G3107-1000
Soil Measuring and Segregation System

Overview and Description

The ANTECH Series G3107-1000 Soil Measuring and Segregation System (SMSS) designed and manufactured by ANTECH for the measurement and segregation of cradioactive contaminated soil. The G3107 consists of a soil conveyor system with a sensitive large volume gamma ray scintillation detector for detecting low levels of radioactive contamination contained in soil or rubble passing along the conveyor in close proximity to the detector.

The variable speed belt conveyor is connected to a 3-way soil diverter or sorter which is controlled by the detector. Radioactive contaminated soil is diverted in one of three ways depending whether it is below the lower level contamination concentration threshold, above the upper level contamination concentration threshold or between the thresholds. Two way diversion in relation to a single contamination concentration threshold is also possible.

The G3107-1000 Soil Measuring and Segregation System is used in conjunction with the following commercially available soil or rubble processing and handling equipment which is normally provided by the customer or rented for the period of a measurement campaign:

a. Soil excavating and moving equipment such as a front end loader to excavate or extract the contaminated soil and place it in the soil screening machine. This unit is typically rented for the project from a third party supplier.

b. Soil screening machine with output conveyor. This unit is typically rented for the project from a third party supplier. The soil screening machine is used to screen the contaminated soil or rubble to remove large size objects and stones and provides the input feed of soil to the Model G3107-1000 detection and segregation or sorting unit.

c. Up to three soil stacking conveyors, typically rented for the project from a third party supplier, for stock-piling of soil for later disposition.

Note that the great advantage of using the G3107-1000 SMSS is that non-contaminated soil or rubble that has been measured by the SMSS and declared “free of radioactive contamination or clean” can be returned to the site without further treatment. In practical cases where the soil sorting process has been employed in the past, typically between 50% and 80% of the soil or rubble is declared “clean” and returned to the site without further processing. The soil sorting process using the G3107-1000 will save a substantial amout of the total cost by greatly reducing the quantity and hence the cost of disposing of radioactive contaminated soil.

Operation

The Model G3107-1000 SMSS is normally mounted on or in a 6 metre ISO container unit and consists of an inclined variable speed electrically powered conveyor and in-feed hopper to receive soil or aggregate from pre-processing equipment (soil screening machine). Mounted in close proximity above the conveyor is a shielded chute detector assembly with shadow shielding above and below the conveyor. The

purpose of the steel shielding is to reduce the effect of ambient radiation background on the measurement process.

Soil pre-processing is accomplished using a conventional Soil Screening Machine (supplied by a third party supplier) with output conveyor. This unit removes oversized objects such as large stones and boulders and screens the soil so that it is suitably separated for measurement. Typically the soil screening machine will have its own diesel engine to drive the screening mechanism and the integral output conveyor.

A levelling bar fitted to the output of the hopper of the soil measurement conveyor on the SMSS ensures roughly constant depth (thickness) of soil passing along the conveyor following receipt of potentially contaminated soil or rubble in the measurement conveyor input hopper of the SMSS. Once the soil passes through the measurement position of the SMSS, it travels to the discharge point at the top end of the measurement conveyor. From the discharge point the soil falls into the input hopper of the 3-way diverter device.

The diverter comprises an input-hopper, a motor driven rotating inclined chute and 3 fixed and enclosed output chutes. The output chutes are normally aligned with the input hoppers of up to 3 stacking conveyors (typically rented for the project from a third party supplier) which transport sorted and segregated soil to its various destinations. These could include a stockpile, filling a vehicle (dump truck) or filling a $1m^3$ material handling bag.

The position (orientation) and movement of the rotating inclined chute is controlled by the data processing electronics of the SMSS in order to effect the soil segregation following soil measurement by the scintillation detector. In 2-way sorting or segregation, contaminated soil above the sorting criterion is diverted in one direction and clean, uncontaminated soil (below the criteria) is diverted in another direction.

In 3-way sorting, contaminated soil above the sorting criterion is diverted in one direction, clean uncontaminated soil (below the criteria) is diverted in another direction and, for example, soil with activity just above or below the sort criteria can be diverted to a stockpile, perhaps for sorting again with greater sensitivity (improved counting statistics) using a lower throughput rate (slower belt speed).

In other cases, alternative sort criteria can be established and applied to sort soil into 3 categories, contaminated, slightly contaminated for landfill disposal and clean (uncontaminated) soil which can be returned to the site. With a 3-way sorting capability the ANTECH Model G3107-1000 Soil Measuring and Segregation System provides significant flexibility for soil sorting and segregation.

