

SAS Institute Inc. World Headquarters SAS Campus Drive Cary, NC 27513 Tel: 919.677.8000 Fax: 919.677.4444 www.jmp.com

Statistical Discovery.™ From SAS.

Example of a complex design combining 4 types of factors with additional constraints including the mixture proportion summing to less than 1, i.e. some component(s) held constant in the blend

The number of each type of design factor:

- 6 mixture
- 2 continuous
- 1 nominal (categorical)
- 1 blocking (limited to 8 trials per day).

The factors and their ranges/levels are:

1. Bas	e	0.40	0.55	mixture
2. Fil	ler	0.20	0.40	mixture
3. X-1	inker	0.01	0.03	mixture
4. A-P	olymer	0.00	0.30	mixture
5. B-P	olymer	0.00	0.30	mixture
6. C-P	olymer	0.00	0.30	mixture
7. Cur	e Time	15	45	continuous
8. Tem	perature	140	160	continuous
9. Mix	er Brand	А	В	nominal
10.	Days	1 thr	ough 7	blocking

How the ranges and levels look entered in the Custom Design platform:

Factors				
Add Factor 🖌 Remov	e Add N Factors	1		
Name	Role	Changes	Values	
4 Base	Mixture	Easy	0.4	0.55
1 Filler	Mixture	Easy	0.2	0.4
X-Linker	Mixture	Easy	0.01	0.03
A-Polymer	Mixture	Easy	0	0.3
B-Polymer	Mixture	Easy	0	0.3
C-Polymer	Mixture	Easy	0	0.3
Time	Continuous	Easy	15	45
1 Temp	Continuous	Easy	140	160
🖊 Mixer	Categorical	Easy	Brand-A	Brand-B
Davs	Blocking	Fasy	1 2 3 4	5 6 7

Additional Constraint: Base + Filler ≤ 0.7 How the constraint looks entered into JMP.

Ŷ	Define Factor Constraints	
	Add Constraint	
	1 Base + 1 Filler + 0 X-Linker + 0 A-Polymer + 0 B-Polymer + 0 C-Polymer + 0 Time + 0 Temp ≤ • 0.7	

Sum of all mixture components = 0.98 (balance of blend being held constant at 2%)

Where to find the **Mixture Sum** option – Pull down hot spot menu on **Custom Design** and choose **Advanced Options** > **Mixture Sum**

1	1MD / (505) -1	DOE- Cu	tom F	ecian													
File	Edit	Tablec	Doll- Cu	Cole		Juza	Graph	Toola	View	Wie	dow	Hala						
File	Euli		- ROWS	COIS			: Graph	10015										
1		ğ 📕		1	È LL L	3 ?	'¢>+€	₩ (!!!)	<u>א</u> א	<u>م</u>	+		5 4	$\hat{v} \in$	기	seala	ant-factors	
F	JMP :	Starter																_ [
	DOE-	Custor	n Desigi	1														
15	(The second sec	lietan	Decid	10														
Π	L s	iave Res	ponses															
	۰.	oad Res	ponses															
	s	iave Fac	tors				tore	1										
	L	oad Fac	tors															
	9	iave Con	straints					Char	iges	Valu	Jes							
	-	oad Con	straints			e		Easy	,	0.4						0.5	55	
		et Dand	om Seed			e		Easy	1	0.2						0.4	4	
	-	seudete i		_		e		Easy		0.01						10.0)3	
	-	imulate i	Response	5		e		Easy	,	0						0.3	3	
	5	ave X M	atrix			e		Easy	,	0						0.3	3	
	C)ptimality	/ Criterior	1		re i		Easy	,	0						0.3	3	
	N	lumber o	f Starts			nu	ous	Easy	'	15	<u> </u>					45	-	
	A	dvanced	d Options			<u>ا_</u> د	Search P	oints Per	Factor		<u> </u>					16	0	
		ave Scri	pt to Scrip	ot Wind	ow	_	Mixture S	Sum			Use t	his op	tion w	vhen	you v	vant t	to express	the _
		Days			BIC	C	Split Plot	Variance	e Ratio		l sum o I mixtu	re tot	ne ing al is ti	gredie he su	ents ti im of .	o be (all the	other than e ingredier	1. The
	~ D	efine	Factor	Con	straints	5	Prior Par	ameter \	'ariance	:	amou	nts.					o ingrodior	
	A	dd Const	raint			_												
		1	Base +		1 Fille	r + [0	X-Lini	ker +		0	A-Po	lymei	r + [0	B-Polym	er +
	▼ M	odel																

