

Rockwell Automation Library of Process Objects: Tank Strapping Table (P_StrapTbl)

Version 3.5

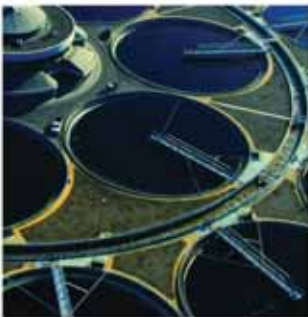
IMPORTANT

This manual applies to the Rockwell Automation Library of Process Objects version 3.5 or earlier.
For Rockwell Automation Library of Process Objects version 5.0, see

- [PROCES-RM200](#)

For Rockwell Automation Library of Process Objects version 4.0 or later, use the following manuals:

- [PROCES-RM013](#) contains logic instructions
- [PROCES-RM014](#) contains display elements



Important User Information

Read this document and the documents listed in the additional resources section about installation, configuration, and operation of this equipment before you install, configure, operate, or maintain this product. Users are required to familiarize themselves with installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards.

Activities including installation, adjustments, putting into service, use, assembly, disassembly, and maintenance are required to be carried out by suitably trained personnel in accordance with applicable code of practice.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

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Throughout this manual, when necessary, we use notes to make you aware of safety considerations.



WARNING: Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.



ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence.

IMPORTANT

Identifies information that is critical for successful application and understanding of the product.

Labels may also be on or inside the equipment to provide specific precautions.



SHOCK HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.



BURN HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.



ARC FLASH HAZARD: Labels may be on or inside the equipment, for example, a motor control center, to alert people to potential Arc Flash. Arc Flash will cause severe injury or death. Wear proper Personal Protective Equipment (PPE). Follow ALL Regulatory requirements for safe work practices and for Personal Protective Equipment (PPE).

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Notes:

This manual contains new and updated information. Changes throughout this revision are marked by change bars, as shown to the right of this paragraph.

Software Compatibility and Content Revision

Table 1 - Summary of Changes

Topic	Page
Changed version from 3_1 to 3_5	8

For the latest compatible software information and to download the Rockwell Automation® Library, see the Product Compatibility and Download Center at <http://www.rockwellautomation.com/rockwellautomation/support/pcdc.page>.

For general library considerations, see Rockwell Automation Library of Process Objects, publication [PROCES-RM002](#).

Additional Resources

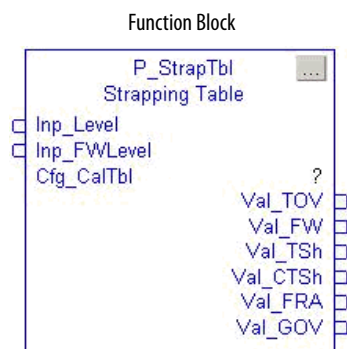
These documents contain additional information concerning related products from Rockwell Automation.

Resource	Description
PlantPAx® Distributed Control System Selection Guide, publication PROCES-SG001	Provides information to assist with equipment procurement for your PlantPAx system.
PlantPAx Distributed Control System Reference Manual, publication PROCES-RM001	Provides characterized recommendations for implementing your PlantPAx system.
Rockwell Automation Library of Process Objects, publication PROCES-RM002	Provides general considerations for the PlantPAx system library of process objects.
FactoryTalk® View Machine Edition User Manual, publication VIEWME-UM004	Provides details on how to use this software package for creating an automation application.
FactoryTalk View Site Edition User Manual, publication VIEWSE-UM006	Provides details on how to use this software package for developing and running human-machine interface (HMI) applications that can involve multiple users and servers, distributed over a network.
Logix5000™ Controllers Add-On Instructions Programming Manual, publication 1756-PM010	Provides information for designing, configuring, and programming Add-On Instructions.
Rockwell Automation Library of Process Objects: Basic Analog Input Reference Manual, publication SYSLIB-RM001	Provides information on how to use the Add-On Instruction to monitor one analog value, typically from a channel of an analog input module, and deal with alarms when the analog value exceeds user-specified thresholds (high and low).

