Makeup Unit Operation Functionality in the Symmetry* Process Software Platform

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Many processes have streams that need to maintain a composition for certain key components. In certain situations, these processes may need to introduce a special feed to compensate for losses of these key components. For example, the circulating rich amine in a gas sweetening plant is often maintained at a specific composition and water and/or amine need to be introduced to the recycle stream to compensate for losses. The makeup unit operation in Symmetry was created to facilitate the creation of these types of simulation models. This article describes the rich functionality and applications of the makeup unit operation (based on Symmetry 2020).

Amine Applications

Gas sweetening is commonly done with amine solutions that are put in contact with the sour stream to capture the acid gas components. This amine solution is then regenerated and recirculated for a continuous operation. The recirculated amine solution is expected to lose water during normal operation and there also may be some minor amine losses. These losses are addressed by adding enough solution to keep the recirculated amine composition as constant as possible. A typical amine plant flowsheet is shown in Figure 1.

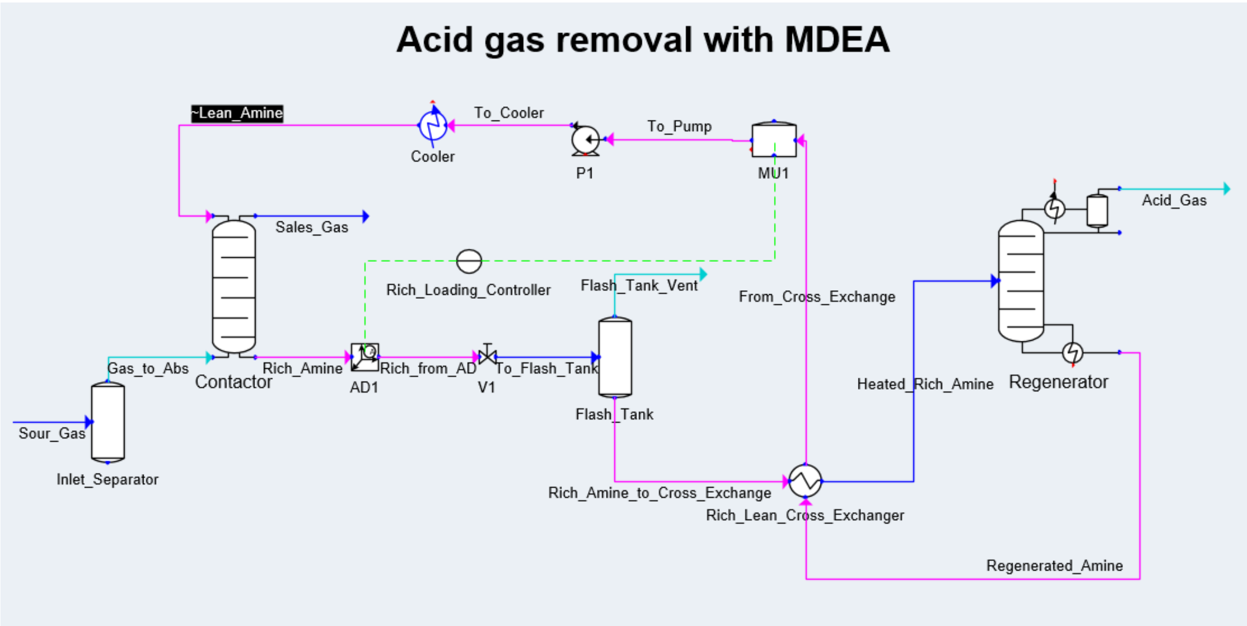


Figure 1. Acid gas removal using makeup unit operation

The makeup unit operation MU1 is used in this simulation to calculate the necessary make up stream to maintain a circulation rate composition. Figure 2 contains a typical specification for an amine plant. The key variables are highlighted in red squares and are set by default when the property package is set to Amines.

