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.

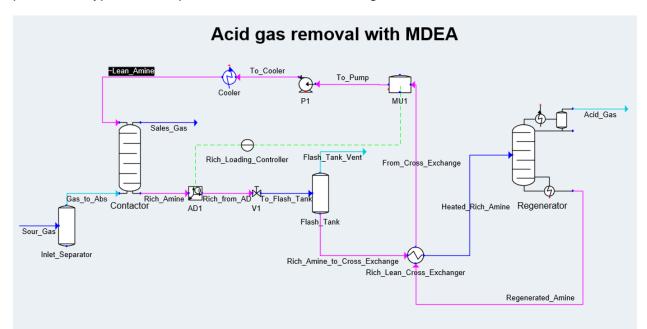


Figure 1. Acid gas removal using makeup unit operation



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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.

📄 🌻 🗌 /MU1 (Makeup)					
		Solved			
Name MU1				De	escription
From_Cross_Exchange		→ To_Pump	•		
Summary Settings Equil	ibrium Results	lotes			
✓ Main Data / Configuration Name > Va Out Q [8tw/h] 0 Outlet Composition Mode S Keep Flow Constant 0	specify Species -		lbmol/h] lb/h] ıme Flow [ft3/s]	Value 11427.08 333141.96 1.456	
V Outlet Composition Configure Name	ation Value		ume Flow [MMSCFD]		
Outlet Concentration Basis	Mass	% → Component		Specification	
Makeup Composition Mode Is Fresh Solvent	Makeup is Pure Wa 🗹		IETHANOLAMINE • Add Component> •		
Makeup Composition Mode Is Fresh Solvent Material		<	Add Component> ¬	-	
Makeup Composition Mode Is Fresh Solvent Material PortName	In	Makeup_	Add Component> ¬	Balance	
Makeup Composition Mode Is Fresh Solvent Material PortName Is Recycle Port	In	Makeup	Add Component>	-	^
Makeup Composition Mode Is Fresh Solvent Material PortName Is Recycle Port Connected Stream/Unit Op	In /From_Cross v	Makeup	Add Component> Out /To_Pump.In +	Balance	Í
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Makeup Composition Mode Is Fresh Solvent Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [F]	✓ In /From_Cross ▼ 0.00 174.57	Aakeup	Add Component> ▼ Out /To_Pump.In ▼ 0.00 174.57	Balance	Í
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Makeup Composition Mode Is Fresh Solvent Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [F] P [psia] Mole Flow [Ibmol/h]	✓ In /From_Cross ▼ 0.00 174.57 19.5000 11376.85	Makeup □ 19,5000 50,23	Add Component> ▼ Out /To_Pump.In ▼ 0.00 174.57 19.5000 11427.08	Balance	
Makeup Composition Mode Is Fresh Solvent Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [F] P [psia] Mole Flow [lbmol/h] Mass Flow [lb/h]	✓ In /From_Cross ✓ 0.00 174.57 19.5000 11376.85 332237.08	Makeup □ 19,5000 50,23	Add Component> ▼ Out /To_Pump.In ▼ 0.00 174.57 19.5000 11427.08 333141.96	Balance	
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Makeup Composition Mode Is Fresh Solvent Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [F] P [psia] Mole Flow [Ibmol/h] Mass Flow [Ib/h] Volume Flow [ft3/s] Std Liq Volume Flow [ft3/s]	✓ In /From_Cross ✓ 0.000 174.57 19.5000 11376.85 332237.08 1.476 1.452	Makeup 19,5000 50,23 904,96 0.004	Add Component> ▼ Out /To_Pump.In ▼ 0.00 174.57 19.5000 11427.08 333141.96 1.480 1.456	Balance 0.00 174.57 19.5000 0.00 0.00 0.09 0.000 0.000 0.000	Í
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Makeup Composition Mode Is Fresh Solvent Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [F] P [psia] Mole Flow [lbmol/h] Mass Flow [lb/h] Volume Flow [ft3/s] Std Liq Volume Flow [ft3/s] Std Gas Volume Flow [ft3/s] Std Gas Volume Flow [MMSCFD] P Properties (Alt+R) Mole Fraction [Fraction]	✓ In /From_Cross ✓ 0.000 174.57 19.5000 11376.85 332237.08 1.476 1.452	Makeup 19,5000 50,23 904,96 0.004	Add Component> ▼ Out /To_Pump.In ▼ 0.00 174.57 19.5000 11427.08 333141.96 1.480 1.456	Balance 0.00 174.57 19.5000 0.00 0.00 0.09 0.000 0.000 0.000	
