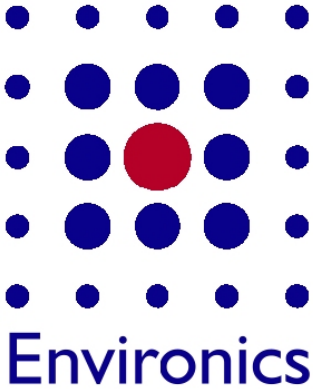


EnviScreen

System
Technical Description
V1.3

ENVISCREEN TECHNICAL DESCRIPTION

TABLE OF CONTENTS

1 GENERAL

Gas leaks, fires, chemical accidents, chemical warfare and risk of terrorist activity cause potential threat to the safety of public sites, such as shopping centers, airports, subways, as well as for military sites or vessels and industrial or governmental facilities. With the EnviScreen system, it is easy to control the entire area and site from a single location.

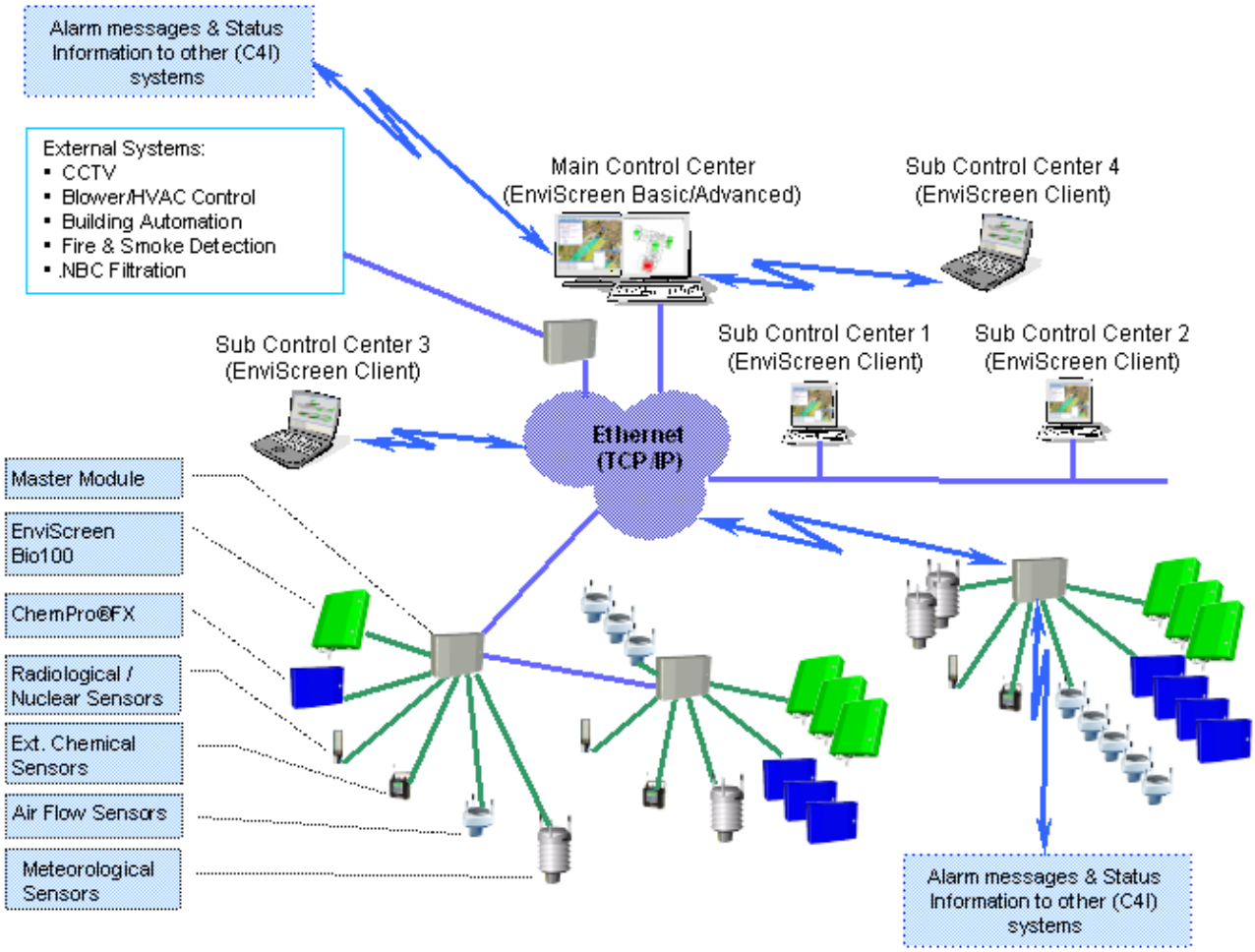
EnviScreen is an integrated safety and environment monitoring system that has its own applications also on military area. Its core consists of a dynamic database that gathers data on the control area on a continuous basis. Information can be provided to the system by devices such as toxic industrial compound (TIC) detectors, chemical warfare agent (CWA) detectors, biological detectors, radiological/nuclear detectors, fire detectors and weather sensors. Thus EnviScreen enables full CBRN (NBC) monitoring system. The data accumulated by the sensors can be uploaded via a cable or by using a wireless connection.

All the data collected in the system can be viewed online in a clear graphic format. The system is capable of processing thousands of events/sensors simultaneously. At the same time, it provides explicit online information about what has happened, where, and what action should be taken. What is more, the EnviScreen user interface provides versatile actuator control for emergency management.

Should anything happen that requires a response, EnviScreen will promptly notify the predefined group of individuals. This makes it possible to tackle the situation head-on and to minimize the potential consequences of the risk.

2 SYSTEM STRUCTURE AND COMPONENTS

EnviScreen Safety System consists of detectors and sensors connected to computer based control center. System can include different type of sensors and detectors as well as connections to other systems such as building automation, Emergency Management Systems etc. Data communication from sensors to the Control Center(s) can be wireless and/or hardwired. Picture 1 shows the basic schematic of the system.



Picture 1. General system schematic

Generally, all the system sensors are connected to the Control Center (computer with EnviScreen Basic/Advanced software). First, the sensor data is processed by the EnviScreen Master Module. Then Master Module sends the data to the Control Center by using communication network. The Control Center receives and logs the data and shows it in real time on a graphic interface. The status of each sensor and detector can be seen in real time. In case of an alarm, external systems, such as ventilation and smoke removal system can be activated/shut down by the operator in Control Center. This action can also be done automatically by the system.

2.1 Control Center

The computer based Control Center is the master user of the system. Control Center is based on computer hardware that includes EnviScreen Basic or Advanced system software. Control Center has full accessibility to all the sensors connected to network communication system. The Control Center can monitor the online status of all detectors and sensors. The Control Center consists of the following components.