You can view or download publications at <http://www.rockwellautomation.com/literature/>. To order paper copies of technical documentation, contact your local Allen-Bradley distributor or Rockwell Automation sales representative.

Notes:

Tank Strapping Table (P_StrapTbl)



Guidelines

The P_StrapTbl (Tank Strapping Table) Add-On Instruction calculates the volume of product in an upright cylindrical tank, given the level of the product and the tank calibration table. This instruction can optionally compensate for free water at the bottom of the tank (given a product/water interface level) or for thermal expansion of the tank shell (given the coefficient of linear expansion of the shell material and product and ambient temperatures).

This instruction also can optionally compensate for a floating tank roof if the product density is provided.

Use this instruction in these situations:

- You want to determine the volume of product in an upright cylindrical tank given its level.
- You have the Strapping Table (tank calibration table) data for the tank.

This instruction interpolates level between strapping table calibration points linearly. Do **not** use this instruction if you have a spherical tank, a conical tank, or other tank shape for which the volume does not vary more-or-less linearly with level.

To determine the mass of product in the tank, take the volume result from the P_StrapTbl instruction and compensate for product density with further calculations. See the American Petroleum Institute (API) Manual of Petroleum Measurement Standards (MPMS) for the appropriate calculations.

Functional Description

The P_StrapTbl instruction is intended only as a calculation function, between other blocks, and so no HMI components are provided.

For a faceplate or alarm, send the calculated corrected volume to a P_AIn (Analog Input) instruction. See the Rockwell Automation Library of Process Objects: Basic Analog Input (P_AIn) Reference Manual, publication [SYSLIB-RM001](#), for alarming and display information.

Required File

The Add-On Instruction import, P_StrapTbl_3_5-00_AOIL5X, must be imported into the controller project to use the instruction in the project. The service release number (boldfaced) can change as service revisions are created.

The import file can be downloaded from the Product Compatibility and Download Center at <http://www.rockwellautomation.com/rockwellautomation/support/pcdc.page>.

There are no visualization files because the P_StrapTbl object does not use display elements or faceplates.

Controller Code

This section describes the parameter references for this Add-On Instruction.

Tank Strapping Table InOut Structure

InOut parameters are used to link the Add-On Instruction to external tags that contain necessary data for the instruction to operate. These external tags must be of the data type shown.

InOut Parameter	Data Type	Description
Cfg_CalTbl	P_StrapTblRow[N]	<p>Tank calibration table (level to volume), each entry containing the following members:</p> <ul style="list-style-type: none"> Major (Real): Number of major units (feet, meters) Minor (Real): Number of minor units (inches, centimeters, millimeters) Volume (Real): Tank volume (barrels, gallons, liters) at a given level <p>The array size [N] must be greater than or equal to the number of calibration points provided in the strapping table.</p> <p>IMPORTANT: Make this array long enough to hold all of the strapping table entries for your tank. For example, if your tank is 30 ft tall and the strapping table provides data every inch, create a tag of type P_StrapTblRow[361] (361 entries = empty row+ 30 x 12 data rows).</p>

Tank Strapping Table Input Structure

Input parameters include the following:

- Input data elements (Inp_) are typically used to connect field inputs from I/O modules or signals from other objects.
- Configuration data elements (Cfg_) are used to set configurable capabilities and features of the instruction.