Makeup Composition Mode Is Fresh Solvent Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [F] P [psia] Mole Flow [lbmol/h] Mass Flow [lb/h] Volume Flow [ft3/s] Std Liq Volume Flow [ft3/s] Std Gas Volume Flow [ft3/s] Std Gas Volume Flow [MMSCFD] P Properties (Alt+R) Mole Fraction [Fraction]	✓ In /From_Cross ✓ 0.000 174.57 19.5000 11376.85 332237.08 1.476 1.452	Makeup 19,5000 50,23 904,96 0.004	Add Component> Out /To_Pump.In ▼ 0.00 174.57 19,5000 11427.08 333141.96 1.480 1.456 1.0407E+2	Balance 0.00 174.57 19.5000 0.00 0.00 0.09 0.000 0.000 0.000	
Makeup Composition Mode Is Fresh Solvent Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [F] P [psia] Mole Flow [Ibmol/h] Mass Flow [Ib/h] Volume Flow [It3/s] Std Gas Volume Flow [ft3/s] Std Gas Volume Flow [MMSCFD] Properties (Alt+R) Mole Fraction [Fraction] Mass Fraction [Fraction]	✓ In /From_Cross ✓ 0.00 174.57 19.5000 11376.85 332237.08 1.476 1.452 1.0362E+2	Makeup 19.5000 50.23 904.96 0.004 4.575E-1	Add Component> Out /To_Pump.In ▼ 0.00 174.57 19,5000 11427.08 333141.96 1.480 1.456 1.0407E+2	Balance 0.00 174.57 19.5000 0.00 0.00 0.000 0.000 6.7916E-6	
Makeup Composition Mode Is Fresh Solvent Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [F] P [psia] Mole Flow [Ibmol/h] Mass Flow [Ib/h] Volume Flow [It3/s] Std Liq Volume Flow [It3/s] Std Liq Volume Flow [It3/s] Std Gas Volume Flow [It3/s] Std Gas Volume Flow [It3/s] Mole Fraction [Fraction] ▲ Mass Fraction [Fraction] ■ NITROGEN	✓ In /From_Cross ✓ 0.00 174.57 19.5000 11376.85 332237.08 1.476 1.452 1.0362E+2 1.0362E+2 0.00	Makeup 19.5000 50.23 904.96 0.004 4.575E-1 0.00	Add Component> ▼ Out /To_Pump.In ▼ 0.00 174.57 19.5000 11427.08 333141.96 1.480 1.456 1.0407E+2 0.00 0.00033	Balance 0.00 174.57 19.5000 0.00 0.00 0.000 6.7916E-6 0.00	
Makeup Composition Mode Is Fresh Solvent Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [F] P [psia] Mole Flow [Ibmol/h] Mass Flow [Ib/h] Volume Flow [It3/s] Std Liq Volume Flow [It3/s] Std Liq Volume Flow [It3/s] Std Gas Volume Flow [It3/s] Std Gas Volume Flow [It3/s] Std Gas Volume Flow [It3/s] Mole Fraction [Fraction] Mass Fraction [Fraction] Mass Fraction [Fraction] CARBON DIOXIDE	✓ in /From_Cross ✓ 0.00 174.57 19.5000 11376.85 332237.08 1.476 1.452 1.0362E+2 0.00 0.000 0.00033	Makeup 19,5000 50,23 904,96 0.004 4,575E-1 0.00 0.00	Add Component> ▼ Out /To_Pump.In ▼ 0.00 174.57 19.5000 11427.08 333141.96 1.480 1.456 1.0407E+2 0.00 0.00033	Balance 0.00 174.57 19.5000 0.00 0.00 0.00	
Makeup Composition Mode Is Fresh Solvent Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [F] P [psia] Mole Flow [Ibmol/h] Mass Flow [Ibmol/h] Mass Flow [Ib/h] Volume Flow [It3/s] Std Liq Volume Flow [It3/s] Std Gas Volume Flow [It3/s] Std Gas Volume Flow [It3/s] Std Gas Volume Flow [It3/s] Std Gas Volume Flow [It3/s] Mole Fraction [Fraction] Mass Fraction [Fraction] Mass Fraction [Fraction] MITROGEN CARBON DIOXIDE HYDROGEN SULFIDE	✓ In /From_Cross ✓ 0.00 174.57 19.5000 11376.85 332237.08 1.476 1.452 1.0362E+2 0.00 0.00033 0.00025	Makeup 19,5000 50,23 904,96 0.004 4,575E-1 0.00 0.00 0.00 0.00	Add Component> ▼ Out /To_Pump.In ▼ 0.00 174.57 19.5000 11427.08 333141.96 1.480 1.456 1.0407E+2 0.00 0.00033 0.00025	Balance 0.00 174.57 19.500 0.00 0.00 0.00 0.000	Í

