Application Note:
Volume measurement configuration for SmartScan25 and SmartScan50

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APPLICATION NOTE

VOLUME MEASUREMENT CONFIGURATION FOR SMARTSCAN25 AND SMARTSCAN50

Revision Record:

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1. SCOPE

This document defines the configuration procedure of ***SmartScan*** unit for volume measurement. The term ***SmartScan*** is used in this document for both ***SmartScan25*** and ***SmartScan50***.

2. OBJECTIVES

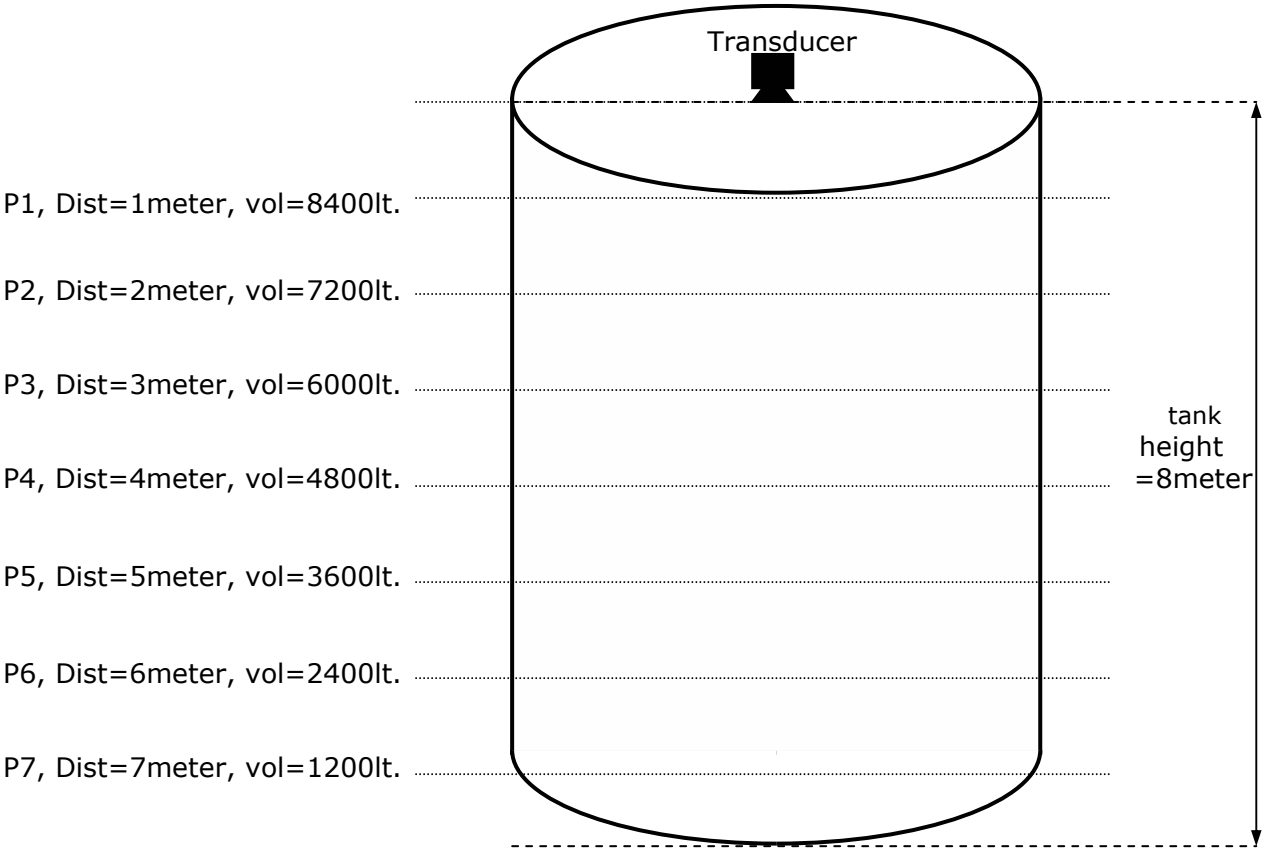
- Familiarize the user with ***SmartScan*** configuration methods for volume measurements.
- Familiarize the user with ***SmartScan*** volume measurements using manually inserting of strapping table.
- Familiarize the user with ***SmartScan*** volume measurements using semi-automatic inserting of strapping table.
- Familiarize the user with 4-20mA configurations for volume measurements.
- Familiarize the user with configuration guidance for special vessel shapes.
- Familiarize the user with 'K factor' for weight calculations.

