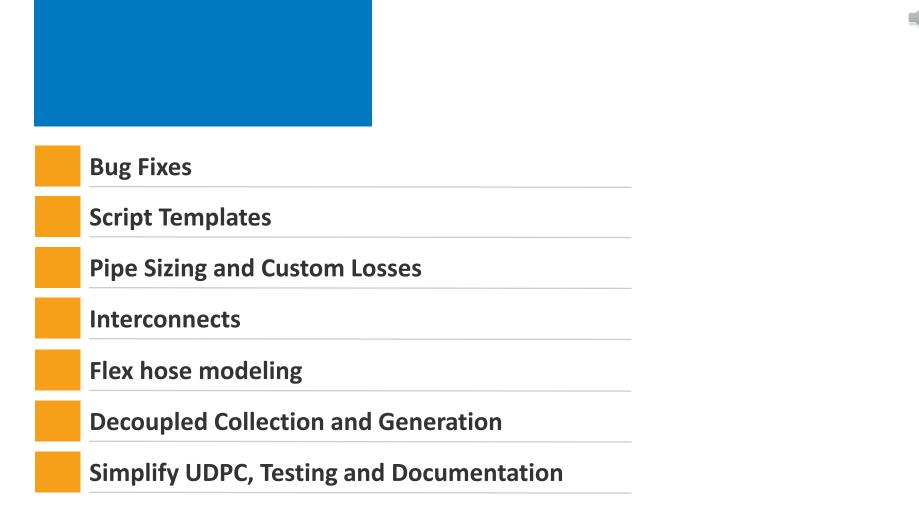




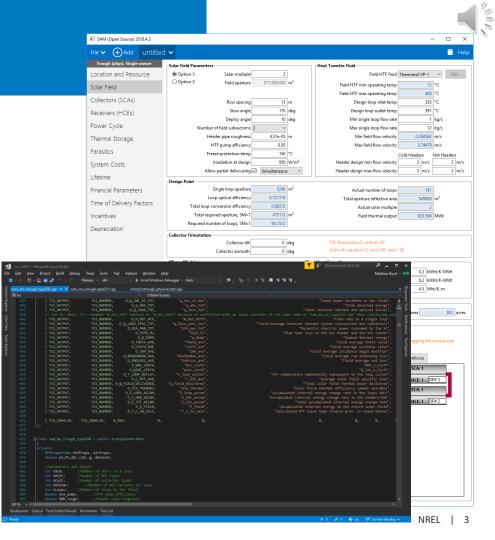
SAM Parabolic Trough Updates

Matthew Boyd 2018-Oct



Bug Fixes

- Header sizing algorithm considers all sections when progressively downsizing the diameters
- Internal energy of the inlet, outlet, and crossover piping (IOCOP) now fully accounted for
- Runner pressure drop calculation accurately counts expansions and contractions
- Calculation of thermal energy storage (TES) and steam generator system (SGS) piping volumes now more precise





Bug Fixes

Script Templates

Pipe Sizing and Custom Losses

Interconnects

Flex hose modeling

Decoupled Collection and Generation

Simplify UDPC, Testing and Documentation

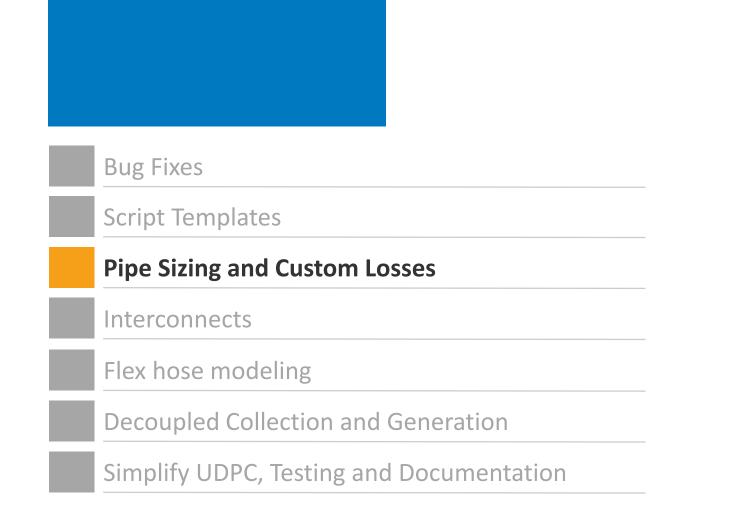
Script Templates

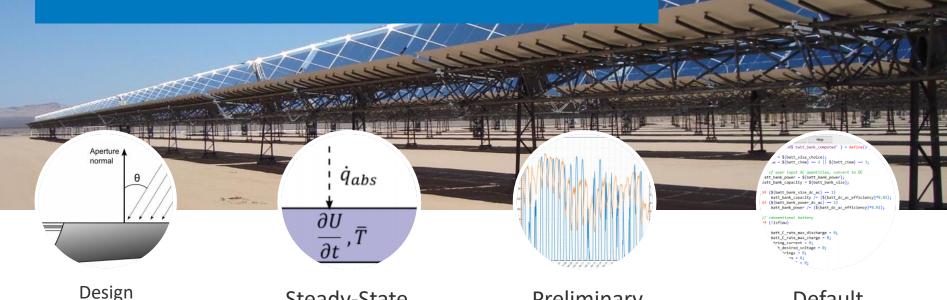
- Script templates added for implementing the new advanced features listed here
- Located in:

/sam/samples/LK Scripts for SAM/
 molten_salt_trough.lk (main script)
 ms_trough_funs.lk (helper functions)

SAM (Open Source) 2018.4.3							- 0		×
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Open project	to download for single-year or P50,P90 Ctrl-O	analyses, see neip t	or details.						
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Save	Ctrl-S	for weather data th	an the NREL N	ISRDB. See Help for	details.		Data Sources		
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Save with hourly results	default library contains legacy weather fi	les. See Help for det	ails.						
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Conditions Calculates (and outputs) HTF properties at design conditions in each pipe section

Steady-State

Model runs until steady-state is achieved

Preliminary

Occurs before yearly simulation

Default

Default is to perform, but can be skipped

Field Design Conditions

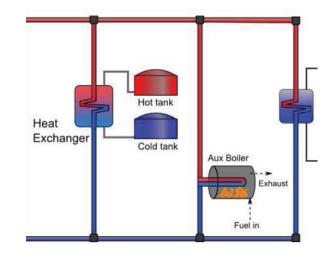
Configurable Advanced Options (Field)

