

Q.iMPACT 101 **A Quick Start Guide**



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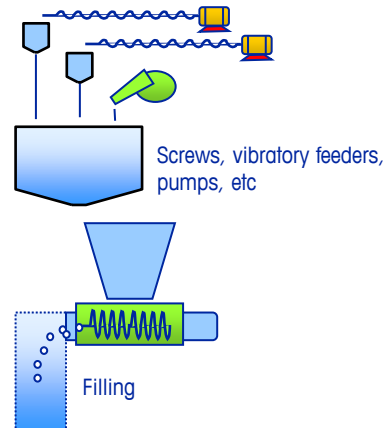
Introduction

The purpose of this guide is to explain the basic concept of optimized filling with IND780 Q.iMPACT, and to provide examples of how anyone can easily install and configure a basic system without needing to be a "Q.iMPACT expert". I will provide step-by-step examples that you can follow to get the system up and running as quickly as possible. Let's start with an overview of why Q.iMPACT exists, where it is used and what are its advantages.

Q.iMPACT (for convenience we'll simply refer to it as Q.i) is a very powerful system for optimized filling that lets customers increase their productivity up to 30% and their feed precision up to 90%, thereby reducing production errors and provides an outstanding return on investment. Customer savings with Q.i systems deployed in various regions of the world have been tremendous; typically, they pay for the Q.i system within 3 months of installation.

The patented and powerful mathematical algorithms inside the IND780 Q.i are exclusive to Mettler-Toledo International, LLC, and can be applied to a large number of processes in many different industries as shown below:

Bulk Materials: Granulated Powders Liquids Mixtures	Types of industries: Chemical Personal products Food & beverages Pharmaceutical
Measuring tools: Scales Weigh modules Flow meters	Applications: Batching Filling Dosing



Q.i has many advantages, but the two key points that everyone should know are its ability to achieve **accuracy and throughput simultaneously**, and the **simplified system design** it enables.

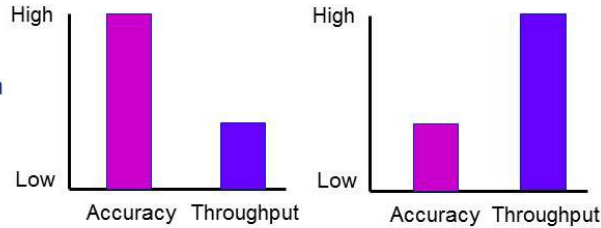
A traditional (non-Q.i based) system that needs highly accurate filling must work very slowly, which means production throughput is poor. Customers who need high throughput lose out on accuracy, and may overfill containers and waste raw materials. In other words, there's a trade-off: Either you get accuracy or you get throughput. Q.i eliminates this tradeoff. **Q.i provides both Accuracy and Throughput at the same time.**

Accuracy and Throughput

The manufacturing challenge:

Optimize the tradeoff between feed accuracy and process throughput

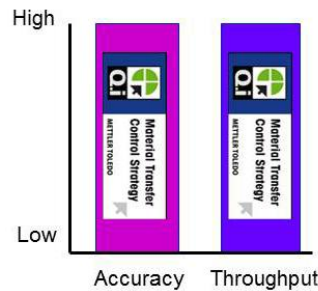
Accuracy OR Throughput



The Q.iMPACT advantage:

Feed the **Exact** amount of material in the **Shortest** possible time... **Every time**

Accuracy AND Throughput



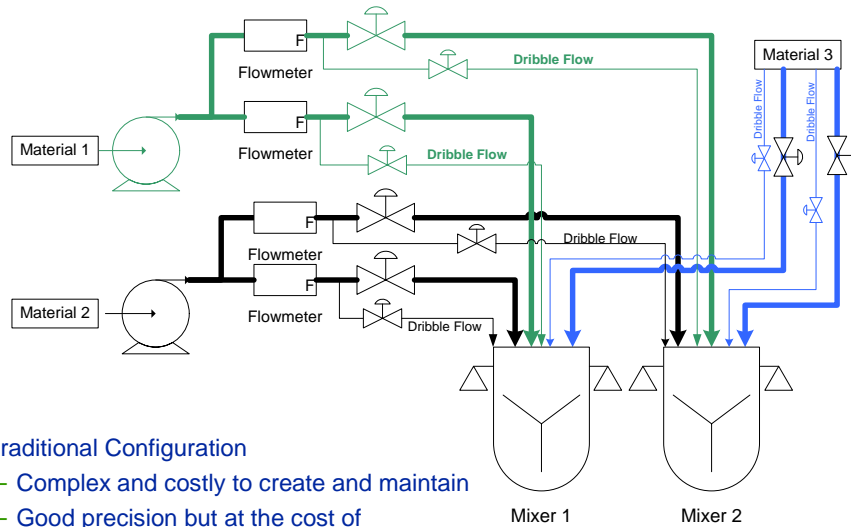
How does Q.i do this? The answer is simpler than you'd expect. **Q.i monitors the filling process in real time so the IND780 can adjust for changes in real time, during the filling process.** Traditional "non-Q.i based" systems rely solely on the history of the previous filling operations. It simply isn't possible for history-based systems to optimize both accuracy and throughput at the same time.

One of the key effects of measuring the flow of material during the filling process is that changes in the material viscosity due to temperature variations, or flow rate changes due to pressure variations in the system, are compensated for immediately by Q.i, so that it feeds the exact amount of material in the shortest possible time EVERY TIME. History based system can't do this! This means that Q.i. is particularly effective for "difficult" applications with fluctuating conditions where traditional filling equipment has failed to deliver good accuracy or throughput.

Simpler System Design

The second key advantage is a simpler filling system. One of the tricks that traditional "history based" filling systems use to lessen the Accuracy vs Throughput problem is a two-speed filling process. Two-speed systems can achieve good accuracy but they still sacrifice much of the throughput. Moreover, the filling system is more complex and costly to maintain. Q.i eliminates the waste by using a single speed filling system that is cheaper to buy and much simpler to maintain.

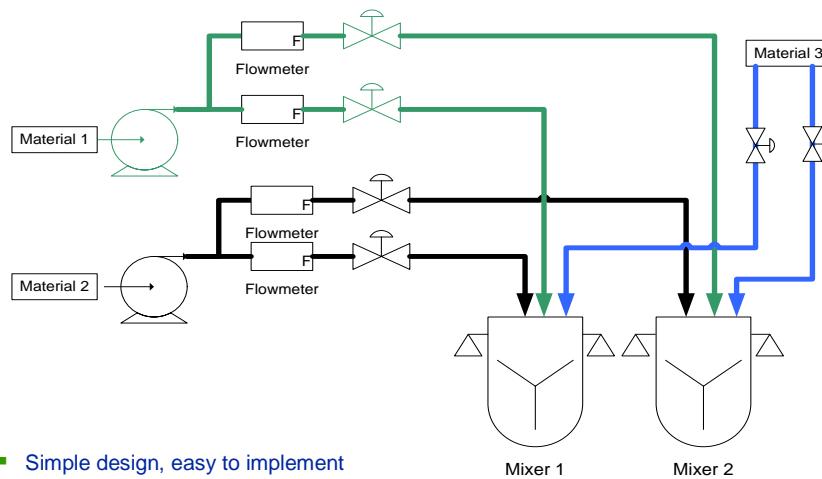
Look at the example below of a typical "history based" two-speed filling system without Q.i. I think you will agree that it looks like a mess and presents a maintenance nightmare!



- Traditional Configuration
 - Complex and costly to create and maintain
 - Good precision but at the cost of throughput

Internal usage only

Compare the tradition two-speed filling system with the Q.i optimized system below. It is easy to see why Q.i is a better design. By the way, if the customer has a two speed feed setup but wants to use Q.i, they can simply use the fast feed valves and ignore the slow speed valves. Q.i retrofits of existing systems don't have to be complicated.



- Simple design, easy to implement
- Lower cost, less maintenance, less spare parts
- Flexible, fast y precise



Internal usage only

This rest of the body of this guide provides step by step instructions for how to configure a system with a single-valve filling a single container. One of the things to understand about Q.i as you read through the examples is that the configuration is in two parts:

1. Initial configuration to set up the system.
2. Tweaks that you may make to the configuration after running a couple of filling cycles.

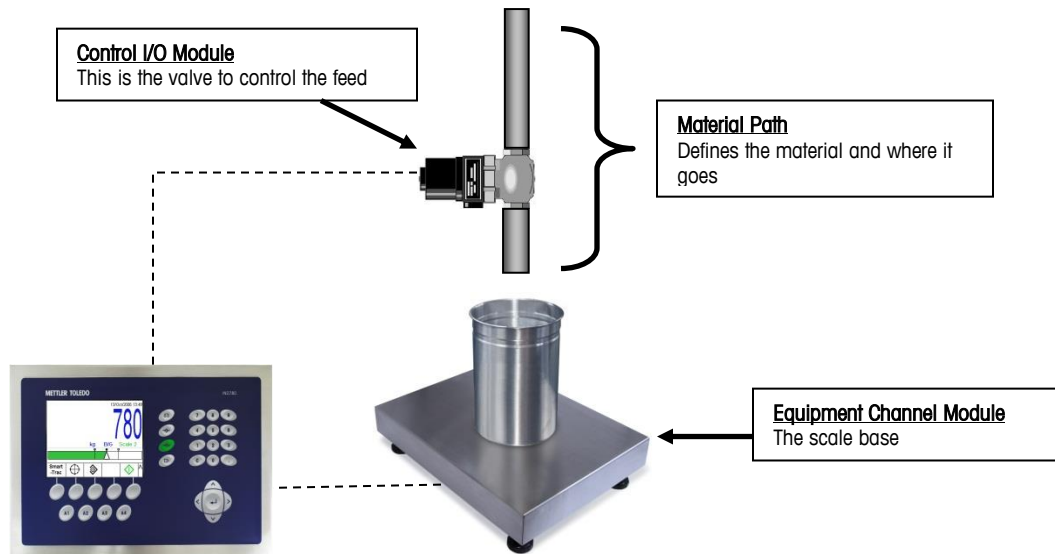
Q.i is unique in that it gives you information on how the filling process is running. You can use this data to go back into the configuration setup and make a few tweaks to the configuration to optimize the process

and save the customer even more money. I'll show you where to look and what values to tweak in the examples; I'll also include a separate chapter on simple optimization techniques.

Model of a Q.i Filling System

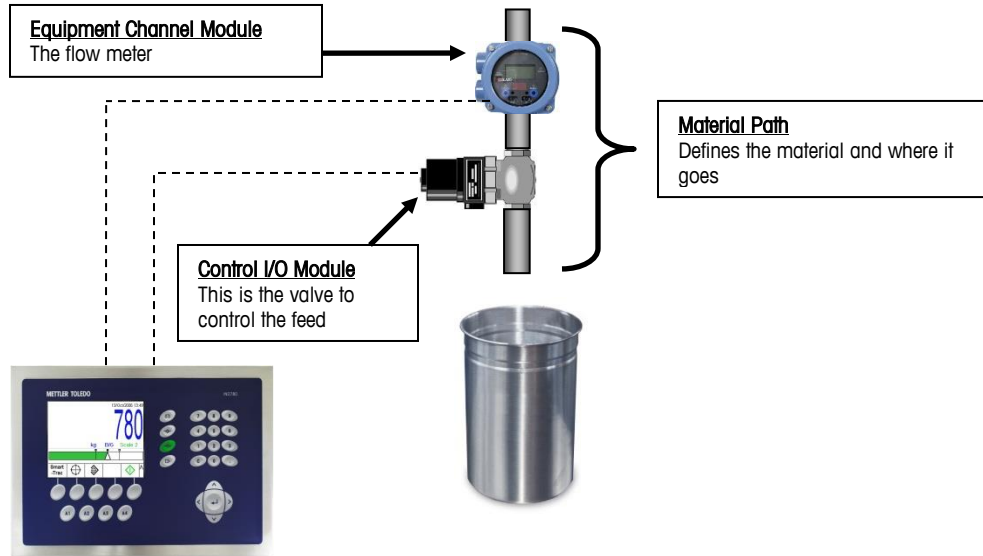
Once you understand how to set up a single system the same concept applies to two, three or more containers and scales.

Q.i uses terminology based on the globally accepted ISA S88 standard for batching and process controllers to talk about equipment such as valves, scales and filling materials. While S88 is very general we only need to apply a few basic terms to the IND780 with Q.i.



As you can see in the picture above, the IND780 controls the entire operation from reading the weight on the platform to controlling the valve. The **Control I/O Module** defines the digital I/O to control the valve. The **Equipment Channel Module** defines the instrument that takes the measurements – in the example above it's a scale platform. Lastly, we need to define the material with the **Material Path**. The Material Path is the description of the material, its destination (in the example above, the destination is the scale base) and filling parameters to optimize the process.

Sometimes the filling process uses a flow meter rather than a scale. **Flow meters normally measure volume but some flow meters can be calibrated to calculate an equivalent weight and they send out pulses as the equivalent weight increases. These pulses are treated as weight increments by an IND780 equipped with a flow meter option card.** In this case the Equipment Channel Module is a flow meter. The picture below shows the same system configuration using a flow meter instead of a scale.

