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Line Material Tracking

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unit tracking

Line Material Tracking

Material tracking is at the core of any Manufacturing Execution System (MES). A typical plant will have many different types of materials and a variety of resources that may be linked to form a processing line.

As materials change their characteristics during the course of the manufacturing process, capturing the real-time state of materials, and having a clear understanding of what is happening, and how, to materials as they progress from one resource to the next, is essential for production floor operations.

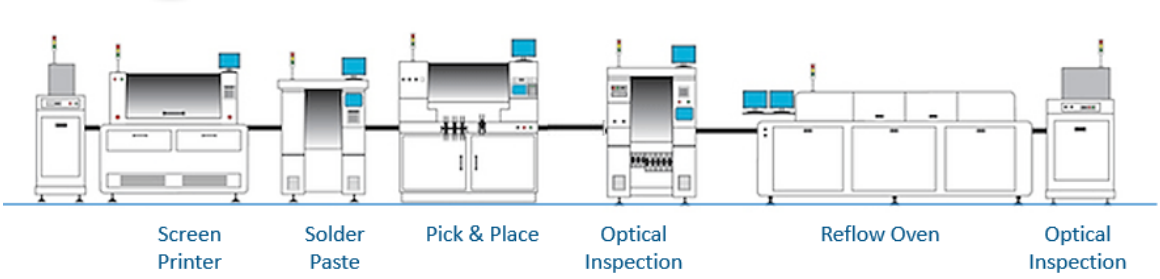
Knowing how to manage and process materials in a Line Resource is at the core of Line Material Tracking and is a critical part of an effective process in the discrete manufacturing sector.

This document will guide you through the setup of a Line and the Material tracking whilst on it.

Overview

In the context of this tutorial, a Line consists of a set of linked resources (e.g. equipment connected through a conveyor belt). Material tracking throughout a Line differs from the regular Material tracking, so over the next sections it is explained how to model a production process with a Line Resource and how to track a Material through it.

The image below shows an SMT Line and its individual resources, a practical example of a Line Resource.



Concepts

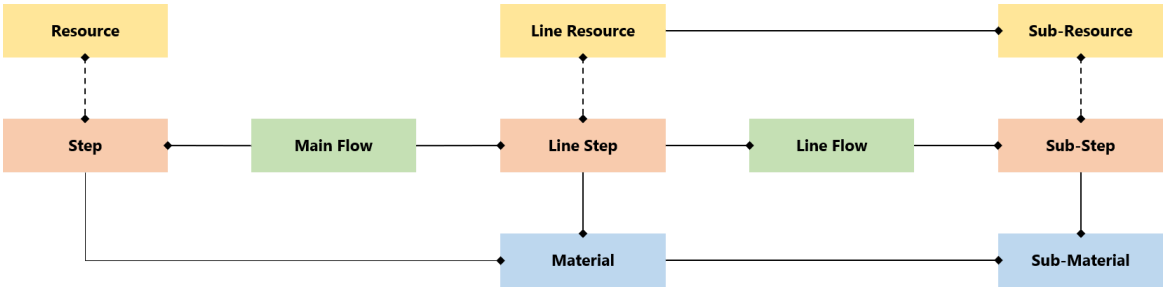
The table below describes the main concepts related to Line Material tracking.

Concept	Description
Main Flow	The Main Flow defines the flow for the Main Material.
Line Step	The Line Step represents the complete Line Resource set of operations. The Main Material is simply tracked in and tracked-out through the Main Step.
Line Flow	A Flow which contains the In Line Steps.
Sub-Step	A Step of the Line Flow. Sub-Materials are tracked through the different Sub-Steps.

Concept	Description
Service	A Service is a certain process capability that is required by a Material for a certain context, and that is provided by Resources. When a Resource provides the Service that is required by the Material, the Material can be dispatched and processed at that Resource.
Sub-Resource	A physical Resource that is used to process Material at a Sub-Step.
Line Resource	A virtual Resource which represents the complete line. This resource must be of processing type *Line*.

Table: Line Material tracking main concepts

To link the concepts presented above, the object model is shown in the figure below.



Setting up a Line

To be able to track a Material through a Line, it is necessary to create not only the Line Resource, but also the Sub-Resources, as well as all the Sub-Steps of the Line Flow. The next sub-sections will cover the Line production process configuration steps in more detail.

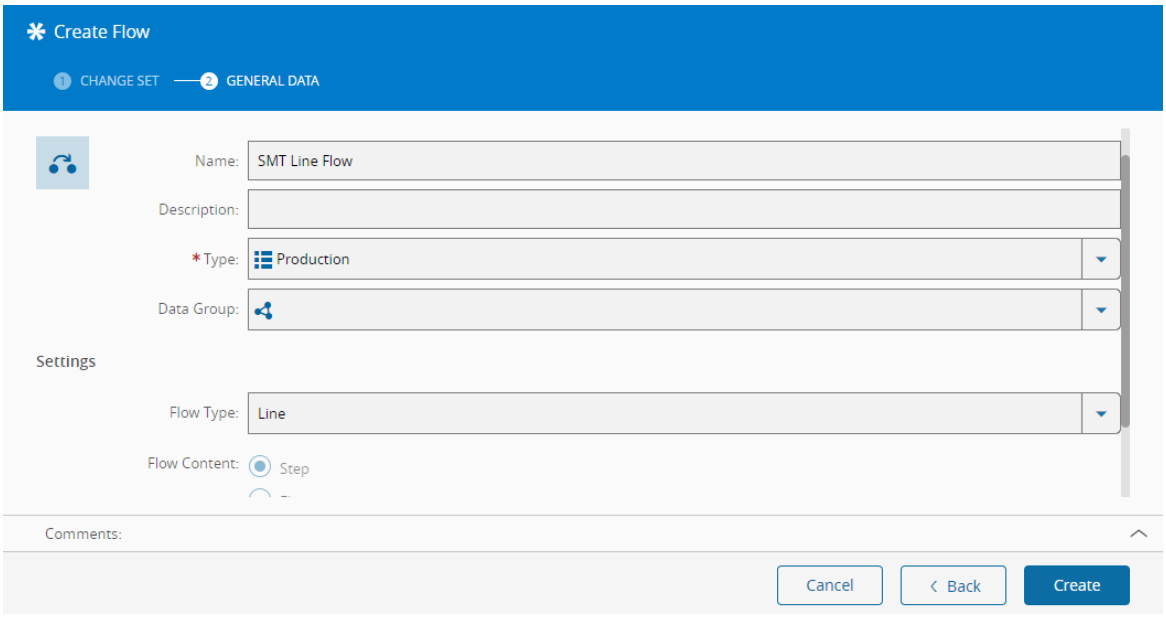
Create a Line Flow

The Line Flow describes the sequence of Sub-Steps matching the individual operations performed throughout the Sub-Resources of the Line Resource. The Line Flow is intended for Sub-Materials. To create a Line Flow, the Steps of Processing Type *Process* (Sub-Steps) must be already created.