A number of factors affect the accuracy and precision of the system. These include:

- Measurement counting statistics (partially dependant on conveyor speed), soil density, soil moisture content and sample volume size
- Shielding from higher density objects in the soil (small stones that have passed through the screen)
- Calibration uncertainty (volume weighted calibration)
- Distribution of activity in the soil waste stream

While these factors are important they are addressed by a number of features of the system, including the high detection efficiency, shielding and shadow shielding of the detectors, large detector surface area and the ability of the system to sort on variable volumes of soil. The system is capable of diverting very small volumes as contaminated soil or larger volumes over which the measurement (detection) results are averaged. The volume of soil over which results are averaged is a user adjustable parameter and it is conventional to average over a sufficient volume of soil to reduce the effect of these factors.

It should be noted that the system is also capable of detecting "hot spots" or small objects of significantly higher activity. The system can be configured to divert small volumes of soil associated with a hot spot. Alternatively, the measurement conveyor can be stopped at a precise point so that the hot spot material can be located while on the measurement conveyor and manually removed.

Detector Systems (Option)

As an option, two detector types may be employed in the detection subsystem. The first (primary) detector mounted above the conveyor, in a shielded position, is a large volume NaI(Tl) (Sodium Iodide) low resolution gamma ray spectrometer (LRGS) detector, with typical dimensions 2" x 4" x 16". Using the NaI(Tl) detector the SMSS is able to segregate soil on the basis of the presence of specific radio-nuclides even with other radio-nuclides present. Specific regions of interest in the gamma ray spectrum can be monitored and photo peak areas collected in a short time are used for the segregation criteria. The segregation criteria can be based on the use of the Sequential Probability Ratio Test (SPRT) algorithm as employed in ANTECH portal monitors.

The second (optional detector) is a shielded large surface area and volume plastic scintillator detector with photomultiplier tube and high-speed microprocessor based electronics. Data analysis involves the use of the SPRT algorithm as employed in ANTECH portal monitors. The large area plastic scintillator detector is particularly sensitive to higher energy gamma rays such as those arising from Cs-137, and the system is able to measure very low concentrations of activity. The two detection systems can be used in parallel to provide the most sensitive segregation criteria.

Detection Limits and Throughput

In general the system provides continuous segregation and sentencing of soil waste using an integrated count of selected peak areas again using either SPRT or pre-set criteria (NaI detector) and, where appropriate, a preset total activity threshold based on use of the SPRT algorithm (plastic scintillator detector).

The nominal average throughput capability is 50m^3/hr, depending on an adequate supply of feedstock. For the current design of the Model G3107-1000 SMSS, and assuming an average soil density of about 1.5, a mass flow rate of 50m^3/hr corresponds to an operating conveyor belt speed of 0.4 m/s and a mass transfer rate over 80 metric tons per hour. The system is, however, able to operate at lower throughput rates. A lower rate may be necessary if the proportion of contaminated soil is significant or the soil is delivered into 1 m^3 material handling bags.

Calibration

Energy and efficiency calibrations are carried out using point sources with multiple energy lines, such as a combination of Eu-152 and Am-241. Confirmation and validation of the system can be accomplished using prepared samples consisting of small point sources placed in soil filled bags (sand bags), which are allowed to pass under the detector head. Alternatively, contaminated soil on a given site can be used to generate a secondary standard. If appropriate, the radioactive contaminated soil is sampled for gamma ray spectroscopy analysis and blended to have a specific activity content of the required radionuclide. A batch of this secondary standard can then be passed through the system to establish/ confirm the calibration and sorting criterion. The small batch of soil constituting the secondary standard(s) may be retained for further confirmation measurements as required.

The calibration process is supported by Monte Carlo modelling analysis using the MCNP Code. Modelling is used to correct for geometric effects (for example point versus distributed sources) and to confirm detection performance.

Instrumentation

ANTECH offers the model G3107-1000 Soil Measuring and Segregation System with automation based on an imbedded microprocessor system that is integrated with the detection and data analysis system. The control system is linked to the measurement control computer and controls conveyor speed and operation of the soil diverter/ sorter. An Emergency Stop System (EMS) or circuit is implemented in hardware with EMS buttons for safety on the SMSS control station and on the SMSS unit.

The control station of the SMSS consists of a ruggedised personal computer (PC) and associated safety circuitry housed in an armoured Pelicon case. The control station is connected to the SMSS by a set of cables incorporating power, Ethernet and the EMS circuit. The control station can be located close to or at a distance from the SMSS unit. In addition to controlling the operation of the SMSS, the control station also records, displays and archives operating parameter data for the system.

References

1. IAEA Safety Guide, Application of the Concepts of Exclusion, Exemption and Clearance, International Atomic Energy Agency, Publication No. STI/PUB/1202, August 2004.

2. ANTECH model G3107-1000 Soil Measuring and Segregation System (SMSS) data sheet, 2.0, A4.

3. A. J. Lombardo, R. F. Orthen, J. J. Shonka and L. M. Scott, “Soil Segregation Technology: Reducing Uncertainty and Increasing Efficiency During Radiological Decommissioning – A Case Study”, *Proceedings of the WM2007 Symposium*, Paper -07266, February 25 – March 1, 2007, Tucson, Arizona, USA.

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