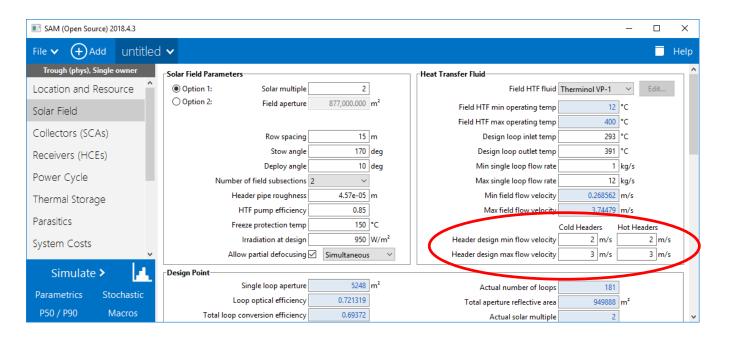
- North/south distance between subfields (northsouth_field_sep)
- Minimum number of runner expansion loops for each constant diameter segment (Min_rnr_xpans)
- Frequency of runner expansion loops (L_rnr_per_xpan)
- Expansion loop lengths (L_xpan_hdr, L_xpan_rnr)
- Maximum number of header diameters (N_max_hdr_diams)
- Location of the first header expansion loop (offset_xpan_hdr)
- Number of collector loops per header expansion loop (N_hdr_per_xpan)



Configurable Advanced Options (TES/PB)

- Bypass valve operation during field recirculation (has_hot_tank_bypass)
 - Bypass just hot tank and feed into cold tank (=true)
 - Bypass both tanks and rest of TES/PB (=false)
- Minimum HTF temperature that may enter the hot tank (T_tank_hot_inlet_min)
- Length of runner pipe in and around the power block (L_rnr_pb)
- Lengths of the TES/PB piping (sgs_lengths)
- Design-point velocity for sizing the TES/PB pipe diameters (V_tes_des)
- Minor losses of TES/PB pipe fittings (k_tes_loss_coeffs)
- Pressure drop within the steam generator system (DP_SGS)

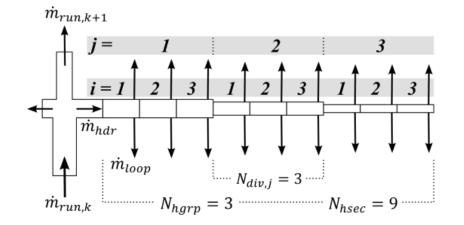




 Separate design velocities added for sizing hot and cold headers



- Runner and header diameter sizing algorithm revamped:
 - More robust in edge cases
 - Preferentially selects smaller diameter (cheaper) pipes for out-of-range cases
 - Diameter limit less restrictive for hot (costlier) than cold header pipes





Custom TES/SGS Pressure Drops

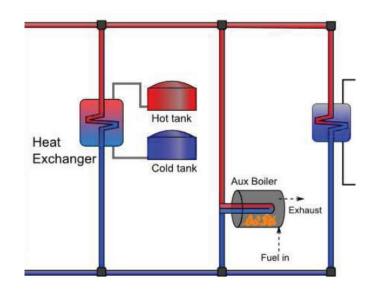
- Default is to use pumping coefficients (kJ/kg)
- New advanced option to calculate using:
 - Darcy–Weisbach equation

 $\Delta P = f \ge U^2 \ge L \ge \rho / (2 \ge D)$

• Minor pressure losses

 $\Delta P = K \ x \ U^2 \ x \ \rho \ / \ 2$

with minor loss coefficients (k) for each section as input parameters





- Reporting all applicable SGS, runner, header, and loop:
 - Lengths
 - Diameters
 - Wall thicknesses
 - Number of expansion loops



- If using script templates:
 - Outputting:
 - SGS.csv
 - Runners.csv
 - Headers.csv
 - Loop.csv
 - Pre-simulation checks for open, unwritable output files to avoid wasted simulation time

А	В	С	D	E	F	G	Н	I.
ndex	Diameter_m	WallThk_m	Length_m	Expansions	MassFlow_kg_s	Velocity_m_s	Temp_C	P_gauge_bar
0	0.635	0.012319	30	0	1617.61	2.74602	291.352	12.0232
1	0.635	0.012319	50	1	1582.44	2.68632	291.349	12.0032
2	0.635	0.012319	30	0	1547.28	2.62662	291.347	11.9004
3	0.635	0.012319	50	1	1512.11	2.56693	291.345	11.8821
4	0.635	0.012319	30	0	1476.95	2.50723	291.343	11.7882
5	0.635	0.012319	50	1	1441.78	2.44754	291.34	11.7714
6	0.635	0.012319	30	0	1406.62	2.38784	291.338	11.686
7	0.635	0.012319	50	1	1371.45	2.32814	291.335	11.6707
8	0.635	0.012319	30	0	1336.28	2.26845	291.333	11.5935
9	0.635	0.010010	50	1	1201-12	2 20075	201.22	11.5796
10	0.635	Notice					>	< 11.51
11	0.635							11.4975
12	0.635							11 4353
		Runr	ners.csv lers.csv).csv	ollowing	files befor	e proceed	ling:	
						OI	K	

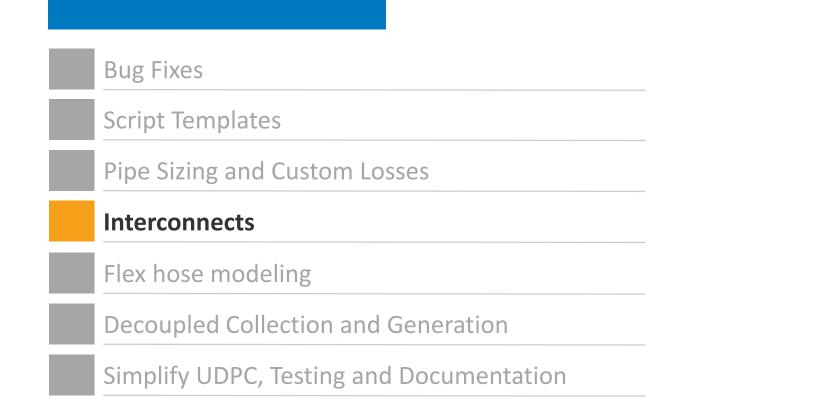
- If setting advanced parameter flag option, output files become input files for custom:
 - Diameters
 - Wall thicknesses
 - Lengths