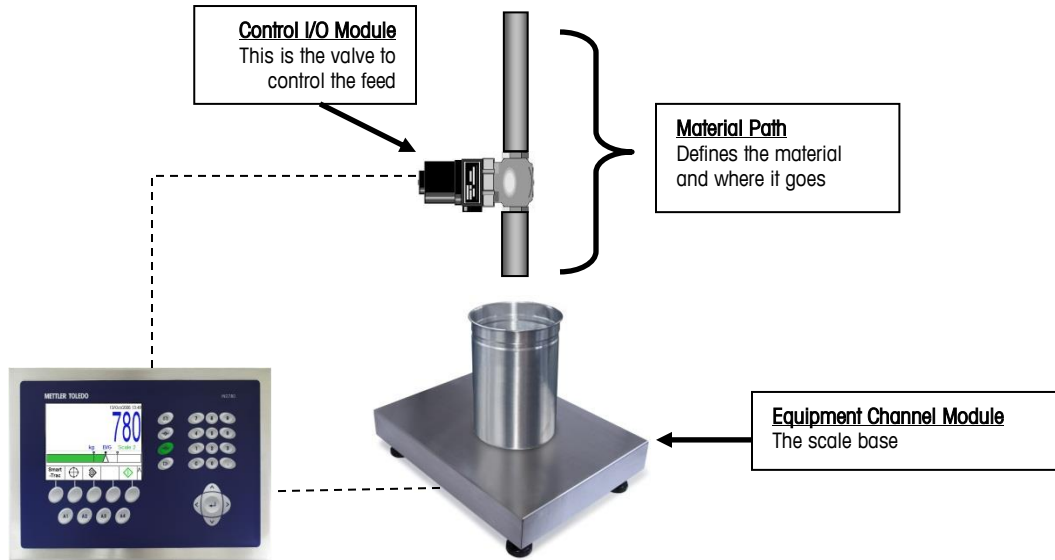


With these two basic filling configurations you can use Q.i for a variety of customer applications. In fact there are already such applications installed in the field with a single IND780 and a single valve running Q.i. It is that simple – Q.iMPACT does not need to be complicated! Did you notice there is no PLC in the diagram? I’m going to show you how the IND780 with Q.i can be used as a standalone controller without using any PLC connection.

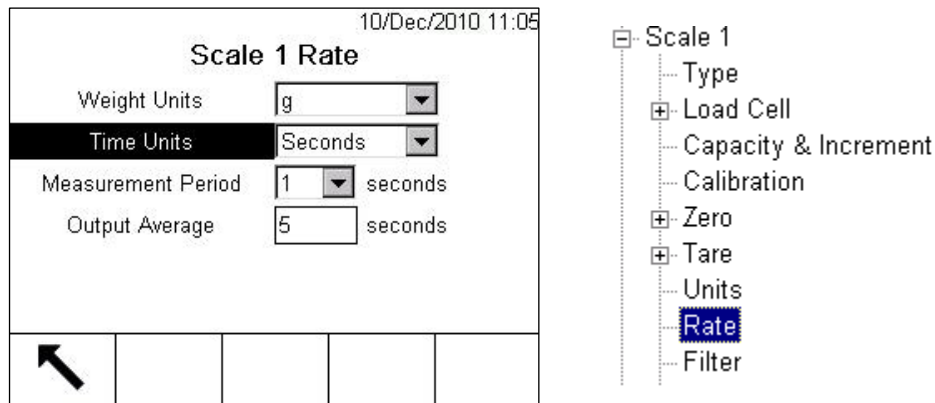
An interesting detail to mention is the number of Equipment Channel Modules, i.e. the number of scales or flow meters. The examples in this chapter show 1 Equipment Channel Module but the IND780 supports many more: 4 scales or up to 12 flow meters. I want to point this out to you because the price of Q.i is based on the number of Equipment Channel Modules. When you purchase a Q.i license you specify the number of Equipment Channel Modules required and the IND780 is configured from the factory to support the correct number.

Example 1 – Configuring Q.i with a single valve and single scale

In this example we will go through the configuration to set up an IND780 with a single channel Q.i license, for the equipment shown below.

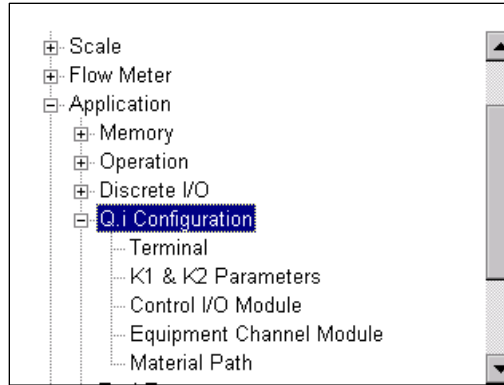


Q.i can measure the flow rate of material. Without a flow meter it simply uses the change of weight measured at the scale base. So the first thing to set up is the scale Rate setting in setup at **Scale 1 > Rate**.



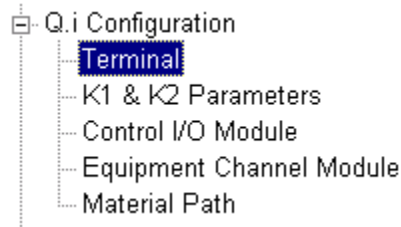
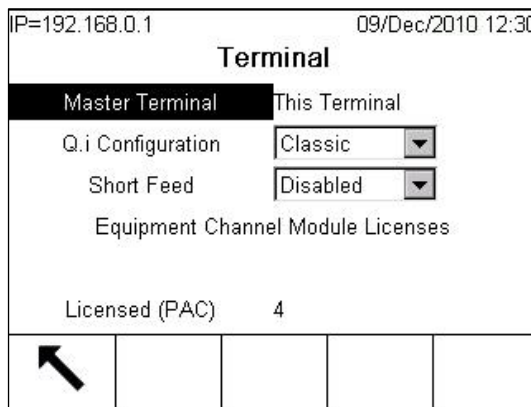
The only required parameter to select is the weight unit of Lbs, Kg, or Grams.

There are two options to perform the Q.i configuration: use the IND780 setup menu or use a PC application called "Q.i Configuration Tool". For this first example I am going to show you how to use the IND780 setup menu.



The screen above shows the IND780 setup menu with a Q.i. i-button software pac installed. Under **Application > Q.i Configuration** we see: **Terminal**, **K1&K2 Parameters**, **Control I/O Module**, **Equipment Channel Module** and **Material Path**. All of the Q.i configuration is located in this section of the setup menu.

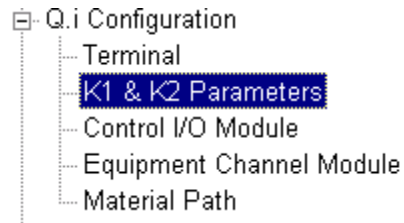
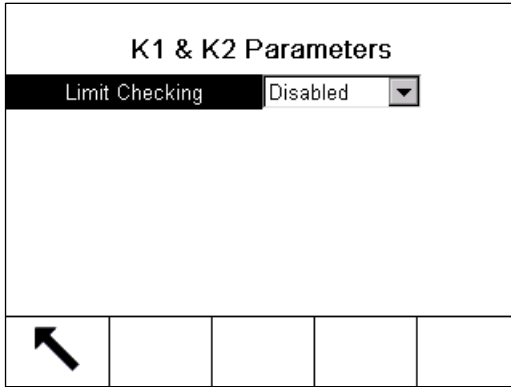
As we progress through the screens you'll see there are many values that a typical system will never need to use. Q.i has a very flexible interface and can be used for simple applications or very complex applications. Don't let the large number of configuration fields intimidate you. I'll point out what you can ignore and what is important as we continue. For our simple system, the requirements are quite basic.



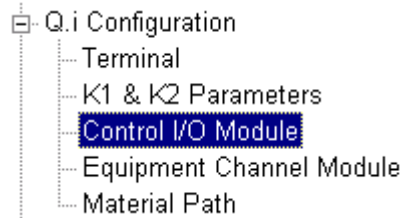
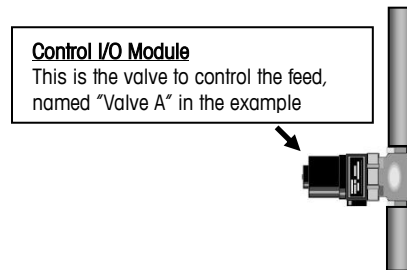
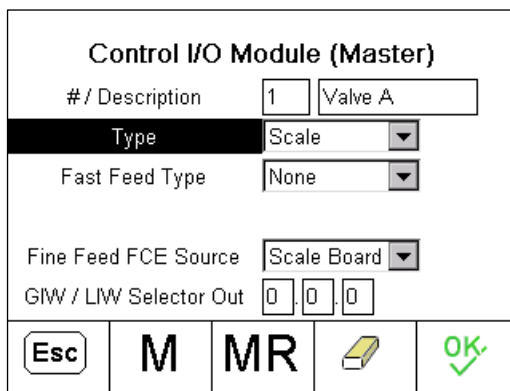
The terminal configuration can remain in its default state. The **Master Terminal** is this terminal because we only have one IND780 in the system. The **Q.i configuration** should stay as "Classic". Don't worry too much about "Classic", which defines the type of PLC communication used. Since our example does not use a PLC the selection of "Classic" is arbitrary.

The **Short Feed** should be "Disabled". Short feed is for filling operations lasting less than 7 seconds. Q.i needs to measure the rate of change of weight to be able to correct itself during the filling process. The algorithm needs *at least* 5 seconds, but 7 seconds is a safer number to use. Therefore, all Q.i filling operations should last for at least 7 seconds. If you follow that rule you will never need to enable the short feed.

Lastly, there is some information on which license you purchased for the IND780. My IND780 has a 4 channel license (the number of supported total equipment channel modules) even though we are only using 1 channel (i.e. one scale base as the equipment channel module) in this example. You don't have to use all the channels, and if a customer is thinking about adding additional scales and valves later then buying a few extra channels up front is not a bad idea.



Q.i has two algorithms: K1 and K2. K2 is a very specialized application to optimize “non-linear” filling. Sometimes filling is non-linear because of a pump that is forcing the material into the container or sometimes horizontal pipes spill material into the container in a non-linear manner. Most applications, such as this example (using a gravity feed), will just use K1, so that is all we are going to talk about. Leave the **Limit Checking** “Disabled” for the moment. I’ll talk about Limit Check more in the Optimization section.



The first part of the Control I/O Module Screen shows **#/Description**. Each control module must have an identification number assigned. The number can be from 1 to 297. In this case I chose the number 1. After entering a number you will see the screen as shown above. I gave a description of “Valve A” to name this control module.

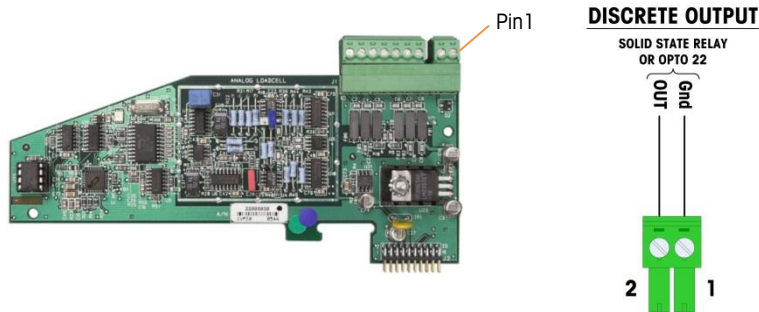
The **Type** is “Scale” because Valve A is controlling the flow of material into a container sitting on a scale base. This lets the IND780 know which type of measuring instrument – scale or flow meter – to determine when to turn the valve ON or OFF.

Fast Feed Type will be “None”. The **Fine Feed**, which is the feed using Valve A is what we need to concentrate on. Don’t let the term “fine feed” confuse you; there is only one valve “Valve A” and one feed. In Q.i, this “fine feed” can have a rather high flow rate.

There are two choices for the **Fine Feed FCE Source**: “Scale Board” and “Other I/O”. Don’t be confused by the “FCE” or Final Control Element. It is simply a confusing term that means this output is controlling the valve. This setting is used to select which digital I/O inside the IND780 controls the valve. Remember the IND780 uses three types of I/O:

- Scale Card I/O
- Digital I/O option boards
- ARM100 external I/O modules

As shown in the pictures below, the first two pins on the IND780 analog load cell option board have a digital I/O relay.



Q.i applications should use the “Scale Board” setting. “Scale Board” refers to the digital output port located on the IND780 analog scale card. It’s important to use this output port because the scale card provides the fastest target comparison rate – 50 comparisons per second compared to the digital I/O option card rate of 20 comparisons per second – and it controls the valve with the least “jitter”, i.e. small time delays to turn the valve ON or OFF. The analog option card output will give the customer the best filling results.

The last part of the Control I/O Module screen shows a setting for **GIW/LIW Selector Out**. This means **Gain in Weight** or **Loss in Weight** Selector Out, and it’s used in tank weighing applications to control which valve the scale board I/O controls: the valve to **fill** the tank, or the valve to **dump** the contents out of the tank. Our application example doesn’t use that because we are simply filling the container, so we will leave the digital I/O address as 0.0.0.



■ **Note:** You can only leave the address at 0.0.0 if the IND780 has firmware 7.3.x or above. Earlier versions of IND780 firmware required the user to enter a non-zero digital I/O address. The best workaround for firmware versions earlier than 7.3.x is to simply configure with the Q.i Configuration Tool shown in Example 2, rather than directly in the IND780 Q.iMPACT.

Next, move to the Equipment Channel Module configuration screen. Remember, in this example the Equipment Channel Module is the scale base.

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Equipment Channel Module (Master)

# / Description	1	Scale 1
Equipment Type	Scale Unit	
Device Number	1	
Terminal Node Number	1	
Bridge Terminal Number	1	
Bridge Slot Number	1	

Esc M MR  

- Q.i Configuration
 - Terminal
 - K1 & K2 Parameters
 - Control I/O Module
 - Equipment Channel Module**
 - Material Path





The Equipment Channel Module also needs an identification number assigned. The number can be from 1 to 297. For **#/Description** I chose "1" and entered "Scale 1". The **Equipment Type** is a "scale unit" because the example uses a scale base for weight measurements. The **Device Number** is which scale in the IND780 (scale 1 to scale 4). This example only has one analog scale card, which is scale 1 – so the device number is "1".

The next three fields: **Terminal Node Number**, **Bridge Terminal Number** and **Bridge Slot Number** should contain the default value of "1". Those values are used for systems that have multiple IND780 units, but they don't apply to this example.

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Equipment Channel Module (Master)

Auto Weigh-In CIM	1
Auto Weigh-Out CIM	1
Man. Weigh-In CIM	
Man. Weigh-Out CIM	
Stable Device Wait Time	5 sec.
OLP Feed Alone Time	0 sec.

