SECTION 5 - THE RADIOGRAPHY SYSTEM

CONTENTS

A - The Radiography System

1. General

1.1 The core of the site, designated for cargo inspections, is the Radiography system creating images to be interpreted by the operators.

1.2 Stationary - The facility of the X-ray system shall be a stationary one, in a designated fixed structure including the radiation tunnel with radiation shielding doors, operational and managerial rooms.

1.3 Gantry - The system shall be based on Gantry architecture: one horizontal radiography layout.

1.4 High Energy X-ray - The main Radiography system shall generate images using high energy x-ray radiation

1.5 Material Discrimination – The proposed imaging system shall include material discrimination features enabling differentiation between organic and inorganic materials.

1.6 System main components:

The system shall include, at least:

1.6.1 An X-ray emission subsystem:

1.6.2 An X-ray detection subsystem, sensitive to X-rays, which produces digitized information corresponding to the detected radiation;

1.6.3 Command and control subsystem; including the processing subsystem to process the digitized information and output this information in the form of high-definition images;

1.6.4 The radiography system shall operate in a way providing automatic co-ordination of these subsystems, independently of any other facility systems, including the power supply system.

1.7 System's minimal performances are defined in this document.

1.8 System description - A detailed description will be provided in Bidder's proposal, including specific reference to the following issues:

1.8.1 System architecture, subsystems

1.8.2 System operation

1.8.3 Image Workstation: hardware, software, operation

1.8.4 Data Architecture, linkage to all subsystems

1.8.5 Material Discrimination feature

1.8.6 Image Processing Tools

1.8.7 System Performance

2. Radiography system Minimal Requirements

2.1 The System Minimum Performance will be expressed in the following parameters (as defined in this document) Ultimate Penetration, Resolution, Contrast, Material Discrimination and Throughput.

2.1.1 Ultimate Penetration

2.1.1.1 The Ultimate Penetration shall be at least 400mm at least at two out of the 9 defined positions.

2.1.2 Resolution

2.1.2.1 Wire resolution, when measured at the middle of the container at height corresponding to the center of the beam (or best position) will be, at least:

- 2% for 100mm clutter (2mm wire behind 100mm)
- 2.5% for 200mm clutter (5mm wire behind 200mm)

2.1.3 Throughput

2.1.3.1 The Radiography system will be able to inspect at least 20 trucks / hour.

2.1.4 Material Discrimination; proven and verified capability of material discrimination, as defined here and after in this document

2.1.5 Bidder's System Performance - Obligatory

2.1.5.1 The bidder is requested to submit the following table, referring to system performance, expressed in the defined parameters according to the test

methodology as defined in this document.

Position	a	b	c	d	e	f	g	h	i
Penetration (mm)									
Value									
Wire IQI (%)									
Behind 50mm									
Behind 100mm									
Behind 150mm									
Behind 200mm									
Behind 250mm									
Behind 300mm									
Hole IQI (%)									
Behind 50mm									
Behind 100mm									
Behind 150mm									
Behind 200mm									
Behind 250mm									
Behind 300mm									

2.1.5.2 Basic Material discrimination capability at each of the 9 defined location.

Position	a	b	c	d	e	f	g	h	i
Basic									

3. System Operational Requirements

3.1 Inspected Objects types

The radiography system shall be able to scan and image the following objects:

3.1.1 Container on truck

The system must be capable of screening hi-cube ISO containers loaded on trucks, usually standard 20ft or 40 ft containers.

3.1.2 Cargo loaded on Truck/flatbed

Pallets loaded on trucks or pickups shall be inspected

3.2 Scan dimensions

3.2.1 The layout of the radiography system should be optimized for the objects having the following dimensions:

3.2.1.1 Min. height - 0.3 m above ground level

3.2.1.2 Max. Height - 4.8 m

3.2.1.3 Width - 2.8m

3.2.1.4 Length - 40ft (12m) container, total length of 20m.

3.2.2 Height alert system will be supplied and installed – device location and indications TBD at DR

3.2.3 For each of the above mentioned objects the radiography image shall be displayed in full on the screen without distortion or corner cut-off.

3.2.4 The bidder shall describe the scan procedures adapted for each case, including particulars of operator's required operations and of the provided means (for example: ramp, etc) in order to acquire the optimal image of each object.

3.3 Scanning procedure

3.3.1 The scanning process must enable a continuous flow of trucks

3.3.2 One screening cycle, in standard operation, will comprise of screening two (2) objects, for example: two 40 ft long containers loaded on two trucks (each of up to 20 m length, including truck cabin) and positioned one after the other in the radiation tunnel.

3.3.3 While screening two (2) trucks the system will display each shipment as a separate image. (Each loaded truck has a specific Shipment ID).

3.3.4 While screening "Full trailer" (Truck with two containers on separate beds) the system will display the whole truck as one image.

3.3.5 In addition to the above configuration, scanning procedure shall be optimized (with reference to scan time, radiation, etc.) for operations when only one object is positioned in the tunnel. Example: while screening one (1) regular truck the screening process will end at the end of the truck and the "gantry" will proceed to the end point of the rail without emitting x-ray radiation.

3.3.6 The system shall afford screening in both directions: either forward or backward without performance degradation.

3.3.7 Metal traffic guide bars (steel pipe) shall be supplied and installed along the traffic lane, protecting the scanner from damage. Indication lines for traffic lane and “STOP” sign shall be marked on the ground.

3.4 The duty cycle of the radiography system should be not less than 100% for 16 hours/day 5 1/2 days/week.

3.5 The availability of the system should be not less than 95%.

3.6 The System must meet the following minimum performance criteria under normal working conditions:

3.6.1 Time to turn on the system shall not exceed 30 minutes.

3.6.2 The throughput of the system for 40ft long containers in the standard configuration; two objects (40ft long containers on trucks) shall be not less than 20/h.

3.7 Environmental Conditions

3.7.1 The system must operate under Israeli climatic conditions.

3.7.2 Operational ambient temperature: minimum temperature of 0°C and maximum temperature of 50°C (0°C to 50°C). The average summer temperature is 45°C. The maximum measured temperature is 49°C

3.7.3 The system must function normally and without impact on its performance at humidity levels between and including 10% to 98%.

3.8 The system must be moisture, dust and sand resistant.

3.9 The contractor will be obliged to supply a declaration confirming compliance of the system with Israeli law, regulations and requirements including by the Israeli Ministry of Environmental Protection.

3.10 Electricity

3.10.1 System's feeding electricity will be based on E-chain or other feeding system approved by the customer at the design reviews.

3.10.2 An air-conditioned power room will be provided for all required electricity components, as well as a UPS, in an air-conditioned room, for all radiography system needs.

3.10.3 The supplied UPS will allow completion of the scanning session in case of electrical failure and proper shutdown of the system, at least for 15 minutes.

3.10.4 As previously stated, all data transfer communication between system's components, including all relevant, items will be based on Optic fiber as defined.

4. Geometry of the Radiography System

4.1 The Bidder shall design system's geometry so that all operational requirements shall be achieved.

4.2 The layout of the radiography system shall be optimized to image the specified objects, for example: height from 0.3m to 4.8 m, width: 2.8m and container length of a 40ft- total length of one object: 20 m.

4.3 Positioning of the X-ray Emission unit and the detector array will be adapted so that any object positioned in the tunnel will be scanned and imaged in full without corner cut-off.

4.4 The Bidder will optimally design the position of radiation beams centers relative to the center of the X-rayed object to achieve best system performance as expressed in each one of the acquired images. As needed, beam symmetry will be corrected by electronic correction.

4.5 The system will be designed so that beam angle opening will be minimum, taking into consideration scanning system horizontal dimension on one side and performance requirements on the other.

4.6 The Radiography system includes:

4.6.1 X-ray emission subsystem

4.6.2 Detector Array

4.6.3 Screening system

4.7 The radiography system will provide automatic coordinated operation of all the subsystem, including the facility subsystems working independently

5. The X-Ray Emission Subsystem

5.1 The proposal will include a detailed technical description of the radiation emission subsystem, referring to each one of the specified issues:

5.1.1 Control and management (automatic)

The X-ray emission subsystem will consist of high-stability radiation sources (one or more according to Bidder's specific system) automatically controlled and managed with manual control maintenance and a friendly user interface.

5.1.2 Source Energy - adequate to provide the required radiation dose to achieve the required penetration

The X-ray emission subsystem will enable high penetration by using electron linear accelerators (Linac type) with energy of at least 6 MeV (highest mode).