	Α	В	С	D	E	F	G	н	1
1	index	Diameter_m	WallThk_m	Length_m	Expansions	MassFlow_kg_s	Velocity_m_s	Temp_C	P_gauge_bar
2	0	0.635	0.012319	30	0	1617.61	2.74602	291.352	12.0232
З	1	0.635	0.012319	50	1	1582.44	2.68632	291.349	12.0032
4	2	0.635	0.012319	30	0	1547.28	2.62662	291.347	11.9004
5	3	0.635	0.012319	50	1	1512.11	2.56693	291.345	11.8821
6	4	0.635	0.012319	30	0	1476.95	2.50723	291.343	11.7882
7	5	0.635	0.012319	50	1	1441.78	2.44754	291.34	11.7714
8	6	0.635	0.012319	30	0	1406.62	2.38784	291.338	11.686
9	7	0.635	0.012319	50	1	1371.45	2.32814	291.335	11.6707
10	8	0.635	0.012319	30	0	1336.28	2.26845	291.333	11.5935
11	9	0.635	0.012319	50	1	1301.12	2.20875	291.33	11.5796
12	10	0.635	0.012319	30	0	1265.95	2.14906	291.327	11.51
13	11	0.635	0.012319	50	1	1230.79	2.08936	291.325	11.4975
14	12	0.625	0.012219	20	n	1195 62	2 02966	291 322	11 4353

- Flags:
 - For field:
 - custom_sf_pipe_sizes
 - For TES/PB: custom_sgs_pipe_sizes

Custom for all files: SGS.csv, Runners.csv, Headers.csv, Loop.csv



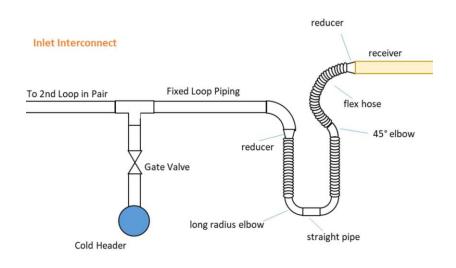


- Configurable interconnects have been added as an advanced option at the:
 - inlet
 - outlet
 - crossover
 - connections between solar collector assemblies (SCAs)
- Exposes hard coded component sizes and associated losses
- Using defaults will replicate the original hard coded values and respective calculated outputs





- Pressure losses modeled according to component type:
 - Fitting (minor loss coeffs.)
 - Pipe (Darcy–Weisbach)
 - Flex hose (empirical model)
- Heat losses modeled according to component geometry:
 - Global heat loss coefficient
 - Fitting heat losses neglected



Inter Interconnect To 2nd Loop in Pair Fixed Loop Piping Gate Valve Inter Interconnect Fixed Loop Piping Gate Valve Inter Interconnect Interconnect

/sam/samples/LK Scripts for SAM/

physical_trough_interconnect_components.csv

defines library of individual components

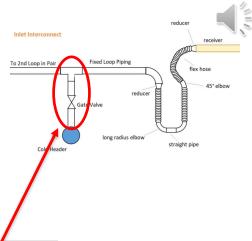
	Α	В	С		E	F
1	Name	Component Description	Minor Loss Coefficient	Flow Diameter	Length	Туре
2	Units	-	-	m	m	flag:[0=fitting 1=pipe 2=flex_hose]
3	[0]	intc_cpnt	cpnt_K	cpnt_D	cpnt_L	cpnt_type
4	e1	Expansion 1	0.15	0.085	0	0
5	c1	Contraction 1	0.05	0.085	0	0
6	11	Elbow 1, long	0.6	0.085	0	0
7	12	Elbow 2, long	0.6	0.0635	0	0
8	13	Elbow 3, 45 deg	0.42	0.0635	0	0
9	v1	Valve 1, gate	0.19	0.085	0	0
10	t1	Tee 1	0.9	0.085	0	0
11	p1	Pipe 1	0	0.0635	0.5	1
12	p2	Pipe 2	0	0.085	2	1
13	р3	Pipe 3	0	0.0635	1	1
14	f1	Flex hose 1	0	0.0635	1	2
15	w1	Weldolet 1	0.9	0.085	0	0

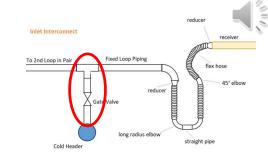
/sam/samples/LK Scripts for SAM/

- physical_trough_interconnect_components.csv
- physical_trough_interconnect_definitions.csv

defines assemblies of components (interconnects)

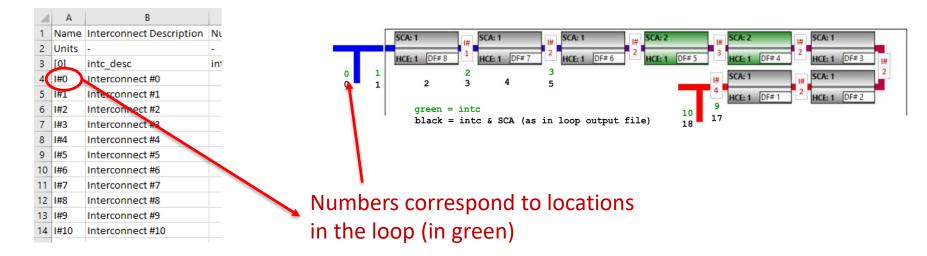
	Α	В	С	D
1	Name	Interconnect Description	Number of Components	Components
2	Units	-	-	-
3	[0]	intc_desc	intc_n_cpnts	inte epits
4	I#0	Interconnect #0	3	w1-p3-v1-p3-t1
5	I#1	Interconnect #1	11	p2-l1-c1-f1-l2-p1-l2-f1-l3-f1-e1
6	I#2	Interconnect #2	11	c1-f1-l3-f1-l2-p1-l2-f1-l3-f1-e1
7	I#3	Interconnect #3	11	c1-f1-l3-f1-l2-p1-l2-f1-l3-f1-e1
8	1#4	Interconnect #4	11	c1-f1-l3-f1-l2-p1-l2-f1-l3-f1-e1
9	I#5	Interconnect #5	11	c1-f1-l3-f1-l2-p1-l2-f1-l3-f1-e1
10	I#6	Interconnect #6	11	c1-f1-l3-f1-l2-p1-l2-f1-l3-f1-e1
11	1#7	Interconnect #7	11	c1-f1-l3-f1-l2-p1-l2-f1-l3-f1-e1
12	I#8	Interconnect #8	11	c1-f1-l3-f1-l2-p1-l2-f1-l3-f1-e1
13	I#9	Interconnect #9	11	c1-f1-l3-f1-l2-p1-l2-f1-e1-l1-p2
14	I#10	Interconnect #10	5	t1-p3-v1-p3-w1

