Critical manufacturing
an ASM PT company

Weigh And Dispense

10.2

March 2024

DOCUMENT ACCESS

Public

Weigh And Dispense

Estimated time to read: 21 minutes

In formulation industries, it is very importance that different raw materials are correctly and precisely weighed and placed into appropriate containers. The Weigh and Dispense module helps with this time consuming process, which is sensitive, prone to errors, and involves both manual material handling operations as well as interaction with electronic scales.

The Weigh and Dispense module also ensures full traceability and meets the defined regulatory compliance requirements.

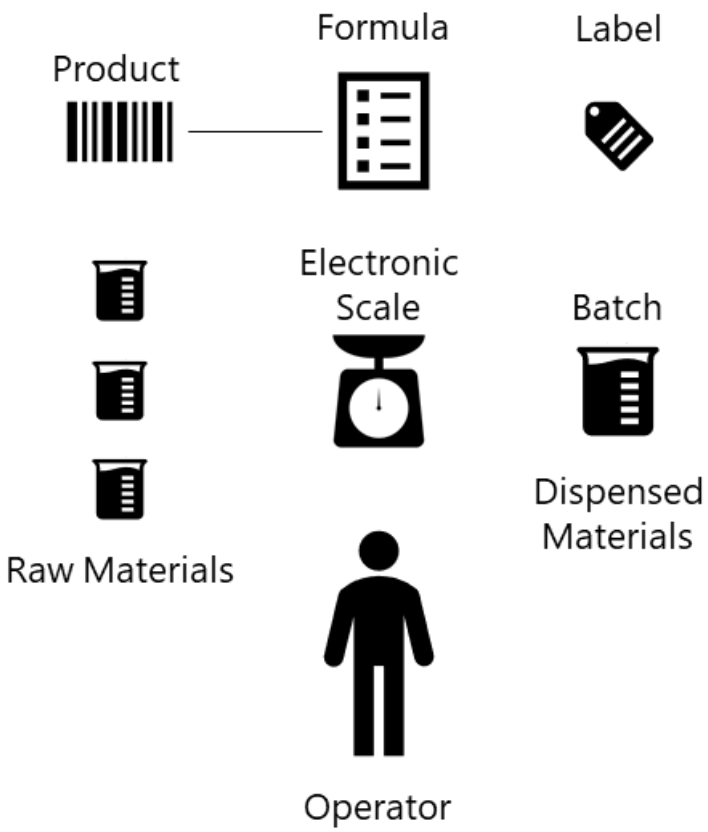
> **Info**
>
> Weigh and Dispense is a separately licensed module.

This document will guide you through the Weigh and Dispense process and the necessary system configurations to setup and use the Weigh and Dispense functionality.

Overview

Weigh and Dispense is a method to provide a controlled, computer-aided process to guide the operator through the weighing and dispense process.

As shown in the figure below, there is a formula that defines the composition of raw materials that are required in certain quantities or proportions to manufacture a certain product. To carry out the Weigh and Dispense process, the operator, following the instructions as provided by the application, picking raw materials of the specified products and then weighing their quantities using an electronic scale until the dispensed quantity falls within the tolerances defined in the formula. Each raw material can be dispensed into the same or different containers and multiple materials of the same product can be used for particular ingredient. After each dispense (partial or complete) the system can print a label that the operator can stick into the dispensed container.

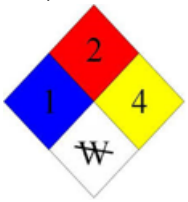
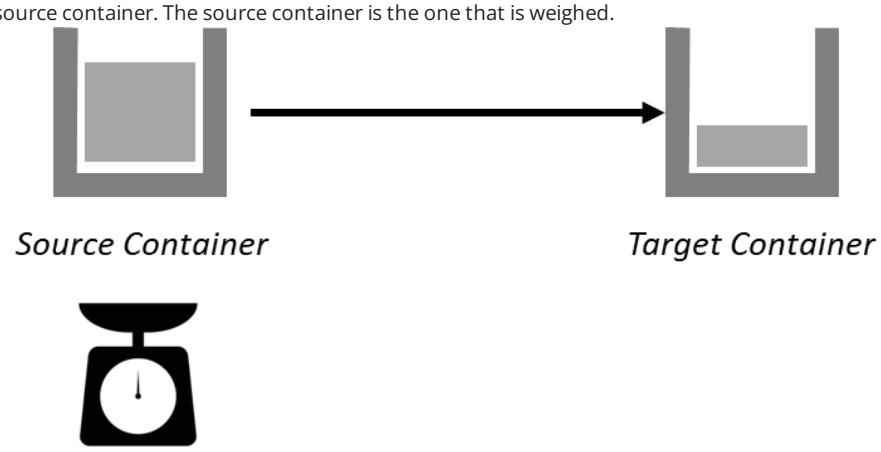


Because the dispensed process may involve dangerous materials and it may require protective equipment, the system will present the operator at all times, the product safety information.

Concepts

The following table describes the main Weigh and Dispense terms and concepts.

Term / Concept	Description
Electronic Scale	An integrated electronic scale that provides the weight values to the system.
Formula	Defines the list of source products, their required quantities and tolerances. In the application, it's modeled as a BOM of scope *Weigh and Dispense*.
Gross [Weight]	The total loaded weight of a container.

Term / Concept	Description
Hazard Classifications	Product safety classifications according to four dimensions: - Health Hazard (shown in diamond with the blue color) - Fire Hazard (shown in diamond with the red color) - Instability Hazard (shown in diamond with the yellow color) - Specific Hazard (shown in diamond with the white color) The classifications for dimensions health, fire and instability are ranked from zero which represents no hazard until four which represents the most extreme hazard. The specific hazard is a qualitative one. 
Hazard Symbols	Additional product hazard classifications (e.g.: Oxidizing, Biohazardous, etc.).
Ingredients	A list of source products required by a certain Weigh and Dispense process.
Negative Weighing	A weighing method where the weigh is determined by the amount that is removed from the source container. The source container is the one that is weighed. 
Net [Weight]	The Gross weight minus the tare weight.

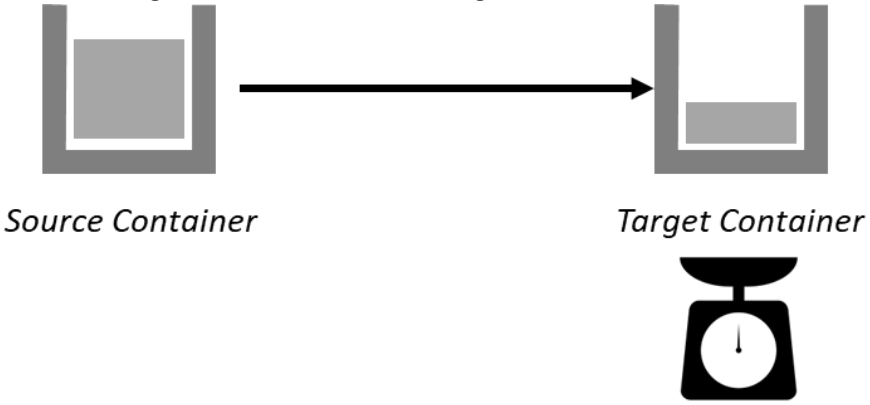
Term / Concept	Description
Positive Weighing	A weighing method where the weight is determined by the amount that is added to the target container. The target container is the one that is weighed. 
Protection Equipment	Different protective equipment (e.g.: goggles, boots, dust mask) that is required to handle material of certain dangerous products.
Raw Material	Same as ingredient - a source material of a certain product used to prepare a certain batch.
Routes of Exposure	A safety indication about the routes of exposure of a certain substance (Inhalation, Skin (or Eye) absorption, Ingestion or Injection).
Safety Data Sheet	A document that contains product safety information.
Tare [Weight]	The weight of an unloaded container.
Target [Batch] Material	A material of a certain product and quantity, for which the raw materials of certain products must be dispensed in the right quantities.
Technical Data Sheet	A document that contains product technical information.

