screen changes;

4. Improve the fit of the O-ring into the grooves of the hose mount;

5. Add a quick disconnect device to the wand nozzle end, so as to change nozzle tips quickly and easily for different sampling applications;

6. Revamp or remove the railings in the Walk-thru portal, to avoid snagging passenger baggage;

7. Put a rubberized coating on the end of the wand nozzle, to avoid accidental scratching of passengers' cameras, computers and other fragile items;

8. Add a pressure hose to the nitrogen tanks, to simplify the process of cleaning and changing the filters and sample collectors;

9. Install a paging system to silently alert airport security officials of an alarm;

10. Add a flexible skirt to the end of the wand nozzle to simplify the external scanning method.

Suggestions 1 through 5 have been acted upon by CPAD. The other suggested modifications are currently being studied.

8.6 Impact on Human Resources

As mentioned in paragraph 8.1.4, the EDSS™ equipment was operated in non-alarm mode at first, in part to give Aeroguard Security personnel time to adjust to the new equipment. During the early days of operation, a few security employees wondered if their jobs might be changed or eliminated. The test supervisor and Aeroguard Security assured all security personnel that no changes of this kind were forthcoming.

8.6.1 Expertise Required

For the operational field trials, all persons hired to operate the EDSS™ equipment were given intensive training on both the Walk-thru Personnel Scanner and General Purpose Scanner on the premises of CPAD Holdings Ltd. and at the Ottawa Airport. CPAD's training provides the trainee with practical procedures for low, medium and high-threat situations, including experience with actual alarms. In addition, all maintenance and troubleshooting procedures are covered, along with practical tips on good public relations. This course is presently given by CPAD's test supervisor. It requires a total of 25 hours of training over a three-day period.

This course has proven adequate for the purposes of the new operators at the airport trials. None of the operators questioned felt that the EDSS™ is a difficult machine to understand or operate, and all were confident that they knew enough about the equipment to handle all manner of practical situations. The test supervisor expressed his satisfaction with the way his assistants managed the various tasks involved, and was able to leave the equipment under their care for extended periods of time with no adverse consequences.

8.6.2 Staffing Requirements

As mentioned above in the discussion of equipment location (paragraph 8.1) two persons were the initial staffing requirement for the EDSS™ equipment at the Ottawa Airport during the operational field trials. One operator was stationed at the Walk-thru Personnel Scanner just outside the security gate, and the second was located at the General Purpose Scanner inside Gate 3. The second operator could see the Remote Control and Display monitor from the General Purpose Scanner location, and could access its controls easily, when required.

The Walk-thru station was phased out during the last 6 weeks of the operational field trials. The Walk-thru is normally left in Continuous Cycle operation and, given that its results are available from the Remote Control, it does not require direct observation. The operator stationed at the General Purpose Scanner is able to manage the Remote Control whenever direct intervention is required. Thus only one operator is required to manage the two scanners.

For a full coverage situation involving perhaps two Walk-thru units and three General Purpose Scanners, three operators would be required at the baggage scanner locations. An existing security guard (one with other duties) could be assigned to respond to signals emanating from a series of Walk-thru units. These units are designed to operate in a fully automatic manner, and require attention only for such matters as turning the unit on, setting it in standby mode, and responding to alarm signals.

If we assume that regular airport hours are from 5:30 a.m. to 10:30 p.m., 7 days per week, the yearly operating requirements of the EDSS™ system are:

```
17 hours per day  X  365 days per year  =  6205 hours per year
```

If we also assume that the average full-time operator works 7 hours per day, 5 days per week, with 2 weeks vacation time and 7 statutory holidays, the number of hours a single operator is available to operate the EDSS™ in one year is:

```
7 hours per day  X  5 days per week  X  49 weeks  =  1715 hours per year
```

Under the minimum EDSS™ configuration of one Walk-thru unit and one General Purpose Scanner, with one operator working at all times, the person-year requirement is:

```
6205 operating hours  / 1715 operator hours per year  =  3.6 person-years
```

Under the full-coverage EDSS™ configuration with three operators working at all times, the person-year requirement would be three times that for the minimum configuration, that is, 10.8 person-years.

8.7 First and Second-Level Maintenance Tasks

Regular maintenance of the EDSS™ system is an important factor in ensuring an adequate supply of ultra-high purity nitrogen gas and providing good operating conditions for the sample collection and analytical subsystems. Table 8.9 on the following page gives the maintenance schedule for both the General Purpose Scanner and the Walk-thru Personnel Scanner's analytical unit. This schedule is applicable to units being operated 18 hours per day, 7 days per week, or 6,570 hours per year.

The daily and weekly tasks are the first-level maintenance tasks, and the monthly tasks are the second-level tasks. Weekly tasks should be executed more often if the equipment is operating in a very dusty or dirty atmosphere. Extended cleaning can be done on a daily basis during off hours when the equipment is not in use.

The procedures for carrying out these tasks are given in the last section of the *Operations Manual*, which appears here as Appendix B.

Table 8.9 EDSS™ Regular Maintenance Schedule

	FIRST-LEVEL TASKS		SECOND-LEVEL
ITEM	DAILY TASKS	WEEKLY TASKS	MONTHLY TASKS
NITROGEN GAS	Check and resupply when necessary Check gas flow daily and each time sample collectors are replaced.		
SAMPLING HOSE	Check and clean		Replace
WAND NOZZLE	Clean periodically during sampling		
WAND LINT SCREEN	Clean periodically during sampling		
VCAD FILTER #1		Replace	
PCAD FILTER #2		Replace	
PCAD SAMPLE COLLECTORS	Replace		
VCAD SAMPLE COLLECTORS			Replace
EXTENDED CLEANING	4 to 6 hours		
BACKGROUND CONDITIONER			Replace

8.8 Projected Operation and Maintenance Costs

For each EDSS™ scanner in operation, there should be a sufficient supply of replacement parts on hand to provide uninterrupted and trouble-free service. Refer to Table 8.9 for a schedule of parts replacement. The required parts are as follows:

1. Two spare sampling hoses per machine;
2. One month's supply of Filters #1 and #2, that is, 4 of each filter for each machine;
3. Two week's supply of PCAD sample collectors, that is, 42 PCAD sample collectors per machine;
4. Two month's supply of VCAD sample collectors, that is, 6 VCAD sample collectors per machine;
5. One month's supply of background conditioners, that is, 1 background conditioner for each machine.

The sampling hoses can be cleaned and reused many times, so the two spare hoses should last for an extended period. The PCAD and VCAD sample collectors can also be reused if they are sent to CPAD Holdings Ltd. for refurbishing on a regular basis. CPAD now offers a service program that includes the refurbishing of sample collectors. Filters #1 and #2 are quite inexpensive, and should be replaced rather than refurbished for the most cost-effective maintenance program.

The projected cost of maintaining the EDSS™ system is given on the next page. All items are calculated on a monthly basis. These maintenance costs are applicable to units being operated 18 hours per day, 7 days per week, or 6,570 hours per year. The cost of extra sampling hoses and sample collectors is a one-time purchase that should be made when acquiring the equipment, and is not included with the general maintenance costs. Note that all prices have been established at the date of publication of this report, and are subject to change.

Filters #1 and #2 (8 filters @ $3.75)	$ 30
PCAD sample collectors:	
Refurbishing (21 sample collectors per week)	$ 399
VCAD sample collectors:	
Refurbishing (3 sample collectors per month)	$ 115
Background conditioner (1 conditioner @ $15)	$ 15
TOTAL MONTHLY MAINTENANCE COST	**$ 559**

The projected cost per month of consumables for each EDSS™ scanner is as follows (based on current prices for nitrogen gas and electricity in the Ottawa area):

UHP nitrogen (55.2 kg/month @ $4.35)	$ 240
Electricity (700 kwh/month @ $0.076)	$ 53
TOTAL MONTHLY OPERATION COST	**$ 293**

Taken together, the projected monthly cost of maintenance and operations for the EDSS™ system is approximately $852.

9. ANALYSIS AND DISCUSSION OF RESULTS

This section presents a summary and analysis of the results of all phases of testing performed on the EDSS™ system. These include the analytical performance tests (Chapter 4), operational performance tests (Chapter 5), longevity and stability tests (Chapter 6), controlled line voltage variation tests (Chapter 7) and the operational field trials (Chapter 8). The implications of these results as to the general success of the EDSS™ test and evaluation stage are also discussed.

9.1 Analytical Performance Tests

The purpose of the analytical performance tests was to ascertain the range of explosives detected, the limit of detection for each explosive, and any identifiable interferents.

9.1.1 Range of Explosives and Taggants Detected

During the analytical performance tests it was found that the following explosive compounds and taggants can be positively identified by the EDSS™:

DMNB, EGDN, P-MNT, O-MNT, NG, DNT, RDX, PETN and TNT

This range of explosives and taggants is detected using the factory calibration. The equipment can be calibrated to detect other compounds.

9.1.2 Limits of Detection

The lower detectable limits of explosive detection are dependent on the type of explosive sampled. From Table 4.1 we see that for vapour detection the range is from 1.9 ppt for DMNB, to 161.0 ppt for P-MNT. In Table 4.2 the minimum detectable concentrations for plastic explosives are also widely variant: 600 to 800 pg for RDX, versus 2 to 2.5 ng for PETN.

For vapour detection the minimum mass flow of explosive vapours is directly proportional to the minimum detectable concentration, that is, the least mass flow required is 0.2 ng/sec for DMNB, and the greatest mass flow required is 12.8 ng/sec for P-MNT. One exception here is DNT, which requires more than the expected mass flow of vapours.

The degree of sensitivity of the EDSS™ system to the range of explosives detected can be ordered from most readily detected explosive to least readily detected explosive, as follows:

Vapour Detection:

1. DMNB
2. EGDN
3. NG
4. DNT
5. O-MNT
6. P-MNT

Plastic Explosives Detection:

1. RDX
2. PETN

To integrate these two types of explosive detection as a single list, we have as a reference point the fact that NG and PETN display similar signals on the EDSS™ system. They have, in fact, been combined under a single window on the EDSS™ bar graphs (see Appendix C for sample graphic displays). The overall range of lower detectable limits can thus be postulated as the following, from most readily detected explosive to least readily detected explosive:

Overall Explosives Detection:

1. DMNB
2. RDX
3. EGDN
4. NG/PETN
5. DNT
6. O-MNT
7. P-MNT

Note that the lower detectable limit of TNT detection was not calculated during the analytical performance tests.

9.1.3 Particle Calibration Source

The overall test results given in Table 4.3 point to accurate detection of very small amounts of plastic explosives. In 25 of the 32 tests performed, the EDSS™ identified the explosive substance on the last thumbprint made. That is, even the weakest imprint of the material was sufficient to cause an alarm. Semtex-H and DM12 were detected at the weakest levels on all surface materials.

Deta Sheet and C-4 were less easily detected, particularly when applied to stainless steel and, to a lesser extent, hard plastic. Vinyl and polyethylene also proved problematic for Deta Sheet, and leather was a difficult surface material for C-4. There were variations in the detection levels of Deta Sheet as well, in that some thumbprints between two positively identified prints did not raise an alarm. This may be attributed to the sampling method used. The testing team noted that sampling with the nozzle at 45° was far less effective in producing an alarm than sampling with the nozzle held perpendicular to the surface material.

It should be noted that Deta Sheet was not originally on the list of compounds to be tested, as no other explosives detection system has been able to detect it in the past, and it was considered an unreasonable test. The fact that Deta Sheet was detected by the EDSS™ in at least some of the tests is thus a noteworthy result.

9.1.4 Identifiable Interferents

A broad range of substances was tested for interference properties. A false alarm on car exhaust can be attributed to the need for adjustment of the equipment calibration. No interferents were positively identified on the standard software version of the EDSS™. This conclusion is corroborated by the results of the operational field trials, during which no interferent substances were discovered over a period of nearly four months.

9.1.5 Discussion of Results

The EDSS™ has proven capable of detecting a wide range of explosive compounds, including plastic explosives. The sensitivity of the system is highly acute, requiring minimal amounts of explosive material to set off an alarm condition. Even the least readily detected substance, P-MNT, is detectable at very low vapour concentrations. Minimal levels of the plastic explosives are also detected, with some variation for Deta Sheet and C-4 according to the surface material used. In practical terms, the EDSS™ system is an operationally viable explosives detection system with a high level of sensitivity to a wide range of explosive and taggant compounds, and a low false alarm rate.

9.2 Operational Performance Tests

The purpose of the operational performance tests was to characterize the capability of the EDSS™ system to identify the presence of explosives on a person or in parcels or baggage.

9.2.1 Identification Capabilities

The ICAO Suitcase Test on the General Purpose Scanner revealed a variable rate of detection for the various explosives tested. The NG and EGDN box was the most rapid to raise an alarm: 1 hour, 11 minutes. Positive identification of DMNB was achieved after 6 hours, 4 minutes on the first day of testing, and after 5 hours, 50 minutes on the second day. The slight difference between these two reaction times is probably due to reopening the slit, which increased the flow of vapours and produced richer samples on the second day. With a properly opened slit, alarm level concentrations for DMNB are reached within a shorter detection time.

TNT was the most difficult material to detect, requiring 51 hours, 15 minutes before an alarm was raised. One hypothesis which may explain this difficulty is that the vapour generator was unable to produce vapours equivalent to 1 bar of TNT. When the opposite side of the box was slit an alarm was raised immediately, pointing to variations in the amount of TNT vapours present inside the box.

The vapour detection evaluation of the Walk-thru Personnel Scanner was very successful, producing positive results within one hour on the first day of tests, and in four minutes on the second day. Alarms were raised for DMNB from both the Walk-thru portal and the sampling hose. Test results show a significant increase in sensitivity when scanning a person with the wand, without the wand coming in contact with the person, compared to scanning from the Walk-thru portal.

For the plastic explosives detection evaluation an alarm was raised after external sampling in four out of six tests at the second level of difficulty. The two tests that did not raise an alarm at this level of difficulty concerned Semtex-H in a glass jar and C-4 in a plastic container. Semtex-H was detected during the equivalent test at the first level of difficulty. C-4 tested at the first level of difficulty did not raise an alarm on external sampling, but was detected on internal sampling.

9.2.2 Discussion of Results

Conclusive results for the Walk-thru Personnel Scanner have been obtained. This device is able to identify the presence of explosives on a person within a very short time period. The speed with which the General Purpose Scanner can detect explosive vapours in parcels varies widely depending on the explosive present. This variation may depend on how well the opening to the interior of the box is made, or the way the vapours are generated.

The General Purpose Scanner has a strong capability to detect plastic explosives in parcels. Tests have shown that in most cases the equipment is able to detect explosives in sealed containers under a rigorous test scenario using non-intrusive sampling.

9.3 Longevity and Stability Tests

The purpose of these tests was to determine the longevity and stability of the EDSS™ through performance tests over a continuous long-term operational period.

9.3.1 EDSS™ Longevity and Stability

The two EDSS™ scanners tested underwent an operational testing period of 7 days (168 hours). In addition to the regular maintenance procedures identified in Table 8.9, the General Purpose Scanner required a slight tension adjustment, and the Walk-thru Personnel Scanner required installation of an additional cooling system after an electronic failure occurred on the IMS.

The consumption of ultra-high purity nitrogen during the test period was 47.0 kg for the General Purpose Scanner, and 81.1 kg for the Walk-thru unit. These levels are higher than expected, with the gas consumption for the Walk-thru as much as five times the levels experienced at the CPAD plant. A slight leak in the high-pressure manifold of the Walk-thru is suspected.

Equipment status was generally stable throughout the 7-day period. One unexpected alarm occurred on the General Purpose Scanner, caused by an air leak. The Walk-thru unit had a few abnormal analog graphs for the first three days, due to overheating and electrical contact problems. Once the cooling system was installed, no further problems were encountered.

The results of the Longevity and Stability Tests given in Tables 6.1 and 6.2 show a marked difference in signal value levels for explosive samples versus non-explosive samples. This difference was consistent throughout the test period. For the General Purpose Scanner the average explosive sampling value over all 12 tests performed was 566 egu, whereas the average non-explosive value was 94 egu. For the Walk-thru Personnel Scanner the average explosive sampling value was 135 egu, whereas the average non-explosive value was 21 egu over all tests performed. In other words, for both scanners the signal value displayed for an explosive substance is approximately 6 times the signal value displayed for a non-explosive substance. This multiple would probably be higher in a real-life situation, where the equipment is subjected to a much lower rate of explosive samples.