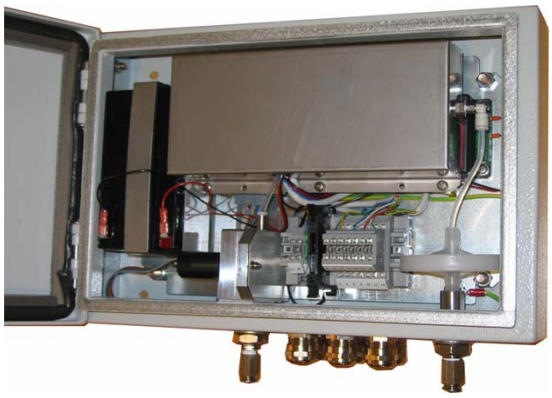
2.2 Detectors and Sensors

2.2.1 Chemical warfare agent (CWA) Detectors

CWA detectors are used to monitor and detect the chemical warfare agents. Detectors can indicate the chemicals based on their type. Typically the CWAs are divided into three groups:

- Nerve Agents
- Blister Agents
- Blood Agents

Detected agent type as well as the concentration level (low, medium, high) is indicated by CWA detectors. This information including the possible malfunctions and failure status is shown in the main control center of EnviScreen system. Picture 2 shows ChemProFX Chemical Detector and Picture 3 shows EnviScreen CWA detection station. The CWA detectors of EnviScreen systems are either M90-AKU (with M90-D1-C) or ChemPro100 type. Detectors are manufactured by Environics Oy.



Picture 2. ChemProFX

Picture 3. EnviScreen CWA Detection Station – M90 based technology

2.2.2 Toxic Industrial Compound (TIC) Detectors

TIC detectors are used to monitor and detect other toxic gases and chemicals than chemical warfare agents. Depending on the type of the sensor, these detectors indicate:

- Name of the detected chemical
- Exact concentration of the detected chemical/level of the concentration
- ON/OFF type alarm information
- Diagnostics information, such as malfunction or failures

EnviScreen is compatible with many different TIC sensor types independently from their manufacturer.

2.2.3 Biological Detectors

EnviScreen Bio100 Detector is a continuously-operating sensor that detects potentially harmful airborne biological threats. It detects the concentrated levels of biological materials released during a bio-threat event. Typical agents include anthrax, tularemia, viruses and toxins. EnviScreen Bio100 Detector provides initial response in 30 seconds to 2 minutes depending on sensitivity required. Additionally it automatically collects a particulate sample (for identification such as, PCR analysis) when elevated levels of biological materials are detected.

The detection principle is based on UV fluorescence together with particle size analysis. Picture 4 shows EnviScreen Bio100 Detector.

Picture 4. EnviScreen Bio100 Detector

2.2.4 Radiological/Nuclear Detectors

Radiological/nuclear detectors are used to detect and monitor radiation and nuclear threat. Typically the following radiological parameters are monitored:

- alfa
- beta
- gamma
- X-ray

EnviScreen is compatible with many different radiological/nuclear sensor types independently from their manufacturer.

Picture 5.
RD-02 Radiation Detector

2.2.5 Meteorological Sensors / Air flow sensors

The information generated by meteorological / air flow sensors are used for several purposes depending on the application. In case of outdoor area monitoring, the information together with the information from chemical sensors is used to calculate the contaminated area scenario i.e. for dispersion modelling. So, in order to use EnviScreen Dispersion Modeling feature, meteorological information is required, minimum from one meteorological station located inside the monitored area. Meteorological station includes:

- Wind Speed Sensor
- Wind Direction Sensor
- Temperature Sensor
- Relative Humidity Sensor
- Barometric Pressure Sensor
- Precipitation Sensor

Picture 6.
WXT510 Weather Sensor

Air flows sensors (wind speed and direction) are used mainly in special application related to underground facilities, such as subways, tunnels and shelters. Since the dispersion model is not applicable in case of indoor safety monitoring, it is still needed to monitor the air flows. For example in subway safety systems, the emergency management decisions (e.g. smoke removal and ventilation control) are based on the current air flow situation.

2.3 Data Communication

EnviScreen System can be equipped with hardwired or wireless communication system. System works equally with any communication system. Typically, the communication between sensors and Data Processing Units is using TCP/IP or serial type of communication. Data Processing units are then connected to TCP/IP network together with Control Center computers.

However, the communication system will be designed according the customer requirements

3 ENVISCREEN SOFTWARE MODULES

EnviScreen is based on module structure, which enables a wide range of different applications. EnviScreen software includes the following components:

- EnviScreen Server Module
- EnviScreen Client Module
- EnviScreen Trend Module
- EnviScreen Adaptor Module
- EnviScreen Dispersion Module
- EnviScreen Simulation Module
- EnviScreen CCTV Module

Depending on the requirements of the application and selected modules, there are three different versions of EnviScreen available:

- EnviScreen Lite
- EnviScreen Basic
- EnviScreen Advanced

Following chapters describe the main features each software modules and versions.

3.1 EnviScreen Server

EnviScreen Server acts as a server for the EnviScreen Client components either locally or through Ethernet. EnviScreen Server communicates with EnviScreen Adaptor component collecting measurement data from the measurement devices connected to the system. The main features of EnviScreen Server:

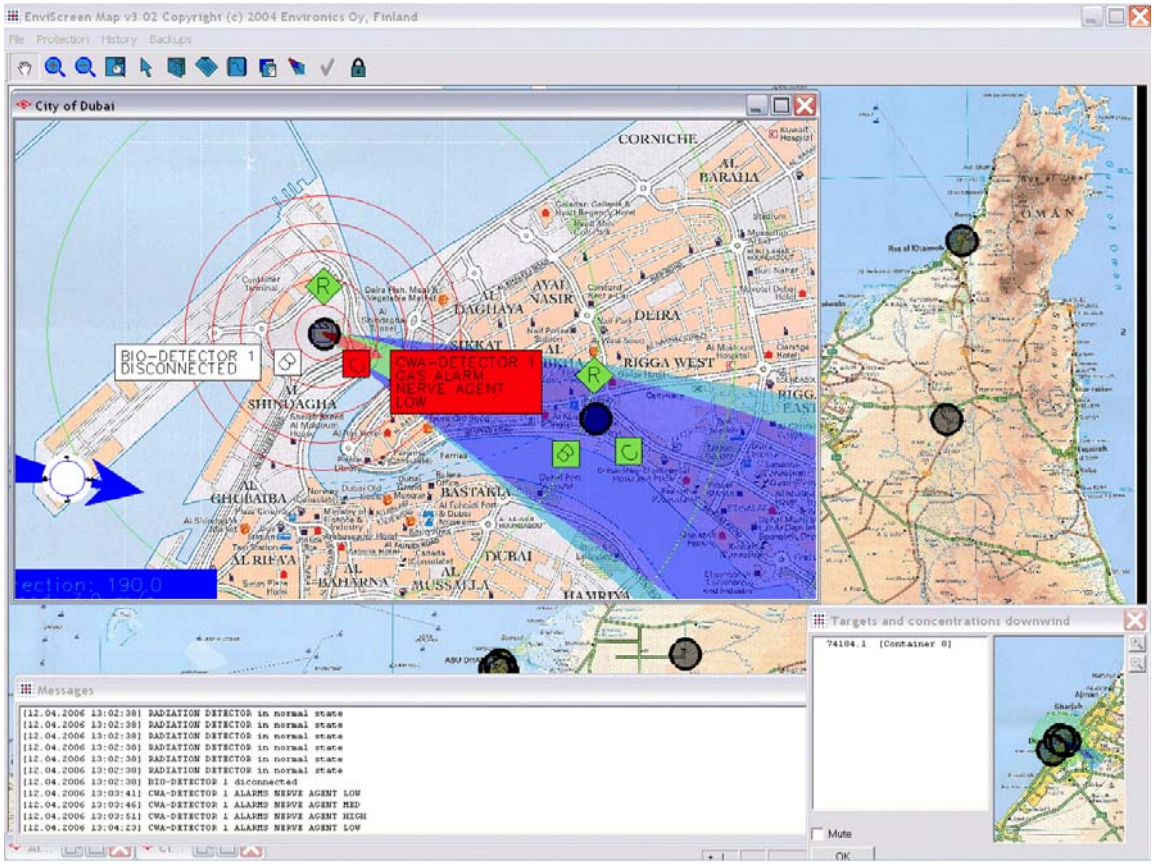
- Prepares text log from the measurement data for later inspection.
- Supports Several EnviScreen Client Module Connections via TCPI/IP Ethernet