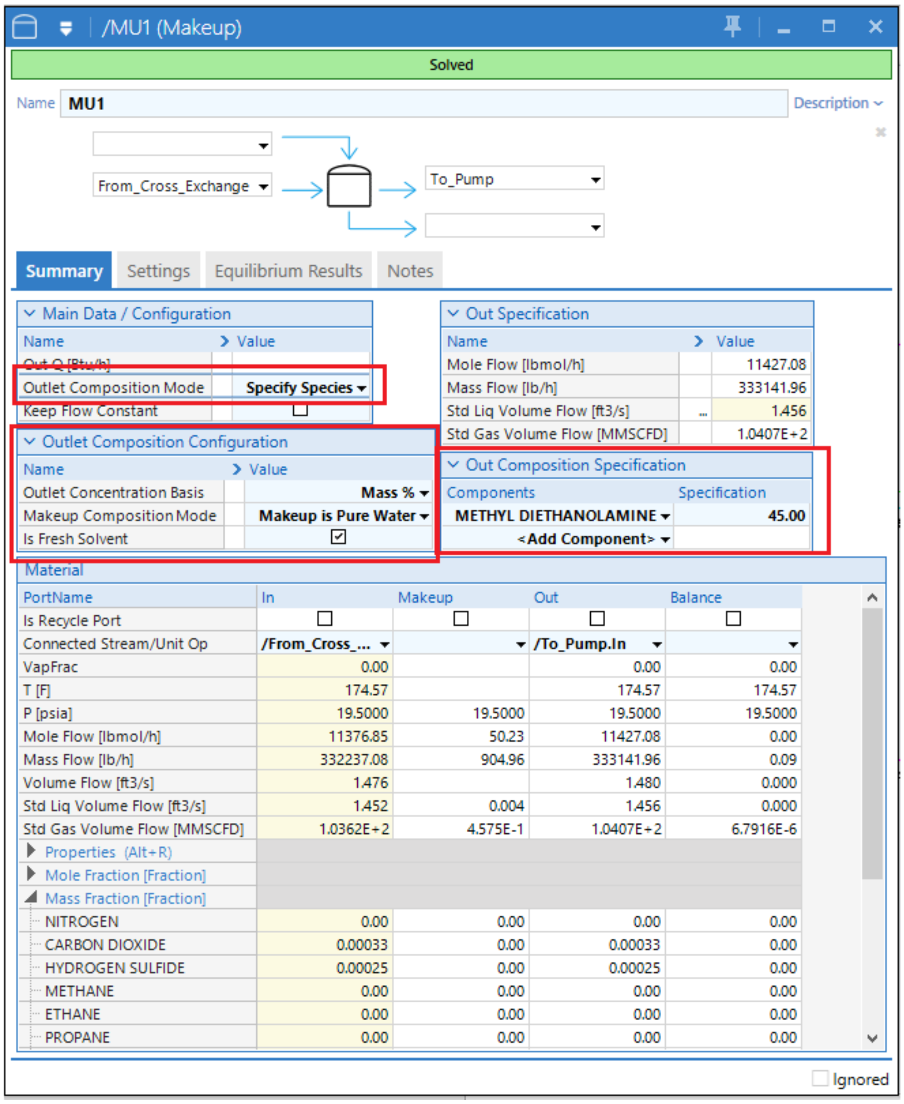


Figure 2. Makeup unit operation to maintain a 45% MDEA mass composition

The main variables are described below:

Outlet Composition Mode: This variable when set to *Specify Species* allows the user to define the composition of the outlet port from the make up unit operation. This mode exposes the frames called *Outlet Composition Configuration* and *Out Composition Specification*.

Outlet Composition Basis: This variable defines the basis of the specifications used in the *Out Composition Specification* frame. Mass % is the most common basis for amine systems.

Makeup Composition Mode: When this variable is set to *Makeup is Pure Water* the composition of the Makeup port is automatically set to only include water and any trace of amine necessary to close the mole balance.

Is Fresh Solvent: The context of this variable is that amine applications usually have a target mass % of amine in the circulated amine. This mass % is defined only including amine and water ignoring the minor amount of acid gas that may be contained in the stream. When this variable is checked, the target makeup composition only is calculated with respect to water.

Out Composition Specification: This frame is used to the select the key components that we want to specify in the outlet stream. Any number of components can be specified in these fields.

The outlet flow is typically specified in the *Out Specification* frame but it could also be set in the outlet port or material stream. The Balance material port is used in case the Makeup port would end up with a negative value. Instead of calculating a negative value, the flow is assigned as a positive number on the Balance port.