The Line Flow must have the Flow Type defined as *Line*, as shown in Figure below.

Info

A Step can only be used once in a Line Flow.



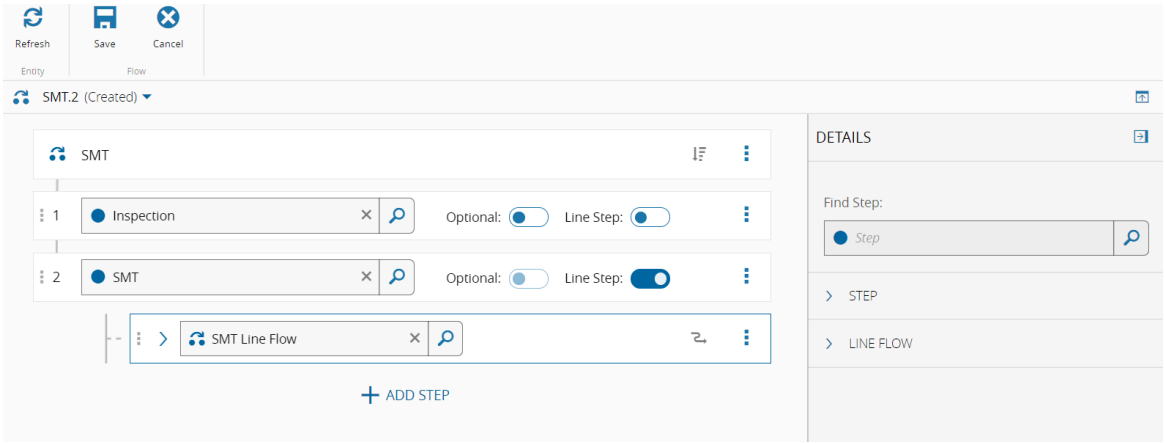
Create a Main Flow

The Main Flow describes the sequence of high-level Steps intended for the Main Material which also includes the Line Step. To create a Main Flow, the Steps of Processing Type *Process* and the Line Flows must be already created.

The Main Flow must have the Flow Type defined as *Sequential*, *Alternate* or *Non-Sequential Block*.

The production Step for the Line Resource must be marked as a Line Step and one or more Line Flows must be added to the Line Step, as shown in Figure below.

> **Info**
>
> To track a Material throughout the Sub-Steps, the Line Step must have the *Sub-Material Track State Depth* set to `one`. If the Material is not to be tracked throughout the Sub-Steps but it is intended to setup and verify the Line configuration, then the *Sub-Material Track State Depth* must be set to `zero`.



In the Line Step, the Line Flow Context must be defined. This context will determine which Line Flow will be used when performing a track-in of a Material in the Line Step, since there may be more than one Line Flow for the same Line Step. The Line Flow Context configuration is shown in the table below.

Property	Description
Line Validation Mode	Defines the point in time when the Line configuration will be validated. The validation is performed for the BOM, Durables and Recipe. The following options are available: - **AtEverySubTrackIn**: each one of the Material Line Flow Resources will be validated at every track-in on a Sub-Resource - **AtFirstSubTrackIn**: each one of the Material Line Flow Resources will be validated at the first track-in on a Sub-Resource - **AtTrackIn**: each one of the Material Line Flow Resources will be validated at the track-in on the Line Resource - **None**: no validation is performed
Line Assembly Mode	The Assembly Mode that will be performed for the Topmost Material in the Line Step. The following options are available: - **AutomaticAtTrackIn**: the assembly will be performed at track-in. For the Topmost Material Primary (or Secondary) Quantity matching the BOM Units, it is automatically consumed for every Step of the Material Line Flow having the BOM Assembly Type defined as AutomaticAtTrackIn, taking the first Resource for every In Line Step - **AutomaticAtTrackOut**: the assembly will be performed at track-out. For the Topmost Material Primary (or Secondary) Quantity matching BOM Units, it is automatically consumed for every Step of the Material Line Flow having BOM Assembly Type defined as AutomaticAtTrackOut, taking the first Resource for every In Line Step - **None**: no assembly is performed

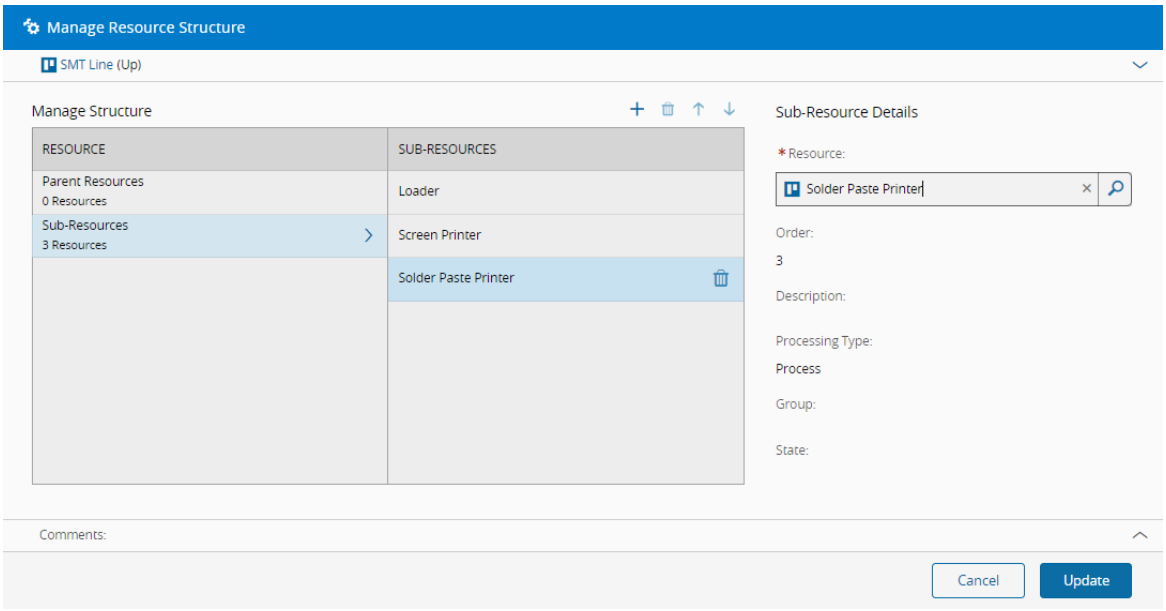
Table: Line Flow Context properties

Create a Line Resource

The Line Resource is a virtual resource that represents all the Sub-Resources that make up the Line. To create a Line Resource, the Line Sub-Resources must be already created having the Processing Type defined as *Process*.

The Line Resource must have the Processing Type defined as *Line* and the option *Enable Sub-Material Tracking* must be set to True.

In the *Manage Resource Structure* wizard, the Line Sub-Resources should be configured, as shown in the figure below.



Configure the Required Services

A Resource provides Services and Materials require Services at a Step, as defined by the Service Context. In order to configure the Services, they must be already created on MES with the Processing Type defined as *Process*.