- Supports Several EnviScreen Trend Module Connections
- Supports Several EnviScreen Adaptor module Connections
- Maintain Virtual Database to share GIS information to EnviScreen Client modules

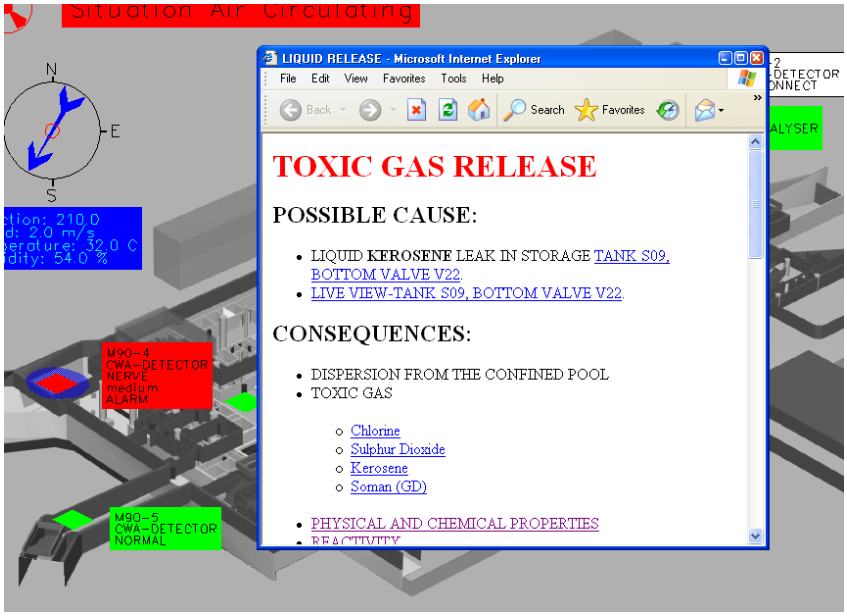
3.2 EnviScreen Client

EnviScreen Client Module is a component that provides the system with graphic user interface, using maps, satellite images, drawings, etc. Client communicates with EnviScreen Server component either locally or trough Ethernet. Several EnviScreen Client modules can be connected to one server at the same time. The main features of EnviScreen Client:

- Wide range of different type of map handling functions, like zoom, pan, create new windows and focus on alarming device
- Supports vector and raster graphics mixed together
- Supports several map layers
- Devices status symbols and text-fields are presented on the map in clear zoom able vector format
- Provides operator with different user levels, i.e. enabling different rights to operate and preventing un-authorized use/access
- HTML-based emergency instructions can be added to describe instructions to support and help decision making during emergency management
- Audio alarms related gas alarms and/or failure
- Acknowledge of alarms and failures
- Communicates via TCP/IP Ethernet with EnviScreen Server Module
- Can be located in several different computers at same time enabling equal user interface to different locations via TCP/IP Ethernet



Picture 7. Example of User Interface of EnviScreen Area Monitoring System



Picture 8. Example of User Interface with Emergency Instructions

3.3 EnviScreen Adaptors

EnviScreen Adaptor acts as an interface between the sensor/measurement device and EnviScreen Server. The main features of EnviScreen Adaptors are:

- Adapts device/sensor data communication protocol to EnviScreen Server compatible format
- Handles data communication to devices/sensors
- Communicates with EnviScreen Server module via TCP/IP Ethernet
- Records raw data from devices to ASCII files if needed
- Enables device simulations for test- and simulation purposes

4 ENVISCREEN SOFTWARE VERSIONS

4.1 EnviScreen Lite

EnviScreen Lite is a GIS system designed for chemical detection and monitoring based on real-time information produced by Environics chemical detectors. This software enables an easy-to-use interface that provides the operator with high level of situational awareness. EnviScreen Basic integrates the chemical detectors on field as complete monitoring system.

Graphic user interface can be based on any full colour map(s) or picture(s) provided by the operator. EnviScreen Lite has versatile management tools for user interface configuration, including sensor symbol editing, windowing, zooming etc. With EnviScreen Lite it is possible to create versatile and novel networks of all types of Environics chemical detectors. Data communication can be wireless or hardwired.

EnviScreen Lite supports the following measurement devices:

Device	Use	Connection Type
M90-D1-C	**Chemical Detection (CWA)**	**RS232/485/ETH**
ChemPro100	**Chemical Detection (CWA & TIC)**	**RS232/485/ETH**
ChemProFX	**Chemical Detection (CWA & TIC)**	**RS485/ETH**
Master Module	**Data Communication**	**ETH**
M90-CLU41/81 Control Unit	**Data Communication**	**RS232/485/ETH**

EnviScreen Lite systems are based on one Control Center. This software does not support Client feature.

4.1.1 Training and Simulation

The EnviScreen user can simulate different type of devices. With EnviScreen Lite the operator can simulate ChemProFX Chemical Detector.

4.1.2 Hardware requirements

Minimum:

- 19” Display (1024 x 768)
- Pentium 400MHz Processor
- 256 MB RAM
- CD-RW drive for software installation
- Connections for devices
- Mouse and Keyboard
- Ethernet 10/100MB
- Windows 2000/XP OS

Recommended:

- Two 21” Displays (1280 x 1024)
- Pentium Class 2 GHz Processor
- 512 MB RAM
- CD-RW drive and USB for software installation and measurement and event data backups
- Connection for devices
- Mouse and Keyboard
- Ethernet 10/100MB
- Changeable HDD-drive for fast system recovery.
- Server type PC for gain more reliability operation.
- Windows 2000/XP OS