5.1.3 Modes of Operation – Material Discrimination

Bidder's proposal will include a detailed description of the proposed X-ray emission subsystem operational modes, required to enable material discrimination capability, either by operation at dual-energies: generating images at two energies, or other.

5.1.4 Source Power consumption - The accelerators should have low power consumption, be able to be switched on/off whenever it is needed and as compact in size as possible.

5.1.5 Focal spot - The focal spot of the high energy X-ray generator will be as small as possible, not larger than 2mm.

5.1.6 Collimation subsystem - in order to optimize the coverage of the height of the detector arrays, while minimizing the “cross talk” effect and radiation dose in the inspection tunnel.

5.2 The Maximum Absorbed Dose per inspection will be less than 10mR (100µGy) measured at center of testing position.

5.3 The X-ray generators will include protection against an uncontrolled rise in temperature above the permitted working temperature to enable continuous use of the system at a very high capacity, and with minimal wear and tear.

5.4 The lifetime expectation of the X-ray generators operated in a duty cycle of 100% for 16 hours a day, 6 days a week, will be at least 10 years with adequate maintenance and component replacement program.

5.5 The x-ray emission subsystem shall comply at least with the following:

5.5.1 Manufactured by a worldwide leading producer of linear accelerators with proven experience in manufacture and sell of more than 10 years

5.5.2 The proposed model will have a confirmed and reliable history of operational use for at least two years

6. The Detector Array

6.1 The Bidder shall specify detector's type and provide detector's parameters affecting their performance, including, among other parameters:

- Number of arrays - requiredto minimize image distortion in the proposed geometry, based on object dimensions and considerations relating to the “Gantry” system architecture.
- Detector type / array

- Detector size; detector size facing the X-ray beam shall be not larger than 5 mm x 5 mm
- Number of detectors / array / module – to form images in the required resolution and without loss of information
- Array design
- Spectral response
- Dynamic range - to ensure reasonable image quality in dense zones where transmitted radiation flux is small.
- Temporal response
- Detector Collimation;
- Environmental effects (temperature, humidity, electrical interference, etc);

6.2 The proposal will specify the mounting architecture of the detector modules, manual treatment required and replacement method in the case of service.

6.2.1 The detector array will be arranged in a high-resolution linear geometry, to prevent image distortion. The detector array will be continuous, with a standard diffusion of the detectors without spaces between the detectors or between the modules, which may cause distortions or deficiencies in the X-ray image of the screened object.

6.2.2 The detectors will not need to be manually treated at all during 16 successive hours of daily operation.

6.3 The Electronics of the Detector Array

6.3.1 The Bidder proposal will describe the number of bits corresponding to the useful signal (signal/noise ratio or with/without beam signal).

6.3.2 The proposal will specify technique used to send the digitized signals for processing at the processing sub-system, detailing methods used to reduce the influence of any electromagnetic background and to exclude mutual interference by radiation leakage and scattered radiation, warning messages, etc.

6.3.3 Real-time diagnostic system and warning messages, designated to monitor and represent detectors status and performance quality, will be detailed in the proposal.

The Bidder will specify the technique used to reduce the influence of any electromagnetic background and to exclude mutual interference by radiation leakage and scattered radiation.

6.3.4 Bidder will specify the lifetime expectation of the X-ray detectors operated in a duty cycle of 100% for 16 hours a day, 6 days a week, and with adequate maintenance and component replacement program

7. Scanning subsystem

7.1 General

Image acquisition of an object is achieved as a result of a relative movement of two systems: the x-ray set, comprising of the x-ray accelerator and detector array, and the object to be imaged.

7.2 Gantry System

X-ray system, as specified in this SOW will be a "Gantry" based system.

7.2.1 The scanning method will be comprised of a moveable gantry with the x-ray system fastened to it, while moving along the static objects.

7.3 As per Bidder design, the scanning system may include rails (fixed on the concrete surface) with the scanning units mounted on it, if so required for smoother and faster inspection.

7.4 Scan routine procedure

7.4.1 Standard scan routine shall be based on one scan, either forward or backward, of the two (2) loaded trucks positioned in a row, one after the other, in the radiation tunnel.

7.4.2 All images required for images analysis, including images part of material discrimination process, will be created in one scan.

7.4.3 The system shall afford both forward and reverse scanning modes.

7.4.4 The system should be able to detect the length and number of objects positioned in the tunnel to be scanned and accordingly, to adapt the scan length. In this procedure, when only one object is positioned in the tunnel, the scan will halt after completing its irradiation.

The main advantage of this object adapted scan procedure will be reducing of irradiation time, dose and accelerator operation.

7.5 Scan velocity

In order to achieve high throughput a variable constant velocity is required:

7.5.1 Nominal (standard) – Bidder specification for the required performance of the system;

7.5.2 High velocity – higher than the nominal (Bidder's specification); to be used for higher throughput in case of low density objects

7.6 The Bidder will provide detailed description of the offered scan system, including specifications referring to its parameters, including among others, the following:

- System Architecture (concept, reasons, advantages and disadvantages)
- System Weight;
- Dimensions: Vertical and horizontal distances;
- System’s movement command and control system;
- Scanning velocities;
- Scanning stability;
- Characteristic times (while changing scanning mode);
- Operational Options
- Power requirements

8. Command and Control Subsystem

8.1 The major function of the command and control subsystem is to control each of the subsystems and the system as a whole by taking responsibility for the communication and coordination within all parts of the system and between the components of the system and the host systems.

8.2 The control and command sequence starts with the completion of scanning of a container. It will build up a corresponding processing queue and files of the

transmitted information. The sequence control indicates that an IAW is ready to receive the images and data of a container for evaluation.

8.3 When several IAW s are in use, a pipeline operation is a necessity.

8.4 The Image Command and Control subsystem will make it possible to examine the image and data of a container while the next one is being inspected, and the Radiography images of a previously inspected unit is at the same time awaiting examination. At the same time there may also be one or more units being rechecked because suspicious items have been detected on the Radiography images.

8.5 The data processing system must support the pipeline operation.

8.6 Any image stored in the system shall be designated to any IAW in order to increase the system's flexibility of use. Without any intervention, the next image to be examined is transmitted to the first free IAW.

8.7 Cargo’s data will be linked to all Radiography images. Depending on the decision being "suspicious" or "non-suspicious", the Image Command and Control subsystem directs the data either to the workstation at the manual search facility, where the marked images can appear on the screen and/or on video printouts, or immediately to the archive system.

8.8 Each operation (storage, visualization) shall be stored in the Image processing system’s logbook to enable tagging of the processing done by a given operator on a given image.

8.9 One of the standard features of the system will be the possibility of image and data transfer from the IAW for archiving purposes and for future reference.

8.10 The Image Processing command and control subsystem will provide the all IAW with free and immediate access of the following information:

8.10.1 Real-time Radiography images and data;

8.10.2 Radiography images and data from Archive

9. Material Discrimination Capability

9.1 General

9.1.1 Visual analysis of x-ray images acquired in x-ray inspection technology based on transmitted radiation only has a limited capability for identifying materials within the cargo. Specifically, detecting contraband covered or shadowed by shielding materials.

Today, one of the means deployed in order to enhance operator's capability, in addition to the traditional radiography, is based on material discrimination.

9.1.2 Material discrimination feature, including the basic and operational tests as defined in this document, is a mandatory requirement and shall be deployed as part of the proposed system.

9.1.3 Generally, the term of "material discrimination" corresponds to the ability, either to enhance organic materials, and/or to identify, in areas of the inspected cargo, the effective atomic number (Z) of the content and to correlate it to groups of materials: organic, metallic, heavy metals, etc.

9.1.4 Evaluation of the effective atomic number results from the fact that the x-ray attenuation factor - μ (E, Z) (as result of absorption and/or scatter processes), depend on the x-ray energy (E) and on material's atomic number (Z). Therefore, using adequate, sophisticated image fusion algorithm the effective atomic number can be estimated from comparisons of pairs of images: x-ray transmittance images acquired at various, at least two, predefined energies or from comparisons of transmittance images and scattered radiation images.

9.2 Bidder's proposal shall include detailed description of the proposed material discrimination feature that shall be implemented as part of the inspection system, with specific reference to the following topics.

9.2.1 Method

9.2.1.1 Basic technological and theoretical approach, including Bidder's approach detailing the advantages / disadvantages of the preferred method that will be

implemented in the system:

- Chosen X-ray Energies

9.2.2 Application Method

9.2.2.1 Description of the proposed solution, including technical details of the system, referring to the following topics:

- Method to implementation: imaging at two (2) chosen energies or other (two sources/ other)
- Considerations (pros/cons)

9.2.2.2 System Hardware – implemented in the system

- Accelerator / accelerators type
- Alternating energies
- Detectors technical specifications (type, number of arrays, detector/ array, etc)
- Image workstation (IAW) additional hardware, ex: displayed Image/ images (type, number, etc.)