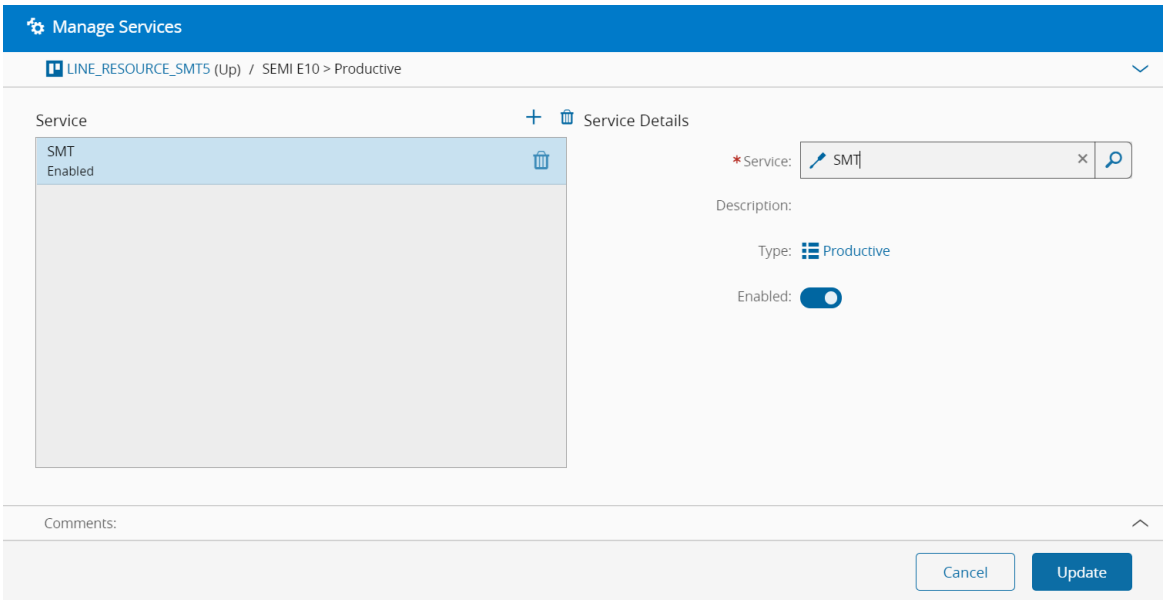
Info

The Sub-Resource must provide the same Service as the one required on the Sub-Step.

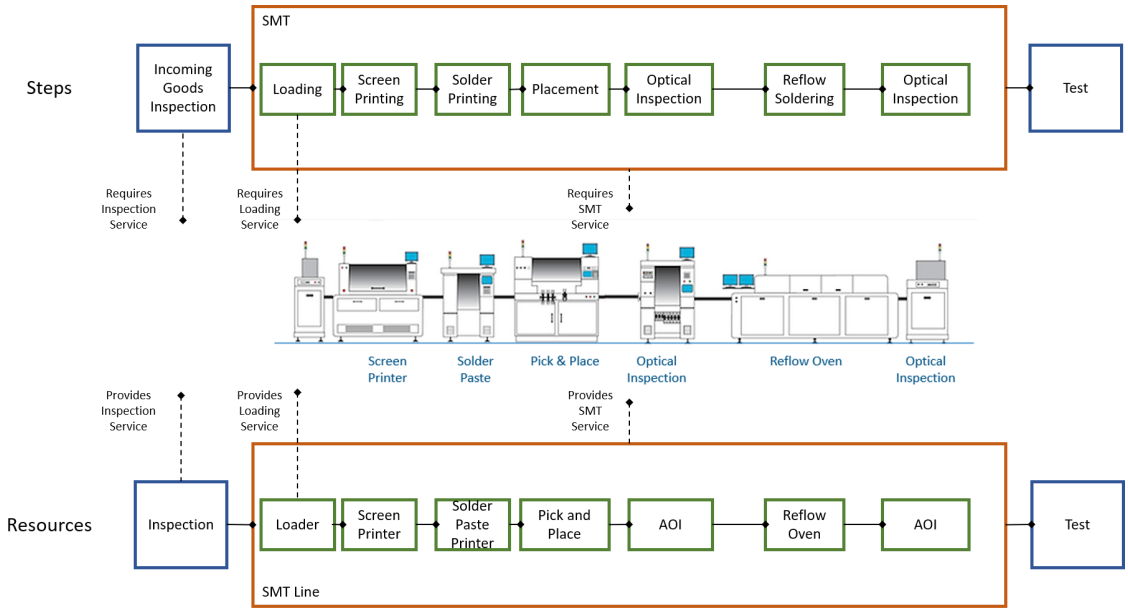
Info

The Line Resource must provide the same Service as the one required on the Line Step.

The Service is configured through the *Manage Services* wizard found either on the Resource or on the Service page, as shown in the figure below.



Considering the given SMT Line example and the concepts described so far, the combination of both schemes is shown in the figure below.



Caption:

Configure the Bill-of-Materials Context

The Material consumption for the production of a Product (Target Product) in a Step is defined through the configured Bill-of-Materials (BOM).

The BOM must have the Scope defined as Materials and the Units must match the Step Units.

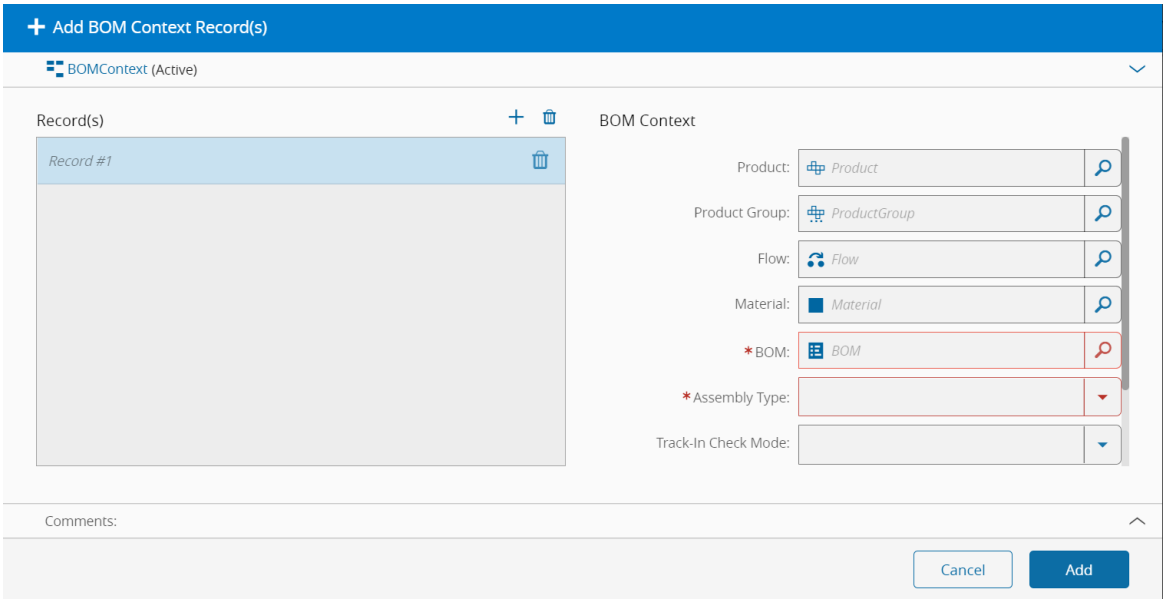
The BOM is configured in a Step through the *Add BOM Context Record* wizard, as detailed in the table and image below.

