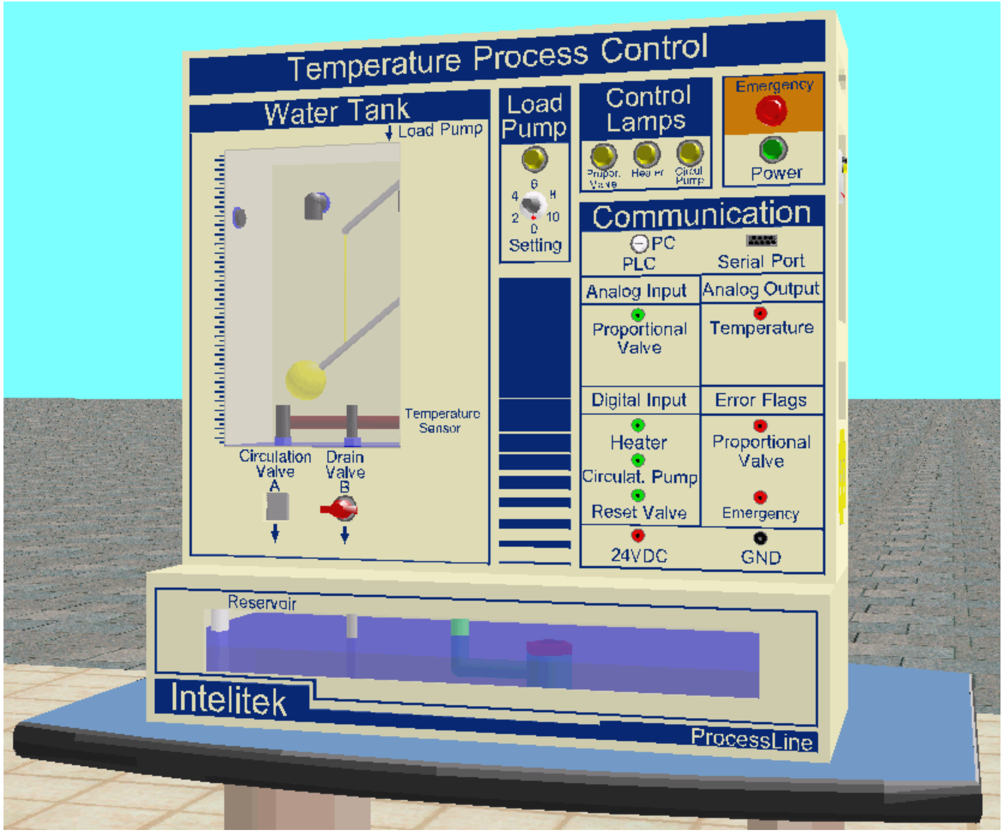
ProcessMotion



USER MANUAL

For Version 3.0 and Higher

intelitek®

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ProcessMotion User Manual

For ProcessMotion Version 3.0 and Higher

ProcessMotion Cat. # 63-9238-0000

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March 2019

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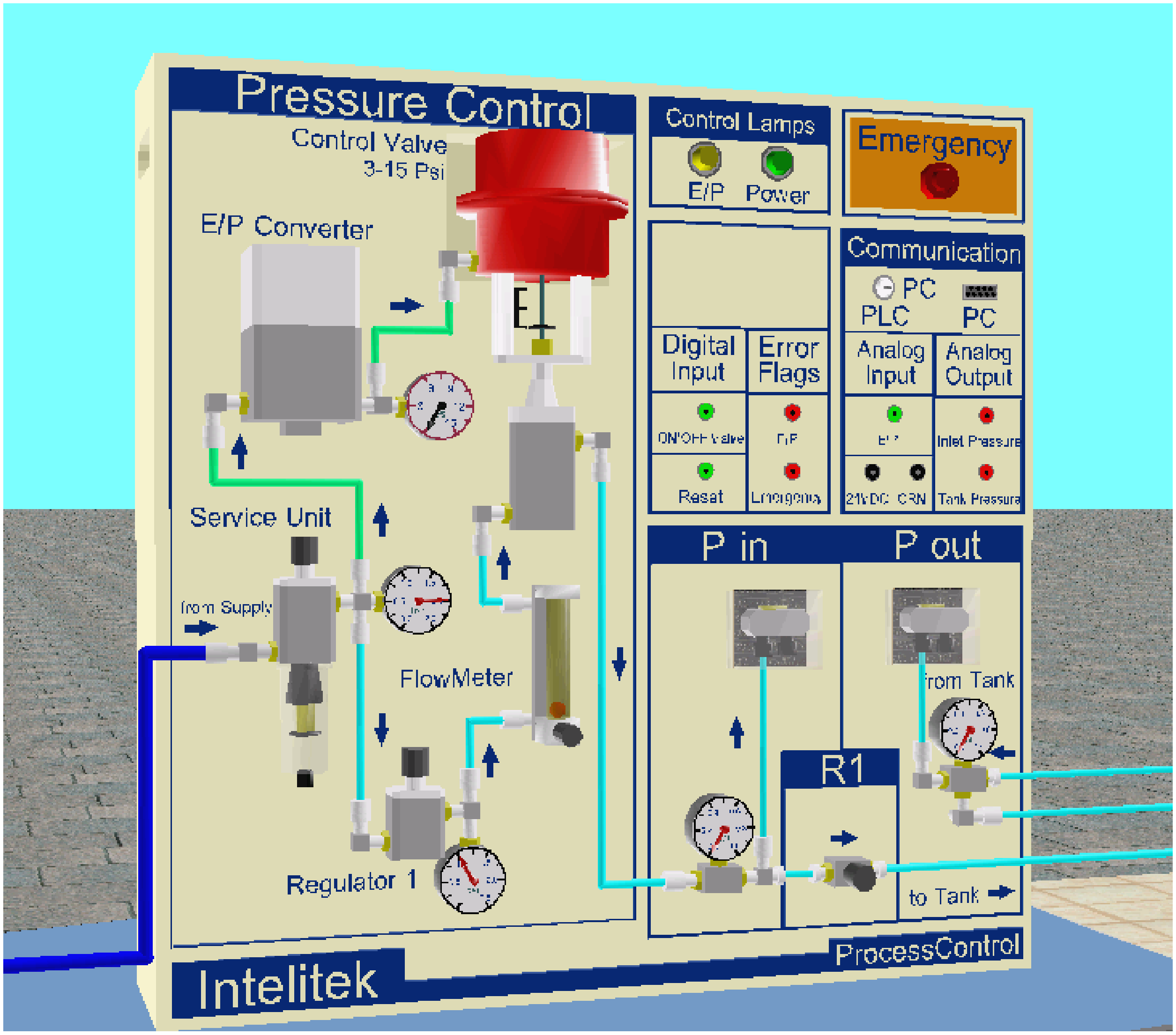
Introducing ProcessMotion

Thank you for purchasing ProcessMotion!

ProcessMotion is a process control simulator for level and flow, temperature, and pressure control systems.

This manual covers all features, menus, and commands of ProcessMotion Version 3.0.



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1. Starting ProcessMotion

The following sections describe the steps involved in getting started with ProcessMotion.

1.1. SYSTEM REQUIREMENTS

For best performance, the following system is recommended:

- Intel Core i5 2400 GHz 2400 GHz or higher
- At least 1 GB RAM
- A hard drive with at least 200 MB of free disk space
- One of the following operating systems:
  - Windows 7 Home Premium or higher (32 or 64 bit) with SP1
  - Windows 8.1 Pro or higher (64 bit only)
  - Windows 10 Pro or higher (64 bit only)

Note: *Your operating system might have additional hardware requirements.*

1.2. SOFTWARE LICENSING

ProcessMotion is protected by a licensing agreement. Full details on the Intelitek software licensing are provided in the Intelitek Software Licensing Guide.

1.3. INSTALLING THE SOFTWARE

Close any applications that are open before proceeding with the installation procedures. If you are about to reinstall the software or install a newer version to an existing ProcessMotion directory, it is recommended that you back up any existing user-created files before you begin the installation. It is also recommended that you remove the previous ProcessMotion version for Windows installation using the software's Uninstall utility (For more information on uninstalling ProcessMotion, see 1.5 Uninstalling ProcessMotion on page 6).

