Container X-Ray Scanning Portal

Product Code: 1050-03

Key Features

- **Capable of Scanning 150 x 40' Containers per hour**
- **Contraband & Stowaway Detection**
- **Drive Through Operation**
- **Penetrate Steel up to 320 mm**
- **Maximum Vehicle Size – Width 3.5 m x Height 4.85 m**

Overview

The Container X-Ray Scanning Portal is a drive through system for the inspection of containers for contraband, explosives, weapons and verification of contents to manifests.

Drivers simply drive through the system, the scanning process starts after the driver's cabin has passed through the portal, ensuring the driver is not exposed to x-rays.

The system is capable of scanning up to 150 x 40' containers per hour alleviating inspection bottlenecks and delays.

Note: This system does not Scan the Truck Cab and is not suitable for Scanning Box Type Vans

An optional license plate reader and container ID recognition can be connected via a network so that the data can be incorporated with the container image data.

Features

- Container x-ray scanning
- Drive through operation
- Up to 150 containers per hour
- Steel penetration 320 mm
- Ideal for use in Ports
- CCTV monitored

Container X-Ray Scanning Portal

Applications

The Container X-Ray Scanning Portal ideal solution for the inspection of containers for contraband, explosives, weapons and verification of contents to manifests at Critical infrastructure facilities, Customs inspection, Government facilities, Logistics facilities, Military bases, Seaports.

System Introduction

The Container X-Ray Scanning Portal system has been designed to enable the rapid and effective scanning of containers with the minimum of impact on the import / export process. It is easy to operate and maintain making it a financially viable proposition.

This has been achieved by using well proven techniques and technologies that are housed in a robust structure designed to withstand the rigors of operating in the harsh environment typically found in ports

The system uses a 7.5 MeV Betatron pulsed x-ray source that is deployed in systems worldwide with linear scintillator photodiode detector arrays.

It has a high container throughput, with simple and easy operation, it provides reliable, high-quality images and low radiation dose, the system is radiation safe for the truck driver the X-ray function is only activated when: -

- the driver's cab is past the beam scan area;
- the cargo container is in the beam scan area and,
- the truck is moving above a minimum safe speed

Performance

The system is capable of a sustained throughput of 150 trucks / containers per hour (i.e. 1 x 18 metre truck every 23 seconds) assuming each truck is travelling at 8 Km/hr. The actual throughput depends on how the user wants to handle the trucks while awaiting the results of the image analysis. Some cargos will be cleared very quickly but more complex cargos will take longer, the next truck will have to wait for a decision on the previous truck before being scanned.

In reality such high throughputs are rarely required however the ability to scan that quickly means the minimum of delays should several trucks arrive at the scanner at the same time.

The system will penetrate over 320 mm of steel at the ANSI N42.46 test

Operation

The scan sequence is controlled by a Programmable Logic Controller, it uses both optical and magnetic sensors to track progress of the truck through the system and triggers the various events needed to safely capture an image.

The Image data is collected, distributed, displayed and stored using several PCs connected through an Ethernet network. In the event of a power failure the computer network is protected by a UPS that is capable of keeping the network running until power is restored or it is powered down in a controlled way so that data is not lost.

CCTV cameras enable the operator to monitor both the progress of a scan and to ensure that nobody is in the scan area. A loudspeaker system allows the operator to communicate with anyone seen there

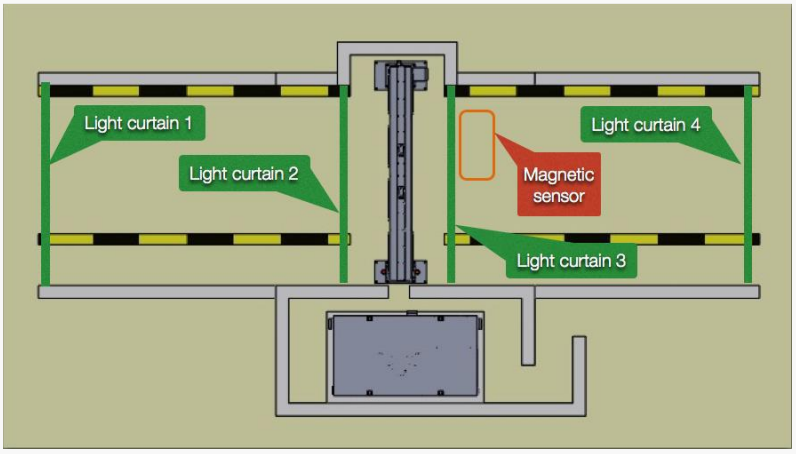
The license plate reader / container ID recognition is also connected via the network so that the data from it can be incorporated with the image data. The system control computer always displays the current system status. It shows whenever a sensor is triggered, when X-rays are being generated and whether an E-stop of interlock has been activated. The X-Ray Betatron source status is also shown here. The control panel operation is easy to understand and operate the sequencing is automated

Operation Contd.