These tests also demonstrated the EDSS™ ability to quickly recuperate to near-background levels after being subjected to an explosive sampling. For all 12 tests, and on both units, only three non-explosive sampling cycles were permitted between each sampling of the explosive substance. The explosive was sampled 5 times per test. In spite of this high frequency of contact with explosives the EDSS™ was able to recover completely within the three non-explosive sampling cycles.

9.3.2 Discussion of Results

Over the continuous long-term operational period of these tests the performance of the EDSS™ scanners was not without incident. In particular, hardware modifications were required to maintain the equipment in operable condition under the duress of constant long-term operations. This kind of problem could be considered typical of a highly sophisticated apparatus in the early stages of performance testing. The rapidity with which CPAD was able to rectify all problems during the longevity and stability tests is noteworthy.

When the aspects of longevity and stability are taken separately, the EDSS™ scanners appeared to be very stable as far as the ability to detect explosives is concerned, but somewhat less dependable when put in rigorous non-stop operation over an extended period of time. However, the equipment modifications resulting from these tests have permitted uneventful long-term operations of the EDSS™ during the operational field trials (see paragraph 9.5).

It should be noted that under the actual operating schedule for the Ottawa airport field trials both units were left on 24 hours per day, 7 days per week. They were in operating mode during airport hours, and cleaning cycle during off hours. This continuous long-term operating situation was carried out under normal maintenance procedures. The ongoing tests at the Ottawa airport can thus be taken as an extension of the longevity and stability tests. Refer to section 9.5 for a discussion of the operational field trial results.

9.4 <u>Controlled Line Voltage Variation Tests</u>

The purpose of the controlled line voltage variation tests was to evaluate the performance of the equipment at less than ideal voltage levels.

9.4.1 Performance at High Voltage Levels

At a voltage level of 132 VAC, the General Purpose Scanner displayed an average signal value of 2744 eiu for RDX, compared to an average value of 2715 eiu at the normal 120 VAC voltage level. The high voltage readings were thus 1.1 percent higher than the normal voltage readings.

The Walk-thru Personnel Scanner displayed an average signal value of 128 egu at 132 VAC, compared to an average value of 114 egu at 120 VAC. For this unit, the high voltage readings were 12.3 percent higher than readings at a normal voltage level.

9.4.2 Performance at Low Voltage Levels

At a voltage level of 102 VAC, the General Purpose Scanner displayed an average signal value of 1790 eiu for RDX, compared to an average value of 2715 eiu at the normal 120 VAC voltage level. The low voltage readings were thus 34.1 percent lower than the normal voltage readings.

The Walk-thru Personnel Scanner displayed an average signal value of 118 egu at 102 VAC, compared to an average value of 114 egu at 120 VAC. For this unit, the low voltage readings were 3.5 percent higher than readings at the normal voltage level.

9.4.3 Discussion of Results

The performance of the EDSS™ General Purpose Scanner is slightly more sensitive at voltage levels as high as 132 VAC, although this improvement cannot be taken to be significant. The Walk-thru unit's performance is significantly more sensitive when operating at a high voltage level.

At low voltage, the capacity of the General Purpose Scanner deteriorates, whereas the Walk-thru unit continues to behave at satisfactory levels of sensitivity. The difference in performance between these two units at low voltage levels could be due to the difference in their scanning techniques. For the General Purpose Scanner air samples are taken at close range and in relatively small amounts. The Walk-thru unit, on the other hand, collects large amounts of air from the entire portal area. This technique appears to be unaffected by reduced voltage.

The results of the controlled line voltage variation tests point to the desirability of voltage stabilization at 120 VAC, since detection efficiency is hampered by low voltage levels. As an alternative solution, the analytical process could be adjusted to take into account a reduction of power.

During the operational field trials at the Ottawa Airport, it was discovered that voltage levels would go as low as 104 VAC when the EDSS™ equipment was in operation. CPAD opted for the voltage stabilizer solution, which proved satisfactory for the purposes of maintaining high sensitivity on both the General Purpose Scanner and the Walk-thru Personnel Scanner. In addition, new process control motors installed during the operational field trials allow the EDSS™ to accommodate a wider voltage variation, and the impact of fluctuating voltage is considerably lessened.

9.5 Operational Field Trials

The purpose of the operational field trials was to:

1. Identify the most effective and efficient location of the EDSS™ equipment;
2. Determine the general effectiveness of the scanners in an airport environment;
3. Provide concrete suggestions regarding desirable enhancements to the EDSS™ system;
4. Examine projected operation and maintenance costs;
5. Examine the impact on human resources;
6. Determine the first and second-level maintenance tasks required in a real-life scenario.

9.5.1 Ideal Equipment Location

The ideal location for the Walk-thru Personnel Scanner in an airport environment is directly outside the entrance to the security gate, so that passengers can pass thru the Walk-thru portal before entering the X-ray and metal detectors area. The unit should be installed such that the path taken through the portal is directly in line with the security gate entrance. In this way, passengers are more likely to go through the Walk-thru portal without hesitation. Two 15 amp circuits along with proper electrical wiring and grounding should be made available in the near vicinity of the Walk-thru, away from the traffic flow area.

The ideal airport installation for the General Purpose Scanner is inside the security gate, right next to the X-ray equipment area. In this way security personnel who are operating the X-ray machines can easily pass selected bags to the scanner operator for inspection. It is suggested that a counter be made available for the baggage that is to be scanned, and that the EDSS™ scanning be carried out before executing a hand search, so that the scanner results are available at the time of the search. Once again, two 15 amp circuits in the vicinity of the scanner are required for proper installation.

The best location for the Remote Control and Display unit is an area that is within sight of a scanner operator's station, and close enough to that station that the operator could move to the Remote Control monitor quickly. That is, there should be a minimum of obstructing walls, equipment or counters between the operator's habitual location and the location of the Remote Control and Display. Depending on the equipment configuration, the Remote Control may be placed inside the security gate area, or outside the security gate near the Walk-thru unit. The determining factors of the ideal location are the number of scanner operators available for supervision of the Remote Control, and their usual positions relative to the Remote Control.

9.5.2 Effectiveness of the EDSS™ in an Airport Environment

The EDSS™ equipment has proven effective and reliable in detecting concealed explosives both during operational tests and ongoing daily operations. The few alarms that occurred when scanning passenger traffic were due to the following:

1. A military bag that tested positive for NG/PETN;
2. A briefcase that indicated the presence of NG/PETN;
3. A passenger carrying NG-based heart pills;
4. A passenger who set off a low-level RDX signal on external sampling only (in the Walk-thru);
5. A coat that once belonged to an air base officer who had been in contact with explosives two years prior to the trials;[7]

[7] The passengers on several military flights were scanned during the airport trials, with no false alarms occurring.

6. A visiting military officer who, during an equipment demonstration, tried passing through the Walk-thru carrying a small explosive sample in his pocket;

7. Mechanical problems requiring equipment modification, as outlined in paragraph 8.4;

8. Incorrect equipment calibration, or alarm thresholds set too low.

The importance of frequent equipment calibration cannot be overemphasized. If the EDSS™ scanner is not properly calibrated, a non-explosive signal can drift into explosive signal areas, causing a false alarm. This is especially true of materials which have distinct signals that are close together on the analytical graphs, such as leather and TNT or RDX. The high number of alarms occurring on the Walk-thru for DNT in the first, second and third evaluation periods (Tables 8.5., 8.6 and 8.7, respectively) as well as for NG/PETN on the first and fourth evaluation periods (Tables 8.5 and 8.8) are due to improper calibration of the equipment. In the case of the NG/PETN alarms in the fourth evaluation period, all alarms occurred within a 36-hour period during which the machine was not calibrated. Many of these alarms occurred when there was no one in the unit.

The scanning techniques, and the scanning units themselves, have no deleterious effect on traffic flow. Slowdowns, which are common at the Ottawa Airport during rush hours, cannot be attributed to the EDSS™.

Passenger reaction has been favourable, with no objection to the scanning techniques used. In fact, many have expressed their interest and appreciation of the new security procedure. Airport management, the RCMP, Air Canada and Aeroguard Security have all reported favourably on the equipment and passenger reaction to it.

The EDSS™ units were easily integrated with the other security gate procedures, both at the mechanical level and the level of human resources (see paragraph 9.5.5). The scanners were installed in effective locations at the security gate such that normal security procedures were unimpeded. In addition, there was a smooth transition between the X-ray scanning and EDSS™ scanning of passenger baggage.

9.5.3 Desirable Enhancements

A few equipment enhancements have been suggested by the equipment operators, who have gained considerable experience with the scanners over the months of the airport trials. They concern ergonomic factors and the enhancement of an integrated security gate procedure. No changes have been suggested as yet for improving the performance and reliability of the EDSS™.

Several of the proposed enhancements have already been incorporated into the EDSS™ equipment. Other modifications await further study and approval. The details of all proposed modifications are presented in paragraph 8.5.

9.5.4 Operation and Maintenance Costs

The projected monthly cost of maintenance and operations including equipment consumables, spare parts and refurbishing, is approximately $852. This amount is quite reasonable when measured against the enhancements to security and public confidence in transportation systems that the EDSS™ provides.

9.5.5 Impact on Human Resources

The regular security personnel at the Ottawa Airport were impressed with the effectiveness of the scanners, had no difficulties understanding their function, and felt secure that their jobs would not be negatively affected by the new technology.

A training course designed by CPAD was used to train all scanner operators during the airport trials. The 25-hour course has proven sufficient for gaining a fundamental understanding of the operation and maintenance of the machines. Continued supervision by a trained supervisor is suggested during the first six to eight weeks of a new operator's employ.

The staffing requirements for the EDSS™ configuration in an airport environment would entail the hiring of 8 to 15 full-time operators, depending on the number of units installed. This figure could be reduced if the Walk-thru unit was left to operate automatically during low traffic hours, or if the General Purpose Scanner was modified for combined operation with the X-ray units, as described in paragraph 8.5.

9.5.6 Required Maintenance Tasks

The maintenance tasks required for the EDSS™ system are summarized in Table 8.9. It is suggested that a set time be allocated each day for these maintenance activities, preferably at the beginning of the day or during low traffic periods. The equipment should also be calibrated and the background levels set during regular maintenance activities.

10. CONCLUSIONS

The conclusions and recommendations presented here are based objectively upon the facts presented in this report.

The tests documented in this report have shown the EDSS™ system to be an effective and reliable explosives detection device. The EDSS™ demonstrates high sensitivity to a broad range of low-level explosive compounds: DMNB, EGDN, P-MNT, O-MNT, NG, DNT, RDX, PETN and TNT. Explosive detection and accompanying alarm signal are executed within 10 seconds from the initial sampling time.

Throughout the testing period the EDSS™ system performed satisfactorily, meeting or surpassing the test procedure requirements in 95 percent of the tests performed. The only performance difficulty encountered was during the line voltage variation tests, where it was found that the performance of the EDSS™ is slightly impaired by low voltage levels. This, however, was readily corrected by the installation of voltage stabilizers.

The ease of installation, operation and maintenance of the system make it an acceptable tool for airport security procedures. In addition, the scanning techniques used pose virtually no inconvenience to boarding passengers.

While awaiting action concerning the implementation of this type of explosives detection scanning in airport security procedures, a continuation of this type of testing would provide meaningful information with respect to:

1. Identification of the best possible location for the General Purpose Scanner, the Walk-thru unit and the Remote Control and Display in an airport environment, since not all locations were tested;

2. Proposed modifications to the equipment that have been suggested during the course of the operational field trials to improve certain ergonomic factors;

3. Exploration of proposals concerning the integration of the EDSS™ system with existing airport security procedures on a permanent basis.

A recurrent problem during the testing stage was the lack of standard test procedures. Some procedures required one or more modifications to ensure adequate testing of the EDSS™, indicating that the requirements for this kind of device are not properly established. It is suggested that the present document be used as a basis for the eventual development of a standard requirements specification.

APPENDIX A

Test and Evaluation Procedures

The procedures drawn up by CPAD Holdings Ltd. and approved of by the Transportation Development Centre to test and evaluate a broad range of performance criteria of the EDSS^{TM} system. These procedures also appear as Appendix II of TDC contract T8200-1-1511/01-XSD.

APPENDIX II

TEST AND EVALUATION PROCEDURES

October 15, 1991
Contract #T8200-1-1511/01-XSD

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OBJECTIVE:

1. To determine the Explosives Detection Security System's (EDSS™) capability to:

   a) detect bombs in packages, brief cases, checked luggage or on persons,
   b) operate reliably in an airport environment.

2. To finalize the test and evaluation on an urgent basis so that any endorsement emanating from the tests would act as a catalyst to secure the significant benefits to Canada which are inherently part of the project.

GENERAL: The Test and Evaluation Plan set out below calls for:

1. Laboratory Tests of analytical performance to identify:

   a) range of explosives detected,
   b) limit of detection for each of these explosives,
   c) identification of any interferents.

2. Controlled operational tests to characterize EDSS™ capability of identifying the presence of explosives on a person or in parcels or baggage.

3. Laboratory tests to determine longevity and stability.

4. Controlled line voltage variation tests.

5. Operational field trials to determine:

   a) The identification of:
      i) The most effective and efficient location of equipment to scan persons with carry-on baggage, and to scan checked baggage:
      ii) The most effective and efficient placement of the EDSS relative to metal detectors and x-ray units.

   b) Effectiveness of EDSS in terms of
      i) Detecting concealed explosives;
      ii) Impact on traffic flows;
      iii) Operating the systems as elements of an integrated security gate involving metal detectors and x-ray units.

c) Any alterations/modifications to EDSS' configuration which would act to enhance:
   i) Performance and reliability;
   ii) Ergonomic factors;
   iii) Integration with existing airport architecture at security gates and other locations where it may be desirable to locate the equipment.

d) Projected operation and maintenance costs.

e) The impact on human resources:
   i) Level of expertise required to operate equipment;
   ii) Person year requirements per system.

f) An estimate of first and second level maintenance tasks.

1. LABORATORY TEST OF ANALYTICAL PERFORMANCE

OBJECTIVE: To identify EDSS' capability in terms of:

1. The range of explosives' compounds it identifies.

2. The limit of detection of each compound.

GENERAL: Under the Laboratory Test of Analytical Performance the evaluation of explosives detection is covered in separate components. Section A deals with vapour detection, Section B with plastic explosives detection, and Section C with testing the impact of potential interferents.

SECTION A - VAPOUR EVALUATION

1.1 Compounds:

a) EGDN,
b) DNT,
c) NG,
d) Taggant Candidates:
OMNT, PMNT, & DMNB.

1.2 Establishing Lower Detectable Limit of Overall Detector System, ie. Sampling and Analyses for the Sampling Times of 5 and 10 Seconds:

a) Lower detectable limit is taken as a signal emanating from an explosive sample which is beyond twice the noise in the baseline of the unit with no sample present.

b) Procedure:

i) Establish baseline (blank) results for at least 6 samples of ambient atmosphere;
ii) Introduce sample to unit and record units output;
iii) Allow unit to reestablish baseline reading;
iv) Re-introduce sample to unit and record the unit's output;
v) Repeat steps iii - iv several times.
vi) Decrease the sample size until the signal is detectable within 2 to 3 standard deviations of the baseline noise.
vii) Record all findings on form ET-GPS or ET-WT, whichever is appropriate.

1.3 Establishing Clear Down Time

a) Definition: Time required to return to the approximate (2-3 times original baseline values) baseline value.

b) Procedure:

Subject EDSS to high (5 to 50 ppb) and low (10 to 100 ppt) concentrations of EGDN and then determine time the system requires to return to baseline levels.

1.4 Vapour Detection Evaluation of the EDSS General Purpose Scanner

a) Explosive Vapour Generator Apparatus Used

i) Primary Vapour Generator

The primary vapour generator is a high volume explosive vapour generator based on the following dilution ratio:

$$C^{air} = C_0(f/F) \qquad (1)$$

where

C_0 = equilibrium vapour pressure concentration at a given temperature
f = flow though the vapour generator $f < F$
F = flow of the dilution gas (air)
C^{air} = the concentration of the gas stream emitted from the vapour generator.

The primary vapour generator is used at CPAD to perform an initial evaluation of the EDSS system. The second function of the primary vapour generator is to calibrate a secondary vapour generator system.

ii) Secondary Vapour Generator

The secondary vapour generator is a device that emits an explosive vapour at a constant rate. This device operates on the principle of a calibrated leak emitter. The generator is placed at a reproducible position with respect to the sample orifice of the EDSS system.

b) Evaluation Procedure

Evaluation procedure is as set out in 1.2 b) above and the sample is introduced to the sample nozzle at the end of the sampling hose.