Makeup on Bulk Flow

The makeup unit operation can also be used as a flexible mass balance to ensure an outlet flow that is met by adding a makeup stream with a pre-defined composition. Figure 3 shows a gas dehydration simulation with a makeup unit operation to maintain a constant circulation rate.

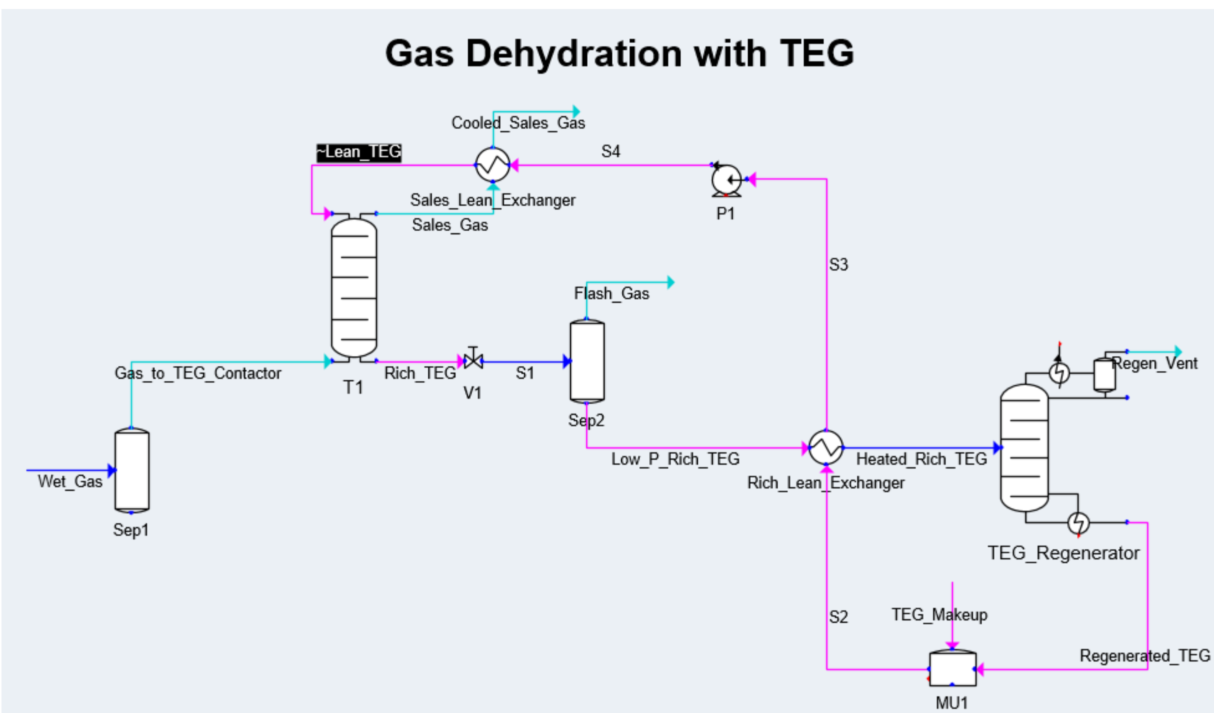


Figure 3. Gas dehydration using a TEG makeup stream

In this example, the makeup composition is specified directly, and the unit operation solves the mass balance. Figure 4 shows the Outlet Composition Mode variable set to *Calculate From Balance*. This option configures the unit operation to monitor the degrees of freedom of the unit operation to solve.