Ethernet – The system uses an Ethernet network to connect the various subsystems, allowing easy connection to external networks which can enable the system to access to manifest databases and remote workstations to analyse images stored on the Image Server.

Imaging – The imaging system geometry defines the size of object that can be scanned, how much of it will be in the image and the viewpoint of the image, the imaging area is wider than a truck to allow the driver some latitude when driving through the scanner. The imaging area is higher than a normal truck to allow for trucks that are over-height.

The viewpoint will be from the side looking slightly upwards, the beam centre, which is where the penetration will be the best, will pass through about 1/3 from the bottom of a shipping container. Cargoes are typically densest in this region.



Vehicle Sensors Locations

Typical Scan Sequence – Traffic lights and a vehicle barrier (customer provided) will be used to let the driver know whether he can enter. If the system is operational but still scanning another truck the traffic light will be red. It will only turn green once the previous scan has been completed. The

The X-ray source will be switched off if the system detects that a truck has entered system when the traffic light is still red.

The truck will pass through a series of light curtain sensors as it passes through the scanner.

The scan will be aborted should this sequence happen in the wrong order or the truck take too long to reach the next sensor. The entry and exit light curtains will also detect whether a person has entered the scan area.

A Doppler radar sensor like that used to detect speeding vehicles also measures the truck speed. This is displayed so that the driver can more easily maintain the optimum speed through the system.

The speed information is also used by the imaging system to correct the displayed image so that a container always looks the same length on the display no matter what speed the truck was traveling.

A magnetic sensor will detect when the truck cab and driver are past the point where the X-ray beam is emitted. This allows us to minimize the dose to the driver.

Once the rear of the truck passes the X-ray beam the X-rays will be switched off. This is detected by a light curtain just past the X-ray beam. In addition, the X-rays will automatically be switched off after the time it would take to scan a container at the slowest allowable speed.

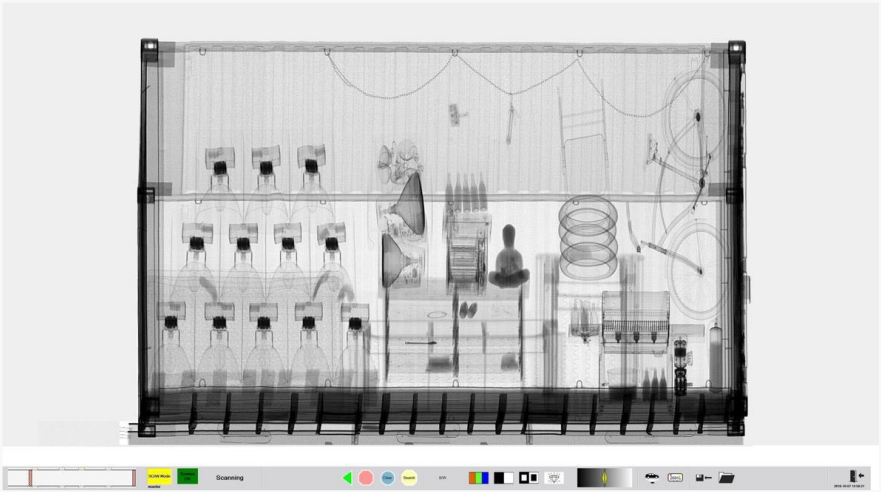
As soon as the X-rays are produced the data collection system will assemble all the image data into a single image. The image file is then sent to the next available Image Analysis Workstation for analysis.

Container X-Ray Scanning Portal

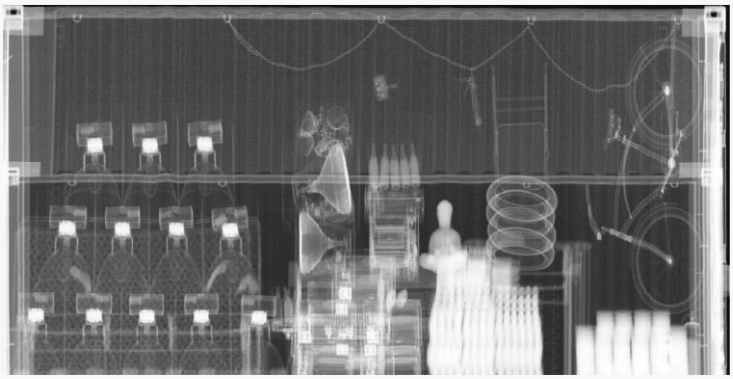
X-Ray Betatron

The maximum dose rate of a Betatron is lower than the linear accelerators (Linac) widely used by other portal manufacturers. In a portal system the dose rate has to be kept low in order to limit any possible exposure to the truck driver. A portal therefore only needs a low dose source and the extra power available in the more expensive and more complex Linac would be wasted.