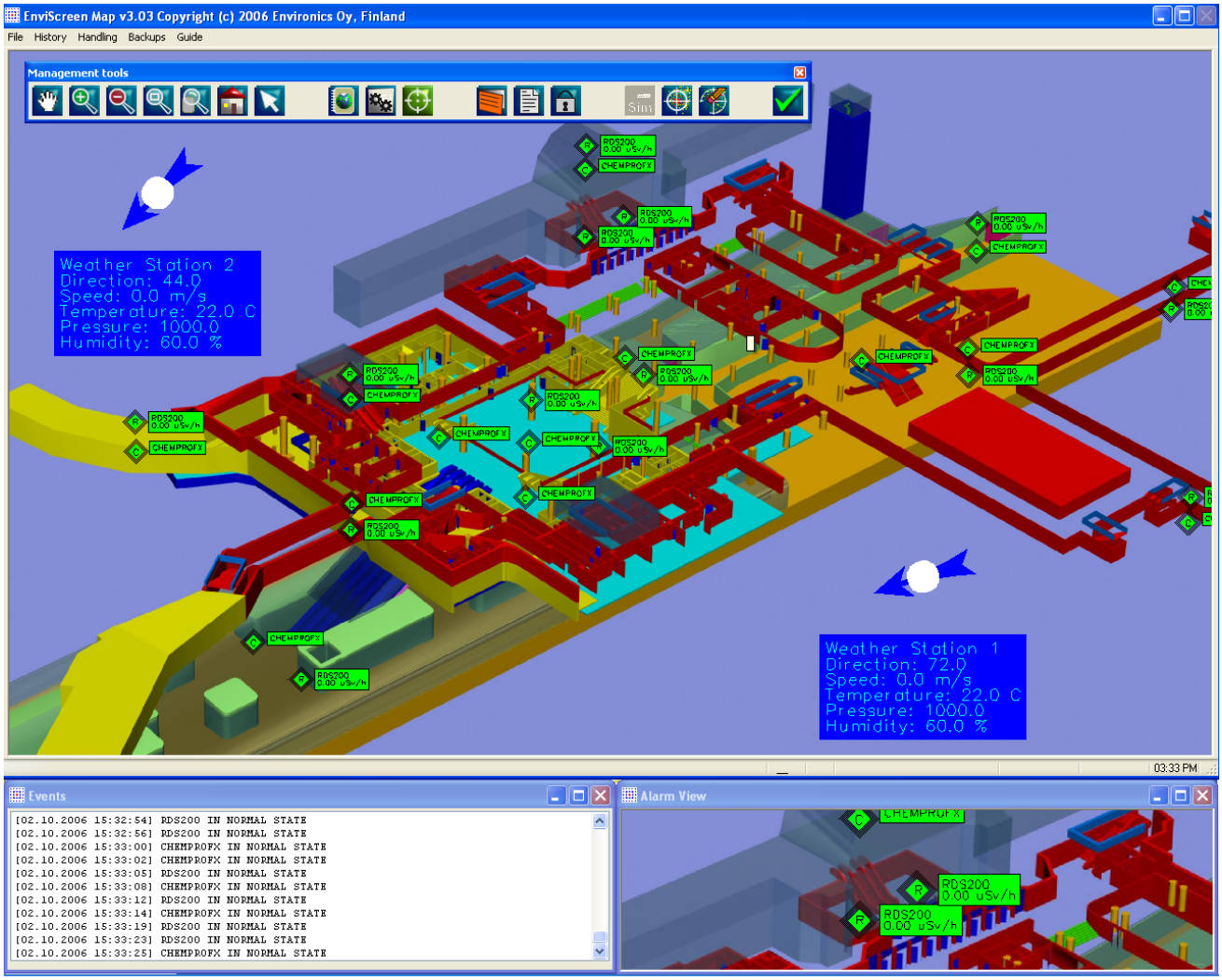
4.2 EnviScreen Basic

EnviScreen Basic is a GIS system designed for safety and environmental monitoring based on real-time information produced by not only EnviScreen sensors and detectors but also 3rd party devices. This software enables an easy-to-use interface that provides the operator with high level of situational awareness. EnviScreen Basic integrates the field devices as complete monitoring systems.

With EnviScreen Basic it is possible to create versatile and novel networks of different sensors, detectors and devices. It is compatible with wide range of chemical, biological, radiological, nuclear and meteorological sensors and detectors.

Graphic user interface can be based on full colour raster map(s) or picture(s) provided by the operator. EnviScreen Basic has versatile management tools for user interface configuration, including sensor symbol editing, windowing, zooming etc. System information can be decentralized in real-time due to the fact that EnviScreen Basic Systems can have up to 8 pieces of Control Centers based on EnviScreen Basic Clients.

EnviScreen Basic is fully functional software package to be installed in one PC computer to Windows 2000/XP environment.



Picture 9. Example of main window for EnviScreen Building Safety System

EnviScreen Basic supports the following measurement devices:

Device	Use	Connection Type
M90-D1-C	**Chemical Detection (CWA)**	**RS232/485/ETH**
ChemPro100	**Chemical Detection (CWA & TIC)**	**RS232/485/ETH**
ChemProFX	**Chemical Detection (CWA & TIC)**	**RS485/ETH**
Bio100	**Biological Detection**	**RS232/485/ETH**
ChemPro100 Radiation Detector Module *	**Radiation Detection**	**RS232**
RDS-200	**Radiation Detection**	**RS232/ETH**
RD-02	**Radiation Detection**	**RS232/ETH**
RD-02L	**Radiation Detection**	**RS232/ETH**
WXT510	**Weather Measurement**	**RS232/485/ETH**
WMT50	**Tunnel Airflow / Wind**	**RS232/485/ETH**
WS425	**Tunnel Airflow / Wind**	**RS232/485/ETH**
Master Module	**Data Communication**	**ETH**
M90-CLU41/81 Control Unit	**Data Communication**	**RS232/485/ETH**

* = requires Master Module

4.2.1 Training and Simulation

The EnviScreen user can simulate different type of devices. With EnviScreen Basic the supported devices for simulation are:

- ChemProFX Chemical Detector
- Bio100 Biological Detector
- RD02 Radiation Sensor
- WXT510 Weather Sensor

Simulations can be operated from any Control Center (Computer with EnviScreen Basic or EnviScreen Basic Client). The simulation mode applies then to all connected Control Centers.

Within simulation mode it is possible to set alarms and configure certain weather conditions.

4.2.2 Hardware requirements

Minimum:

- 19” Display (1024 x 768)
- Pentium 400MHz Processor
- 256 MB RAM
- CD-RW drive for software installation
- Connections for devices
- Mouse and Keyboard
- Ethernet 10/100MB
- Windows 2000/XP OS

Recommended:

- Two 21” Displays (1280 x 1024)
- Pentium Class 2 GHz Processor
- 512 MB RAM
- CD-RW drive and USB for software installation and measurement and event data backups
- Connection for devices
- Mouse and Keyboard
- Ethernet 10/100MB
- Changeable HDD-drive for fast system recovery.
- Server type PC for gain more reliability operation.
- Windows 2000/XP OS

4.3 EnviScreen Advanced

EnviScreen Advanced is a GIS system designed for emergency and consequence management including safety and environmental monitoring based on real-time information. This software enables customized user interfaces that provide the operator with high level of situational awareness. EnviScreen Advanced integrates the field devices as complete monitoring systems. With EnviScreen Advanced it is possible to create versatile and novel networks of different sensors, detectors, devices and systems. It is compatible with wide range of chemical, biological, radiological, nuclear, and meteorological sensors as well as with other devices and systems

Real-time emergency and consequence management requires information from several systems. EnviScreen Advanced integrates critical systems, such CCTV, fire detection, ventilation, smoke removal and NBC filtration and one complete management system. EnviScreen Advanced also includes additional software modules, such as Trend and Dispersion Modelling.