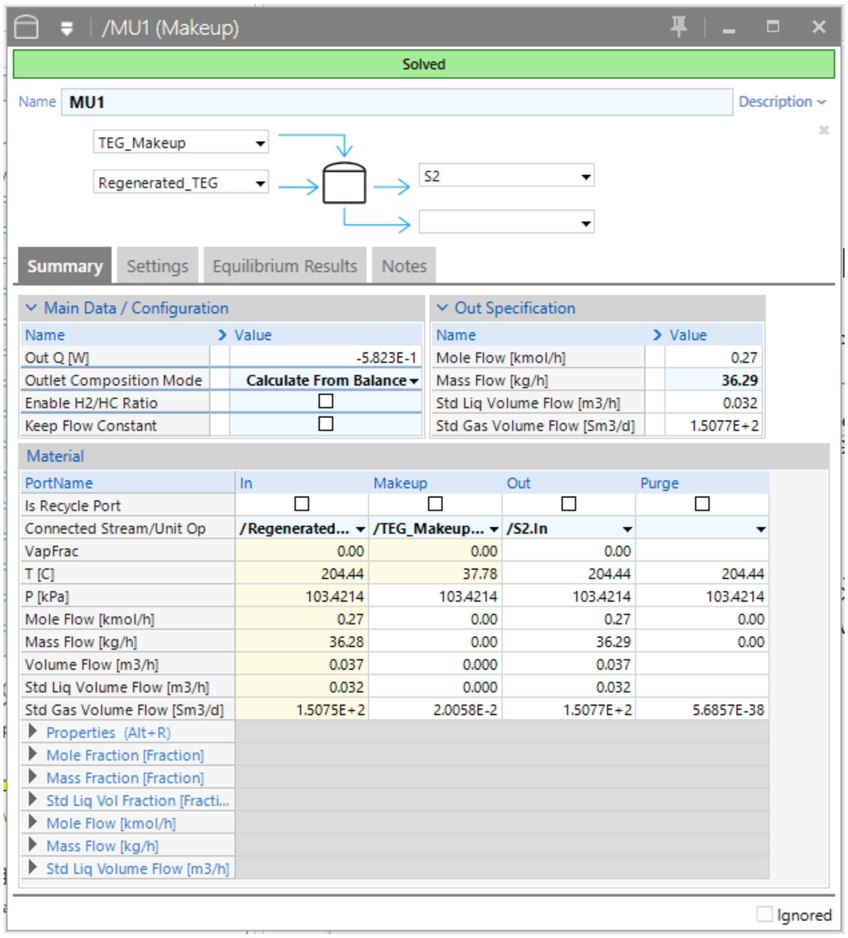


Figure 4. Makeup specification for TEG process

One extra variable for this mode includes:

Enable H2/HC Ratio: This setting will enable a variable to specify or calculate the hydrogen to hydrocarbon ratio in the outlet port. The flow in the Makeup is calculated but the composition of the Makeup port must be specified.

Composition Specification

The makeup unit operation can also be used as a flexible calculator to specify composition of some components while normalizing the other components. This avoids the need to modify the flowsheet with streams and mixers to adjust the composition of one component.

The example shown in Figure 5 is a detailed rating example of a multi stream exchanger to liquify natural gas using a freon stream and a mixed refrigerant. In these systems it is often desired to adjust the composition of the mixed refrigerant in order to follow the heating curve of the natural gas in such a way that is a close as possible to a pinch target throughout the whole heat exchange.