9.2.2.3 Operational issues (scan routine, scanning options)

9.2.2.4 Algorithm and processing features (groups coloring, etc)

10. System Workstations

10.1 General

10.1.1 Each work station will include all the necessary infrastructure, hardware and software needed for the proper operation of the systems according to the operational flow process and requirements as described in Section 3.

10.1.2 The following sections describe system's various work stations and their minimal required content.

10.1.3 The bidder is obligated to describe each work stations and detail its content and capabilities in his proposal.

10.2 Radiography System Operators' Workstations

10.2.1 General

10.2.1.1 Operators' main room (in Radiography Building) will comprise of, at least, the following workstations:

- System Operator
- Image Analysts – three (3)
- Training (stand alone)

10.3 The workspace will be designed considering human engineering principles.

10.4 System Operator (SO)

10.4.1 The system will include a control and monitoring workstation that will enable operation and monitoring of the radiography system status.

10.4.2 The workstation will operate in real-time mode.

10.4.3 The provided information will be comprehensive and include:

10.4.3.1 Scanning speed

10.4.3.2 X-ray emission status.

10.4.3.3 Scanning Mode (Single / Dual Energy / other)

10.4.3.4 Subsystem Status

10.4.3.5 Radiation Safety Status, including all Interlocks and doors status

10.4.3.6 CCTV display of the tunnel

10.4.3.7 Error or warning indicators

10.4.3.8 Errors messages will be clearly presented.

10.4.3.9 The system operator workstation will enable full diagnosis of system malfunctions.

10.4.4 Radiography System Controls

10.4.4.1 The operator’s workstation should provide to the greatest possible extent, automatic operations, minimizing manual intervention

10.4.4.2 The system operator workstation will enable parameters to be set based on the technician access authorization.

10.4.4.3 The system must be user-friendly.

10.4.4.4 All controls and screens will be in English. The system shall support Hebrew, including Hebrew/English character keyboard.

10.4.4.5 All physical labeling on the work station will be in English and Hebrew with heavy duty labels.

10.4.4.6 Operational procedures and controls must be clear, without any ambiguity.

10.4.4.7 Operational activities will be displayed and monitored on the operator's workstation.

10.4.4.8 The system will be self-protective, so that operator errors will not damage the system or scanning procedures.

10.4.5 Receptionist Workstation

10.4.5.1 The Receptionist WS is part of system's operation WS and will be operated by the system operator.

It enables performance of the following:

10.4.5.2 Opening / closing the doors of the radiography tunnel (after directing the trucks, using PA system, into the required positions inside the tunnel).

10.4.5.3 Supervising the drivers, using the CCTV display, out of the tunnel and confirming no one is in the tunnel

10.4.5.4 Verification of Drivers ID tags

10.4.5.5 Authorize start of the screening process

10.4.5.6 At the end of screening procedure, supervise the drivers return to the trucks and out of the tunnel, while directing the next trucks in queue to the correct positions.

10.4.6 The receptionist's role (function and responsibility) will be performed by the operator of the radiography system: the tasks of the receptionist and system

operator united. Therefore operators/receptionist workstation shall have all devices and subsystems defined for operations of these functions.

10.4.7 The workstation includes, at least:

10.4.7.1 Radiography System controls

10.4.7.2 CCTV

10.4.7.3 SDMS WS

10.4.7.4 Drivers tag reader

10.4.7.5 Customs computer

10.4.7.6 PA

10.5 **Image Analyst Work station** (IAW)

10.5.1 General scope

10.5.1.1 The Radiography inspection system includes the supply of six IAWs: three (3) routine Image Workstations, one Training WS and two (2) at the Recheck (manual) building. This configuration will assure inspection throughput rates, even during high traffic hours, while enabling a thorough examination of each image.

10.5.1.2 The digitized signals from the data acquisition electronics of the Detector Array/arrays will processed in real time to produce one or more images of the scanned object (as per Bidder specific system).

10.5.1.3 The images (at least at 16 bit) shall be available less than 3 seconds after the end of the image acquisition process

10.5.1.4 The radiography transmission images, linked to the computerized data file of the cargo, will be routed to one of the 3 Image Analyst Workstations (IAW).

10.5.1.5 At the IAW, the Image Operator's task is to examine the acquired radiographic images of the cargo, each one on a screen, using Bidder's image processing tools.

10.5.1.6 The information in the data file linked to the specific cargo, containing the shipment data: manifest, packing bill etc., assists the Image Analyst to verify

this information and to spot irregularities and anomalies while evaluating the actual radiography image

10.5.1.7 At the end of this process the image Operator enters the results of his evaluation into the examination data file. In case of suspicion, he marks the suspicious area in the image and enters a verbal description (input in Hebrew) of the reason and nature of the suspected area into the computerized data file of the scanned object. This accumulated data will be available for supervision and for further inspection at the Recheck Workstations located at the manual search installation.

10.5.2 Each IAW will be composed of these major components:

10.5.2.1 Images Display (dedicated screen with H/E characters keyboard and mouse) – quantity tailored to Bidder's specific system

10.5.2.2 Data Display (system's and Customs) and Processing

10.5.2.3 Storage of Images and Data

10.5.3 Image Display

The Image Display module shall be presented in the proposal with specific reference to the following issues:

10.5.3.1 The Image Display system of each IAW will be composed of dedicated monitors (consistent with number of the acquired images), a keyboard with Heb./Eng. characters and a mouse.

10.5.3.2 Display monitor

The following parameters will be specified in Bidder's proposal:

- Screen type, size, resolution
- Display frequency and colors.
- Additional features: flicker-free, anti-reflective, “human touch”, scratch protected.
- Compliance with regulations TCO99 / MTR.

10.5.3.3 Each image of the screened object will be displayed on a high resolution monitor, as will be customary at the time of deployment, at least: 24’’ for a LED

type (or equivalent) If feasible, the screens will be flicker-free and anti-reflective

10.5.3.4 Bidder's proposal shall include detailed description of proposed image displays and provided image manipulations.

10.5.4 Generally the screen comprises of the following main parts:

- Data & Menu bar
- Main image part
- Coordination / Overview window (Bottom / Top)

10.5.4.1 The control bar comprises of groups of functions offering information data, image processing, image manipulations and visualization tools.

10.5.4.2 The Data part of the Menu Bar contains information on the currently displayed image. It will display data needed for identification of the inspected object, including: date, time of x-ray, image number, inspection number, etc.

10.5.4.3 The Menu Bar will contain a graphic interface (as Icons), containing all the necessary commands for the activation of all available image manipulation modes,

10.5.5 Main window

10.5.5.1 The Main window of the screen displays, by default, the Overall (Global) Image of the scanned object.

10.5.5.2 The Image Analyst will be able to select a particular zone or portion of the whole Image (Local Image) and utilize all the various basic or advanced image manipulation modes. In that case, the Local Image will be displayed on the Main window in full resolution.

10.5.6 Coordination (orientation) window

10.5.6.1 The Bottom/Top window of the screen will display the Overview Image, while the Local Image is being displayed in the Main field. The Local Image outline will be marked for orientation on the Coordination Image by a highlighted frame.

10.5.6.2 Time for obtaining a local image after selection of a zone on the global image

shall be immediately.

10.5.6.3 The graphic interfaces will be activated by a. mouse on the Icons.

10.5.7 Image Manipulation Features

10.5.7.1 General

10.5.7.1.1 Image processing features available for the Image Analyst at the IAW shall be designed to meet two basic requirements:

- Support the Image Operator in detecting a large variety of contraband concealed in different types of goods;
- Enable the Image Operator to conduct an efficient image examination and interpretation and to reach a reliable decision as fast as possible;

10.5.7.1.2 The Bidder will submit a full technical and functional description of the processing image features, addressing each of the following desired image manipulation features in a detailed method.

10.5.7.1.3 Image processing features will be presented at the Design reviews meetings, subject for approval by the Customer.

10.5.7.2 Feature Activation: graphic interfaces - by a mouse or trackball on the Icons.

10.5.7.3 Independent application: if so desired, any image processing function can be applied independently, without pre-conditioning. (For example: gray scale modification / zoom etc.

