The background of the slide is a photograph of a modern industrial manufacturing facility. It features several robotic workstations with prominent yellow and orange safety enclosures. Overhead, there are complex systems of cables and pneumatic lines. The lighting is bright and even, typical of a factory environment. The overall scene conveys a sense of advanced automation and precision engineering.

Case Study: Utilizing Quantum XL for Product Design with Multifactorial Parameters

Plackett-Burman Design for Development of Servo-hydraulic Power Units

by Ramon Balisnomo

May 4, 2026



History Behind Screening DOE

- The British Ministry of Supply asked **Robin Plackett** and **Peter Burman** to develop a method for efficient learning under severe experimental constraints. Their goal was to study many variables with very few experimental runs.
- They assumed **interaction effects were negligible**, allowing focus on main effects only.
- Oxford University Press published their journal **The Design of Optimal Multifactorial Experiments** in June 1946.

Background

Identify the design variables that most significantly impact system efficiency or pressure ripple during the early development of a servo-hydraulic power unit. The coefficient of determination must be at least 85 percent.



11 Design Variables

Factor	Variable (Typical Eaton Relevance)	Low (-1)	High (+1)
X1	Pump displacement (cc/rev)	18	24
X2	Pump rotational speed (rpm)	1800	2400
X3	System operating pressure (bar)	180	250
X4	Oil viscosity @ 40 °C (cSt)	32	68
X5	Valve spool land overlap (mm)	0.02	0.08
X6	Orifice diameter (mm)	1.2	1.8
X7	Case drain back-pressure (bar)	0.5	2.0
X8	Electrical supply voltage (V)	22	28
X9	Solenoid coil resistance (Ω)	6	10
X10	Ambient temperature ($^{\circ}\text{C}$)	0	40
X11	Internal leakage clearance (μm)	8	14



QXL DOE >Create Design >Create Plackett-Burman Design

Create Design ▾

Modify Design ▾

Analyze Design ▾
Optimize Design ▾

Modeling

Create 2-Level Factorial Design

Create 3-Level Factorial Design

Create N-Level Factorial Design

Create CCD Design

Create Box-Behnken Design

Screening

Create Plackett-Burman Design

Create Taguchi Design

Special

Setup Historical Analysis

Create Custom Design

Create D-Optimal Design

Import

Import From DOE PRO XL

Plackett-Burman Design

Select Plackett-Burman design

Select number of factors:

Select number of runs:

Help

Cancel

Next >

Finish



QXL DOE >Create Design >Create Plackett-Burman Design

Create Design ▾ | Modify Design ▾ | Analyze Design ▾ | Optimize Design ▾

Modeling

- Create 2-Level Factorial Design
- Create 3-Level Factorial Design
- Create N-Level Factorial Design
- Create CCD Design
- Create Box-Behnken Design

Screening

- Create Plackett-Burman Design
- Create Taguchi Design

Special

- Setup Historical Analysis
- Create Custom Design
- Create D-Optimal Design

Import

- Import From DOE PRO XL

Plackett-Burman Design

Enter Factor Names and Coding

For Quantitative Inputs enter the low and high values (e.g. low=10 high=20)
For Categorical Inputs enter the name of each level (e.g. Red,Blue)

Name	Low (or Name)	High (or Name)	Categorical
A	-1	1	<input type="checkbox"/>
B	-1	1	<input type="checkbox"/>
C	-1	1	<input type="checkbox"/>
D	-1	1	<input type="checkbox"/>
E	-1	1	<input type="checkbox"/>
F	-1	1	<input type="checkbox"/>
G	-1	1	<input type="checkbox"/>
H	-1	1	<input type="checkbox"/>
I	-1	1	<input type="checkbox"/>

Help

Cancel

< Back

Next >

Finish



QXL DOE >Create Design >Create Plackett-Burman Design

Create Design ▾ | Modify Design ▾ | Analyze Design ▾ | Optimize Design ▾

Modeling

- Create 2-Level Factorial Design
- Create 3-Level Factorial Design
- Create N-Level Factorial Design
- Create CCD Design
- Create Box-Behnken Design

Screening

- Create Plackett-Burman Design
- Create Taguchi Design

Special

- Setup Historical Analysis
- Create Custom Design
- Create D-Optimal Design

Import

- Import From DOE PRO XL

Plackett-Burman Design

Enter Factor Names and Coding

For Quantitative Inputs enter the low and high values (e.g. low=10 high=20)
For Categorical Inputs enter the name of each level (e.g. Red,Blue)

Name	Low (or Name)	High (or Name)	Categorical
Viscosity	32	68	<input type="checkbox"/>
Overlap	.02	.08	<input type="checkbox"/>
Office	1.2	1.8	<input type="checkbox"/>
BackPressure	0.5	2	<input type="checkbox"/>
Voltage	22	28	<input type="checkbox"/>
CoilResistance	6	10	<input type="checkbox"/>
Temperature	0	40	<input type="checkbox"/>
Clearance	8	14	<input type="checkbox"/>

Help

Cancel

< Back

Next >

Finish

4 Response Variables

Measure the following performance metrics per run:

Y_1 : Overall system efficiency (%)

Y_2 : Pressure ripple amplitude (bar RMS)

Y_3 : Valve response time (ms)

Y_4 : Power loss / heat generation (W)



QXL DOE > Create Design > Create Plackett-Burman Design

Create Design ▾ | Modify Design ▾ | Analyze Design ▾ | Optimize Design ▾

Modeling

- Create 2-Level Factorial Design
- Create 3-Level Factorial Design
- Create N-Level Factorial Design
- Create CCD Design
- Create Box-Behnken Design

Screening

- Create Plackett-Burman Design
- Create Taguchi Design

Special

- Setup Historical Analysis
- Create Custom Design
- Create D-Optimal Design

Import

- Import From DOE PRO XL

Plackett-Burman Design

Define outputs (responses)

Select number of outputs:

Weights and sample size columns are only available with stacked replicates

Name: Efficiency %	Type: Quantitative	<input type="checkbox"/> Has weights column
Name: Pressure Ripple bars	Type: Quantitative	<input type="checkbox"/> Has weights column
Name: Valve Response ms	Type: Quantitative	<input type="checkbox"/> Has weights column
Name: Power Loss W	Type: Quantitative	<input type="checkbox"/> Has weights column

Design format

Table
 Stacked

Help Cancel < Back Next > Finish



QXL DOE > Create Design > Create Plackett-Burman Design

Create Design ▾ | Modify Design ▾ | Analyze Design ▾ | Optimize Design ▾

Modeling

- Create 2-Level Factorial Design
- Create 3-Level Factorial Design
- Create N-Level Factorial Design
- Create CCD Design
- Create Box-Behnken Design