Info

If the Material consumption tracking occurs at the Sub-Steps level, then the BOM should be configured in the Sub-Steps. If the Material consumption tracking occurs at the Line Step level, then the BOM should be configured in the Line Step.

Property	Description
Assembly Type	How the BOM Materials will be assembled. The following options are available: - **AutomaticAtTrackIn**: The Material will be automatically assembled when a Material is tracked in - **AutomaticAtTrackOut**: The Material will be automatically assembled when a Material is tracked-out - **Explict**: The Material is manually assembled and its quantity is not increased - **ExplictAdd**: The Material is manually assembled and its quantity is increased
Track-In Check Mode	Only used for the AutomaticAtTrackOut mode, to check if the required consumables are attached at the Resource

Table: BOM Context properties

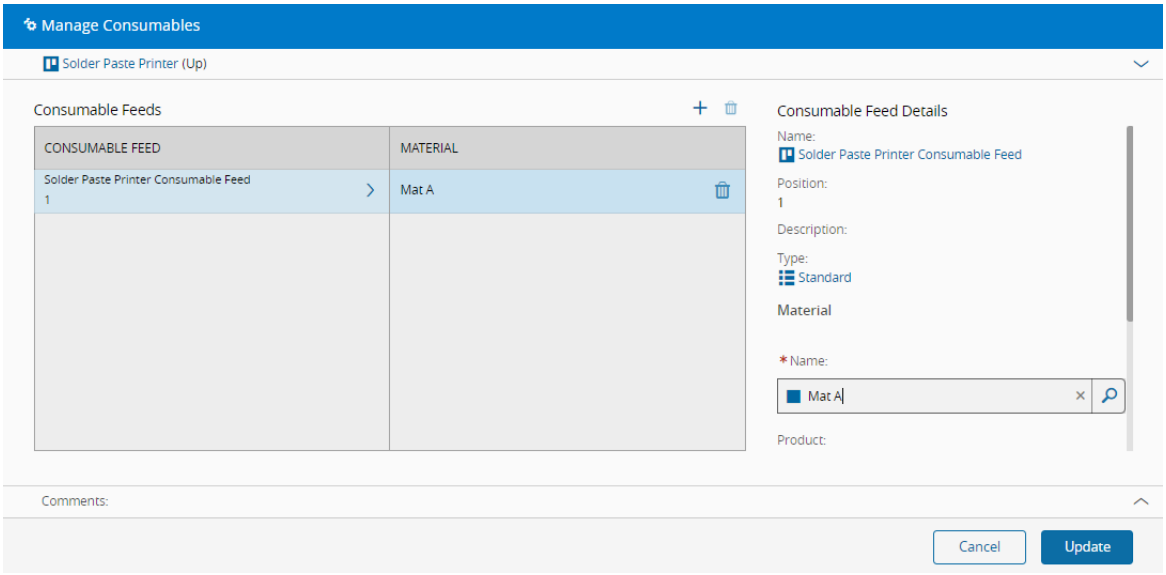


The table below describes how the Line Assembly Mode, as defined in the Line Flow Context, works together with the Assembly type, as defined in the BOM Context.

Line Assembly Mode	Assembly Type	Description
AutomaticAtTrackIn	**AutomaticAtTrackIn**	Assembly will be automatically performed at the topmost Material track-in, for all the In Line Steps having AutomaticAtTrackIn Assembly Type configured at the BOM Context.

Line Assembly Mode	Assembly Type	Description
AutomaticAtTrackIn	**AutomaticAtTrackOut, Explict or ExplicitAdd**	No automatic assembly is performed at the topmost Material track-in.
AutomaticAtTrackOut	**AutomaticAtTrackOut**	Assembly will be automatically performed at the topmost Material track-out, for all the In Line Steps having AutomaticAtTrackOut Assembly Type configured at the BOM Context.
AutomaticAtTrackOut	**AutomaticAtTrackOut, Explict or ExplicitAdd**	No automatic assembly is performed at the topmost Material track-out.
Explict or ExplicitAdd	**AutomaticAtTrackIn, AutomaticAtTrackOut, Explict or ExplicitAdd**	No automatic assembly is performed.

Table: Line Resource Material consumption



Configure the Durables Context

The Durables required in a Step are defined through the configured Bill-of-Durables.

The BOM must have the Scope defined as *Durables*.

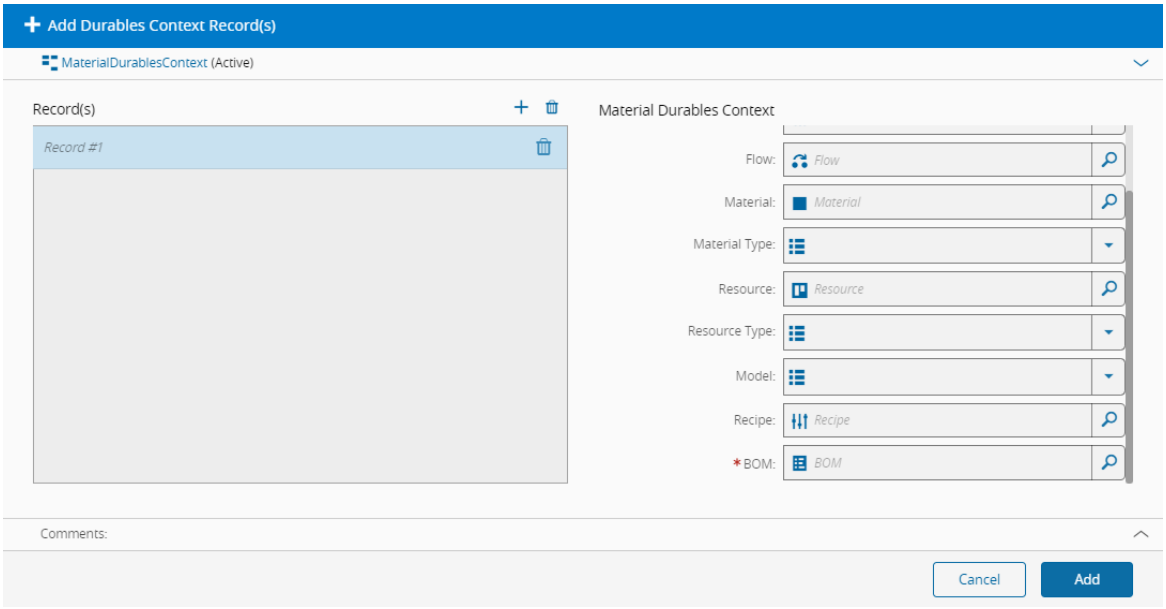
The BOM Items are configured through the *Manage BOM Items* wizard on the BOM, as described in the table below.