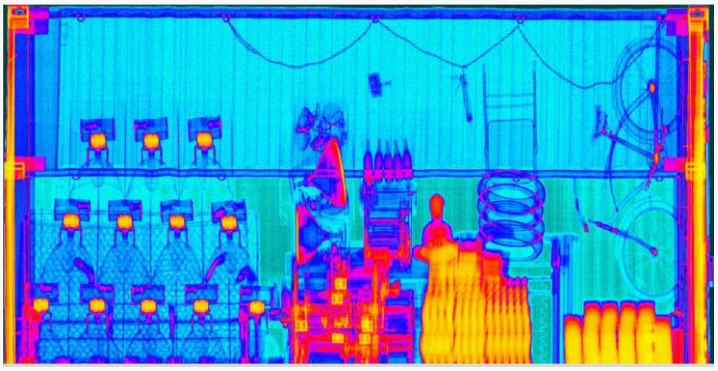
Typical Scanned Images



Zoom – The image can be zoomed up to x64



Inverse – This inverts the grayscale image so that white represents maximum attenuation and black none



Pseudo colour image

Typical Scanned Images Contd.

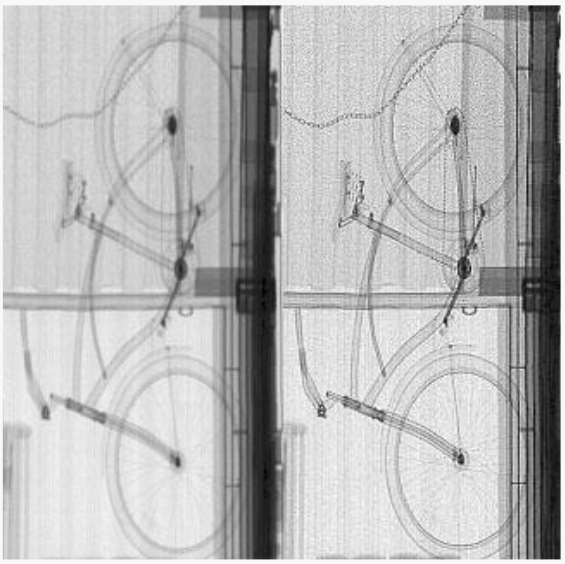
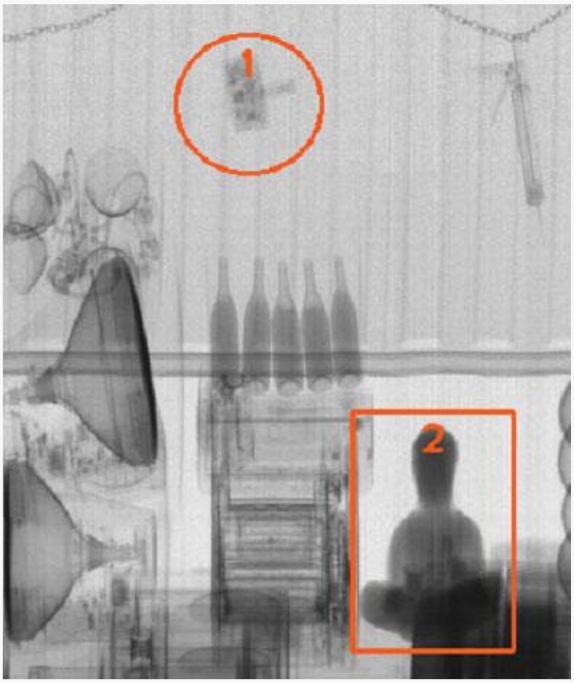


Image Sharpening before and after

Picture Perfect – This is a proprietary feature that combines several algorithms including adaptive histogram equalisation in order to enhance the image. In many cases this will be the only image processing function the operator needs to use

Object measurement – The measurement function allows the size of an individual object to be displayed



Objects of interest can be highlighted. This information is stored with the image data.

Image annotation – The image analyst can add comments to an image, these are recorded with the image data.