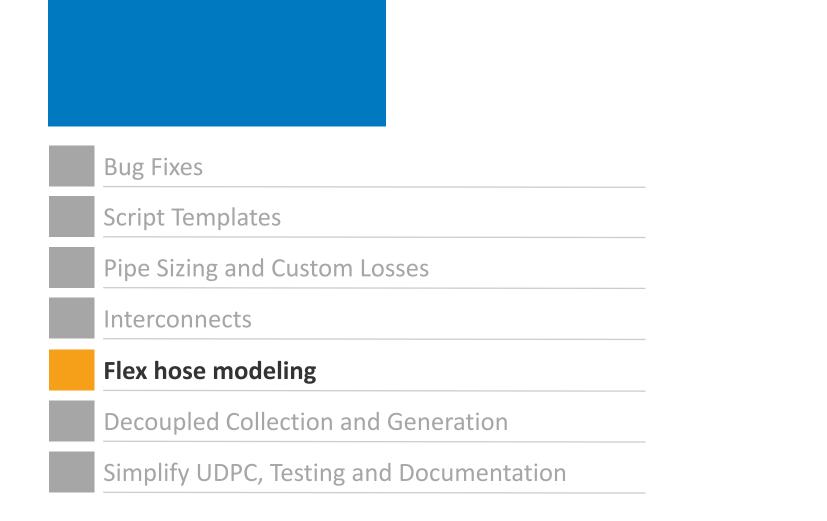




/sam/samples/LK Scripts for SAM/

- physical_trough_interconnect_components.csv
- physical_trough_interconnect_definitions.csv





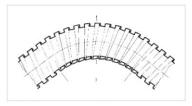


Flex Hoses

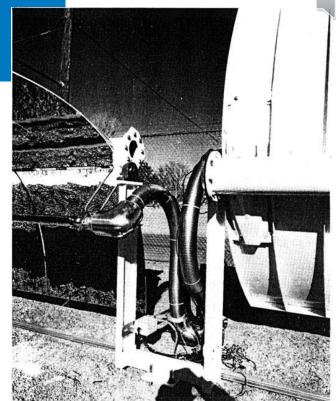
- Added as an advanced modeling option
- Pressure drop dependent on:
 - Туре
 - Size
 - Flex radius and angle
- Formulation a modification of Darcy-Weisbach equation that accounts for bending:

$$\Delta p = \left[f\left(\frac{L}{D}\right) + \zeta_b \right] \left(\frac{\rho}{2}\right) V^2$$





Courtesy: Witzenmann GmbH



Courtesy: Sandia National Laboratories





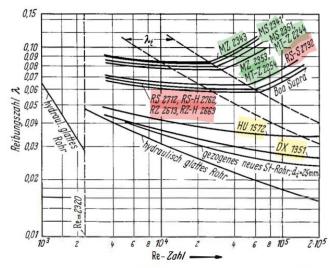
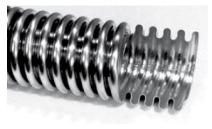


Figure 7. Friction numbers of winding and corrugated hoses (27W 25); Winding hoses DX, HU, corrugated hoses RZ, R5, helical hoses MT, MZ, M5 (factory picture)

Gropp, R., Pforzheim, 1974. Flow Resistance of flexible metallic lines

Helical (helically corrugated)



Corrugated (annular)



Winding (stripwound)

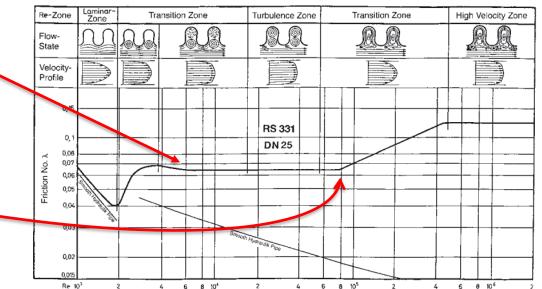




Flow Regimes

- Quickly enters fully rough zone (near constant ff)
- At higher Reynold's numbers, enters additional, higher friction factor zones instead of staying constant

Courtesy: Witzenmann GmbH

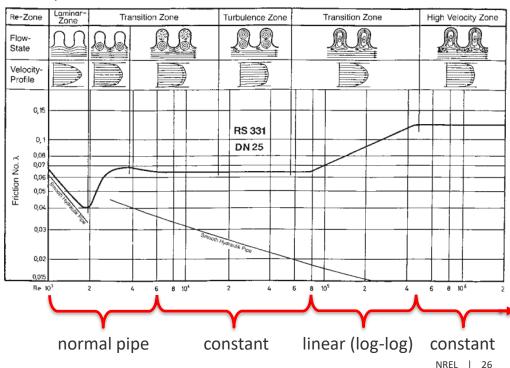


Courtesy: Witzenmann GmbH



Modeling of Friction Factor (ff)

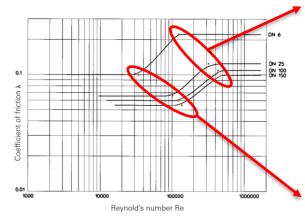
- *Re* < 6000:
 - Normal pipe
 - Laminar *ff* = 64 / *Re*
 - Turbulent transition = Colebrook (iterative)
- *Re* >= 6000
 - Annular corrugated with average characteristics
 - Simple model (Re vs. D)
 - Linear log-log (ff vs. Re)



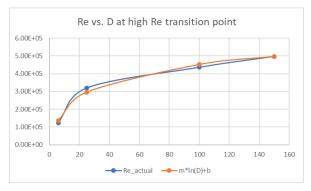
Flex Hose Modeling

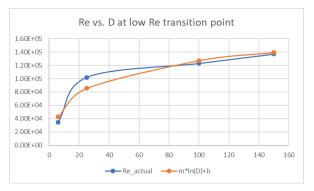
- *Re* transition points as function of diameter
 - Data from corrugated hose model RS331
 - Model form:

$$Re = m \cdot ln(D) + b$$

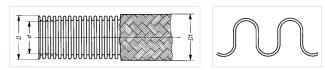


Courtesy: Witzenmann GmbH



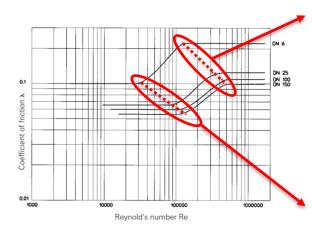


RS 330 / 331

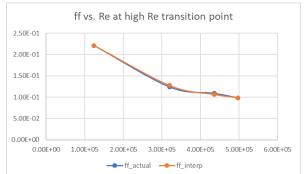


Flex Hose Modeling

- *ff* transition points as function of *Re*
 - Linear log-log
 - Two models
 - at low trans.
 - at high trans.