Property	Description
Product	Durable Product.
Step	Step in which the Material of the Durable Product is found, if filled.

Property	Description
Position	Position where the Durable must be found in the Resource.
Optional	If set to True, the Durable must be present in the Resource when tracking-in the Material.
Usage Step	Step in which the Durable is required.

Table: Manage BOM Items properties

The BOM is configured in a Step through the *Add Durables Context Record* wizard, as shown in the figure below.



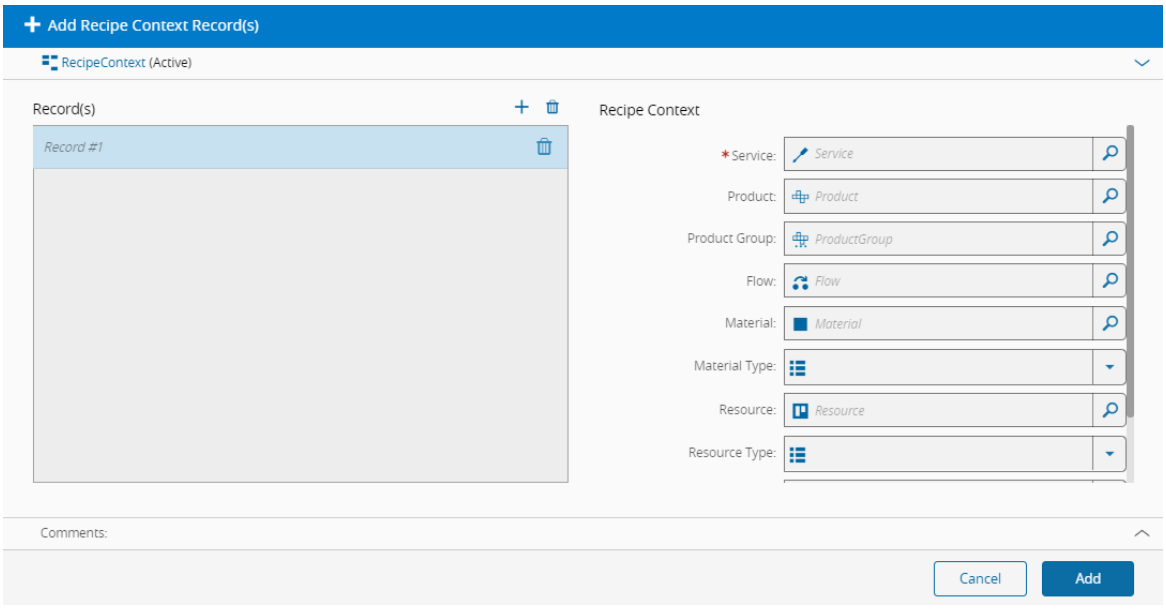
Configure the Recipe Context

To process a Material in a Step, the required Resource information must be defined on a Recipe.

The Recipe is defined through the *Add Recipe Context Record* wizard, as shown in the figure below.

Info

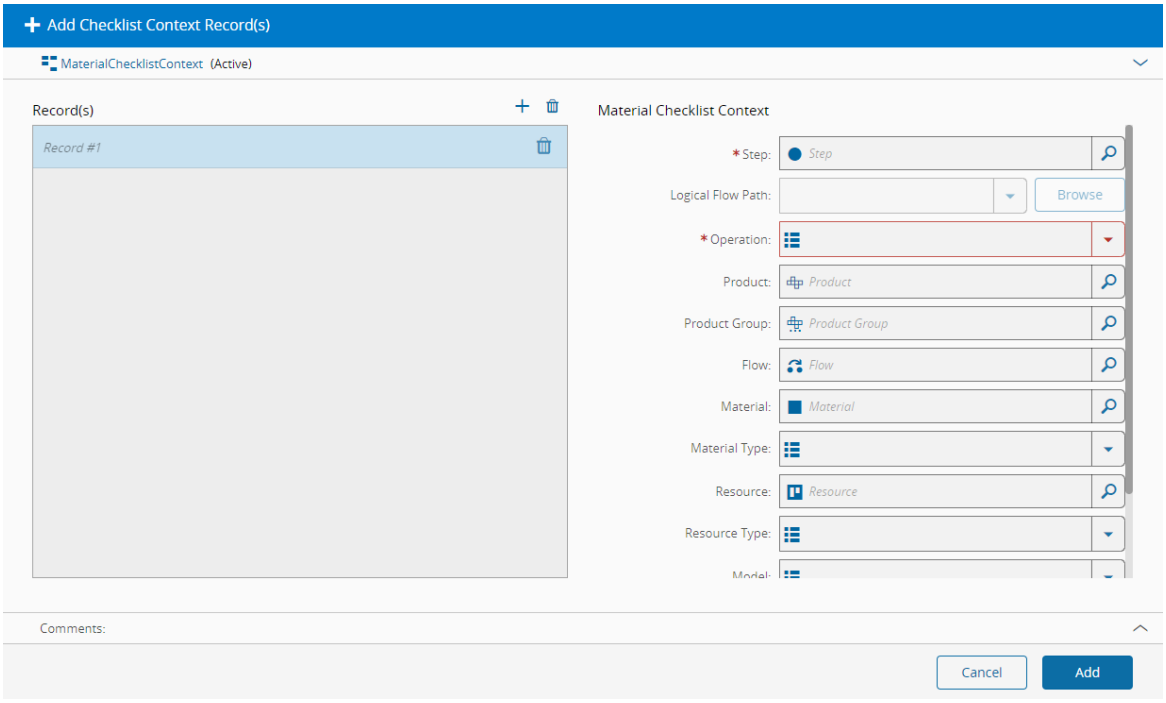
The Resource must have the property Recipe Management Enabled set to True.



Configure the Checklist Context

If a Checklist is required the necessary context information must be defined.

The Checklist is defined through the *Add Checklist Context Record* wizard, as shown in the figure below.



Line Context Resolution and Validation

The Line Flow Context resolution is performed when tracking-in the Main Material in the Line Step. In this moment, the Line Flow for the Sub-Materials is selected.

For the Line Step, the Recipe, Durables, BOM, Data Collections, Documents and Checklists are resolved normally for the Main Material and the Recipe and BOM of Durables Instances are created for the Main Material. At the same time, for the Sub-Steps, the Recipe, Durables, BOM and Data Collections are resolved

using always the Main Material in the Context resolution. Any Recipe and BOM of Durables Instances are created at this time and will be applied for all the Sub-Materials when tracking through the Sub-Steps.