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*.



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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

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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.

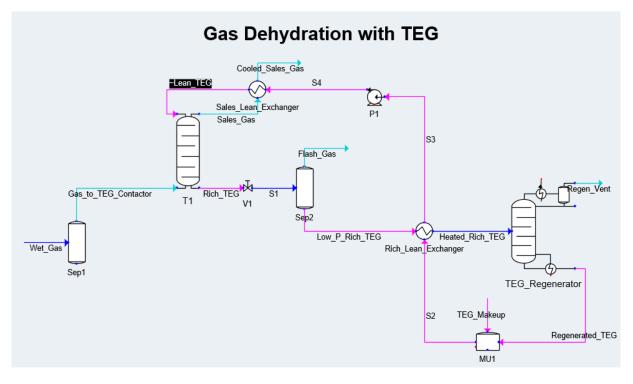


Figure 3. Gas dehydration using a TEG makeup stream



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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.

		Solv	/ed				
Name MU1						Desc	riptior
TEC Malaura							
TEG_Makeup	• <u> </u>						
Regenerated_TEG	$\rightarrow \frown$	\rightarrow	52	-			
		\rightarrow L		•			
Summary Settings Ed	quilibrium Results	Notes					
✓ Main Data / Configuration	1		✓ Out Sp	ecification			
-	Value		Name		> V	/alue	
Out Q [W]	-5	.823E-1	Mole Flow	/ [kmol/h]		0.27	
Outlet Composition Mode	Calculate From Ba	lance 🔻	Mass Flow	/ [kg/h]		36.29	
Enable H2/HC Ratio			Std Liq Vo	lume Flow [m3/h]		0.032	
Keep Flow Constant			Std Gas V	olume Flow [Sm3/d]		1.5077E+2	
Material							
PortName	In	Makeup		Out	Purge		
Is Recycle Port							
Connected Stream/Unit Op	/Regenerated 🔻	/TEG_M	akeup 🔻	/S2.In 🔻		•	
VapFrac	0.00		0.00	0.00			
T [C]	204.44		37.78	204.44		204.44	
P [kPa]	103.4214		103.4214	103.4214		103.4214	
Mole Flow [kmol/h]	0.27		0.00	0.27		0.00	
Mass Flow [kg/h]	36.28		0.00	36.29		0.00	
Volume Flow [m3/h]	0.037		0.000	0.037			
Std Liq Volume Flow [m3/h]	0.032		0.000	0.032			
Std Gas Volume Flow [Sm3/d]	1.5075E+2		2.0058E-2	1.5077E+2		5.6857E-38	
Properties (Alt+R)							
Mole Fraction [Fraction]							
Mass Fraction [Fraction]							
Std Liq Vol Fraction [Fracti							
Mole Flow [kmol/h]							
Mass Flow [kg/h]							
Std Liq Volume Flow [m3/h							

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.





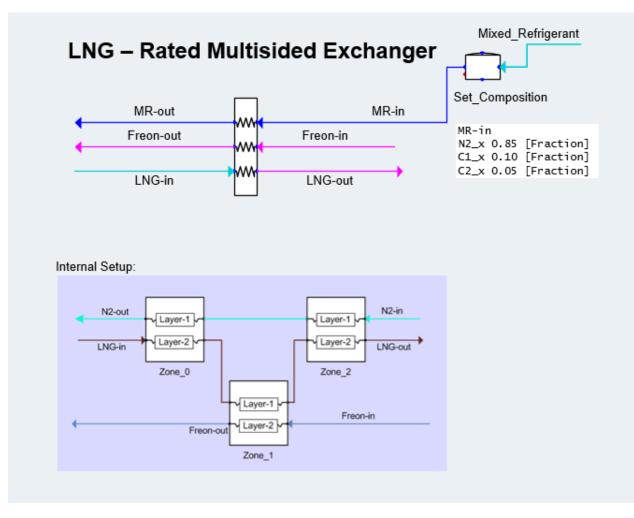


Figure 5. Mixed refrigerant composition specification with makeup operation

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.