10.5.7.4 Moveable Window

Image modification function will be applied in two modes:

10.5.7.4.1 On the whole image

10.5.7.4.2 On operator's pre-selected local zone (detail window)

In this mode, if applicable, the dynamic modifications will be performed continually sliding or resizing the selected “window” along the image.

10.5.7.5 ZOOM - local (in arbitrarily selected and varied in size window) image enlargements (zoom), on at least 3 levels: x2; x4; x8.

10.5.7.6 Pan and scroll - provide easy movement of the selected window within the displayed image.

10.5.7.7 Negative and mirror - reverse monochrome/mirror Radiography image.

10.5.7.8 Edge Enhancement - may provide an improved image definition and better identification of individual objects and items. For efficient work the function will be activated inside a screen window (detail window) of variable area as selected by the Image Analyst.

10.5.7.9 Contrast - to optimize the whole image as well as an operator pre-selected area:

10.5.7.9.1 Contrast modification of the whole image according to pre-selected zone as a calculation reference

10.5.7.9.2 Dynamic Gray-scale modification of a selected zone (detail window) with the middle of the window as a calculation reference, window size will be variable in size. For this, the image operator will adjust the contrast sensitivity by continually sliding a “window” along the image gray-scale.

10.5.7.9.3 The activation of different contrast modes (adapted to low / high/ very high radiation absorption) will be achieved by pointing the Contrast Icon in a down drop manner.

10.5.7.9.4 Image modification based on Histogram equalization function on operator-selected area will be provided.

10.5.7.10 High Density Alarm

10.5.7.10.1 A warning referring to an area in the screened object where the X-ray absorption level does not enable effective inspection of its contents (hereinafter: “High Density Alarm”).

10.5.7.10.2 The High Density Alarm will be displayed to the operator by flashing the corresponding area on the image displayed on the screen.

10.5.7.10.3 It will be possible to adjust the absorption level and the number of pixels which will activate the High Density Alarm to any level and size

10.5.7.10.4 Access to this adjustment will be protected by a password.

10.5.7.11 Marking the Suspicious Area

10.5.7.11.1 The feature is used to mark objects in the image, especially those that could not be identified or were found to be suspicious.

10.5.7.11.2 Marking method: position and size of the Suspect Designation Marking Window, pointing device i.e. mouse, trackball, colored frame

10.5.7.11.3 Adding Hebrew annotation, X and Y coordinates will be indicated on the image.

10.5.7.11.4 The marking will appear as a colored frame on the screen and on the hard copy printed by the video printer. The frame color will contrast with the image background.

10.5.7.11.5 After an area of the image has been marked, the Image Analyst will be able to switch off the mark that has appeared on the screen, to avoid interference with the examination of the rest of the image. The marked area coordinates will be stored with the image so it will be possible to show all the marked areas by a single command.

10.5.7.11.6 It will be possible for the Image Analyst to delete or add a marked area.

10.5.7.12 Measuring Displayed Objects - to measure the real size of an object displayed on the screen.

10.5.7.13 Split Screen

10.5.7.13.1 The function will enable simultaneously comparison of the current image with previous one (loaded from the archive)

10.5.7.14 Pseudo-Colors

10.5.7.14.1 The representation of the image by a wide range of the available combinations of colors and shades, in addition to the limited visible gray levels, may improve the visual contrast sensitivity.

10.5.7.14.2 Several preset color charts, each consisting of 256 different colors for the full gray scale, will be available to be selected by the Image Analyst.

10.5.7.14.3 Dynamic Gray-Scale Manipulation will be available for the Pseudo-color feature as described above.

10.5.7.15 Special Features

The bidder will implement further image processing features to support the Image Analyst in detecting a large variety of contraband, i.e. weapons, explosives, drugs concealed in different types of goods.

10.5.7.16 Material discrimination – while scanning in material discrimination mode the system will have the ability to display, at least:

10.5.7.16.1 Density image (gray levels).

10.5.7.16.2 Image of both Organic and Inorganic materials in different colors

10.5.7.16.3 Image of only Organic materials Highlighted in Orange color

10.5.7.16.4 Image of Inorganic materials Highlighted in Blue color

10.5.7.16.5 High Energy Image (image created at high energy)

10.5.7.16.6 Low Energy Image (density image created at low energy)

10.5.7.16.7 All image processing functions (as defined above) should work on the material discrimination image.

10.5.7.16.8 The proposal shall include description of:

- Material discrimination Software
- Reference image database
- Discrimination features of the proposed system:
  - Groups of materials discriminated (number and type: Organic, inorganic, light / heavy metals, unknown)
  - Display features, color coding

10.5.7.17 Pre-set Image Processing - Bidder's set of preset image processing adapted

for best visualization of the operator;

10.5.7.18 Image Comparison - loading a previously archived radiography images and data from Archive for comparison with currently analyzed image

10.5.7.19 Undo

10.5.7.19.1 Ability to return "one step" back of the image manipulation

10.5.7.19.2 Ability to the original scanned image by "one click"

10.5.7.20 Special Features- The bidder will implement further image processing features to support the Image Analyst as far as possible in detecting a large variety of contraband, i.e. weapons, explosives, drugs concealed in different types of goods

10.5.7.21 Print - ability to print the following:

10.5.7.21.1 Original scanned image

10.5.7.21.2 Processed image

10.5.7.21.3 Image displayed

10.5.7.21.4 All printing will include relevant details (date, time, analyzer's decision, etc.) and suspicious markings.

10.5.7.21.5 The proposal will include Laser color printer.

10.5.7.22 Save

10.5.7.22.1 The System will have the capability to save scanned images to a specific folder, defined by user, or to an external media (flash drive etc.)

10.5.7.22.2 Images will be saved as raw data or exported to known format (JPG, BPM etc.)

10.5.8 A detailed technical and functional description of the image processing features at the IAW, including the operating GUI, shall be submitted in the proposal.

10.5.9 The final design of the system, including the MMI will be subject to Client's approval at the Design Review meetings.

10.5.10 Pause – Operator that activates the pause option will assure that no new images will be send to that WS until he is back and the IAW is operational again.

10.5.11 Data Display

10.5.11.1 General

10.5.11.1.1 Each IAW includes Data and Image displays and processing. The workstation will be connected to the SDMS.

10.5.11.1.2 Data Display comprises of two separate parts, each displayed separately:

- Radiography Computerized Data File (connected to Radiography site's systems)
- Customs Computerized Data (part of Customs main Database) – displayed on Customs computer (supplied by the Customer -not part of this tender)

10.5.11.1.3 The Radiography Computerized Data File of the object will be automatically transmitted to the Data Display Apparatus simultaneously with the transmission of the Radiography images to the Image Displays.

10.5.11.1.4 The radiography data file will be displayed on a 24” LCD color monitor.

10.5.11.1.5 A user-friendly graphic Man Machine Interface will operate the Data Display and Processing equipment.

10.5.11.1.6 The Image Analyst operator will receive on the Data Displays a full and clear data containing all the relevant information on the scanned object and its contents. This information will include:

- Data scanned and keyed-in during the check-in process
- Additional data displayed in Customs Computer

The data will enable the operator to verify this information by comparing it with the real contents of the shipment/ object description, shown in the Radiographic image.

10.5.11.2 Validation area

10.5.11.2.1 The proposal will present detailed description for the application of the validation method consistent with the operational process and following the principles outlined hereafter.

10.5.11.2.2 At the end of the analysis process the Image operator will enter the result of his evaluation using a dialog box interface approach. When a graphic “Decision” button on the screen is clicked, a dialog box will show-up containing two graphic buttons:

- “**Suspicious**” (a symbol **(X)** in red)
- “**Non-Suspicious**” (symbol (√) in green)

10.5.11.2.3 "**Non-Suspicious**"

Clicking the **Non**-**Suspicious** button will activate a secondary dialog box containing the phrase:

- “**Are you sure**?” and two graphic buttons:
  - **"Confirm"**.
  - **"Cancel"**.

10.5.11.2.4 Confirming the non-suspicious decision will terminate the analysis process of that object and automatically initiate the following:

10.5.11.2.4.1 Reception of the next images and data pending in the queue on the IAW;

10.5.11.2.4.2 Traffic Control system (SDMS) will be automatically updated and notified that the cargo is cleared and allowed to exit the site

10.5.11.2.5 In addition, the operator will update the Customs Computer regarding the results.

10.5.11.2.6 “**Suspicious**"

10.5.11.2.6.1 Clicking the “**Suspicious**” will open a dialog box that will enforce the image analyst to indicate the reason for suspicion. An active file will be displayed and the Image Analyst is required to select from a list of categories one representing the type or reason for suspicion, key-in a verbal description and/or comments, and reference to a specific marked area (free form).