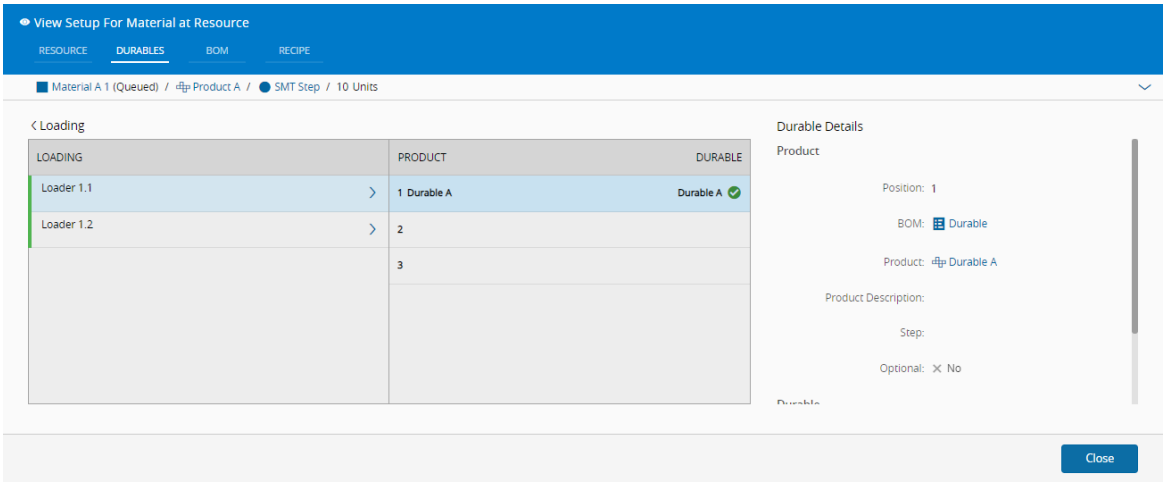
The validation of Durables and Consumable Feeds required throughout the Line Flow is performed depending on the defined *Line Validation Mode*.

Using a Line

Before tracking in a Material in a Line Resource, it is necessary to setup the Line. Depending on the Line configuration, there are validations regarding the Line Durables, Consumables and Recipe Parameters definition.

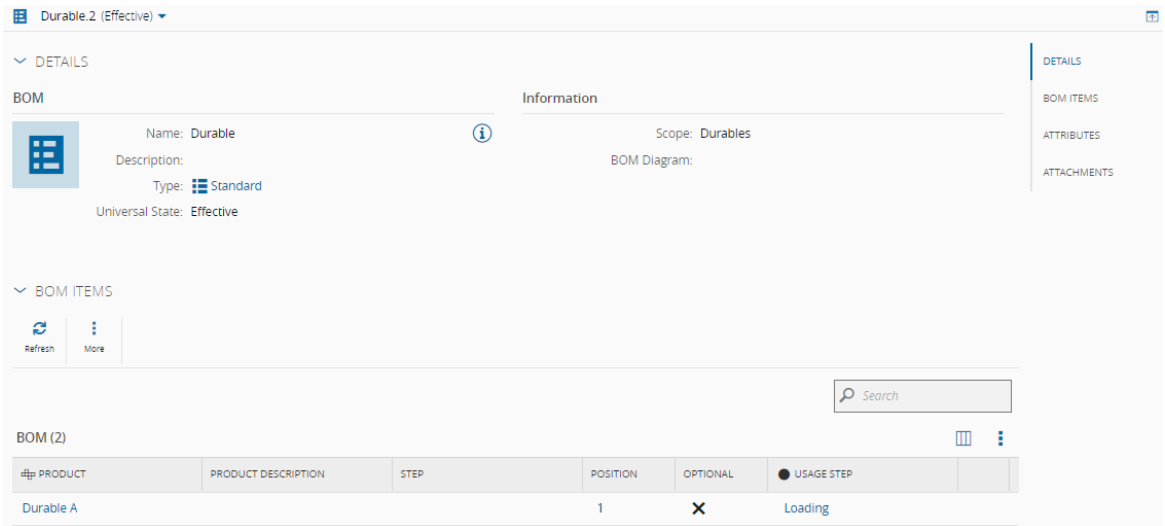
Perform Setup

The Line setup information can be accessed on the *View Setup* wizard, available on the Line Resource view, by selecting the Material to be tracked in, as shown in the figure below.



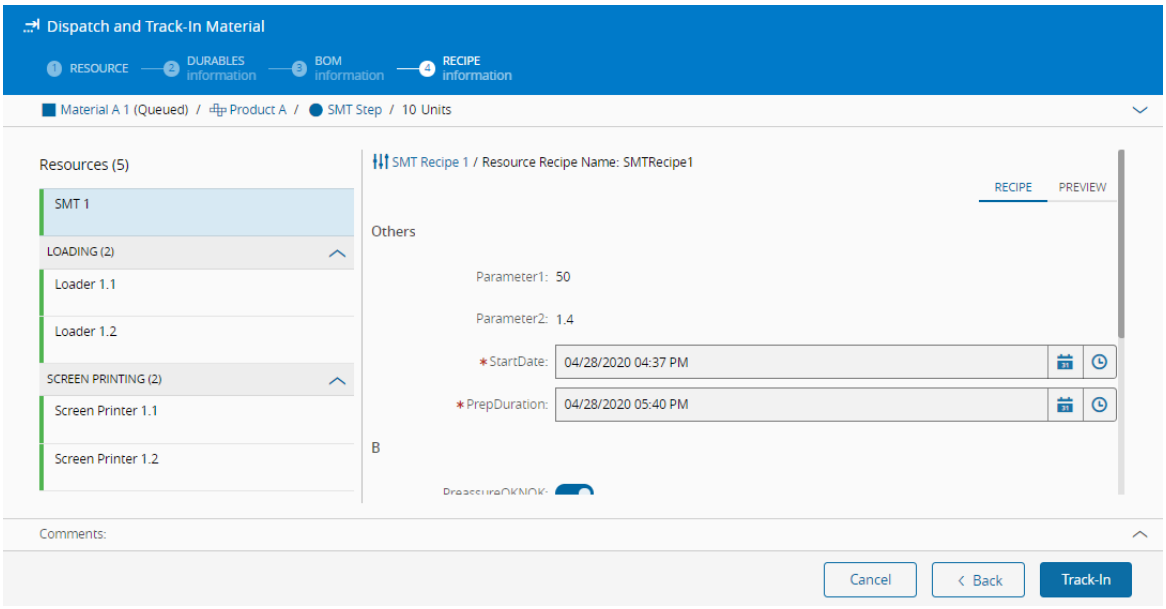
Taking the example of a Line Resource with the Line Validation Mode defined as *AtTrackIn*, all the Line Sub-Resources will be validated, at track-in, regarding:

- Durables required through the different Line Sub-Steps must be attached to the Sub-Resources Position as defined in the BOM of Durables, as shown in the figure below;
- Consumables required throughout the Line Sub-Steps must be attached to the Sub-Resources Consumable Feeds Position as defined in the BOM.