Table: Weigh and Dispense Concepts

Setting Up Weigh and Dispense

In order to setup Weigh and Dispense it's necessary to follow the steps as described in the table below:

Step	Title	Description
1	**Create the Necessary Products**	Create the necessary Products -- including the target material Product and the source Product.
2	**Create a Formula**	Create a BOM of scope *Weigh and Dispense* to define the formula.

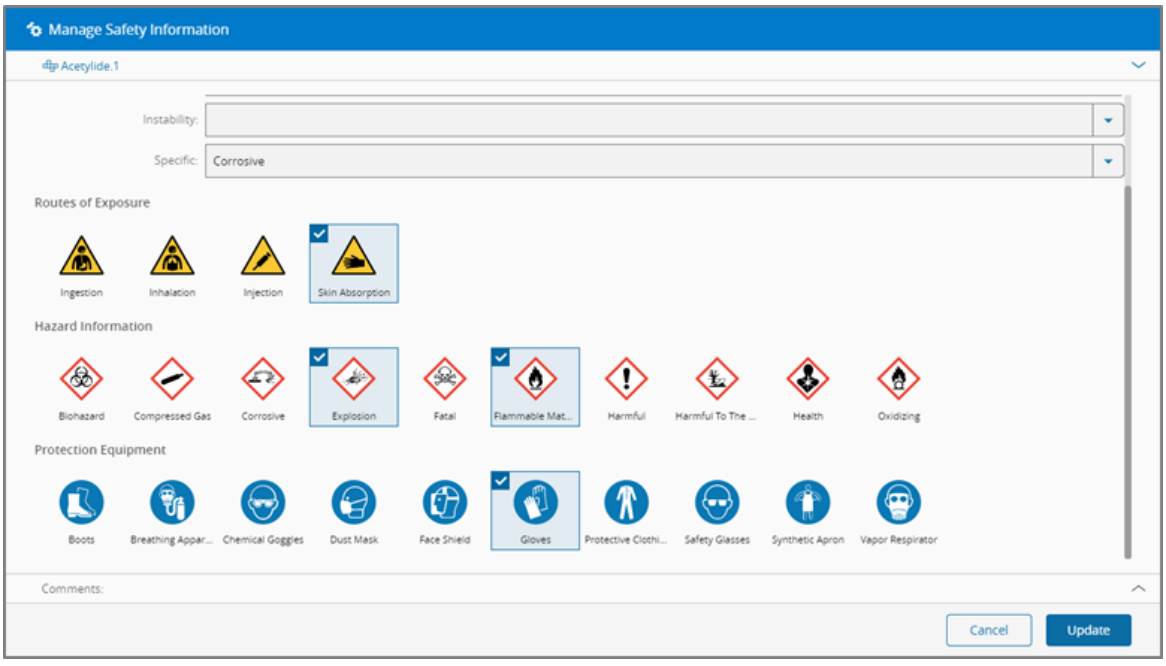
Step	Title	Description
3	**Create an Electronic Scale**	Create a **Resource** of type *Instrument* to represent the electronic scale.
4	**Link the Dispense Resource with Electronic Scales**	Make sure that the **Resource** that represents the Dispensing Station has an *Instrument Service* defined to link **Resources** with electronic scales.
5	**Define BOM Context**	Create the BOM Context in the right Step linking the BOM defined in Step 1.
6	**Manage the Printer Context**	Optionally, edit the PrinterTypePrintersContext Smart Table to specify the printers to be used for a particular context.

Table: Weigh and Dispense Setup steps

The individual steps are explained in more detail in the sub-sections below.

Create the Necessary Products

Both the target material Product and source Products are created as regular Products. The safety information is edited as part of the Product as shown in the figure below.



Info

Product *Safety Data Sheets* and *Technical Data Sheets* are added as attachments of predefined types. The predefined are configured in the application configuration in the following configuration entries:

- `/Cmf/System/Configuration/Product/SafetyDataSheet/` - for the Safety Data Sheet attachment type
- `/Cmf/System/Configuration/Product/Technical/` - for the Technical Data Sheet attachment type

Create a Formula

A formula is modeled after a BOM object of scope *Weigh and Dispense*. There are two possible formula types as shown in the following table:

Type	Description
Absolute	- Formula is expressed in absolute values. - The sum of the BOM quantities can add up to any value. - Tolerances are expressed in absolute values.
Relative	- Formula is expressed in relative values (percentages). - The sum of the BOM quantities must add up to a value between 99 and 101 (%). - Tolerances are expressed as percentages against the calculated dispensed quantity.

Table: Weigh and Dispense formula types

Furthermore, a BOM of scope *Weigh and Dispense* can reference a Printable Document of scope *Weigh and Dispense Label* to define a label that will be printed automatically after each partial or complete dispense. Printable Documents of scope *Weigh and Dispense Label* cannot have the *Applies To* defined, and the data contexts as defined in the table below will be created automatically so that they can be referenced in the label.

Info

The usage of Printable Documents requires a license for the Advanced Layout & Printing module.

Name	Type	Source Type
DispensedFromMaterial	Input	Object
DispensedFromProduct	Input	Object
DispensedFromStep	Input	Object
DispensedFromContainer	Input	Object
DispensedToMaterial	Input	Object
DispensedToProduct	Input	Object
DispensedToStep	Input	Object
DispensedToContainer	Input	Object
DispensedToContainerType	Input	String
DispensedEmployee	Input	Object
DispensedQuantity	Input	Decimal

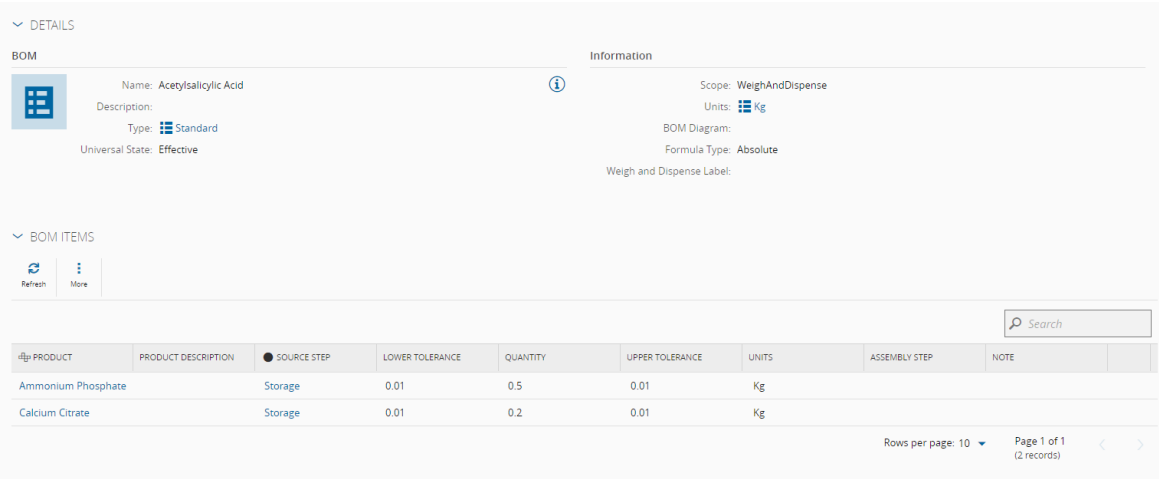
Name	Type	Source Type
DispensedUnits	Input	String
DispensedResource	Input	Object
DispensedScale	Input	Object

