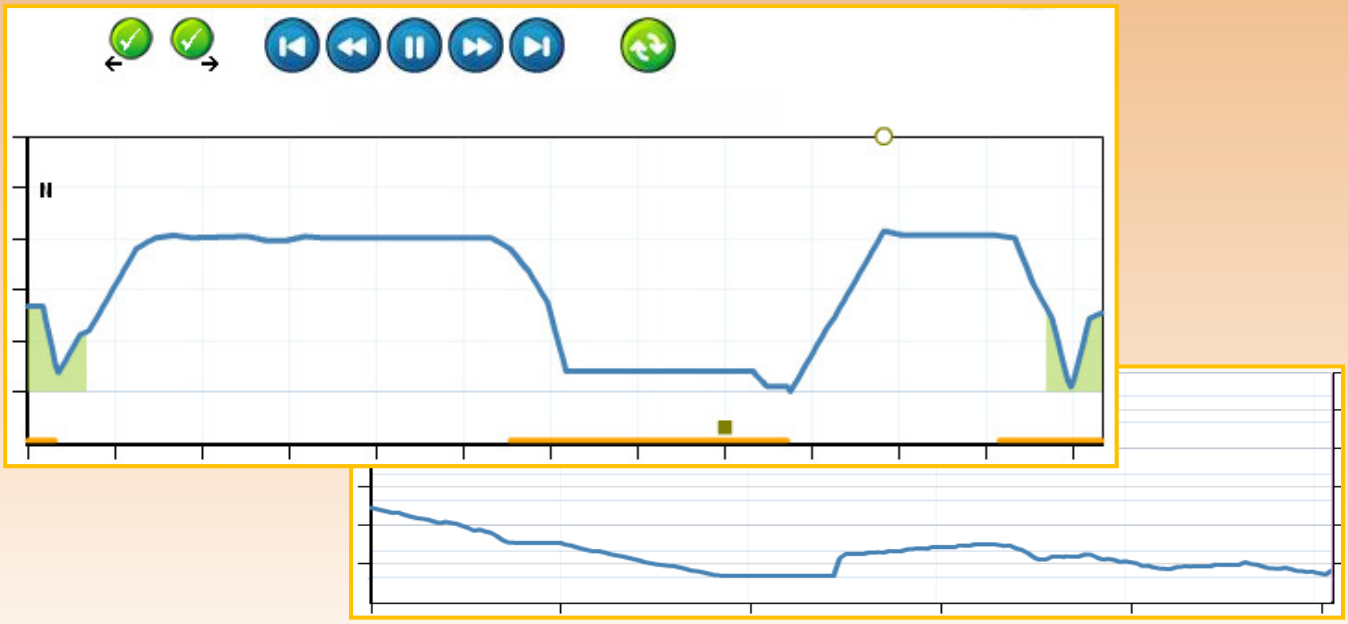

Inlibra® Suite

Stockpile Tracker (ST) Brochure

Inlibra Software Solutions Corp.
Suncor Energy Centre West Tower
150 - 6th Avenue SW, Suite 3000
Calgary, AB Canada T2P 3Y7
Tel: +1 403 538 8790

help@inlibra.com

http://www.inlibra.com

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Introduction

Inlibra Stockpile Tracker (ST) is a software application developed by Inlibra Software Solutions Corp. (Inlibra SSC) to track and display the shape of a stockpile of a granulated solid, thereby also calculating the inventory as mass. ST was originally created specifically for a urea stockpile but the technology is applicable to other granulated solids as well.

Using real-time measurements pertaining to both additions and removals, Stockpile Tracker models the volume and mass of a granulated solids stockpile over time, providing up to date inventory via intranet web displays and storing the data in a database from which it can be queried for reports.

Stockpile Tracker is able to model the changes in stockpile shape because the shape only changes at two places:

- where there are additions to the stockpile, usually poured onto the pile from above
- where there are removals from the stockpile, usually scraped onto a conveyor belt by scraper arms

All that is required is sufficient measurement at those two critical places.

Stockpile Tracker has been successfully deployed in the largest urea warehouse in the western hemisphere (released under the name Warehouse Tracker).

The problem

The problem that Stockpile Tracker addresses is that companies that deal with granulated solid products find they need to know at a particular instant in time how much inventory they have on hand. While granulated solids can be measured by belt scale meters as they flow into an out of the warehouse, these meters contain a degree of error. Over time, the calculated inventory will differ from real inventory significantly. In one case, Inlibra SSC found that without correction, the running inventory calculated solely from meters would have a 20% error by the end of one year.