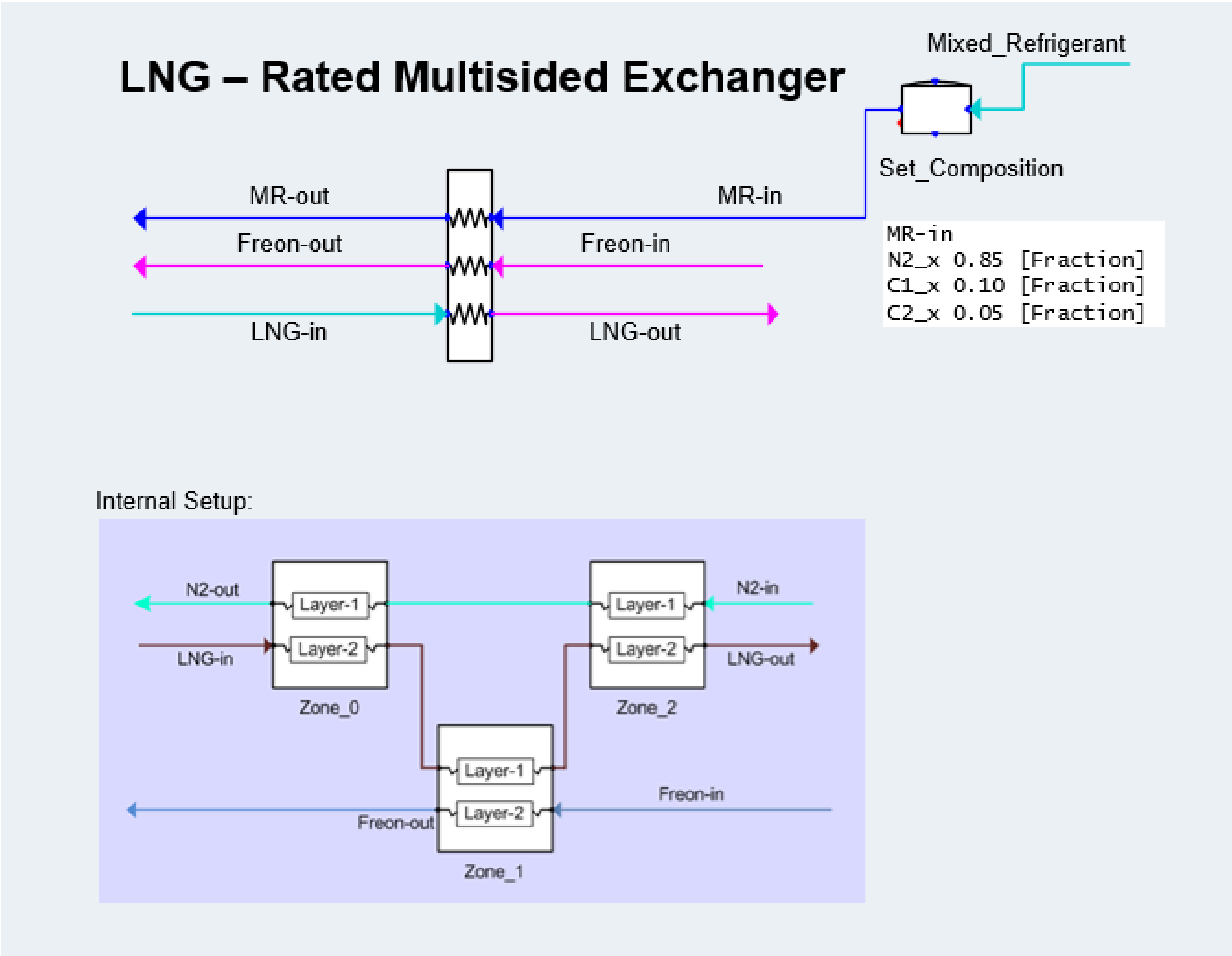


Figure 5. Mixed refrigerant composition specification with makeup operation

For this application the refrigerant feed is made of Nitrogen and the makeup unit operation is used to specify directly the composition of METHANE and ETHANE. See Figure 6.