Screening

- Create Plackett-Burman Design
- Create Taguchi Design

Special

- Setup Historical Analysis
- Create Custom Design
- Create D-Optimal Design

Import

- Import From DOE PRO XL

Plackett-Burman Design

Enter number of replicates and number of blocks

Replicates

Select number of replicates:

Help Me Choose Power/Sampling

Select number of blocks:

Block Design

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Help Cancel < Back Finish

Quantum XL

Plackett-Burman Design

11 Factors in 12 Runs

Number of replicates: 3

Run	A	B	C	D	E	F	G	H	I	J	K
	Pump_Displacement	Speed	Pressure	Viscosity	Overlap	Orifice	BackPressure	Voltage	CoilResistance	AmbientTemp	Clearance
1	24	2400	180	68	0.08	1.8	0.5	22	6	40	8
2	18	2400	250	32	0.08	1.8	2	22	6	0	14
3	24	1800	250	68	0.02	1.8	2	28	6	0	8
4	18	2400	180	68	0.08	1.2	2	28	10	0	8
5	18	1800	250	32	0.08	1.8	0.5	28	10	40	8
6	18	1800	180	68	0.02	1.8	2	22	10	40	14
7	24	1800	180	32	0.08	1.2	2	28	6	40	14
8	24	2400	180	32	0.02	1.8	0.5	28	10	0	14
9	24	2400	250	32	0.02	1.2	2	22	10	40	8
10	18	2400	250	68	0.02	1.2	0.5	28	6	40	14
11	24	1800	250	32	0.08	1.2	0.5	22	10	0	14
12	18	1800	180	32	0.02	1.2	0.5	22	6	0	8

USL				
LSL				
Efficiency %				
Y1	Y2	Y3	Y-bar	S
83.47	83.09	83.01	83.19	0.25
72.75	73.07	72.97	72.93	0.16
80.58	80.18	80.22	80.33	0.22
76.11	75.15	76.12	75.79	0.56
81.09	80.94	80.51	80.85	0.30
69.28	69.87	69.97	69.71	0.37
79.68	78.92	79.08	79.23	0.40
82.50	82.28	82.91	82.57	0.32
82.32	82.14	81.49	81.99	0.44
73.83	74.46	74.08	74.12	0.32
81.52	81.83	81.17	81.51	0.33
80.36	81.36	80.13	80.62	0.65

USL				
LSL				
Pressure Ripple bars				
Y1	Y2	Y3	Y-bar	S
6.80	6.78	6.77	6.78	0.01
6.10	6.07	5.98	6.05	0.06
2.98	2.99	3.06	3.01	0.05
4.26	4.28	4.33	4.29	0.04
4.98	5.00	5.01	4.99	0.02
3.54	3.64	3.53	3.57	0.06
2.83	2.82	2.84	2.83	0.01
4.46	4.45	4.56	4.49	0.06
3.10	3.10	3.08	3.09	0.01
2.68	2.59	2.64	2.63	0.05
3.04	3.11	3.04	3.06	0.04
0.83	0.86	0.85	0.85	0.02

USL				
LSL				
Valve Response ms				
Y1	Y2	Y3	Y-bar	S
47.20	48.91	48.36	48.16	0.88
47.73	42.36	46.55	45.55	2.83
33.64	36.62	34.11	34.79	1.60
42.41	44.76	40.99	42.72	1.90
47.16	46.93	45.05	46.38	1.16
51.65	55.48	53.80	53.64	1.92
40.17	39.68	40.44	40.10	0.39
47.57	40.13	47.56	45.09	4.29
50.17	53.29	53.87	52.45	1.99
38.16	37.64	40.25	38.68	1.38
47.02	51.01	50.81	49.61	2.25
42.35	42.03	40.71	41.69	0.87

USL				
LSL				
Power Loss W				
Y1	Y2	Y3	Y-bar	S
452.43	407.30	367.05	408.92	42.71
508.49	580.28	646.57	578.44	69.06
468.29	467.34	543.96	493.19	43.96
497.56	486.27	472.58	485.47	12.51
475.26	494.41	531.18	500.28	28.42
514.86	514.60	581.30	536.92	38.43
561.49	583.49	599.71	581.56	19.18
485.32	511.07	484.31	493.56	15.17
556.06	464.68	554.55	525.09	52.33
581.55	619.95	543.43	581.64	38.26
513.63	587.19	545.80	548.87	36.88
394.38	439.30	443.97	425.88	27.38



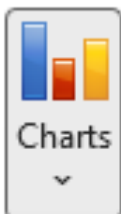
Analyze Design ▾

Run Regression

Uncoded Coefficients

Reduce Coded Model: QXL DOE >Analyze Design >Run Regression

Efficiency %						
Y-Hat						
Factor	Coeff	SE	T	P	VIF	In Model
Const	78.35	0.07	1170.71	0.00		<input type="checkbox"/>
Pump_Displacement (A)	2.68	0.07	39.98	0.00	1.04	<input checked="" type="checkbox"/>
Speed (B)						<input type="checkbox"/>
Pressure (C)	-0.17	0.07	-2.56	0.02	1.04	<input checked="" type="checkbox"/>
Viscosity (D)	-1.34	0.07	-17.95	0.00	1.25	<input checked="" type="checkbox"/>
Overlap (E)	0.12	0.07	1.85	0.07	1.04	<input checked="" type="checkbox"/>
Orifice (F)						<input type="checkbox"/>
BackPressure (G)	-1.68	0.07	-25.16	0.00	1.04	<input checked="" type="checkbox"/>
Voltage (H)	0.47	0.07	7.01	0.00	1.04	<input checked="" type="checkbox"/>
CoilResistance (I)						<input type="checkbox"/>
AmbientTemp (J)	-0.17	0.07	-2.48	0.02	1.04	<input checked="" type="checkbox"/>
Clearance (K)	-2.11	0.07	-31.60	0.00	1.04	<input checked="" type="checkbox"/>
R ²	0.99					
Adj R ²	0.99					



- Analysis**
- Pareto Regression Coefficients
- Interaction Plots
- Main Effects Plot
- Thumbnail Plot
- Surface And Contour Plot
- Regression Diagnostics**
- Residual Plots

Charts

Create Pareto report

Source for the plots: Efficiency % Y-Hat, Pressure Ripple bars Y-Hat, Valve Response ms Y-Hat, Power Loss W Y-Hat

Regression sheet 'Regression (2)' (Active)