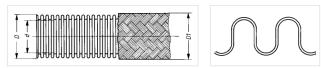


Courtesy: Witzenmann GmbH





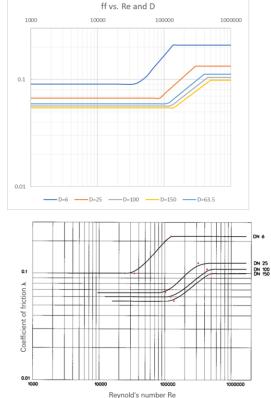
RS 330 / 331

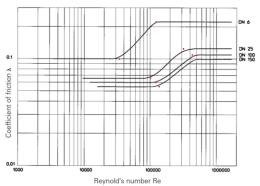




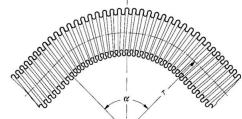
Flex Hose Modeling

- Results
 - Good fit
 - Plot includes one known implemented diameter of 2.5" (63.5 mm)





Courtesy: Witzenmann GmbH



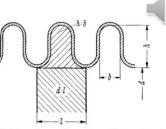


Figure 8. Bent metal hose (factory picture)

Figure 6. Relative roughness of metal hoses (factory picture)

3.5 spezifische Widerstandszahl ζ_t MS 2341 2.0 -Boa Supra S-H 2762 HU 1572 DX 1351 2 2 0 r/d, -

Figure 9. Specific resistance coefficients 5t of winding and corrugated hoses (NW 25); Winding hoses DX, HU, corrugated hoses RZ, RS, helical hoses MT, MZ, MS (factory picture)

Gropp, R., Pforzheim, 1974. Flow Resistance of flexible metallic lines NREL | 30

Flex Hose Modeling

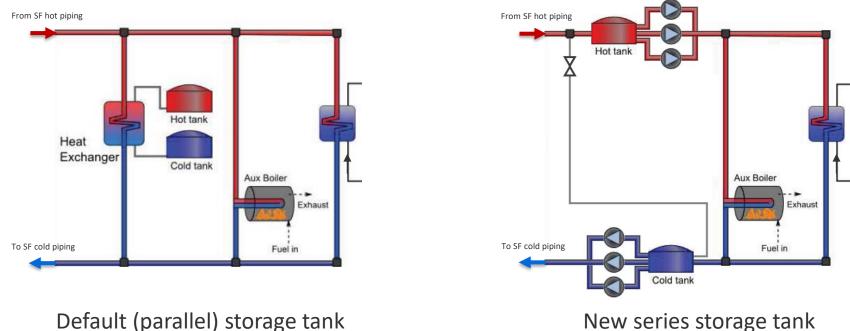
- Bending effects
 - Not implemented
 - Possible future feature
 - Determination of *in situ* hose angles is the more difficult task

$$\Delta p = \left[f\left(\frac{L}{D}\right) + \zeta_b \right] \left(\frac{\rho}{2}\right) V^2$$
$$\zeta_b = \zeta \frac{\alpha}{180^{\circ}}$$

Bug Fixes
Script Templates
Pipe Sizing and Custom Losses
Interconnects
Flex hose modeling
Decoupled Collection and Generation
Simplify UDPC, Testing and Documentation

Decoupled Collection and Generation





option

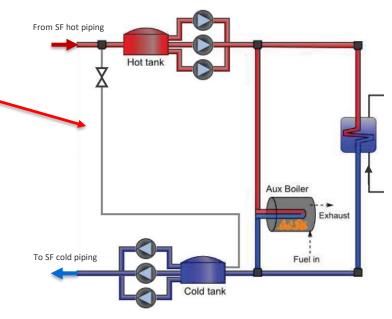
Default (parallel) storage tank configuration

Decoupled Collection and Generation



TES in Series with Field

- tanks_in_parallel = true
- has_hot_tank_bypass = true
 - Field HTF circulates through cold tank (instead of straight back to field) when *T_tank_hot_inlet_min* is not met
- Field and TES/PB are now effectively decoupled

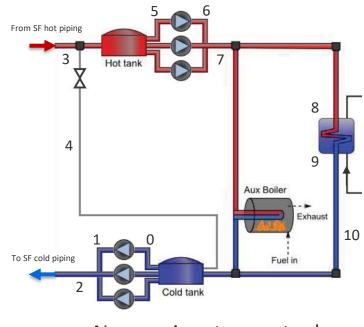


New series storage tank option

Decoupled Collection and Generation



Number	From	То
0	Cold thermal storage tank	Individual solar field (SF) pump inlet
1	Individual SF pump discharge	SF pump discharge header
2	SF pump discharge header	SF runners
3	SF runners	Hot thermal storage tank
4	SF runners	Cold thermal storage tank
5	Steam generator system (SGS) pump suction header	Individual SGS pump inlet
6	Individual SGS pump discharge	SGS pump discharge header
7	SGS pump discharge header	Steam generator supply header
8	Steam generator supply header	Inter-steam generator piping
9	Inter-steam generator piping	Steam generator outlet header
10	Steam generator outlet header	Cold thermal storage tank



New series storage tank option

Decoupled Collection and Generation

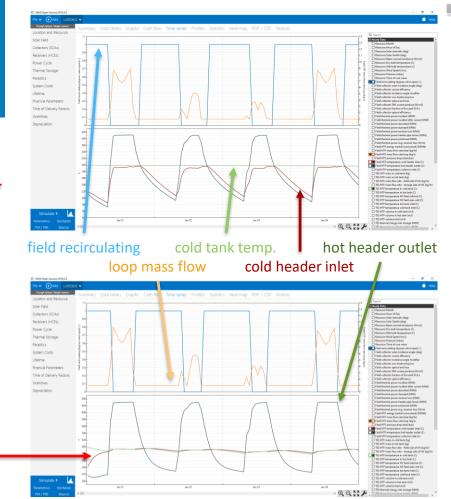
Example behavior of:

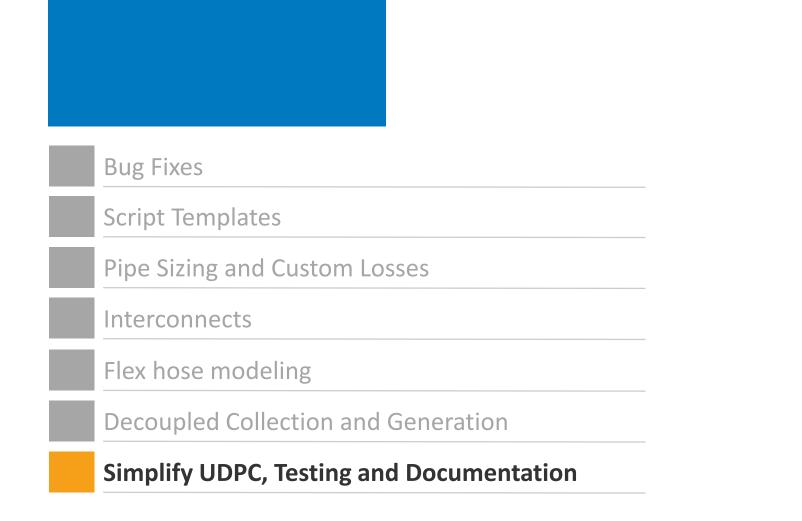
Field in parallel with TES

VS.

Field in series with TES

Cold-tank a thermal reservoir, keeping field HTF at a higher temperature





Simplify UDPC



User Defined Power Cycle 🗸

Cooling sy	stem water	usage		0 kg/s	5	Gross p	ower consur	ned by co	ling sy	stem		0.0 MWe		
rformance as Functio	n of HTF T	emperatu	ıre											
ow, design, and high i	mass flow	rates (m) f	or parame	ter interact	tions with	HTF tem	perature:							
Low n	ormalized	HTFm		0.3										
Design n	ormalized	HTF m		1.0										
High n	ormalized	HTF m		1.2										
					Import		Export	Co	v	P	aste	Rows:		20
1177							· ·							^
HTF temperature °C (at HTF m ⇒)	Ŵ cycle low	Ŵ cycle design	Ŵ cycle high	Heat in low	Heat in design	Heat in high	Ŵ cooling low	Ŵ coolii design		:ooling 1iqh	rin water low	rh water design	rh water high	<u></u>
			0.0665246		-	-		1	1		1	1	1	
	0.0229681			0.0391514				1	1		1	1	1	
311.579	0.0338339	0.161843	0.181637	0.0568743	0.189581	0.227497	1	1	1		1	1	1	
	0.0440820	0.215174	0.241489	0.0745972	0.248657	0.298389	1	1	1		1	1	1	
317.368									1		1	1	1	
	0.0564088	0.269829	0.302829	0.0923201	0.307734	0.36928	1	1						
323.158			0.302829	0.0923201 0.110043		0.36928 0.440172		1	1		1	1	1	
323.158 328.947 224.727 rformance as Functio	0.0564088 0.0681055 n of HTF M	0.32578 0.303 Mass Flow	0.365623 Rate	0.110043	0.36681	0.440172	1							~
323.158 328.947 rformance as Functio ow, design, and high a Low amb Design amb	0.0564088 0.0681055 n of HTF M mbient ter	0.32578 Mass Flow mperature erature	0.365623 Rate	0.110043	0.36681	0.440172	1	1	1		1	1	1	~
323.158 328.947 rformance as Functio ow, design, and high a Low amb Design amb	0.0564088 0.0681055 n of HTF M mbient terr pient temp	0.32578 Mass Flow mperature erature	0.365623 Rate	0.110043 0.13775 neter intera 0.°C 3.0.°C	0.36681	0.440172	1	1	1		1	1	1	20
323.158 328.947 328.947 ov, design, and high a Low amb Design amb High amb	0.0564088 0.0681055 n of HTF M imbient temp oient temp oient temp oient temp	0.32578 Mass Flow mperature erature	0.365623 Rate	0.110043 • 137766 • 1377766 • 137766 • 1377676766 • 1377666 • 1377666 • 1377666 • 1377666 • 13776	0.36681 actions with	0.440172	Export	1	opy g Ŵ	cooling	1	Rows:	1	
323.158 328.947 rformance as Functio ow, design, and high a Low amb Design amb High amb HIFF mass flow rate (at ambient temp)	0.0564088 0.0681055 a concert of HTF M mbient terr oient temp oient temp oient temp	0.32578 Aass Flow nperature erature erature erature W cycle	0.365623 Rate s for param 4 Ŵ cycle	0.110043 • • • • • • • • • • • • • • • • • • •	0.36681 actions with Impo Heat in	0.440172	1 ass flow rate: Export W cooling	ů ů Ŵ coolin	opy g Ŵ		Paste m water	Rows:	n water	20
223.158 228.947 rformance as Functio ow, design, and high a Low amb Design amb High amb HTF mass flow rate (at ambient temp =) 0.3	0.0564088 0.0681055 a concert of HTF M mbient temp oient temp oient temp oient temp oient temp oient temp oient temp oient temp oient temp oient temp	0.32578 Mass Flow mperature erature erature erature W cycle design	0.365623 A 2004 Rate s for param 4 Ŵ cycle high	0.110043 neter intera 0 °C 3.0 °C 55 °C Heat in Iow	0.36681 actions with Impo Heat in design 0.3	0.440172 0.511052 th HTF m rt Heat in high 0.3	Export W cooling low	V coolin design	opy g W		Paste m water low	Rows:	n water high	20
323.158 328.947 Formance as Functio ow, design, and high a Low amb Design amb High amb HTF mass flow rate (at ambient temp =) 0.3 0.347368	0.0564088 0.0681055 n of HTF M mbient temp oient temp oient temp oient temp 0.241845 0.292622	0.32578 Aass Flow mperature erature erature w cycle design 0.209054 0.252946	0.365623 Rate s for param 4 Ŵ cycle high 0.200307	0.110043 heter intera 0 °C 3.0 °C 55 °C Heat in low 0.3 0.347368	0.36681 actions with Impo Heat in design 0.3	0.440172 0.511052 th HTF m rt Heat in high 0.3 0.347368	Export W cooling low 1	V coolin design	opy g W		Paste m water low	Rows: m water design 1	n water high	20
323,158 328,947 rformance as Functio ww, design, and high a Low amb Design amb High amb HITF mass flow rate (at ambient temp	0.0564088 0.0681055 0.000777 n of HTF M mbient temp oient temp oient temp oient temp 0.241845 0.292622 0.345525	0.32578 Aass Flow mperature erature erature w cycle design 0.209054 0.252946	0.365623 Rate s for param 4 W cycle high 0.200307 0.242363 0.28618	0.110043 heter intera 0 °C 3.0 °C 55 °C Heat in low 0.3 0.347368	0.36681 actions with Impo Heat in design 0.3 0.347368 0.394737	0.440172 0.511053 th HTF m rt Heat in high 0.3 0.347368 0.394737	ass flow rate: Export W cooling low 1 1	V coolin design	opy g Ŵ 1 1		Paste m water low 1	Rows: mwater design 1	m water high 1	20
223.158 228.947 rformance as Functio ow, design, and high a Low amb Design amb High amb HTF mass flow rate (at ambient temp =) 0.3 0.347368 0.347477 0.442105	0.0564088 0.0681055 0.000777 n of HTF M mbient temp oient temp oient temp oient temp 0.241845 0.292622 0.345525	0.32578 Aass Flow mperature erature erature w cycle design 0.209054 0.252946 0.298676 0.346085	0.365623 Rate for param 4 W cycle high 0.200307 0.242363 0.28618 0.331606	0.110043 eter intera 0 °C 3.0 °C 55 °C Heat in low 0.3 0.347368 0.394737	0.36681 actions with Impo Heat in design 0.3 0.347368 0.394737 0.442105	0.440172 0.511053 th HTF m rt Heat in high 0.3 0.347368 0.394737 0.442105	ass flow rate: Export V cooling low 1 1 1	W coolin design	opy g W 1 1 1 1 1		Paste rin water low 1 1 1	Rows:	n water high 1 1 1	20
223.158 328.947 rformance as Functio ow, design, and high a Low amb Design amb High amb HTF mass flow rate (at ambient temp =) 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3	0.0564088 0.0681055 0.000777 n of HTF N mbient temp oient temp oient temp 0.241845 0.292622 0.345525 0.400371 0.457012 0.515323	0.32578 Aass Flow mperature erature erature w cycle design 0.209054 0.252946 0.298676 0.346085	0.365623 Rate s for param 4 W cycle high 0.20307 0.242363 0.331606 0.378519 0.426815	0.110043 neter intera 0 °C 3.0 °C 55 °C Heat in low 0.3 0.347368 0.394737 0.442105	0.36681 actions with Impo Heat in design 0.3 0.347368 0.394737 0.442105 0.489474 0.536842	0.440172 a 511073 th HTF m Heat in high 0.3 0.347368 0.394737 0.442105 0.489474 0.536842	Export V cooling low 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	W coolin design 1 1 1	ору g W 1 1 1 1 1 1 1		Paste miwater low 1 1 1	Rows:	1	20