1.5 Vapour Detection Evaluation of the EDSS Walk-thru Personnel Scanner

a) Explosive Vapour Generator Apparatus

i) Primary Unit

The vapour generator to test the Walk-thru unit is a device that emits the explosive vapour at a constant rate. The rate is determined by:

$$R^{air} = C_0 f \quad (2)$$

where C_0 and f are defined in equation (1) as set out in 1.3 a) i) above.

A calibrated set of sample generators remain at CPAD and all other generators are calibrated against the primary calibrated set.

ii) Secondary Unit

The secondary unit is an exact copy of the primary unit. The sample cartridges contain a source of the particular vapour. To test the Walk-thru unit for the performance of a specific explosive compound, the operator chooses the appropriate sample cartridge and places it in the generator. Next, the generator is taken into the Walk-thru unit for a specified amount of time.

b) Evaluation Procedure

As set out in 1.2 b) above. The sample is introduced:

i) in the non-pause mode and the pause mode for sampling periods of five seconds, and
ii) at various locations in the Walk-thru's chamber.

SECTION B - PLASTIC EXPLOSIVES DETECTION EVALUATION

1.6 Explosives' compounds to be tested are those found in C-4, DM12, Semtex-H, and Deta Sheet or similar sheet explosive.

a) RDX,
b) PETN.

1.7 Establishing Lower Detectable Limit of Overall Detection System ie. Sampling and Analyses, for the Sampling Times of 5 and 10 Seconds:

a) Lower detectable limit is taken as a signal emanating from a sample explosive compound which is beyond twice the noise in the baseline of the unit with no sample present.

b) Procedure:

i) Establish baseline (blank) results for at least 6 samples taken from clean/blank surfaces;
ii) Inject a metered volume of a standard solution of RDX or PETN onto a sample collector, to determine the inherent sensitivities of the analyzer;
iii) Record results;
iv) Allow unit to reestablish baseline reading;
v) Re-introduce a metered volume of the solution and record the results;
vi) Repeat steps iv - v several times;
vii) Decrease the volume of solution until the RDX or PETN signal is detectable within 2 to 3 standard deviation units of the baseline noise.

1.8 Particle Calibration Source

A series of 6-10 test squares (3" x 3") of:

a) stainless steel,
b) vinyl,
c) cardboard,
d) nylon,
e) polyethylene,
f) leather,
g) canvas,

are contaminated with a 'thumbprint' of each plastic explosive (Sec 1.6). Alternate squares are analyzed in the laboratory (washing with solvent, injection on GC), remaining squares are sampled with EDSS.

SECTION C - INTERFERENCE TESTS

1.9 Interferent compounds can include:

a) Smoke (cigarette, cigar, pipe),
b) Car exhaust,
c) Perfumes,
d) Freons,
e) Chlorinated solvents,
f) Acetone
g) food stuff.

2. CONTROLLED OPERATIONS TESTS

OBJECTIVE: To identify and characterize the EDSS' capability in terms of identifying the presence of explosives carried on a medium such as persons or parcels.

GENERAL: In the operational performance tests the alarm thresholds are set at appropriate levels and the unit's alarm signal is used as the indicator of the presence of the sample explosive. Thus, during these tests EDSS™ operates in a binary mode: Alarm or No Alarm.

As in 1 above, Section A deals with vapour detection and Section B with plastic explosives detection.

SECTION A - VAPOUR EVALUATION/OPERATIONAL PERFORMANCE

2.1 Compounds:

a) EGDN,
b) DNT,
c) NG,
d) Taggant Candidates;
O-MNT, P-MNT, and DMNB.

2.2 Evaluating the EDSS™ General Purpose Scanner (ICAO Suitcase Testing Will be Carried Out):

<u>Procedure</u>:

a) A sample mass of approximately 50 grams of marked explosives samples is placed in the centre of a sealed cardboard box of approximately 1.33 cu. ft. capacity (6" x 16 " x 24"). The explosive sample is sealed in a thin polyethylene bag which is then wrapped in a cotton layer and surrounded by 500 grams of crumpled newspaper.

b) All edges and openings of the box are sealed with tape.
c) The vapour sample is taken from a slit 10 cm long cut at mid height on one side with a razor sharp knife.
d) The cardboard box is sampled immediately after it is sealed. Time = t_o.
c) Next, the box is sampled at specific time intervals after t_o.
d) Results are recorded on form ET-GPS-2 for each compound.

2.3 Evaluating the EDSS™ Walk-thru Personnel Scanner

Procedure:

a) An explosive sample containing EGDN, DMNB etc in a cardboard (cigarette box) container is located under garments on a person.
b) Initial soak time on the person is at least 15 minutes.
c) The person walks through the chamber of the Walk-thru at a normal pace.
d) Results are recorded on form ET-WT-2.
e) As an optional procedure the Walk-thru is switched to the Hand Wand Sampling Unit and the person is scanned with the Hand Wand.
f) Results are recorded.
g) Tests are repeated over specific time intervals.

SECTION B - PLASTIC EXPLOSIVES DETECTION/OPERATIONAL PERFORMANCE

2.4 Explosives' compounds to be tested are those found in C-4, DM-12, Semtex-H and Deta Sheet or similar sheet explosive.

a) RDX,
b) PETN.

2.5 Plastic Explosives Detection Evaluation

Operational Performance of the EDSS™ General Purpose Scanner:
The medium to be sampled is a suitcase or box at three levels of difficulty.

2.6 Preparation of the medium:

a) A handler kneads and shapes a plastic explosive into a bomb-like shape.
b) First Level of Difficulty:
   The sample installed in an appropriate appliance and then placed in a box or suitcase.
c) Second Level of Difficulty:
   The handler transfers the appliance to an accomplice who then packs it in the box or suitcase.
d) Third Level of Difficulty:
   The handler places the appliance in a bag and then gives the bag to the accomplice who packs it in a box or suitcase.

2.7 Sampling Procedure

a) The container is sampled on the outside in the normal manner and the results recorded.
b) The container is then sampled by a wiping technique and the results recorded.
c) If the result of subparagraph a) or b) is negative the container is opened and sampled on the inside.
d) Results are recorded on form ET-GPS-2.

3. LABORATORY TESTS TO DETERMINE EDSS™ LONGEVITY AND STABILITY

OBJECTIVE: To check the performance of the EDSS™ over a continuous operational period of 7 days (168 hours).

GENERAL: During this test, the EDSS™ units will be operated in the Continuous Cycle mode for an 18 hour period commencing at 6 A.M. and ending at midnight.

From midnight until 2 A.M. they will be set in the Cleaning Mode. From 2 A.M. until 6 A.M. they will enter the Standby Mode. Regular maintenance and operating procedures as set out in the Operators manual are to be followed.

Note: During day 6 and day 7 the systems will be in the Standby Mode.

3.1 Overall Test Plan

The following is a sequential listing of the overall test plan, details are provided in Section 3 herein.

a) Pre-test Activities:

Startup procedures as set out in the Operator's Manual.

b) Test Activities:

			Elapse Time (hrs)
Day 1	09:00	Start	
		Perform 1st set of tests	0
	15:00	Perform 2nd set of tests	6
Day 2	09:00	Perform 3rd set of tests	24
	15:00	Perform 4th set of tests	30
Day 3	09:00	Perform 5th set of tests	48
	15:00	Perform 6th set of tests	54
Day 4	09:00	Perform 7th set of tests	72
	15:00	Perform 8th set of tests	78
Day 5	09:00	Perform 9th set of tests	96
	15:00	Perform 10th set of tests	102
Day 6	09:00	Perform 11th set of tests	120
Day 7		Standby	
Day 8	09:00	Perform 12th set of tests	168

c) Post-test Activities:

Detailed inspection of the equipment plus preparation of final report (reference paragraph 3.4 herein).

3.2 Details

3.2.1 Test Activities - Walk-thru Personnel Scanner

a) Check Diagnostic Display through threes cycles to ensure all systems are normal.
b) A sample of DMNB generated by the Secondary Vapour Generator is injected into the Walk-thru Personnel Scanner by a test subject carrying the generator at waist height through the unit using fixed emission rate of approximately 1 mg per minute. The vapour generator is to be on for the total travel time through the chamber.
c) Each test is to be repeated five times and results noted on form ET-WT-1.

3.2.2 Testing the General Purpose Scanners

a) Check Diagnostic Display through three cycles to ensure all systems are normal.
b) A sample of DMNB generated by the Secondary Vapour Generator, is collected from the generator by EDSS™.
c) A sample of RDX, is collected from a prepared calibration source by EDSS™.
d) Each test is repeated five times and results are recorded on form ET-GPS-2.

3.2.3 Testing Activities Common to Both the Walk-thru and General Purpose Scanners

a) Before and after tests, check and report on:
   i) level of gas supply,
   ii) condition of sample collectors,
   iii) condition of Clean Cycle filter,
   iv) condition of Dust Filter,
   v) condition of Lint Filter,
   vi) diagnostic display data.

b) Before and after tests, check and report on any abnormal conditions such as hot spots, mechanical wear points etc.
   Note: *Use Equipment Inspection Record - Form ET-LS to report on these activities.*

4. CONTROLLED LINE VOLTAGE VARIATION TESTS

4.1 Objective:

To check the performance of EDSS™ over a static line voltage range of 120 VAC, + 10% - 15%. During this test the equipments are to be operated in the Continuous Cycle.

4.2 Voltage Test Range:

102 - 132 VAC, single phase, 60 Hz.

4.3 Static voltage test levels and test sequence:

102 VAC - test #6
108 VAC - test #5
114 VAC - test #3
120 VAC - test #1
126 VAC - test #2
132 VAC - test #4

Pre-test activities:

a) Check, and replace if necessary, the following: filters, sample collectors, columns, impulse heater screens and their related electrical contacts,
b) Visually inspect the overall system from an electrical/mechanical point of view.
c) Check the overall system calibration and adjust where necessary.
d) Prepare test samples.

4.5 Testing the Walk-thru Personnel Scanner

a) Check and report on Before Test values as set out on Line Voltage Variation Test form ET-LVV.

b) Set line voltage at value for the test (refer to 4.3 above) at least 15 minutes prior to commencement of test.

c) The compounds to be tested is DMNB.

d) Samples of these compounds, generated by the Secondary Vapour Generator are injected into the Walk-thru Personnel Scanner by a test subject carrying the generator at shoulder height, either on the left or on the right, through the unit. The generator is to be on for the total travel time through the chamber.

e) Each test is to be repeated five times and the results noted on the Line Voltage Variation Test form ET-LVV.

f) Check and report on After Test valves as set out on the Line Voltage Variation Test form ET-LVV.

4.6 Testing the General Purpose Scanners

a) Check and report on Before Test values as set out on the Line Voltage Variation Test form.

b) Set line voltage at value for the test (see 4.3 above) at least 15 minutes prior to commencement of the test.

c) Compound to be tested is: RDX.

d) Samples of the compound on the particle calibration source are collected by the General Purpose Scanner using its normal sample collection method.

e) Each test is to be repeated five times and the results noted on the Line Voltage Variation Test form.

f) Check and report on After Test values as set out on the Line Voltage Variation Test form.

4.7 Test Records

Test records are to be completed. Final report is to be typed, dated and signed. Test record sheets are to include the actual time and date that the test took place plus signature of the tester(s).

5. OPERATIONAL FIELD TRIALS/TEST AND EVALUATION PLAN

OBJECTIVE: To determine the EDSS™ Walk-thru Personnel Scanner's and the General Purpose Scanner's ability to:

a) detect explosives concealed in packages, briefcases, checked luggage and on persons; and
b) operate reliably in an airport environment.

GENERAL: During these trials, each EDSS™ unit is to be fitted with a remote muffler and software to record data significant to the evaluation. The units are to be set up at appropriate locations relative to other security equipments and passenger movements to determine the optimum location in respect of effectiveness, minimum impact on human resources, and maximum positive impact on passenger attitudes.

5.1 Pre-test Activities

5.1.1 Select Equipment Field Trial Locations

a) Some considerations:
   i) Initially, locate the equipment such that scanning is restricted to low traffic situations and gradually build up to a full impact situation.
   ii) Locate the equipment such that the Walk-thru is in front of the x-ray and a General Purpose Scanner is placed so that it can scan bags as they are placed on the x-ray. Alternatives to this arrangement should also be tested.
   iii) Checked baggage scanning should also be tested by locating a General Purpose Scanner at the check-in counter or in the baggage gathering back-room areas.

5.1.2 Establish in detail a scanning protocol for operators taking into account:

a) a low threat scenario
b) a medium threat scenario
c) a high threat scenario
d) procedure to be followed when equipment detects explosives' residue and bomb situations.

Some considerations:

- Equipment sensitivity set to reflect threat situation.
- Scanning techniques set to reflect threat situations.

5.2 Operational Tests

5.2.1 Detecting Concealed Explosives

Objective: To evaluate the equipment's ability to detect explosives under different threat scenarios.

General: Controlled tests will be scheduled to occur during general scanning of passengers and luggage as well as during standby periods.

5.2.1.1 Details

Tests will involve a range of explosives and three different scanning methods:

a) non-intrusive scanning;
b) a statistically significant sampling procedure involving non-intrusive and intrusive scanning;
c) intrusive scanning.

5.2.1.2 Testing the Walk-thru Personnel Scanner

a) Each of the scanning methods set out in 5.2.1.1 will be tested a statistically significant number of times. The explosive material should be of a realistic size.

b) Equipment will be calibrated taking into consideration the threat scenario under which it will operate.
c) Under the non-intrusive testing scenario the test subject will walk through the portal with the material, packaged and strapped to his body in an appropriate manner 30 minutes prior to entry.
d) Under the statistical sampling technique involving non-intrusive and intrusive scanning, a pre-set number of passengers will be subject to additional scanning with the hand wand.
e) Under the intrusive sampling scenario, each passenger will be subject to scanning with the hand wand attached to the Walk-thru.
f) The alarm or no alarm results will be related to the case and the results recorded.

5.2.1.3 Testing the General Purpose Scanners

a) Each of the scanning methods set out in 3.2.1.1 will be tested. A range of explosive material and cases will be used. A statistically significant number of tests will be completed.
b) The equipment will be calibrated taking into account the threat scenario under which it will operate.
c) Under the low threat scenario, the non-intrusive sampling method will be used. The sample case will be scanned externally.
d) Under the medium threat scenario, the statistical sampling method, a per-set number of cases will be opened and sampled internally. The other cases will be sampled on their external surfaces.
e) Under the high threat scenario, each case will be opened and sampled internally.
f) Alarms or no alarm results will be related to the case and the results recorded.

5.2.2 Testing General Operating Characteristics

During the Operational Field Trials, a test supervisor and assistant(s) will operate the equipment and maintain a log giving account of the factors of interest to the Trials. A draft of detail to be included in the log is set out in the Operational Field Trials - Daily Log.

5.2.3 Post-test Activities

The results of the Operational Field Trail Tests will be compiled into a final report.

APPENDIX B

Operations Manual

Instructions for installing, operating and maintaining the EDSS™ system. This document has been developed by CPAD for the use of security personnel and their supervisors. It is annexed here to provide the reader with a more detailed description of how the EDSS™ is used and maintained.

PROTECTED

EXPLOSIVES DETECTION SECURITY SYSTEM

(EDSS^{TM})

GENERAL PURPOSE SCANNER

OPERATOR'S MANUAL

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3 March 92

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LIST OF FIGURES

1 INTRODUCTION

1.1 Product Description

The Explosives Detection Security System's (EDSS™) General Purpose Scanner is designed to screen for explosives in essentially real time. Its size, easy maneuverability and long sampling hose with operator controls at the end have been carefully planned to facilitate the search for concealed explosives in baggage, parcels, buildings, rooms, vehicles, aircraft etc. The sampling period is variable and analyses are completed in approximately 9 seconds.

The EDSS™ General Purpose Scanner (see Figure B.1) is comprised of:

1. The cabinet containing the EDSS™ and its central control and display centre,
2. Two 15 amp power lines for connection to two, separate circuit, conventional 15 amp outlets,
3. A sampling hose with operator controls and signal displays on a Wand at the sampling end of the hose,
4. A remote vacuum and muffler unit.