- Efficiency %
 - Efficiency % Y-Hat
 - Efficiency % S-Hat
- Pressure Ripple bars
 - Pressure Ripple bars Y-Hat
 - Pressure Ripple bars S-Hat
- Valve Response ms
 - Valve Response ms Y-Hat
 - Valve Response ms S-Hat
- Power Loss W
 - Power Loss W Y-Hat
 - Power Loss W S-Hat

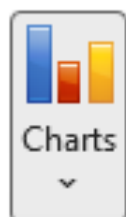
Regression sheet 'Regression'

- Efficiency %
 - Efficiency % Y-Hat
 - Efficiency % S-Hat
- Pressure Ripple bars
 - Pressure Ripple bars Y-Hat
 - Pressure Ripple bars S-Hat
- Valve Response ms
 - Valve Response ms Y-Hat
 - Valve Response ms S-Hat
- Power Loss W

Output

- Efficiency % Y-Hat
- Pressure Ripple bars Y
- Valve Response ms Y
- Power Loss W Y-Hat

Help



- Analysis**
- Pareto Regression Coefficients
- Interaction Plots
- Main Effects Plot
- Thumbnail Plot
- Surface And Contour Plot
- Regression Diagnostics**
- Residual Plots

Charts

Create Pareto report

Source for the plots: Efficiency % Y-Hat, Pressure Ripple bars Y-Hat, Valve Response ms Y-Hat, Power Loss W Y-Hat

Output	
Efficiency % Y-Hat	<input checked="" type="checkbox"/>
Pressure Ripple bars Y-Hat	<input checked="" type="checkbox"/>
Valve Response ms Y-Hat	<input checked="" type="checkbox"/>
Power Loss W Y-Hat	<input checked="" type="checkbox"/>