Table 2 - P_StrapTbl Input Parameters

Input Parameter	Data Type	Default	Description
EnableIn	BOOL	1	<p>Ladder Diagram: If the rung-in condition is true, the instruction's Logic routine executes. If the rung-in condition is false, the instruction's EnableInFalse routine executes.</p> <p>Function Block Diagram: If true, or not connected, the instruction's Logic routine executes. If the parameter is exposed as a pin and wired, and the pin is false, the instruction's EnableInFalse routine executes.</p> <p>Structured Text: No effect. The instruction's Logic routine executes.</p>
Inp_Level	REAL	0.0	Input: Tank innage level (feet or meters).
Inp_FWLevel	REAL	0.0	Input: Tank innage free water (interface) level (feet or meters).
Inp_ObsAPI	REAL	30.5	Input: Observed density (degrees API) at product temperature . This is used for floating roof compensation to calculate displacement based on weight of roof.
Inp_AvgProdTemp	REAL	60.0	Input: Average product temperature (degrees Fahrenheit or Celsius).
Inp_AmbTemp	REAL	60.0	Input: Ambient temperature (degrees Fahrenheit or Celsius).
Cfg_MinorPerMajor	REAL	12.0	Table Minor units (inches, centimeters, millimeters) per major unit (feet or meters) (type 0.0 if minor units not used).
Cfg_HasCTSh	BOOL	0	0 = No correction for temperature of tank shell. 1 = Include correction for temperature of tank shell.
Cfg_HasFRA	BOOL	0	0 = Do not use floating roof adjustment. 1 = Include floating roof adjustment to account for displacement of fluid level.
Cfg_CalTemp	REAL	60.0	Temperature of tank calibration (typically 60 °F or 15 °C).
Cfg_ShellCoefOfExp	REAL	6.2E-06	Tank shell linear coefficient of thermal expansion (1 per degree Fahrenheit or 1 per Celsius).
Cfg_K	REAL	7.0	Temperature weighting (type 0.0 for insulated tank) (see API MPMS 2.2A app. D).
Cfg_FloatRoofLevel	REAL	0.0	Lowest level at which to add/subtract floating roof compensation (feet).
Cfg_FloatRoofCalAPI	REAL	30.5	Degrees API for which table includes floating roof data.
Cfg_FloatRoofVolPerAPI	REAL	-2.5	Adjustment to table values for API <> CalAPI (volume/degrees API, typically a negative number).

Tank Strapping Table Output Structure

Output parameters include the following:

- Value data elements (Val_) are numeric outputs of the instruction for use by the HMI. Values also can be used by other application logic or software packages.
- Status data elements (Sts_) are bit outputs of the instruction for use by the HMI. Status bits also can be used by other application logic.

Table 3 - P_StrapTbl Output Parameters

Output Parameter	Data Type	Description
EnableOut	BOOL	Enable output: The EnableOut signal is not manipulated by this instruction. Its output state always reflects EnableIn input state.
Val_TOV	REAL	Raw total observed volume from Cal. Table (barrels, gallons, liters).
Val_FW	REAL	Free Water Volume (barrels, gallons, liters).
Val_TSh	REAL	Calculated tank shell temperature (degrees Fahrenheit or Celsius).
Val_CTSh	REAL	Correction for temperature of tank shell (multiplier).
Val_FRA	REAL	Floating roof adjustment volume (barrels, gallons, liters).
Val_GOV	REAL	Primary value: Gross observed volume (see API MPMS 12.1.1).
Sts_UnderMin	BOOL	Inp_Level is below lowest level in strapping table.
Sts_OverMax	BOOL	Inp_Level is above highest level in strapping table.
P_StrapTbl	BOOL	Unique parameter name for auto-discovery.

Tank Strapping Table Local Configuration Tags

Configuration parameters that are array, string, or structure data types cannot be configured as parameters for Add-On Instructions. Configuration parameters of these types appear as local tags to the Add-On Instruction. Local tags can be configured with Studio 5000 Logix Designer® application by opening the Instruction Logic of the Add-On Instruction instance and then opening the Data Monitor on a local tag. These parameters cannot be modified by using controller logic or Logix Designer application export/import functionality.

The P_StrapTbl instruction does not include visualization elements (global objects or faceplates). However, these local configuration tags for descriptive strings are provided for use in custom visualization elements if desired.

Table 4 - P_StrapTbl Local Configuration Tags

Tag Name	Data Type	Default	Description
Cfg_Desc	STRING_40	'Tank Strapping Table'	Description for display on HMI. This string is shown in the title bar of the faceplate.
Cfg_Label	STRING_20	'Strapping Table'	Label for graphic symbol displayed on HMI. This string appears on the graphic symbol.
Cfg_LevelIEU	STRING_8	'Feet'	Level engineering units for display on HMI.