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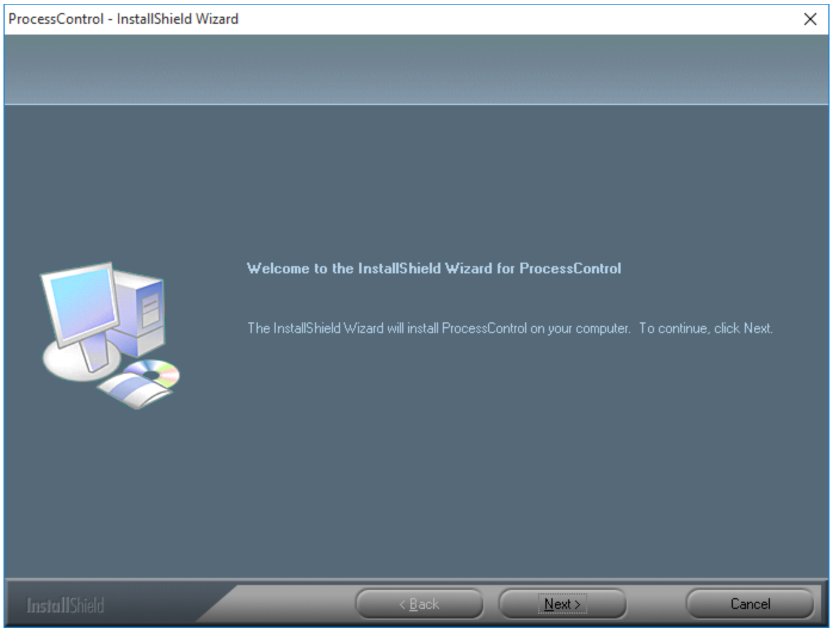
To install ProcessMotion:

1. Double-click the ProcessControl.exe file to start the installation procedure.
2. Wait until the InstallShield window is displayed.



3. Click **Next**. The License Agreement window is displayed.

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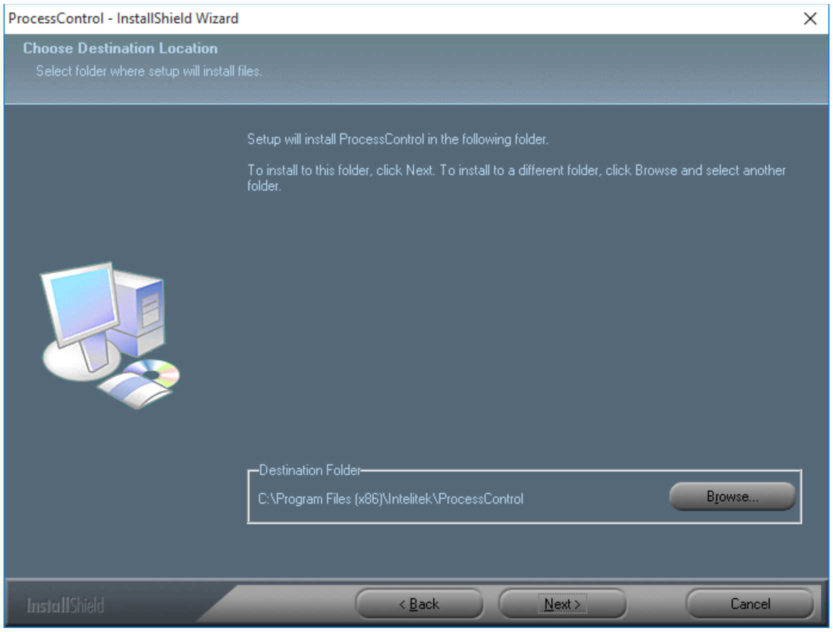
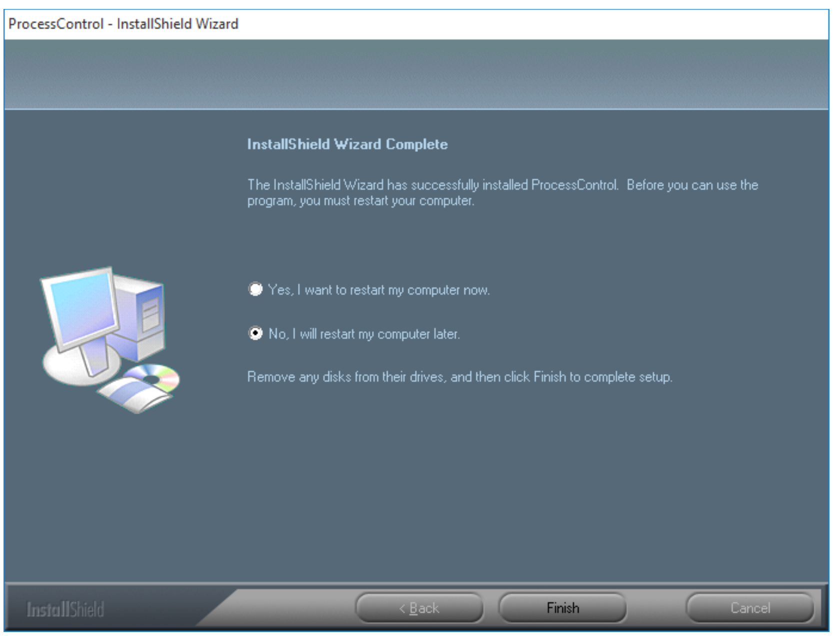
4. Review the Intelitek software license agreement. You must accept the terms of this agreement in order to proceed with the installation. To accept, select **Yes**. The Destination Location Window is displayed.

5. Click **Next**. The InstallShield Wizard is ready to Install the program.



6. Click **Next**. The software is installed.



7. Click **Finish** to complete the installation.

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1.4. PROCESSMOTION UTILITIES

ProcessMotion contains three different utilities:

- Level and Flow
- Pressure
- Temperature

You can access each of these utilities from your computer's start menu.

1.5. UNINSTALLING PROCESSMOTION

To uninstall ProcessMotion:

1. From the ProcessMotion program group, select **Uninstall**.
2. Follow the instructions that are displayed on the screen.

The Intelitek Software Licensing Guide provides full details on the procedures for protecting your license, transferring the license from one PC to another, and returning the license to Intelitek for retrieval at a later time.

1.6. QUITTING THE SOFTWARE

To close any one of the three ProcessMotion utilities, perform any of the following:

- Select **File | Exit**.
- Click the **X** in the ProcessMotion title bar.

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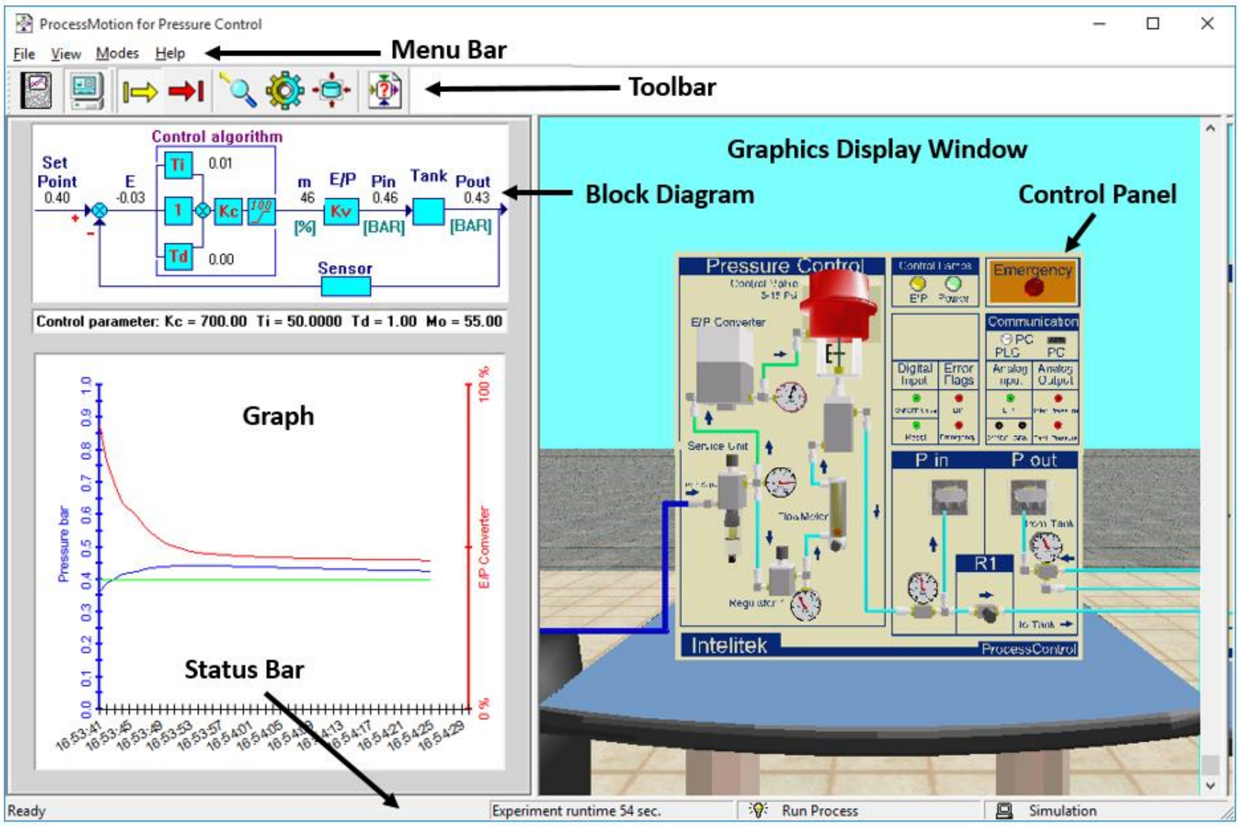
2. The ProcessMotion Interface