Track-In a Material

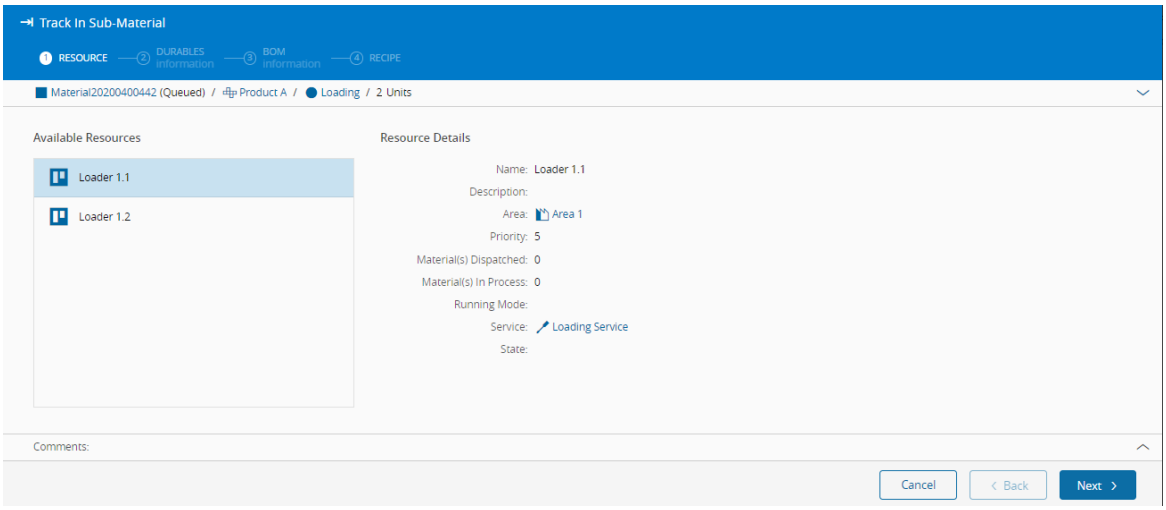
At track-in, information on Durables, BOM and Recipe is displayed for the entire Line and Line Sub-Resources. For the Line Resource Recipe, the Recipe Parameters can be filled and edited, as shown in the figure below.



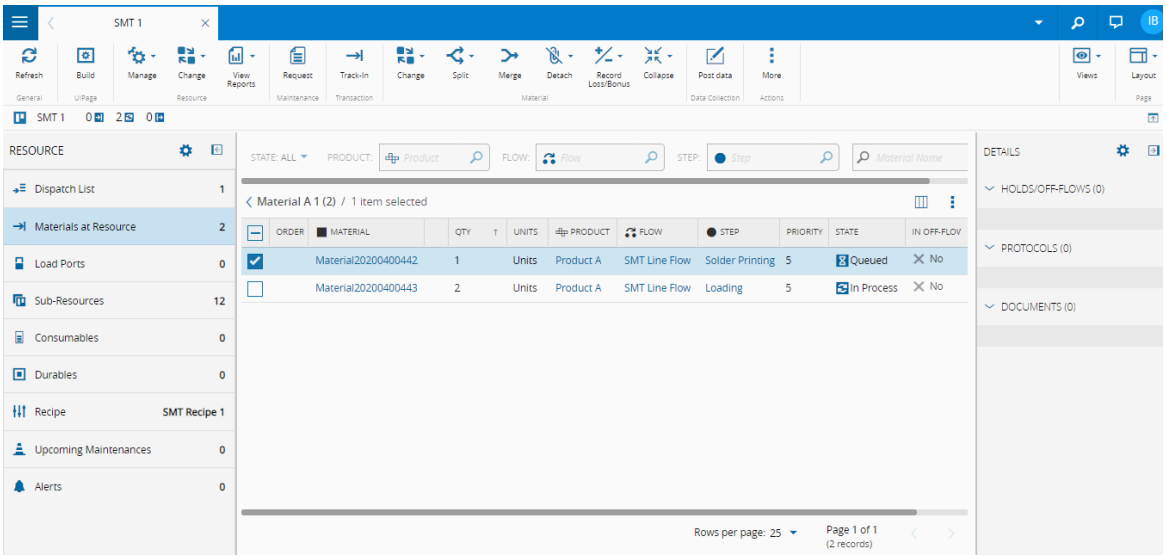
When tracking-in the Main Material in the Line Step, the Flow Path of the Sub-Materials is defined and the Sub-Materials are moved to the first Sub-Step of the resolved Line Flow.

If the Line Step has the *Sub-Material Track State Depth* set to one, then the Sub-Materials can be tracked in, as shown in the figure below.

The Assembly in the Sub-Steps may be performed when tracking-in the Main Material, depending on the defined *Line Assembly Mode*.



The Sub-Materials can be tracked in and tracked-out in the Sub-Resources through the Line Resource or Line Step Views, as shown in the figure below.



Info

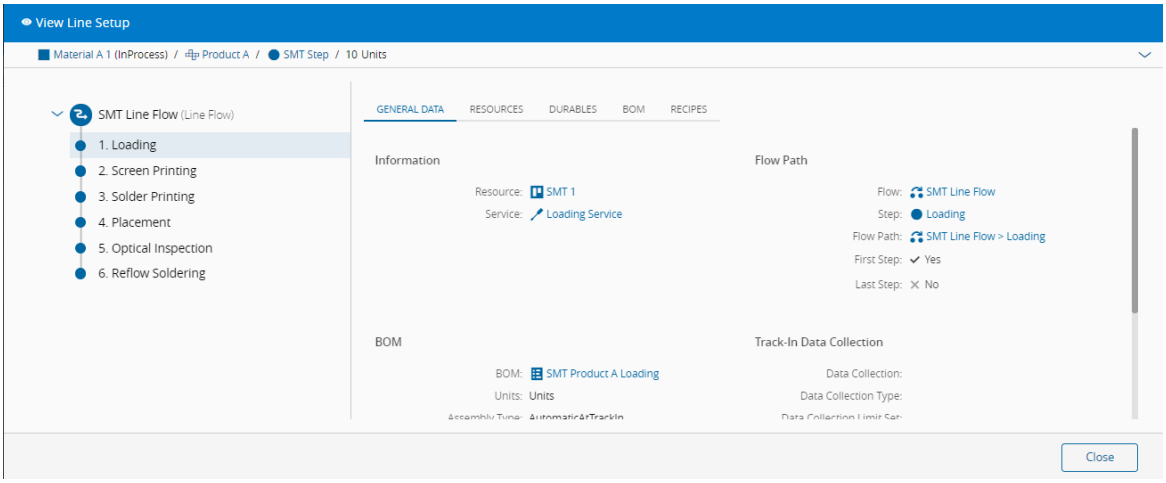
When configured, a Checklist will be resolved and displayed considering the Material Line Step Resource and Material Line Step Recipe contexts for Track-In.

Material Information

After tracking-in a Material in a Line Resource, the processing information regarding the Sub-Steps, Sub-Resources, Durables, BOMs and Recipes of the Sub-Material throughout the Line Flow can be viewed in the Line Flow view, as shown in the figure below.