3. THE METHOD OF MEASRUING VOLUME

Ultrasonic devices measure the **distance** between the transducer and the measured material top surface. By knowing the tank height, the ultrasonic device calculates the level by decreasing the measured distance from the tank height.

When volume measurement is required, the user should configure the ***SmartScan*** device to the relation between the volume capacity of the material within the vessel and the corresponding distance.
Solid AT SmartScan devices enable the configuration of a strapping table using 24 linear points. **Per each point the user should define the distance from the transducer and the corresponding volume for this distance.**

The drawing below illustrates the inserted distance points on the strapping table:



A strapping table is defined according to the following structure:
Step one: Point number.
Step two: Distance from transducer.
Step three: Volume value. The value entered in two separate screens, enables better resolution.

For example, entering a value of 4800lt will be as follows:
First screen: 000000 set to 004800.
Second screen: 800.000

Note that the last three digits entered in the previous step, are displayed before the decimal point and that the user can enter one digit after the decimal point.
The strapping table that corresponds to the above drawing should be as follow:

Point	Distance	Volume First step	Volume Second step
1	1 meter	008400	400.000
2	2 meter	007200	200.000
3	3 meter	006000	000.000
4	4 meter	004800	800.000
5	5 meter	003600	600.000
6	6 meter	002400	400.000
7	7 meter	001200	200.000

ⓘ Important notes!

1. Note that values entered in **Distance** form and not **Level**.
2. Note that the first point indicates the top of the vessel and the maximum allowed volume. As you add more points to the strapping table, the distance increases and the volume decreases (going top to bottom).
3. Note that there is no need to add a point with a distance that equals to the tank height to represent the bottom of the vessel with zero volume.
4. Note that the thickness of the strapping table "slices" doesn't need to be even. On the contrary! For different vessel shapes it is quite reasonable to define thinner slices where the volume doesn't increase linearly.
5. Note that a minimum of 8 strapping points is required.

How to set ***SmartScan*** device to volume measurement?

From the main configuration menu you will need to set the following parameters:

- Type of application – set to Distance.
- Units – set your own units (i.e. meter, inch, feet, etc.).
- Tank height – set vessel height top to bottom.

Don't define the 4-20mA current values yet.

From the 'additional configuration' menu you will need to set the following parameters:

- Pr.0 – set Ind1 for volume measurement.
- Pr.1 or Pr.2 – Define strapping table.
  With ***SmartScan*** it is possible to define the strapping table in two methods:
  - Manually inserting of strapping table: The user enters both distance and volume values.

- Semi-automatic inserting of strapping table: SmartScan measures the distance automatically and the user enters the corresponding volume value.

After defining a strapping table in one of the methods mentioned above, set 4mA and 20mA values as described in the user manual.

The device is ready for volume measurement after exiting the configuration menu.

ⓘ Important notes!

It is always recommended to map vessel interferences using Scan Distance option (refer to page 56 in the SmartScan User Manual).

4. MANUALLY INSERTING OF TABLE

Use 'Manually inserting of strapping table' when:

1. The ratio between distance and volume for your vessel is well known.
2. The vessel has standard shape (cylinder, cone or a combination of the two) and it is quite easy to calculate the ratio between distance and volume (refer to appendix A for more information about standard volume calculations).
3. It is not possible to use semi-automatic mode.

Manually inserting of strapping table is done from additional menu configuration, Pr.1.
When entering Pr.1, the device will prompt the first point, P1.
For each point it is now possible to define the required distance and the corresponding volume.

For example, for the table discussed before:

P1 <Ent>	
Distance:	001.00 <Ent>
Volume, first screen:	008400 <Ent>
Volume, second screen:	400.000 <Ent>
P2 <Ent>	
Distance:	002.00 <Ent>
Volume, first screen:	007200 <Ent>
Volume, second screen:	200.000 <Ent>
P3 <Ent>	
Distance:	003.00 <Ent>
Volume, first screen:	005000 <Ent>
Volume, second screen:	000.000 <Ent>
...	
P7 <Ent>	
Distance:	007.00 <Ent>
Volume, first screen:	001200 <Ent>
Volume, second screen:	200.000 <Esc>

Pressing **<Esc>** after the seventh point defines that this is the strapping table's last point.

5. SEMI-AUTOMATIC INSERTING OF TABLE

Use 'Semi-Automatic inserting of strapping table' when:

1. The ratio between distance and volume for your vessel is not known.
2. The vessel has unique shape and it is complicated or impossible to calculate the ratio between distance and volume.