		Sol	ved				
lame Set_Composition							Descriptio
Mixed_Refrigerant	vuilibrium Results	→ Notes	MR-in	•			
 Main Data / Configuration 		THOLE.		ecification			
	Value		Name			> Value	
Out Q [W]			Mole Flow	/ [kmol/h]			0.31
Outlet Composition Mode	Specify Species 🗸		Mass Flow			26658	
Keep Flow Constant				Jume Flow [m]	3/h]		508
 Outlet Composition Confid 	uration			olume Flow [Sr		5.6306	E+5
	·			mposition Sp		on	
Name Outlet Concentration Basis	> Value Mole Fra						
Makeup Composition Mode	Normalize From		Compone		Specific	0.1000	
Transformation		reeu ♥ one> ▼		ETHANE V		0.0500	
nansionna don		one, i	< Add Co	omponent> +		0.0500	
Material							
PortName	In	Makeup)	Out	В	alance	
Is Recycle Port		in an e ap					
Connected Stream/Unit Op	/Mixed Refri •		-	/MR-in.In	•		•
			-	/MR-in.In	* 2604		• 1.00
Connected Stream/Unit Op	/Mixed_Refri •		-	/MR-in.ln 0.9	2604 58.00		▼ 1.00 58.00
Connected Stream/Unit Op VapFrac	/Mixed_Refri 1.00		-	/MR-in.In 0.9 -1		-1!	
Connected Stream/Unit Op VapFrac T [C]	/Mixed_Refri ▼ 1.00 -158.00		•	/MR-in.In 0.9 -1 500	58.00	-1!	58.00
Connected Stream/Unit Op VapFrac T [C] P [kPa]	/Mixed_Refri ▼ 1.00 -158.00 500.0000		▼ 500.0000	/MR-in.In 0.9 -1 500 9	58.00	-1: 500/ 14	58.00 0000
Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [kmol/h]	/Mixed_Refri ▼ 1.00 -158.00 500.0000 990.31		500.0000 148.55	/MR-in.In 0.9 -1 500 9 266	58.00 .0000 90.31	-1: 500, 14 416	58.00 0000 48.55
Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [kmol/h] Mass Flow [kg/h]	/Mixed_Refri ▼ 1.00 -158.00 500.0000 990.31 27742.03		500.0000 148.55	/MR-in.ln 0.9 -1 500 9 266 161	58.00 .0000 90.31 58.31	-1: 500, 14 416 263	58.00 0000 48.55 51.30
Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [kmol/h] Mass Flow [kg/h] Volume Flow [m3/h]	/Mixed_Refri ▼ 1.00 -158.00 500.0000 990.31 27742.03 1755.900		500.0000 148.55 3077.58	/MR-in.ln 0.9 -1 500 9 266 161 8	58.00 .0000 90.31 58.31 9.072	-1: 500, 14 416 263	58.00 0000 48.55 51.30 3.385 3.063
Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [kmol/h] Mass Flow [kg/h] Volume Flow [m3/h] Std Liq Volume Flow [m3/h] Std Gas Volume Flow [Sm3/d] ▶ Properties (Alt+R)	/Mixed_Refri ▼ 1.00 -158.00 500.0000 990.31 27742.03 1755.900 87.087		500.0000 148.55 3077.58 9.484	/MR-in.ln 0.9 -1 500 9 266 161 8	58.00 0000 90.31 58.31 9.072 3.508	-1! 500, 14 416 263 13	58.00 0000 48.55 51.30 3.385 3.063
Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [kmol/h] Mass Flow [kg/h] Volume Flow [m3/h] Std Liq Volume Flow [m3/d] Std Gas Volume Flow [sm3/d] Properties (Alt+R) Mole Fraction [Fraction]	/Mixed_Refri ▼ 1.00 -158.00 500.0000 990.31 27742.03 1755.900 87.087		500.0000 148.55 3077.58 9.484	/MR-in.ln 0.9 -1 500 9 266 161 8	58.00 0000 90.31 58.31 9.072 3.508	-1! 500, 14 416 263 13	58.00 0000 48.55 51.30 3.385 3.063
Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [kmol/h] Mass Flow [kg/h] Volume Flow [m3/h] Std Liq Volume Flow [m3/h] Std Gas Volume Flow [sm3/d] Properties (Alt+R) Mole Fraction [Fraction] Mass Fraction [Fraction]	/Mixed_Refri ↓ 1.00 -158.00 500.0000 990.31 27742.03 1755.900 87.087 5.6306E+5		500.0000 148.55 3077.58 9.484	/MR-in.ln 0.9 -1 500 9 266 161 8	58.00 0000 90.31 58.31 9.072 3.508	-1! 500, 14 416 263 13	58.00 0000 48.55 51.30 3.385 3.063
Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [kmol/h] Mass Flow [kg/h] Volume Flow [m3/h] Std Liq Volume Flow [m3/h] Std Gas Volume Flow [m3/d] Properties (Alt+R) Mole Fraction [Fraction] Mass Fraction [Fraction] Std Liq Vol Fraction [Fracti]	/Mixed_Refri ↓ 1.00 -158.00 500.0000 990.31 27742.03 1755.900 87.087 5.6306E+5		500.0000 148.55 3077.58 9.484	/MR-in.ln 0.9 -1 500 9 266 161 8	58.00 0000 90.31 58.31 9.072 3.508	-1! 500, 14 416 263 13	58.00 0000 48.55 51.30 3.385 3.063
Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [kmol/h] Mass Flow [kg/h] Volume Flow [m3/h] Std Liq Volume Flow [m3/h] Std Gas Volume Flow [sm3/d] P Properties (Alt+R) Mole Fraction [Fraction] Mass Fraction [Fraction] Std Liq Vol Fraction [Fracti] Mole Flow [kmol/h]	/Mixed_Refri ↓ 1.00 -158.00 500.0000 990.31 27742.03 1755.900 87.087 5.6306E+5		500.0000 148.55 3077.58 9.484 8.4459E+4	/MR-in.In 0.9 -1 500 9 2266 161 161 8 5.630	58.00 .0000 90.31 58.31 9.072 3.508 6E+5	-1: 500/ 14 416 263 13 8.4459	58.00 0000 18.55 51.30 3.385 8.063 9E+4
Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [kmol/h] Mass Flow [kg/h] Volume Flow [m3/h] Std Liq Volume Flow [m3/h] Std Gas Volume Flow [sm3/d] P Properties (Alt+R) Mole Fraction [Fraction] Mass Fraction [Fraction] Std Liq Vol Fraction [Fracti Mole Flow [kmol/h] NITROGEN	/Mixed_Refri ▼ 1.00 -158.00 500.0000 990.31 27742.03 1755.900 87.087 5.6306E+5 990.31		500.0000 148.55 3077.58 9.484 8.4459E+4 0.00	/MR-in.In 0.9 -1 500 9 2266 161 161 8 5.630	58.00 .0000 90.31 58.31 9.072 3.508 6E+5 41.76	-1: 500/ 14 416 263 13 8.4459	58.00 0000 48.55 51.30 3.385 3.063 9E+4 48.55
Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [kmol/h] Mass Flow [kg/h] Volume Flow [m3/h] Std Liq Volume Flow [m3/h] Std Gas Volume Flow [m3/h] Mole Fraction [Fraction] Mass Fraction [Fraction] Mass Fraction [Fraction] Mole Flow [kmol/h] NITROGEN METHANE	/Mixed_Refri ↓ 1.00 -158.00 500.0000 990.31 27742.03 1755.900 87.087 5.6306E+5 990.31 0.00		500,0000 148.55 3077.58 9,484 8,4459E+4 0,00 99,03	/MR-in.in 0.9 -1 500 9 266 161 1 8 5,630	58.00 .0000 90.31 58.31 9.072 3.508 6E+5 41.76 99.03	-1: 500/ 14 416 263 13 8.4459	58.00 0000 48.55 51.30 3.385 3.063 9E+4 48.55 0.00
Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [kmol/h] Mass Flow [kg/h] Volume Flow [m3/h] Std Liq Volume Flow [m3/h] Std Gas Volume Flow [sm3/d] P Properties (Alt+R) Mole Fraction [Fraction] Mass Fraction [Fraction] Std Liq Vol Fraction [Fracti Mole Flow [kmol/h] NITROGEN	/Mixed_Refri ▼ 1.00 -158.00 500.0000 990.31 27742.03 1755.900 87.087 5.6306E+5 990.31		500.0000 148.55 3077.58 9.484 8.4459E+4 0.00	/MR-in.in 0.9 -1 500 9 266 161 1 8 5,630	58.00 .0000 90.31 58.31 9.072 3.508 6E+5 41.76	-1: 500/ 14 416 263 13 8.4459	58.00 0000 48.55 51.30 3.385 3.063 9E+4 48.55