EnviScreen Advanced supports the following measurement devices:

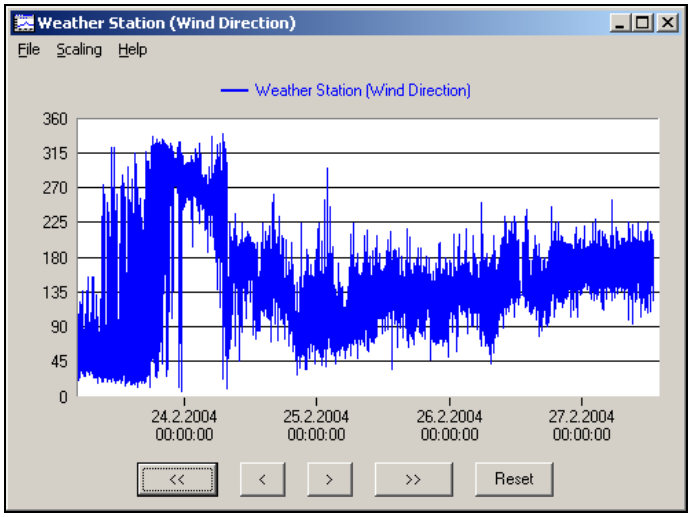
Device	Use	Connection Type
M90-D1-C	**Chemical Detection (CWA)**	**RS232/485/ETH**
ChemPro100	**Chemical Detection (CWA & TIC)**	**RS232/485/ETH**
ChemProFX	**Chemical Detection (CWA & TIC)**	**RS485/ETH**
Bio100	**Biological Detection**	**RS232/485/ETH**
ChemPro100 Radiation Detector Module *	**Radiation Detection**	**RS232**
RDS-200	**Radiation Detection**	**RS232/ETH**
RD-02	**Radiation Detection**	**RS232/ETH**
RD-02L	**Radiation Detection**	**RS232/ETH**
WXT510	**Weather Measurement**	**RS232/485/ETH**
WMT50	**Tunnel Airflow / Wind**	**RS232/485/ETH**
WS425	**Tunnel Airflow / Wind**	**RS232/485/ETH**
MILOS500	**Weather Measurement**	**RS232**
GASMET	**Gas Analyzer**	**RS232**
Cerberus	**Fire Detection (Fiber)**	**RS232**
Master Module	**Data Communication**	**ETH**
M90-CLU41/81 Control Unit	**Data Communication**	**RS232/485/ETH**

* = requires Master Module

4.3.1 EnviScreen Trend

EnviScreen Trend module is a component that runs together with EnviScreen Client. Trend module enables the graphic view of sensor data from devices that are connected to the system and have capability to produce numeric data. The main features of Trend Module are:

- EnviScreen Trend Module graphic user interface shown in picture 11 allows the trend data of the applicable sensors connected to EnviScreen to be observed
- Y-axis scale is updated automatically with coming measurement data or manually from the scale window
- EnviScreen Trend enables adjusting of the timescale in relation to the x-axis
- Maximum 1 months time period of sensor data is available



Picture 10. User Interface of EnviScreen Trend module

4.3.2 EnviScreen Dispersion Modelling

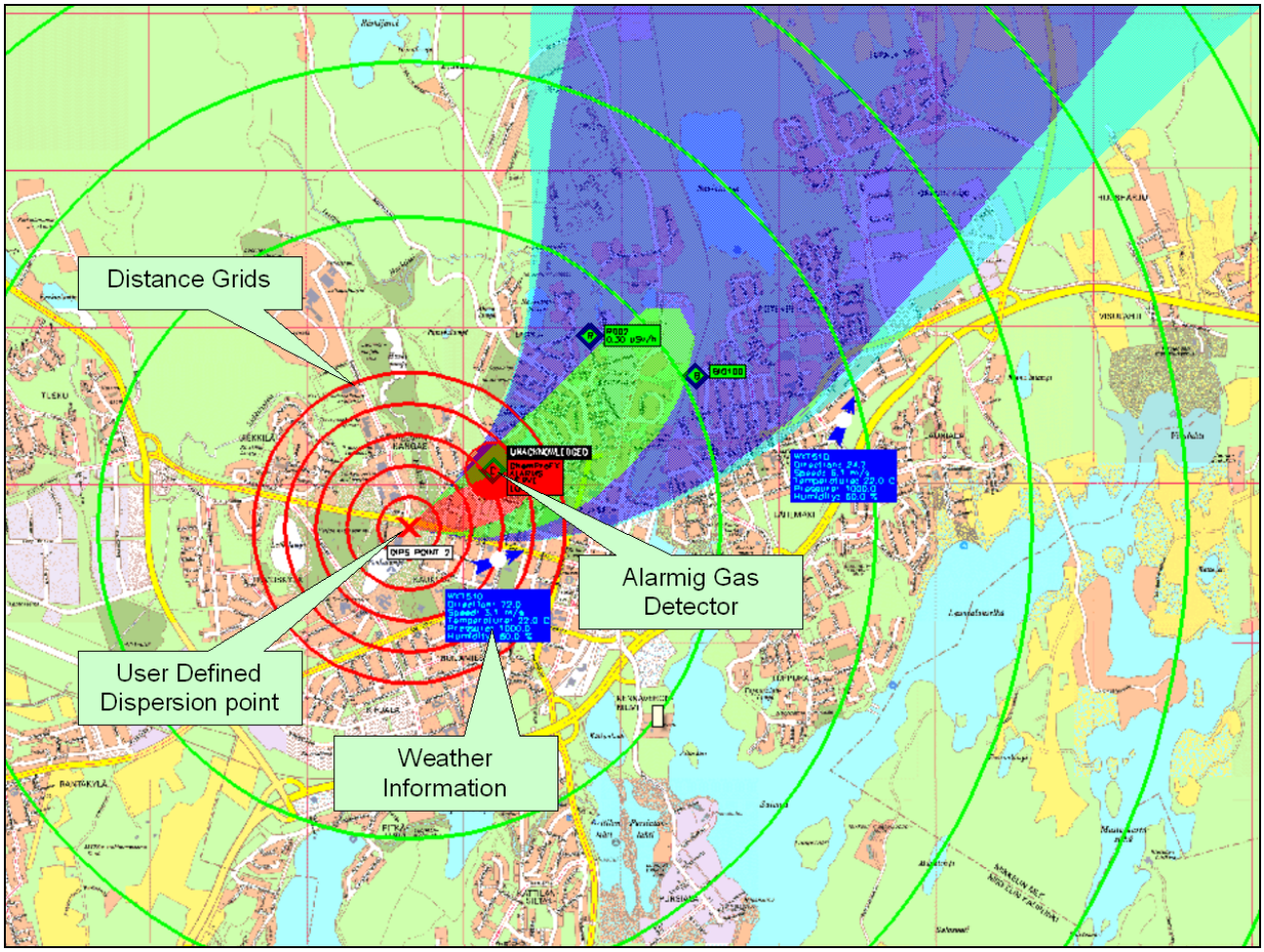
The EnviScreen user can create gas dispersion clouds based on real measurement data from devices or simulated data. This feature is only supported on EnviScreen Advanced. Basic principal of modeling is that user places dispersion point or points on the map where the cloud will be calculated. Based on gas detector/sensor information and weather conditionings EnviScreen calculates worst case scenario cloud or clouds by calculating backwards from the alarming sensor. The main features of dispersion modeling are:

- When gas leak is detected the estimation of gas dispersion is shown on map in real time
- The response time for the calculation is less than 3 seconds
- Lists all digitalized CRITICAL SITES on the map that are estimated to be in danger
- Shows an incident (for example liquid release) related info pop-up window

.

Dispersion cloud consist from:

- User defined dispersion point
- Dispersion Grids (Distance between red grids is 200 meters and green grids 1000 meters)
- Dispersion cloud (Red = HIGH concentration, Green is MEDIUM, Blue is LOW and Light blue is certitude factor)
- Alarming Gas Sensor/Device
- Weather Information



Picture 11. Example of Calculated Dispersion Modeling

EnviScreen is real time software for leakage point and gas dispersion area estimation. Real time parameters like wind speed and direction, temperature, humidity, air pressure, and precipitation together with the source term estimates and chemical substance attributes are used to calculate a prediction of maximum gas dispersion area. Leakage point estimation is calculated by using probability based back calculation method. These results with real time variables are displayed on a map based user interface.