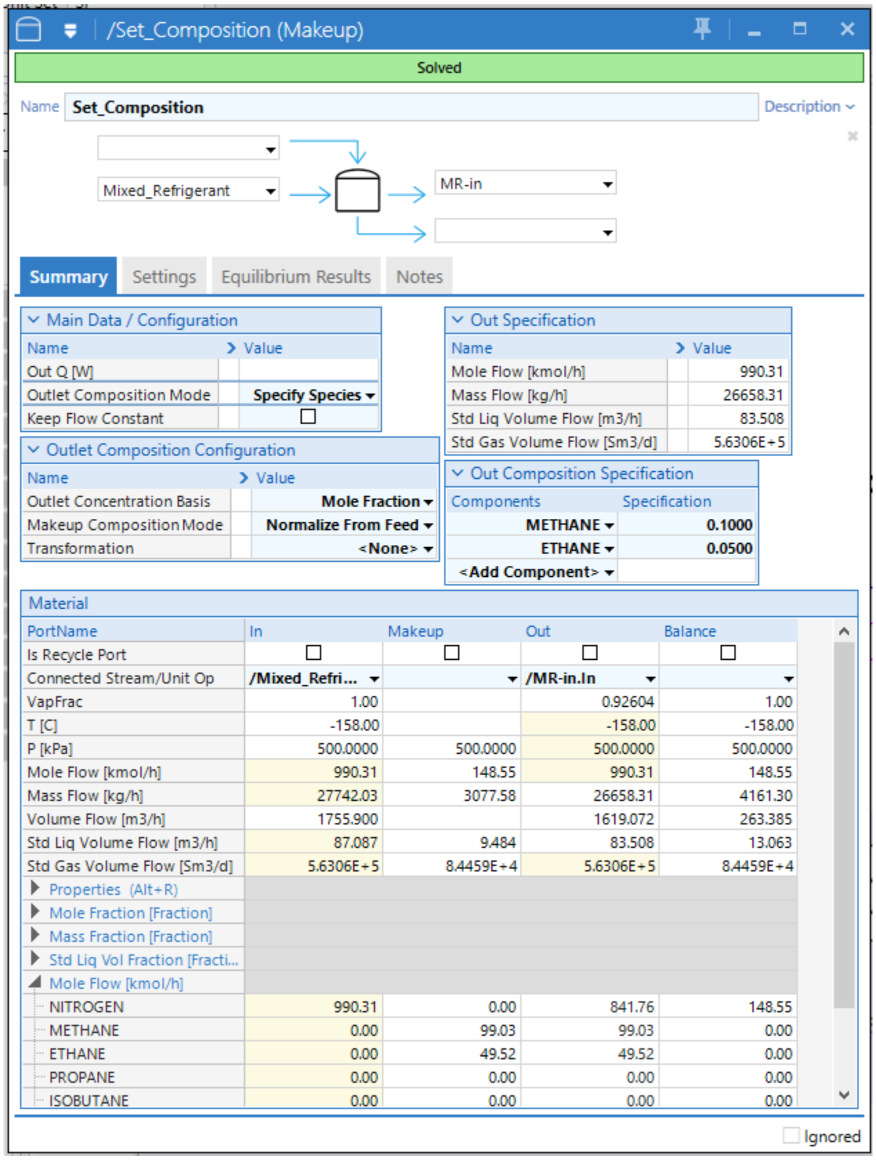
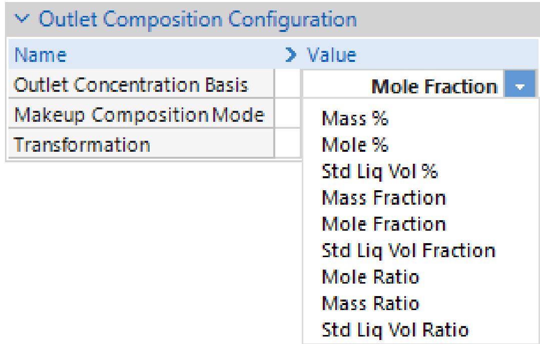


Figure 6. Specification of METHANE and ETHANE mole composition

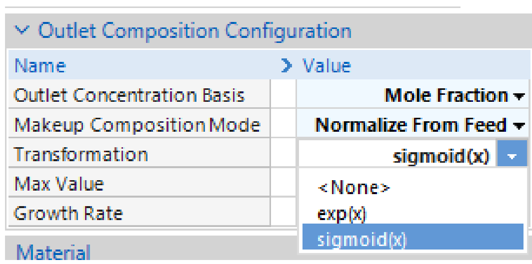
Figure 6 shows that the Makeup Composition Mode is set to *Normalize From Feed* which is different to that of the Amine example. This option specifies the composition directly on the outlet port and the rest of the components are kept on their original proportions but normalized to add up to 1.0. This specification enables a few more Concentration Basis options and the Transformation variable.

These variables are described below:

Outlet Composition Basis: This variable defines the basis of the specifications used in the *Out Composition Specification* frame. In the *Normalize From Feed* mode, this variable offers also the options to specify the component amounts as ratios (Mole, Mass, Std Liq Vol). These ratios are defined based on a user defined reference component.



Transformation: This variable can be used to define a transformation equation for the specification per component to avoid the fact that compositions are only valid between 0.0 and 1.0. This is very useful when the variables are being manipulated by an optimizer because it removes the need for constraints.