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.





✓ Outlet Composition Conf	iguration
Name	> Value
Outlet Concentration Basis	Mole Fraction 💌
Makeup Composition Mode	Mass %
Transformation	Mole %
	Std Liq Vol %
	Mass Fraction
	Mole Fraction
	Std Liq Vol Fraction
	Mole Ratio
	Mass Ratio
	Std Liq Vol Ratio

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.

✓ Outlet Composition Conf	iguration
Name	> Value
Outlet Concentration Basis	Mole Fraction -
Makeup Composition Mode	Normalize From Feed -
Transformation	sigmoid(x) 🔽
Max Value	<none></none>
Growth Rate	exp(x)
Material	sigmoid(x)

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.



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		Solv	ved				
lame Set Composition							Des
Mixed_Refrigerant	➡ → □	→ [→ [MR-in	•	•		
 Main Data / Configuration 			V Out Sp	ecification			
	Value		Name	centeactorr		> Value	
Out Q [W]	Funde		Mole Flow	/ [kmol/h]			990.31
Outlet Composition Mode	Specify Species 🔻		Mass Flow				821.60
Keep Flow Constant				Jume Flow [m	13/h]		70.033
 Outlet Composition Config 	uration			olume Flow [5.63	06E+5
	> Value		Y Out Co	mposition S	pecificat	ion	
Outlet Concentration Basis	Mole Fra	ction -	Compone			ication	
Makeup Composition Mode	Normalize From		compone		Specii	ICation	
				METHANE -		10.0	0
				METHANE -		10.0	
Transformation		oid(x) 🔻	< Add Co			10.0 -5.0	
			< Add Co				
Transformation Max Value		oid(x) + 0.5000	< Add Co				
Transformation Max Value Growth Rate		oid(x) ▼ 0.5000 1.00		ETHANE		-5.0	
Transformation Max Value Growth Rate Material PortName	sigmo	oid(x) ▼ 0.5000 1.00 Makeup					
Transformation Max Value Growth Rate Material PortName Is Recycle Port	sigmo	oid(x) ▼ 0.5000 1.00 Makeup		ETHANE	E	-5.0	
Transformation Max Value Growth Rate Material PortName Is Recycle Port Connected Stream/Unit Op	in	oid(x) ▼ 0.5000 1.00 Makeup		Out	.58838	-5.0	
Transformation Max Value Growth Rate Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac	sigmo In /Mixed_Refri ▼	oid(x) ▼ 0.5000 1.00 Makeup		Out	-	-5.0	
Transformation Max Value Growth Rate Material	in /Mixed_Refri ▼ 1.00	oid(x) ▼ 0.5000 1.00 Makeup		Out	-	-5.0	1.00
Transformation Max Value Growth Rate Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [C]	in /Mixed_Refri ↓ 1.00 -158.00	oid(x) ▼ 0.5000 1.00 Makeup		Out /MR-in.In 50	- - - - - - - - - - - - - -	-5.0	1.00
Transformation Max Value Growth Rate Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [C] P [kPa]	in /Mixed_Refri ▼ 1.00 -158.00 500.0000	oid(x) ▼ 0.5000 1.00 Makeup	500.0000	Out /MR-in.In 50		-5.0 ialance Cl	1.00
Transformation Max Value Growth Rate Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [kmol/h] Mass Flow [kg/h] Volume Flow [m3/h]	in /Mixed_Refri ▼ 1.00 -158.00 500.0000 990.31 27742.03 1755.900	oid(x) ▼ 0.5000 1.00 Makeup	500.0000 498.45 8042.79	Out /MR-in.In 0 211 10	.58838 .58838 .158.00 .00000 .990.31 .821.60 .28.431	-5.0 ialance G	1.00 -158.00 00.0000 498.45 3963.22 883.786