Table 4 - P_StrapTbl Local Configuration Tags

Cfg_Tag	STRING_20	'P_StrapTbl'	Tagname for display on HMI. This string is shown in the title bar of the faceplate.
Cfg_TempEU	STRING_8	'Deg F'	Temperature engineering units for display on HMI
Cfg_VolumeEU	STRING_8	'Gallons'	Volume engineering units for display on HMI.

Operations

The P_StrapTbl Add-On Instruction uses tank calibration data and a tank level measurement to calculate tank volume. Tank calibration data can be obtained from the tank manufacturer or design firm, or determined through calibration. Example calibration methods are provided by the American Petroleum Institute's (API) Manual of Petroleum Measurement Standards (MPMS) section 2.2A or 2.2B.

This instruction performs its calculations by using the same methods described in API MPMS Section 12.1 Part 1. The instruction calculates the following items:

- Total Observed Volume (TOV)
- Free Water Volume (FW)
- Correction for Temperature of Tank Shell (CTSh)
- Floating Roof Adjustment (FRA)
- Gross Observed Volume (GOV, the primary output of this instruction)

All calculations require the overall level input and the tank calibration table ('strapping table'). The FW calculation is a specific requirement when calculating petroleum storage to adjust for free water content. This requires an additional level signal for the product/water interface.

The CTSh calculation compensates for thermal expansion of the storage tank. If used, this calculation requires these measurements and configuration settings:

- Product temperature and the ambient temperature
- Configuration of the tank shell coefficient of linear expansion (fraction per degree)
- Calibration temperature for the tank calibration table
- Configuration constant for weighting the two measured temperatures (a reasonable default is provided)

The FRA calculation compensates the level measurement for displacement caused by a floating roof. This calculation requires a measurement or input of the product actual density and additional configuration data about the floating roof.

The final GOV calculation is provided without correction for product density and temperature (other than the shell temperature above) or included sediment and water. Those calculations depend on the product, not just the tank calibration table, and are beyond the scope of this general-purpose instruction.

Modes

The P_StrapTbl Add-On Instruction only performs calculations and does not have any modes. The instruction does not contain an embedded P_Mode instruction.

Alarms

The P_StrapTbl Add-On Instruction only performs calculations and does not have any alarms. The instruction does not contain an embedded P_Alarm instruction.

To provide High-High, High, Low, and/or Low-Low threshold alarms for the input or output of P_StrapTbl, use the P_AIn Analog Input instruction.

Refer to the Rockwell Automation Library of Process Objects: Basic Analog Input (P_AIn) Reference Manual, publication [SYSLIB-RM001](#), for more information.

Simulation

The P_StrapTbl Add-On Instruction does not have simulation capability.

Use the simulation capability of associated analog input instructions to simulate level or temperature inputs or volume outputs.

Execution

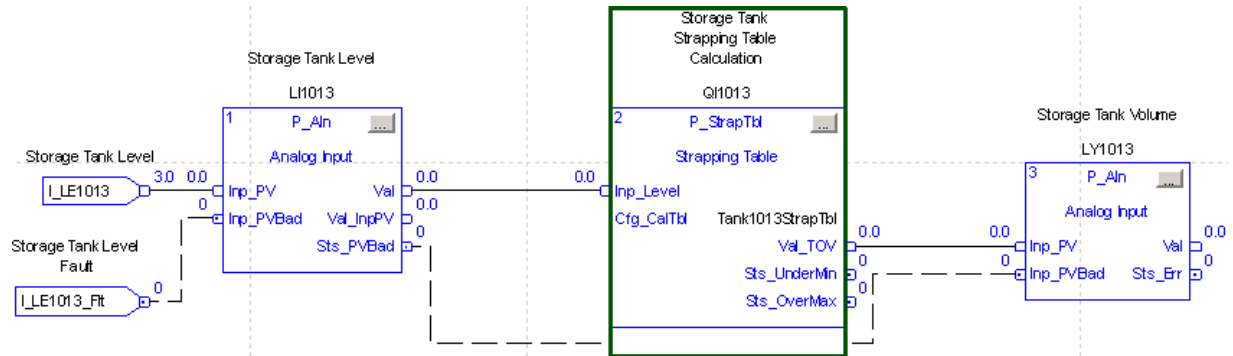
The following table explains the handling of instruction execution conditions.