10.5.11.2.6.2 After completing entry of the data necessary for further handling of the suspicious object, the Image Analyst will be able to terminate the process and to automatically initiate the reception of the next pending image for analysis.

10.5.11.2.6.3 Traffic control system (SDMS) will be updated and notified that the truck/car are suspicious and are not allowed to exit the site

10.5.11.2.6.4 In this case (“Suspicious"="Send to Manual”), the accumulated data of the suspicious cargo will be transferred to the Image Analysis Workstation in the Manual area. The data, including a color hard copy printing of the image with the markings of the suspicious areas, will serve the inspectors at the manual inspection area to pursue the inspection and effectively allocate the suspicious items.

10.6 Manual Recheck Workstation (RCW)

10.6.1 The RC workstations: one (1) located at the manual inspection site and the other at pit office, display all radiographic images that were defined as suspicious by the Image Analyzer.

Based on these remarks the manual inspector / mechanics checks the object

10.6.2 Each workstation will include:

10.6.2.1 Image analyst workstation (IAW) as defined in this clause with adapted dialog box

10.6.2.2 Driver's tag reader, SDMS workstation, PA system

10.6.3 At the end of the examination the Manual Inspector/mechanics, using the RCW, will enter inspection results using a dialog box interface approach.

10.6.4 The dialog box will show-up containing two graphic buttons (in Hebrew), for example:

- “**Irregular"** (a symbol **(X)** in red)
- “**Clear**” (symbol **(√)** in green)

10.6.4.1 "Clear"

10.6.4.1.1 Clicking the "Clear" button will activate a secondary confirmation dialog box containing the phrase:

- “**Are you sure**?” and two graphic buttons:
  - **"Confirm"**.
  - **"Cancel"**.

10.6.4.1.2 Confirming the "clear" decision will terminate the inspection process of that object and automatically initiate the following:

- Traffic control system (SDMS) will be updated and notified that the truck/car's status is "cleared" and it is allowed to exit the site.

10.6.4.1.3 The operator will update the Customs computer regarding the results.

10.6.4.1.4 Manual check results submitted will be recorded in addition to the Image Analyst decision and will not replace it.

10.6.4.2 “**Irregular"**

10.6.4.2.1 Clicking the “**Irregular"** will open an active file in which the Inspector is required to select from a list of categories one representing the type or reason for the findings, key-in in freeform a verbal description and/or comments.

10.6.4.2.2 After completing entry of the data necessary for further handling of the object, the Inspector will be able to terminate the process.

10.6.4.2.3 Traffic control system (SDMS) will be updated and notified that the truck/car is not allowed to exit the site

10.6.4.2.4 The operator will update the Customs computer regarding the results

10.6.5 The data workstation will also serve as an interface for the Image Processing command and control subsystem, which will be managed by the Image Analyst during his assignment to the IAW (password, authorization, start, brake, etc.).

10.6.6 The final configuration of the dialog boxes will be defined by the customer at System Design Review.

10.7 Archive

10.7.1 The Archive module designated for storing all images, and its linked data, which were produced as result of site's inspections, will be detailed in Bidder's proposal.

The Archive database is required to afford:

- Future analysis and / or for future investigation purposes
- Comparison of real-time images and shipment data to previously inspected similar shipments;
- Statistics of system and operators performance

10.7.2 The proposal will include a detailed functional and technical description of the archive module hardware and software, with reference to the following issues.

10.7.3 The data base of the stored files for each inspected cargo shall include, at least, the following:

- The raw (pre-processed) radiography image;
- The data file of the cargo
- Inspection data: Analyzer's name, date, time
- Final Processed Image – the result of operator’s processing, initiated by the operator;
- Log file of Image Analyzer’s operations;

10.7.4 The archive subsystem will provide capabilities for storage, search, load, organization, export and retrieving data with extensive data capacities, taking into consideration the actual system throughput, the requested duty cycle, and the expected volumes for at least one year.

10.7.5 Search, export and report capabilities

10.7.5.1 The proposal will present system search capabilities and a detailed description of reports formation (defining report format, keywords, parameters, etc.)

10.7.5.2 This shall include search according to a large variety of keywords and parameters, for example at least the following:

- Inspection date, period
- Analyst name,
- Customs ID,
- Goods type
- Shipper's name
- Shipping date
- Goods origin
- Goods destination
- Sender, etc

The final parameters will be defined by the customer at System Design Review.

10.7.5.3 Data exporting: methods for extracting and publishing stored images/data using standard image formats (jpg, bmp, etc) and methods for evacuating storage space will be detailed.

10.7.6 Option for an analyst-training tool of the archive system, adaptable by the user on request, will be proposed.

10.7.7 The archive system will include an option to send cargo file (data and images) to a customer through the internet network, the specifications depend on the field of application and will have to be adjusted accordingly.

10.7.8 The bidder will submit a full and detailed functional and technical description of the proposed archive system including hardware, software, administration, performance and all other items.

10.7.9 The archive volume must support at least one (1) year of operations.

10.7.10 The archive system will include:

10.7.10.1 Storage unavailability warning

10.7.10.2 Routine for transferring the data to a removable storage device and freeing up

active storage space

10.7.10.3 Internal HD with one (1) year storage capability FIFO.

10.7.10.4 External HD with one (1) year storage capability

10.7.11 The system must include data backup function, including periodic back-up reminders.

10.8 Threat Image Projection - Option

10.8.1 The bidder will propose an option for a Threat Image Projection module. The function of this feature is to project a threat object radiography image into the real-time Radiography image of the container for the purpose of testing the alertness and skill of the Image Analyst.

10.8.2 The Threat Image Projection module will consist of a threat image database, administration software and a special algorithm enabling fast and realistic integration of the threat image into the real time container image.

10.8.3 The bidder will submit a full and detailed functional and technical description of the proposed Threat Image Projection module, including hardware, software, administration, performance and others.

11. Computerized Training System for Image Analysts

11.1 Training of Image Analysts is crucial since the Radiography scanning system can only be as effective as the level and skill of its Image Analysts.

11.2 The computerized training System, installed as a stand alone WS, should expose the trainee to a large variety of container images with and without a threat objects.

11.3 The system shall include a large variety of interactive lessons and tests designed to gradually upgrade the Image Analyst's skill. It will also enable an instructor to test and monitor the analyst's progress.

11.4 The system will be designed as an “open system” capable of adapting to any specific application. For that purpose it will be possible to input new images, update the image database, and prepare new lessons and tests.

11.5 The system will have the capability to load raw images from an external media (USB, Ext. HD)

11.6 The bidder will submit a full and detailed functional and technical description of the Training system, including hardware, software, administration, performance etc.

12. System access authorization levels

12.1 The system will have protection against viruses, spywares and malwares.

12.2 The system computers will not have remote access capability

12.3 The system shall include three defined access authorization levels - user, administrator and technician.

12.4 User Level

12.4.1 The system shall allow users to run only applications required for system operations, including archive system applications.

12.4.2 The system files and operating system shall be protected against alternations and deletions.

12.4.3 The user will not be authorized to copy or install any other software on the system.

12.4.4 Log-in shall be associated with user’s name or ID number. The system shall allow multiple log-ins, with each user assigned a separate personal log-in and password.

12.4.5 The Image Analyst's decision and Manual Inspector's findings will be documented with their names/id which will be saved with the cargo record, available for retrieval, if and when necessary.

12.5 Administrator Level

12.5.1 The Administrator level shall include all user level access authorizations.

12.5.2 Additionally, the administrator shall have access to:

- CD/DVD Burner
- Screening logs
- Managing user data base/authorizations
- Viewing system parameters
- Other authorizations, as decided by ITA/Customs.

12.5.3 The administrator will NOT be authorized to:

- Alter system parameters
- Alter/delete system files
- Copy or install any other software

12.6 Technician Level will have all levels of access.

12.7 In case the operating system software (such as Windows, UNIX etc.) version is not supported anymore, the vendor is obliged to upgrade the operating system to a newer version and accordingly the scanner software.

13. Stand-alone software

13.1 The vendor will supply 2 sets of stand-alone image analyzer work station software for the purpose of self-training or for instructor demonstration.

13.2 The stand-alone software will be completely identical to the system software.

13.3 In case of system software upgrading, the vendor will supply identical updated stand-alone software.

13.4 The software will have the capability to load raw images from an external media (USB, External HD).

14. Reliability and Availability

14.1 Radiographic System availability will be 95%.

14.2 The duty cycle of the facility will be as follows: 16 hours/day, 5 1/2 days a week, 52 weeks a year.

14.3 System Mean Time between Failures should be minimal in order to provide high reliability. The Contractor must include in the proposal statistical data of the proposed radiography system MTBF.