Esc M MR  

- Q.i Configuration
 - Terminal
 - K1 & K2 Parameters
 - Control I/O Module
 - Equipment Channel Module**
 - Material Path

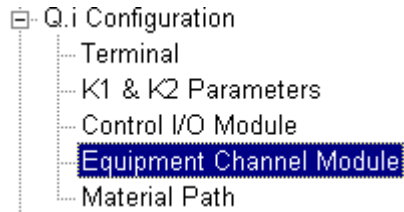
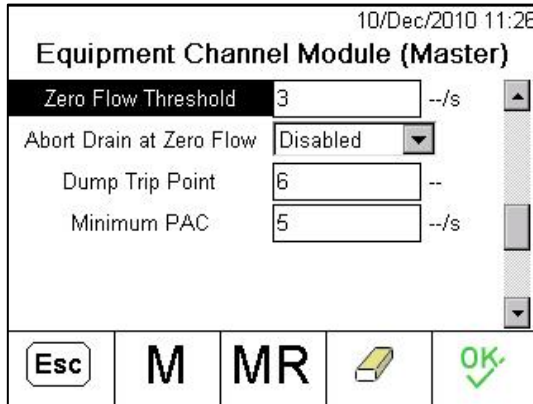


You need to associate the Equipment Channel Module (scale) with the Control I/O Module (valve) to be used. This is the purpose of **Auto Weigh-in CIM** (Auto Weigh-in Control I/O Module). Enter the Identification Number of the Control I/O Module (remember I arbitrarily chose "1" as the ID associated with the valve). Therefore the Auto Weigh-in CIM has the value "1". The **Auto Weigh-Out CIM** doesn't apply in this example but it can't be blank so simply choose the same ID of "1". Having a value has no effect, since it isn't used.

The **Man. Weigh-in CIM** and corresponding **Man. Weigh-Out CIM** are used for manual operations, when an operator adds a predetermined amount of material to the container. These fields are not used in this example, so they can be left blank.

The **Stable Device Wait Time** is a timer that inserts a delay between the start feed command and the actual start of feed. Normally, you can just use the default of 5 seconds.

The **OLP Feed Alone Time** should remain "0". OLP stands for Overlapping Feeds and does not apply to this example.

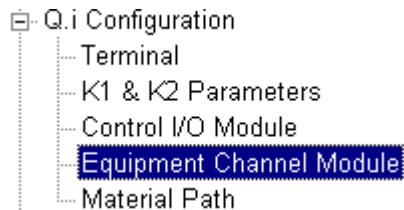
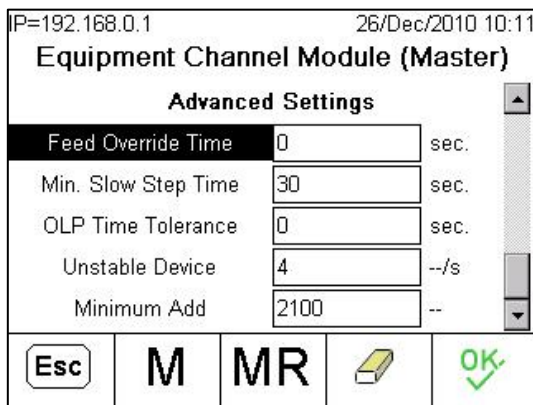


Q.i calculates the flow rate based on the change of weight on the scale. Just as a terminal waits for a scale to return to zero, Q.i waits for the flow rate (change in weight using a scale base) to go below a certain threshold to know the process is finished. **Zero Flow Threshold** is this value. Typical values are 3 g/s or 0.01 kg/s.

Abort Drain at Zero Flow is a diagnostic that nobody except the most advanced users will need. Leave this "Disabled".

The **Dump Trip Point** is only used in tank applications where the contents are dumped out of the tank until it is empty. It is the point where Q.i starts looking for a zero flow. It can't be blank so put in a value such as 6 g

Minimum PAC is the minimum flow rate where the Q.i algorithm turns ON to start monitoring the process. Simply use the values 5g/s.



The **Feed Override Time** should be "0". The **Min. Slow Step Time** is a rather confusing name so I'll simply describe what it does. If your feed takes too long to complete (much longer than normal based on target and flow rate) then you get an error. On shorter feeds Q.i might calculate a very short time. The Minimum Slow step Time overrides the calculation and provides the shortest feed time. I chose the shortest feed time to be "30" seconds

OLP Time Tolerance should be set to "0". **Unstable Device** should have the values 4g/s or 0.03 kg/s.

Unnecessary but interesting Theory

Unstable Device is a rather confusing way of saying we are filling the container. Unstable Device is a threshold measured in flow rate related to the Zero flow rate. We set the zero flow rate at 3 g/s to indicate all process are finished. We set the Unstable Device to 4 g/s to indicate we are now in process (in a non-zero state). What is between 3g/s and 4g/s is a tolerance for indicating not filling or filling.

The best way to describe the relationship of Zero and Unstable Device is the way center of zero works on a static scale. The scale has a center of zero and a tolerance (in counts) around center of zero. Inside the tolerance the scale is at center of zero. Outside of the tolerance the scale displays a weight. The Zero Flow Rate and Unstable Device are the flow rate equivalents of center of zero and its associated tolerance.

Minimum Add is important because it defines the minimum amount of material the user can add to the container, i.e. the minimum target weight. Remember Q.i needs the feed to take at least 7 seconds so the algorithm can calculate things properly. So the minimum add is how much material will take at least 7 seconds to fill the container. You can calculate this by: Average Flow Rate (units/second) x 7 seconds = Minimum Add. For purposes of this example I simply chose 300g/s x 7 seconds = 2100 g. If the user selects a target lower than the Minimum Add the IND780 will not start the filling operation.

The final configuration step is to configure the Material Path. Remember the material path defines the filling characteristics of the material and where the material goes.

The screenshot shows the 'Material Path (Master)' configuration window. The fields are as follows:

# / Description	1	Material A
Source ECM	1	
Feed Algorithm	K1 Feed - GIW	
Destination ECM	1	
Drain Time	5	sec.
Avg. Flow Rate Low Limit	0	--/s

Navigation buttons: Esc, M, MR, [Home Icon], OK.

The diagram to the right shows a vertical pipe labeled 'Material Path' with a bracket indicating it 'Defines the material and where it goes'. Below the pipe is a cylindrical container. A tree view on the right shows the configuration hierarchy: Q.i Configuration, Terminal, K1 & K2 Parameters, Control I/O Module, Equipment Channel Module, and Material Path (highlighted).

The Material Path also needs an identification number assigned. Values can range from 1 to 999. For **#/Description** I arbitrarily chose "1", and entered a **Description** of "Material A". **Source ECM** (Source Equipment Channel Module) is the device being used to measure Material A. In this example the IND780 is

measuring weight from a scale base, which is an Equipment Channel Module I previously defined with the ID "1". Therefore Source ECM has the value "1".

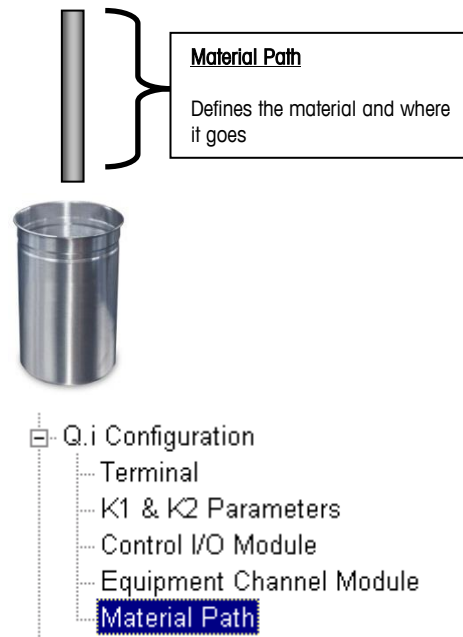
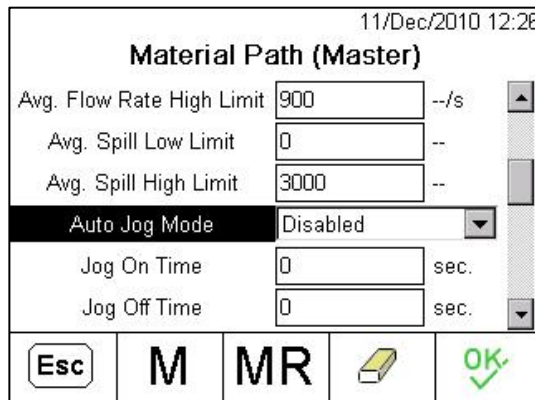
The **Feed Algorithm** for this example is "K1 Feed - GIW". The GIW is Gain in Weight. If you had a tank application you might use the Loss in Weight version, but that doesn't apply to this example. You will see other selections such as Spill Only and K2 Feed. Spill Only does not use the Q.i adaptive predictive algorithm so you can test to see the difference between using Q.i and not using Q.i.

K2 is another Q.i algorithm used for non-linear filling. For example if a pump is forcing material through the valve then the weight of the material in addition to the pressure from the pump creates a non-linear filling situation. People choose K1 or K2 based on the application. This example assumes a gravity feed which is linear and should use K1.

The **Destination ECM** will be the same as the Source ECM and so is "1". Q.i can control processes where the material is transferred from one tank to another, and in those cases the Source and Destination Equipment Channel Modules will have different numbers, but that doesn't apply to this example.

The **Drain Time** is how long Q.i waits after the valve has been closed before completing the process. Remember Q.i is collecting data as it goes so we need to tell it when to stop collecting data. In this example I set it to 5 seconds. You should start with a guess of how long you think it should be. Your best guess is **the time it takes from closing the valve until the flow of material stops**. This depends upon the system you are working with. After you run a few filling cycles you can time this and refine the value so it's more realistic.

The **Average Flow Rate Low Limit** will have the value of "0" for now. Later, in the optimization chapter, I'll show you how you can change this to get a little more performance out of Q.i, but the algorithm will work perfectly well if you leave this value at "0".



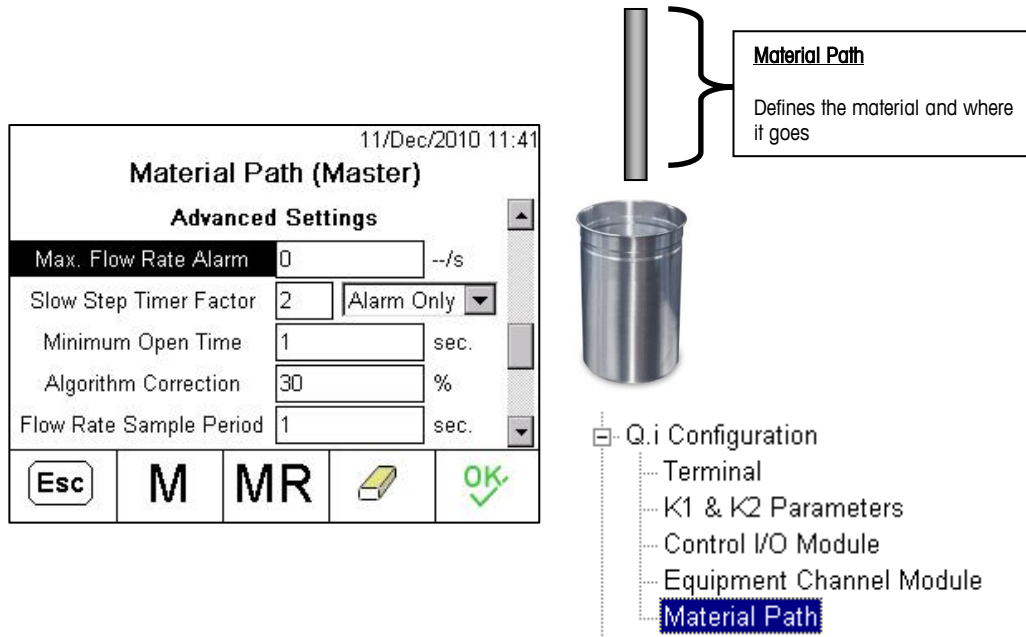
Continuing to the next page of the Material Path configuration, we find the **Average Flow Rate High Limit**. This number needs to be calculated. Firstly, you need to know the average flow rate of material going through the valve in g/s or kg/s. If you don't know this value then take your best guess and make the number much larger. In this example I assume an average flow rate of 300 g/s so I multiplied it by 3 to get 900 g/s.

At the end of the Material Path configuration there is a field that Q.i will populate with information on the average flow rate. After doing a couple filling cycles you can look back at this Material Path in the IND780, write down the measured average flow rate and multiply by 3 to get a more precise value to put in the Average Flow Rate High Limit.

The **Average Spill Low Limit** is "0" for now and that will work perfectly fine. We may adjust that value a bit later in the optimization chapter, but this is not a required step.

The **Average Spill High Limit** is something you need to know. Remember, spill is the amount of material that is still falling through the air after the valve turns off. If you don't know the correct value, just guess what you think the typical spill value would be and make the number really large, 3 times your guess. I guessed 1000g for this example and multiplied by 3 to get a 3000g limit. After you run a few filling cycles, at the end of the Material Path configuration screens you'll see a Q.i populated field with Average Spill values. Take the Average Spill value that Q.i measures for you and multiply it by 3 to get the correct value for the Average Spill High Limit.

Auto Jog Mode should be "Disabled". By using Q.i + the K1 Feed algorithm you will be in tolerance during each filling cycle and using Jog to add material to reach the target will not be necessary. Likewise, you can completely disable the **Jog On Time** and **Jog Off Time** by simply entering "0" in these fields.



Maximum Flow Rate Alarm should be "0", which disables this alarm. This alarm was designed for a very specific application and in 99.99% of all cases needs to be disabled.

Slow Step Timer Factor is just a multiplier for an alarm in case the filling takes too long to complete. The Minimum Slow Step Timer value was already set up in the Equipment Channel Module so here in the Material Path just use the value of "2" and set it to "Alarm Only".