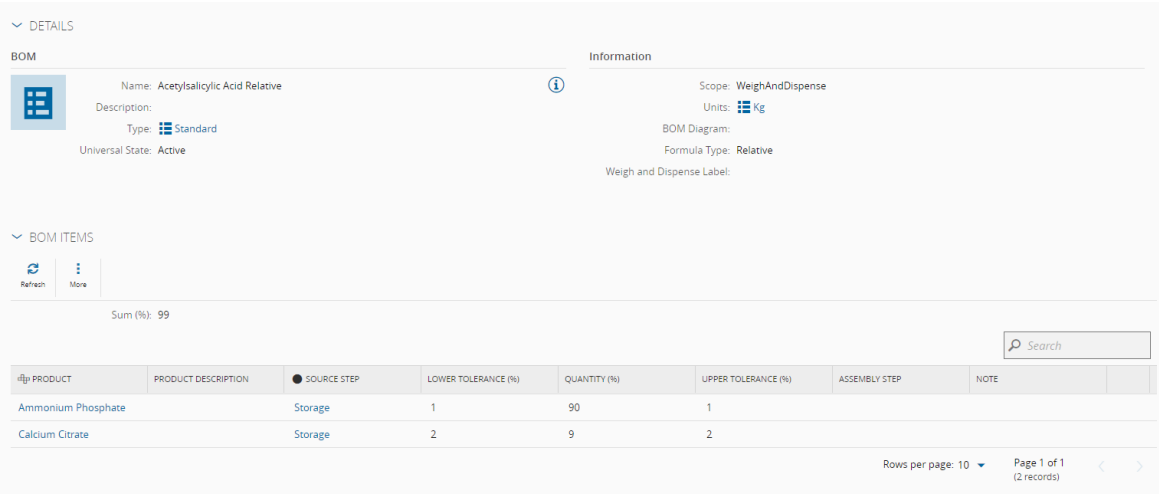
Table: Weigh and Dispense Label Data Contexts

The two figures below show two examples, using the Absolute formula type and a formula of type Relative.

Info

While a BOM may include different units of measure for the different ingredients, for BOMs of scope Weigh and Dispense there must be unit-of-measurement conversion factors between the ingredient product units and the target material batch primary units. These factors are defined at the Product level in the Unit Conversion Factors section.





Create an Electronic Scale

An electronic scale is a **Resource** of type Instrument. The important properties for the instrument **Resources** are the *Measurement Units* and *Calibration Status* as shown below:

Info

Either the **Resource** is configured to provide the weight in the target material batch primary units or there must be an entry in the generic table *UnitConversionFactors* to convert the scale units of measure to the target material batch primary units.

Info

Be sure to create and add some Services of type Instrument to the electronic scale **Resource** as well, so that the **Resource** can be used to provide Instrument Services.

Info

Only calibrated **Resources** of the same Facility can provide Instrument Services.

Info

The electronic scale **Resource** must be properly integrated with the system so that the Weigh and Dispense wizard can receive the electronic scale values automatically. Please refer to **Electronic Scale Integration Information** for more information.

Manage Instrument Capabilities

After creating the Instrument, it is possible to add specific characteristics regarding the capabilities of the Instrument. The Manage Instrument Capabilities wizard can be accessed through the Measurement Capabilities section of the **Resource** details page.

Property	Description
Mode	The Name of the Measurement Capability Mode. If the Instrument only contains one measurement capability, the mode must not be defined.
Parameter	Optionally, the User can define a Parameter and it must be of data type Decimal, Long or Boolean and have Units defined. This is relevant when the instrument can measure different physical properties with the same measurement units.

Property	Description
Measurement Units	If a Parameter is defined, the Measurement Unit is the one defined in the Parameter's Units and it cannot be changed.
Lower Range	Minimum value that can be measured.
Upper Range	Maximum value that can be measured.
Range Units	Units of Range.
Resolution	The minimum readable value.
Resolution Units	Units the Resolution.
Precision	Difference between repeated measurements at the same location, which can also be given as resolution divided by two.
Precision Units	Units of Precision.
Accuracy (%)	How close the measurement is to the true value being measured.

Table: Manage Instrument Capabilities properties

Warning

At least one of the Resolution, Precision, or Accuracy properties must be defined. However, if Precision is defined, Resolution cannot be defined and vice-versa.

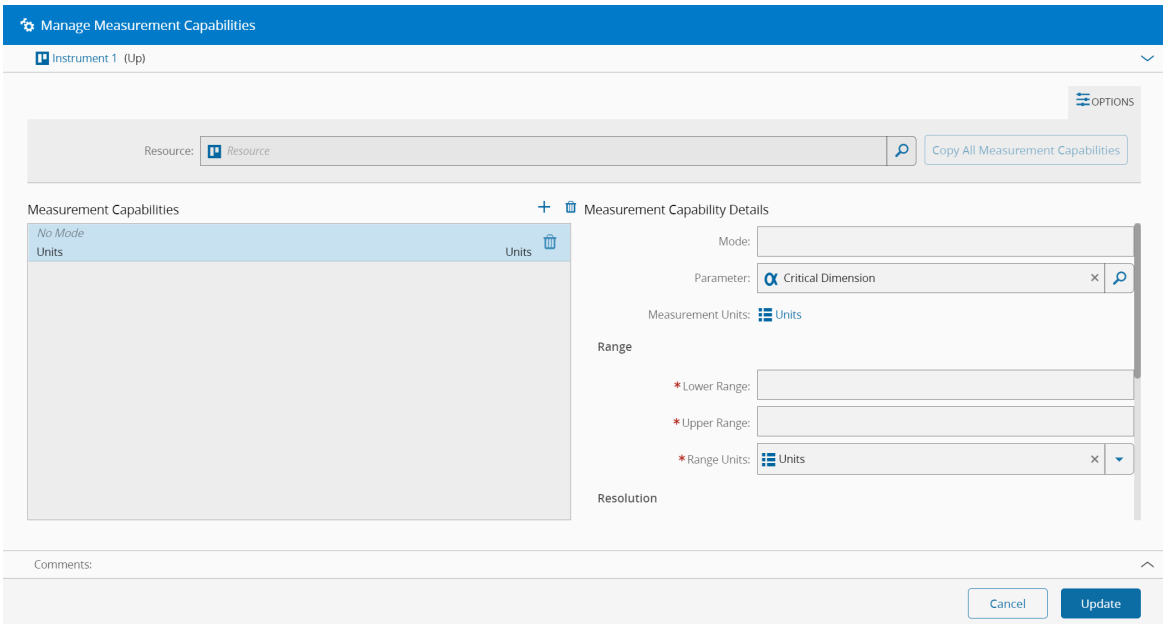
Info

The User can select a specific method to match the precision of the scale by setting the following configuration entry value: `/Cmf/System/Configuration/WeighAndDispense/ScalePrecisionMatchingMethod/`. If *Legacy* is selected, the system will consider only Instruments that have a defined Precision and ignore Instruments with only Resolution or Accuracy properties defined.