1.2 Scope of Manual

This manual provides technical information for the EDSS™ system operator. It is intended primarily as a guide for the EDSS™ operator and, includes regular maintenance information. It should not be used as a service manual.

It begins with instructions on how to set up, operate and shut off the system. This is followed by detailed descriptions of the different operating modes, the different system operating configurations, and then maintenance instructions.

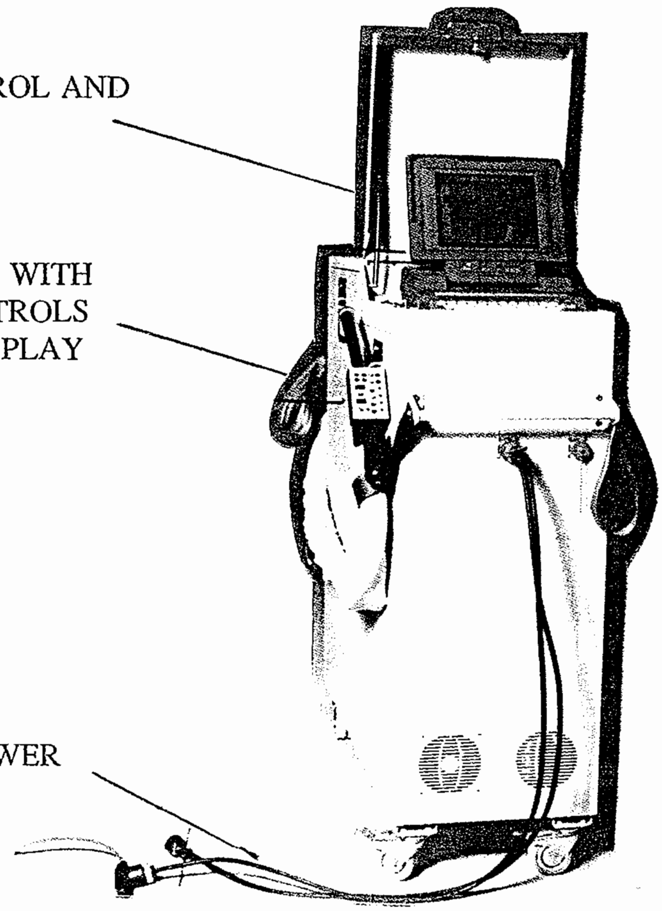


Figure B.1 EDSS™ General Purpose Scanner

2 SETTING UP AND OPERATING THE GENERAL PURPOSE SCANNER

PREPARATION

2.1 Nitrogen Gas Supply

Operation of the EDSS™ General Purpose Scanner is dependent on a continuous supply of ultra pure nitrogen. It may be supplied from an external tank connected to EDSS™ at the quick-connect fitting located on the control end of the unit (see number 8 in Figure B.2A), or from two internal tanks located in the cabinet (see number 1 in Figure B.2B).

The first step in preparing the General Purpose Scanner for operations is to turn on the gas and to ensure that it is adequate. The procedure is as follows:

1. Open left (rear) door of cabinet;

2. If external tank is to be used:
    a) Check to ensure that valves on the two internal tanks as well as the two green Nupro valves are closed;
    b) Connect the external tank to EDSS™ using the flexible hose with the quick-connect end;
    c) Purge any gases from the flexible hose by opening the valve on the tank to fill the hose and plumbing (up to the lower green Nupro valve) with nitrogen;
    d) Close the valve on the tank and open the valve on the flexible hose to allow the gas to escape to the atmosphere. Repeat this purging action at least twice;
    e) Open the valve on the tank and allow nitrogen to flow through the flexible hose and vent to the atmosphere by opening the valve on the flexible hose;
    f) Close this valve as the gas is flowing through it;
    g) The external gas supply is now ready to be fed to the EDSS™ by opening the two green Nupro valves;

1. External Ultra Pure Nitrogen Tank
2. Valve on top of external tank
3. Internal Ultra Pure Nitrogen tanks
4. Valves on top of internal tanks
5. Upper Green Nupro Valve
6. Lower Green Nupro Valve
7. Flexible hose
8. Quick-connect fitting on end of flexible hose
9. Purging valve on flexible hose
10. Gauges

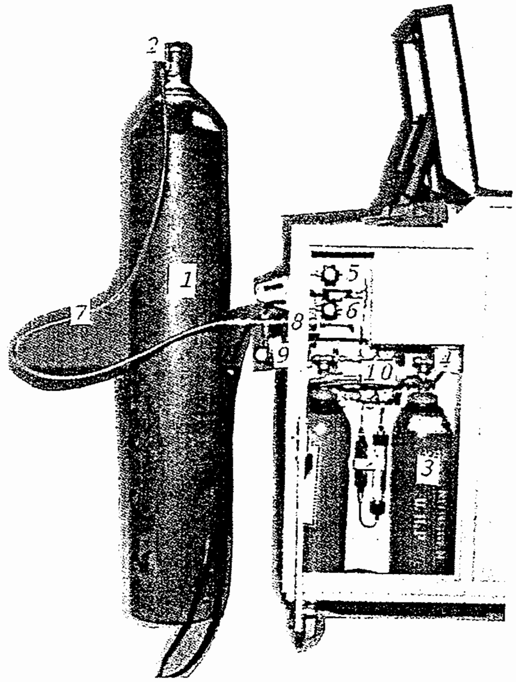


Figure B.2A External Nitrogen Gas Supply

1. Internal Ultra Pure Nitrogen tanks
2. Valves on top of internal tanks
3. Upper Green Nupro Valve
4. Lower Green Nupro Valve
5. Gauges

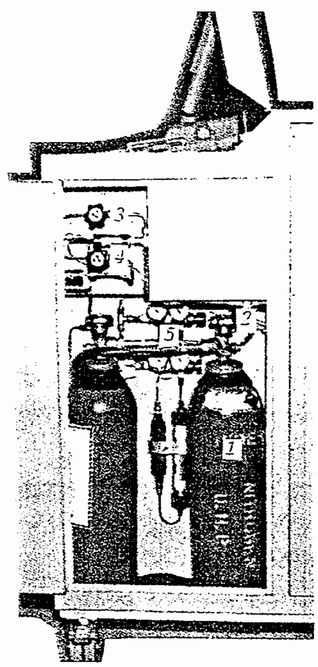


Figure B.2B Internal Nitrogen Gas Supply

h) Observe gauges on the two gas regulators. Each regulator has a high pressure and a low pressure gauge. The high pressure gauge (see number 5 in Figure B.2B) is an indicator of available gas. It should have a value greater than 500 psi to ensure an adequate gas supply. If 500 psi or less the bottle should be changed or refilled. When system is turned on, the gas status light on the control panel should be green. If gas pressure falls blow 500 psi an alarm with long intermittent beeps will be sounded to indicate refilling is required. The low pressure gauges (see number 5 in Figure B.2B) should read a value of approximately 40 psi.

i) Close and lock door.

3. If the internal tanks are to be used:
   a) Check to ensure that the lower green Nupro valve (see number 4 in Figure B.2B) is closed;
   b) **VERY SLOWLY** turn (counterclockwise) each valve located on top of each gas cylinder (see number 2 in Figure B.2B) until fully open;
   c) Open the upper green Nupro valve, (see number 3 in Figure B.2B);
   d) Observe gauges on the two gas regulators. Each regulator has a high pressure and a low pressure gauge. The high pressure gauge (see number 5 in Figure B.2B) is an indicator of available gas. It should have a value greater than 500 psi to ensure an adequate gas supply. If 500 psi or less the bottle should be changed or refilled. When system is turned on, the gas status light on the control panel should be green. If gas pressure falls below 500 psi an alarm with long intermittent beeps will be sounded to indicate refilling is required. The low pressure gauges (see number 5 in Figure B.2B) should read a value of approximately 40 psi.
   e) Close and lock the cabinet door.

4. If the internal tanks are to be refilled:
   a) Using an external tank with the flexible hose with the quick-connect fitting attached, connect to the quick-connect (see Figure B.2A) in the gas supply section of the EDSS™ cabinet;
   b) Check to ensure that valves of the two internal tanks as well as the two green Nupro valves are closed;
   c) Purge any gases from the flexible hose by opening the valve on the external tanks to fill the hose and plumbing (up to the green Nupro valve) with nitrogen;
   d) Close the valve on the external tank and open the valve on the flexible hose to allow the gas to escape to the atmosphere. Repeat this action two or three times;

e) Open the valve on the external tank and allow nitrogen to flow through the flexible hose and vent to the atmosphere by opening the valve on the flexible hose;

f) Close the valve on the flexible hose as the gas is flowing through it;

g) Open valves on the two internal tanks;

h) Open the lower green Nupro valve to allow the gas to flow through into the two internal tanks. A rushing gas sound will be heard;

i) When the rushing gas sound has subsided, the internal tanks have been replenished to the extent the volume in the external tank will permit;

j) Close the two valves on the internal tanks and the lower green Nupro valve;

k) Close the valve on the external tank;

l) Release the pressure in the flexible hose by opening its pressure release valve;

m) Disconnect the external tank at the quick-connect fitting. The internal gas supply has now been replenished.

2.2 Electrical Hook Up

1. The female connector of the power line cable assembly is connected to the cabinet at the central control end as shown in Figure B.3A.

2. For 120 volt main electrical supply, access to two separate 115 volt, 15 amp circuits is required.

3. Two EDSS™ power lines are connected directly to the separate circuit electrical outlets. For 220/240 volt main electric supply, the Power Converter is connected to the main power supply and the two EDSS™ power lines are connected to its outlets.

2.3 Sampling Hose Hook-up

The Sampling Hose is connected to the cabinet by:

1. Connecting the electrical operating control cable (see Figure B.3B), and

2. Connecting the vacuum hose (see Figure B.3C).

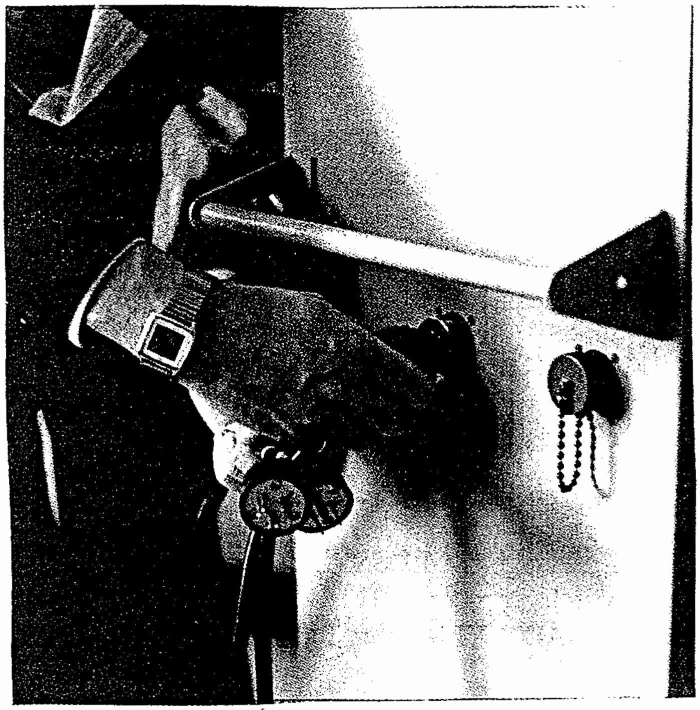


Figure B.3A Electrical Hook-up

Figure B.3B Sampling Hose Control Line Hook-up

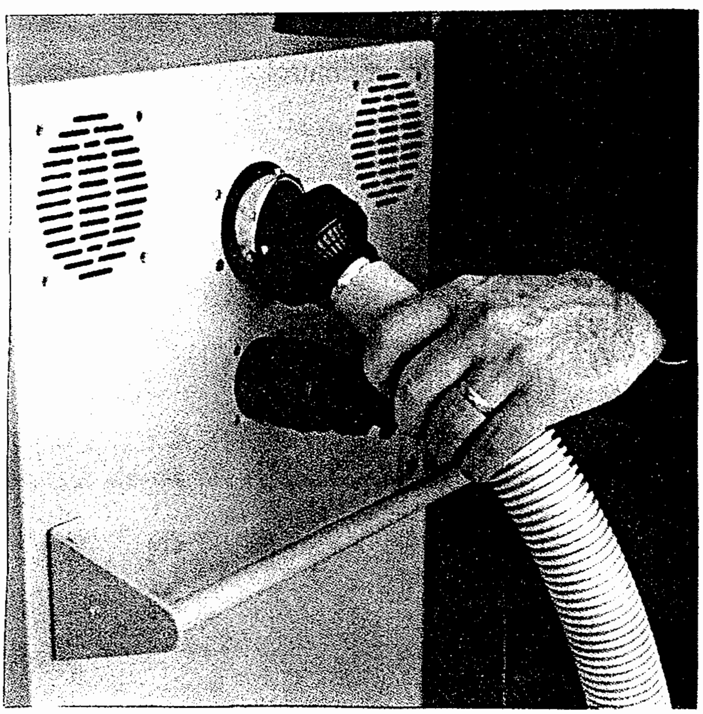


Figure B.3C Sampling Hose Hook-up

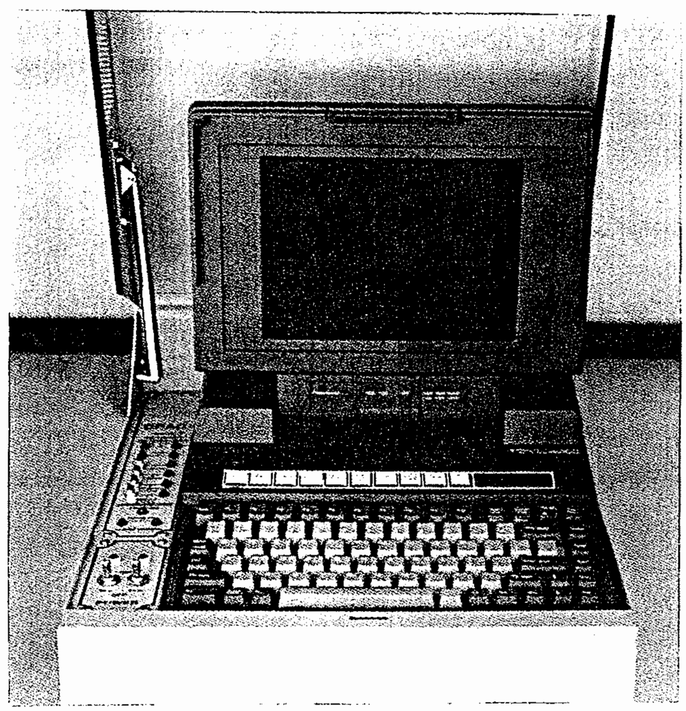


Figure B.3D Computer Display & Controls

2.4 Turning on the General Purpose Scanner

For access to the central controls, unlock and lift the top cover of control centre (see Figure B.1). The computer, display and controls are as displayed in Figure B.3D. To activate the system turn the system's On/Off Power Switch to the On position. The computer will automatically boot up and the monitor will display:

EDSS™
Countdown to Start-up
60
Minutes

Immediately following the display of the above-mentioned message the EDSS™, automatically under computer control, goes through a preparation process. This will last 60 minutes. At completion of the preparation process the READY YES green light and the STANDBY amber light turn on and the monitor displays:

R E A D Y

EDSS™ is now ready and the READY display will be replaced with the Bar Graph display as set out in Figure B.4 when the operator depresses any of the other control buttons.