To avoid cumulative error, companies engage topographical surveyors to measure the shape of the stockpile mound with surveying equipment such as theodolites.

Topographical surveys are not an ideal solution as they are costly and can only be done infrequently (perhaps once a month). It is therefore desirable to have a more frequent reported inventory value, which can act as a check on both the meters and on the topographer's results. This is the need that Stockpile Tracker answers.

What Stockpile Tracker Provides

Stockpile Tracker models the shape of the mound, not just a numeric mass or volume. Thus, the program has information not only on total mass, but on where that mass is physically located within the warehouse. The information is made available via a web browser page in graphical form, with an update period of one hour. (This period could be customized if desired.)

Personnel can therefore monitor:

- whether there is enough material on hand to satisfy shipping needs
- whether there is danger of stockpile overflow
- whether the stockpile is being built/scraped correctly

One snapshot image is stored every period (by default, every hour) so that personnel can look backwards in time at earlier snapshots and see how the image of the mound changed through time.

What Your Plant Needs in Order to Use Stockpile Tracker

Stockpile Tracker is a valid solution for modeling the stockpile shape as long as these requirements are met:

- The shape of the stockpile is a long, essentially triangular mound or a series of such mounds.
- The mechanism for removal of material from the pile corresponds in general to the type of scraper arms around which Stockpile Tracker was designed.
- The granulated solid tends to form a mound slope at a constant angle (e.g., approximately 28° for urea) .
- There is sufficient instrumentation and the measurement data from those instruments can be captured by software and fed to Stockpile Tracker. This is normally done via a plant data historian such as PI or PHD. The needed measurements are:
    - Pile height at the point where new material is poured onto the pile
    - Position where new material is being added
    - Angle of scraper arm(s)
    - Location of scraper arm(s) along the length of the pile

The geometry of the freshly poured areas of the mound is calculable by assuming that new material accumulates a pile with a fixed slope. The exact shape of scraped areas can be calculated by knowing the range of motion of the scraper arm(s).

It is likely that Stockpile Tracker will need to be tailored to accommodate the exact situation in any given plant. The amount of tailoring will depend largely whether, how and to what degree to which the above requirements are met. Even if a plant's situation differs greatly from the above, Inlibra SSC may still be able to develop a suitable alternative, so please do not hesitate to discuss your situation with Inlibra SSC.

GUI Features

The main user experience centers on the use of the web-based interface, an example of which is shown below:

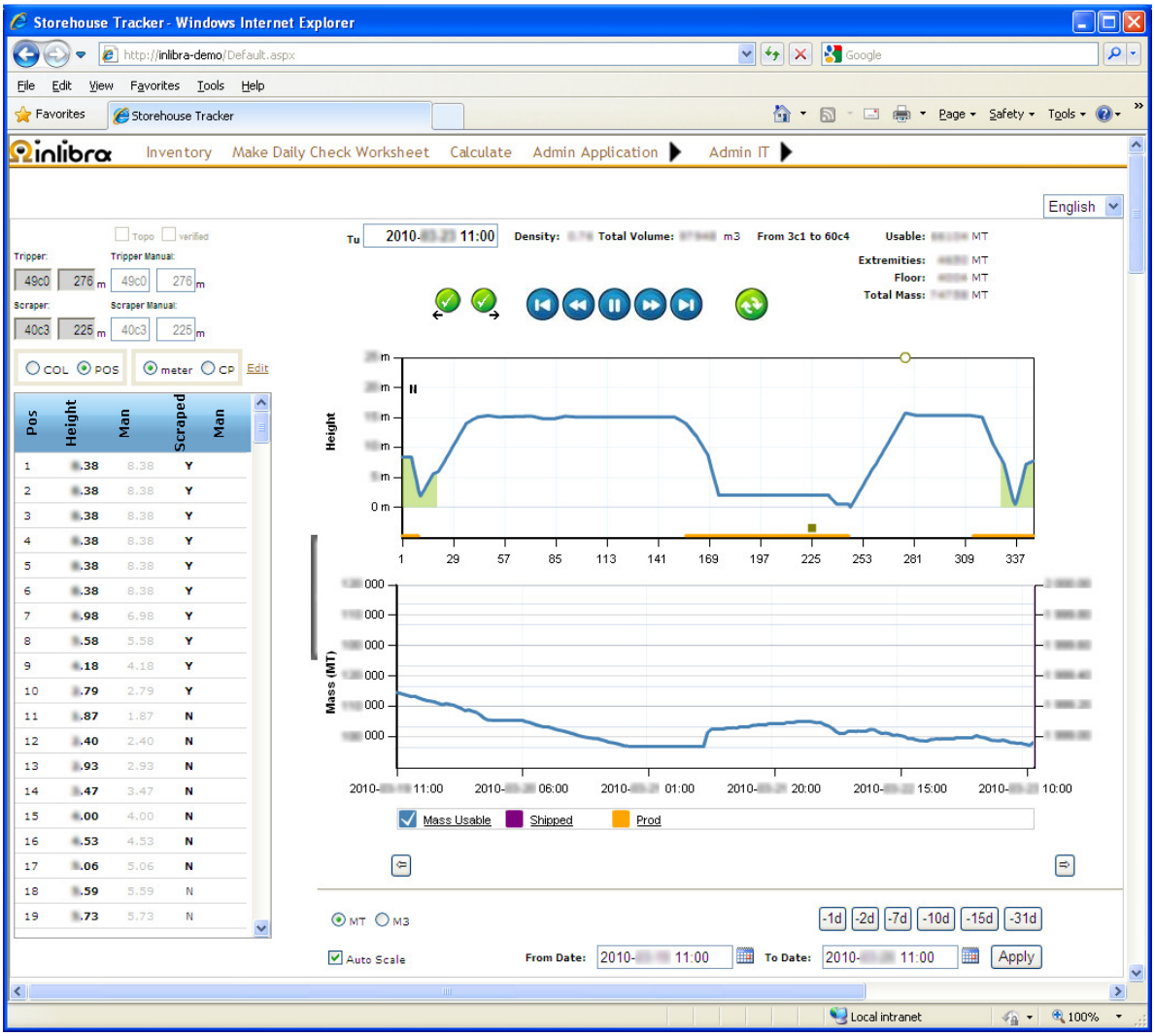

Figure 1 - Main intranet application web interface page

The GUI is divided into three main areas:

1) A data grid on the left, which is used to view or, in certain cases, edit, the data shown to the right

2) A “Profile Graph” in the upper left that shows the shape of the mound as viewed from the side.

3) A “Trend Graph” in the lower left that shows the total inventory changing over the day/weeks.

We will briefly describe each area below.[1]

Visual Component 1: The Profile Graph

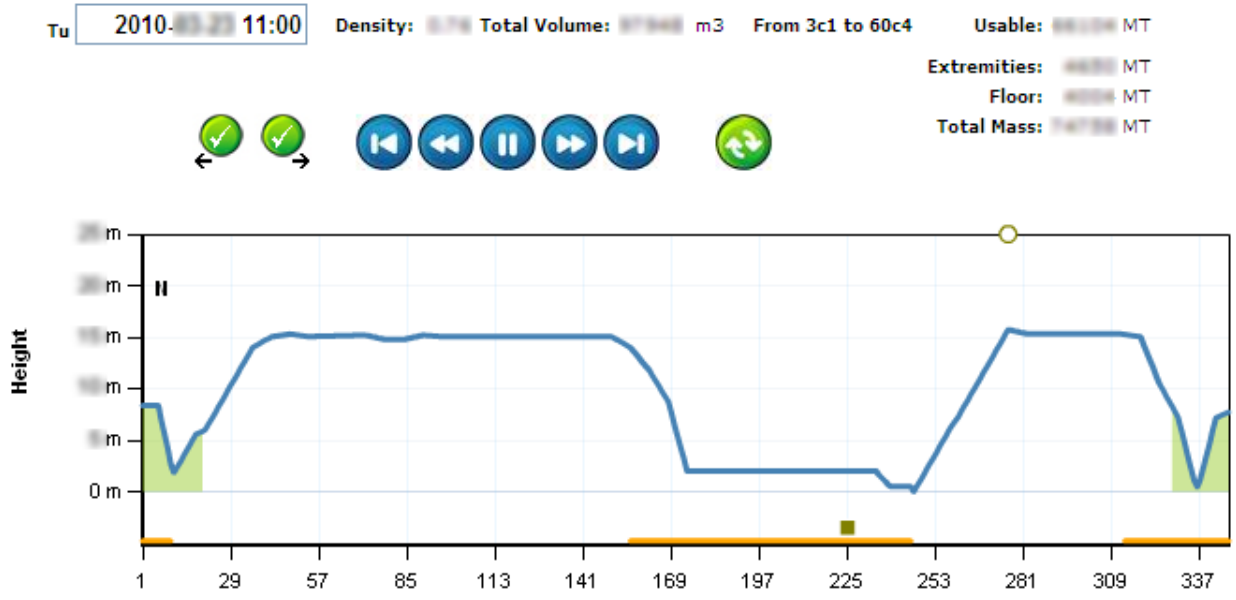

Figure 2 - The Profile Graph

Please note that the vertical axis does not use the same scale as the horizontal one so the angle of the urea pile shown above appears exaggerated. In reality, it is 28°.