Transformation Max Value Growth Rate Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [kmol/h] Mole Flow [kg/h] Volume Flow [m3/h] Std Liq Volume Flow [m3/h]	sigmo In /Mixed_Refri ↓ 1.00 -158.00 500.0000 990.31 27742.03 1755.900 87.087	oid(x) ▼ 0.5000 1.00 Makeup	500.0000 498.45 8042.79 26.779	Out /MR-in.In 0 21: 10	.58838 .58838 .158.00 .00000 .990.31 821.60 28.431 .70.033	-5.0	1.00 -158.00 498.45 3963.22 883.786 43.833
Transformation Max Value Growth Rate Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [kmol/h] Mass Flow [kg/h] Volume Flow [m3/h] Std Liq Volume Flow [m3/h] Std Gas Volume Flow [sm3/d]	in /Mixed_Refri ▼ 1.00 -158.00 500.0000 990.31 27742.03 1755.900	oid(x) ▼ 0.5000 1.00 Makeup	500.0000 498.45 8042.79	Out /MR-in.In 0 21: 10	.58838 .58838 .158.00 .00000 .990.31 .821.60 .28.431	-5.0	1.00 -158.00 00.0000 498.45 3963.22 883.786
Transformation Max Value Growth Rate Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [km0l/h] Mass Flow [kg/h] Volume Flow [m3/h] Std Liq Volume Flow [m3/h] Std Gas Volume Flow [m3/d] ▶ Properties (Alt+R)	sigmo In /Mixed_Refri ↓ 1.00 -158.00 500.0000 990.31 27742.03 1755.900 87.087	oid(x) ▼ 0.5000 1.00 Makeup	500.0000 498.45 8042.79 26.779	Out /MR-in.In 0 21: 10	.58838 .58838 .158.00 .00000 .990.31 821.60 28.431 .70.033	-5.0	1.00 -158.00 498.45 3963.22 883.786 43.833
Transformation Max Value Srowth Rate Material PortName s Recycle Port Connected Stream/Unit Op VapFrac [C] P (KPa] Mole Flow [kmol/h] Mass Flow [kg/h] Volume Flow [m3/h] Std Liq Volume Flow [5m3/d] Properties (Alt+R) Mole Fraction [Fraction]	in /Mixed_Refri ↓ 1.00 -158.00 500.0000 990.31 27742.03 1755.900 87.087 5.6306E+5	oid(x) ▼ 0.5000 1.00 Makeup	500.0000 498.45 8042.79 2.6.779 2.834E+5	Out /MR-in.In 0 21: 5.63	58838 158.00 0.0000 990.31 821.60 28.431 70.033 06E+5	-5.0	1.00 -158.00 00.0000 498.45 3963.22 883.786 43.833 834E+5
Transformation Vax Value Srowth Rate Vaterial PortName s Recycle Port Connected Stream/Unit Op /apFrac r [C] v[kPa] Vole Flow [kmol/h] Vass Flow [kg/h] /olume Flow [m3/h] Std Liq Volume Flow [m3/h] Std Gas Volume Flow [Sm3/d] Properties (Alt+R) Mole Fraction [Fraction] NITROGEN	in /Mixed_Refri ↓ 1.00 -158.000 500.0000 990.31 27742.03 1755.900 87.087 5.6306E+5 1.00	oid(x) ▼ 0.5000 1.00 Makeup	500.0000 498.45 8042.79 2.6.779 2.834E+5 0.00	Out /MR-in.In 0 - - - - - - - - - - - - -	58838 158.00 0.0000 990.31 821.60 28.431 70.033 06E+5	-5.0	1.00 -158.00 00.0000 498.45 3963.22 883.786 43.833 834E+5 1.00