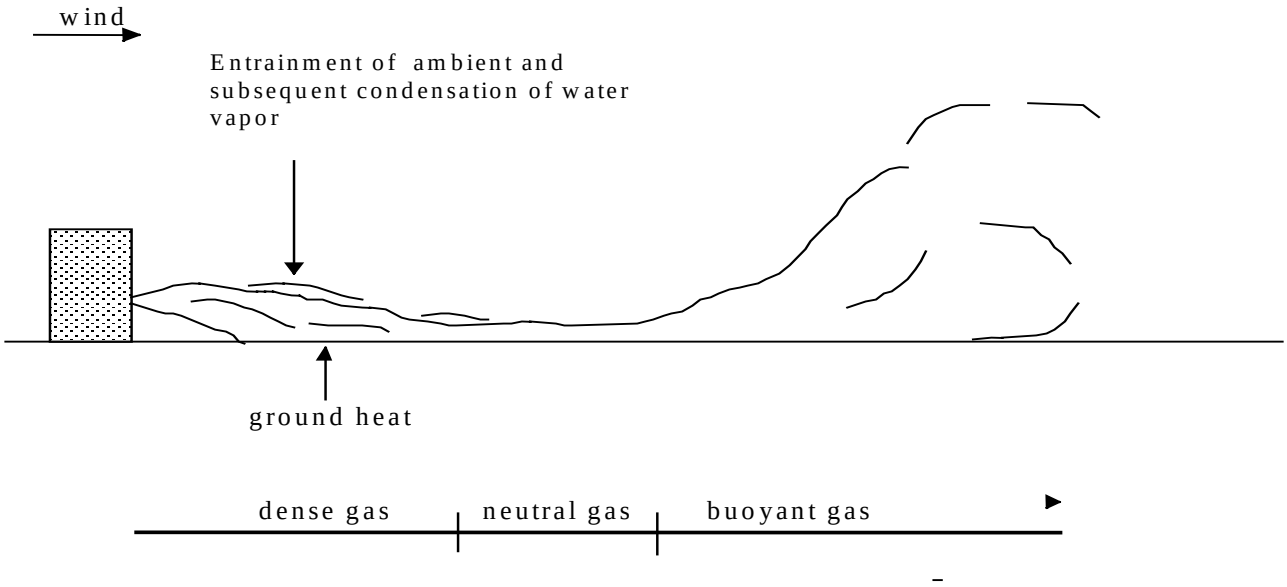
EnviScreen is a GIS system platform is developed to be a basis for demanding control room and operational management applications. In EnviScreen, the estimate on the size of the release is based on the gas detector(s) information and backward calculation. Furthermore, list of possible site specific release sources can be used. The source is estimated to behave like in a continuous release until the gas detectors indicate that the situation is over. In an accident, a fast and reliable box-model type approach is used in the calculation of continuous dense gas dispersion [Kakko 1991]. Passive dispersion is calculated by using continuous

well-known Gaussian dispersion model [TNO 'Yellow Book' 1992]. Instantaneous dispersion models can be used in simulation. Results are displayed on maps covering the traces that a cloud leaves behind.

In dispersion models, with the exception of the passive model, an enthalpy balance includes simple mixing model with humid air. After the evaporation of all the aerosol droplets in the cloud, the total enthalpy of the system is conserved. For clouds in the ground the enthalpy balance has to take into account heat transfer from the surface below. The possibility of chemical reactions, rainout of the liquid droplets, and dry or wet deposition in the dense gas phase are not taken into account. The air entrainment coefficients in passive dispersion [Hosker 1974] have been modified to better fit with those given in TNO 'Yellow Book' [1992].

The dense gas models in EnviScreen have been compared with the dense gas dispersion model DEGADIS (DEnse GAs DISpersion which was developed by Havens and Spicer [1985]. The comparison showed that EnviScreen dispersion model concentration predictions concur with DEGADIS predictions. DEGADIS is an adaptation of the Shell HEGADAS model described by Colenbrander [1980] and Colenbrander and Puttock [1983], and theoretical paper by van Ulden [1983]. The predicted concentration profiles of DEGADIS concur with large-scale experiments such as Thorney Island and Maplin Sands tests [Havens and Spicer 1985], and Dessert Tortoise and Goldfish tests [Hanna et al. 1991].

The dispersing vapor cloud can be buoyant/neutral or dense depending on the density difference between the vapor cloud and ambient air. Buoyant/neutral vapor cloud models are used to predict the concentration downwind of the source, and the relevant calculation models are based on the concept of Gaussian dispersion. The mechanism of dense gas dispersion differs markedly from that of buoyant/neutral clouds. At first, the dense gas cloud sinks due to gravity. As the vapor cloud moves further, gravity and heating make the cloud spread (Picture 12). The cloud becomes more diluted and its density approaches the density of ambient air. In this phase, turbulence is responsible for the dispersion, and the cloud is assumed to have a Gaussian distribution. Near the source, the deviation of a dense gas cloud from a Gaussian distribution can be significant.



Picture 12. Different phases of dense gas dispersion

The classification of a dense gas is not always straightforward. It is obvious that gases having molecular weights greater than air will be dense (e.g. carbon dioxide, chlorine and LPG). These are commonly stored and transported as liquids, either at atmospheric pressure by refrigeration and insulation or at ambient temperature by pressurization. Gases that are lighter than air and liquefied at cryogenic temperatures form a dense gas cloud because they are very cold at the time of their release (e.g. LNG). A dense gas cloud can also result from the rapid decompression of a pressurized tank, which is carrying liquefied gas at atmospheric temperatures (e.g. chlorine or anhydrous ammonia). In the initial flashing of the release, very small droplets of liquid escape and form an aerosol mist; these droplets will be denser than air and will behave like a dense gas (e.g. anhydrous ammonia). Following the aerosol formation, the droplets start to evaporate, causing the cloud to cool and become dense.

4.3.2.1 Buoyant Gas Modeling

Model (Gaussian model) can be used to estimate dispersion resulting from a continuous or instantaneous release. Gaussian models are directly applicable to neutral and positively buoyant releases, as the models have been validated over a wide range of emission characteristics [Hanna et al. 1982]. They may also be applied to smaller releases of dense gas emissions where the dense phase of the dispersion process is relatively short compared with the neutrally buoyant phase.

