



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. Base	0.40	0.55	mixture
2. Filler	0.20	0.40	mixture
3. X-linker	0.01	0.03	mixture
4. A-Polymer	0.00	0.30	mixture
5. B-Polymer	0.00	0.30	mixture
6. C-Polymer	0.00	0.30	mixture
7. Cure Time	15	45	continuous
8. Temperature	140	160	continuous
9. Mixer Brand	A	B	nominal
10. Days	1 through 7		blocking

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

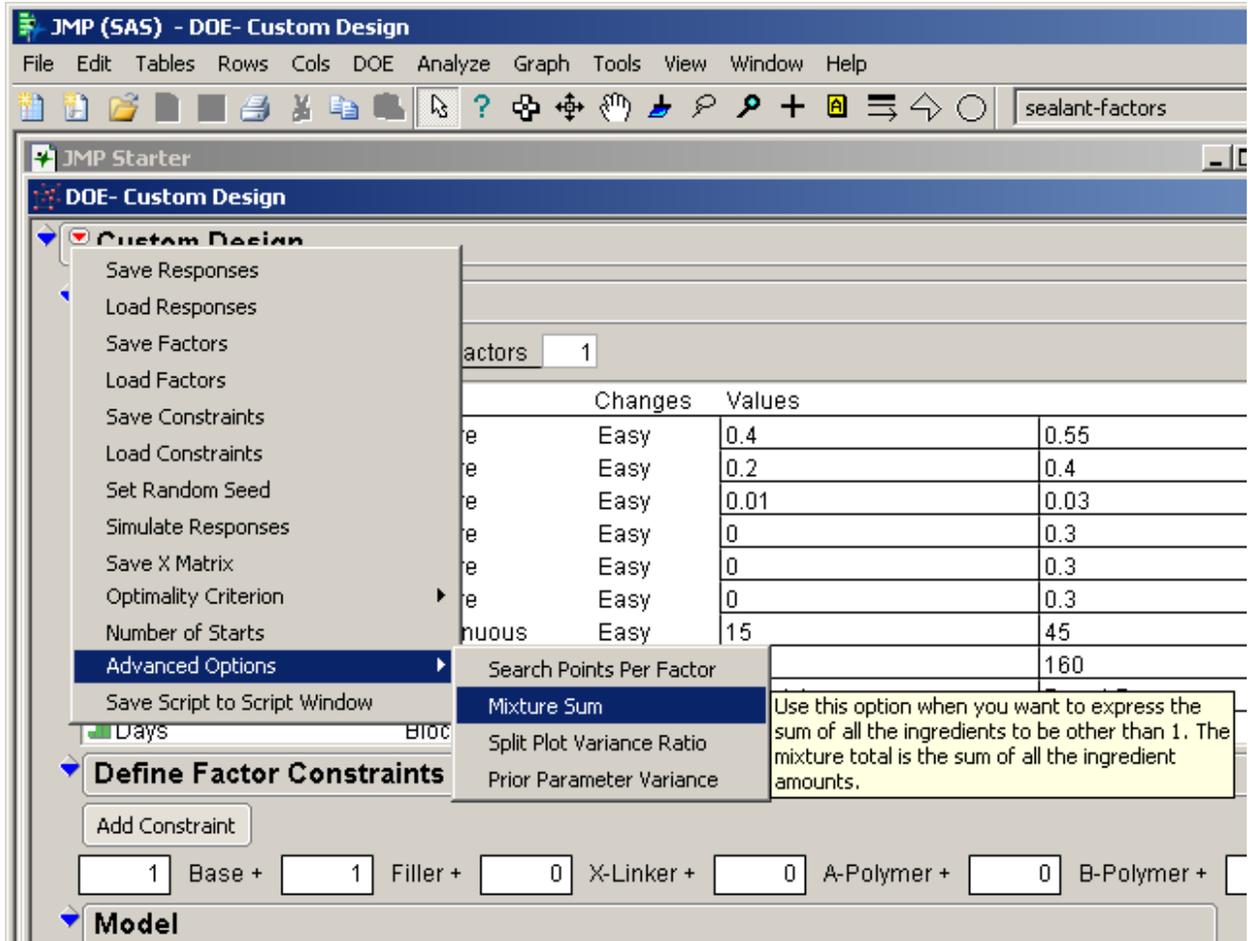
The screenshot shows the 'Custom Design' window in JMP. Under the 'Factors' section, there are buttons for 'Add Factor', 'Remove', and 'Add N Factors' (set to 1). Below is a table of factors:

Name	Role	Changes	Values
Base	Mixture	Easy	0.4 0.55
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
Temp	Continuous	Easy	140 160
Mixer	Categorical	Easy	Brand-A Brand-B
Days	Blocking	Easy	1 2 3 4 5 6 7