2.1. OVERVIEW

ProcessMotion has three different utilities, but the interface for each is the same with the exception of several utility-specific elements.

The main elements of the ProcessMotion window are shown here.



Initially, before a process is started, the Block Diagram and Graph areas are hidden.

This table summarizes the main parts of the screen:

ProcessMotion Interface	
Screen Element	**Description**
Menu Bar	Provides the menu commands for working with ProcessMotion.
Toolbar	Provides access to commonly used commands, such as starting and stopping simulations and changing the view of the panel.
Graphics Display Window	Displays the ProcessMotion panel and the system equipment.
Graph	Displays the responses of the system.

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ProcessMotion Interface	
Screen Element	**Description**
Block Diagram	The Block Diagram reflects the parameters of the system and the system response.
Status Bar	Provides system information such as experiment runtime.

2.2. THE MENU BAR

The menu bar provides the menu commands for working with ProcessMotion.

The table below summarizes the options in the menu bar.

Menu Bar Options	
Option	**Description**
File	Enables you to open, set and save parameters, print your results, and exit the software. You can also print charts and images of the Graphics Display Window.
View	Allows you to view or hide the toolbar and the status bar. It also lets you redirect the camera for different views of the screen.
Modes	Allows you to change system modes and parameters.
Help	Provides information about your ProcessMotion software.

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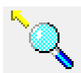
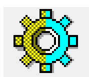
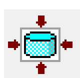
2.3. CONTROLLING THE VIEW

The Graphics Display Window displays the control panel and equipment for whichever of the three utilities you are using. You can modify the view in the window and even open additional windows to view the equipment from multiple angles. This section describes how to do so.

2.3.1. Basic View Controls

Options in the View menu and Toolbar, in addition to operations you perform with your cursor, allow you change the view in the Graphics Display Window. This table summarizes the viewing options.

ProcessMotion View Options		
Icon/Operation	**Option**	**Summary**
 + Click	Redirect Camera	Centers the view to where you clicked on the Graphics Display Window.
	Cutaway View	Displays the internal workings of the equipment. Click this icon again to return to the regular view.
	Center Camera	Centers the view to the original view (the center of the control panel).
Right-click + left/right	Rotate	Right-click anywhere on the Graphics Display Window and drag the cursor leftwards or rightwards to rotate the view.
Right-click + up/down	Zoom	Right-click anywhere on the Graphics Display Window and drag the cursor upwards or downwards to zoom in or out on the view center, respectively.
Ctrl + Right-click + drag	Brightness	Hold down the Ctrl key, right-click, and drag the cursor to alter the brightness of the Graphics Display Window.

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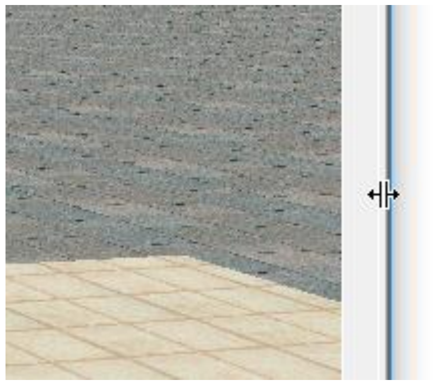
2.3.2. Splitting the Graphic Display

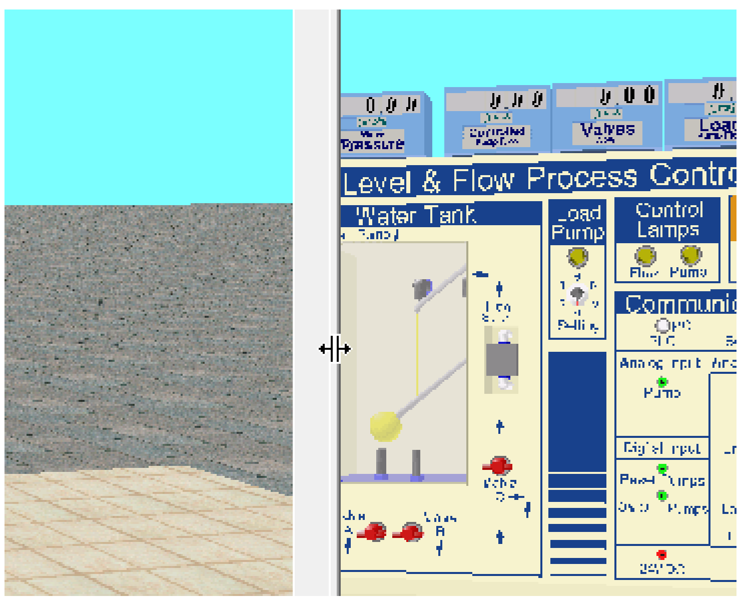
When you first open ProcessMotion, only the main graphic display window is visible. The graphic display can be split into three different windows, allowing you to concurrently display three different views of the control panels and equipment and to manipulate each of these displays.

To open the two secondary display windows:

1. Move the cursor to the far right edge of the graphics display window until the cursor changes into a double arrow.



2. Click and drag the cursor, dragging the right frame towards the center of the screen. A second display appears to the right of the original display.



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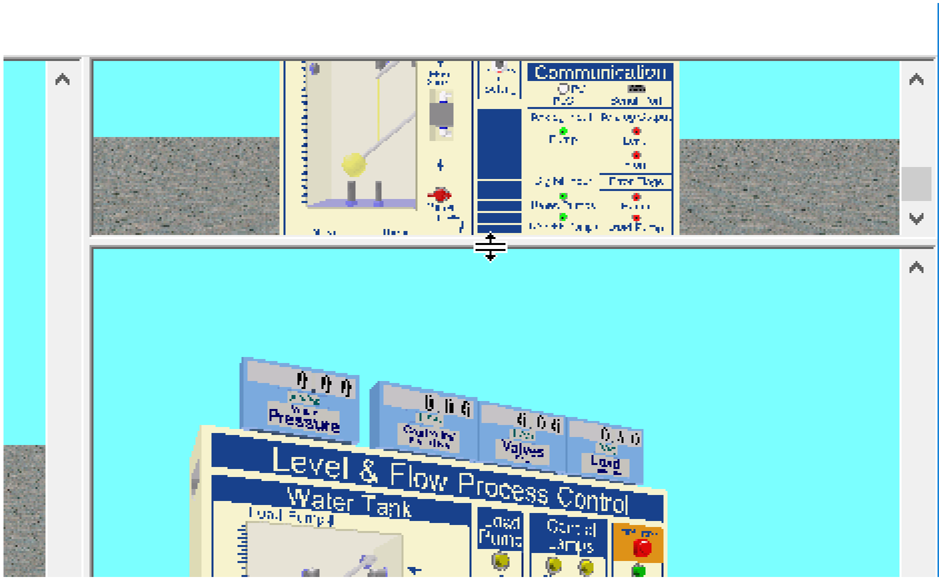
3. Move the cursor to the top of the new graphic display window. When the cursor becomes a double arrow, click and drag the frame downward to reveal the third graphic display window.