The *y* axis is the height of the mound in meters. The *x* axis shows the position in meters along the length of the stockpile mound.

There are two important pieces of equipment whose positions are shown:

a) The equipment that deposits new material onto the mound. (Often called a "tripper car.") It is shown as a circle positioned along the top.

b) The scraper arm assembly responsible for removing material is shown as a square along the bottom. Note that the golden yellow bars along the base of the graph indicate which parts of the mound have been scraped since they were last poured.

The VCR-like buttons above the graph permit users to go backward and forward in time to show profiles of earlier or later instants. The Play button simply puts the application into a mode that always shows the latest profile, perfect for continuous monitoring.

The volume and mass shown at the top apply to the part of the stockpile visible in the graph, which changes if the user zooms and pans. Zooming limits the view to a subset of the full mound, in which case

[1] Example data has been intentionally blurred to protect privacy.

Stockpile Tracker will change the volume and mass figures to show only the amount available in the zoomed part of the mound.

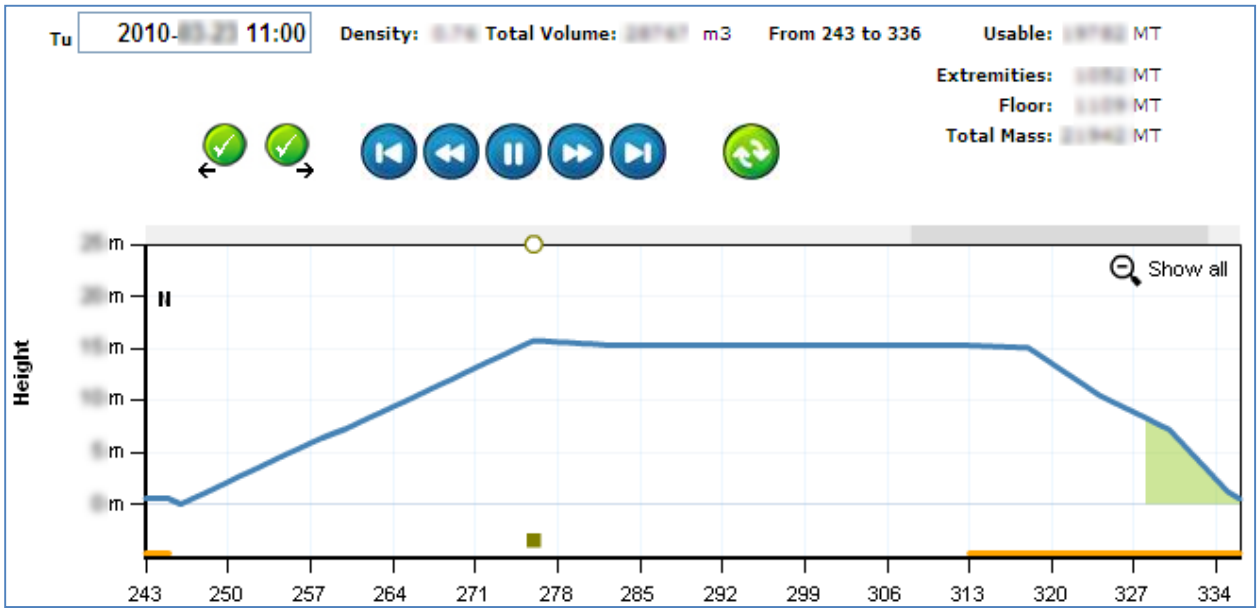

Figure 3 - If user zooms to select a region of mound, graph shows volume and mass for selection

The zoom feature is extremely useful for planning shipments, since it is possible to see in advance whether a certain part of the warehouse contains enough material to satisfy a particular planned shipment.