Well-known Gaussian models describe the behavior of buoyant gases released in the air, and approximate the behavior of any vapor cloud at a specified distance downwind from the release point. The model here is based on the TNO 'Yellow Book' [1992] Gaussian model. The concentration can be calculated by using following equations:

$$C(x,y,z,h)= m'/\{2\pi u_w \sigma_y(x)\sigma_z(x)\}\{EXP[-y^2/(2\sigma_y^2(x))]\}* \quad (1)$$

$$\{EXP[-(z-h)^2/(2\sigma_z^2(x))]+EXP[-(z+h)^2/(2\sigma_z^2(x))]\}$$

for continuous dispersion and

$$C(x,y,z,h,t)= m/\{(2\pi)^{3/2}\sigma_{xl}\sigma_{yl}\sigma_{zl}\}\{EXP[-(x-u_w t)^2/(2\sigma_{xl}^2)]\}* \quad (2)$$

$$\{EXP[-y^2/(2\sigma_{yl}^2)]\}*$$

$$\{EXP[-(z-h)^2/(2\sigma_{zl}^2)]+EXP[-(z+h)^2/(2\sigma_{zl}^2)]\}$$

for instantaneous dispersion. m' is the flow rate [kg/s] of a continuous source and m is the mass [kg] of released material. The uw is the wind speed [m/s] and h is the source height. The values for continuous and instantaneous si's can be found in TNO 'Yellow Book' [1992]. Plume rise has been estimated using the TNO 'Yellow Book' [1992] model. The methodology of the Gaussian dispersion model is well defined and well validated [TNO 'Yellow Book' 1992 and Guidelines... 1989]. More information available from following references:

- Guidelines... 1989. Guidelines for chemical process quantitative risk analysis. New York, Center for Chemical Process Safety of the American Institute of Chemical Engineers. 585 pp.
- Hanna, J.M., Briggs, S. A. and Hosker, R. O., Jr. 1982. Handbook on atmospheric diffusion. Oak Ridge, TN, U.S. Department of Energy, Technical Information Center, Office of Scientific and Technical Information. 102 pp.
- TNO 'Yellow Book' 1992. Methods for the calculation of the physical effects - resulting from releases of hazardous materials (liquids and gases). The Netherlands, Voorburg, the Director-General of Labour, Committee for the Prevention of Disasters. Second edition 1992. Several pages.

4.3.2.2 Dense Gas Modeling

Dense Gas Model can be used to estimate dispersion resulting from a continuous or instantaneous dense gas release. The model does not take into account:

- Chemical reactions
- Rainout of liquid droplets
- Dry or wet deposition

The dense gas dispersion model theory of CRUNCH [Jagger 1983] and DENZ [Fryer and Kaiser 1979] has been modified to include a simple mixing model with humid air [Kakko 1991]. A mixture of dry and humid air is assumed when the cloud is denser than air. Relative humidity affects the density of the air, the air entrainment and the heat balance of the dense cloud. Slight changes in the density of the air and air entrainment due to the moist air have minor effects on the dispersing dense gas cloud [Kakko 1991]. The heat exchange process has greater influence on the concentration profile.

In the entrainment region, it is assumed that the total enthalpy of the system is conserved and that the entrained air does not contain water in liquid form. The possibility of chemical reactions and rainout of the liquid droplets in the dense gas phase is not taken into account. If the vapour cloud contains aerosol, the aerosol droplets will transfer heat from the cloud when evaporating. The rate of evaporation will depend on the temperature variation within the dense vapour cloud and the amount by which the ambient air is cooled when entraining into the dense vapour cloud. The liquid water droplets in the ambient air can condense and release their latent heat of vapourisation to the vapour cloud.

After the evaporation of all the aerosol droplets in the cloud, the total enthalpy is conserved by the air entrainment. Therefore, the mass of contaminant gas is increased by the mass of aerosol. The enthalpy balance is obtained by an iterative procedure that determines the thermodynamic state of the vapour mixture in the cloud. The enthalpy balance equation can be written in the form:

$$m_{g,tot}(1-X)H_v(T_b) \approx m_{g,tot}\{H_g(T_b)-H_g(T_c)\}+ m_aC_{pa}(T_{amb}-T_c)$$
$$+ m_wk(T_c)H_w+m_wC_{pw}(T_{amb}-T_c) \quad (3)$$

where H_v is the latent heat of vapourisation of the dispersing gas, and X is the mass fraction of vapour phase in the release. H_g and H_w are enthalpies of gas and water vapour, respectively. $m_{g,tot}$, m_a, and m_w are the masses of gas (total mass of dispersing gas), dry air and water vapour. The mass of water vapour is estimated to be $AH \cdot m_a$ where AH is the absolute humidity of air. Relative humidity gives the ratio of the quantity of water vapour present in the atmosphere to the quantity which would saturate at the existing temperature. Relative humidity can be changed to absolute humidity, which is the mass of water vapour present in the unit volume of atmosphere.

The total change of air mass flux, due to simultaneous edge and top entrainment, can be given by

$$dm'_a/dx = 2L\rho_a u_e + \rho_a V'\alpha_e/L\ (dL/dx) \quad (4)$$

for continuous dispersion and

$$dm'_a/dt = \pi\rho_a u_e L^2 + 2\rho_a V'\alpha_e/L\ (dL/dt) \qquad (5)$$

for instantaneous dispersion. The u_e is the edge entrainment velocity, which depends upon the 'Richardson number', and a_e is the edge entrainment constant. r_a is the density of dry or moist air, and dL/dx or dL/dt presents the rate of growth of dense cloud due to gravitational spreading. The gaseous mass flux of a dense vapour cloud element is given by

$$m'_a + m'_w + m'_{g,tot} = 2\ L\ H\ u_c\ \rho_c \qquad (6)$$

for continuous dispersion (L is the half-width of the cloud) and

$$m'_a + m'_w + m'_{g,tot} = \pi\ L^2\ H\ \rho_c \qquad (7)$$

for instantaneous dispersion (L is the radius of the cloud). H is the height of the plume, and u_c is the velocity of the cloud.

The transition to the neutral/buoyant phase and subsequent calculation of Gaussian dispersion is the same as in the original Fryer [1980] model. The HMP model [Hoot, Meroney and Peterka 1973] has been used to estimate the plume rise.

The dense gas models introduced here have been compared with the dense gas dispersion model DEGADIS [Kakko 1991]. The comparison showed that current model concentration predictions concur with DEGADIS predictions. The DEGADIS (DEnse GAs DISpersion) model was developed by Havens and Spicer [1985] and is an adaptation of the Shell HEGADAS mode described by Colenbrander [1980] and Colenbrander and Puttock [1983], and a theoretical paper by van Ulden [1983]. The predicted concentration profiles of DEGADIS concur with large-scale experiments such as Thorney Island and Maplin Sands test [Havens and Spicer 1985], and Dessert Tortoise and Goldfish tests [Hanna et al. 1991]. More information available from following references:

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4.3.2.3 Leak Point Estimation - Bayesian Method

Let us have a gas container G, which we assume is either in order i.e. not leaking at all, which we denote by G_0, or leaking by some amount, which we denote by G_a. We also have some wind measurements. Suppose the we have a gas measurement M_k and an estimate of the probability for the measurement given the leakage hypothesis and wind measurements:

$$p(M_k \mid G_a)$$

and a probability estimate for the measurement given no leak at all (eg. measurement error):

$$p(M_k \mid G_0)$$

We also need a priori probability estimates $p(G_0)$ and $p(G_a)$. Now the probability for G_a according to the Bayesian formula:

$$\frac{p(M_k \mid G_a)p(G_a)}{p(M_k \mid G_a)p(G_a) + p(M_k \mid G_0)p(G_0)}$$

and correspondingly for G_0:

$$\frac{p(M_k \mid G_0)\,p(G_0)}{p(M_k \mid G_a)\,p(G_a) + p(M_k \mid G_0)\,p(G_0)}$$

If we imagine a diminishing measurement probability given the wind and a leakage, the probability for a measurement error will grow according to the formulae above.