Material Discrimination

The Betatron can generate X-rays at two different peak energies., the system derives information about the material being scanned by making each alternate X-ray pulse a different energy, in this case 7.5 MeV and 4 MeV.

The difference in attenuation at the two energies will vary with the atomic number of the material being scanned. Colour is used to indicate material type, Orange is used for organic materials. The inspector has the option to display only colour organic material in the image.

The material type indicated will be that of all the material in the path of the X-ray beam.

If more than one type of material is present, then the display will show their averaged atomic number. For example, a small quantity of organic material behind metal is likely to be shown as inorganic.
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The lower energy signal will not penetrate as well as the high energy one so in denser cargo it will not be possible to compare the two. In those cases, no material information will be displayed.

System Diagnostics

A real time diagnostics display is used to show the status of the various parts of the system. It shows the state of each of the interlocks and E-stops. It will also show when any of the vehicle sensors are activated and when the source is radiating. The internal temperature of both the array and source housings is monitored which allows the performance of both the air-conditioning units to be checked.

The Betatron has an additional diagnostic display that shows both X-ray energy and dose rate. It also monitors key voltages and temperatures. Error messages are displayed if any of the key parameters such as Filament and Injection voltages require adjustment.

Offline tools are available to allow technicians to monitor the performance of the array, this allows faulty detector modules or individual detectors to be identified.

Image Server

The image server is used to store image files and the data associated with them such as the truck number, operator name and operator annotations. Images in the database can be searched using these parameters as well as the time and date of the scan. Older files can be removed automatically if required. Storage of 500,000 scans is achievable.

Radiation Safety

The safety features in the system are designed to protect three groups of people: The drivers of the trucks being scanned, the operators of the system and members of the public who might be nearby.

Protecting the Drivers – The driver of a scanned truck will be fairly close to the X-ray beam when it turns on, although not in the X-ray beam itself the driver will be exposed to some radiation scattered from the main beam by the cargo. The exact amount will depend on the cargo, but calculations and measurements have shown that the scattered radiation reaching the cab and driver will be no more than 0.1 µSv.

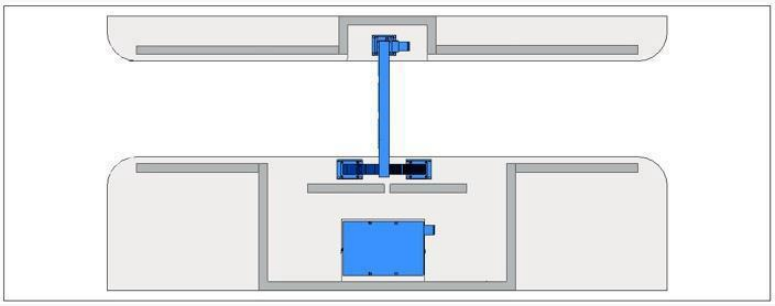
This meets the requirements of ANSI N43.17 (Radiation Safety for Personnel Security Screening Systems Using X-ray or Gamma Radiation). The ANSI applies to the X-ray systems used to screen passengers at some airport and allows that level on the assumption that a person is likely to be scanned no more than 2,500 times a year.

That would be 10 times every single working day for a year. 0.1 µSv is an extremely low number and is actually quite hard to measure. The annual background exposure varies depending on location but is typically less than 1 mSv. That equates to just over 0.1 µSv an hour which means that going through the scanner only exposes the driver to the same amount of radiation he will have been exposed to naturally for one hour.

Radiation Shielding Walls

Radiation Shielding Walls will need to be installed by the customer to house the system and to limit radiation scatter. will be that of all the material in the path of the X-ray beam.

Example of Construction of Radiation Shielding Walls to house one Scanning Portal



Radiation Shielding Walls Layout

Radiation Safety Sub-System

Several sub-systems are dedicated to preventing unnecessary radiation exposure.

Cameras – CCTV cameras are used to ensure there is nobody in the controlled area during scanning. Being in the scan tunnel during a scan is mainly dangerous because there will be large trucks driving through it. The radiation exposure to someone inside the tunnel during a single scan will cause no harm.

Warning Lamps and Alarms – Warnings lamps that are visible from all around the system are on whenever X-rays are being emitted. Scanning operations cannot begin until the controlled area is clear of any personnel. A warning alarm is sounded and a warning lamp flashed for 10 seconds. That provides sufficient time for people to either leave the controlled area or press an E-Stop that will inhibit X-ray emissions.