The procedure of using semi-automatic inserting of strapping table involves a calibration phase using controlled emptying process and after interferences were mapped using 'Scan Distance '.
The procedure is as following:

1. Start with a full vessel where the volume contained is known.
2. The distance is calculated automatically in 'Semi-automatic' mode. Accept distance by pressing <Ent>.
3. Enter the known volume value.
4. Empty the tank with known volume value. As a result the level of the material within the vessel will be decreased.
5. For a new point, the unit will calculate the new distance.
6. For the new point enter the new volume value.
7. Repeat steps 4 to 6 until the last point required.

This method enables more accurate volume indications than the manual method, but entails slower calibration due to the need of emptying the vessel with known value of volume per point.
This method is activated from Pr.2 of the 'Additional menu'.
For example, the process is as following:

P1 <Ent>	
Distance:	Searching
	001.00 <Ent>
Volume, first screen:	008400 <Ent>
Volume, second screen:	400.000 <Ent>
P2 <Ent>	
Distance:	Searching
	002.00 <Ent>
Volume, first screen:	007200 <Ent>
Volume, second screen:	200.000 <Ent>
P3 <Ent>	
Distance:	Searching
	003.00 <Ent>
Volume, first screen:	005000 <Ent>
Volume, second screen:	000.000 <Ent>
...	
P7 <Ent>	
Distance:	Searching
	007.00 <Ent>
Volume, first screen:	001200 <Ent>
Volume, second screen:	200.000 <Esc>

Pressing **<Esc>** after point seven defines that point seven is the last point in the strapping table.

6. CURRENT CONFIGURATION FOR

VOLUME

Once the user configures the ***SmartScan*** to volume and sets the strapping table points, it is possible to configure 4mA and 20mA parameters by volume values.

The value of volume should be entered in two separated screens for high and low numbers.
Five (5) - enables digits for 'low' numbers.
Four (4) - enables digits for 'high' numbers.

With this in mind, for a volume of up to 99,999 you should configure the 'low' numbers only and leave 'high' numbers set to zero.
For volume above 99,999 (six digits required), the low five digits should be configured in the 'low' screen, and high numbers (starting the sixth digit) should be entered in the 'high' screen.

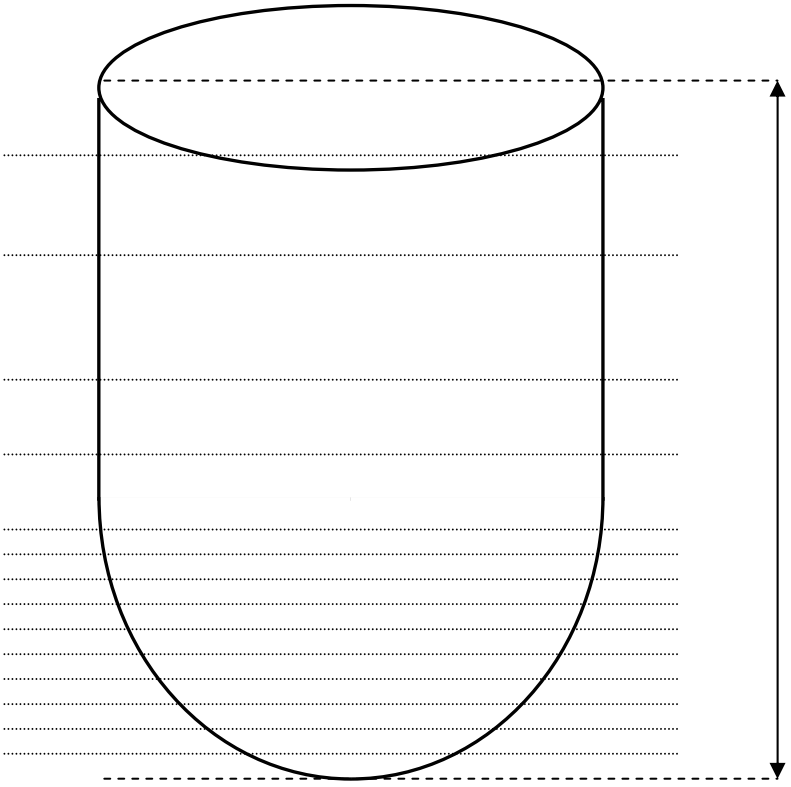
Following are a few examples:

	H	**L**
Defaults	000000	000000
Enables	XX0000	X00000
8500	000000	008500
12960	000000	012690
125850	000001	025850
109803	000001	009830

7. CONFIGURING SPECIAL VESSEL SHAPES

For vessels, which are not completely conical or cylindrical in shape, the volume is not linear with tank height. As a result, user may like to define the strapping tables "slices" unevenly – at least on the non-cylindrical part.