Number of bars

Display all coefficients

Display top coefficients

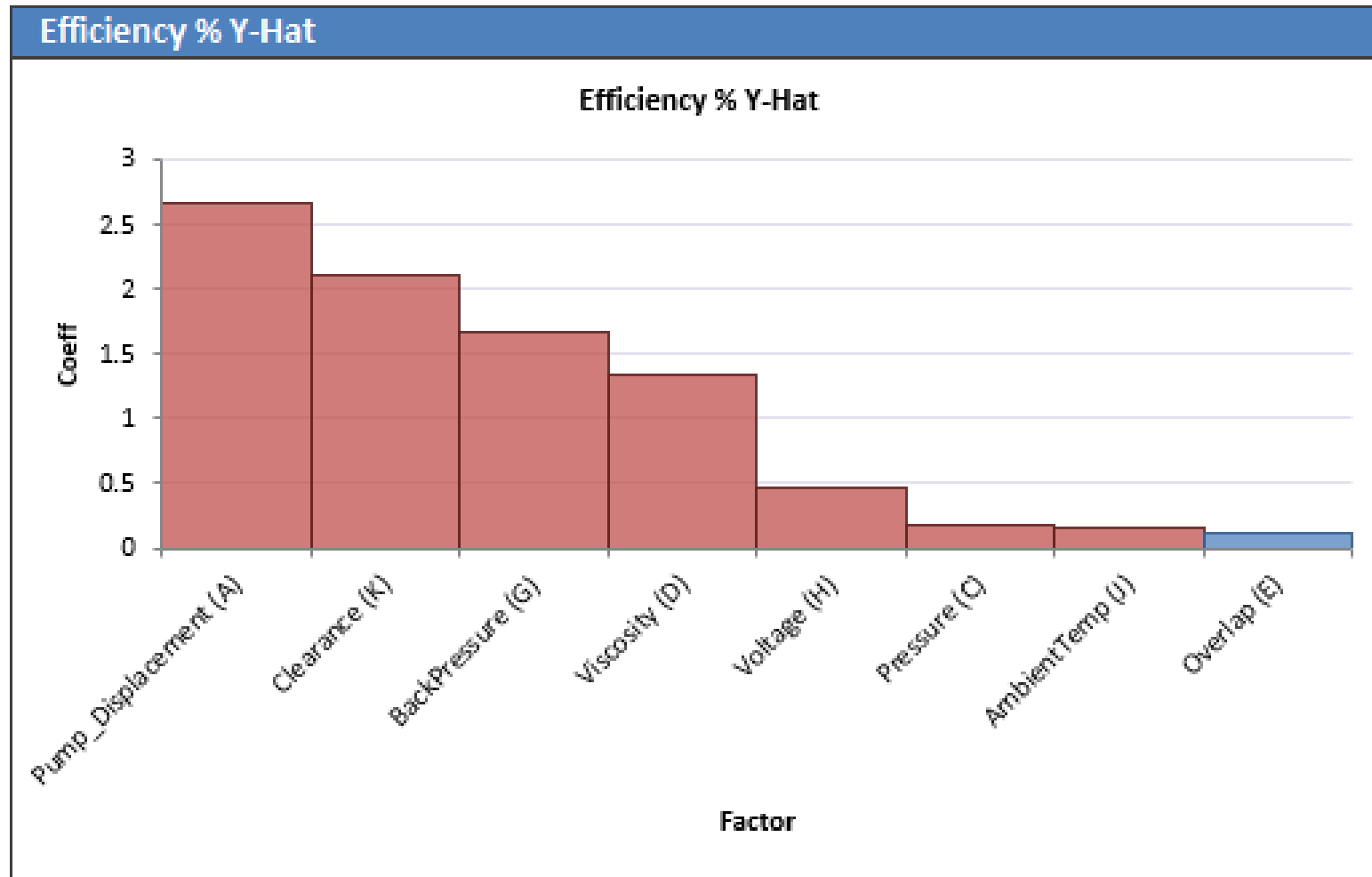
Display bars

Horizontally

Vertically

Help Close Create and don't exit Create and Exit

Pareto Analysis of Factor Influence for Each Response Variable



$R^2 = 99\%$



Analyze Design



Run Regression

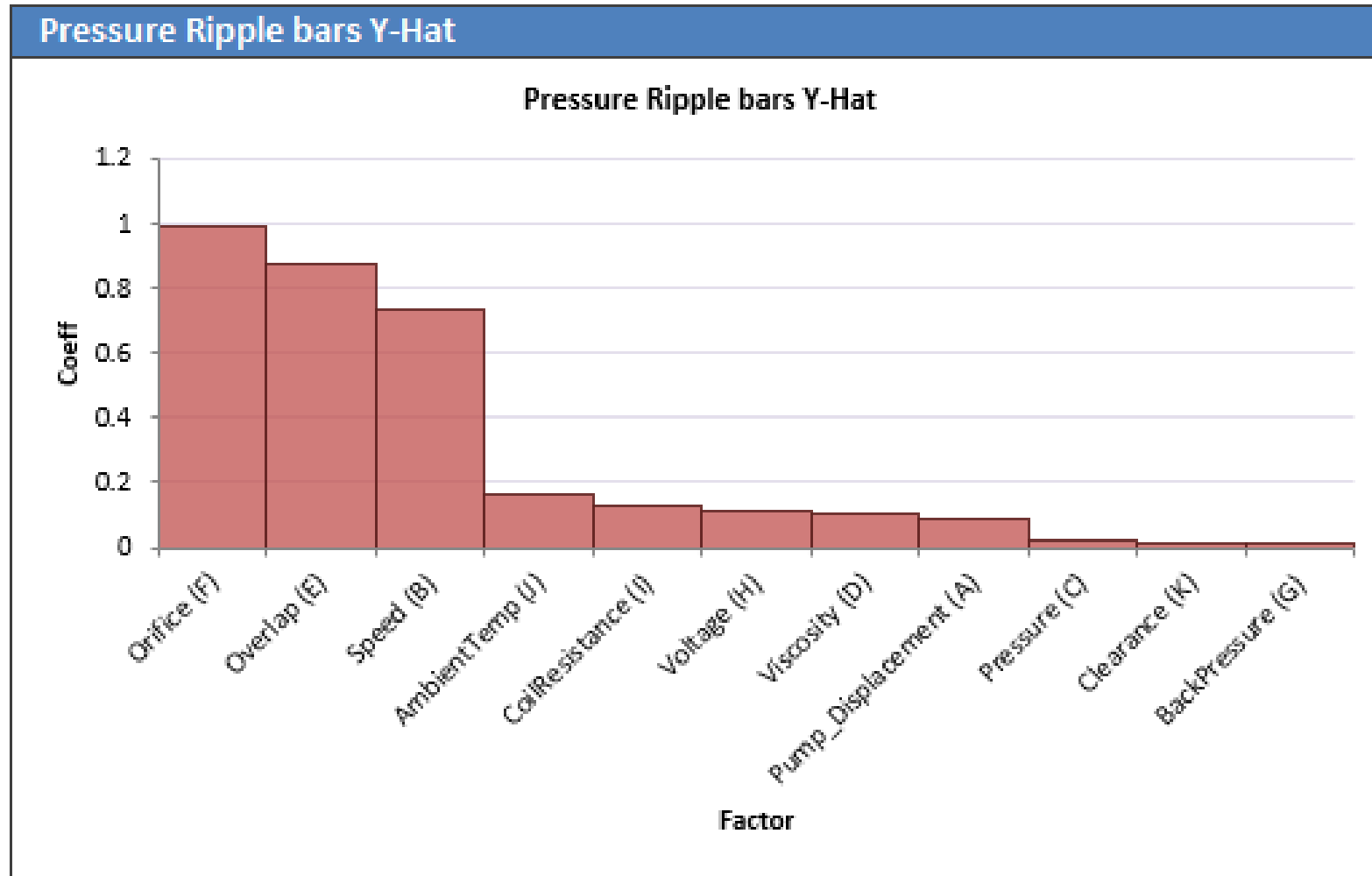


Uncoded Coefficients

Reduce Coded Model: QXL DOE >Analyze Design >Run Regression

Pressure Ripple bars						
Y-Hat						
Factor	Coeff	SE	T	P	VIF	In Model
Const	3.82	0.01	558.53	0.00		
Pump_Displacement (A)	0.09	0.01	13.28	0.00	1.04	<input checked="" type="checkbox"/>
Speed (B)	0.73	0.01	107.33	0.00	1.04	<input checked="" type="checkbox"/>
Pressure (C)	0.02	0.01	3.08	0.01	1.04	<input checked="" type="checkbox"/>
Viscosity (D)	0.10	0.01	13.02	0.00	1.40	<input checked="" type="checkbox"/>
Overlap (E)	0.88	0.01	128.77	0.00	1.04	<input checked="" type="checkbox"/>
Orifice (F)	0.99	0.01	145.32	0.00	1.04	<input checked="" type="checkbox"/>
BackPressure (G)	-0.01	0.01	-2.11	0.05	1.04	<input checked="" type="checkbox"/>
Voltage (H)	-0.11	0.01	-16.68	0.00	1.04	<input checked="" type="checkbox"/>
CoilResistance (I)	0.13	0.01	18.92	0.00	1.04	<input checked="" type="checkbox"/>
AmbientTemp (J)	0.16	0.01	23.70	0.00	1.04	<input checked="" type="checkbox"/>
Clearance (K)	-0.01	0.01	-2.13	0.04	1.04	<input checked="" type="checkbox"/>
R ²	1.00					
Adj R ²	1.00					