Minimum Open Time is going to be "1". It is how long Q.i waits after starting the filling process before starting the Q.i algorithm.

Unnecessary but interesting Theory

You might recall that there was a Minimum PAC defined in the Equipment Channel Module. The flow rate must be higher than the Minimum PAC before the Q.i algorithm will start. The Minimum Open

Time is how long Q.i waits before it checks the Minimum PAC. Both conditions need to be met to start the Q.i algorithm.

Another unnecessary bit of trivia for you is that when a filling cycle starts the flow rate of material can vary a lot, but Q.i needs the flow rate calculations to use the predictive adaptive part of its algorithm. It is important to wait for a short period of time to ensure there is a stable enough flow rate to get good data. Hence the existence of the Minimum PAC and Minimum Open Time.

Algorithm Correction should be set to "30" and **Flow Rate Sample Period** should be set to "1".

The screenshot shows the 'Material Path (Master)' configuration window with the following fields:

Avg. Flow Rate "A"	300	--/s
Avg. Spill "AA"	1000	--
Fast Feed Cutoff	1	--
Reset PAC Variables	No	

Below the window are buttons for Esc, M, MR, a USB icon, and OK. To the right, a diagram shows a vertical pipe labeled 'Material Path' and a cylindrical container. A text box explains: 'Material Path Defines the material and where it goes'. Below this is a tree diagram for 'Q.i Configuration' with the following items: Terminal, K1 & K2 Parameters, Control I/O Module, Equipment Channel Module, and Material Path (highlighted in blue).

Next on the list are Avg. Flow Rate "A" (Average Flow Rate) and the Avg. Spill "AA" (Average Spill). The Average Flow Rate and Average Spill are **calculated by the IND780 Q.i application**, so when you revisit this page after running a few filling cycles you'll see the true measured averages which are needed for calculating the **Average Flow Rate High Limit** and **Average Spill High Limit** respectively.

■ Note: With IND780 firmware 7.3.x or above you don't need to enter anything in these field. As I said, the IND780 Q.i calculates the averages and puts the values in these fields for you. However, there is a bug in earlier versions of firmware (earlier than 7.3.x) where the IND780 forced you to enter something. There are two choices:

1. Use the Q.i Configuration Tool shown in Example 2. The Q.i Configuration tool allows you to leave these fields blank.
2. You can make a guess and enter your guess. It won't matter because the IND780 Q.i will overwrite the value there anyway. I guessed a flow rate of 300 g/s and a spill of 1000g.

The **Fast Feed Cutoff** field is not used in this application and you can enter "0" if you have IND780 firmware version 7.3.x or above. If you have an earlier version of IND780 firmware Q.i makes you enter a value here but doesn't use this value. Simply enter the number "1". Just put in the number to make the IND780 Q.i happy and then ignore it as you won't use it later.

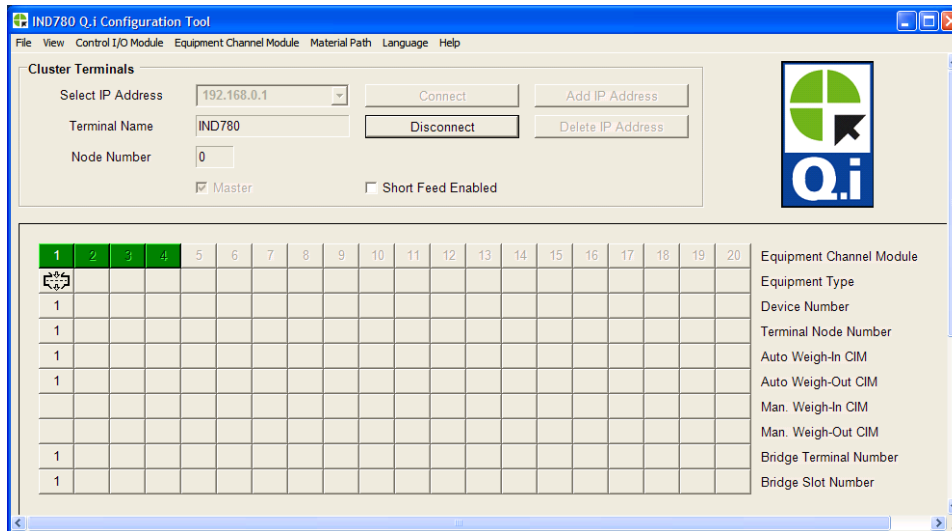
Reset PAC variables is to be left in the "No" setting.

And there you have it: you've configured an IND780 Q.iMPACT application!

Example 2 – Configuring Q.i with a single valve and single scale (Q.i Tool)

I'm going to show you the same configuration as example 1 again, but this time I'll configure the system using a PC application called Q.i Configuration Tool. Make sure you read example 1 first because it has all the detailed information on each configuration setting. The Q.i Configuration Tool is located on the PAC CD included with all Q.i-enabled IND780 units. Other than the couple of points I made in example 1 where IND780 versions earlier than 7.3.x have some errors the choice of using the IND780 HMI or the Configuration Tool is completely up to you and depends on which method you like better.

The main screen for the Q.i Configuration Tool looks like this:

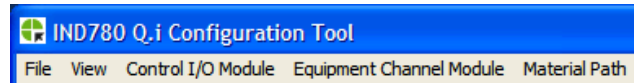
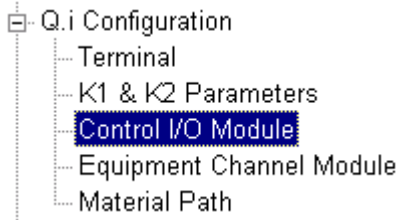


When you first start the tool, it needs to connect to the IND780 terminal. Connect your IND780 via Ethernet and enter the terminal's IP address into the Select IP Address box. Press the Add IP Address button to include the address in a list and then press **Connect** to start working with the IND780.

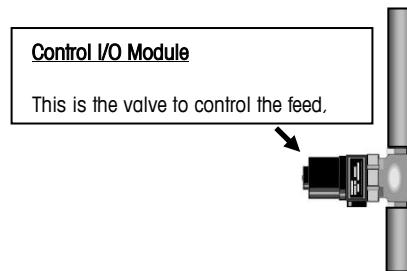
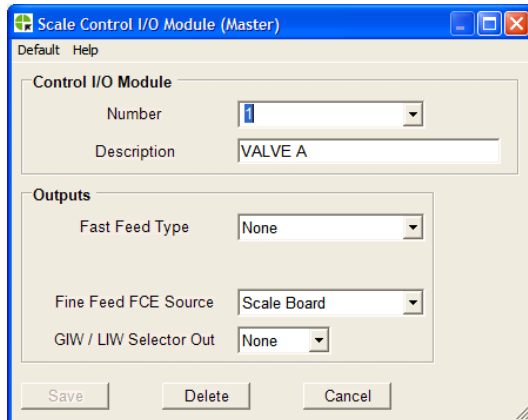
Don't worry about the Terminal Name, Node Number or any of the check boxes such as Master or Short Feed Enabled. Just leave those as is. Notice that column headers 1 through 4 are in green. These indicate I have a license for up to 4 channels. Columns 5 to 20 are gray because I don't have a channel license to let me define more than 4 channels.

Looking down column 1 there is an icon in the first row, and the number "1" in several other rows. This is an overview definition for the Equipment Channel Module "1". These numbers exist because we already defined the Equipment Channel Module in example 1 and the program read the existing database after I connected to the IND780. Otherwise these fields would be blank.

Looking at the menu at the very top of the window you should see: **Control I/O Module**, **Equipment Channel Module**, and **Material Path**. Each one of these menu items opens a window to configure various parameters just as we configured them on the IND780 in example 1. As you may have noticed from example 1, the Control I/O Module needs to be defined first, followed by the Equipment Channel Module second and finally the Material path. So just as the IND780 setup menu goes from top to bottom, here you need to move left to right on the Q.i Configuration Tool menu, starting with Control I/O Module.



First let's take a look at the Control I/O Module. Select it from the menu bar and select Scale since the IND780 will be reading scale data to determine when to turn ON or OFF the control module.

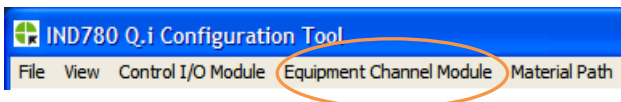


You have to enter a number from 1 to 297. Since I previously defined a Control I/O Module with ID number "1", I simply selected "1" from the drop down list. The Description is "VALVE A", and Fast Feed Type is "None." The Fine Feed FCE Source which controls the valve comes from the analog scale board.

As I stated in example 1 we don't use the GIW/LIW (Gain in Weight/Loss in Weight) Selector Out for our application. This selector is used if you are filling a tank and need to empty out the tank. It is used to control which valve (filling valve or emptying valve) the Scale Board I/O is connected to. Sometimes people call this steering logic.

If you are entering new information or make any changes, don't forget to press the Save button to save your changes into the database. Please note that the changes are only saved to the Q.i Configuration Tool database. Later before you exit the Configuration Tool you will synchronize the data to the IND780. **Please make sure the IND780 is not in doing any Q.i filling operations when you synchronize with it!**

Next we will look at the Equipment Channel Module. From the main menu we select Equipment Channel Module and Scale because in fact the scale is our Equipment Channel Module!





Equipment Channel Module

Scale Equipment Channel Module (Master)

Default Help

Equipment Channel Module

Number	1	Description	Scale 1
Node	1	Scale	1
Minimum Add	2100	Units	--
Dump Trip Point	6	Capacity	----- --

Control I/O Modules

Auto Weigh-In CIM	1 VALVE A	Man. Weigh-In CIM	
Auto Weigh-Out CIM	1 VALVE A	Man. Weigh-Out CIM	

Flow Rate Thresholds

Zero	3	--/s	Abort Drain at Zero Flow	Disabled
Minimum PAC	5	--/s	Unstable Device	4

Process Times

Feed Override Time	0	sec.	OLP Feed Alone Time	0	sec.
Min. Slow Step Time	30	sec.	OLP Time Tolerance	0	sec.
Stable Device Wait Time	5	sec.			

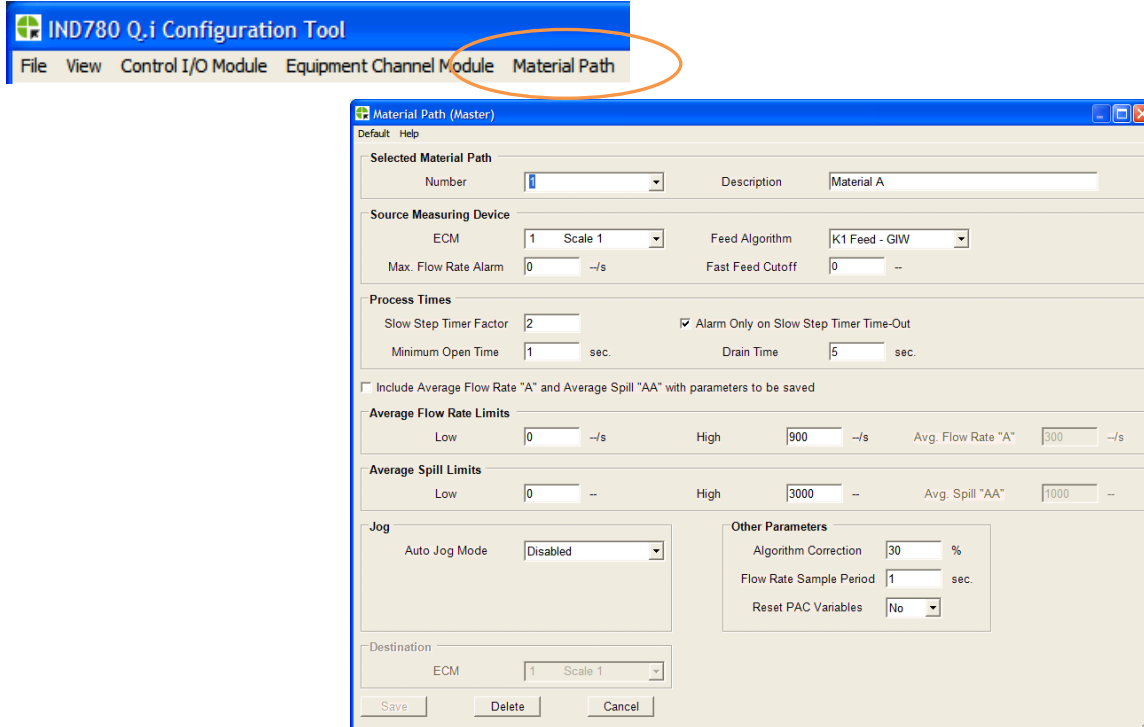
PLC Bridge

Bridge Terminal Number	1	Bridge Slot Number	1
------------------------	---	--------------------	---

Save Delete Cancel

The Q.i Configuration Tool provides a nice screen to display all the Equipment Channel Module configuration in a single window instead of using the IND780 setup window and scrolling around to enter the various parameters. You either need to enter a value from 1 to 297 in the Number field and then enter the parameters or select from the list of existing modules. The screen you see here is from the IND780 database configured for example 1 where the Equipment Channel Module had ID Number "1". Since this is exactly the same as example 1 there is no need to review details about the individual parameters as they have already been explained.