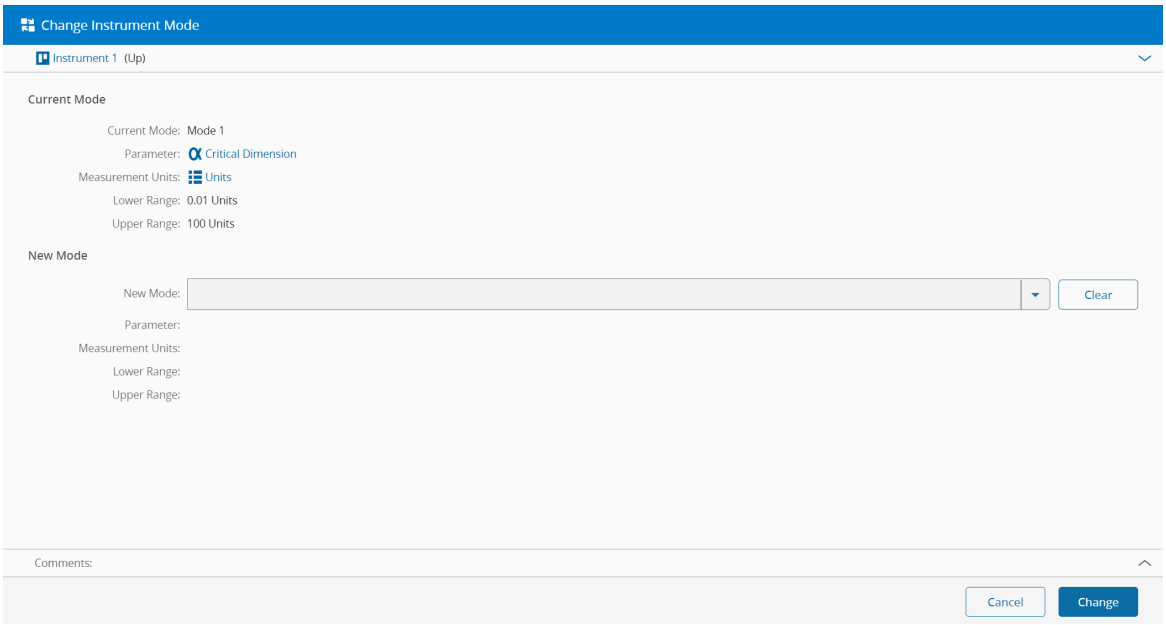
The system will then perform a Precision test in order to select the adequate scales to be used. Using **NumberOfDecimalPlaces** as the number of decimal places associated with the Precision (for the selected Measurement Capability), with the minimum value being 0, the scales selected will be the ones that obey the rule:

`LowerTolerance (rounded up to NumberOfDecimalPlaces) <= UpperTolerance (rounded down to NumberOfDecimalPlaces)`

Measurement Capabilities can also be copied from other Instruments, using the 'Copy All Measurement Capabilities' Option, as displayed in the Figure below.



To define the Instrument Mode, the User should access the Change Instrument Mode wizard available in the **Resource** View, as displayed in the Figure below. The Instrument Modes available are the ones defined as Measurement Capabilities.

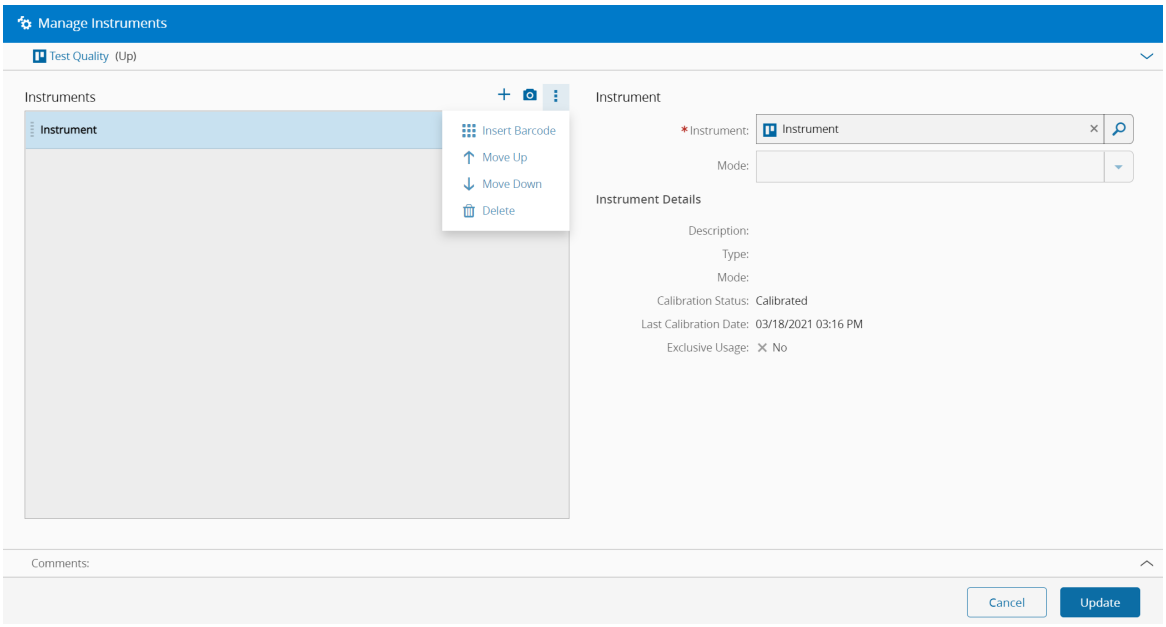


Manage Resource Instruments

To associate an Instrument to a **Resource**, the User must access the Manage Instruments wizard through the **Resource** page. The User can either select an Instrument through the search box or through a barcode reader, as displayed in the Figure below. The User can check which are the Instruments attached to a **Resource** in the Instruments section of the **Resource** page.