Condition	Description
EnableIn False (false rung)	No EnableInFalse logic is provided. The instruction maintains its last state when EnableIn is false.
Powerup (prescan, first scan)	No Pre-scan or First Scan logic is provided. The P_StrapTbl instruction simply performs its calculation every scan when EnableIn is true.
Postscan	No SFC Postscan logic is provided.

Refer to the Logix5000 Controllers Add-On Instructions Programming Manual, publication [1756-PM010](#), for more information.

Programming Example

This example uses the P_StrapTbl instruction to calculate the volume of product in a storage tank based on the measured storage tank level and storage tank strapping table information. In this example, there is no floating roof so there is no compensation for displacement. There are no adjustments based on temperature to account for thermal expansion of the tank.



The measured storage tank level is connected into the P_StrapTbl instruction by using the input Inp_Level. In this example, the level is reported in units of feet.

The storage tank is a 4 ft tall tank, and strapping table information has been provided by the tank vendor. Strapping tables often list data in terms of major and minor units. In this example, data has been provided at 6-in increments. The vendor-provided strapping table has nine rows and looks like the following table.

Level (ft-in.)	Volume (barrels)
0-00	3.1
0-06	136.6
1-00	264.2
1-06	402.7
2-00	541.4
2-06	692.7
3-00	844.1
3-06	990.8
4-00	1137.5

To store the strapping table information in the controller, the tag Tank1013StrapTbl is created as type P_StrapTblRow[9] (a nine-element array of strapping table information).

The parameter `Cfg_MinorPerMajor` is left at its default of 12, so that the instruction can convert the input (feet) to major and minor units (feet and inches). This allows the strapping table to be configured by using the same major and minor units as provided by the vendor.

Table 5 - Strapping Table Calculation Examples

	.Major	.Minor	.Volume
Tank1013StrapTbl[0]	0	0	3.1
Tank1013StrapTbl[1]	0	6	136.6
Tank1013StrapTbl[2]	1	0	264.2
Tank1013StrapTbl[3]	1	6	402.7
Tank1013StrapTbl[4]	2	0	541.4
Tank1013StrapTbl[5]	2	6	692.7
Tank1013StrapTbl[6]	3	0	844.1
Tank1013StrapTbl[7]	3	6	990.8
Tank1013StrapTbl[8]	4	0	1137.5

The InOut tag `Cfg_CalTbl` of the `P_StrapTbl` instruction is modified to point to the new array `Tank1013StrapTbl` to provide the instruction with the strapping table information. The output of `P_StrapTbl` is then connected to another `P_AIn` instruction. The output is the calculated volume of the storage tank.

The local configuration tags `Cfg_Desc`, `Cfg_Label`, and `Cfg_Tag` are not required to be set. The `P_StrapTbl` instruction does not include visualization elements (global objects or faceplates). However, these string parameters are provided for use in custom visualization elements, if desired.

Rockwell Automation Support

Rockwell Automation provides technical information on the Web to assist you in using its products.

At <http://www.rockwellautomation.com/support> you can find technical and application notes, sample code, and links to software service packs. You can also visit our Support Center at <https://rockwellautomation.custhelp.com/> for software updates, support chats and forums, technical information, FAQs, and to sign up for product notification updates.

In addition, we offer multiple support programs for installation, configuration, and troubleshooting. For more information, contact your local distributor or Rockwell Automation representative, or visit <http://www.rockwellautomation.com/services/online-phone>.

Installation Assistance

If you experience a problem within the first 24 hours of installation, review the information that is contained in this manual. You can contact Customer Support for initial help in getting your product up and running.

United States or Canada	1.440.646.3434
Outside United States or Canada	Use the Worldwide Locator at http://www.rockwellautomation.com/rockwellautomation/support/overview.page , or contact your local Rockwell Automation representative.

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