For example, if the Transformation is set to exp(x), then any specification, negative or positive is transformed to a positive value (useful for ratios). The sigmoid(x) transformation is useful to keep values between 0 and a user defined Max Value and can be further tuned with a Growth Rate. The shape of the equation is:

sigmoid(x) = MaxVal / (1 + e ^ (- GrowthRate * x))

Figure 7 shows the compositions of METHANE and ETHANE being specified with a sigmoid transformation. Max Value is se to 0.5 therefore a “high value” for METHANE, in this case 10.0, is transformed into 4.999. ETHANE on the other hand, has a negative value which approaches 0.0.

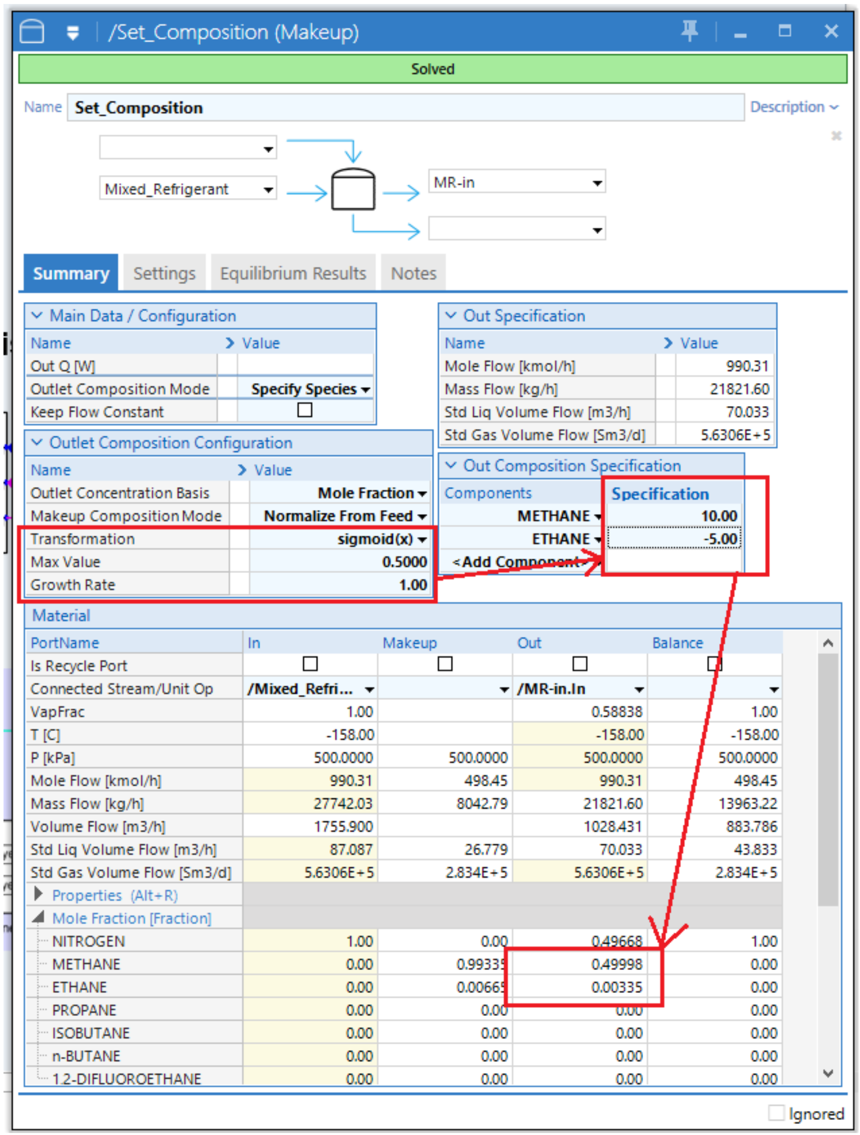


Figure 7. Specification of compositions through a sigmoid equation

Conclusion

This article described the versatility of the makeup unit operation in Symmetry. The three examples include an amine composition circulation rate specification, a flow specification in a TEG dehydration process and an application to specify compositions of two components of a mixed refrigerant stream. The option to do transformations on the specifications are useful for optimization applications to avoid the need to constraints. In general, the makeup unit operation is designed to simplify the creation of flowsheets by capturing typical workflows that may be otherwise cumbersome to configure.

Please contact your local Schlumberger office if you have any questions or feedback related to the makeup unit operation or to learn more about the Symmetry Process Software Platform.

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