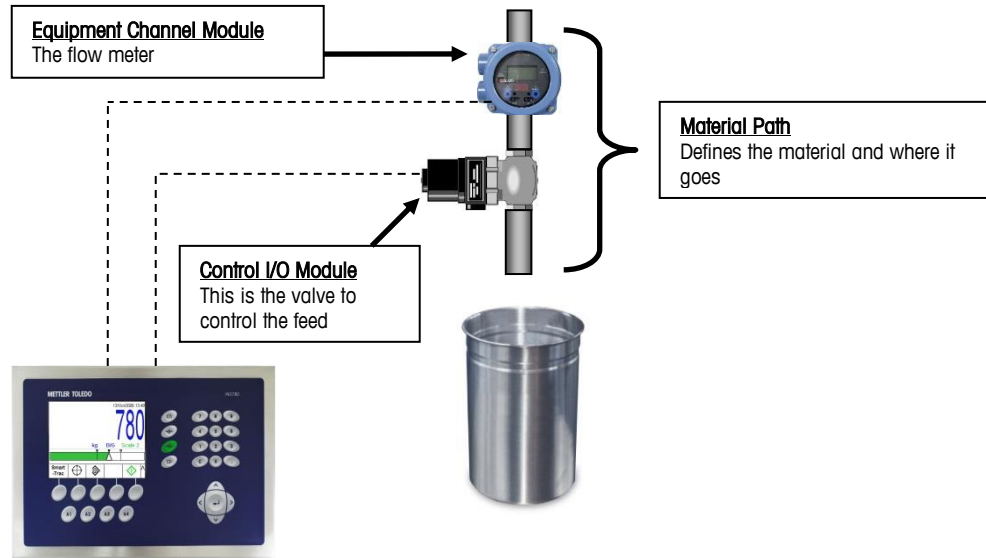
Lastly we need to visit the Material Path part of the menu.



You need to enter an identification number for the material path in the Number field (values from 1 to 999 are valid) or select from the drop down list in the same field to view previously created entries. I selected "1" since this was the material path previously defined in example 1. Again, all of the parameters have been previously explained.

Example 3 – Configuring Q.i with a single valve and single Flow Meter

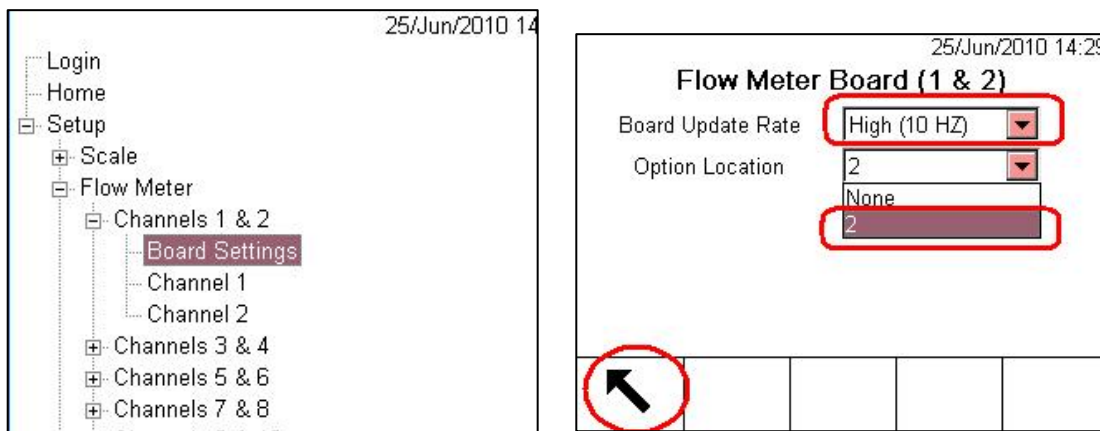
In this example we are going to configure a Q.i system that uses a flow meter, rather than a scale, to measure the amount of material delivered.



Before setting up the Q.i configuration, you need to set up the flow meter interface. The IND780 technical manual has an appendix with further information and specifications for the flow meter card.

From the point of view of the IND780, a flow meter is essentially a pulse counter. In fact a flow meter is easier to set up than a scale base. It already comes calibrated from the flow meter manufacturer. The flow meter data sheet shows how many pulses per liter of material. You enter those values in the IND780 and the terminal does the rest of the work for you.

To set up the flow meter, go into the IND780 setup menu as shown below. There are two channels per flow meter board, so if you have one option board you will do the configuration under Channels 1 & 2.



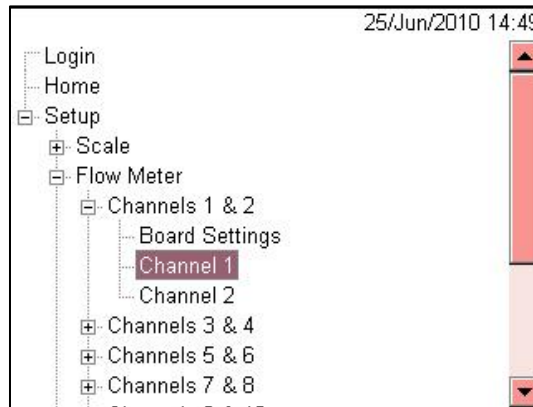
You need to select the Board update rate. The name "Board Update Rate" might give you the wrong impression. It is not the update rate of the flow meter information but rather it is the update rate of the

IND780 LCD screen. The flow meter board can accept up to 50,000 pulses per second from the flow meter itself. By the way, there is no minimum frequency. The board is simply counting pulses as the pulses come in.

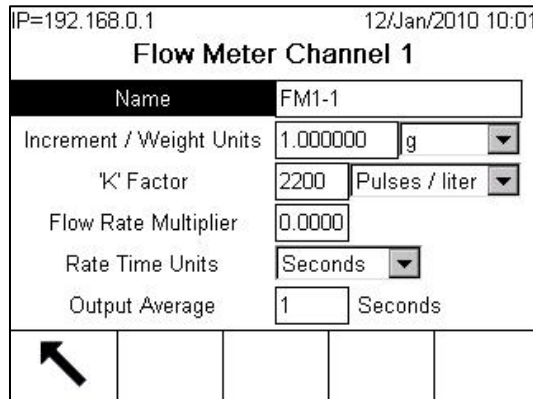
Next select the option slot where the flow meter card is located in the IND780. In the example above the flow meter card is located in slot 2. Afterwards press the back arrow soffkey to save the changes.

Please Note: The terminal will restart to write the changes to its internal memory. This restart is normal.

The input from the pulse flow meter into the flow meter card needs to be configured under the Channel settings. This is a bit like configuring the capacity, units and calibration of a regular scale except we need to match the number of flow meter pulses with the correct weight value.



Remember there are two channels per flow meter board. For this example there is only one flow meter and only one channel needed. Select Channel 1.



The flow meter channel is given a name. Though it really doesn't matter what you call it, I follow the convention of **FM1-1**, indicating Flow Meter 1 on Channel 1. The Increment/Weight Units and the K Factor are the key elements used to configure (or perhaps I should use the word "calibrate") the flow meter card.

I'm going to start with the **K Factor** because this is the most important parameter. This example shows 2200 pulses per liter. *The value for the K Factor is always provided by the flow meter manufacturer on the flow meter data sheet.* It is typically given in Pulses/Liter. So for every liter of material flowing through the flow meter it provides some number of pulses. On the IND780 side all you have to do is enter the number of pulses and choose that it is **Pulses/liter**. The IND780 automatically calculates the equivalent weight of 1 liter of material. In this example the weight is in grams.

Below is a chart from an Omega flow meter data sheet. I used this chart to get the **K Factor** used in this example.

Part Numbers	Flow Ranges				Pulses		Frequency
	Normal		Extended		Per Gallons	Per Liters	Output
3/8" NPT	GPM	LPM	GPM	LPM	Per Gallons	Per Liters	Output
FTB2001	.13 - 1.3	.5 - 5	.07 - 2.6	.25 - 10	26100	6300	58 - 575 Hz
FTB2002	.26 - 2.6	1 - 10	.07 - 2.6	.25 - 10	12500	3300	55 - 550 Hz
FTB2003	.26 - 4	1 - 15	.07 - 4	.25 - 15	17400	4500	76 - 1150 Hz
FTB2004	.26 - 4	1 - 15	.07 - 5.3	.25 - 20	8300	2200	37 - 550 Hz
FTB2005	.53 - 7.9	2 - 30	.13 - 7.9	.5 - 30	3800	1000	33 - 500 Hz

In the lab I have an Omega **FTB2004** flow meter. Looking at the table above, it shows 2200 pulses per liter. In the IND780's in lab I simply enter 2200 for the **K Factor** and then choose whichever weight value: grams, kilograms, etc. that I need to use. The IND780 automatically calculates the correct weight value.

Moving back to the **Increment/Weight Units**, you specify the increment size that you need. In my example the increment size is 1 g. You need to be careful about what increment size you pick. Just as you have to have at least one count per division in a scale base, you have to have at least one pulse per increment to have a valid increment.

If you pick an increment value that is too small, the IND780 will give you a "Calibration Error" message. In my example 1g works fine, but 0.1g does not.

Unnecessary but interesting information

Although the IND780 will automatically warn you about increment sizes that are too small, it is fairly easy to calculate it yourself. The key to all of this is to know that the IND780 uses the density of water to calculate weight from liters. Remember 1 liter of water weighs 1000g. Also 1 gallon of water weighs 8.34 Lbs.

So if the flow meter is providing 2200 pulses/liter then it is really providing 2200pulses/1000g. If I want to choose an increment size of 0.1g then we solve the equation

$$\frac{2200Pulses}{1000g} = \frac{x}{0.1g}$$

In plain English – if 2200 pulses give me 1000g, then how many pulses give me 0.1g?

$$x = (0.1g \times 2200 \text{ pulses})/1000g = 0.22 \text{ pulses per increment (0.1g)}$$

This cannot work because there is less than 1 pulse per increment. Here's the result if I choose 1g as my increment:

$$\frac{2200Pulses}{1000g} = \frac{x}{1.0g} \text{ Then } x = (1.0g \times 2200 \text{ pulses})/1000g = 2.2 \text{ pulses per increment}$$

This works because there is at least one (in this case more than one) pulse per increment.

The **Flow Rate Multiplier** should be disabled with a setting of "0.000." Remember I just said that the IND780 uses water as a reference to convert liters to grams (or whatever weight unit you choose). You might be asking yourself "what if I'm not using water as a material?" The water calculation is close enough that for most materials it makes no real difference, but what about the few cases where it does? The Flow Rate Multiplier is the answer. It is a correction factor for the density of water. In this example and in most of your customer applications this will be "0.000".

The **Rate Time Units** should be "Seconds" and the Output Average should be "1".

Even more unnecessary but interesting information

For those of you interested in how you might use the **Flow Rate Multiplier**, I'll show you the equation used by the IND780 to calculate pulses/weight using the example in grams.

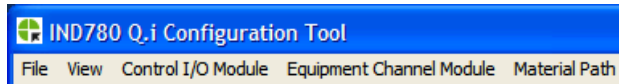
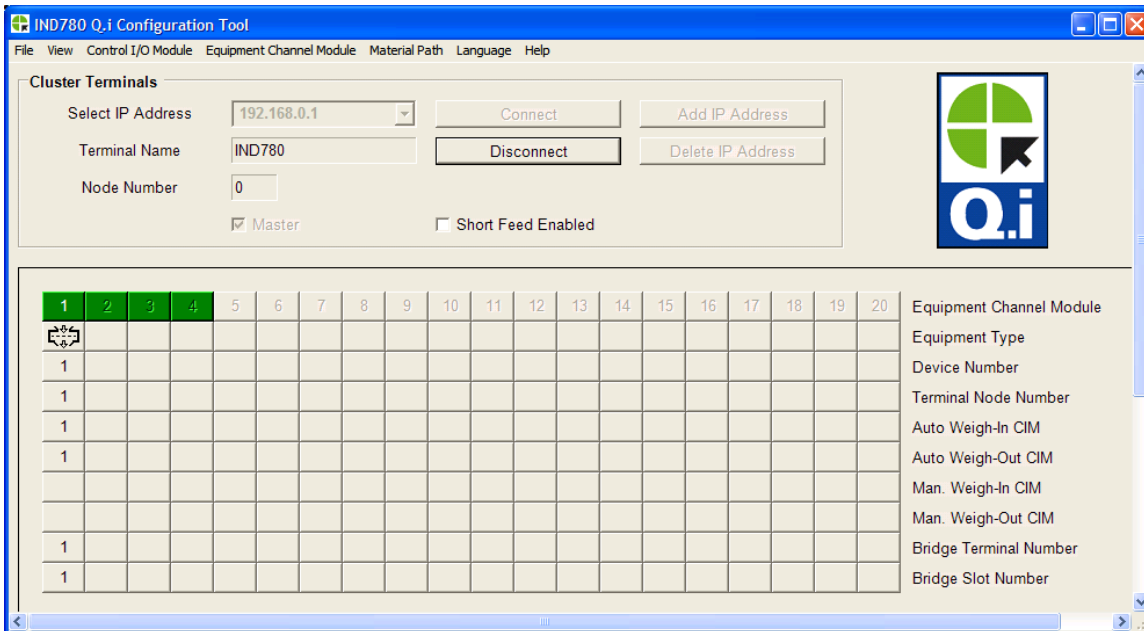
$$Pulses / g = \frac{2200Pulses}{1Liter} \times \frac{1Liter}{1000g} \times (FlowRateMultiplier)$$

If you set the **Flow Rate Multiplier** to anything other than "0.000" it is enabled and the calculation above is used. What this means is that the flow rate multiplier as a correction factor is a *ratio of the density of the material relative to water*. For example if you are filling isopropyl alcohol the density of this material is 1Liter/785.40g. Since the water calculation is always in the equation, the Flow Rate Multiplier has to be calculated as 1000g/785.40g.