Selecting the **Mixture Sum** option brings up the following dialog:

🕴 Mixture Amount Dialog	
Choose a number greater than zero for the sum of all the mixture components.	OK Cancel

Change the default sum of 1 as shown above to 0.98 as shown at top of next page:

ŧ	Mixture Amount Dialog	
	Choose a number greater than zero for the sum of all the mixture components.	0.98
		OK Cancel

Model in this case is defined to be all 2^{nd} order interactions among all factors except the blocking factor, Days. (Full 48 term model is not shown.)

Define Facto	or Constrain	ts				
Model						
Main Effects	Interactions 👻	Cross	Powers 🗸	Scheffe Cubic	Remove Term	
Name			Es	timability		
Base			Nec	essary		
Filler			Nec	essary		
X-Linker			Nec	essary		
A-Polymer			Nec	essary		
B-Polymer			Nec	essary		
C-Polymer			Nec	essary		
Days			Nec	essary		
Base*Filler			Nec	essary		
Base*X-Linker			Nec	essary		-

The design **Number of Runs:** choice for the **Design Generation** is shown below. The minimum design size, 48, would take six days to run if only 8 trials can be run each day and have zero degrees of freedom for estimating model error. The choice of 56 trials adds one more day but also 8 degrees of freedom for estimating model error. A choice of 64 would have added another day but would have yielded 16 degrees of freedom for model error estimation.

🕈 🖻 Custom Design		<u>-</u>						
Design Generat	tion							
Group runs into random blocks of size:								
Number of Runs:								
🔘 Minimum	48							
 Default 	88							
 User Specified 	56							
Make Design		-						
•		► I						

The first 28 trials of the resulting design are shown prior to data table generation:

' 🖻 Custo	om Desigr	า								
▼ Desig	n									
Run	Base	Filler	X-Linker	A-Polymer	B-Polymer	C-Polymer	Time	Temp	Mixer	Days
1	0.4	0.2	0.38	0	0	0	15	140 8	Brand-A	1
2	0.4	0.2	0.183662	0	0.196338	0	45	140 8	Brand-A	1
3	0.5	0.2	0.01	0	0	0.27	15	160 8	Brand-A	1
4	0.4	0.2	0.01	0	0	0.37	45	160 8	Brand-A	1
5	0.465539	0.234461	0.01	0	0.27	0	45	140 E	3rand-B	1
6	0.4	0.240766	0.01	0	0.138156	0.191078	45	140 E	3rand-B	1
7	0.4	0.2	0.01	0.1832	0	0.1868	15	160 E	3rand-B	1
8	0.466962	0.2	0.313038	0	0	0	45	160 E	3rand-B	1
9	0.4	0.2	0.01	0.37	0	0	15	140 8	Brand-A	2
10	0.5	0.2	0.28	0	0	0	45	140 8	Brand-A	2
11	0.4	0.2	0.01	0.166739	0.203261	0	45	140 8	Brand-A	2
12	0.443658	0.2	0.01	0.144422	0	0.18192	45	140 8	Brand-A	2
13	0.5	0.2	0.28	0	0	0	15	160 8	Brand-A	2
14	0.4	0.2	0.188751	0	0	0.191249	15	160 8	Brand-A	2
15	0.4	0.239609	0.156895	0.183496	0	0	45	160 E	3rand-B	2
16	0.5	0.2	0.01	0.27	0	0	45	160 E	3rand-B	2
17	0.5	0.2	0.01	0.27	0	0	15	140 8	Brand-A	3
18	0.4	0.2	0.01	0	0	0.37	15	140 8	Brand-A	3
19	0.4	0.256603	0.01	0	0.313397	0	45	140 8	Brand-A	3
20	0.5	0.2	0.01	0	0.27	0	45	160 8	Brand-A	3
21	0.4	0.2	0.01	0	0.37	0	15	140 E	3rand-B	3
22	0.440827	0.259173	0.01	0	0	0.27	15	140 E	3rand-B	3
23	0.4	0.2	0.01	0.37	0	0	45	140 E	3rand-B	3
24	0.4	0.3	0.01	0	0	0.27	45	160 E	3rand-B	3
25	0.4	0.3	0.106214	0.173786	0	0	15	160 8	Brand-A	4
26	0.4	0.2	0.01	0	0.37	0	15	160 8	Brand-A	4
27	0.4	0.256442	0.198511	0	0	0.125047	45	160 8	Brand-A	4
28	0.4	0.3	0.01	0	0.27	0	15	140 E	3rand-B	4