You can manipulate all three windows in the same manner. This allows you to view different areas of the panel independently.

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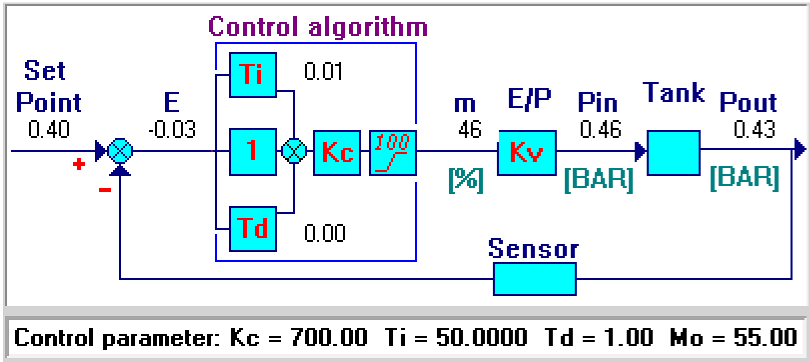
2.4. THE BLOCK DIAGRAM AND CONTROL PARAMETERS

The Block Diagram area reflects the parameters of the system and the system response.



Example Block Diagram

This table summarizes the parameters for all three of the ProcessMotion utilities. For more information, see the Appendix: Understanding Process Control on page 25.

Block Diagram Parameters		
Parameter	**Relevant for**	**Summary**
Set Point	All utilities	The desired level of the tank temperature (T_{in}) pressure (P_{out}) or level (H).
E	All utilities	The error: The difference between the set point and T_{in} / P_{out} / H.
m	All utilities	The PID controller output, which is the percentage of power sent to the heating element (Temperature Control), E/P device (Pressure Control) or pump (Level and Flow Control).
K_c	All utilities	Represents the proportional control setting of the PID algorithm.
T_i	All utilities	Represents the integral algorithm setting of the PID algorithm.
T_d	All utilities	Represents the derivative algorithm setting of the PID algorithm.
M_o	All utilities	Represents a constant bias for the PID algorithm. When the proportional, integral, and derivative algorithm output equals zero, m equals M_o.
P_{in}	Pressure Control	The pressure at the system input.
P_{out}	Pressure Control	Tank pressure (System Output)
T_{in}	Temperature Control	Tank temperature (System Output)
q_{in}	Level and Flow Control	Flow input
H	Level and Flow Control	Tank Level (System Output)

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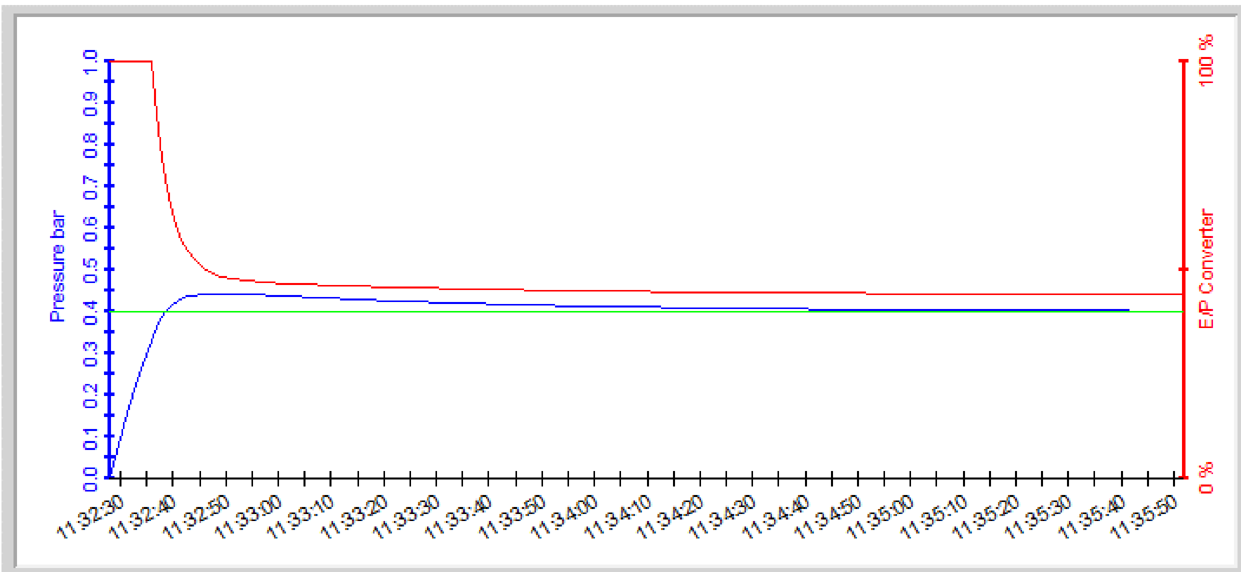
2.5. THE GRAPH

2.5.1. Elements of the Graph

The graph displays the responses of the system.

- The green line represents the set point (or set points) of the system.
- The red line represents the percentage of power sent to the heating element (Temperature Control), E/P device (Pressure Control) or pump (Level and Flow Control).
- The blue line represents the system output.

All of the responses are displayed as a function of time (*X-axis*).

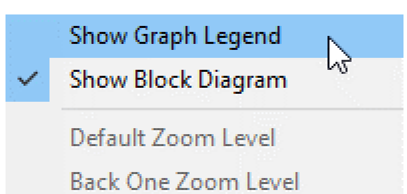


2.5.2. Graph Legend

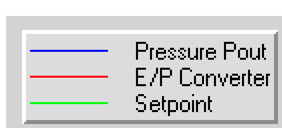
The purpose of the graph legend is to clarify the elements of the graph.

To display the legend:

1. Right-click anywhere on the graph.
2. In the pop-up dialog, select **Show Graph Legend**.



The legend is displayed.



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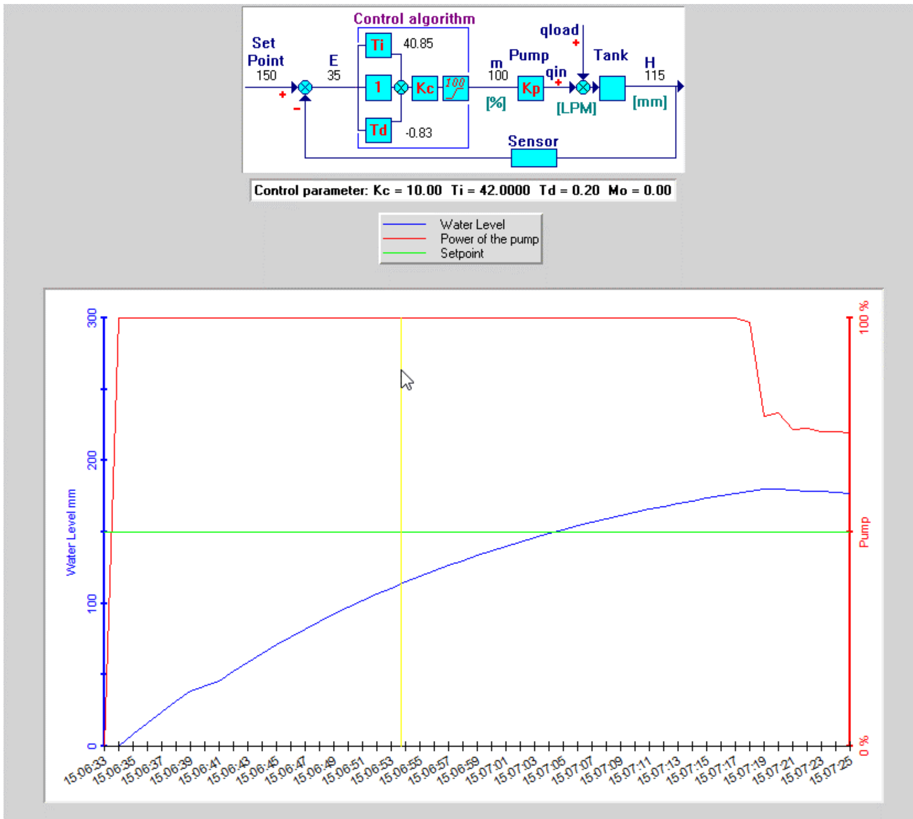
2.5.3. Graph Point Values

You can observe data values of the process for specific points in time. Once a process is stopped, a vertical yellow line is displayed on the graph. The values that are intersected by this yellow line are displayed in the Block Diagram.