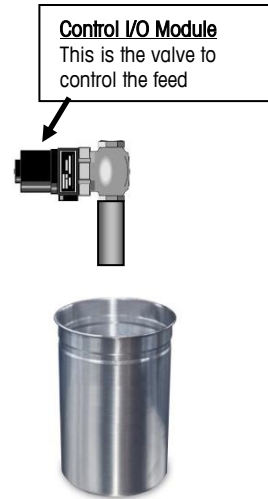
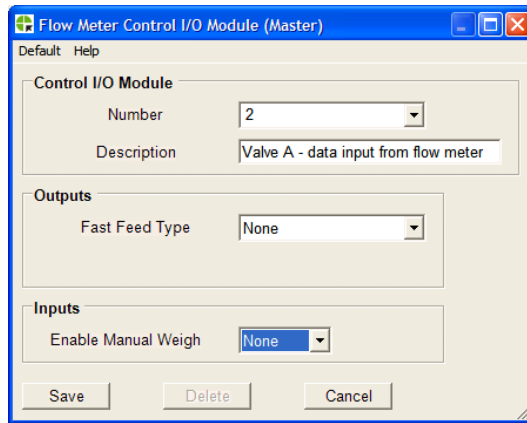
$$Pulses / g = \frac{2200Pulses}{1Liter} \times \frac{1Liter}{1000g} \times \frac{1000g}{785.40} = 2.8$$

So 2.8 pulses equals 1 gram of isopropyl alcohol, compared to 2.2 pulses for 1 gram of water.

At this point the flow meter board has been configured. In the next steps I'm going back to the Q.i Configuration Tool to setup the appropriate **Control I/O Module**, **Equipment Channel Module** and **Material Path** to enable Q.impact with the flow meter.

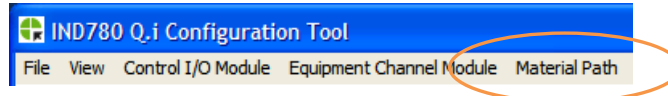


Under the menu item **Control I/O Module** select "Flow Meter". The Control I/O Module is the valve as shown in the lower right picture, but the data used to control whether this valve is on or off will come from the flow meter instead of a scale.

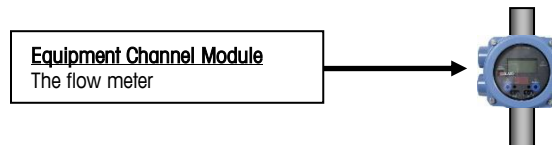


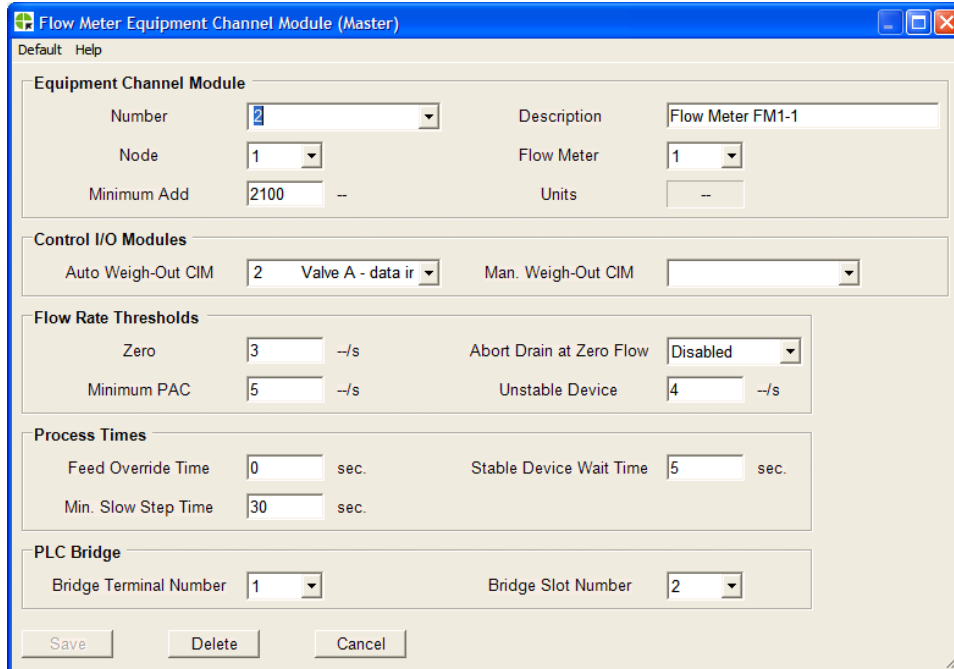
Example 1 used a Control I/O Module with ID=1 so I can't use the same number again. It is already defined. Therefore I put "2" in the **Number** field. The **Description** is "Valve A – data input from flow meter". The **Fast Feed Type** is "None". This example doesn't have any manual inputs, also called hand-adds. Therefore **Enable Manual Weigh** is "None".

You may be asking yourself where the digital I/O is to control the valve. Just like the analog scale card the flow meter interface board also has a digital output. The IND780 automatically uses the digital I/O from the flow meter interface board for the channel you've configured.



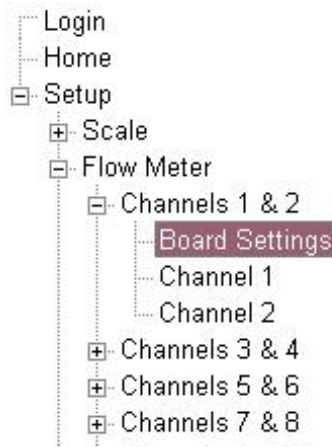
Under the menu Equipment Channel Module select flow meter. This will define the parameters for the flow meter interface FM1-1 that we configured in the IND780.





This example makes the same application assumptions as example 1. Since example 1 already has an Equipment Channel Module with ID as "1" and this is already stored in the IND780, I simply chose "2" for the **Number** field. If you were starting from scratch (starting with an empty database) you could just as easily use "1" for the ID number.

The **Description** is "Flow Meter FM1-1". **Node** is "1". The Flow Meter number means which flow meter channel. If you recall from the IND780 settings there are Channels 1, 2, 3, 4 etc up to 12 (maximum 6 flow meter boards with 2 channels each). In this example **Flow Meter** is set to "1".



The **Minimum Add** is the minimum amount of material that can be filled in the container. In other words it is the minimum target. The minimum target is based on your assumptions about the flow rate because Q.i needs a bit of time (typically 7 seconds is the best number to use) so that the algorithm can calculate things properly. This means your feed needs to last at least 7 seconds. Calculate the Minimum Add by: Average Flow Rate (units/second) x 7 seconds. In this example I chose Minimum Add as 300g/s x 7 seconds = "2100g".

The Equipment Channel Module (Flow Meter) needs to know which Control I/O device (Valve) it is associated with. The **Auto Weigh-Out CIM** (Auto Weigh-Out Control I/O Module) field is assigned "2 Valve A

– data input from flow meter” – because that’s the descriptive information we entered for the flow meter we’re using.

Unnecessary but interesting information

Notice that the choice is Auto Weigh-Out CIM, but in example 1 there was an Auto Weigh-In CIM. That’s because the material was flowing into a container sitting on a scale, but in this example we have material flowing out of a flow meter. It is considered a Weigh-Out process.

There is no need to enter anything into the **Man. Weigh-Out CIM** (Manual Weigh-Out Control I/O Module) because there is no hand-add operation in this example.

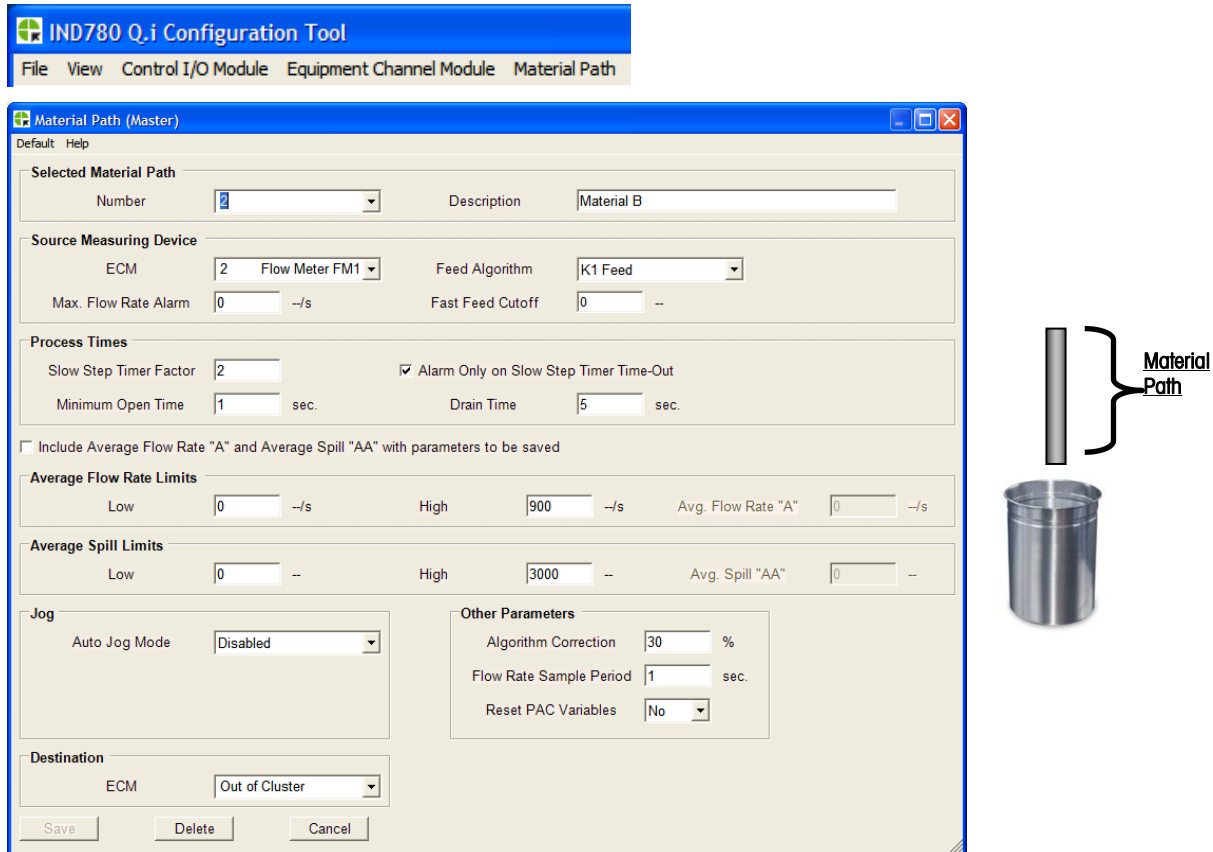
The **Zero** field is set to “3 g/s”, while **Unstable Device** is set to “4g/s”. If you remember from example 1 these two values act together just the way center of zero operates in a scale base. If the flow of material is “3 g/s” or less we assume the process is done. If the flow of material is 4 g/s or more the process is running. The **Minimum PAC** comes into play at “5g/s” and is the value at which the Q.i algorithm starts to operate. Leave the **Abort Drain at Zero Flow** as “Disabled”.

Moving into the section on **Process Times**, leave the **Feed Override Time** as “0”. The **Stable Device Wait Time** is a timer that waits to start a feed after the start feed command is issued. Just leave it in the default state of “5 seconds”.

The **Min. Slow Step Time** is a rather confusing name so I’ll simply describe what it does. If your feed takes too long to complete (much longer than normal based on target and flow rate) then you get an error. On shorter feeds Q.i might calculate a very short time. The Minimum Slow step Time overrides the calculation and provides the shortest feed time. I chose the shortest feed time to be “30” seconds.

The PLC Bridge settings of **Bridge Terminal Number** and **Bridge Slot Number** are confusing names. We don’t have a PLC in this example. However, the key thing to understand is that Q.i also has to maintain unique identifiers in its database for information regarding each Equipment Channel Module so whether the information is setup for PLCs to read or for Q.i to store in its database, the entries need to be organized in a unique way. So the **Bridge Terminal Number** is “1” because there is only one terminal in this example. The **Bridge Slot Number** is “2” because Q.i’s database already has an Equipment Channel Module defined from Examples 1 and 2.

The last configuration window that we need to set up is the Material Path. Go to the main menu of the Configuration Tool and select Material Path.



The Material Path **Number** needs an identification number between 1 and 999 assigned to it. Since I already have a material path defined as “1” from example 1, I defined this one as “2” with a **Description** of “Material B”.

The Source Measuring Device block tells Q.i what Equipment Control Module to use and which algorithm. The **ECM** (Equipment Control Module) field shows that the flow meter (with identification number “2”) will be used to measure the flow of this material. The **Feed Algorithm** should be “K1 Feed”. Ignore “K2” for now. “K2” is used with non-linear flow such as the output from pumps. This example uses a gravity feed, which should provide a linear flow suitable for use with the “K1 Feed”.

The **Max. Flow Rate Alarm** (Maximum Flow Rate Alarm) should be “0”, which disables the alarm. This was designed for a very special application and won’t apply to 99.99% of filling applications.

The **Fast Feed Cutoff** should be “0” to disable it. **Fast Feed Cutoff** is for two-speed feed systems. Q.i is primarily for single speed feed systems.

The **Slow Step Timer Factor** is just a multiplier for an alarm in case the filling takes too long to complete. Just leave the field as “2” and you shouldn’t need to worry about this value. Don’t forget to check the box **Alarm Only on Slow Step Timer Timeout**. This is another one of those special diagnostic cases that doesn’t apply to 99.99% of everything Q.i is doing. If you leave the box checked you will never need to worry about it.

The **Minimum Open Time** is “1”. It is how long Q.i waits after starting the filling process before the Q.i algorithm starts collecting real time data.

The **Drain Time** is how long Q.i waits after the valve has been closed before completing the process. Remember Q.i is collecting data as it goes so we need to tell it when to stop collecting data. In this example

I set it to 5 seconds. You should start with a guess of how long you think it should be. Your best guess is the time it takes from closing the valve until the flow of material stops. This depends upon the system you are working with. After you run a few filling cycles you can time this and change the value to something more accurate.

The next parameters are the average flow rates and average spill. Firstly, there is a checkbox **Include Average Flow Rate "A" and Average Spill "AA" with parameters to be saved**. Just leave this unchecked. The Q.i system will measure these values for you after you run a few filling cycles. However for the four fields with low and high limits you will need to take a guess and then come back later to put in the right values.