Pareto Analysis of Factor Influence for Each Response Variable



$R^2 = 100\%$



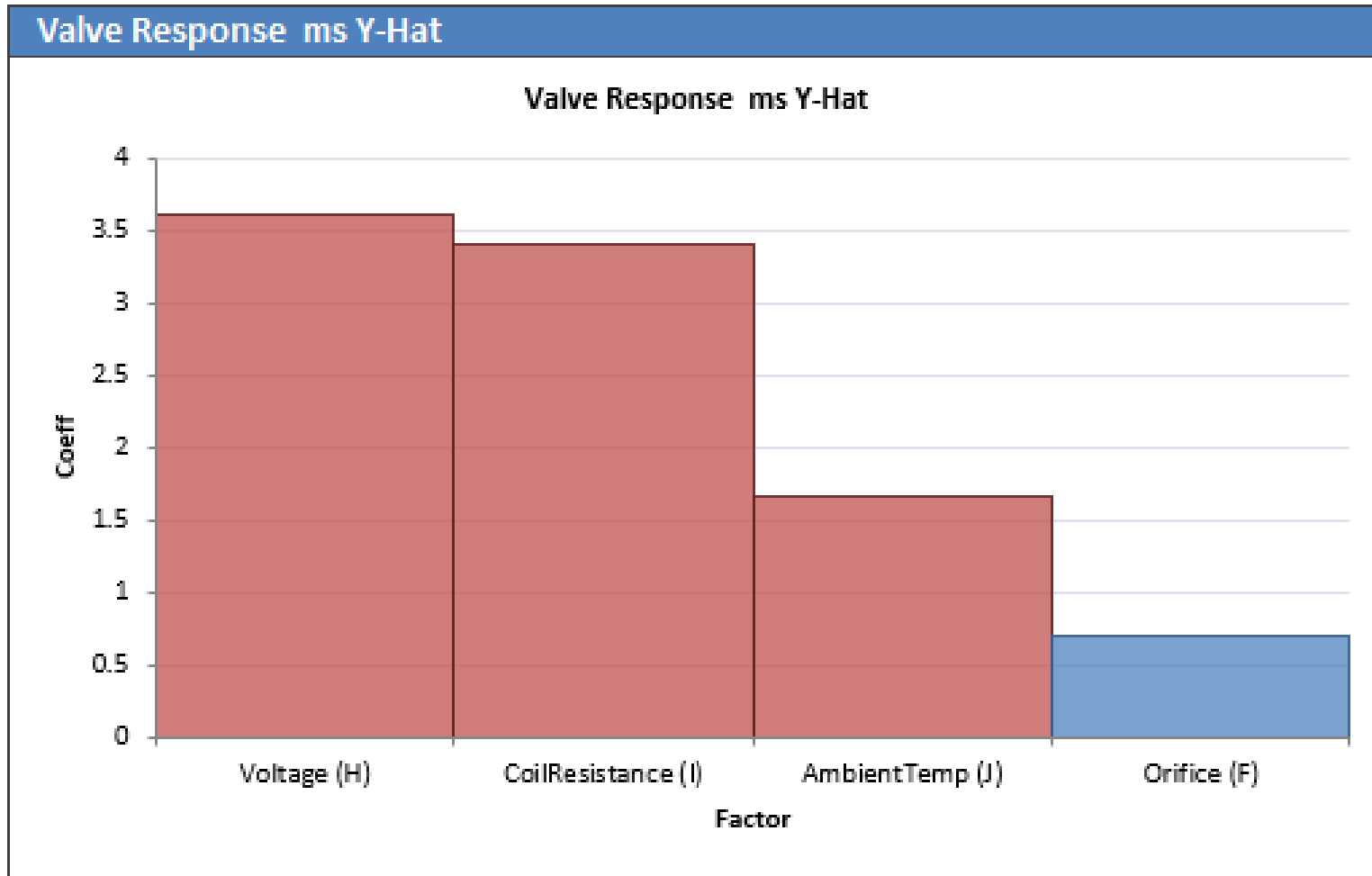
Reduce Coded Model: QXL DOE >Analyze Design >Run Regression

Run Regression

Uncoded Coefficients

Valve Response ms						
Y-Hat						
Factor	Coeff	SE	T	P	VIF	In Model
Const	44.90	0.35	127.42	0.00		<input type="checkbox"/>
Pump_Displacement (A)						<input type="checkbox"/>
Speed (B)						<input type="checkbox"/>
Pressure (C)						<input type="checkbox"/>
Viscosity (D)						<input type="checkbox"/>
Overlap (E)						<input type="checkbox"/>
Orifice (F)	0.70	0.35	1.97	0.06	1.00	<input checked="" type="checkbox"/>
BackPressure (G)						<input type="checkbox"/>
Voltage (H)	-3.61	0.35	-10.25	0.00	1.00	<input checked="" type="checkbox"/>
CoilResistance (I)	3.41	0.35	9.68	0.00	1.00	<input checked="" type="checkbox"/>
AmbientTemp (J)	1.66	0.35	4.72	0.00	1.00	<input checked="" type="checkbox"/>
Clearance (K)						<input type="checkbox"/>
R ²	0.88					
Adj R ²	0.86					