E-Stops – The E-Stops are located at several locations both inside and at edge of the controlled area. A pull wire is located along the length of the shield wall so that an E-stop can be enabled from anywhere in the tunnel.
Pressing an E-Stop will immediately stop any X-ray emissions. Resetting an E-Stop will not result in the X-rays coming back on. That will only happen after a system restart.

Interlocks – Interlocks are used to prevent X-rays being emitted when radiation protection items are not in place. In the HXP the main example is the collimator, which can be moved to enable servicing of the Betatron. The Betatron cannot emit X-rays unless this are back in position. The doors to the source housing are also interlocked

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Environmental Performance

The system can operate at temperatures between – 30° and 50° C and humidity levels up to 95%.

Cooled air is passed along the length of the array using a dedicated HVAC unit, this both keeps the array temperature within acceptable levels and keeps the array dry which is particularly important. A separate HVAC unit is used to cool the source cabin. The Betatron is air–cooled so does not require a separate cooling unit.

Wind modelling has shown that the system will only deflect 1.7 mm in a 60–mph wind (96 Km/hr). This is well within the beam–width, so images will still be captured under those conditions. The system can operate in any wind conditions that it is safe to drive a truck.

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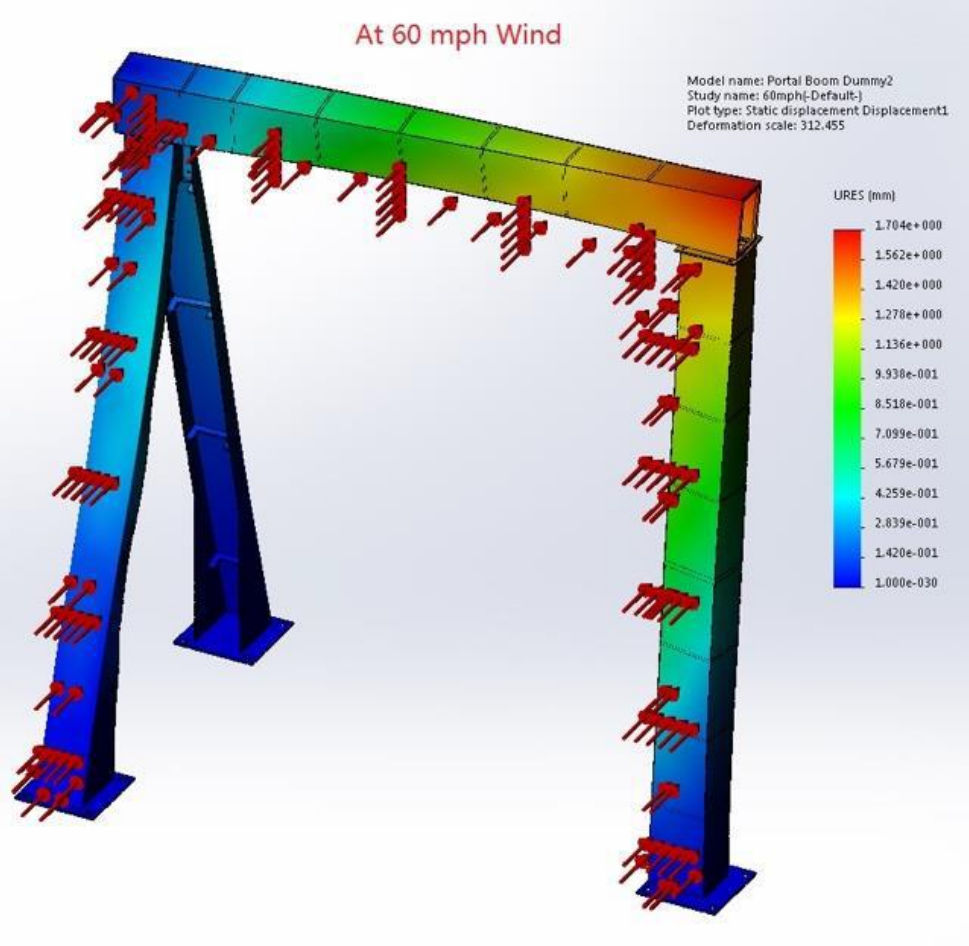

Electrical Power

Electrical Power – The system requires 3-phase 380V 14kVA 50Hz electrical supply, a voltage stabiliser is used to protect the system from fluctuations in local power.

Standby Power – The system computers will be protected by a UPS which both keeps them running if the power is interrupted and provides them with a constant voltage.

Diesel Generator – The customer can provide a diesel-powered generator that can be used to power the system if the local mains power it not available.

IT System

The IT system consists of a local server, a disc storage array and a number of workstations (such as check-in, image data acquisition, and image inspection), which are all connected via a network switch.