To select an Instrument the following conditions have to be met:

- The **Resource** must have the Processing Type defined as Process or Line
- The **Resource** and the Instrument must be in the same Facility
- If the Instrument property *Exclusive Usage* is set to True, then it can not already be associated with a Resource



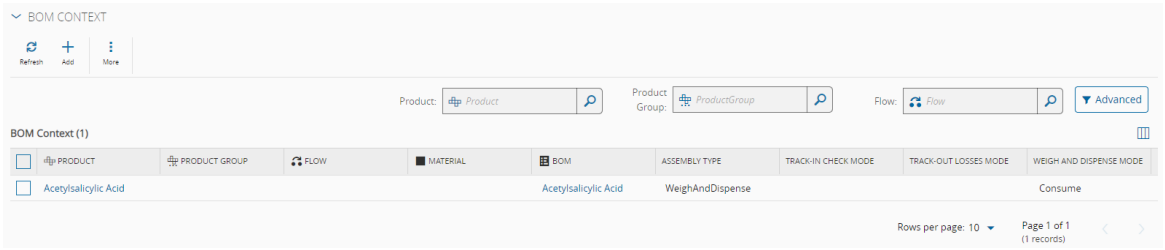
Define the BOM Context

The BOM Context is managed normally, defining the Assembly type as *Weigh and Dispense*. There are two possible Weigh and Dispense modes as shown below:

Mode	Description
Attach	A mode in which at the end of the Weigh and Dispense process the dispensed raw materials will be attached as sub-materials to the target batch material, thus the weight of the target batch material at the end of the Weigh and Dispense process will be zero (as all the quantity will be attached as sub-materials).
Consume	A mode in which at the end of the Weigh and Dispense process the dispensed raw materials are consumed by the target batch material. The quantity of the target batch material at the end of the Weigh and Dispense process will be equal to the sum of the dispensed quantities.

Table: Weigh and Dispense assembly modes

An example of a BOM Context for *Weigh and Dispense* is shown in the figure below:



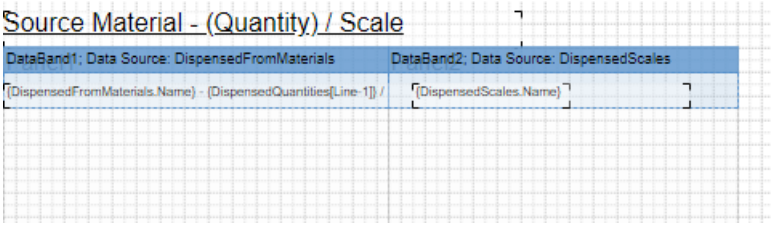
Manage the Printer Context

Optionally, edit the PrinterTypePrintersContext Smart Table to specify which printer must be used to print Weigh and Dispense labels for a particular context.

When using Dispense & Continue if you need to print multiple elements of a list, you need to use a Data band. A data source is specified to each Data band providing a table with data fields. It is possible to output

a table by placing text components with references to these fields. One data source can specify a previously unknown number of rows with data. The Data band displays as many rows as exist in the specified data source (e.g. if there are 100 rows in the data source, the Data band will show 100 entries). When there is not enough space on one page, a second page will be generated and printing will continue.

Definition for multiple entries:



Info

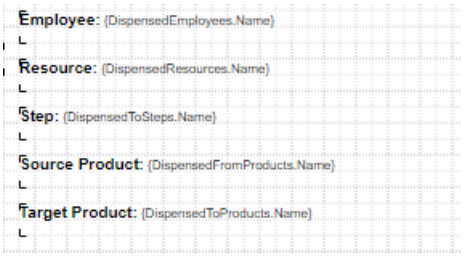
To print a list of integers or strings, we need to use `'Name_List'[Line - 1]` inside the Data band.

Result: (two dispenses)

Source Material - (Quantity) / Scale

CookiePart1_001 - 0.1 /	Cookie Scale 00
CookiePart1_002 - 0.1 /	Cookie Scale 02

Definition for single entry:



Result: (only the first element of the list will be printed)

Employee: Services user

Resource: Cookie Resource for WD

Step: Cookie WD

Source Product: CookieToAssemblePart1

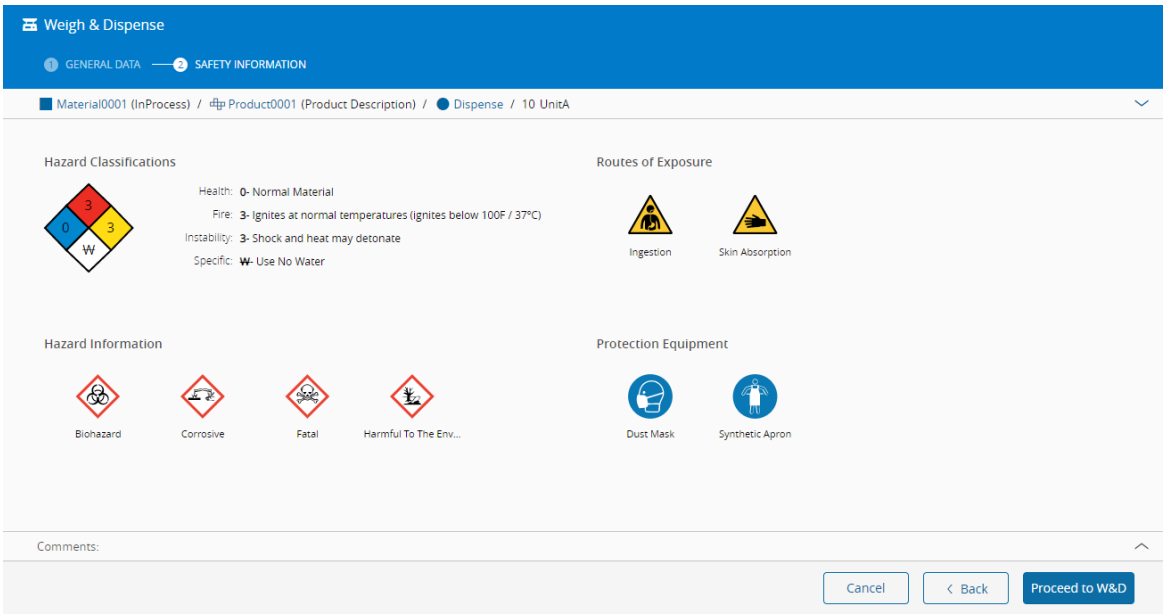
Target Product: CookieAssembled

Performing Weigh and Dispense

Once a Material is tracked-in for the setup described in this document, the user can call the Weigh and Dispense wizard. The Weigh and Dispense itself consists of two wizards as shown below:

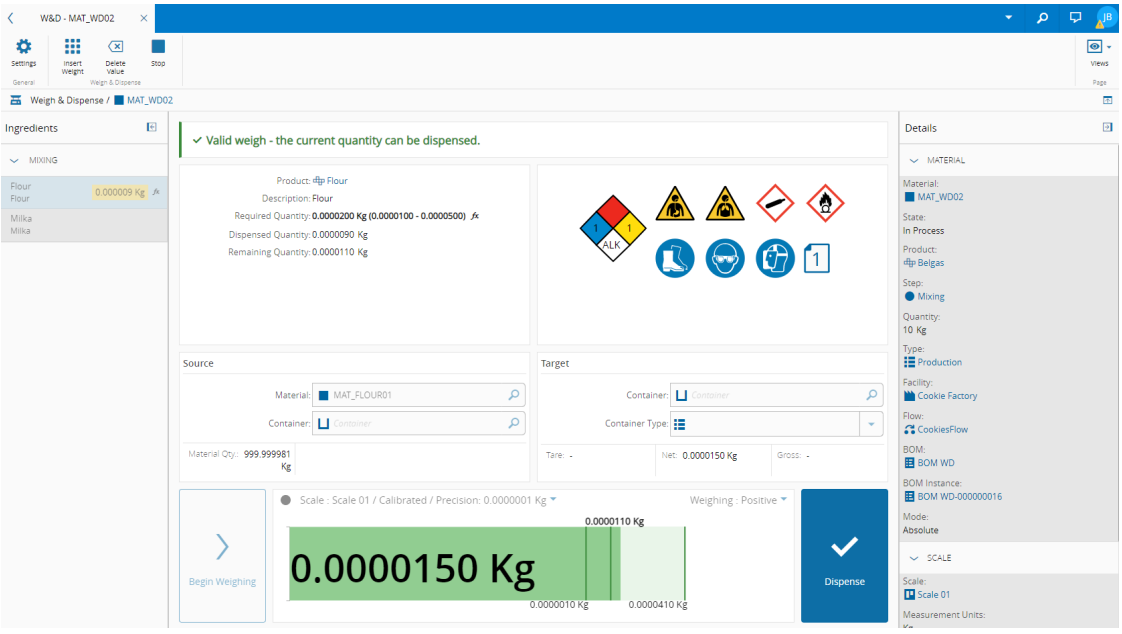
Preparation

1. Collect information about the label associated with the BOM by selecting the printer to be used.
2. Display safety information for the Weigh and Dispense process -- the system will merge all the safety information from all the BOM Products and the target Product.



Execution

1. The execution wizard is used to perform the partial or complete dispenses for the different ingredients.



2. In the execution wizard, the user can:
3. Change the printer by pressing the *Settings* button.
4. Select a different scale by choosing the appropriate value in the weighing panel.
5. Alternate between views (Execution view and Summary view) by pressing the appropriate View button.
6. View *Safety Data Sheet* and *Technical Data Sheets* by clicking on the documents icon that also displays the number of documents available.

7. Dispense material by first selecting the source (either by specifying a Material name or a Container name that contains only one Material) and then:
    - Using the positive weighing method pressing *Set Tare & Begin*
    - Using the negative weighing process pressing *Begin Weighing*
8. Weigh some quantity and then dispense the material partially or completely.
9. Undo a previous dispense by pressing the *Undo* button.
10. Stop the current weighing by pressing the *Stop* button.

Info

In case it's not relevant the usage of containers, the container controls can be hidden by setting the following configuration entry to true: `/Cmf/System/Configuration/WeighAndDispense/HideContainerFields/`

Info

For partial dispenses, it's possible to configure the default button by setting the following configuration entry value: `/Cmf/System/Configuration/WeighAndDispense/DefaultPartialDispenseButton/`.

There are two possible options:

- *DispenseAndReset* -- the default button will reset the dispensed quantity to zero and adjust the target quantity accordingly
- *DispenseAndContinue* -- the default button will not reset the dispensed quantity, and the target quantity will remain the same

Example:

Dispense & Reset

Final Target	200		
			Target
First Weighing		100	200
After Dispense & Reset	0		100
Before Second Weighing	0		100
After Second Weighing		100	

Dispense & Continue

Final Target	200		
			Target
First Weighing		100	200
After Dispense & Continue		100	200
Before Second Weighing		100	200
After Second Weighing		200	

Info

If the user has access to the feature Material.WeighAndDispenseManual, the user can enter the weight manually without using an electronic scale.

Info

To capture an electronic signature at the end of the Weigh and Dispense transaction, set the property *Force signature* in the security feature Material.**CompleteWeighAndDispense**.

Info

If the Material.WeighAndDispense feature has the *Force Signature* setting as `true`, the signatures required for confirmation depend on the `/Cmf/System/Configuration/WeighAndDispense/ForceVerification/` configuration:

- if `false`, the system must ask for the signature of the current user (password or PIN).
- if `true`, the system must ask for two signatures:
  - Performed By - the signature of the Employee who performed the operation.
  - Verified By - the signature of the Employee who verified the operation.

Info

The actual consumption of the raw materials only takes place when the Complete W&D button is pressed -- this means that the whole Weigh and Dispense process must be completed in one shot.

Info

A colored indicator can be seen on the left of the scale, showing the current connection status of the electronic scale. This status will change depending of the state of the **Resource** currently selected:

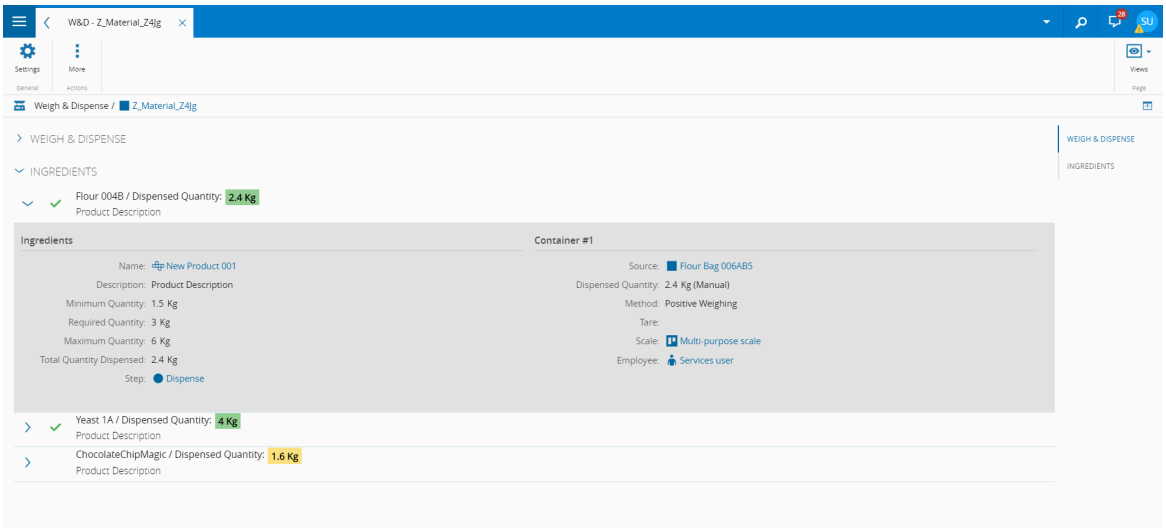
Indicator color	Scale status
Red	Disconnected
Green	Connected
Yellow	Unstable
Grey	Unknown

Table: Electronic scale status indicator

A timeout can be configured by setting the following configuration entry value: `/Cmf/System/Configuration/WeighAndDispense/ScaleTimeOut`. The default value is *30* seconds.

Summary

In any point of the Weigh and Dispense process, the user can have an at-a-glance perspective of the same process by accessing the Summary View in the top left corner.



Weigh and Dispense Quantity Calculations

The calculation for the required quantities and tolerances vary depending on the formula type (Absolute or Relative).

Minimum Tolerance Calculations

Calculating the minimum tolerance takes into account the range of the measurement capabilities of the selected instruments and the BOM Items selected. This multi-step process will produce the result of the high level algorithm below:

```
if (TargetQuantity = Lower Tolerance)
{
    MinimumTolerance = Upper Tolerance - Target Quantity
}
else if (TargetQuantity = UpperTolerance)
{
    MinimumTolerance = Target Quantity - Lower Tolerance
}
else
{
    MinimumTolerance = Minimum (
        Upper Tolerance - Target Quantity,
        Target Quantity - Lower Tolerance
        )
}
```

Afterwards, the value retrieved for Minimum Tolerance will be divided by the value for Precision quantum (configuration entry `/Cmf/System/Configuration/WeighAndDispense/PrecisionQuantum`) and we will obtain a final and adjusted Minimum Tolerance.