B - Radiographic System Performance Tests

1. General

1.1 Radiographic System Performance is defined as the quality of the Radiographic imaging displayed on the IAW image screens. These results from the individual performance qualities of the various subsystems: the X-ray radiation subsystem, the X-ray detectors, scan stability, data acquisition and processing electronics, computing and the images processing systems.

1.2 This section defines both the imaging performance of the system and the methods used to measure them.

1.3 The performance, the tools and test methodology described here are the only one effective for this project. All evaluation tests; the Verification tests, the Factory Acceptance Tests (FAT), the Preliminary Acceptance Test (prior to Training session) and the Final Acceptance Test, will be performed according to the Test Tools and Test Methodology detailed hereby.

1.4 The test results will be determined according to the common human observation capability of the screened test tools on the displayed image.

1.5 All image processing features available for real-time processing and manipulation of the image at the IAW may be used in determining the test results.

1.6 Scan Velocity

1.6.1 Test measurements will be performed at system's nominal scan velocity.

2. Ultimate Penetration

2.1 The definition of Ultimate Penetration for this tender will be: The maximum stainless steel (Type 300 series) clutter thickness through which a totally absorbing object can still be visible.

2.2 The Ultimate Penetration performance parameter represents the feasibility limit of the radiographic imaging of the system.

2.3 Test Tools for measuring the Ultimate Penetration

The Test Tool for measuring the Ultimate Penetration will consist of two parts:

2.3.1 Clutter

The clutter substance will comprise a series of stainless steel plates (Type 300 series) 400X300 mm^2 and 20; 10; 5 mm thick. The required specific clutter thickness will be achieved by combining steel plates with the cumulative thickness required for the measurement.

2.3.2 Target

2.3.3 The target object for this measurement will be a lead brick 50x100x200 mm^3.

2.4 Measurement Protocol for Ultimate Penetration

2.4.1 The Penetration will be measured by scanning the target against clutter thicknesses as written in the appendix: table of performance.

2.4.2 The target will be considered visible if 30% of it or more is observed when the displayed image is examined on screen utilizing the various image processing features.

2.4.3 Positioning the Test Tool

2.4.4 The Target lead brick will be affixed lengthwise to the clutter steel plates.

2.4.5 The Target will be placed on the source side of the clutter steel plates.

2.4.6 In each of the measuring spots described below, the Test Tool will be positioned so that the plane of the Test Tool will be perpendicular to the radiation beam.

2.4.7 The ultimate penetration will be measured in the following nine (9) positions:

a. At the point at which the bottom at the source side wall of the container is located during normal inspection of the container.

b. At the point at which the middle of the height at the source side wall of the container is located during normal inspection of the container.

c. At the point at which the top (roof) at the source side wall of the container is located during normal inspection of the container.

d. At the point at which the middle of the width of the bottom of the container is located during normal inspection of the container.

e. At the point at which the center of the container is located during normal inspection of the container.

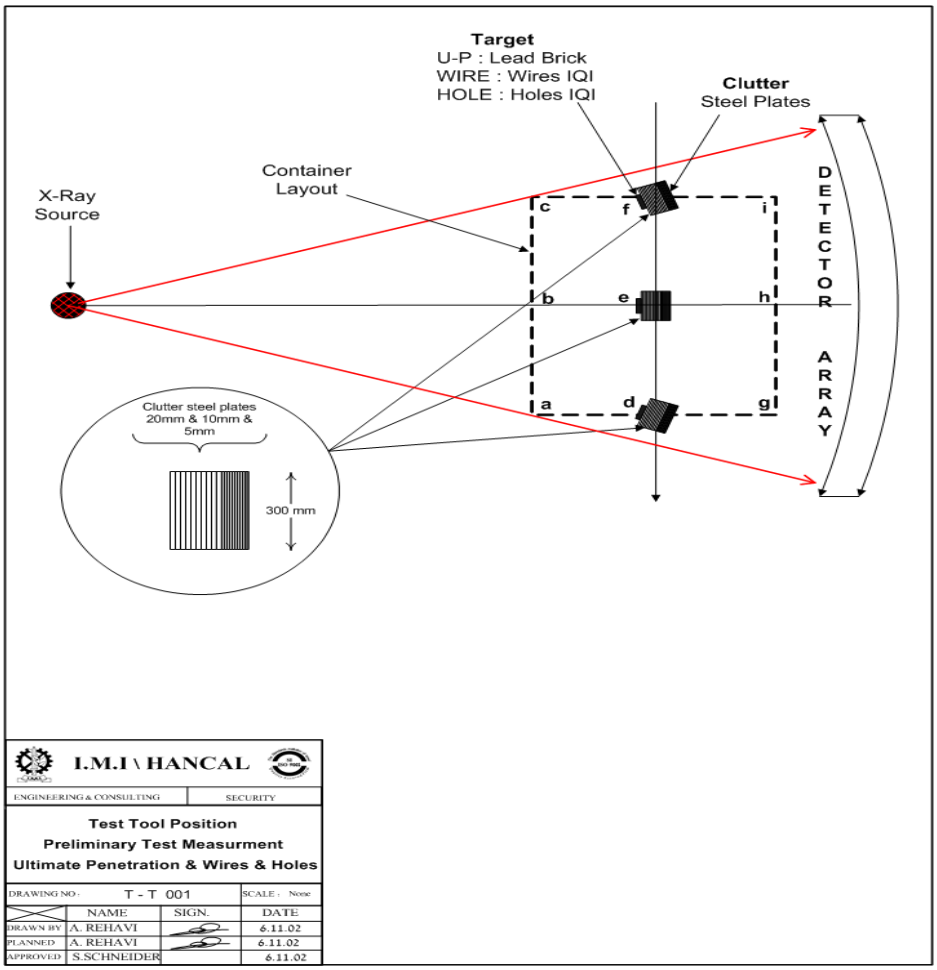
f. At the point at which the middle of the width of the top (roof) of the container is located during normal inspection of the container.

g. At the point at which the bottom at the detector side wall of the container is located during normal inspection of the container.

h. At the point at which the middle of the height at the detector side wall of the container is located during normal inspection of the container.

i. At the point at which the top (roof) at the detector side wall of the container is located during normal inspection of the container.

2.5 The minimum required performances for this project are defined in the following paragraph.


Target
U-P : Lead Brick
WIRE : Wires IQI
HOLE : Holes IQI
Clutter
Steel Plates
Container
Layout
X-Ray
Source
c
f
i
b
e
h
a
d
g
DETECTOR ARRAY
Clutter steel plates
20mm & 10mm &
5mm
300 mm
I.M.I \ HANCAL
ENGINEERING & CONSULTING
SECURITY
Test Tool Position
Preliminary Test Measurment
Ultimate Penetration & Wires & Holes
DRAWING NO - T - T 001
SCALE : None
NAME
SIGN.
DATE
DRAWN BY A. REHAVI 6.11.02
PLANNED A. REHAVI 6.11.02
APPROVED S.SCHNEIDER 6.11.02

3. Wire Image Quality Indicator

3.1 The Wire Image Quality Indicators will be used for evaluation of the contrast sensitivity and spatial resolution of the radiographic imaging of the system.

3.2 The Wire Image Quality Indicator will be defined for this SOW as the ratio between the diameter of the thinnest stainless steel wire (Type 300 series) visible and the thickness of a cluttering stainless steel substance (Type 300 series). The Wire Image Quality Indicator will be expressed in percentage values.

3.3 The Image Quality Indicator values (in %) will be measured for the following stainless steel (Type 300 series) cluttering thickness: 50mm; 100mm; 150mm; 200mm; 250mm; 300mm.

3.4 The Image Quality Indicator values will be measured at locations a-i as described above. The Image Quality Indicator values will be measured for a matrix of operating modes available for the operator.

3.5 Description of the Wire Image Quality Indicators

3.5.1 The Wire Image Quality Indicators will comprise a series of cylindrical steel wires(Type 300 series stainless steel) affixed to a steel plate (Type 300 series stainless steel) 400 by 300 mm in size and 10 mm thick.

3.5.2 The wires shall be arranged along the width of the steel plate (width-wise), in an order of increasing diameter, 30 mm apart from each the other, forming three sinusoidal curves. The wire diameters will be an expanding series; the specific values for the wire diameters will be in accordance with the expected performance of the system.