Note that the mixture components all sum to 0.98 and that the sum of Filler + Base never exceeds 0.7.

										_ [] >
•	Base	Filler	X-Linker	A-Polymer	B-Polymer	C-Polymer	Time	Temp	Mixer	Days
1	0.4	0.2	0.38	0	0	0	15	140	Brand-A	1
2	0.4	0.2	0.18366223	0	0.19633777	0	45	140	Brand-A	1
3	0.5	0.2	0.01	0	0	0.27	15	160	Brand-A	1
4	0.4	0.2	0.01	0	0	0.37	45	160	Brand-A	1
5	0.46553933	0.23446067	0.01	0	0.27	0	45	140	Brand-B	1
6	0.4	0.24076605	0.01	0	0.13815617	0.19107779	45	140	Brand-B	1
7	0.4	0.2	0.01	0.18319955	0	0.18680045	15	160	Brand-B	1
8	0.4669621	0.2	0.3130379	0	0	0	45	160	Brand-B	1
9	0.4	0.2	0.01	0.37	0	0	15	140	Brand-A	2
10	0.5	0.2	0.28	0	0	0	45	140	Brand-A	2
11	0.4	0.2	0.01	0.16673949	0.20326051	0	45	140	Brand-A	2
12	0.44365782	0.2	0.01	0.14442176	0	0.18192042	45	140	Brand-A	2
13	0.5	0.2	0.28	0	0	0	15	160	Brand-A	2
14	0.4	0.2	0.18875126	0	0	0.19124874	15	160	Brand-A	2
15	0.4	0.23960903	0.15689504	0.18349593	0	0	45	160	Brand-B	2
16	0.5	0.2	0.01	0.27	0	0	45	160	Brand-B	2
17	0.5	0.2	0.01	0.27	0	0	15	140	Brand-A	3
18	0.4	0.2	0.01	0	0	0.37	15	140	Brand-A	3
19	0.4	0.25660292	0.01	0	0.31339708	0	45	140	Brand-A	3
20	0.5	0.2	0.01	0	0.27	0	45	160	Brand-A	3 -
21	0.4	0.2	0.01	0	0.37	0	15	140	Brand-B	3
22	0.44082723	0.25917277	0.01	0	0	0.27	15	140	Brand-B	3
23	0.4	0.2	0.01	0.37	0	0	45	140	Brand-B	3
24	0.4	0.3	0.01	0	0	0.27	45	160	Brand-B	3
25	0.4	0.3	0.10621373	0.17378627	0	0	15	160	Brand-A	4
26	0.4	0.2	0.01	0	0.37	0	15	160	Brand-A	4
27	0.4	0.25644236	0.19851088	0	0	0.12504676	45	160	Brand-A	4
28	0.4	0.3	0.01	0	0.27	0	15	140	Brand-B	4
29	0.4	0.2	0.38	0	0	0	45	140	Brand-B	4
30	0.4	0.3	0.01	0.27	0	0	45	140	Brand-B	4
31	0.4	0.3	0.28	0	0	0	15	160	Brand-B	4
32	0.44701901	0.2	0.01	0	0.0507747	0.27220629	15	160	Brand-B	4
33	0.4	0.3	0.28	0	0	0	15	140	Brand-A	5
34	0.4	0.2	0.16550298	0.21449702	0	0	45	140	Brand-A	5

After making the data table and sorting on the Days factor, one can see that each day consists of 8 unique trials.

Tom Donnelly, PhD Principal Customer Advocate Systems Engineer, JMP

SAS Federal LLC 27 Farmingdale Lane • Newark, DE 19711 • USA voice: 302.737.1650 • mobile: 302.489.9291 • fax: 919.677.4444 email: tom.donnelly@jmp.com