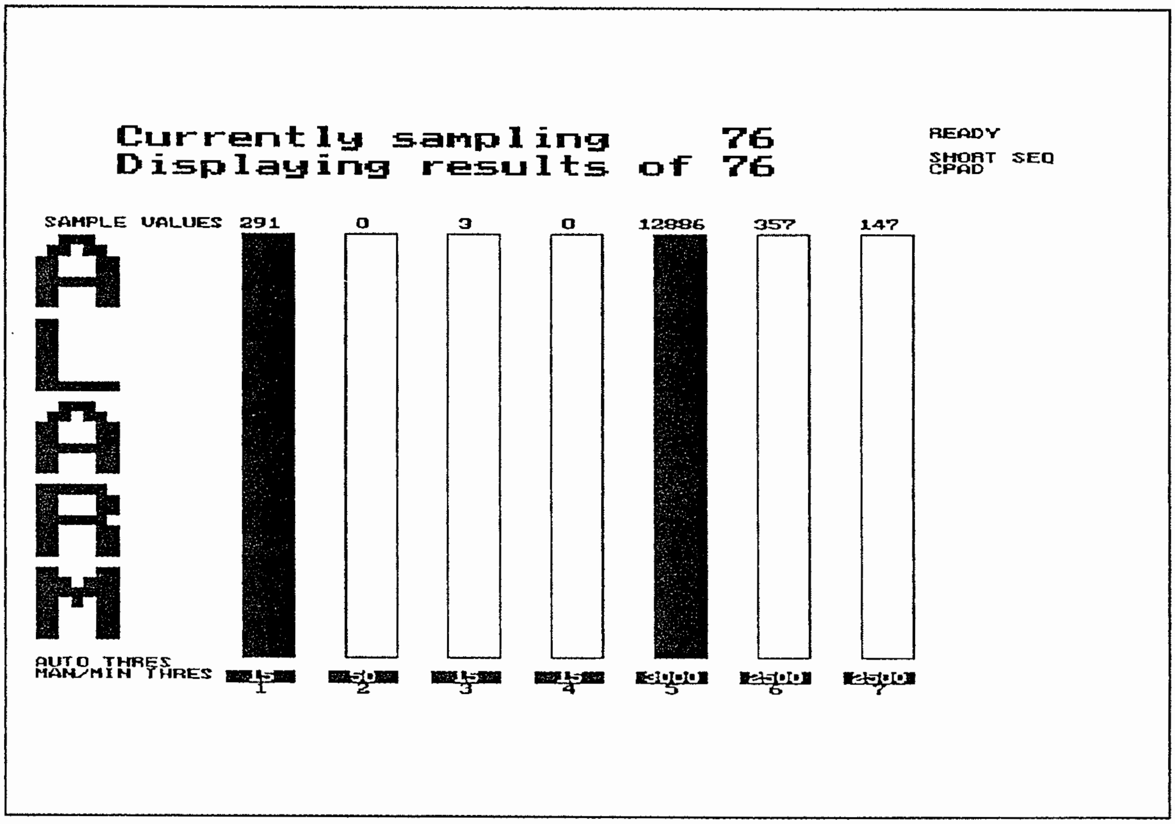


Figure B.4 Bar Graph Display

3 GETTING EDSS™ READY FOR WORK

3.1 Preparation

Before commencing work, a few minutes should be taken to ensure all of EDSS™ subsystems are operational and background thresholds are at an appropriate level. This involves:

1. An observation of the diagnostic display to determine the status of key technical components,

2. Calibration Tests using the calibration standard compounds to ensure the signal indicators accurately reflect the chemical analyses made for each of the compounds, and

3. Appropriate background thresholds have been set for each compound.

A description of each procedure follows.

3.1.1 Determining the Status of Key Technical Components

The technical status of key components is determined by depressing the F8 Trouble-shooting Key. EDSS™ then operates through a SINGLE CYCLE and monitors key operating functions. Results are displayed on the screen. Do this three times and if no "Failure" or "Out of Range" are indicated, then move on to the Calibration Test. If a "Failure" or "Out of Range" signal is present, refer to the Troubleshooting Guide in Section 7.

3.1.2 Calibration Procedure

1. Switch to the Standby position.

2. Press "K" on the computer. It will display:

```
Calibrate Menu
Calibrate Compounds
Adjust Calibration
Add Calibration Peaks
CSP Calibration
```

3. Select CSP Calibration and press ENTER.

4. Using the Standard Sample Generator, take a sample of the compound, for which the EDSS™ is to be calibrated to, through a Single Cycle operation of EDSS™.

5. Press "K" on the computer.

6. Select "Calibrate Compounds" and press ENTER. The display will change to:

```
Select Compound
      1
      2
      3
      A
      4
      5
      6
      7
      B
      C
      D
```

7. Select the number related to the compound sampled and press ENTER. EDSS™ is now calibrated for that sample.

8. Repeat the procedure for each compound.

   Note: A calibration for #6 (TNT) will also calibrate #7 (RDX).

3.1.3 Setting Alarm Level Thresholds

Setting alarm level thresholds for each compound establishes a situation where the quantity of compound detected must rise above the set level before an alarm is sounded. This facility enables EDSS™ to account for the presence of background contamination and continue to detect the compounds giving signals above the set threshold levels.

The setting of Alarm Level Thresholds may be done automatically or manually. Initially, the thresholds are set automatically during the 60 minute preparation process. Manual setting of thresholds overrides the automatic setting and also establishes minimum threshold levels to ensure that, in the automatic threshold setting mode, the setting will not be below these minimum values. Automatic or Manual setting may be used for each compound. That is one compound may be on Automatic Threshold while the other are on Manual settings. If on a Manual setting, only the Manual/Minimum Threshold value for that compound is displayed at the bottom of the Bar Chart. If on Automatic Threshold, the values on the row below each compound on the Bar Chart are highlighted and the minimum threshold values appear in the Manual/Minimum Rows.

1. Setting the Manual/Minimum Thresholds
   a) Depress the F5 key;
   b) The computer will ask "which threshold do you wish to change";
   c) Enter the number of the Bar on the Bar Chart of the compound for which you wish to enter a new threshold;
   d) Using the Backspace, erase the existing value;
   e) Enter the new threshold value and press the "Enter" key;
   f) Repeat steps i) to v) for each new threshold you wish to establish.

2. Setting Automatic Thresholds
   a) Depress F4 key;
   b) The computer will ask "Auto Threshold # to Change";
   c) Enter the number of the Bar on the Bar Chart of the compound to be set on Automatic Threshold;
   d) Press the "Enter" key.

EDSS™ is now ready for work.

3.2 To Sample

1. Determine the sampling time the system is to operate at by pressing the appropriate Soft Key (either Fl for five seconds, F2 for seven seconds, or F3 for ten seconds);

2. Pick up Wand and observe that the STANDBY light is on, press the PAUSE button to move into the operating mode;

3. The operator determines whether to sample continuously or periodically;

4. For periodic sampling the SINGLE CYCLE button is pushed. Observe that:
   a) The PAUSE light goes out and the SINGLE CYCLE light is lit;
   b) If explosives have been detected the red ALARM light will be lit, or if no explosives have been detected, the normal green light will turn on. The process takes approximately nine seconds.

   Note: On the central display, if an explosive has been detected, the bar chart will indicate the type of explosive, and a numerical value to reflect the strength of the signal (see Figure B.5).

5. For continuous sampling, the CONTINUOUS CYCLE button is pushed. Observe that:
   a) The CONTINUOUS CYCLE light is lit;
   b) If an alarm occurs:
      i) The ALARM red light is lit,
      ii) The system ceases operations and moves to a PAUSE status after completing the next sampling operation which has been underway at the time the alarm was indicated,
      iii) The bar chart on the central display will indicate the type of explosive and strength of signal which caused the alarm (see Figure B.5),
      iv) To observe the results of the analyses of the two samples which were taken after the one that caused the alarm press the SINGLE CYCLE button,
      v) You may alternate between the last three samples' results by alternately pressing the SINGLE CYCLE button;

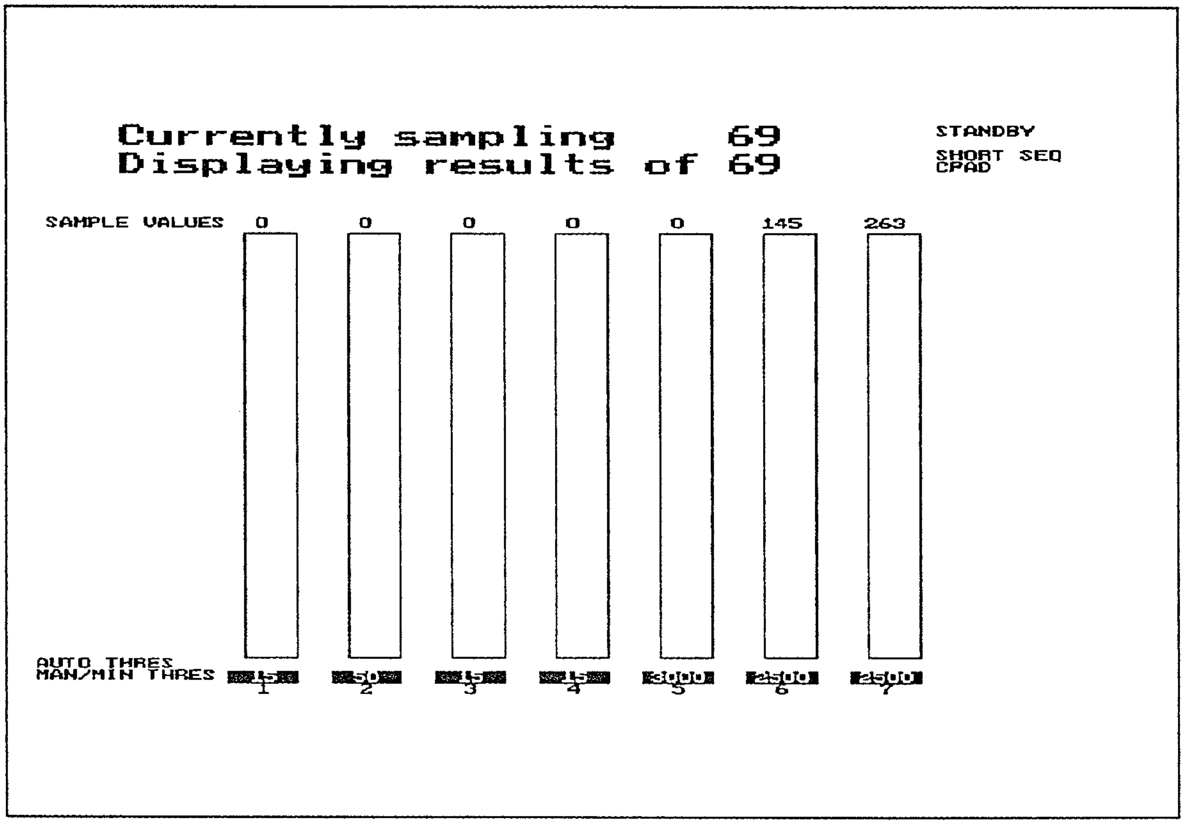


Figure B.5 Central Display

vi) To reactivate the EDSS™ press PAUSE or "Q" on the Central Control Computer.

- If PAUSE is pressed, the system will then automatically enter a cleaning process:
  - The READY signal on the hand wand will display NO; and
  - The central display will indicate:

  System Cleaning
  Please Wait

  The cleaning process is normally completed in approximately one minute. When cleaned, the READY - YES light on the hand wand will be lit and the bar chart on the central monitor will be displayed. The EDSS™ may now be operated in either the SINGLE CYCLE or CONTINUOUS CYCLE mode.

- If "Q" is pressed the cleaning process is circumvented and EDSS™ may be operated in the normal manner.

NOTE: If unit is left unattended in the PAUSE CYCLE mode for longer than 10 minutes, system will automatically go into STANDBY mode.

3.3 Turning Off the Scanner

1. Determine if the General Purpose Scanner is to be turned off for a period of say greater than eight hours or if it is to be maintained in a STANDBY mode to provide for a quick response to possible needs. The difference between a complete shutdown and maintaining the Scanner in the STANDBY mode is that to achieve a READY to sample mode from a complete shutdown takes 60 minutes while the STANDBY mode allows for use immediately.

2. The STANDBY mode is activated simply by depressing the STANDBY button at any time except when the system is displaying NOT READY. It should be noted that the STANDBY mode can be activated at random from any of the other three modes of operation: PAUSE, CONTINUOUS CYCLE OR SINGLE CYCLE.

3. To shut down for an extended period, proceed as follows:
   a) Activate the STANDBY mode;
   b) Turn ON/OFF power Switch to position OFF;
   c) Close valves on top of gas cylinders. The system is now shut down.

4 DESCRIPTION OF OPERATING MODES

4.1 READY

The READY mode informs the operator that the EDSS™ is either ready to be operated or not. During the preparation stage after the unit has been switched on, the READY red light is lit to indicate EDSS™ is not yet ready to be operated. At completion of the preparation period, the READY green light will be displayed and the word READY displayed on the Central Monitor. EDSS™ is then ready for operation.

4.2 STANDBY

The STANDBY mode places the EDSS™ in a standby position which maintains key systems in a readiness state but reduces the flow of the ultra-pure nitrogen gas. At anytime EDSS™ has not been used for ten minutes it automatically enters the STANDBY mode and its yellow light is lit. The STANDBY mode may be entered at any time by depressing its control button.

4.3 PAUSE

The PAUSE mode is a condition where the EDSS™ is in a fully ready state. It may be entered manually by depressing its control button. It is also entered automatically after an alarm has been indicated.

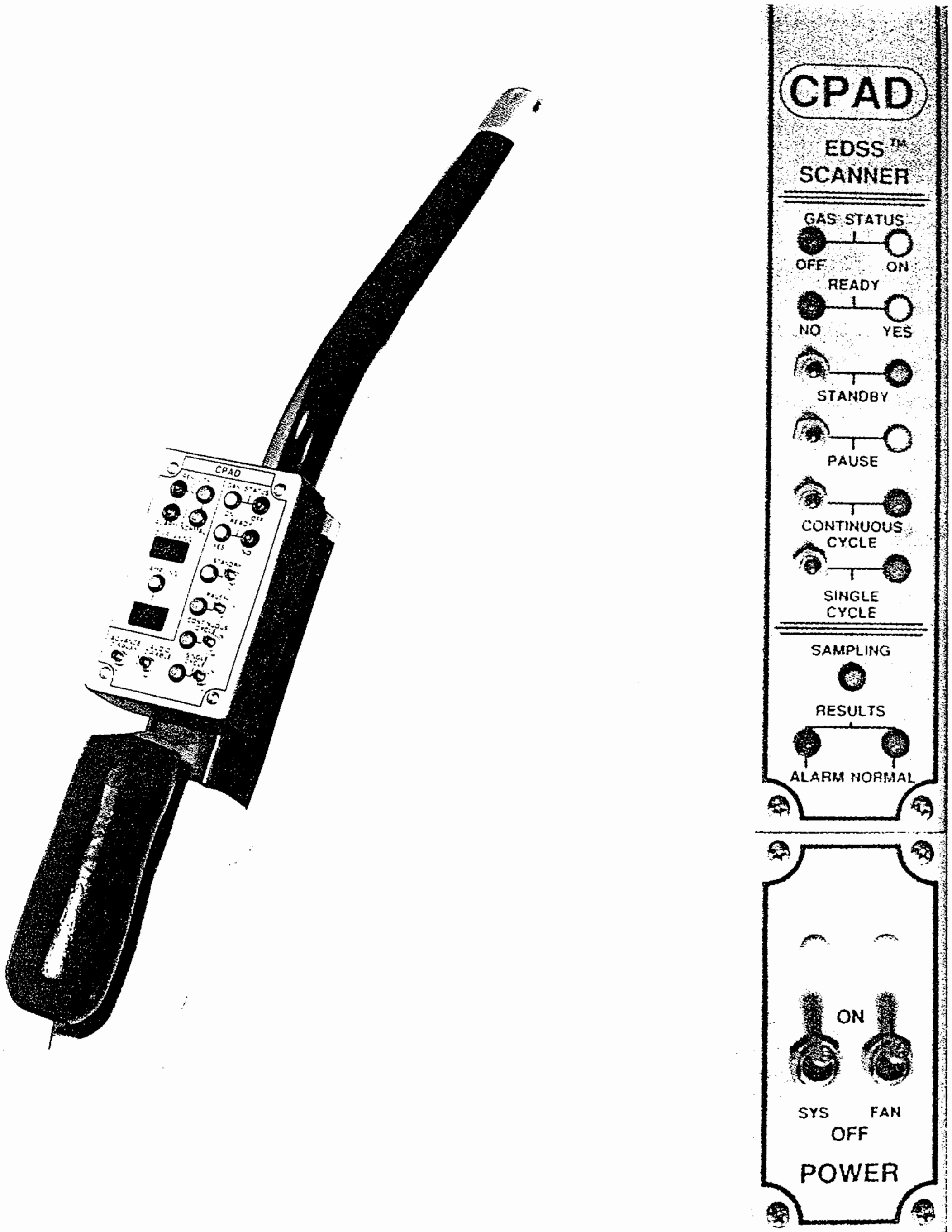


Figure B.6 Hand Wand and Central Operating Controls

4.4 CONTINUOUS CYCLE

CONTINUOUS CYCLE indicates that the EDSS™ is continually moving through the sampling and analyses cycles. In this mode parallel activities are taking place. While the analyses of the previous sample are taking place, the next sample is being taken. A numerical display on the Wand and on the Central Monitor indicates the number of the sample being displayed and the number of the sample being taken. This process is continually repeated until the operator stops it by pushing the PAUSE button or an alarm is sounded.