4.3.3 External System Integrations

4.3.3.1 Fire Detection System Integration

EnviScreen Safety System is typically be integrated with the existing (or new) fire detection system by using RS232 interface. EnviScreen system receives the information from the system and indicates it in the system as follows:

- Fire Detector Status
  - Normal
  - Alarm
  - Disconnected
  - Detector Failure
- Detector Location (address)

It should be noted that the above-mentioned features are depending on the fire detection system capabilities.

4.3.3.2 Building Automation / HVAC Control / NBC Filtration

EnviScreen System will have two-way connection to systems like Building Automation, NBC Filtration, HVAC Control and Smoke Removal System. The connections are as follows:

- Relay output to start-up/shutdown the external system components/devices
- Digital input to indicate the external system components/device statuses in EnviScreen System

4.3.3.3 CCTV

EnviScreen Advanced can integrate CCTV systems enabling interface to existing or new camera systems. It provides real-time video from surveillance cameras in shown in EnviScreen Client modules Map user interface. CCTV integration provides the following features:

- Real-Time surveillance.
- Different type of recording modes: Continuous, Scheduled or driven by external alarm event, motion detection.
- 1-16 simultaneous Camera View Windows
- Local or remote video export to removable media. (CD/DVD or memory stick).
- 240 fps across 16 camera inputs, 15 fps per input, 30 fps per 8 inputs.

Hardware Requirements for CCTV integration are:

- PC requirements are equal to EnviScreen Client module
- At least one Digital Video Recorder connected in same Ethernet than EnviScreen Client module.
- Maximum 16 Cameras per Digital Video Recorder

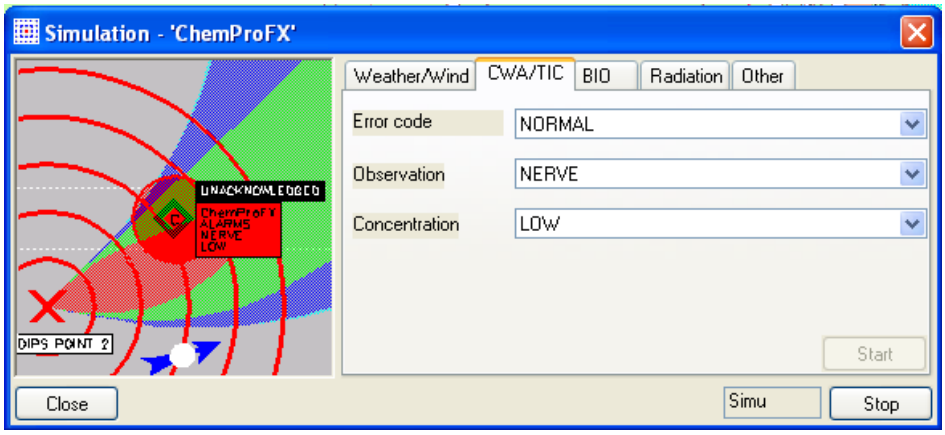
4.3.4 Training and Simulation

The EnviScreen user can simulate different type of devices. With EnviScreen Advanced the supported devices for simulation are:

- ChemProFX Chemical Detector
- Bio100 Biological Detector
- RD02 Radiation Sensor
- WXT510 Weather Sensor

Simulations can be operated from any Control Center (Computer with EnviScreen Advanced or EnviScreen Advanced Client). The simulation mode applies then to all connected Control Centers.

Within simulation mode it is possible to set alarms and configure certain weather conditions. Additionally, the operator can set dispersion points (emission/leakage source) and create different scenarios. Picture 13 shows the simulation start-up window.



Picture 13. Simulation Mode Window of EnviScreen Advanced

4.3.5 Hardware Requirements

Minimum:

- 19” Display (1024 x 768)
- Pentium 400MHz Processor
- 256 MB RAM
- CD-RW drive for software installation
- Mouse and Keyboard
- Ethernet 10/100MB
- Windows 2000/XP OS

Recommended:

- Two 21” Displays (1280 x 1024)
- Pentium Class 2 GHz Processor
- 512 MB RAM
- CD-RW drive and USB for software installation and measurement and event data backups
- Mouse and Keyboard
- Ethernet 10/100MB
- Changeable HDD-drive for fast system recovery
- Windows 2000/XP OS

5 APPLICATIONS

5.1 Industrial Area Safety System

Protecting and monitoring areas, such as industrial areas and complexes is one example of EnviScreen application. Typically it is used to protect and monitor sites, such as:

- Chemical and Petrochemical Plants
- Nuclear Plants
- Harbours (related to chemical transportation)
- Chemical Storage Areas

The structure of the system as well as the type and amount of used sensors and other devices depends on the site and related requirements. EnviScreen Safety and Environmental Monitoring System enables the following detection and monitoring features:

- Toxic Industrial Compound (TIC) detection
- Radiological/Nuclear Detection
- Indoor Air Quality Monitoring
- Outdoor Air Quality Monitoring
- Outdoor Meteorological Measurements
- HVAC Control

5.2 Subway Safety System

Protecting a subway network with related underground facilities is a well-known application of EnviScreen.

The structure of the system as well as the type and amount of used sensors and other devices depends on the desired safety level requirements. With EnviScreen Safety System it is possible to cover all the potential safety threat related to subway network environment. It is recommended that the Subway Safety System includes the following features:

- Chemical Warfare Agent (CWA) detection
- Toxic Industrial Compound (TIC) detection
- Biological Agent detection
- Radiological/Nuclear detection
- Air flow monitoring in tunnels
- Air quality monitoring
- HVAC and smoke removal system control
- Outdoor Meteorological Measurements (one for each station)

Also it is recommended to be integrated/connected to the following external systems:

- CCTV
- Fire and Smoke Detection

5.3 Building Safety System

Protecting buildings and building complexes is another application of EnviScreen. Typically it is used to protect important sites, such as:

- Governmental Buildings
- Airports
- Shopping Centers
- Shelters
- Other high security level buildings

The structure of the system as well as the type and amount of used sensors and other devices depends on the site and related requirements. EnviScreen Safety System enables the following detection and monitoring features:

- Chemical Warfare Agent (CWA) detection
- Toxic Industrial Compound (TIC) detection
- Biological Agent detection
- Radiological/Nuclear Detection
- Indoor Air Quality monitoring
- HVAC Control
- Outdoor Meteorological Measurements

5.4 Safety System for Ships

Naval applications of EnviScreen are mostly related to military use. The purpose of these systems normally is to protect people on board as well as monitor the possible threat of Chemical Warfare Agents. In many cases the ship is also equipped with Radiological/Nuclear detectors and meteorological sensors.

Ship system are also integrated with the ship control system. This integration enables the control of ventilation and/or NBC filtration system of the ship. On the other integration also gives better redundancy to the safety system. Typically trough the ship control system the information from the monitoring/safety system can be sent to other vessels/command centers.

5.5 Vehicle Applications – CBRN Reconnaissance

Vehicles that are equipped with monitoring/detection equipment can be used in military but also in civil area. In military applications, the task of these vehicles in CBRN (Chemical, Biological, Radiological, Nuclear) reconnaissance. Depending on the design and main task of the NBC vehicle, it includes several detectors, sensors and analysers, such as:

- Chemical Warfare Agents (CWA)
  - Indoor Air
  - Outdoor Air
  - Soil
- Toxic Industrial Compound (TIC)
  - Indoor Air
  - Outdoor Air
  - Soil
- Biological Agents
- Nuclear Detection
  - Indoor Air
  - Outdoor Air
- Indoor Air Quality
- Outdoor Meteorological Measurements