Graph of a stopped process with a vertical yellow line. Values of the responses intersected by the yellow line represent the values at the indicated point of time. The values are displayed in the Block Diagram above the graph.

To move the yellow line, move your cursor parallel to the desired point in time on the graph.

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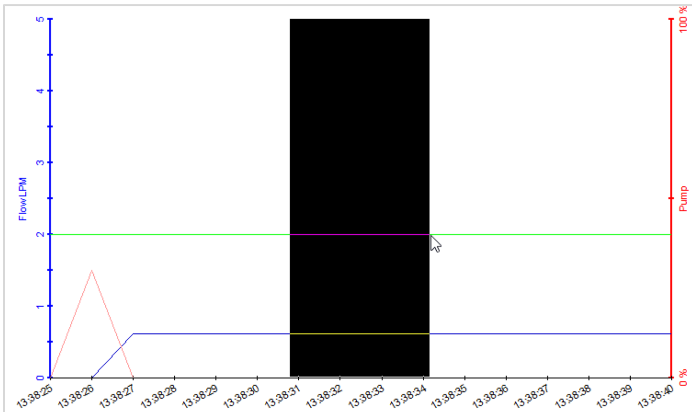
2.5.4. Zooming in on Parts of the Graph

You can zoom in on parts of the graph to view graph data at a higher resolution.

__Note:__ The process must be stopped to zoom in on the graph.

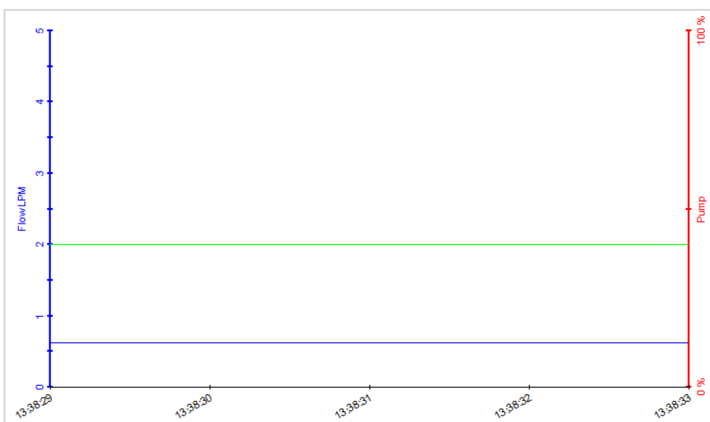
To zoom in on a part of the graph:

1. Click and drag your cursor leftwards or rightwards over the section of the graph to that you want to magnify. The section is highlighted black.



__Note:__ Alternatively, you can click the graph to zoom in on a specific moment in time, instead of dragging your cursor to highlight a selection.

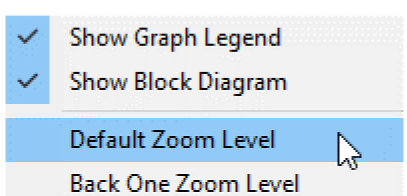
2. Release the mouse button. The highlighted area is magnified.



3. Repeat the previous two steps to zoom in further.

To zoom out:

- Right-click the graph and select **Default Zoom Level** or **Back One Zoom Level**.



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3. Running a Process

3.1. PROCESS OVERVIEW

The main objective of ProcessMotion is to simulate the operation of a temperature control, pressure control, water level, or water flow control system. This chapter explains how to run each type of process in the three utilities of ProcessMotion.

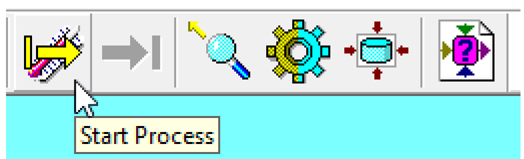
Running a control system involves the following steps:

1. Inputting desired system parameters.
2. Initiating the process.
3. Observing the process and collecting data.
4. Stopping the process and performing a final data analysis.

3.2. STARTING A PROCESS

To run a process in any of the three ProcessMotion utilities:

1. In the Toolbar, click the **Start Process** button. The Level and Flow utility offers two Start Process options: **Level Process** and **Flow Process**.



Temperature Control Process

Pressure Control Process

Level and Flow Control Processes

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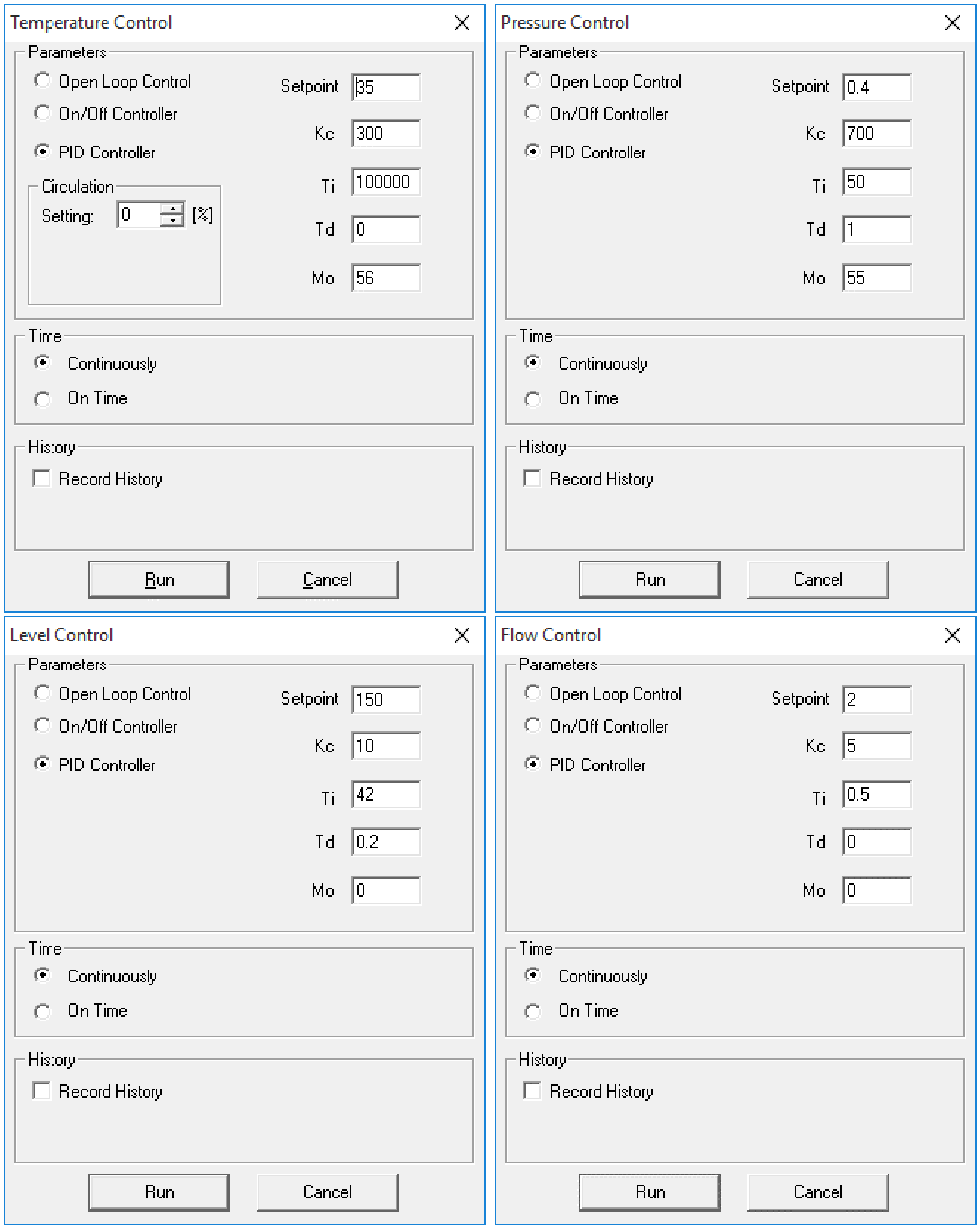
The Control dialog is displayed. The dialog is specific to the utility and to the selected process.



The process control dialogs. Clockwise from top right: Temperature Control dialog, Pressure Control dialog, Flow Control dialog, and Level Control dialog.