Visual Component 2: The Data Grid

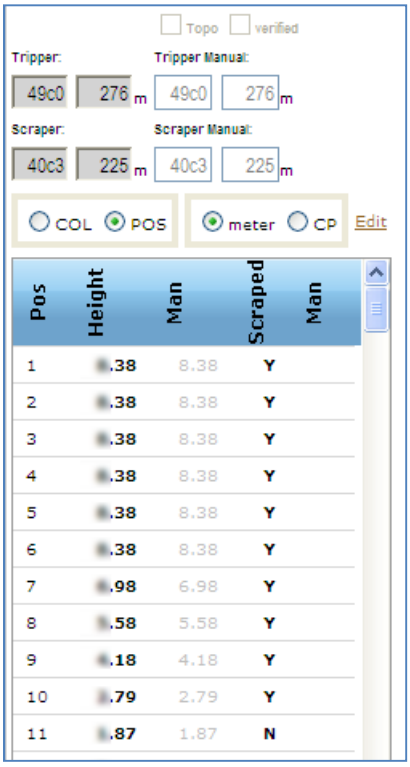

Figure 4 - The Data Grid

This grid shows numerically the same data that is shown visually on the Profile Graph. Editing is permitted (based on user privileges) but is usually unnecessary.

Visual Component 3: The Trend Graph (Inventory)

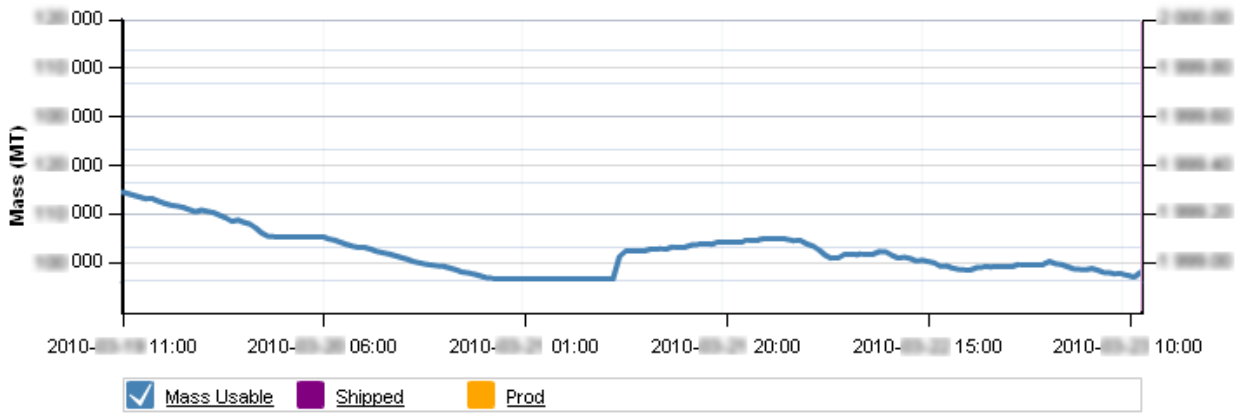

Figure 5 - The Trend Graph

On this graph, the *x* axis is time (hours, days, weeks – shown as timestamps including date), and the *y* axis shows the inventory. During production, the graph will rise, and during shipping it will decline. The user may turn on additional trend lines to show shipping and production rates.

Goals of Stockpile Tracker Design

The application was developed with these goals in mind:

- Minimize human data entry needed to maintain a valid model of stockpile shape
- Provide the ability to calculate from inventory delta the amount of production and shipping, to supplement and serve as a check on other methods such as metering
- Encourage and facilitate timely updating and use of the warehouse inventory data to allow management to make real time decisions that involve the inventory.
- Provide to multiple departments the ability to view warehouse inventory data (not just Operations).
- Permit experimentation with presumed density to determine the value most likely to represent reality. This is important since the actual density of a granulated solid under stockpile conditions is difficult to measure.
- Determine if there is metering error accruing on a daily basis, without waiting for the monthly topographic survey results.
- Reduce the size of the monthly topographic adjustments to calculated inventory.

Modeling Method

The software does not model the mound as a simple triangular prism shape (elongated pyramid). There are irregularities created by the shape of the floor and the action of the scraper(s). To capture this, the algorithm calculates quite detailed cross-sections that differ in nature depending on whether the mound has been scraped in that area, what the shape of the floor is, how the scrapers have affected the shape. The model consists of a series of one-meter-wide cross-sectional slices.