The server-based architecture means that it would be straightforward enable remote access via a dedicated network connection or through a VPN over an Internet connection.

A remote workstation could be used for image analysis or to monitor scanning activities.

The image analysis workstations can create a TIFF image of the processed image and also in other image formats such as BMP, JPG.

The customer control room where the IT server will be located can be up to 100 metres from the scanner, this distance can be increased by the customer by installing suitable switches and cabling.

The system uses several PCs, the specification of each one will vary slightly depending upon its role.

For example, the image server will use a RAID drive to minimize risk of losing archived images but does not need a powerful processor because it distributes images but does not process them.

The image inspection stations will use at least 3.2 GHz i7 processors but do not need large hard drives.

The RAM size will also vary depending on function.

The image inspection stations will use 8 MB.

All of the PCs use the Windows 7 operating system.

Images will be displayed using 23 inch or larger monitors.

A networked colour laser printer will allow hard copies of images to be made.

It will be possible to connect the system to an external network to allow data and images to be accessed remotely.

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System Installation

The installation of the system and its associated facilities takes place in three phases. The customer lays a concrete base to support the system and then builds the concrete shield walls and utilities such as electrical power is installed. If the customer does not already have a control room in close proximity to the system, the customer will construct a building to house the operators.

Once the walls are in place and power is available the system can be installed the base plates are precisely positioned and levelled where the array housing and source housing will be located. The source housing is then installed, followed by the vertical portions of the array housing, which are then bolted to their base plates. This is then followed by the horizontal array housing. Lasers are used to ensure the various sections are correctly aligned.

The Betatron and leakage shielding can then be installed, the vehicle position and speed sensors are installed on the shield walls. Prior to any commissioning work a radiation survey is carried out with the Betatron switched on, the purpose of the survey is to ensure that there are no unexpected hot spots due to unseen voids in the concrete shielding or damage to shielding on the system during shipping.

The Imaging performance will be checked with an ANSI N42.46 test piece modified to include the wire visibility requirements in the requirement specification.

Compliance

System Compliance to International Standards – There are no internationally agreed approvals or certifications that dictate the requirements of high-energy cargo screening systems. There are however several standards that apply to them that the system meets.

Radiation Limits – The ICRP 103 (International Council for Radiological Protection) recommends an exposure limit of 1 mSv per year for members of the public and an average of 20 mSv per year over 5 years with no more than 50 mSv in any one year of occupational workers.

Occupational workers are defined as those who are knowingly exposed to radiation as part of their jobs. Some countries classify the operators of cargo scanners as occupational workers however on most countries the levels applicable to the public are applied. Paragraph 2 of Article 13 of European Union Council Directive 96/29/EURATOM also limits public exposure to 1 mSv/yr. The US EPA (Environmental Protection Agency) also limits public exposure to 1 mSv/yr.

Each individual high-energy system is tested for radiation safety rather than relying on a type certification. This is because the system is relying on concrete for radiation shielding and this concrete is typically procured and erected locally. There are therefore likely to be differences between individual systems. Radiation safety and certification requirements can also vary between countries, certification in one country does not necessary meet the certification requirements of another. The system meets the ICRP 103, EPA and EU Council requirements for exposure to the public i.e. no more than 1 mSv/yr.

Testing – There are two published standards for the testing of high-energy cargo screening systems: –

- ANSI 42.46-2008 American National Standard for Determination of the Imaging Performance of X-Ray and Gamma Systems for Cargo and Vehicle Security Screening
- IEC 62523 2010-06 Radiation protection instrumentation – Cargo/Vehicle radiographic inspection system

Neither standard defines performance requirements, but they define how imaging performance should be tested. Both adopt a similar approach. Although it is an American Standard the ANSI is the most widely used internationally.

Health & Safety

Compliant with ANSI N43.17 for screening of personnel with X-rays.
Compliant with ICRP 103, Paragraph 2 of Article 13 of EU Council Directive 96/29/EURATOM, and United States EPA public exposure limits. (TotalScan is an exception because EU does not allow scanning of the public).
Compliant with United States FDA and WHO food screening limits.
Typical radiation leakage is 0.003 mSv to cargo and 0.06 uSv to the cab drivers.

Container X-Ray Scanning Portal

WESTMINSTER GROUP PLC

Specifications

General Specifications

Tunnel Size: W 3.75 m x H 5.00 m
Dimensions: L17 m x W 12 m x H 5.5 m
Maximum Vehicle Size: W3.5 m x H4.85 m
Net Weight: 7,257.5 kg – 16,000 lbs;
Scanning Speed: Nominal 8 km/hr ,Capable 1 km/hr – 7mph;
Throughput: 150 trucks per hour.