In the case where an alarm has been sounded, the EDSS™ is automatically placed in the PAUSE mode and will be locked out of both the CONTINUOUS CYCLE and SINGLE CYCLE modes. There are always two following analysis underway and their results may be viewed by pressing the SINGLE CYCLE control button. The operator may look at results of all three analyses alternatively by alternately pressing the SINGLE CYCLE Control button. If the operator has manually moved to the PAUSE mode without an alarm being sounded, the EDSS™ may be placed in either the CONTINUOUS CYCLE mode or the SINGLE CYCLE mode at any time.

4.5 SINGLE CYCLE

In this mode the EDSS™ conducts one cycle of sampling, analyses and display and then stops until the SINGLE CYCLE button is again pushed. The operator may move from SINGLE CYCLE to CONTINUOUS CYCLE, PAUSE or STANDBY if no alarm has been sounded. If an alarm has been sounded, all control buttons with the exception of PAUSE are locked out. Depressing PAUSE automatically places the EDSS™ in a short cleaning cycle. At completion the READY light will be green indicating any mode may be activated. The short clean cycle may be bypassed by pressing "Q" on the central control computer.

5 SYSTEM CONFIGURATION AND STATUS CONTROLS

5.1 General

Alteration of EDSS™ system parameters, activation of a more extensive cleaning process and access to a diagnostic display are discussed below.

5.2 Setting Alarm Level Thresholds

Setting alarm level thresholds for each compound establishes a situation where the quantity of compound detected must rise above the set level before an alarm is sounded. This facility enables EDSS™ to account for the presence of background contamination and continue to detect the compounds giving signals above the set threshold levels.

The setting of Alarm Level Thresholds may be done automatically or manually. Initially, the thresholds are set automatically during the 60 minute preparation process. Manual setting of thresholds overrides the automatic setting and also establishes minimum threshold levels to ensure that, in the automatic threshold setting mode, the setting will not be below these minimum values.

Automatic or Manual setting may be used for each compound. That is, one compound may be on Automatic Threshold while the other are on Manual settings. If on a Manual setting, only the Manual/Minimum Threshold value for that compound is displayed at the bottom of the Bar Chart. If on Automatic Threshold, the values on the row below each compound on the Bar Chart are highlighted and the minimum threshold values appear in the Manual/Minimum Rows.

1. Setting the Manual/Minimum Thresholds
   a) Depress the F5 key;
   b) The computer will ask "which threshold do you wish to change";
   c) Enter the number of the Bar on the Bar Chart of the compound for which you wish to enter a new threshold;
   d) Using the Backspace, erase the existing value;
   e) Enter the new threshold value and press the "Enter" key;
   f) Repeat steps i) to v) for each new threshold you wish to establish.

2. Setting Automatic Thresholds
   a) Depress F4 key;
   b) The computer will ask "Auto Threshold # to Change";
   c) Enter the number of the Bar on the Bar Chart of the compound to be set on Automatic Threshold;
   d) Press the "Enter" key.

5.3 Choosing Alternative Sampling Periods

The operator may choose one of three sampling periods: a short sampling time (5 seconds), a medium sampling time (7 seconds), or a long sampling time (10 seconds) by depressing either F1, F2 or F3 respectively when the system is in the STANDBY mode.

5.4 Short Term Cleaning Cycle

A Short Term Cleaning Cycle is designed to clean residue signals which may linger after an alarm has been indicated. It is activated by depressing the PAUSE button after an alarm occurs or by depressing the F6 key and verifying your decision by pressing the Y key when the EDSS™ is in the Standby mode. In this process EDSS™ flush cleans the system to bring all signals below the threshold levels. If the system does not bring alarm signals below the thresholds by this cleansing process, it will return to the operating mode but inform you that the system is not clean and that the thresholds require adjustment.

5.5 Extended Cleaning Process

Periodically it is desirable to clean EDSS™ analytical systems through a more extensive process than the cleaning that occurs after an alarm has been sounded. EDSS™ may be placed in the Extended Cleaning Process from the STANDBY mode by depressing the F7 key and verifying your decision by pressing the Y key. In this mode the not READY indicator is displayed and the system requests a time period. This is done by using the number keys. Next, the "ENTER" key is depressed to activate the cleaning process. If the "ENTER" key is pressed without an amount being entered it will automatically enter a two hour cleaning period.

5.6 Diagnostic Display

The Diagnostic Display as depicted in Figure B.7 is brought up on the computer monitor by depressing the F8 key. This display should be used in conjunction with the Troubleshooting Guide in Section 7.

5.7 Bypass the Long Term Preparation Cycle

One may want to bypass the Long Term Preparation Cycle (60 minutes) which the EDSS™ automatically enters after being turned on. Such cases would normally occur when the EDSS™ was inadvertently or deliberately shut off for a period of less than ten minutes. This may happen when shutting the EDSS™ off for short term servicing or moving the system to a new location. In these cases, after the system has been turned off and then on, it will automatically enter the normal preparation period of 60 minutes and display the 60 minute countdown indication. At this time, it may be disabled by depressing the Q key. EDSS™ will then enter a Short Term Preparation Cycle and when ready for operation will display a READY indicator on both the monitor and control panels. The time this process takes is dependent on how long the EDSS™ was shut off but, normally, it would range between three minutes and ten minutes.

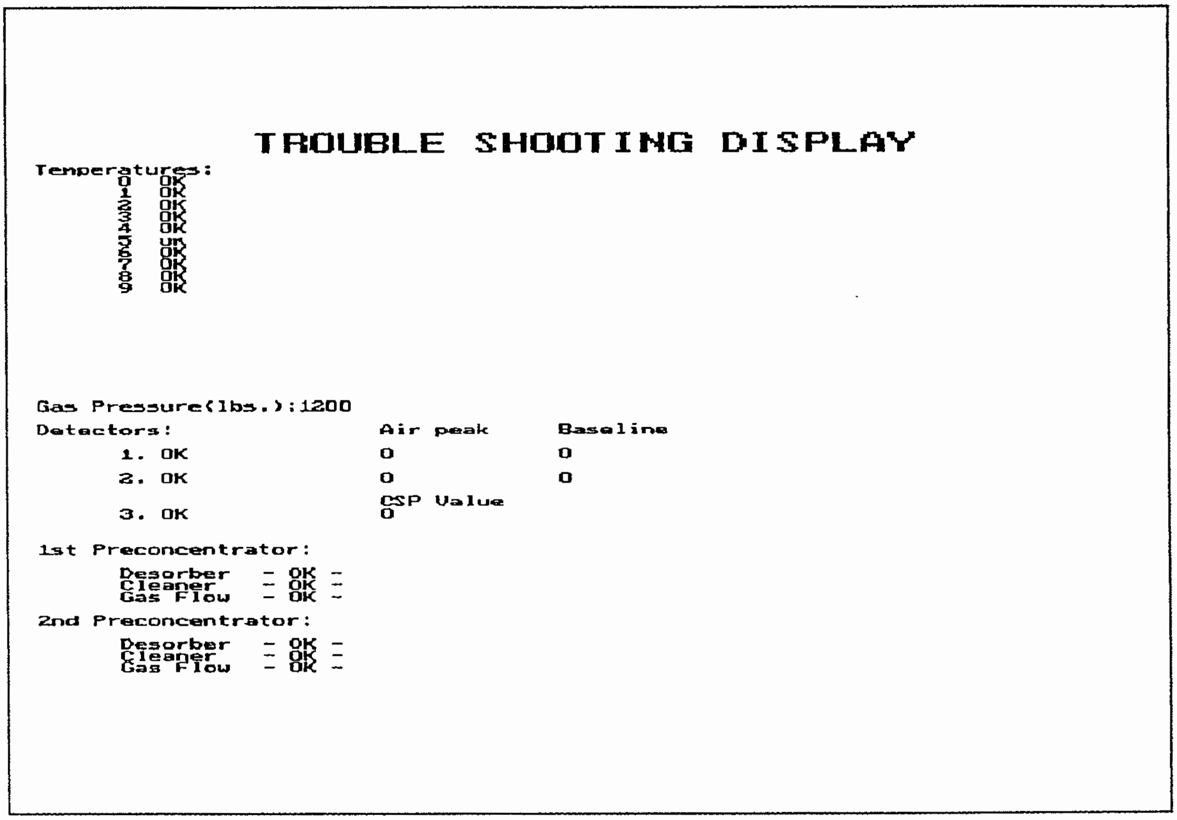


Figure B.7 Diagnostic Display

6 REGULAR MAINTENANCE

Regular maintenance of the EDSS™ is aimed at ensuring an adequate supply of ultra-high pure (UHP) nitrogen gas and the good condition of the sample collection and analytical subsystems. As a guide towards this end, the following regular maintenance schedule should be followed. How each of the regular maintenance activities is carried out is described in separate sections on the following pages.

EDSS™ Regular Maintenance Schedule
(Assumes 18 hours of daily use)

	FIRST-LEVEL TASKS		SECOND-LEVEL
ITEM	DAILY TASKS	WEEKLY TASKS	MONTHLY TASKS
NITROGEN GAS	Check and resupply when necessary Check gas flow daily and each time sample collectors are replaced.		
SAMPLING HOSE	Check and clean		Replace
WAND NOZZLE	Clean periodically during sampling		
WAND LINT SCREEN	Clean periodically during sampling		
VCAD FILTER #1		Replace	
PCAD FILTER #2		Replace	
PCAD SAMPLE COLLECTORS	Replace		
VCAD SAMPLE COLLECTORS			Replace
EXTENDED CLEANING	4 to 6 hours		
BACKGROUND CONDITIONER			Replace

6.1 Nitrogen Gas - Checking and Resupplying

The procedures for checking the adequacy of the gas supply system are described in Section 2.1. Please refer to that Section of this manual.

6.2 Nitrogen Gas Flows

Gas flows are checked by attaching gas flow meters to each of the gas flow outlets depicted in Figure B.9. The reading should be as follows:

```
| 0 ◄ |-- 100 cc/min
| 0 ◄ |-- 100 cc/min
| 0 ◄ |-- 200 cc/min
| 0 ◄ |-- 600 cc/min
```

6.3 Sampling Hose

The sampling hose is cleaned periodically to ensure that it is free of dust, dirt and any explosive material. This is accomplished by:

1. Connecting the hose to a regular vacuum cleaner and shaking this hose as it is being vacuumed to dislodge particles clinging to its internal surface;

2. Connecting the hose directly to EDSS™ remote muffler system and vacuuming the hose as described in a) above;

3. Place EDSS™ in a CONTINUOUS CYCLE mode and then alternatively shaking the hose and surging the vacuum action by blocking the end momentarily and continuously for perhaps ten to fifteen suctions;

4. If it is found desirable to replace the hose, this is accomplished very easily by detaching it from EDSS™ and the Hand-held Wand, and then connecting a new hose.

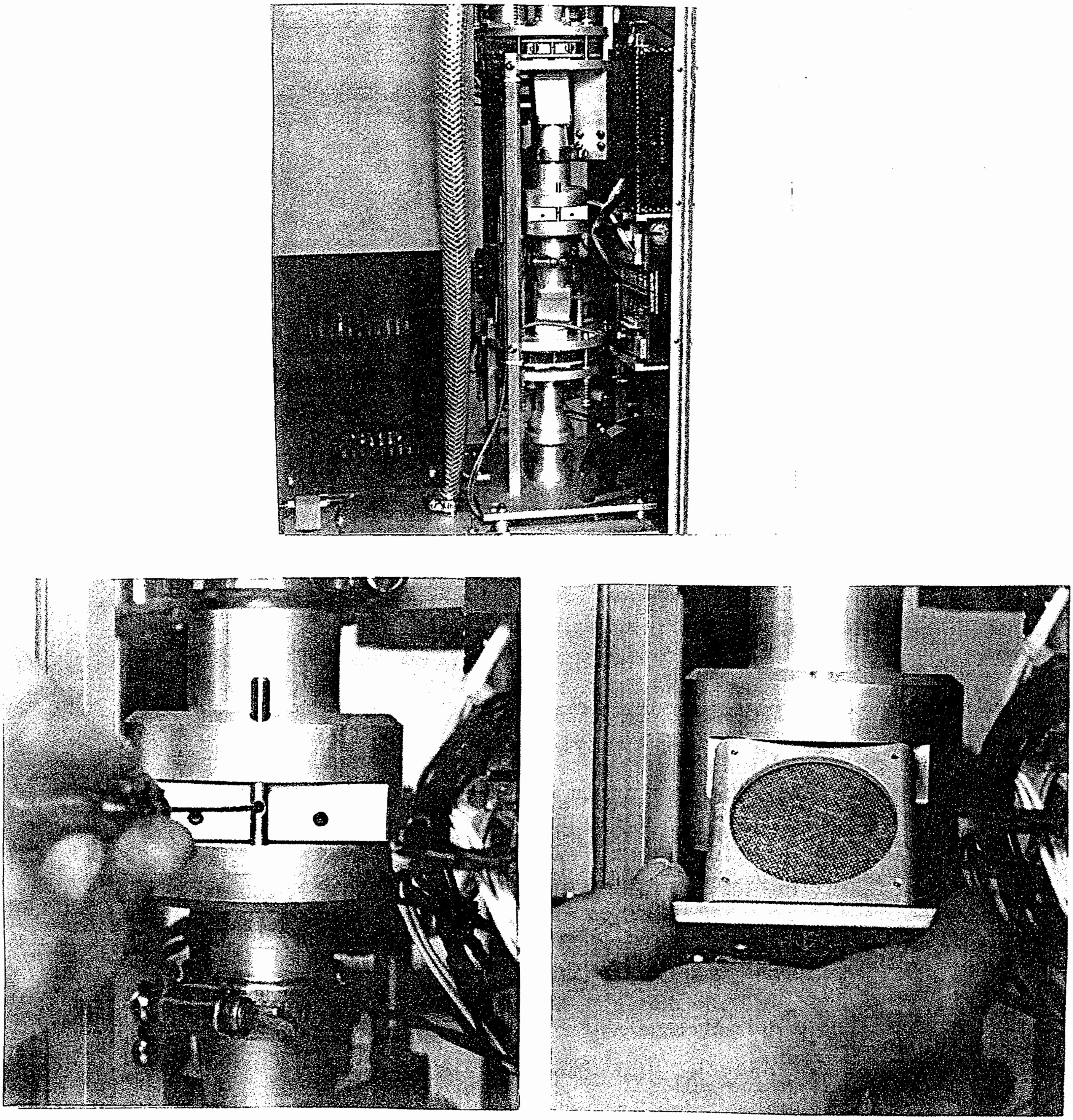
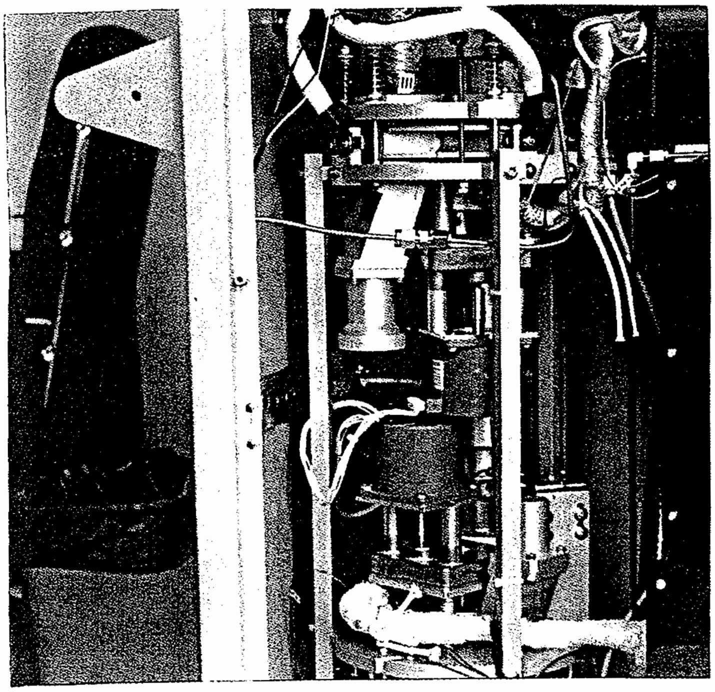
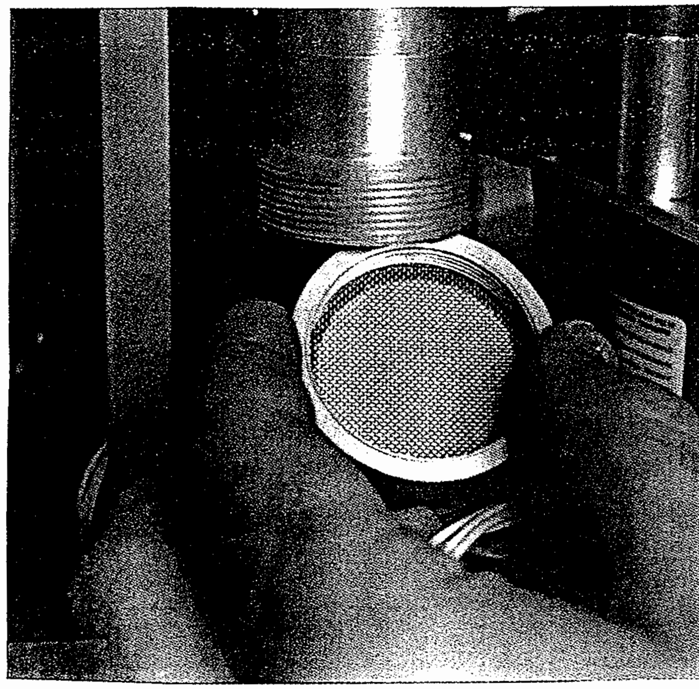