3.5.3 The clutter substance used for measuring the Wire Image Quality will comprise a series of stainless steel plates (Type 300 series) 300X400 mm^2 20; 10; 5 mm thick. The specific clutter thickness required would be achieved by combining steel plates with the cumulative thickness required for the measurement.

3.6 **Positioning of the Wire Image Quality Indicators**

3.6.1 The Wire Image Quality Indicators will be attached in the plane of the Clutter steel plates.

3.6.2 The Wire Image Quality Indicators will be placed on the source side of the Clutter steel plates.

3.6.3 In each of the measuring spots which are described below, the Wire Image Quality Indicators will positioned so that the plane of the Indicators will be perpendicular to the radiation beam.

3.6.4 Positioning of the Wire Image Quality Indicators on a supporting block is acceptable, provided shims are placed under the Indicators. The shims shall exceed the Indicator's dimensions so that the outline of at least three sides of the Indicators image shall be visible on the Radiography image. The supporting block and shims shall be positioned so as not to overlap the Indicators on the Radiography image.

3.6.5 The Image Quality Indicator values will be measured in nine (9) spots as described above.

4. Hole-Type Image Quality Indicators

4.1 The Hole-Type Image Quality Indicators will be used to evaluate the Radiographic Imaging System quality.

4.2 The image quality levels will be designated by a two-part expression X-YT. The first part of the expression X refers to the IQI thickness expressed as the percentage of the clutter specimen thickness. The second part of the expression YT refers to the diameter of the hole and is expressed as a multiple of the IQI thickness, T.

4.3 The Hole-Type Image Quality Indicator values (in X-YT) will be measured for the following stainless steel (Type 300 series) cluttering thickness: 50mm; 100mm; 150mm; 200mm; 250mm; 300mm.

4.4 The Hole-Type Image Quality Indicator values will be measured at locations a-I as described above. The Image Quality Indicator values will be measured for a matrix of operating modes available for the operator.

4.5 **Hole-Type Image Quality Indicators description**

4.5.1 Hole-Type Image Quality Indicator will be designed and manufactured in accordance with the guidelines of the ASTM standard E 1025 latest edition: “Standard Practice for Planning, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology.

4.5.2 The Hole-Type Image Quality Indicator will be fabricated of stainless steel (Type 300 series).

4.6 **Positioning of the Hole-Type Image Quality Indicators**

4.6.1 The Hole-Type Quality Indicators will be attached parallel to the plane of the Clutter steel plate.

4.6.2 The Hole-Type Image Quality Indicators will be placed on the source side of the Clutter steel plates.

4.6.3 In each of the measuring spots which will be described here, the Hole-Type Image Quality Indicators will be positioned so that the plane of the Indicators will be perpendicular to the radiation beam.

4.6.4 Positioning of the Hole-Type Image Quality Indicators on a supporting block is acceptable, provided shims are placed under the Indicators. The shims shall exceed the Indicator’s dimensions so that the outline of at least three sides of the Indicator’s image shall be visible on the Radiography image. The supporting block and shims shall be positioned so as not to overlap the Indicators on the Radiography image.

4.6.5 The Image Quality Indicator values will be measured in 9 spots as described above.

5. Test Device

5.1 As specified, the following tools are required in order to perform each one of the defined tests:

5.1.1 Stainless Steel Plates – to serve as clutter - provided by the Supplier

5.1.2 Test tools: lead brick (provided by the Supplier), wires and holes (provided by the customer)

5.1.3 Test Device – a support, designed for positioning the defined test tools in the required 9 locations (a-i) at the desired angle (provided by the Supplier)

5.2 Supply of one Test Device, the Clutter Plates, and the lead brick is part of this project.

5.3 Test Device Description.

5.3.1 The Test Device will be used to hold the clutter and test-tools in the correct angle so the clutter plates are perpendicular to the radiation. The angle will be varied according to the positioning of the device in each of the required 9 locations (a-i).

5.3.2 It should be possible to position the clutter and test-tools at heights corresponding to the required 9 locations (a-i).

To achieve the desired height, either

(a) The device should have it's own ability to reach the desired heights, or

(b) The device will be designed to be lifted by a standard forklift (or any other standard leverage tool) to the desired height.

5.3.3 The Test Device will enable an easy removal and insertion of clutter plates between scans.

5.3.4 The Test Device will enable viewing the whole surface with no scattering.

5.3.5 In order to optimize testing time, it should be possible to position two (2) sets of clutter + test-tools, side-by-side (each one of at least 300x400 mm). In that way clutter will be removed from one pile and added to the other pile, thus performing two tests in each scan.

5.3.6 Supply of Stainless Steel clutter plates (Type 300 series) in the above dimensions, 20 mm and 10 mm thick and (at least) two (2) 5 mm thick, (total 510mm) designed to be used in the Test Device, is part of this project.

5.3.7 Supply of the lead brick, 50x100x200 mm^3 is part of this project.

5.4 The Supplier will submit the Test Device design drawings and operating method as an integral part of its proposal.

5.5 Test Device Description.

6. Material Discrimination Tests

6.1.1 General

The purpose of these tests is to present the system capability of material discrimination i.e. to display organic materials and inorganic materials in different colors.

6.1.2 The Bidder's proposal shall include detailed description of material discrimination feature, including the proposed test methodology, test device and the expected results.

6.2 Basic Test device - Material Discrimination tests

6.2.1.1 The Bidder's proposal shall include detailed description of

- Material discrimination tests methodology.
- Tests Device (dimensions, materials).
- Test protocol proposed by the bidder.
- Expected results

6.2.1.2 The basic test device may be based on 2 sets of "steps" only.

6.2.1.3 Testing of a system that is capable to present three or more classes of materials a 3rd and 4^{th} set of steps is required.

6.2.1.4 Each set should have 4 steps.

6.2.1.5 Each step should have Surface area of 12.5 cm * 12.5 cm, which will be positioned perpendicular to the x-ray beam.

6.2.1.6 The Thickness of each step is the distance that the x-ray beam needs to pass through the material.

6.2.1.7 The cumulative density of all 4 steps in each one of the sets will be the same and will equal to: material density (g/cm^3) * thickness (cm).

6.2.1.8 Example of dimension and materials of the required sets:

Set	Material	Density g/cm3	Thickness of steps (cm)			
			Step 1	Step 2	Step 3	Step 4
1	Graphite (Organic)	1.87	10.7	21.4	32.1	42.8
2	Aluminum (Intermediate)	2.70	7.4	14.8	22.2	29.6
3	Iron (Inorganic)	7.80	2.6	5.2	7.7	10.3
	Cumulative Density		20	40	60	80

6.2.1.9 In case that the supplier is using different materials with different densities the proposal will include the appropriate calculations.

6.2.1.10 The proposal should include the test device design and dimensions.

6.2.2 Tests methodology

6.2.2.1 The test will be done in all of the previously defined 9 test points (a-i)

6.2.2.2 In each test point the device should be positioned in an angle that will make it perpendicular to the x-ray beam.

6.2.2.3 The steps should be designed and positioned in the device in a way that will prevent shading of one part on another in all the test points.

6.2.3 Required results

6.2.3.1 The organic materials steps should be colored in shades of orange/brown

6.2.3.2 The inorganic material steps should be colored in shades of blue.

6.2.3.3 While looking on the same scanned image without material discrimination manipulation, all sets of steps will look at the same shades of gray

6.2.4 The test device including the sets of steps is part of the scope of supply for this project.

6.2.5 Testing the performance of system's basic material discrimination features will be detailed in Bidder's proposal.

The description will refer to the following subjects:

6.2.5.1 Test tools

- Definition of standards
- Definition of test samples: type, number of samples, each sample's material and size (width, length, thickness)
- Device for positioning the test samples

6.2.5.2 Results evaluation

Results evaluation method will be described, including:

- Characterization of the clutter (type, size, location and parameters) that will be used to test material discrimination
- Accuracy of testing

6.2.5.3 Test Protocol

Detailed test protocol will be submitted for approval, including statistical evaluation of system's performance.

C - Radiographic System Performance

1. **Minimal Requirements**

The System Minimum Performance will be expressed in the previously defined parameters: Ultimate Penetration, Resolution, Contrast and Throughput, Material Discrimination.

1.1 Ultimate Penetration

1.1.1 The Ultimate Penetration will be at least 400mm at least, at two positions out of the defined 9 positions, measured at the standard (nominal) scan velocity

1.1.2 The Ultimate Penetration will be at least 330mm at each of the defined 9 positions measured at the standard (nominal) scan velocity.