Detectors

Cadmium Tungstate Scintillator/Photomultiplier;
18-bit Digitation;
Steel Penetration: 320 mm;
Spatial Resolution: 5 mm.

X-Ray Generator

Energy: 7.5 MeV;
Beam Direction: Horizontally Sideward.

Computer & Video

Platform: Windows® OS;
Dual 28" Flat panel colour Monitors, One 19" Colour Monitor
Display Resolution: 4K Resolution.

Installation & Environmental

Exclusion Zone: None if concrete shield walls installed;
Operating Temperature: -10°C – 50°C ;
Storage Temperature: -20°C – 60°C
Humidity: 0 to 95% Non-Condensing.

Electrical

Power Requirements: 380 VAC, 50 Hz, Three Phase;
Power Consumption: 14 kVA.

Standard Features

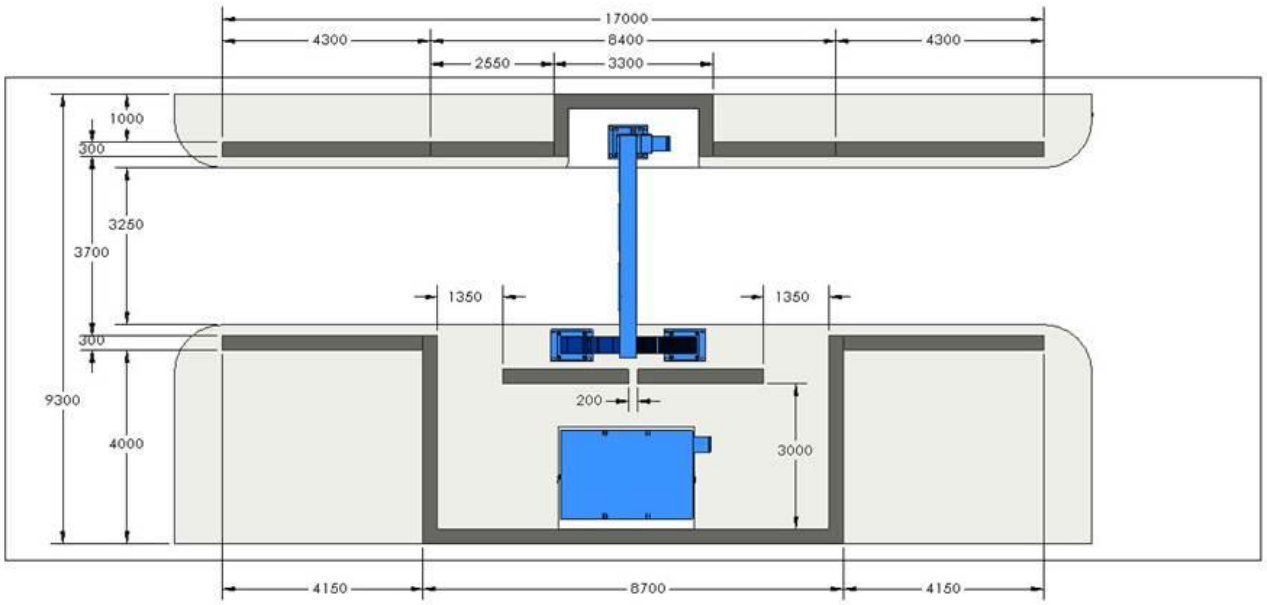
Auto Image Archiving ▪ Material Discrimination;
CCTV Camera System ▪ Multi-Tier Accessibility;
Colour and Black/White Imaging;
Continuous Zoom up to 64x;
Control Pedestal;
Display Workstation;
Image Annotation;
Image Review;
Image Server;
Inspection Workstation up to 100 m away;
Manual Bitmap Archive;
Networkable;
Operator Workstation;
Picture Perfect Imaging;
Print Image Capable;
Pseudo Colour;
Real-time Diagnostics;
Reverse Monochrome
Speedometer;
Vehicle Counter.