Figure B.8 Filter #1





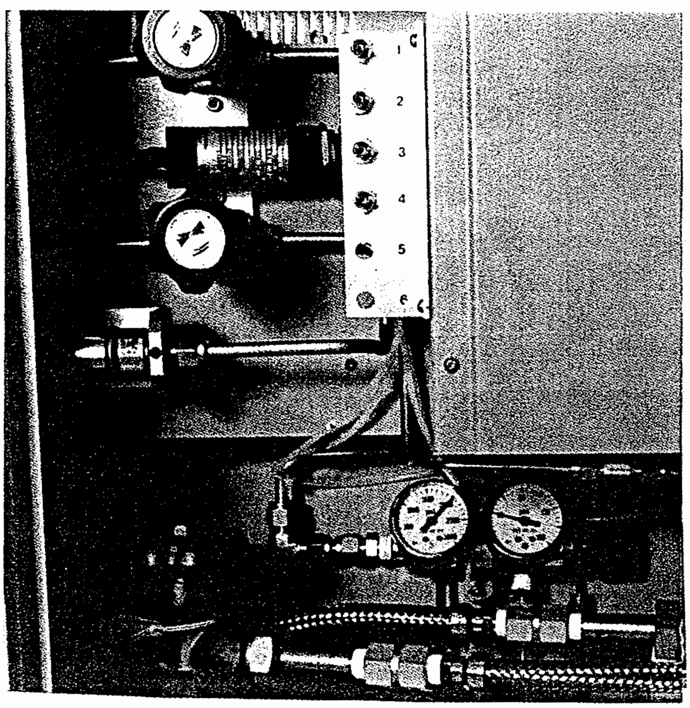


Figure B.9 Filter #2 & Nitrogen Gas Flow Outlets

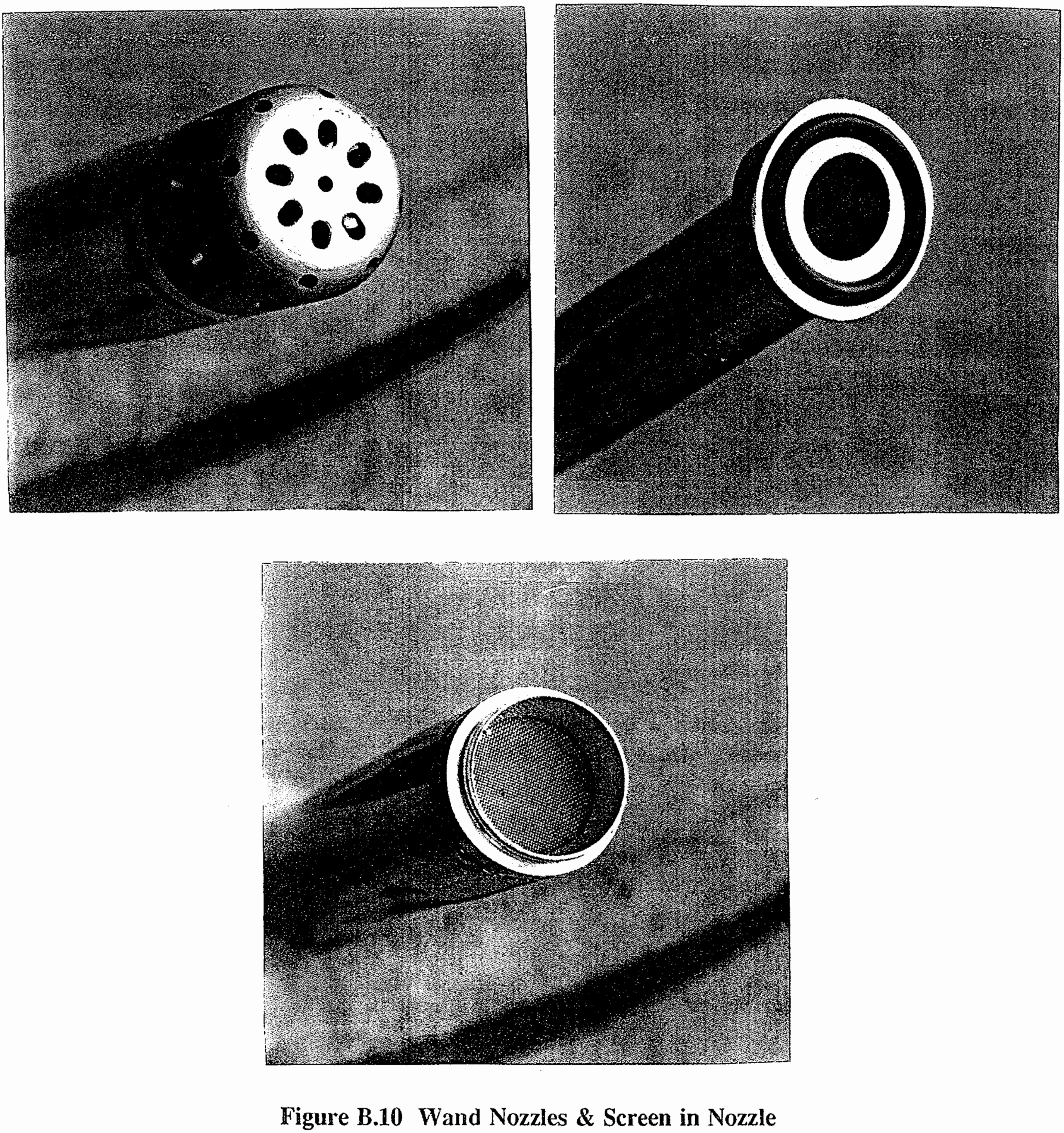


Figure B.10 Wand Nozzles & Screen in Nozzle

6.4 Wand Nozzles

The Wand nozzles (see Figure B.10) should be cleaned daily to remove any dirt or explosive sample that may be lodged in them. Wiping with a lint free swab and periodically wiping with hexane and acetone is desirable.

6.5 Screen in Wand

The screen in the Wand is designed to block the larger pieces of dirt etc. from entering the system. It should be cleaned periodically during sampling by simply removing any lint etc. which may have accumulated on the screen.

6.6 Filter #1

This filter is located between the upper and lower preconcentrators. Replace the filter by removing the existing filter from the filter holder by releasing the set screw and lifting the locking bar so that the filter tab can be pulled out of its holder. Figure B.8 shows the filter holder, locking bar and filter.

Insert the new filter making sure it has an O-ring. Put the locking bar in place and secure and seal the filter by tightening the set screw.

6.7 Filter #2

Filter #2 is located on the upper preconcentrator as shown in Figure B.9. The filter is changed by unscrewing the filter holder and replacing the filter between the two screens with a new filter then reattaching it to the upper preconcentrator.

6.8 Sample Collectors

There are two types of sample collectors, one model for the Upper Preconcentrator (see number 2 in Figure B.11) and another model for the Lower Preconcentrator (see number 3 in Figure B.11). These sample collectors are changed by unscrewing the set screw and removing the securing pin as shown in number 1 in Figure B.11. The sample collector is then removed and its replacement inserted into the cavity. It is then sealed in place by reinserting the securing pin and tightening the set screw.

Note: There are three sample collectors in each preconcentrator. Access to each is accomplished by rotating the holding frame of the sample collectors by depressing "R" on the Central Control computer. Each time the "R" key is pressed **it will rotate the sample collector holder to a new location so that the next sample collector can be removed.**

6.9 Background Conditioner

The Background Conditioner is located in the Nitrogen Gas section of the Cabinet. It is replaced by removing the existing unit from the piping and attaching the new unit. Figure B.12 shows the location and how it is attached to the system.

6.10 Extended Cleaning

EDSS™ may be placed in the Extended Cleaning Process from the STANDBY mode by depressing the F7 key and verifying your decision by pressing the Y key. In this mode the not READY indicator is displayed and the system requests a time period. This is done by using the number keys. Next, the "ENTER" key is depressed to activate the cleaning process. If the "ENTER" key is pressed without an amount being entered it will automatically enter a two hour cleaning period. Should it be desirable to change the cleaning period to say 12 hours or 720 minutes then Backspace to remove the existing time. Next, enter the new value of 720 minutes and then the "ENTER" key. The EDSS™ will now display:

Cleaning Count Down

720 Minutes

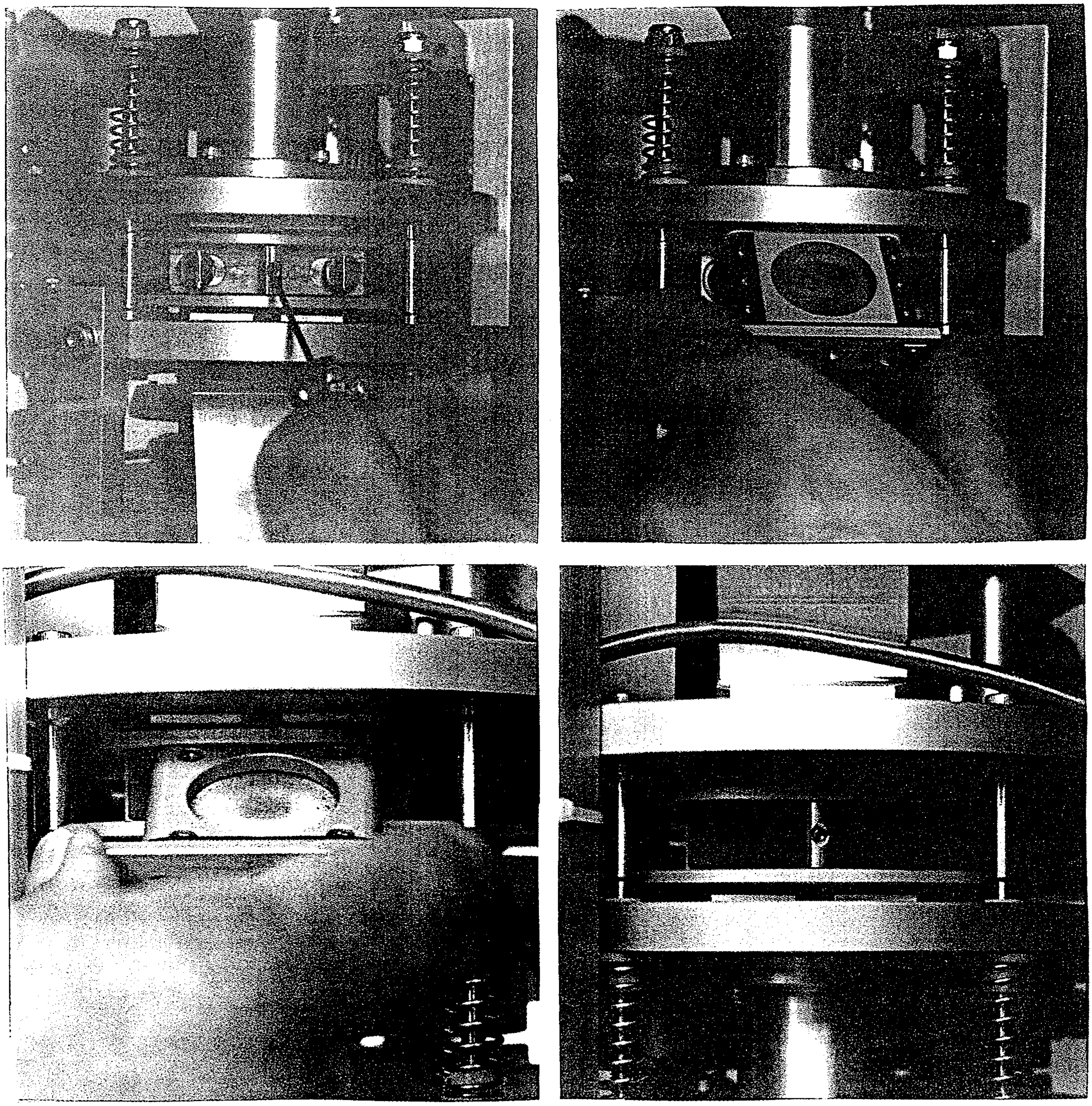


Figure B.11 Sample Collectors

Figure B.12 Background Conditioner

7 TROUBLESHOOTING GUIDE

A troubleshooting guide is given on the following pages.

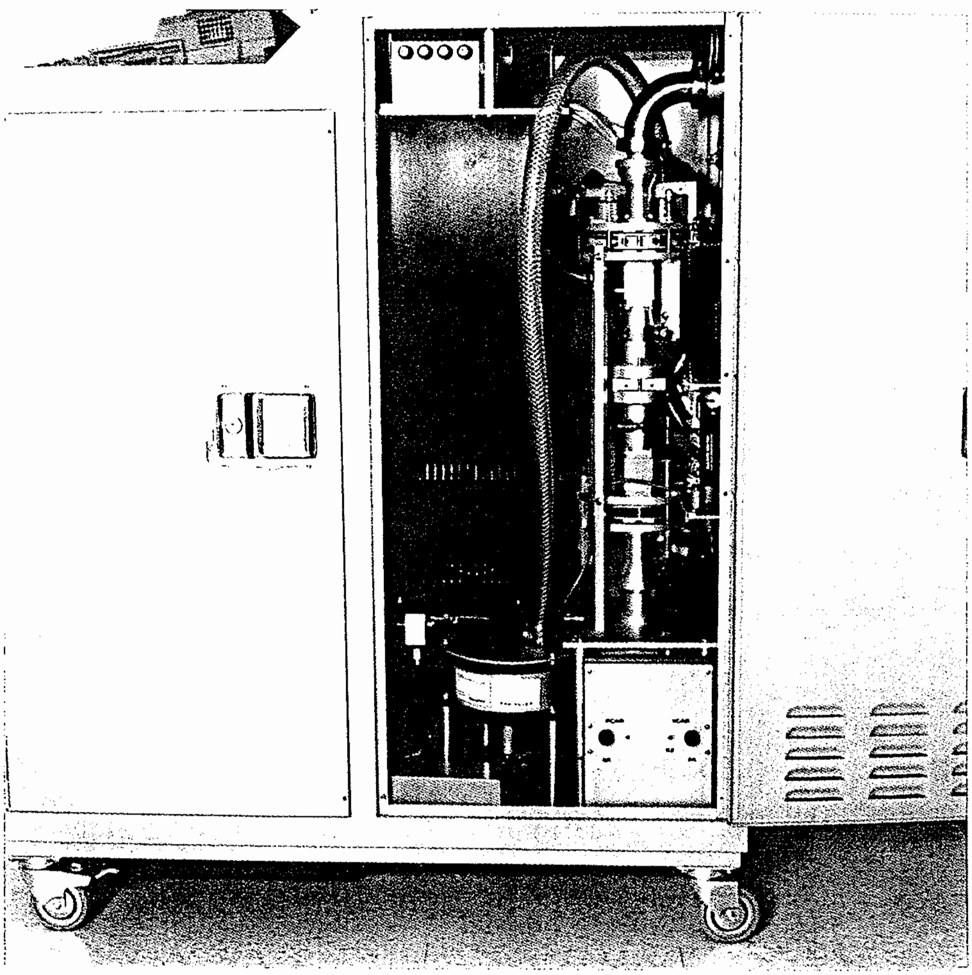


Figure B.13 Location of Fuses

TROUBLESHOOTING GUIDE

	Problem Indicator	Possible Cause	Solution
1.	Electrical power shuts off.	a) Main Breaker Switches have turned off.	a) Main "ON" "OFF" switches on Central Control Panel are breaker switches and will turn off if input current exceeds their rating. Simply turn back on. If switch continues to pop, a more extensive examination by a service representative is required.
		b) Blown fuse. Both inlet power lines are connected to the same 115 V - 15 amp circuit.	b) Connect inlet power lines to separate 115 V - 15 amp circuits.
2.	"READY NO" light is displayed and unit enters the "STANDBY" mode.	Some part of the system has failed.	Check Troubleshooting Display and respond to indicator.
3.	System does not respond to calibration standard samples or "failure" or "Out of Range" signal is given in response to a "Troubleshooting" cycle.	a) UHP nitrogen carrier gas not turned on.	a) Turn on carrier gas.
		b) Desorption heaters in 1st or 2nd preconcentrators may not be functioning because of: i) blown fuse: F_1 VCAD CLEAN 2.A 5.B F_2 VCAD DZRB 2.A 5.B F_3 PCAD CLEAN 5.A 5.B F_4 PCAD DZRB 5.A 5.B	b) i) Replace blown fuses. Fuses are located as indicated in Figure B.13.