Info

This view can be accessed through the Material and Resource View page (*Line Flow View*).

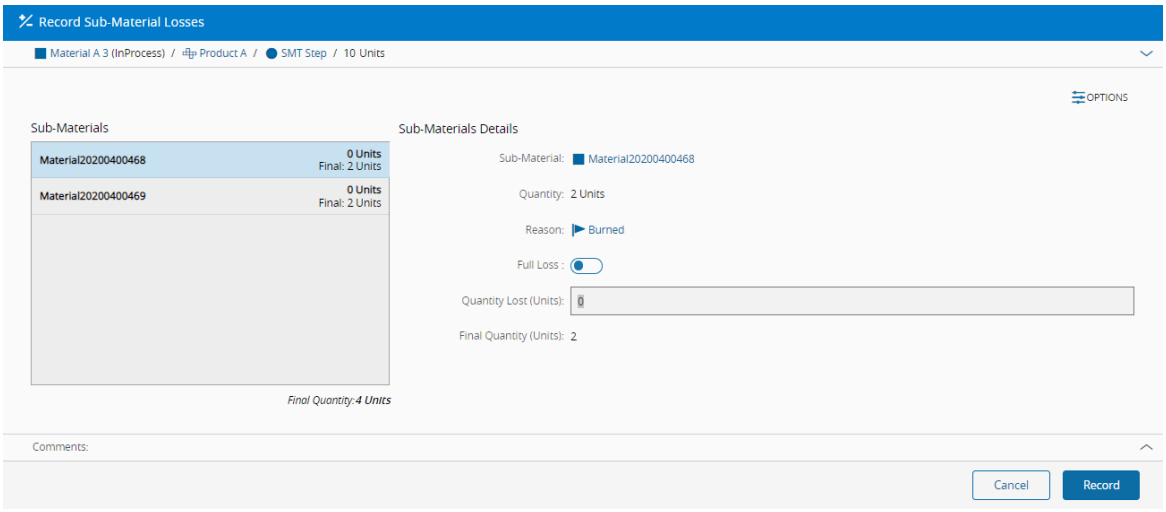


Record Material Losses

To record losses on Sub-Materials, it can be performed not only by selecting the Sub-Material and opening the *Record Material Losses* wizard, but also by selecting the topmost Material and opening the *Record Sub-Material Losses* wizard, as shown in the figure below.

Info

On both wizards, the Loss Reasons available for selection are the ones defined in the current Sub-Material Step.



Losses with Loss Step Considerations

When trying to record losses with a Loss Step, it is necessary to consider that for the loss to be considered for analytical purposes (such as the Resource and Material Cubes, the Yield, Rate of Quality and OEE KPIs), then the Material where the losses are being recorded must have been processed at the Loss Step.

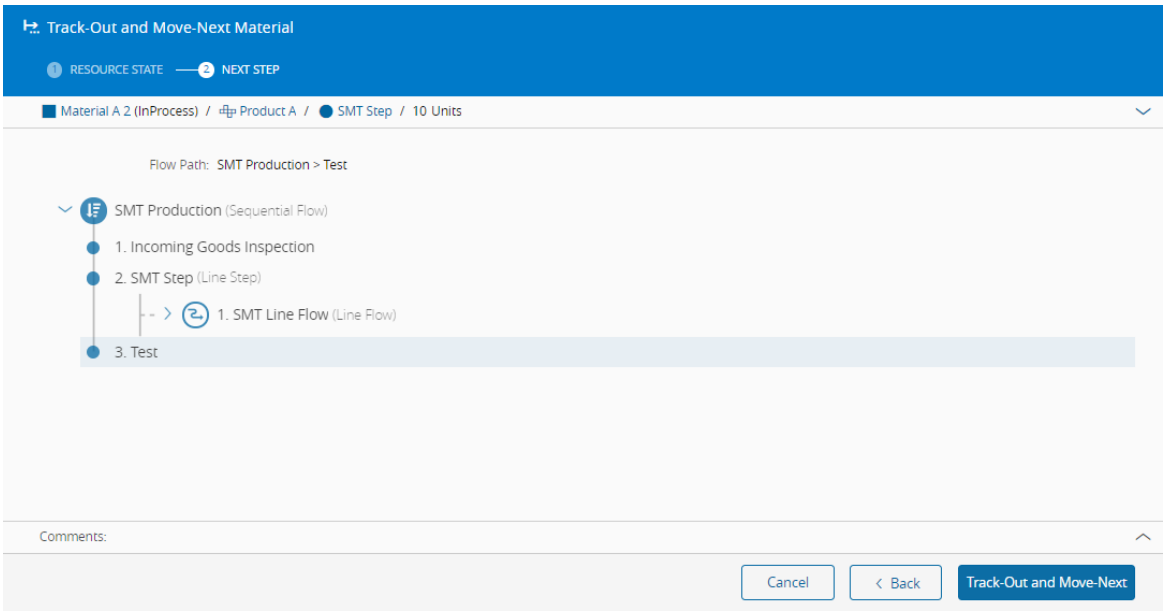
When attempting to set up this scenario for a Line Step, containing a Line Flow, some additional practical considerations are needed:

- The Loss Step must be set according to the hierarchy of the Material where the Loss is being recorded:
- If the Material is the Topmost Material, which was processed in the Line Step itself, then the Loss Step should the Line Step.
- If the Material is a Sub-Material, which was processed in the Steps of the Line Flow, then the Loss Step should be one of the Steps of the Line Flow. Alternatively, it can also be collapsed into the Topmost Material, and then the loss can be recorded with the Loss Step being the Line Step - consider that, in this last case, the loss will not be traceable to the sub-material.
- If a Split is required between the Line Step and the Step where the Loss is recorded, then the quantity where the Loss will be recorded must be kept in a Material which has been processed in the Loss Step. This means that:
- If the Loss is in the Topmost Material, there are two options:
  - The Split occurs when the "Original" Material (the Material being split) is in the Line Step, in state *In Process* or *Processed*, and the Loss is given in the New Material, that is, the Material created during the split;
  - The Loss is given in the "Original" Material directly.
- If the Loss is in the Sub-Material , there are two options:
  - The Split occurs while the Sub-Material hasn't yet reached the Loss Step in the Line Flow - in this case, the Topmost Material may be split, with the Sub-Material being transferred to the new Topmost Material.
  - The Loss is given in the Sub-Material while its Topmost Material is the "Original" Material, that is, the Material which has processed in the Line Step.

Track-Out Material

The Main Material can be tracked-out, as shown in the figure below, if the Step has the Sub-Material Track State Depth set to one, after all the Sub-Materials are Processed in the last Sub-Step. In the case that the Step has the Sub-Material Track State Depth set to zero, it's possible to track-out the Main Material immediately after the Track-In.

The Assembly in the Sub-Steps may be performed when tracking-out the Main Material, depending on the defined Line Assembly Mode.



Info

When configured, a Checklist will be resolved and displayed considering the Material Line Step Resource and Material Line Step Recipe contexts for Track-Out.

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