An example of such configuration is illustrated in the following drawing:



In the above drawing one can see that a small deviation in vessel bottom level creates high deviation in volume, while at higher levels of the vessel the ratio between level and volume is quite linear.
As result, it is better to define more "slices" at the bottom of the vessel (where the high deviation in volume creates accuracy which is not acceptable).
All instructions, which are specified in the prior chapters, should be followed in such case as well.
It is recommended to use all 24 strapping table points for better accuracy, mainly on the bottom of the vessel.

8. WEIGHT CALCULATIONS

In some applications the user would like to see the weight value of the vessel content.

Weight can be calculated by knowing the volume and the material specific gravity density.

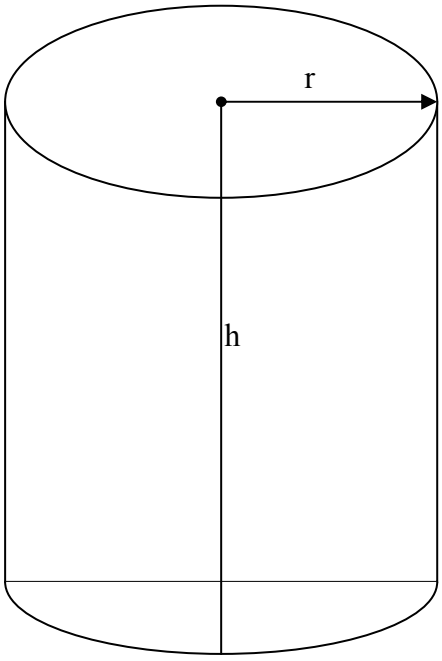
Let the measured volume be 'Y' and the material gravity density be 'K', the weight 'X' can be calculated as follows:

(Weight)= (material gravity density)·(Volume)
$X=K \cdot Y$

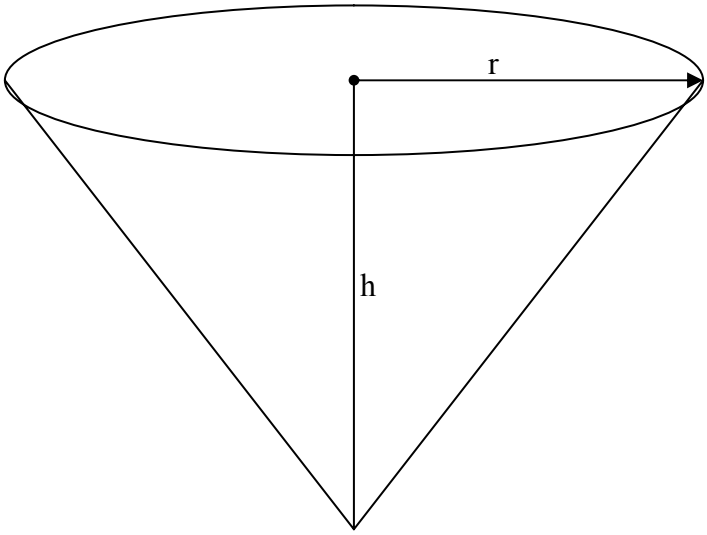
The 'K Factor' should be defined in Pr.3 of the 'additional menu' and the default value of 'K Factor' is 001.000.

APPENDIX A: VOLUME CALCULATIONS

When the vessel has a cylindrical or conical standard shape, it is easy to calculate the volume of the vessel according to basic volume equations.
The following figure illustrates cylindrical and conical vessel volume calculations.



$$V = \pi r^2 h$$



$$V = \frac{1}{3}\pi r^2 h$$

Using the above equations, it is easy to calculate the height-to-volume ratio.
For example, assume a cylinder shaped vessel with 2-meter radius and 8 meter height. The following table defines the height-to-volume ratio:

Height	Volume
1meter	$V = \pi r^2 h = \pi 2^2 1 = 12.57$
2meter	$V = \pi r^2 h = \pi 2^2 2 = 25.13$
3meter	$V = \pi r^2 h = \pi 2^2 3 = 37.70$
4meter	$V = \pi r^2 h = \pi 2^2 4 = 50.27$
5meter	$V = \pi r^2 h = \pi 2^2 5 = 62.83$
6meter	$V = \pi r^2 h = \pi 2^2 6 = 75.40$
7meter	$V = \pi r^2 h = \pi 2^2 7 = 87.96$
8meter	$V = \pi r^2 h = \pi 2^2 8 = 100.53$