Problem Indicator	Possible Cause	Solution
	ii) broken heater elements.	ii) Replace heating element if required. iii) VCAD heater connections should read approximately 10 ohms.
	c) System has not completed Preparation Cycle and has not achieved operational status.	c) If temperatures are not in the operational range, wait until they have achieved this status. If this status in not achieved in a reasonable time, contact CPAD for servicing.
		d) i) If system does not respond, or shows a marked loss of sensitivity to a TNT Standard Sample, replace the PCAD Sample Collectors with new or renewed ones. ii) If system does not respond to EGDN or other compounds related to the first four bars on the Bar Chart, even after the checks noted above have been made, replace the VCAD sample collectors.

	Problem Indicator	Possible Cause	Solution
4.	System reflects Overload or high signals in bars 1 through 4, a Caution signal is displayed on Monitor, the green ALARM signal light is flashing and an audible beeping tone is sounding.	Contaminant has entered the system.	Place EDSS™ in short Term Cleaning cycle.
5.	System continues to alarm after an initial alarm has been sounded and the EDSS™ has passed through a Short Term Cleaning Cycle.	Memory of the alarm remains in the EDSS™ and is creating a signal higher than the relative threshold.	Increase the Threshold for the compound to a value higher than the signal. Operations may then continue.
6.	Gas RED light flashing and audio alarm sounding.	UHP nitrogen gas supply: a) not turned on; b) has fallen below minimum level.	Turn on the gas supply; Replace or refill gas supply.

PROTECTED

APPENDIX C

Sample Graphic Displays

Examples of the bar graph and analog graph readings for various levels of explosive compounds detected by the EDSS™, as well as example troubleshooting displays. These examples have been chosen for their instructional nature, and are not intended to represent average or typical readings.

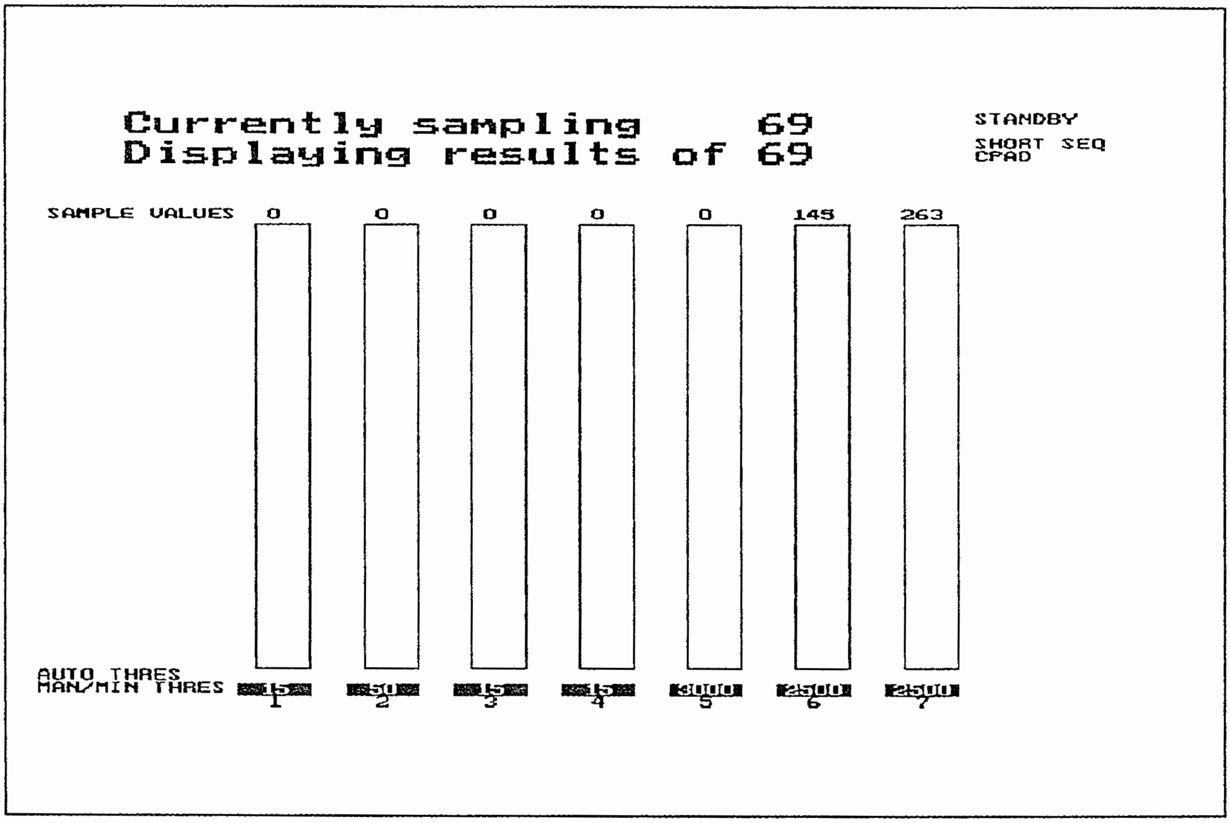


Figure C.1 Bar Graph of a No-Alarm Analysis

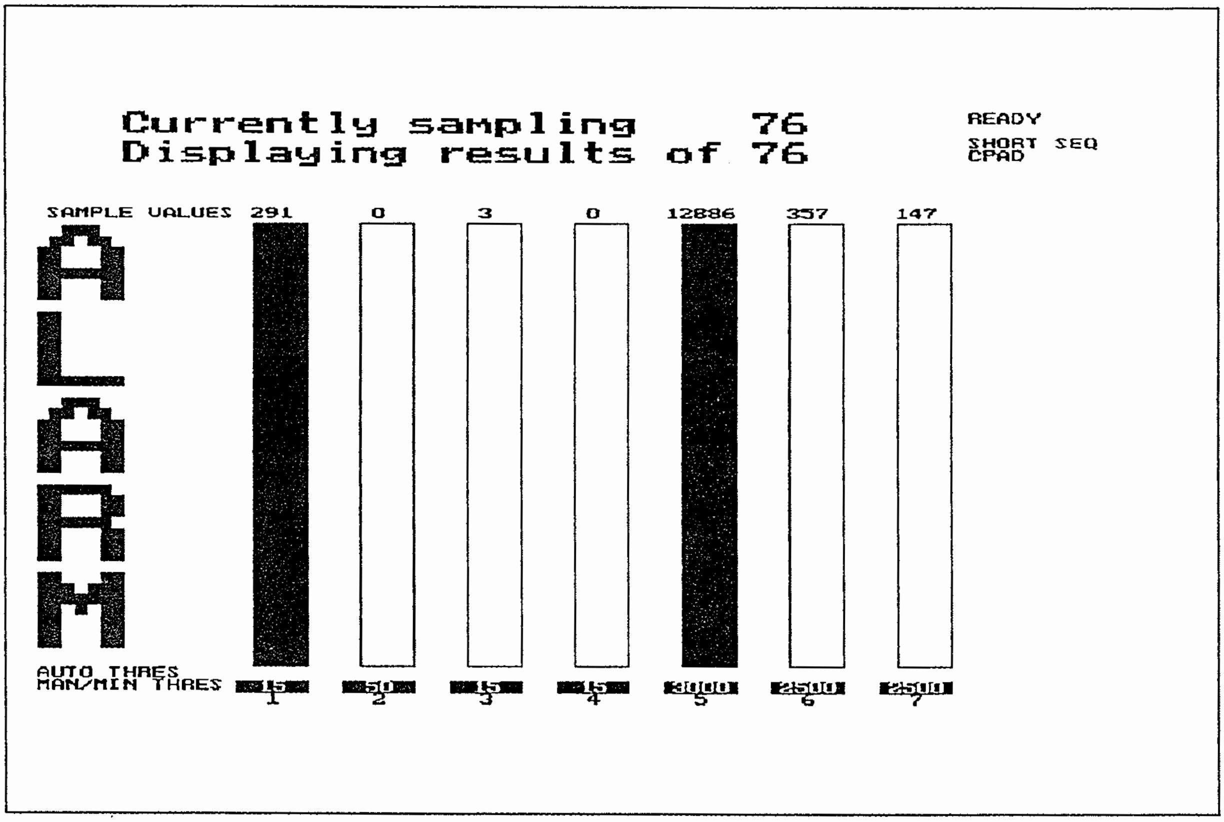


Figure C.2 Bar Graph of an Alarm Analysis (Compounds 1 and 5)

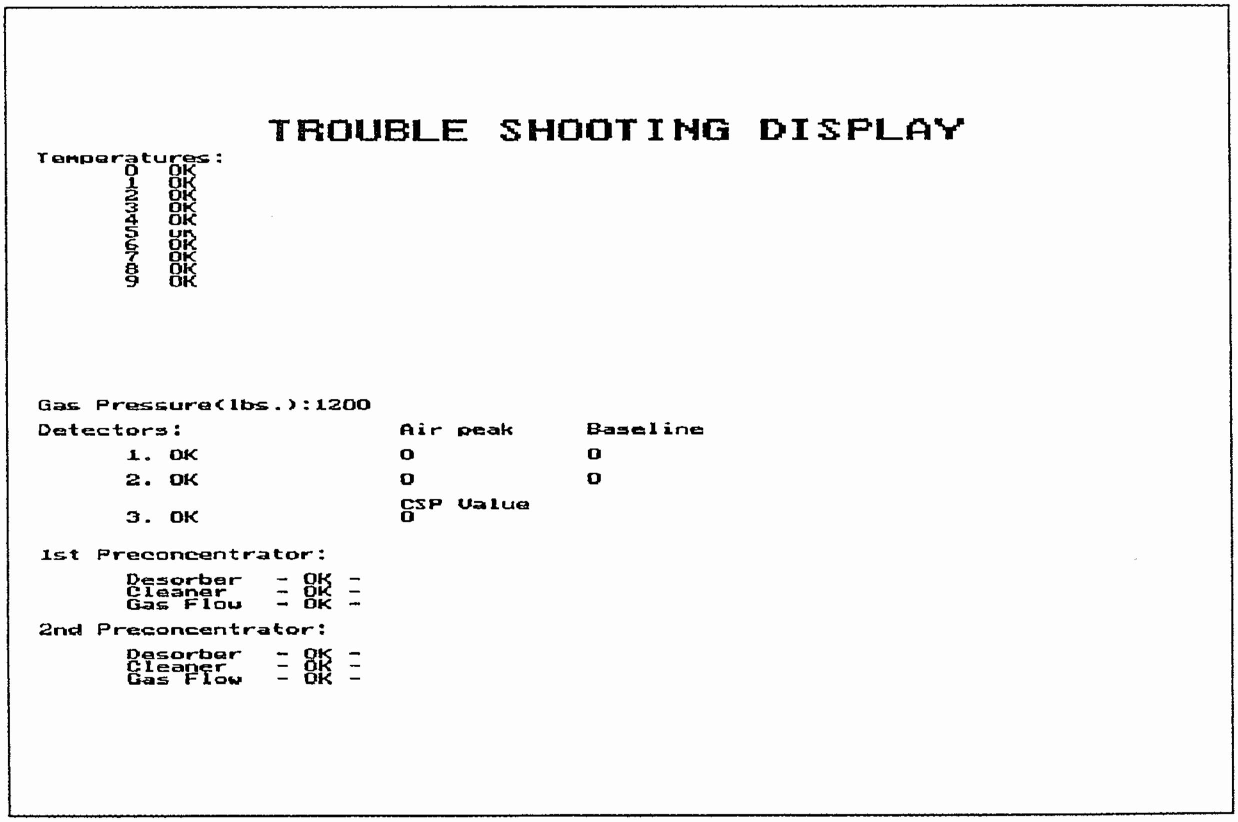


Figure C.3 Troubleshooting Display with Normal Parameter Levels

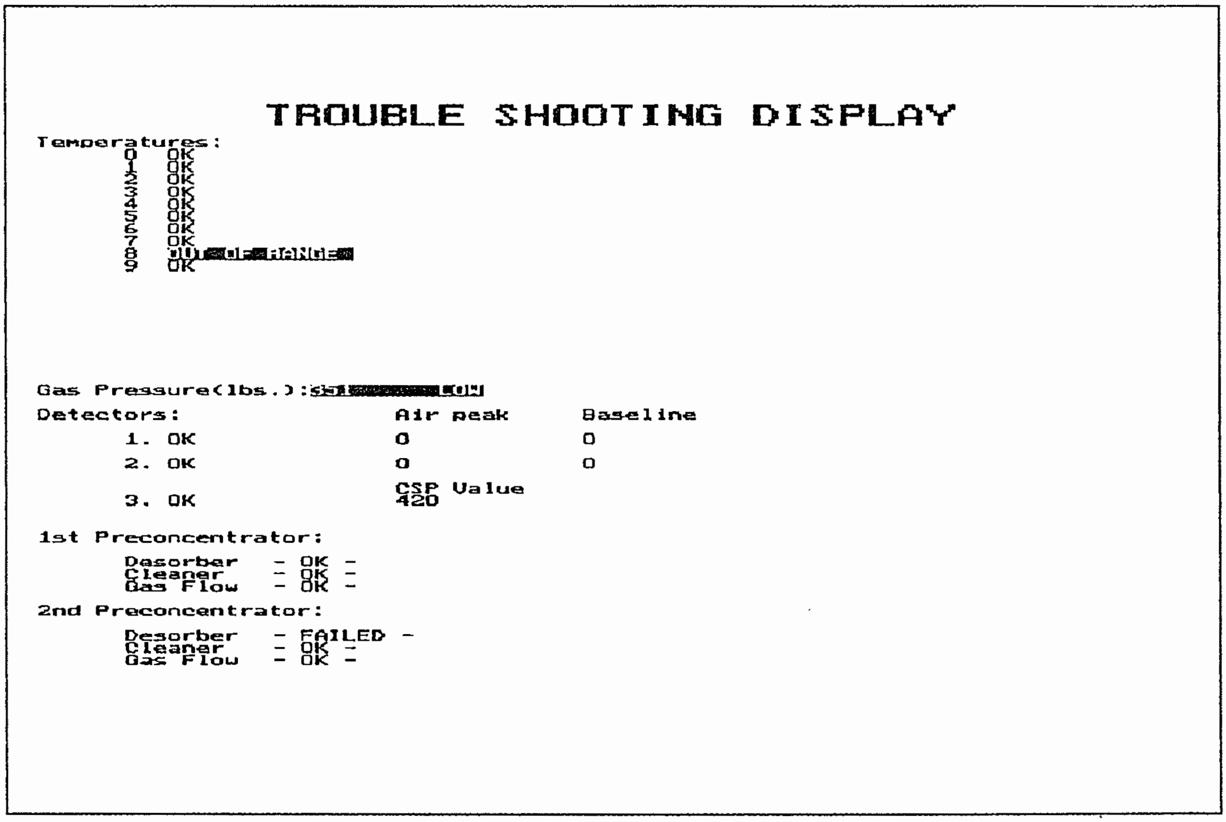


Figure C.4 Troubleshooting Display with Out-of-Range Parameter Levels