Average Flow Rate Limit Low should start with "0". The **Average Flow Rate Limit High** should be 3 x your guess of the average flow rate. In this example I estimated my average flow rate to be 300 grams of material per second. So 3 x 300 is 900 g/s as a high limit. After running a couple of filling cycles, come back and look at the value **Avg. Flow Rate "A"**. Q.i will put a measured average flow rate. At that point you could take the measured value, multiply it by 3, and put the resulting value into the high limit parameter.

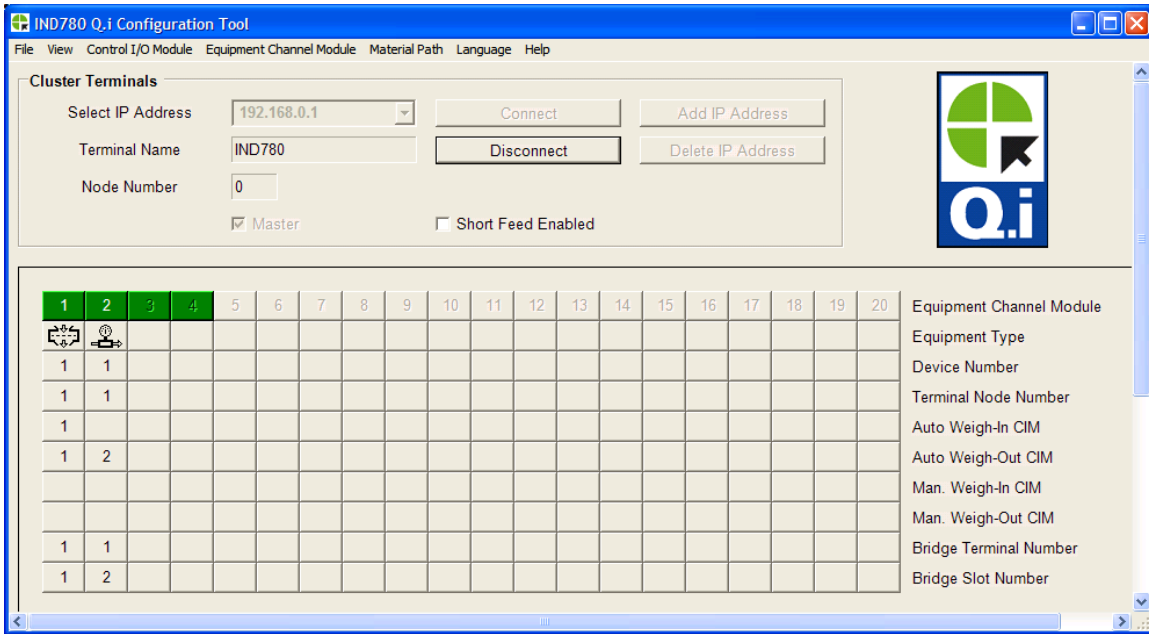
The same idea applies to the Average Spill Limits, spill being the amount of material that is still falling toward the container after the valve closes. Some people call this in-flight material. The **Average Spill Limit Low** should start with "0". The **Average Spill Limit High** should be 3 x your guess of the spill value. I guessed 1000g of spill so 3 x 1000g = 3000g for the high limit. After a couple of filling cycles go back to this screen to see what value Q.i measured and put in the field **Avg. Spill "AA"**. Multiply this value by 3 to calculate a more accurate Average Spill Limit High.

Jog Mode should be "Disabled". Jog Mode is used when the filling doesn't reach the target value properly. When using the K1 algorithm the Q.i system should deliver the right amount of material each time and Jog Mode is not necessary.

The **Destination ECM** (Equipment Control Module) is not necessary because our destination is the container, not a scale. Just select "Out of Cluster", which is simply a confusing way of saying "None". In advanced systems with multiple IND780s the "Out of Cluster" selection makes more sense, but that doesn't apply to this example.

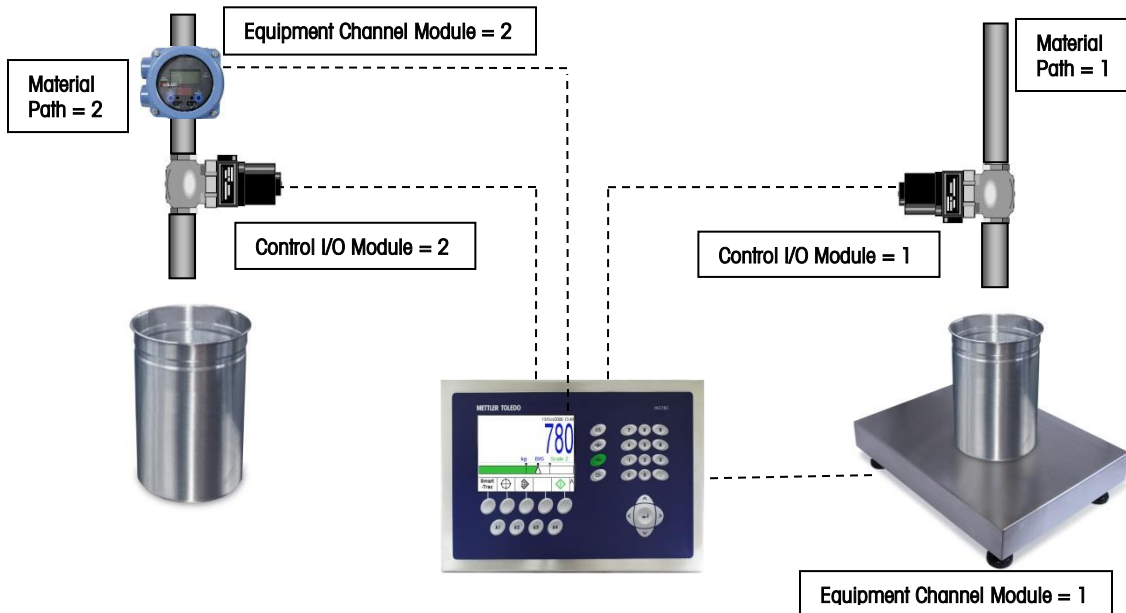
The **Other Parameters** block includes tweaks to Q.i's predictive adaptive algorithm. In general, **Algorithm Correction** should be "30%" as shown in the example. The **Flow Rate Sample Period** is "1". Select "No" for **Reset Pac Variables**.

If you return to the main window of the Q.i Configuration Tool you see that there are now two Equipment Channel Modules defined. The first is from example 1 and the second from the example we've just completed.



You might have been wondering why I didn't start from a clean database for example 3 with the flow meter. I could have very easily done that but I wanted to show what happens when multiple Equipment Channel Modules are configured. The IND780 could either be used for filling a container on a scale base, as in example 1, or filling a container using a flow meter, as in example 3.

However, the same configuration could also be used to do *both* filling processes simultaneously using the same IND780:



This IND780 has the following options installed:

- 1 Analog Scale card connected to Equipment Channel Module #1 (Scale Base) with I/O from the scale card connected to the Control I/O Module #1 (Valve).

- 1 Flow Meter Interface Card Connected to Equipment Channel Module #2 (Flow Meter device) and Flow Meter Card I/O connected to Control I/O Module #2 (Valve)




Now that you have gone through examples 1 to 3 you have the information necessary to expand the IND780 to multiple filling applications. You can mix and match scale bases and flow meters as you wish to run simultaneously or one at a time. Remember the IND780 supports up to 4 analog bases or up to 12 flow meter channels. Q.i doesn't need to be complex but you can create more complex application solutions if you wish.

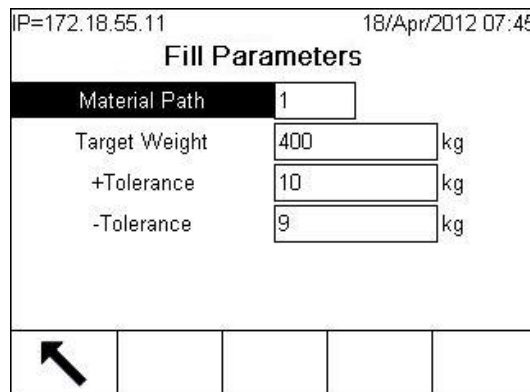
How to Get the Process Running

There are several ways to start a filling cycle with Q.i, ranging from pressing a softkey on the IND780 main screen, to triggering the process using a custom application written on the IND780 or on a PC connected to the IND780.

Softkey Icons

Using the IND780 softkeys (available with firmware version 7.3.x or above) it is a simple matter to start the filling process. The IND780 already knows what valves, scales or flow meters are being used. The only information the user needs to enter is which material path to use, the target value, and the tolerance. This involves three softkeys:

Icon	Description
	Define Feed – Enter which material path to use, the target value and the tolerance. Refer to Fill Parameters screen , below.
	Start Feed – Pressing this icon will start the filling cycle with the information provided from the Define Feed screen
	Abort Feed – Pressing this icon will terminate the filling cycle prior to completion



IP=172.18.55.11 18/Apr/2012 07:45

Fill Parameters

Material Path

Target Weight kg





+Tolerance kg

-Tolerance kg

←

Custom Software Applications

Although the softkey icons can be used to make a complete solution, there are many customers who want the IND780 interface to operate a certain way, or perhaps want to use a different interface on a PC instead. Luckily Q.i is very flexible. There are three main solutions that can be used:

Method	IND780 with Q.iIMPACT	What Controls Q.i
Custom Task Expert Program running on IND780		
Custom .Net Application running on IND780 (IND780 Firmware 7.3.x or above)		
External Computer Interface (Customer uses their own PC application to control Q.i)		

Regardless of which of the three solutions is preferred, the basic idea behind all of the solutions is the same. Q.i uses the IND780 shared data. Starting a feed is as simple as writing basic information such as material path ID number, target value and tolerance to the correct shared data variables and telling one of the shared data variables to start the filling cycle. Task Expert and .Net have direct access to shared data memory from inside the IND780. An external PC will use an Ethernet connection to log into the shared data server (see the IND780 technical manual for details on this) and send commands to write to the shared data memory.

Appendix A of this document has the technical details of which shared data memory and what values to use to help programmers create the appropriate applications.

PLC

Although this guide emphasizes stand-alone solutions for IND780 and it is beyond the scope of this guide to describe PLC connectivity, there are times where the IND780 may need to be integrated into a larger process at the customer's plant.

If a customer is using a PLC to control a process and Q.i is added to control the filling portion of a process, then the IND780 will need to be connected with the PLC using an appropriate PLC option card and some PLC communication configuration will have to be performed in the setup menu of the IND780. There are three main things you need to know:

- The Q.i part of the configuration is **the same** whether the IND780 is stand-alone or integrated with a PLC.
- The information sent between the PLC and the IND780 is fairly simple information. The PLC only needs to tell Q.i what material path, target value and tolerance to use. Q.i will carry out the filling process as if it were a stand-alone unit, and then report back to the PLC when it is finished.
- Mettler-Toledo, LLC provides a driver (called the AIM driver) to help integrate the PLC to IND780 communications. The AIM driver currently supports ControlLogix with Ethernet/IP or ControlNet. The AIM driver may also be used on some MicroLogix platforms but you should contact Mettler-Toledo for further information.

If you need to install Q.i in a system integrated with a PLC, please contact your local METTLER TOLEDO representative, who can put you in contact with resources to help with this integration.

Optimization

As I mentioned in the examples, Q.i collects data such as average flow rates and average spill values after you run several filling processes. Therefore installing a Q.i filling system requires a minimum of 4 steps:

1. Configure the IND780 as shown in examples 1 to 3.
2. Run several Feeds and then look back at the configuration for Average Flow Rates and Average Spill values.
3. Recalculate the High and Low Flow limits and Spill Limits.
4. Enable Limit Checking

Step 1 has already been completed after following any of the first three examples so I'm going to start at step 2. Let's assume you have run several filling process cycles of Material Path #1 "Material A" from Example 1 in this document. The IND780 has now measured the average flow rate of material and the average spill. Remember the spill is the amount of material still falling into the container when the valve is turned off.

Go into the Q.i setup menu and select Material Path. You will see the material path window as shown below with blank fields. Press Enter to go into the first field and enter the number of the material path "1" in this case. Press Enter again (2 times) and the data for Material Path #1 will be displayed.

- Q.i Configuration
 - Terminal
 - K1 & K2 Parameters
 - Control I/O Module
 - Equipment Channel Module
 - Material Path**

Go to the last page of the Material Path setup to find Avg. Flow Rate "A" and Avg. Spill "AA". For the purpose of this example I modified the numbers to make things easy to explain. Although the the screen shows dashes "--/s" and "--", don't worry about that because the primary unit of the IND780 in Example 1 was set to grams. So the measured average flow rate is 200 g/s and the measured average spill is 500 g. This completes step 2.

In step 3 you need to calculate the new low and high limits for the average flow rate and the spill. The two pictures below show the initial guesses from example 1, so I had guessed:

Avg. Flow Rate: Low Limit = 0 g/s and High Limit = 900 g/s

Avg. Spill: Low Limit = 0 g and High Limit = 3000 g

P=192.168.0.1		29/Jan/2010 06:08	
Material Path (Master)			
# / Description	1	Material A	▲
Source ECM	1		
Feed Algorithm	K1 Feed - GIW ▼		
Destination ECM	1		
Drain Time	5	sec.	
Avg. Flow Rate Low Limit	0	--/s	▼
Esc	M	MR	OK

P=192.168.0.1		29/Jan/2010 06:08	
Material Path (Master)			
Avg. Flow Rate High Limit	900	--/s	▲
Avg. Spill Low Limit	0	--	
Avg. Spill High Limit	3000	--	
Auto Jog Mode	Disabled ▼		
Jog On Time	0	sec.	
Jog Off Time	0	sec.	▼
Esc	M	MR	OK

You might remember from example 1 that I didn't really define what these limits are, but rather I simply told you to put in some values to get started. The reason I avoided explaining the limits is that these limits are abstract values used in the Q.i algorithm just to make the mathematics function correctly. The limit values don't really represent the flow rates and spill values as you or I would think of them. Sometimes as shown in this example below the lower limit values are negative. They are used to help the Q.i algorithm keep its mathematical values in a reasonable range so the IND780 can more easily optimize the filling process.