Pareto Analysis of Factor Influence for Each Response Variable



$R^2 = 88\%$



Analyze Design ▾



Run Regression

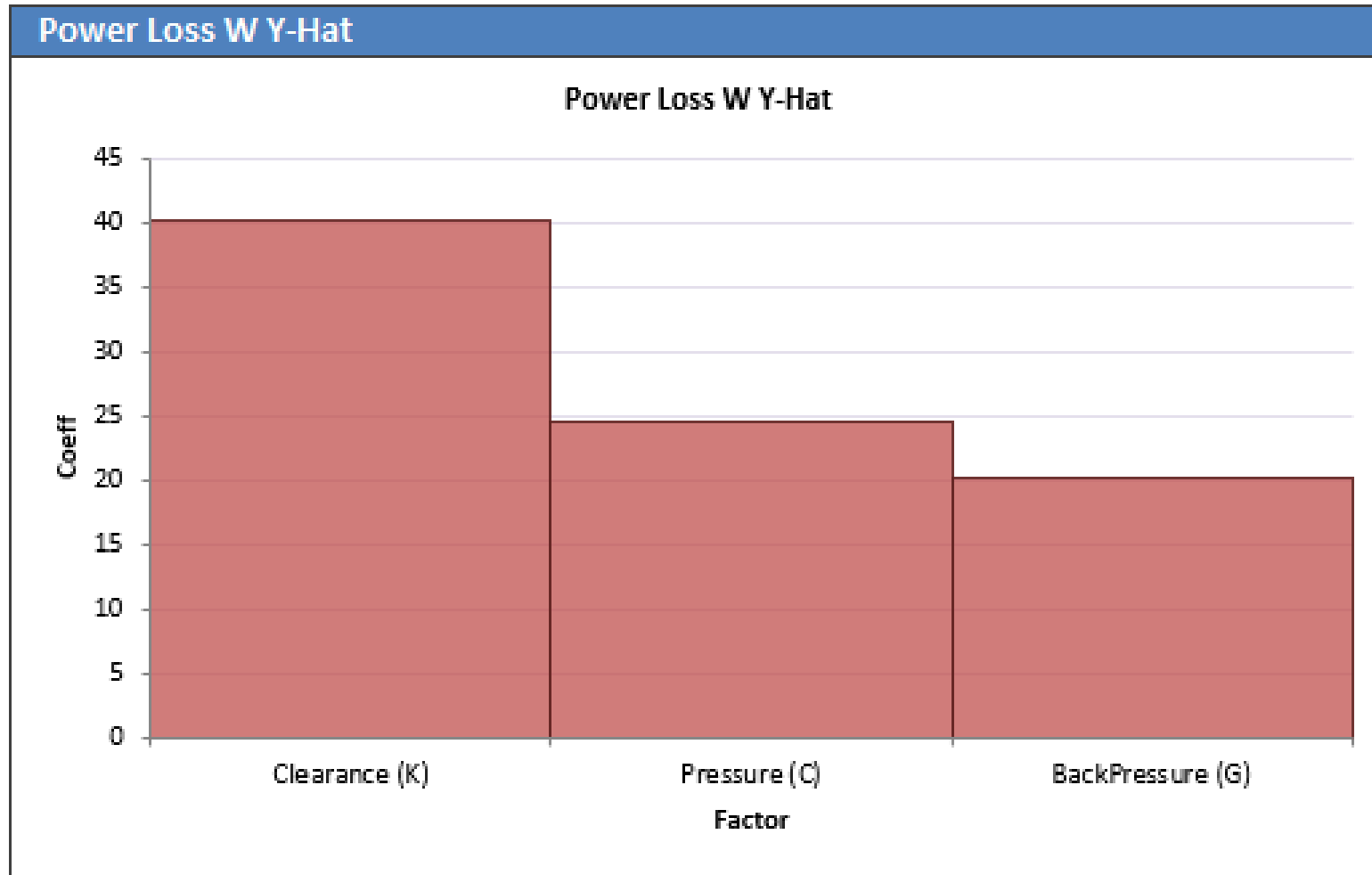


Uncoded Coefficients

Reduce Coded Model: QXL DOE >Analyze Design >Run Regression

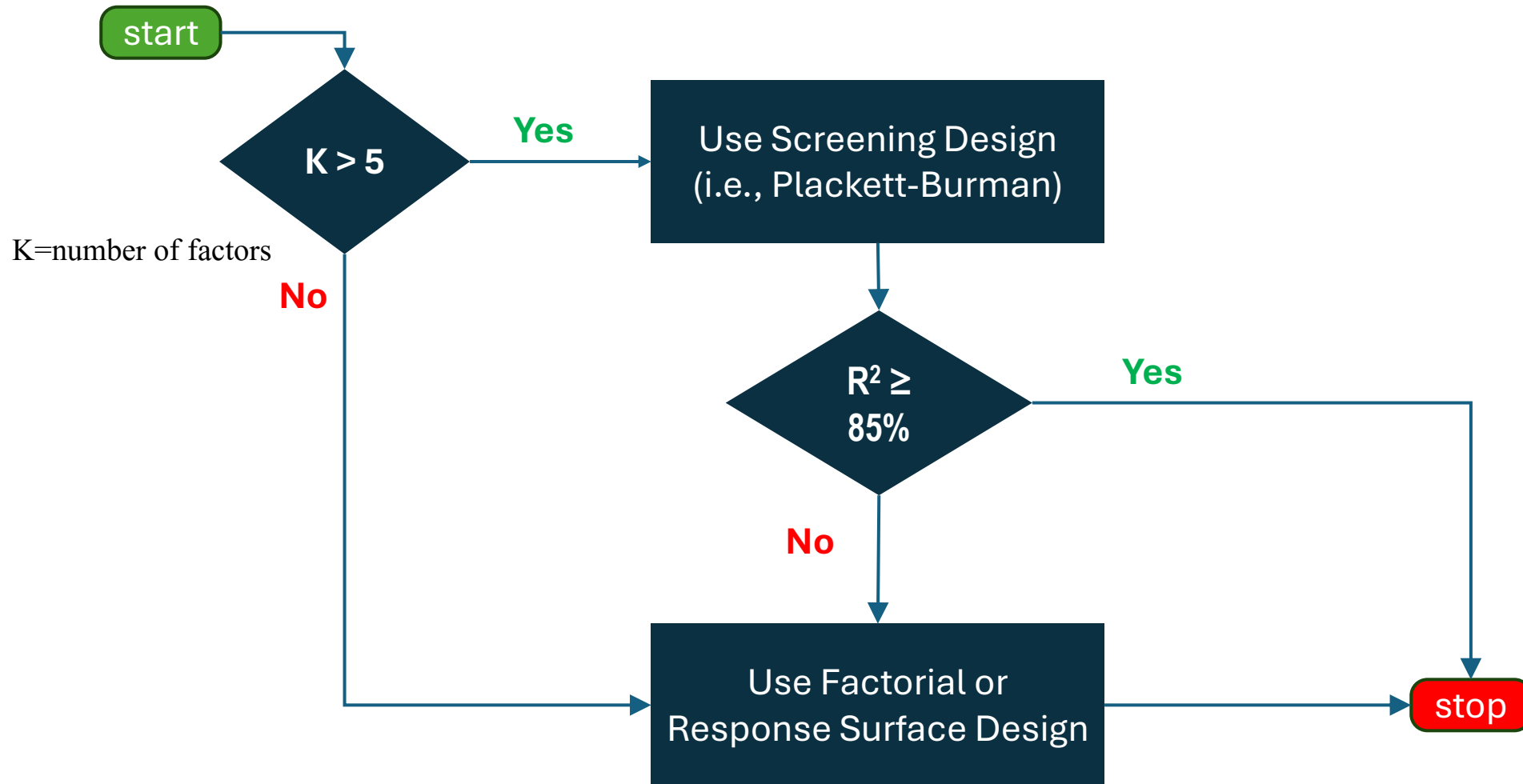
Power Loss W						
Y-Hat						
Factor	Coeff	SE	T	P	VIF	In Model
Const	513.32	6.50	78.95	0.00		<input type="checkbox"/>
Pump_Displacement (A)						<input type="checkbox"/>
Speed (B)						<input type="checkbox"/>
Pressure (C)	24.60	6.50	3.78	0.00	1.00	<input checked="" type="checkbox"/>
Viscosity (D)						<input type="checkbox"/>
Overlap (E)						<input type="checkbox"/>
Orifice (F)						<input type="checkbox"/>
BackPressure (G)	20.13	6.50	3.10	0.00	1.00	<input checked="" type="checkbox"/>
Voltage (H)						<input type="checkbox"/>
CoilResistance (I)						<input type="checkbox"/>
AmbientTemp (J)						<input type="checkbox"/>
Clearance (K)	40.18	6.50	6.18	0.00	1.00	<input checked="" type="checkbox"/>
R ²	0.66					
Adj R ²	0.63					