2. Set the desired settings for the process:

   - **Parameters:** Set the type of control and the parameters of the process. See 2.4 The Block Diagram and Control Parameters on page 12 for more information about parameters.
   - **Time:** Set whether control should be activated continuously or for a set amount of time.
   - **History:** Check the **Record History** box if you want to record and export graph data. If checked, you are prompted to select a file path for the saved .his file.

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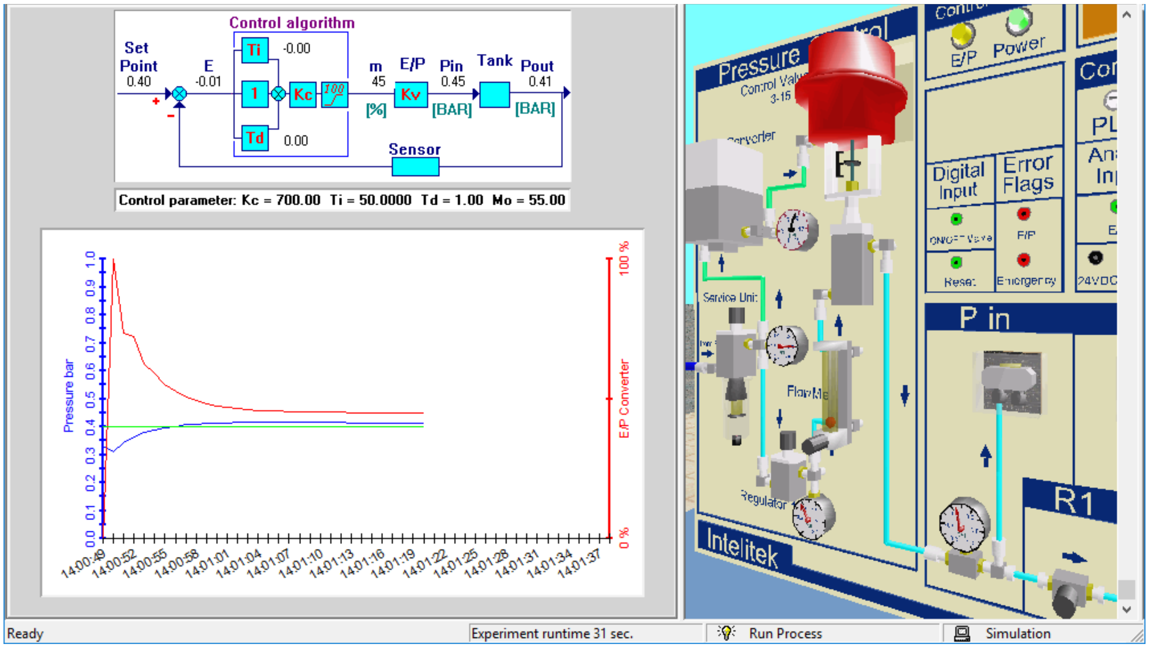
3. Click **Run**.

The process is initiated. You can observe the process in the Graph, the Block Diagram, and the Graphic Display Window. Information about the process is also displayed in the Status Bar. The parameters that you selected for the process are displayed in the Block Diagram.



3.3. STOPPING A PROCESS

You can stop a process at any time.

To stop a process:

- In the Toolbar, click the **Stop Process** button.

Once a process is stopped, you can analyze the data on the graph. See section 2.5 The Graph for more information.

If you chose to record history the .his file, the file is available in the location that you selected.

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4. ProcessMotion Simulated Equipment

4.1. OVERVIEW

The three utilities of ProcessMotion simulate different types of process control systems and equipment. This chapter provides an explanation of the virtual equipment in all three of the utilities.

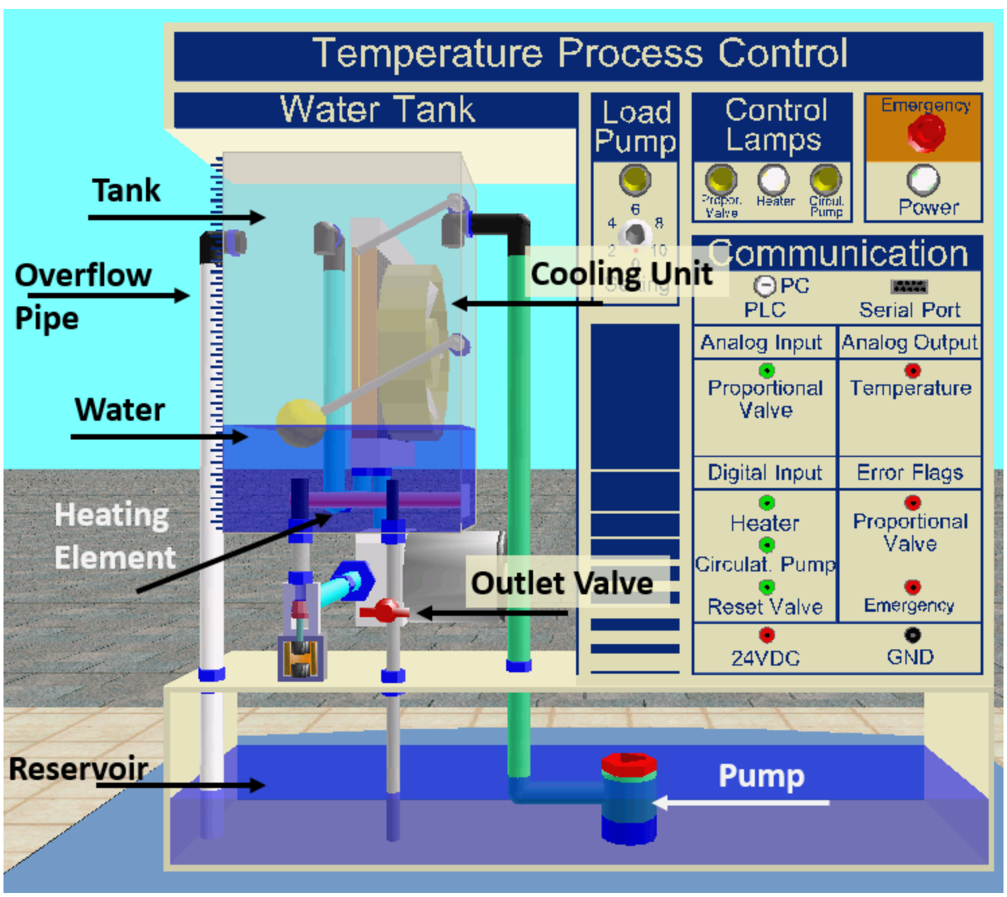
- For temperature control equipment, continue to section 4.2 below.
- For pressure control equipment, see section 4.3 Pressure Control Equipment on page 21.
- For level and flow equipment, see section 4.4 Level and Flow Control Equipment on page 23.

4.2. TEMPERATURE CONTROL EQUIPMENT

4.2.1. Description of Equipment

The Temperature Control panel simulates an instructional panel for experimenting with temperature control. The simulated meters and gauges reflect the readings that would be shown by the meters and gauges on an actual panel.

The main elements of the temperature control panel (shown in cutaway view below) are described in table on the next page.



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Temperature Control Panel	
Part Name	**Description**
Tank	Contains the water in the system.
Overflow Pipe	Prevents the tank from overflowing. Water above the designated level returns to the reservoir via this pipe.
Water	The temperature of the water must be maintained at a user-defined level. A water sensor (not shown) measures the temperature of the water.
Cooling Unit	Cools the water as it is circulated.
Heating Element	Transmits heat energy to the water.
Outlet Valve	Drains water from the tank to decrease the amount of water in the tank when required.
Pump	Pumps water into the tank when required.
Reservoir	Contains excess water to be pumped into the tank when required.

4.2.2. Mode of Operation

The objective of the control system is to maintain the temperature of water in the tank at a user-defined temperature. It does this by adjusting the power sent to a heating element within the tank. The heating element transfers energy to the water, causing the temperature of the water to rise.

The water continually loses heat through the walls of the tank. The controller must ensure that enough energy is transferred to the water by the heating element to maintain the desired water temperature.

A circulation system can be activated to pump water from the tank, through a cooling system, and back into the tank. The cold water flowing into the tank (at a user-defined rate) is a load on the control system. The control system must compensate for this load by adjusting the power sent to the heating element.