1.2 Resolution

1.2.1 Wire resolution, when measured at the middle of the container at height corresponding to the center of the beam (best position) will be, at least:

- 2% for 100mm clutter (2 mm wire behind 100mm)
- 2.5% for 200mm clutter (5 mm wire behind 200mm)

1.3 Throughput

The Radiography system will be able to inspect at least 20 trucks / hour.

2. **System Performance – Periodical tests**

2.1 In order to maintain system performance during operational period the contractor shall test the radiographic performance each year, as part of the service and maintenance routine. Upon tests results the contractor shall modify/fine-tune the system to achieve the required performance.

2.2 These tests, performed according to the procedures described in this document and using the approved test means and test device, shall also be performed following any major change/repair/adjustment of the system.

3. System Performance - Bidder's declaration - Obligatory

3.1 The bidder is requested to submit the following table, referring to system performance, expressed in the previously defined parameters.

Location / Measure	a	b	c	d	e	f	g	h	i
1. Ultimate Penetration (in mm)									
2. Wire Image Quality Indicator (%) a. Behind 50 mm of steel b. Behind 100 mm of steel c. Behind 150 mm of steel d. Behind 200 mm of steel e. Behind 250 mm of steel f. Behind 300 mm of steel									
3. Hole-type Image Quality Indicator (%): a. Behind 50 mm of steel b. Behind 100 mm of steel c. Behind 150 mm of steel d. Behind 200 mm of steel e. Behind 250 mm of steel f. Behind 300 mm of steel									

3.2 Material Discrimination Performance

Bidder declaration, regarding material discrimination capability will be defined at the following:

Position	a	b	c	d	e	f	g	h	i
Basic									

D - The Radiation Safety System

1. The Radiography installation shall include an autonomous and exclusive system designated to ensure the safety in and around the x-ray facility in the site. The radiation safety system will ensure prevention of any danger or injury to the health of personnel working at the site, to drivers, visitors or to the surroundings as a result of the radiation used at the installation.

2. The installations shall meet all the requirements concerning radiation safety which are in force in Israel under any law, regulations, orders or procedures relating to setting up radiation installations, handling Radiation Devices, preventing environmental damage, environmental monitoring of personnel working with ionized radiation and the safety and health regulations for personnel working with ionized radiation.

3. The installation shall meet all the requirements concerning Noise regulation, EM as well as RF radiation, which are in force in Israel under any law, regulations, orders or procedures relating to setting up installations, handling radiation devices, preventing environmental damage, environmental monitoring of personnel working with ionized radiation and the safety and health regulations for site personnel

4. The Bidder will submit an overall safety plan, which shall include a survey of risks and a plan of the means and procedures designed to ensure the required level of safety.

5. After its approval by all authorized bodies in Israel the safety plan will become the certified obligatory safety plan.

6. The Client shall be entitled to demand any change or addition to the safety plan or the safety means if it should seem to him important and necessary for ensuring the prevention of health risks to personnel working at the installations, to visitors or to the environment.

7. The Supplier shall be responsible for arranging all inspections required in Israel under the law in order to obtain all necessary approvals and permits required according to any law for setting up radiation installations, dealing with Radiation

Devices, for operation and installation of radiation devices to ensure the prevention of damage to the environment and to ensure the safety of personnel.

8. The complete implementation of all parts of the radiation safety plan is a critical, mandatory condition for operating the Radiography Installation for the purpose of performing the Acceptance Test.

9. Without prejudice to the general statement aforesaid and in addition to it, the safety measures will ensure the following:

9.1 The system will provide permanent radiation protection for everyone at all times.

9.2 Two types of zones shall be defined in the installation and in its surroundings:

9.2.1 Restricted area: zone exposed to radiation.

9.2.2 A zone protected from radiation.

9.3 <u>The restricted area</u>

9.3.1 The restricted area: a zone exposed to radiation, shall be limited to the Radiography tunnel (including rooms with the X-ray emission subsystem accelerator and collimators and electronics rooms: X-ray Detection). The Bidder shall clearly describe the dimensions of this restricted area.

9.3.2 The radiation - exposed zone will be shielded by permanent means (reinforced concrete wall, lead, steel or other for the shielding doors), that will ensure the shielding of the exterior of the restricted area.

9.4 <u>The radiation protected area</u>

9.4.1 Any part of radiation protected area cannot be a restricted area.

9.4.2 Areas adjacent to radiation shielding means (external to walls/doors) will be part of radiation protected area and not a part of the restricted area.

9.4.3 All areas, rooms, systems and installations required for the operation of the Radiography Installation, including Operators' and Image analysis room will be

in the radiation protected zone: fully protected where no additional precautions are necessary.

9.4.4 All openings and approaches to the zone exposed to radiation will be permanently closed and locked (apart from the doors of the Radiography tunnel which will open and close automatically during the inspection cycle).

9.5 All openings and approaches to the radiation zone will be safe-guarded by an Interlock System. The Interlock System will operate at all times even when the Radiography installation is not operating. Opening an aperture whatsoever at any time, shall result in indications displayed on System Operator's workstation. Radiography system activation will be enabled only after safety confirmation of the operator of the radiography installation.

9.6 CCTV-R (CCTV in the radiography building)

9.6.1 The tunnel and connecting adjacent areas will be surveyed at all times by a CCTV system.

9.6.2 The CCTV-R system shall be designed and deployed as part of the radiography system safety devices (and not as part of site's CCTV subsystem), completely separated from the site CCTV, implying its intact operation is a compulsory required precondition for any authorization of operation of the radiography system.

9.6.3 The HD cameras will cover the entire tunnel at all times including top view of the cargo (camera mounted on top of gantry, looking down).

9.6.4 The CCTV will cover all the volume of the tunnel in a way that will enable identify a person in the tunnel.

The CCTV system displays will be located in the operator workstation on separate screen (at least 36”).

It is possible to use split screen for several cameras. The size of each camera on a split screen will be at least 10".

DVR

9.6.5 All cameras will be connected to a DVR system with capability to export data to a known format (MPEG, AVI, WMV etc.) that will save the data in FIFO (time TBD at the DR).

9.6.6 The proposal will include a detailed scheme of the tunnel with the cameras locations, angles of coverage and technical specification.

9.7 Using hardware only, the Interlock System will prevent the operation of the Radiography System when any opening leading to the radiation - exposed zone is open. The system will immediately stop the operation of the radiation source when the said opening is opened during radiation source operation.

9.8 The x-ray safety system will insure safe access to and in the restricted area using, in addition to the CCTV system, the following elements:

- Emergency stops
- Emergency stop pull-cords
- Sensors (for external doors)
- Warning lights
- Sirens
- Door interlock (switch)
- Beacons for X-ray measure, with automatic siren;
- Service switch
- Public Address

9.9 The above elements will be connected to Radiation Safety System Controller. The controller will gather all safety information and accordingly authorizes or not the functioning of the x-ray. Controller output will be graphically displayed at the following positions;

- Radiography Operator console
- Shift supervisor (at the Radiography building)

9.10 The permitted dose of radiation (following the known updated) in the protected zone will not exceed (half) **0.5 µSv/h** (0.05 mr/h) at any point, at a distance of 10cm from the installation (wall/door). Maximum Dose Rate in Operators working area or in the environment will not exceed **0.5 µSv/h.**

The measurement shall be taken during normal operation of the installation during x-ray irradiation of a full container by source operating at maximum capacity.

It is emphasized that these values are the known values at the time this document is prepared and that it's Bidder responsibility to clarify and validate the method of measuring as well as the permitted values with the Israeli authorities.

9.11 The Maximum Absorbed Dose per inspection will be less than 10mR (100µGy) measured at center of the testing position.

9.12 In all parts of the zone exposed to radiation, audio and visual warnings will be installed which will give warning of a radiation system on Stand-by mode and/or of emission of radiation. The coverage level of these warnings will be 100%.

9.13 In all areas exposed to radiation, emergency cutouts will be installed. These cutouts, operated by hardware alone, will immediately stop the emission of the radiation source.

9.14 In all areas exposed to radiation, an intercom system will be installed to enable contact with the system operator of the Radiography installation.

9.15 All doors (apart from the external door to the Radiography tunnel used by trucks) shall be equipped with special locks, each with only one key to open it. No “master” keys for these doors will be allowed on the installation.

The doors shall be opened from the outside only by this key. The doors may be opened from the inside by means of an emergency (panic) lock. It will not be possible to slam the door shut without the key.

10. Bidder's proposal shall include a detailed description of all safety measures taken in order to ensure the safety of everyone in the site.