> **Note**
>
> The Scale Precision must be **lower** than the Minimum Tolerance.

However, if the test for Precision is not set, the value retrieved for Minimum Tolerance will be:

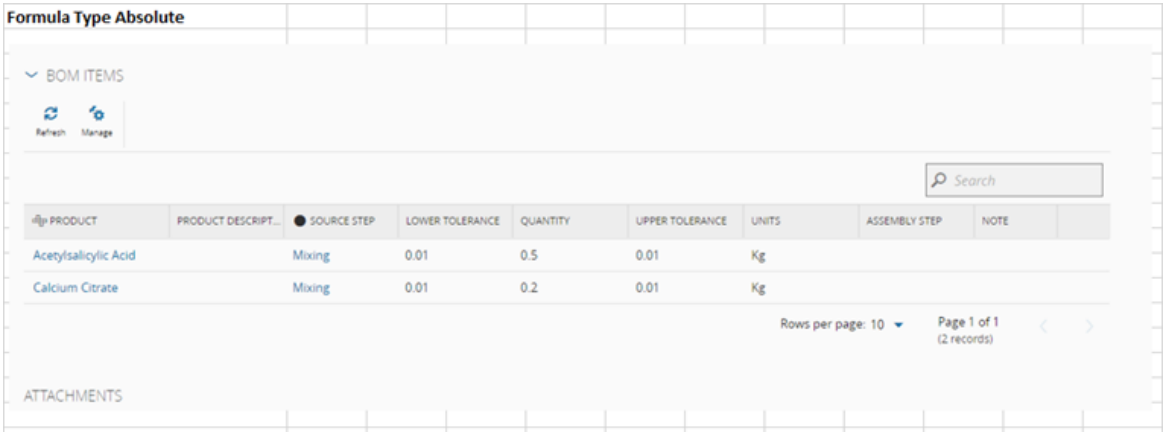
```
Adjusted Minimum Tolerance = Minimum Tolerance / (Target Quantity * Accuracy Quantum)
```

where the value for Accuracy quantum is retrieved from the `/Cmf/System/Configuration/WeighAndDispense/AccuracyQuantum` configuration entry.

> **Note**
>
> The Scale Accuracy must be **lower** than the Adjusted Minimum Tolerance.

Calculation examples

To better illustrate the scenario, let's imagine the case where the target material quantity is 100 Kg, the figures below illustrate the quantity calculations for formulas of type Absolute whereas as well as the quantity calculations for formulas of type Relative.



Formula Type Absolute

Target Material Quantity

Acetylsalicylic Acid	100	Kg								
		For 0,7 Kg					**Adjusted to 100 Kg**			
	Lower T.	Target	Upper T.				Lower T.	Target	Upper T.	
Ammonium Phosphate	0,49	0,5	0,51	Kg			70,000	71,429	72,857	Kg
Calcium Citrate	0,19	0,2	0,21	Kg			27,143	28,571	30,000	Kg
		0,7		Kg				**100**		Kg
Correction Factor (to 100 Kg)		142,8571								

Formula Type Relative

BOM ITEMS

Refresh Manage

Sum (%): 99

Search

PRODUCT	PRODUCT DESCRIPTION	SOURCE STEP	LOWER TOLERANCE (%)	QUANTITY (%)	UPPER TOLERANCE (%)	ASSEMBLY STEP	NOTE
Ammonium Phosphate		Mixing	1	90	1		
Calcium Citrate		Mixing	2	9	2		

Rows per page: 10 Page 1 of 1 (2 records)

Target Material Quantity

Acetylsalicylic Acid 100 Kg

	For 99%				Adjusted to 100%			
	Lower T.	Target	Upper T.		Lower T.	Target	Upper T.	
Ammonium Phosphate	1	90	1	%	90,000	90,909	91,818	Kg
Calcium Citrate	2	9	2	%	8,909	9,091	9,273	Kg
		99		%		**100**		Kg

Correction Factor (to 100 Kg) 1,010101

Automatic tolerance calculations in BOM Products

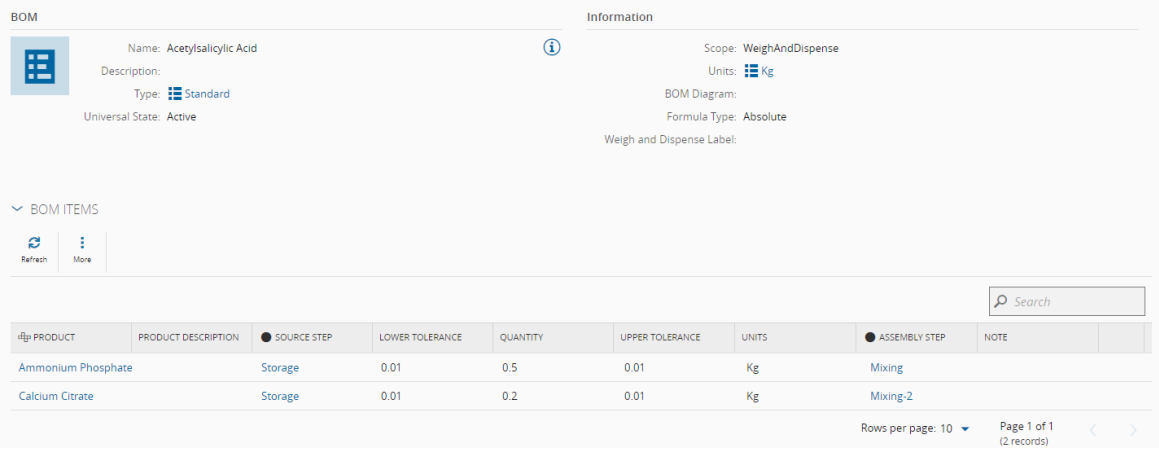
There is a possibility to perform calculations of the values for Lower Tolerance, Required Quantity and Upper Tolerance when defined in the BOM, through the use of a **Rule** and an attached **DEE Action**.

If the current BOM Product has a Quantity Calculation Rule set, after pressing the **Begin Weighing** button the system must call the defined rule, which will return the values for Lower Tolerance, Required Quantity and Upper Tolerance, expressed in the Units defined by the BOM. A visual notation will be displayed next to the BOM Product currently being weighed. If the rule returns an error, this will be presented to the user and the operation cannot begin. If the rule is successful, the values for Lower Tolerance, Required Quantity and Upper Tolerance will be updated on-screen and the user can proceed with the operation.

Using Weigh and Dispense With A Single BOM Across Multiple Steps

In some cases, the dispensing of the different ingredients will take place over multiple steps for the same BOM. This is a supported scenario, but it requires some specific handling as described below:

Create a BOM defining the Assembly Step for every BOM Product



Info

The system only accepts BOMs where either all or none of the BOM Products have the Assembly Steps defined.

Info

It's important to define the BOM products following the dispense sequence so that it's possible to present in the Weigh and Dispense screen the information about previous and upcoming dispenses.

Set the Target Quantity on the Target Material

Because the formula is intended to be applied to a constant target quantity across multiple steps, the reference quantity that must be used for calculating the quantities to be dispensed in this case cannot be the material primary quantity. Therefore, there are two Material properties that must be defined in order for the partial Weight & Dispenses work correctly:

- Target Material Quantity
- Target Material Units

Info

Once these properties are set, the system restricts several Material operations.