The temperature of the water is measured using a temperature sensor. An electrical signal is sent from the temperature sensor to the controller, indicating the temperature of the water.

The controller uses a control algorithm to calculate the amount of power that must be sent to the heating element to maintain the required water temperature.

- To increase the temperature of the water in the tank, the control system must increase the power transferred to the water by the heating element.
- To decrease the temperature of the water in the tank, the control system must decrease the power transferred to the water by the heating element.

Throughout the process, the water loses energy through the walls of the tank, becoming cooler.

- When the power sent to the heating element enables it to supply more energy to the water than is lost through the tank walls, the temperature of the water rises.
- When the power sent to the heating element enables it to supply less energy to the water than is lost through the tank walls, the temperature of the water falls.

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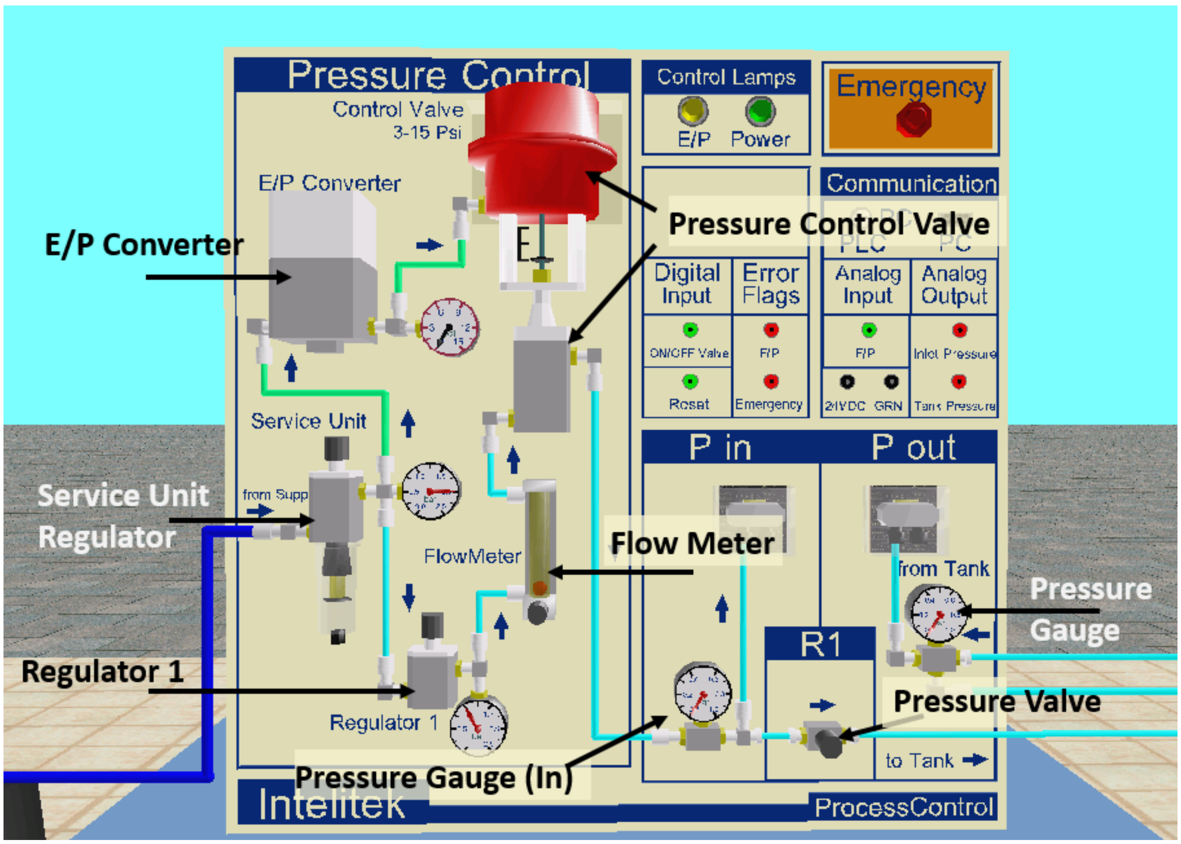
4.3. PRESSURE CONTROL EQUIPMENT

4.3.1. Description of Equipment

The Pressure Control panel simulates an instructional panel for experimenting with pressure control. The simulated meters and gauges reflect the readings that would be shown by the meters and gauges on an actual panel.

The main elements of the level and flow control panel are displayed in the image and described in the table below.



Pressure Control Panel	
Part Name	**Description**
E/P Converter	Converts the electrical controller signal into a pressure signal.
Service Unit Regulator	Divides the air from the compressor between the green and blue pipes.
Pressure Control Valve	Regulates the pressure of air entering the tank.
Regulator 1	Limits the air flow through the lower pipe.
Flow Meter	Measures air flow rate.
Pressure (In) Gauge	Measures the pressure of air entering the tank.
Pressure Gauge	Measures the pressure of air in the tank.

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Pressure Control Panel	
Part Name	**Description**
Pressure Valve	Limits the flow of air entering the tank and prevents air from flowing back from the tank.
Tank (not shown)	Container in which the pressure is controlled.
Compressor (not shown)	Supplies air to the system.

4.3.2. Mode of Operation

The components of the panel form a control system. The objective of the control system is to maintain the pressure in the tank at a user-defined level, by increasing or decreasing the pressure of air entering the tank.

Air enters the panel from a compressor. The control system on the panel changes the pressure of the air before it enters the tank. By controlling the pressure of the air entering the tank, the control system can control the pressure in the tank.

- To increase the pressure in the tank, the control system must increase the pressure of the air entering the tank.
- To decrease the pressure in the tank, the control system must decrease the pressure of the air entering the tank.

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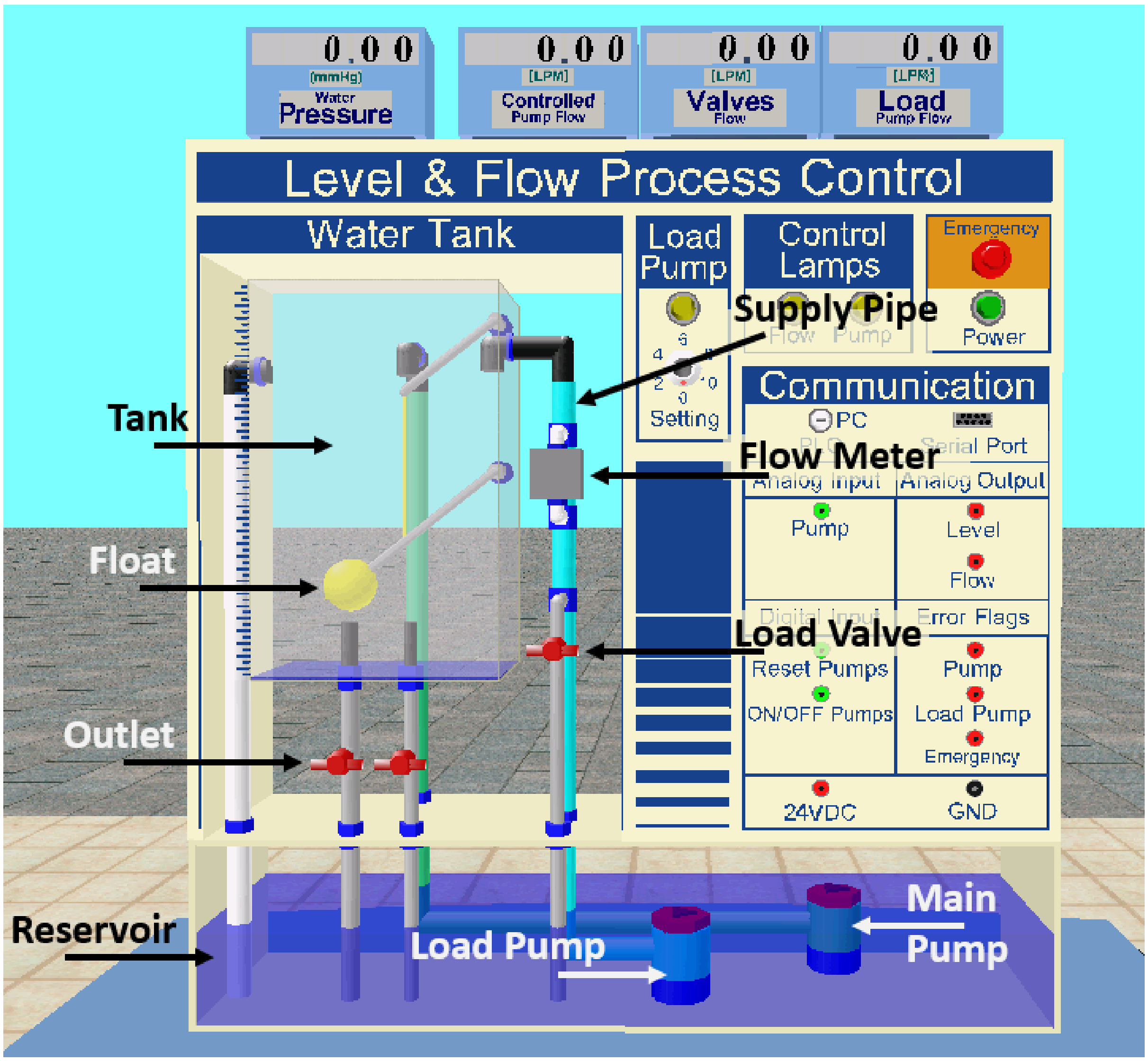
4.4. LEVEL AND FLOW CONTROL EQUIPMENT