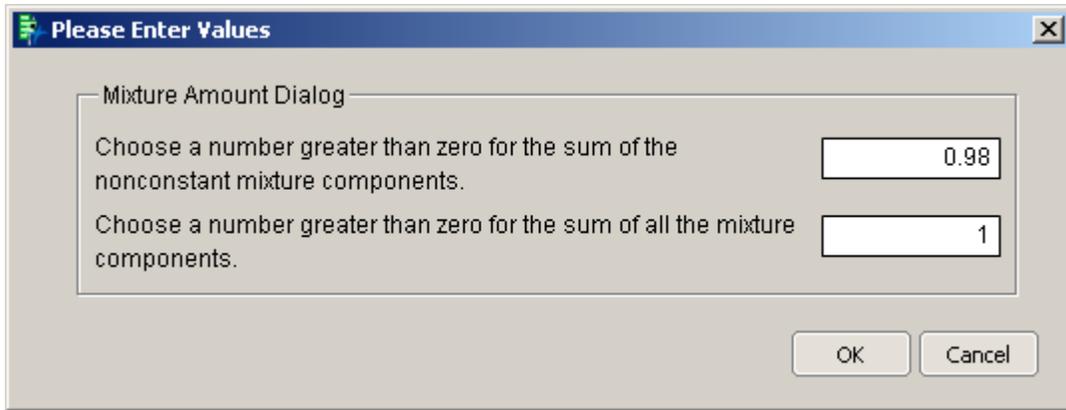
Additional Constraint:  $\text{Base} + \text{Filler} \leq 0.7$   
How the constraint looks entered into JMP.



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**

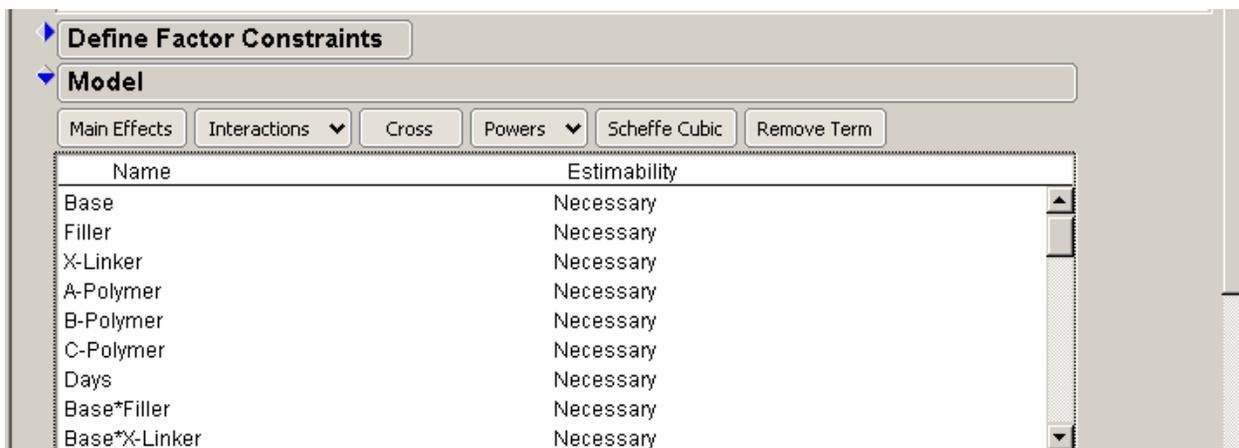


Selecting the **Mixture Sum** option brings up the following dialog:

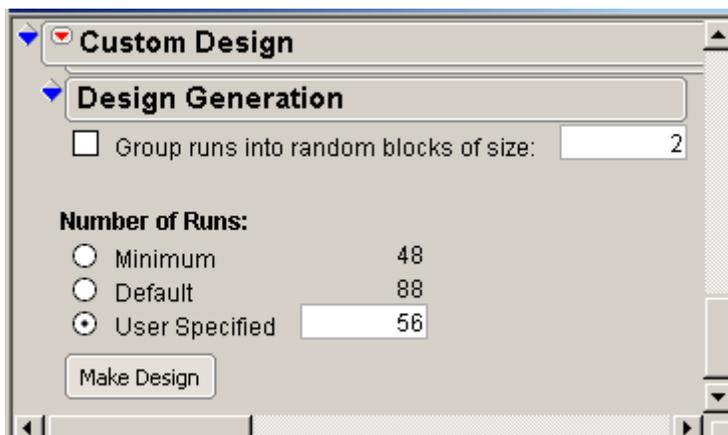


The reason for two boxes is that the top one is to set the mixture sum when some components are being held constant. The second box allows one to choose the units of the mixture. For example, if 100 is entered instead of 1, then the component levels should all be in percentages.

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



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.



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

Custom Design											
Design											
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	Brand-A	1	
2	0.4	0.2	0.183662	0	0.196338	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	0.465539	0.234461	0.01	0	0.27	0	45	140	Brand-B	1	
6	0.4	0.240766	0.01	0	0.138156	0.191078	45	140	Brand-B	1	
7	0.4	0.2	0.01	0.1832	0	0.1868	15	160	Brand-B	1	
8	0.466962	0.2	0.313038	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	0.166739	0.203261	0	45	140	Brand-A	2	
12	0.443658	0.2	0.01	0.144422	0	0.18192	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	0.188751	0	0	0.191249	15	160	Brand-A	2	
15	0.4	0.239609	0.156895	0.183496	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	0.256603	0.01	0	0.313397	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	0.440827	0.259173	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	0.106214	0.173786	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	0.256442	0.198511	0	0	0.125047	45	160	Brand-A	4	
28	0.4	0.3	0.01	0	0.27	0	15	140	Brand-B	4	

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

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

	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

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