User Defined Power Cycle

Jser Define	d Power Cycle Desi	gn Paramete	ers									
	Ambient ten	nperature		43 °C	Gross	power co	nsumed by c	ooling syste	m	0 %		
	Cooling system wa	ter usage		0 kg/s	Gross	power co	nsumed by c	ooling syste	m 🗌	0.0 MWe	2	
						_						-
	e as Function of HT				and Ambien	t lempera	ture					
Low, desig	n, and high paramet	er values for i	input ger	eration:								
Lo	w HTF temperature		300 °C	Low r	normalized H	TF m	0.3	L	ow an	nbient temperature	0	*c
Desi	gn HTF temperature	39	91.0 °C	Design r	normalized H	TE m	1.0	Des	ian an	bient temperature	43.0]•c
	gh HTF temperature		410 °C	-	normalized H		1.2		-	bient temperature	55	
- Di	gn mir temperature		410 C	High r	iormalizeu H		1.2		ign an	ibient temperature] •
	Number of levels		20		Number of I	evels	20			Number of levels	20	1
	annoer er revela						20				20	1
1	Generate Inputs	Import		Export	Сору	P	aste R	ows:	180			
		. ·				_						
		HTF Temp.	HTF m	Ambient Terr		Heat in			^			
		300 305.789	0.3	43 43		0.021429		1				
		305.789	0.3	43		0.039151 0.056874		1				
		317.368	0.3	43		0.030874		1				
		323.158	0.3	43		0.09232		1				
		328.947	0.3	43		0.110043		1				
		334.737	0.3	43		0.127766		1				
		340.526	0.3	43		0.145489		1				
		346.316	0.3	43		0.163212		1				
		352.105	0.3	43	0.117489	0.180934	1	1				
		357.895	0.3	43	0.130457	0.198657	1	1				
		363.684	0.3	43	0.143663	0.21638	1	1				
		369.474	0.3	43	0.157104	0.234103	1	1				
		375.263	0.3	43		0.251826		1				
		381.053	0.3	43		0.269549		1				
		386.842	0.3	43		0.287272		1				
		392.632	0.3	43		0.304995		1				
		398.421	0.3	43		0.322718		1				
		404.211	0.3	43		0.34044		1				
		410	0.3	43		0.358163		1				
		300 305,789	1	43 43		0.071429		1				
		305.789	1	43		0.130505 0.189581		1				
		317.368	1	43		0.189581		1				
		323 158	1	45		0.246037		1				

Simplify UDPC

- If the user already has the three tables from before:
 - Six low and high independent values can be input above the table (initially empty)
 - The number of independent values can be chosen, with the total number of rows calculated
 - The HTF Temp., HTF m, and Ambient Temp. columns then populate
 - Serves as:
 - a guide for copy and pasting from their original tables
 OR
 - inputs to their parametric model run