4.4.1. Description of Equipment

The Level and Flow Process Control panel simulates an instructional panel for experimenting with level control and flow control. The simulated meters and gauges of the virtual flow and level control panel reflect the readings that would be shown by the meters and gauges on an actual panel. The level of water shown in the tank reflects the level of water that would be present in the tank of an actual panel.

The main elements of the level and flow control panel are displayed in the image and described in the table below. The panel is shown in cutaway view.



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Level and Flow Control Panel	
Part Name	**Description**
Tank	The control system controls the rate of flow into the tank.
Float	A buoyant ball that floats on the surface of the water and aids in determining the height of the water.
Outlet	Controls the rate at which water can flow out from the bottom of the tank.
Reservoir	Stores water to be pumped into the tank. Collects water that flows out of the tank and out of the load valve.
Supply Pipe	Water is pumped through this pipe into the tank.
Flow Meter	Measures the rate at which water is pumped into the tank.
Load Valve	Allows water to flow out of the supply pipe and back into the reservoir.
Load Pipe	Pumps water into the tank to simulate a load on the system.
Main Pump	Pumps water from the reservoir up the supply pipe and into the tank.

4.4.2. Mode of Operation

The components of the panel form a control system. The objectives of the control systems are:

- To maintain the level of water in the tank at a user-defined level (level control).
- To maintain the rate at which water flows into a tank at a user-defined rate (flow control).

Water is pumped into the tank by the pump and flows out the tank through a valve at the bottom. The water is pumped into the tank from the reservoir at the bottom of the panel, through the inlet pipe near the top-right corner of the tank.

The controller uses a control algorithm to calculate the amount of power that must be sent to the pump to maintain the required flow rate into the tank or to maintain the tank water level. The required amount of power is communicated to the pump in the form of an electrical signal. The higher the signal, the faster the pump operates.

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5. Appendix: Understanding Process Control

5.1. WHAT IS PROCESS CONTROL?

ProcessMotion is a tool to simulate phenomena associated with process control. But what exactly is process control?

In the modern world, we are surrounded by working systems that have some sort of control mechanism; a mechanism that attempts to control the output of the system by regulating the amount of input introduced into the system. A control mechanism could be a thermostat, an automobile cruise control system, or the cooling system of a nuclear reactor. In industrial applications that require system control, some action is usually taking place within the system. Thus, the entire system is usually involved in some sort of process. Process control, as its name implies, is the control of a physical variable (or variables) within a particular system. By controlling a particular physical variable (or variables), the entire process can be controlled.

5.2. THE CONTROLLER

The task of controlling the physical variable is given to a controller, which automatically regulates the system so that the controlled physical variable stays at the desired value. This eliminates the need for constant human supervision, which is both tedious for the supervisor and not always accurate, especially if the process requires rigid control.

5.3. THE NEED FOR CONTROL SYSTEMS

The need to control systems is a basic, integral requirement for most industrial processes today. Process control allows manufacturers to obtain a higher level of quality control and to conform to stricter safety requirements, creating better products and protecting the safety of workers and consumers. Manufacturers need to control the manufacturing environment in order to produce uniform products. Many chemical reactions are dependent on very specific reaction conditions. For safety reasons, manufacturers often need to control physical variables of processes. These are all reasons why control systems have become so widespread in the modern industrial world.

5.4. COMMONLY MONITORED VARIABLES

There are several variables that are commonly monitored and regulated in the industrial world. ProcessMotion focuses on four of these variables: Pressure, temperature, water level, and water flow.

5.4.1. Pressure

Many processes depend upon a highly regulated pressurized environment, and all pneumatic systems demand some type of air pressure control. The Pressure Control utility of ProcessMotion simulates a hands-on experience with air pressure control, while demonstrating both the principles and some of the performance concerns involved in designing and operating a pressure control system.

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5.4.2. Temperature

Temperature control is needed when the temperature of a defined space or object should be maintained constant despite system changes, such as changes in the ambient temperature or a new temperature requirement. The Temperature Control utility simulates a temperature control laboratory.

5.4.3. Level and Flow

Water level and water flow are two variables that are commonly monitored and regulated in the modern industrial environment. Many industrial processes utilize tanks filled with various liquids whose quantity (or level) and flow should be regulated and monitored. Examples of these include milk tanks in dairies and coolant water tanks in nuclear reactors. The Level and Flow Control utility of ProcessMotion simulates a hands-on experience with water level control and water flow control while demonstrating the principles and performance concerns that come hand-in-hand with designing and operating a control system.

5.5. CONTROL ALGORITHMS

5.5.1. PID Control

There are several different types of control algorithms. One of the common types of control used in process control technology is called PID. PID is a control algorithm used in many automated systems. It is a combination of three individual algorithms, known as Proportional, Integral and Derivative algorithms, respectively.

Although PID is a very common control mode in industrial processes, there are also other control algorithms used for various process control systems.

5.5.2. Open Loop Control

An open loop control algorithm is able to control the system output without the use of feedback. In open loop control, tests are used to determine the typical system response to a specific input. Once the ratio between output and input is determined, the controller knows how much input is needed to produce the desired system output.

5.5.3. On-Off Control

An on-off control algorithm does react to feedback, i.e. it can measure the system output. It then compares the actual system output to the desired output (the setpoint) and reacts accordingly. If the system output is lower than the setpoint, the on-off control algorithm reacts by turning on the system input to 100%. When the system output rises above the setpoint, the controller responds by turning the input off completely until the output falls below the setpoint.

5.5.4. Proportional Control

A proportional control algorithm controls a device by reacting to proportional changes. For example, if you set the cruise control of a car to 60 mph (97 kph) while the car is travelling at 50 mph (80 kph), the cruise control increases the gas flow to the engine to increase the speed. The amount of additional gasoline sent to the engine is proportional to the difference between the programmed speed and the actual speed. When the car is travelling at 50 mph and the error is 10 mph, the controller sends half the amount of gas as when the car is travelling at 40 mph and the error is 20 mph. As the car accelerates and approaches 60 mph, the cruise controller proportionally decreases the gas flow to the engine.

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5.5.5. Integral Control

An integral control algorithm takes into consideration the length of time the difference is present. For example, if your speed has changed from the 60 mph setting for more than 10 minutes, the integral control algorithm corrects the situation, sending the car's speed back to the pre-set 60 mph. The more sensitive the integral control, the shorter the reaction period.

The integral control works in conjunction with the proportional control and can detect small errors over time that a proportional control algorithm would neglect.

5.5.6. Derivative Control

A derivative control algorithm takes into consideration the rate of change. For example, suppose your room has a thermostat attached to an air conditioner, which keeps the room at a comfortable temperature. When the door to your room is abruptly opened, hot air rushes in. This quick, sudden temperature change causes the derivative control algorithm to take immediate action. The feedback signal it sends to the thermostat causes the air conditioner to increase its output. In a sense, the derivative control "anticipates" that a gust of warm air can cause your room temperature to rise very quickly, and it reacts quickly to neutralize this disturbance.

5.5.7. Summary

Each of the last three control algorithms has a specific function, and they are often found together, in a PID control algorithm, working in concert to control various systems.

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