Let's start with the Flow rate. The IND780 measured an average flow rate of 200 g/s. I want to set the limits to be 3 times the average value both above and below that average value. $3 \times 200 \text{ g/s} = 600 \text{ g/s}$. Therefore I can optimize the Avg Flow Rate Limits as:

$$\text{High Limit} = 200 \text{ g/s} + 600 \text{ g/s} = 800 \text{ g/s}$$

$$\text{Low Limit} = 200 \text{ g/s} - 600 \text{ g/s} = -400 \text{ g/s}$$

I need to do the same with the average spill value. The IND780 measured an average spill of 500g. $3 \times 500\text{g} = 1500\text{g}$. Therefore I can optimize the Spill Limits as:

$$\text{High Limit} = 500\text{g} + 1500\text{g} = 2000\text{g}$$

$$\text{Low Limit} = 500\text{g} - 1500\text{g} = -1000\text{g}$$

Put these new limit values back in the Material Path as shown below:

P=192.168.0.1		29/Jan/2010 06:43	
Material Path (Master)			
# / Description	1	Material A	▲
Source ECM	1		
Feed Algorithm	K1 Feed - GIW ▼		
Destination ECM	1		
Drain Time	5	sec.	
Avg. Flow Rate Low Limit	-400	--/s	▼
Esc	M	MR	OK

P=192.168.0.1		29/Jan/2010 06:44	
Material Path (Master)			
Avg. Flow Rate High Limit	800	--/s	▲
Avg. Spill Low Limit	-1000	--	
Avg. Spill High Limit	2000	--	
Auto Jog Mode	Disabled ▼		
Jog On Time	0	sec.	
Jog Off Time	0	sec.	▼
Esc	M	MR	OK

Moving on to step 4 I'm going to go back to the Q.i configuration menu of the K1 & K2 parameters as shown below, but this time I'm going to enable Limit Checking. Use the default values shown which for the K1 +/- Limit should be "10.0" and for the K2 +/- Limit should be "0.1" as shown in the example below.

These are additional (but again rather abstract mathematical values) that keep the K1 and K2 algorithms in check so they function properly.

IP=192.168.0.1 29/Jan/2010 09:18

K1 & K2 Parameters

Limit Checking	Enabled
K1 +/- Limit	10.0
K2 +/- Limit	0.1

⬅

- Q.i Configuration
 - Terminal
 - K1 & K2 Parameters**
 - Control I/O Module
 - Equipment Channel Module
 - Material Path

What I've shown you in this document will allow you to configure and install a system that should give good results. However, there are additional changes that can be made to optimize filling systems. If your customer has very strict requirements for fast high precision filling you might need further optimization techniques. There are additional tools such as the Q.i Dashboard Tool that allow data collection and analysis to help with advanced optimization. Here is a website where you can get more information about Q.i and additional tools:

ftp://ftp-static.mt.com/pub/indmkg/IND780_Qi/Index.htm

There is also a contact list for support at:

ftp://ftp-static.mt.com/pub/indmkg/IND780_Qi/Contact Us/ContactUs.htm

Appendix A – SD variables for Custom Applications

Q.iIMPACT can be controlled by your TaskExpert or C# applications directly from the IND780 terminal or can be controlled remotely from a PC application using Shared Data Server commands. The six basic steps to start Q.i are:

1. Define which equipment module number you want to use
2. Define which Material Path will be active for the feed
3. Define target as well as positive and negative tolerance values
4. Setup a sequence number
5. Send Q.i which command to execute (examples are "start feed" or "stop feed")
6. Send the Batch ID number. This is what triggers the system to start.

The SD variable for this is CQ, which is found in the **Q.i Technical Manual 64068643, Appendix C**. Below are the most important values

Variable	Description
cq--01	Equipment Channel Module Number
cq--02	Message Sequence Number
cq--03	Material Path
cq--04	Command
cq--07	Target Weight
cq--08	Positive Tolerance
cq--09	Negative Tolerance
cq--10	Batch ID Number

Using Example 1 from this guide we would set:

cq0101=1 because scale 1 (the "01" part of cq01) is defined as equipment channel module number 1.

cq0103=1 because scale 1 (the "01" part of cq01) will be fed material using material path 1

cq0107=8000 I want to fill 8000g of material on scale 1

cq0108=400 the positive tolerance is 400g so 8000+400g

cq0109=400 the negative tolerance is 400g so 8000-400g

cq0102=0 because each time Q.i performs a feed it requires that the number be different, i.e. a running sequence. You can use this number to keep track of the feeds or if you wish

simply toggle it between 0 and 1. The only requirement is that the number for the next feed must be different than the last feed.

cq0104=1 as this is the command telling the Q.i software to start a feed.

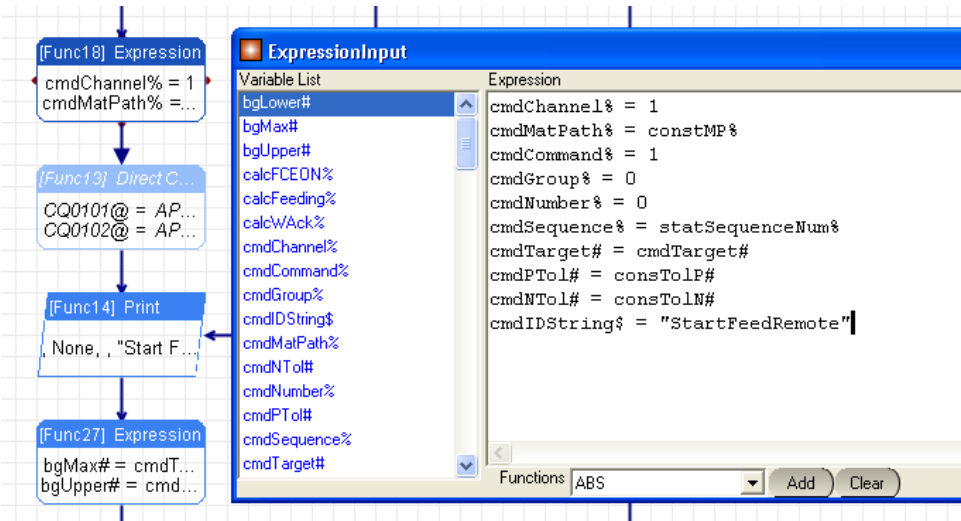
cq0110 = "Any String you wish to put here". This is used to trigger all the previous data you entered. You should always write to this SD variable last! The string needs to change for each command.

Typically the TE programs set up strings such as "start feed", "acknowledge", "abort feed" and so on associated with the command numbers below. The easiest thing to do is send the information for a start feed, then at the end of the feed you send an acknowledge command. Then you will be ready to setup and start the next feed cycle.

Below is a list of the commands used with cq0104. The most common commands are:

Number	Description
1	Start Feed (Net Weight Target)
2	Start Feed (Gross Weight Target)
4	Acknowledge Feed
5	Abort Feed
7	Control Override Mode ON (TE Controls Output)
8	Turn FCE (this is the ouput on the scale/flow meter card) ON in override mode
9	Turn FCE OFF in override mode
10	Turn Control Override Mode OFF (Back to Auto Mode where Q.i controls the feed)

Below are some examples of Task Expert Screens showing how some of the variables could be defined:



Variable Name	Type	Comments
calcWAck% (AS0104)	Integer	
cmdChannel% (CQ0101)	Integer	Channel Number
cmdCommand% (CQ0104)	Integer	Integer Command
cmdGroup% (CQ0105)	Integer	
cmdIDString\$ (CQ0110)	String	String to identify command, REQUIRED !
cmdMatPath% (CQ0103)	Integer	Material Path number
cmdNTol# (CQ0109)	Double	Negative Tolerance
cmdNumber% (CQ0106)	Integer	
cmdPTol# (CQ0108)	Double	Positive Tolerance
cmdSequence% (CQ0102)	Integer	Incrementing Number
cmdTarget# (CQ0107)	Double	Target Value
consDTime% (AP0101)	Integer	
consMaxT# (AF0102)	Double	
consMinT# (AF0103)	Double	

You might also want to read the status of the feed. The SD variable ED--01 provides status as a 1 byte value once per second or immediately if there are critical events that have happened. The bit definitions for ED--01 are:

Bit	Description
0	Data Integrity Bit. Alternates every 5 seconds to let you know the system is still communicating ok. This is used for PLC communications as a heartbeat signal
1	Instrument Data Integrity OK – scale/flow meter card OK. If for any reason the scale or flow meter card stops sending data this bit will indicate that fail condition.
2	Scale over capacity
3	Scale under zero
4	Scale motion
5	Material Transfer Active
6	FCE (scale/flow meter output) 0=OFF, 1=ON
7	Feed complete, waiting for Acknowledge

Bit 5: This bit stays ON ("1") during the feed including the **Drain Time**

Bit 6: This is just status of the output on the scale or flow meter card. You should never use this to control anything such as any external PLC ladder logic you create because it is updated only ever 500mSec. To create internal/external logic control based on the FCE status use DIO105 for Scale 1.

Bit 7: This is set to ON ("1") at the end of the feed. If you send a command cq0104=4 (acknowledge) the bit will be reset.

The confusing part about using the ED shared data variable is knowing which scale channel to use. The charts below should help with this. So if there are scales channels in the IND780 then Scale 1

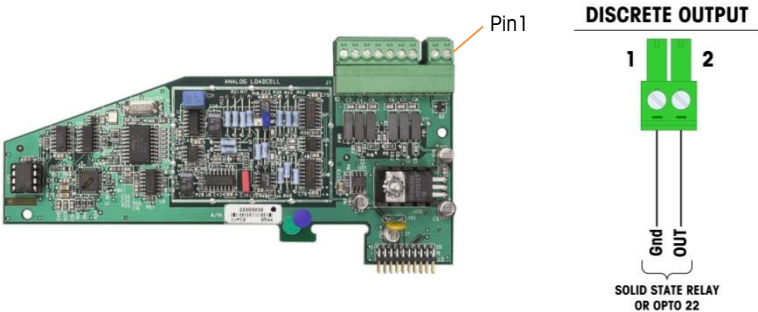
is located in position 9, i.e. ED0901 will be the status of Scale 1 in the system. Flow meter option card channels start at 1 so ED0201 will be the status of flow meter channel 2. Remember there are two flow meter channels on each flow meter option card so channel 2 is still on the first flow meter card.

Channel	Measurement Option	Channel	Measurement Option
1	Flow Meter 1	2	Flow Meter 2
3	Flow Meter 3	4	Flow Meter 4
5	Flow Meter 5	6	Flow Meter 6
7	Flow Meter 7	8	Flow Meter 8
9	Scale 1	10	Scale 2
11	Scale 3	12	Scale 4

If there are no scale cards in the IND780, but rather only flow meter option cards then the chart will look like the one below

Channel	Measurement Option	Channel	Measurement Option
1	Flow Meter 1	2	Flow Meter 2
3	Flow Meter 3	4	Flow Meter 4
5	Flow Meter 5	6	Flow Meter 6
7	Flow Meter 7	8	Flow Meter 8
9	Flow Meter 9	10	Flow Meter 10
11	Flow Meter 11	12	Flow Meter 12

If you want to go beyond the examples in this guide for multiple materials you will want to use TE or C# to select the individual materials. Remember the output that controls the valve should (to get the fastest cutoff) always be the TTL open collector output on the analog scale card or flow meter card.

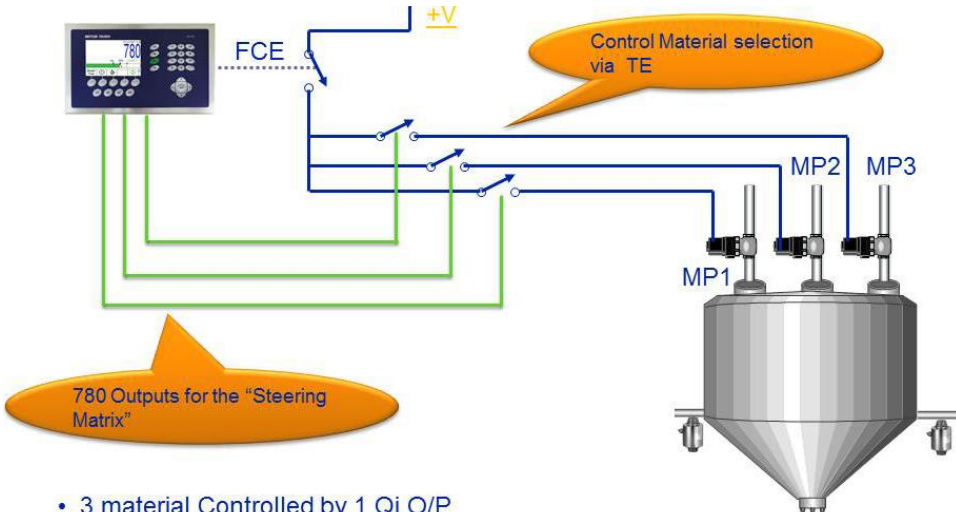


NOTE: Don't forget you need to supply voltage to this output!!! It is only a TTL open collector output and requires an external voltage source from +5V to +30V.

This output is what we call the FCE (Final Control Element). If you use this output the target comparison is 50 times per second. If you use an internal digital I/O option card or the ARM100 digital I/O module then the comparison is only 20 times per second.

But what do you do if you need to fill multiple materials? You only have one FCE from your scale card. The solution is to create external logic to select which valve receives the FCE signal. The external logic can be controlled by the TE or C# program.

The diagram below shows a tank being filled with 3 materials. The TE or C# application will direct the digital I/O from the optional internal I/O card or ARM100 to select which material is active. The FCE from the scale card controls the filling process.



- 3 material Controlled by 1 Qi O/P
- Qi is in DIRECT Control of the FEED
- !! Only ONE Matrix OP on at any one time

Another important point is that your 780 outputs (selecting which material) need to obviously stay ON a little longer than the filling process so you don't interrupt the feeding process. See the timing diagram below.