Pareto Analysis of Factor Influence for Each Response Variable



$R^2 = 66\%$

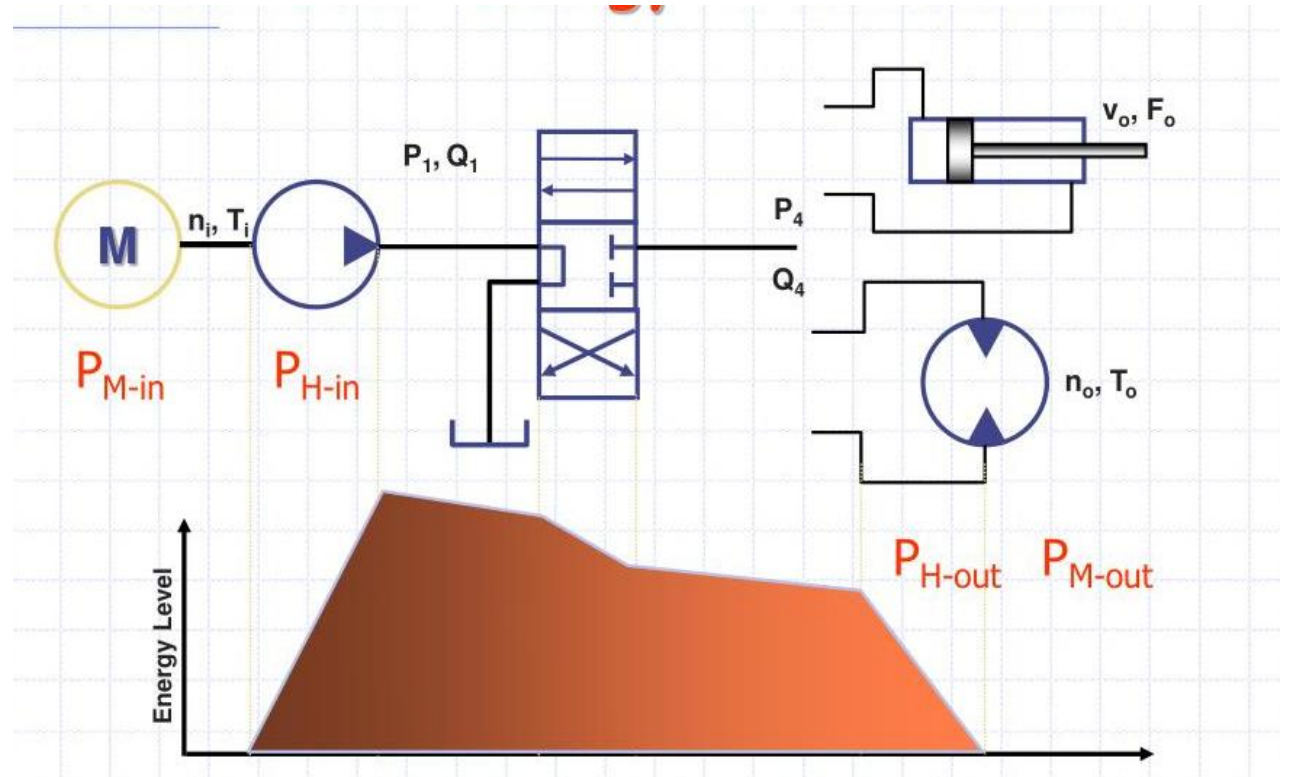
Thought Process Map for Conducting Experiments



Rationale Behind 2nd DOE for Servo-hydraulic Power Loss

The design team aims to better understand power loss. The three factors previously identified from the screening DOE are:

- System Pressure
- Case drain / return back pressure
- Internal clearance (leakage clearance)





QXL DOE > Create Design > Create CCD Design

Create Design ▾ | Modify Design ▾ | Analyze Design ▾ | Optimize Design ▾

Modeling

- Create 2-Level Factorial Design
- Create 3-Level Factorial Design
- Create N-Level Factorial Design
- Create CCD Design
- Create Box-Behnken Design

Screening

- Create Plackett-Burman Design
- Create Taguchi Design

Special

- Setup Historical Analysis
- Create Custom Design
- Create D-Optimal Design

Import

- Import From DOE PRO XL

Central Composite Design

Select the base design

■ Recommended Designs ■ Use with caution

		Factors								
		2	3	4	5	6	7	8	9	10
factorial	Full	Full	Full	Full	Full	Full	Full			
	Half		III	IV	V	VI	VII	VIII		
	Quarter				IV	IV	IV	V	VI	
	Eighth					III	IV	IV	IV	V
	Sixteenth						III	IV	IV	IV

Full factorial, 3 Factors in 8 Runs.
Resolution: Full.

Help Cancel Next > Finish



QXL DOE > Create Design > Create CCD Design

Create Design ▾ | Modify Design ▾ | Analyze Design ▾ | Optimize Design ▾

Modeling

- Create 2-Level Factorial Design
- Create 3-Level Factorial Design
- Create N-Level Factorial Design
- Create CCD Design
- Create Box-Behnken Design

Screening

- Create Plackett-Burman Design
- Create Taguchi Design

Special

- Setup Historical Analysis
- Create Custom Design
- Create D-Optimal Design

Import

- Import From DOE PRO XL

Central Composite Design

Enter Factor Names and Coding

For Quantitative Inputs enter the low and high values (e.g. low=10 high=20)

Name	Low	High
A	-1	1
B	-1	1
C	-1	1

Buttons: Help, Cancel, < Back, Next >, Finish



QXL DOE >Create Design >Create CCD Design

Create Design ▾ | Modify Design ▾ | Analyze Design ▾ | Optimize Design ▾

Modeling

- Create 2-Level Factorial Design
- Create 3-Level Factorial Design
- Create N-Level Factorial Design
- Create CCD Design
- Create Box-Behnken Design

Screening

- Create Plackett-Burman Design
- Create Taguchi Design

Special

- Setup Historical Analysis
- Create Custom Design
- Create D-Optimal Design

Import

- Import From DOE PRO XL

Central Composite Design

Enter Factor Names and Coding

For Quantitative Inputs enter the low and high values (e.g. low=10 high=20)

Name	Low	High
Pressure bar	180	250
Back Pressure bar	0.5	2.0
Clearance um	8	14

Help Cancel < Back Next > Finish



QXL DOE >Create Design >Create CCD Design

Create Design ▾

Modify Design ▾

Analyze Design ▾ Optimize Design ▾

Modeling

Create 2-Level Factorial Design

Create 3-Level Factorial Design

Create N-Level Factorial Design

Create CCD Design

Create Box-Behnken Design

Screening

Create Plackett-Burman Design

Create Taguchi Design

Special

Setup Historical Analysis

Create Custom Design

Create D-Optimal Design

Import

Import From DOE PRO XL

Central Composite Design

Define outputs (responses)

Select number of outputs:

Weights and sample size columns are only available with stacked replicates

Name: <input type="text" value="Power Loss W"/>	Type: <input type="text" value="Quantitative"/>	<input type="checkbox"/> Has weights column
---	---	---

Help Cancel < Back Next > Finish



QXL DOE >Create Design >Create CCD Design

Create Design ▾ | Modify Design ▾ | Analyze Design ▾ | Optimize Design ▾

Modeling

- Create 2-Level Factorial Design
- Create 3-Level Factorial Design
- Create N-Level Factorial Design
- Create CCD Design
- Create Box-Behnken Design

Screening

- Create Plackett-Burman Design
- Create Taguchi Design

Special

- Setup Historical Analysis
- Create Custom Design
- Create D-Optimal Design

Import

- Import From DOE PRO XL

Central Composite Design ✕

Enter number of replicates and number of blocks

Replicates

Select number of replicates:



QXL DOE >Create Design >Create CCD Design

Create Design ▾

Modify Design ▾

Analyze Design ▾ Optimize Design ▾

Modeling

Create 2-Level Factorial Design

Create 3-Level Factorial Design

Create N-Level Factorial Design

Create CCD Design

Create Box-Behnken Design

Screening

Create Plackett-Burman Design

Create Taguchi Design

Special

Setup Historical Analysis

Create Custom Design

Create D-Optimal Design

Import

Import From DOE PRO XL



Modify Design



Axial and center points

Enter the number of center points:

Total number of center points: 4

Total number of runs: 18

Alpha value

Manual:

Optimal orthogonality (1.4142)

Rotatable (1.6818)

Face CCD Alpha = 1

Help

Cancel

Finish

Quantum XL

Central Composite Design

Base design: Full factorial

3 Factors in 18 Runs

4 Center points. Alpha = 1.682

Design is not replicated.