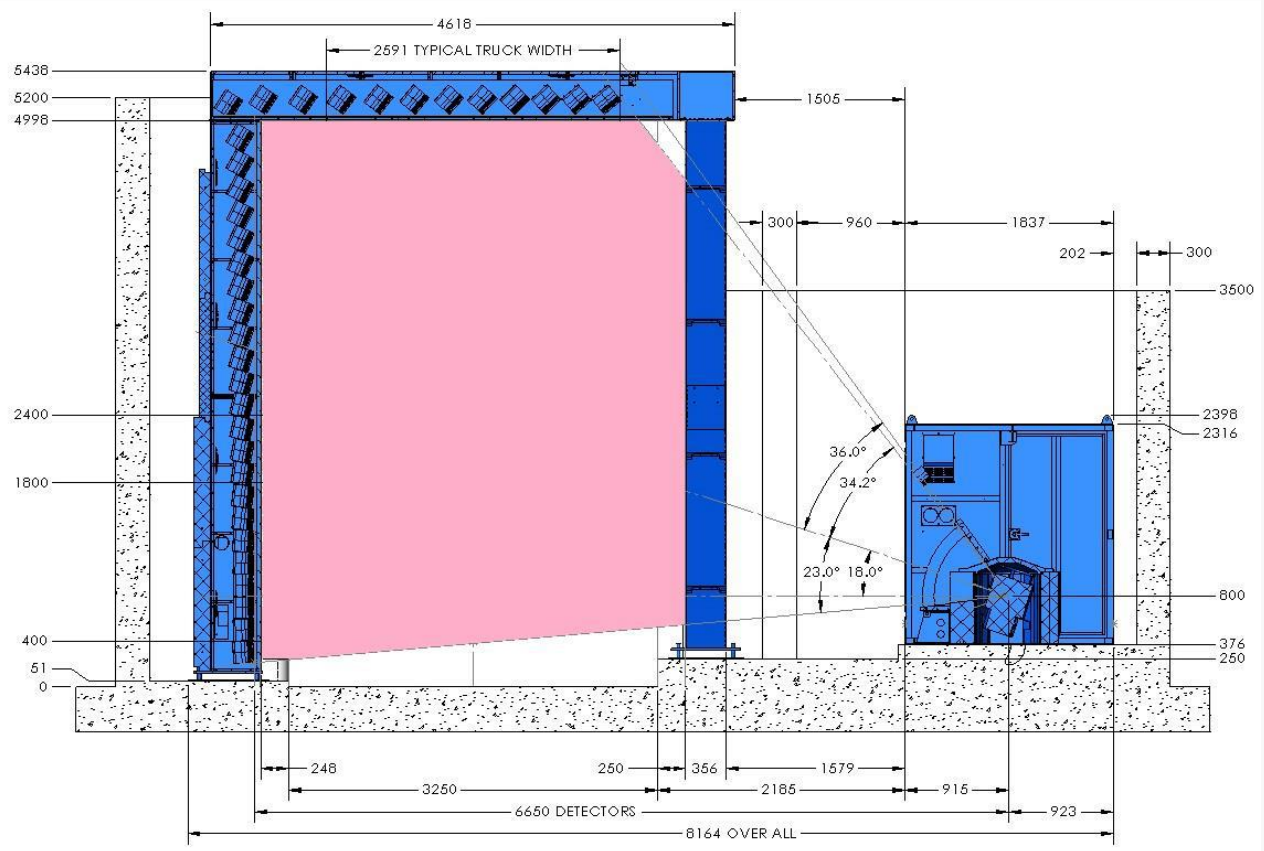
Optional Features

Additional Image Analysis Workstations;
Container Number Reader;
Custom Paint;
Extreme Climate Operating Kit Upgrade;
License/Number Plate Reader;
Local language Support;
Material Discrimination;
Operator Training;
Organic/Inorganic Imaging;
Polar kit: 2 x low temperature A/C with built-in heater, additional insulation;
Radiation Meter;
Radioactive Material Detection;
Remote Inspection Workstation;
Traffic Signals;
Tropical Kit;
Truck License Number Reader;
Truck Photo Storage;
Under Vehicle Inspection System (UVIS

Container X-Ray Scanning Portal

Dimensions





Customer Responsibilities

A concrete base is laid to support the system, the concrete shield walls are then built and utilities such as electrical power brought to facility.

The building housing the operator room can be built / located at the same time.

(Note: A Control Room is not included with this system, it is assumed that this is already in existence or it will be provided by the customer).

Customer Responsibilities

Once the walls are in place and power is available the portal itself can be installed.

Base plates are precisely positioned and levelled where the array housing and source housing will be located.

The source housing is then installed, followed by the vertical portions of the array housing, which are then bolted to their base plates.

This is followed by the horizontal array housing lasers are used to ensure the various sections are correctly aligned. The Betatron and leakage shielding is then installed. The vehicle position and speed sensors are installed on the shield walls.

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Export Licensing

Note: The supply of the Container X-Ray Scanning Portal is subject to Export Licences being granted.