User Defined Power Cycle 🗸

efined Power Cycle De	sign Paramete	rs								
Ambient te	mperature		43 °C	Gross	power con	sumed by c	ooling syste	m	0	%
Cooling system w	ater usage		0 kg/s	Gross	power con	sumed by c	ooling syste	m	0.0	MWe
					_					-
nance as Function of H				d Ambient	lemperat	ure				
design, and high parame	eter values for i	input gen	eration:							
Low HTF temperatur	e	300 °C	Low nor	malized HT	Fm	0.3	L	ow ambient ter	npera	ture 0 *
Design HTF temperatur	e 39	91.0 °C	Design nor	malized HT	Fm	1.0	Desi	gn ambient ter	npera	ture 43.0 °
High HTF temperatur	e .	410 °C	High nor	malized HT	Fm	1.2	Hi	gh ambient ter	npera	ture 55 °
			3					- -		
Number of level	s	20	No	umber of le	vels	20		Numbe	r of le	vels 20
Generate Inputs	Import		Export	Сору	Pa	ite R	ows:	180		
	HTF Temp.	HTF m	Ambient Temp.	Ŵ cycle	Heat in	Ŵ cooling	rh water	^		
	300	0.3	43	0.012392	0.021429	1	1			
	305.789	0.3	43	0.022968	0.039151	1	1			
	311.579	0.3	43	0.033834	0.056874	1	1			
	317.368	0.3	43	0.044983	0.074597	1	1			
	323.158	0.3	43	0.056409	0.09232	1	1			
	328.947	0.3	43	0.068106	0.110043	1	1			
	334.737	0.3	43	0.080067	0.127766	1	1			
	340.526	0.3	43	0.092289	0.145489	1	1			
	346.316	0.3	43	0.104764	0.163212	1	1			
	352.105	0.3	43	0.117489	0.180934	1	1			
	357.895	0.3	43	0.130457	0.198657	1	1			
	363.684	0.3	43	0.143663	0.21638	1	1			
	369.474	0.3	43	0.157104	0.234103	1	1			
	375.263	0.3	43	0.170774	0.251826	1	1			
	381.053	0.3	43	0.184668	0.269549	1	1			
	386.842	0.3	43	0.198783	0.287272	1	1			
	392.632	0.3	43	0.213114	0.304995	1	1			
	398.421	0.3	43	0.227657	0.322718	1	1			
	404.211	0.3	43	0.242407	0.34044	1	1			
	410	0.3	43	0.257362	0.358163	1	1			
	300	1	43	0.059275	0.071429	1	1			
	305.789	1	43	0.109867	0.130505	1	1			
	311.579	1	43	0.161843	0.189581	1	1			
	317.368	1	43	0.215174	0.248657	1	1			
	222 150	1	42	0 260920	0 207724		1			

Unit Testing



- A GoogleTest case has been added for the physical trough model
 - Continual, automated value checks for known working code
 - Verify functions perform as designed

C:\Users\mboyd\Documents\SAM\sam_dev\ssc\build_vs2017\x64\Release\test.exe	-	×
<pre>[OK] windPowerCalculatorTest.windPowerUsingResource lib_windwatts (0 ms) [RUN] windPowerCalculatorTest.windPowerUsingWeibull_lib_windwatts [OK] windPowerCalculatorTest.windPowerUsingWeibull_lib_windwatts (0 ms) [] 2 tests from windPowerCalculatorTest (5 ms total)</pre>		^
<pre>[] 1 test from CMPvwattsV5Integration [RUM] CMPvwattsV5Integration.DefaultNoFinancialModel [OK] CMPvwattsV5Integration.DefaultNoFinancialModel (231 ms) [] 1 test from CMPvwattsV5Integration (232 ms total)</pre>		
<pre>[] 1 test from UsingFileCaseWeatherReader [RUN] UsingFileCaseWeatherReader.IntegrationTest_csp_solver_core [OK] UsingFileCaseWeatherReader.IntegrationTest_csp_solver_core (192 ms) [] 1 test from UsingFileCaseWeatherReader (194 ms total)</pre>		
<pre>[] 1 test from UsingDataCaseWeatherReader [RUN] UsingDataCaseWeatherReader.IntegrationTest_csp_solver_core [OK] UsingDataCaseWeatherReader.IntegrationTest_csp_solver_core (17 ms) [] 1 test from UsingDataCaseWeatherReader (19 ms total)</pre>		
<pre>[] 1 test from PhysicalTroughTest/computeModuleTest [RUM] PhysicalTroughTest/computeModuleTest.RunSimulationTest/0 [OK] PhysicalTroughTest/computeModuleTest.RunSimulationTest/0 (28760 ms) [] 1 test from PhysicalTroughTest/computeModuleTest (28762 ms total)</pre>		
<pre>[] 2 tests from WindPowerIntegrationTest/computeModuleTest [RUN] WindPowerIntegrationTest/computeModuleTest.RunSimulationTest/0 [OK] WindPowerIntegrationTest/computeModuleTest.RunSimulationTest/0 (489 ms) [RUN] WindPowerIntegrationTest/computeModuleTest.RunSimulationTest/1 -</pre>		~

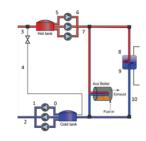
Help File

- SAM Help has been updated:
 - 'Physical Trough Model' section
 - Definitions of new input and output variables
 - For new functionality:
 - Descriptions
 - Equations
 - Diagrams

sgs_lengths [m]

The custom specified thermal energy storage and power block pipe section lengths. The values are utilized if the parameter custom <u>sgs_pipe</u> sizes is set to true. The number of length values needs to match the number of pipe sections. Lengths at indices 0, 1, 5 and 6 are the summed lengths of the multiple individual pump sections. The default values are (0, 90, 100, 120, 0, 0, 0, 80, 120, 80), in meters.

Number	From	То
0	Cold thermal storage tank	Individual solar field (SF) pump inlet
1	Individual SF pump discharge	SF pump discharge header
2	SF pump discharge header	SFrunners
3	SF runners	Hot thermal storage tank
4	SFrunners	Cold thermal storage tank
5	Steam generator system (SGS) pump suction header	Individual SGS pump inlet
6	Individual SGS pump discharge	SGS pump discharge header
7	SGS pump discharge header	Steam generator supply header
8	Steam generator supply header	Inter-steam generator piping
9	Inter-steam generator piping	Steam generator outlet header
10	Steam generator outlet header	Cold thermal storage tank

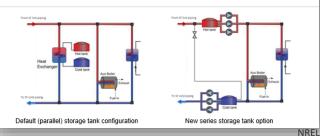


sgs_wallthicks [m]

The custom specified thermal energy storage and power block pipe wall thicknesses. The values are utilized if the parameter custom_sgs_pipe_sizes is set to true. The number of wall thickness values needs to match the number of pipe sections.

tanks_in_parallel [-]

Whether the thermal energy storage tank are in parallel with the field or in series with the field. Tanks in series with the field are specific to direct storage systems as in this configuration the field heat transfer fluid passes through the tanks before entering and after leaving the power block. The default value is false.





Thank you

www.nrel.gov

Questions -> matthew.boyd@nrel.gov

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