Perform the Partial Weigh and Dispenses

Perform the partial Weigh and Dispenses. Note that in each Step, the BOM is filtered by the defined Assembly Step.

Remove the Target Quantity

After all partial Weigh and Dispenses are completed, it's strongly recommended to remove the properties Target Material Quantity and Target Material Units, otherwise there will be several operations restricted for the Material.

Info

When using Weigh and Dispense with a single BOM across multiple Steps, it's important to begin with the Material Primary Quantity set to zero. The reason is that when the *Target Material Quantity* and *Target Material Units* are set, the system will increment the Material Primary Quantity (either directly in the mode *Consume* or indirectly in the mode Attach) with the dispensed quantity of every Weigh and Dispense operation. This contrasts with the case where the Target Material Quantity is not used, where the Weigh and Dispense operation will set the Material Primary Quantity (directly or indirectly) with the dispensed quantity.

Electronic Scale Integration Information

The Weigh and Dispense GUI makes some assumptions about the electronic scale communication via the application message bus. The message structures are described below.

Instrument Configuration

Type	Subject
RequestReply	**Measurement.[ResourceId].Setup**

Table: Instrument Configuration

```
{
    "SendToSubject": "CMF.Resource.[ResourceId].[Guid]",
    "SetTare": true / false
}
```

Begin Weighing

Type	Subject
RequestReply	**Measurement.[ResourceId].Start**

Table: Begin Weighing

```
{
    "SendToSubject": "CMF.Resource.[ResourceId].[Guid]",
    "Timeout": 6000,
    "ResetTare": true/false
}
```

Stop Weighing

Type	Subject
RequestReply	**Measurement.[ResourceId].Stop**

Table: Stop Weighing

```
{
    "SendToSubject": "CMF.Resource.[ResourceId].[Guid]"
```

```
}
```

Notify Weight Value

Type	Subject
RequestReply	The SendToSubject as defined in the Begin Weighing request

Table: Notify Weight Value

```
{
    "Timestamp": "2019-02-05T11:17:51.626Z",
    "Value": 1234.5678,
    "IsStable": false,
    "Extra":
        {
            "TareValue": 0,
            "WeightIncludesTare": false,
            "WeighingUnits": "Kg"
        }
}
```

Interface events

Type	Subject
RequestReply	**Measurement.[ResourceId].Event**

Table: Interface events

Among the possible events to use this message structure are the following:

- Dispense and Continue
- Dispense and Reset
- Dispense
- Begin weighing
- Complete weighing
- Scale change
- Weighting mode change (positive to negative or vice-versa)
- Undo
- Page close (abrupt)
- Ingredient selection (switching ingredients or W&D page open)

Example 1 (Weighting mode change)

```
{
    "OperationType": 10,
    "Data":
    {
        "WeighingMode": "Negative"
    }
}
```

Example 2 (Ingredient selection)

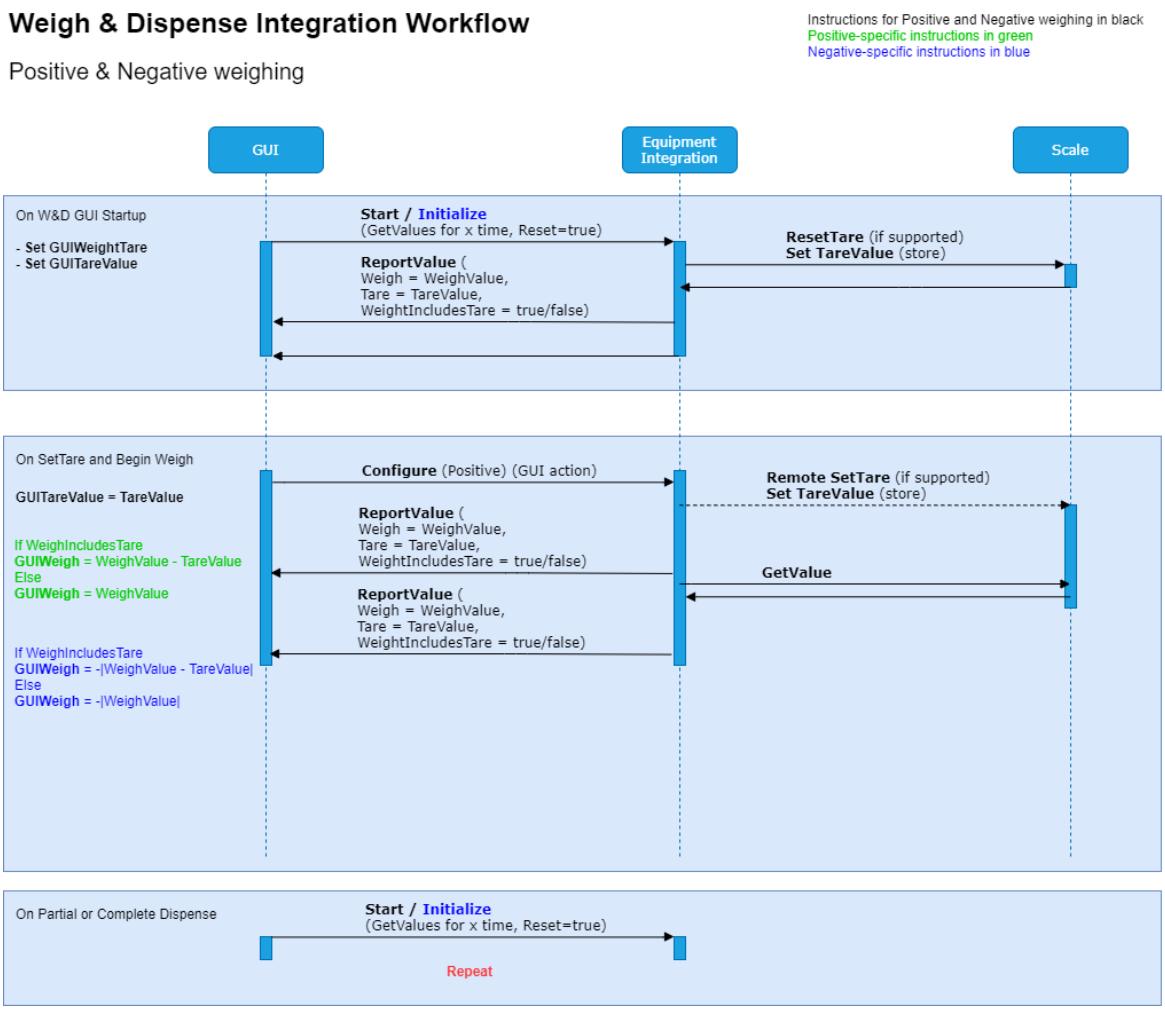
```
{
    "OperationType": 13,
    "Data":
    {
        "tareValue": 0,
        "dispensedQuantity": 0,
        "requiredQuantity": 3,
        "bomProductName": "BomAutomationWD#IG.4ToFlour.6",
        "bomProductId": "2002110227330000006"
    }
}
```

Example 3 (Generic)

```
{
    "OperationType": 6
}
```

Table: Electronic Scale integration messages

IoT and MES integration flows



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