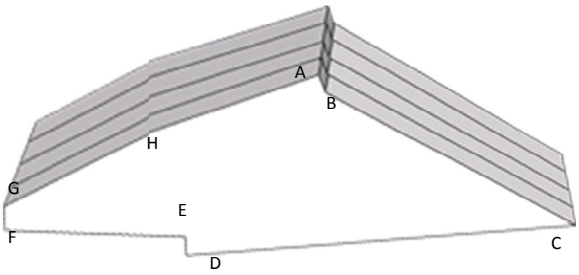

Figure 6 – Sketch of the one-meter-wide cross-sectional slices that form the model

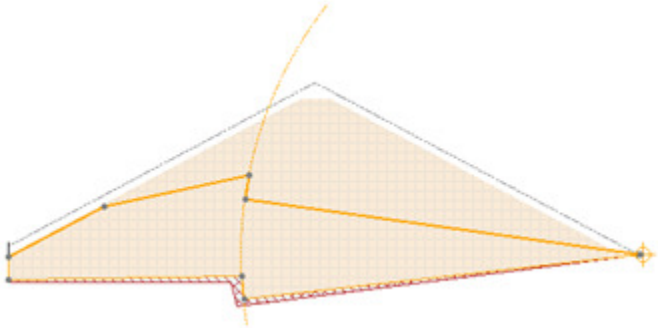

Figure 7 – A cross-section that has been scraped, showing compacted material along the floor

In the figures above, you see how Stockpile Tracker calculates a complex shape for each cross-section, depending on the shape of the floor under the mound and how the upper parts have been scraped.

To accommodate the fact that urea may compact over time and become unusable, Stockpile Tracker is configurable to treat a certain amount of material at the bottom of the mound as compacted, off-spec material that is labeled as “Unusable”. The cross-hatched regions in the above example represent off-spec, compacted urea on the floor which cannot be scraped and shipped. The user may optionally configure a certain number of meters at each end of the mound floor as consisting of off-spec material too, since the material at the extreme ends of the warehouse may be difficult to ship and compact over time. The total amount of unusable tons is shown separately on the main display.

In addition, for areas of the mound that have been poured but not yet scraped, Stockpile Tracker takes into account the fact that the top of the mound does not form a perfect angle, but is rounded. This is approximated by assuming a slightly flattened top for areas of the mound that have been poured but not yet scraped. The assumption of flatness greatly reduces the size of the error introduced by the presence of the rounded crest of the pile (see figure below):

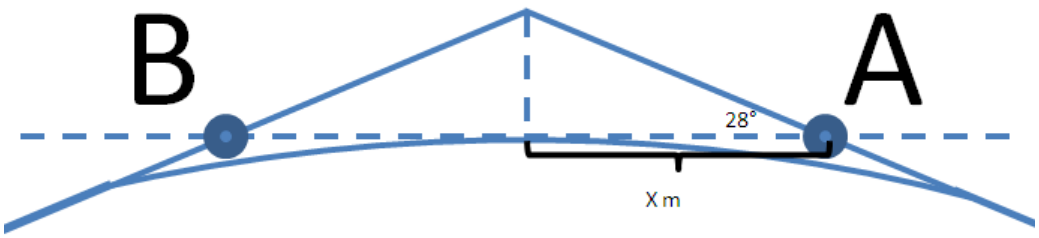

Figure 8 - Assuming a slightly flattened crest eliminates most of the error caused by the curvature

Stockpile Tracker, with appropriate tuning, can produce results that are surprisingly accurate. An early study found that, over several weeks, Stockpile Tracker's estimate of produced granulated solid agreed to within 0.05% with the production as calculated by the customer technical department. Overall inventory should be calculable to within 2% of mound or warehouse capacity.

The accuracy of the model is limited by, among other things, the accuracy of the pile height sensor where new material is added to the mound. Particularly when dealing with urea, there is a lot of dust. This can limit the choice of sensor technology (to ultrasonic sensors) and interfere with accuracy when the mound is low. Fortunately, a low mound is usually a temporary condition, because the mound is generally built up to a height that puts the top of the mound closer to the sensor, thereby restoring the accuracy of the sensor.

Security

You want to have control over who within your plant can edit the stockpile shape data and you may also wish to restrict view-only access to those people who need it. Stockpile Tracker is built around role-based security and the use of Windows security groups. This facilitates assigning view-only, administration and editing privileges to users by group. In addition, all data changes made through the interface create audit records in the database.

Conclusion

You probably have personnel from operations, logistics, marketing and management who all wish they could have an instant overview of the stockpile inventory without having to walk over to the stockpile physically and estimating visually. In that case, Inlibra SSC has pioneered a way to provide them with exactly that. Talk to us about it. Contact info is at:

http://www.inlibra.com