ransformation Aax Value Frowth Rate Vaterial VortName s Recycle Port Connected Stream/Unit Op (apFrac [C] [KPa] Aole Flow [kmol/h] Alass Flow [kg/h] Yolume Flow [m3/h] td Liq Volume Flow [m3/h] td Liq Volume Flow [m3/h] td Gas Volume Flow [m3/h] Mole Fraction [Fraction] MITROGEN METHANE	in /Mixed_Refri ↓ /Mixed_Refri ↓ 1.00 -158.00 500.0000 990.31 27742.03 1755.900 87.087 5.6306E+5 1.00 0.00	oid(x) ▼ 0.5000 1.00 Makeup	500.0000 498.45 8042.79 2.6.779 2.834E+5 0.00 0.99333	Out Out /MR-in.In 0 - - - - - - - - - - - - -	58838 158.00 0.0000 990.31 821.60 28.431 70.033 06E+5 49668 49998	-5.0	1.00 -158.00 00.0000 498.45 3963.22 883.786 43.833 834E+5 1.00 0.00
Transformation Max Value Srowth Rate Material PortName s Recycle Port Connected Stream/Unit Op /apFrac F [C] 2 [kPa] Mole Flow [kmol/h] Mole Flow [kmol/h] Mole Flow [kg/h] /olume Flow [m3/h] Std Gas Volume Flow [sm3/d] Properties (Alt+R) Mole Fraction [Fraction] NITROGEN METHANE ETHANE	in /Mixed_Refri ↓ /Mixed_Refri ↓ /Mixed_Refri ↓ 1.00 -158.00 500.0000 990.31 27742.03 1755.900 87.087 5.6306E+5 1.00 0.000 0.000	oid(x) ▼ 0.5000 1.00 Makeup	500.0000 498.45 8042.79 2.6374 2.834E+5 0.00 0.9933 0.0066	Out Out /MR-in.In 0 - - - - - - - - - - - - -	58838 158.00 0.0000 990.31 821.60 28.431 70.033 06E+5 499668 49998 .00335	-5.0	0 1.00 -158.00 00.0000 498.45 3963.22 883.786 43.833 834E+5 1.00 0.000 0.000 0.000
Transformation Max Value Transformation Max Value Srowth Rate Material PortName s Recycle Port Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [kmol/h] Mass Flow [kg/h] Volume Flow [m3/h] Std Liq Volume Flow [m3/h] Std Liq Volume Flow [m3/h] Std Gas Volume Flow [sm3/d] Properties (Alt+R) MOLE Fraction [Fraction] NITROGEN METHANE ETHANE PROPANE	in /Mixed_Refri ▼ 1.00 -158.00 500.0000 990.31 27742.03 1755.900 87.087 5.6306E+5 1.00 0.000 0.000 0.000	oid(x) ▼ 0.5000 1.00 Makeup	500.0000 498.45 8042.79 2.6379 2.834E+5 0.00 0.9933 0.0066 0.00	Out Out /MR-in.In 0 - - - - - - - - - - - - -	58838 158.00 0.0000 990.31 821.60 28.431 70.033 06E+5 49968 49998 .00335	-5.0	0 1.00 -158.00 498.45 3963.22 883.786 43.833 8348+5 1.000 0.000 0.000 0.000
Transformation Max Value Srowth Rate Material PortName s Recycle Port Connected Stream/Unit Op /apFrac F [C] 2 [kPa] Mole Flow [kmol/h] Mole Flow [kmol/h] Mole Flow [kg/h] /olume Flow [m3/h] Std Gas Volume Flow [sm3/d] Properties (Alt+R) Mole Fraction [Fraction] NITROGEN METHANE ETHANE	in /Mixed_Refri ↓ /Mixed_Refri ↓ /Mixed_Refri ↓ 1.00 -158.00 500.0000 990.31 27742.03 1755.900 87.087 5.6306E+5 1.00 0.000 0.000	oid(x) ▼ 0.5000 1.00 Makeup	500.0000 498.45 8042.79 2.6374 2.834E+5 0.00 0.9933 0.0066	Out Out /MR-in.In 0 - - - - - - - - - - - - -	58838 158.00 0.0000 990.31 821.60 28.431 70.033 06E+5 499668 49998 .00335	-5.0	0 1.00 -158.00 00.0000 498.45 3963.22 883.786 43.833 834E+5 1.00 0.000 0.000 0.000

Figure 7. Specification of compositions through a sigmoid equation



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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.

* Mark of Schlumberger