	A	B	C
Run	Pressure_bar	BackPressure_bar	Clearance_um
1	180	0.5	8
2	250	0.5	8
3	180	2	8
4	250	2	8
5	180	0.5	14
6	250	0.5	14
7	180	2	14
8	250	2	14
9	156	1.25	11
10	274	1.25	11
11	215	0	11
12	215	2.5	11
13	215	1.25	6
14	215	1.25	16
15	215	1.25	11
16	215	1.25	11
17	215	1.25	11
18	215	1.25	11

edit response name (optional) -->

enter spec limits (optional) -->

<-- enter factor names

enter response data here -->

Power Loss W	
USL	
LSL	
Data	
	462.3
	508
	491
	557
	550.5
	619.8
	598.8
	647.7
	489
	591.8
	489.4
	563
	509
	682.9
	518.1
	508.4
	524.4
	521



Reduce Coded Model: QXL DOE >Analyze Design >Run Regression

Run Regression

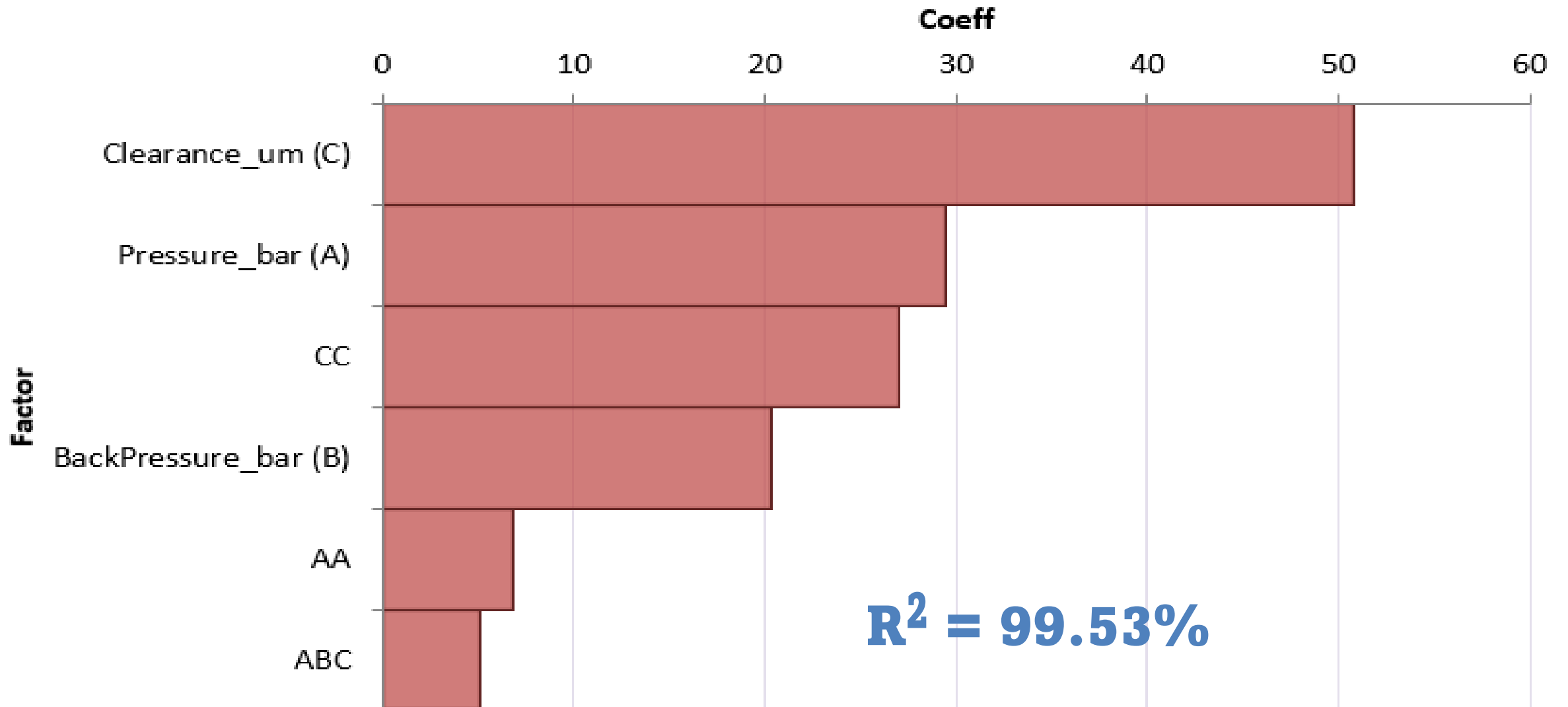
Uncoded Coefficients

Power Loss W							
Y-Hat							
Name	Factor	Coeff	SE	T	P	VIF	In Model
	Const	520.655	2.0523	253.694	0.000		
Pressure_bar	Pressure_bar (A)	29.466	1.3958	21.11	0.000	1.0	<input checked="" type="checkbox"/>
BackPressure_bar	BackPressure_bar (B)	20.402	1.4024	14.548	0.000	1.0	<input checked="" type="checkbox"/>
Clearance_um	Clearance_um (C)	50.779	1.4024	36.208	0.000	1.0	<input checked="" type="checkbox"/>
Pressure_bar*BackPressure_bar*Clearance_um	ABC	-5.0875	1.8255	-2.7869	0.018	1.0	<input checked="" type="checkbox"/>
Pressure_bar*Pressure_bar	AA	6.8691	1.4134	4.8602	0.001	1.0301	<input checked="" type="checkbox"/>
Clearance_um*Clearance_um	CC	27.023	1.4411	18.752	0.000	1.0301	<input checked="" type="checkbox"/>
	R ²	0.9953					

Goal Met: R² > 85%

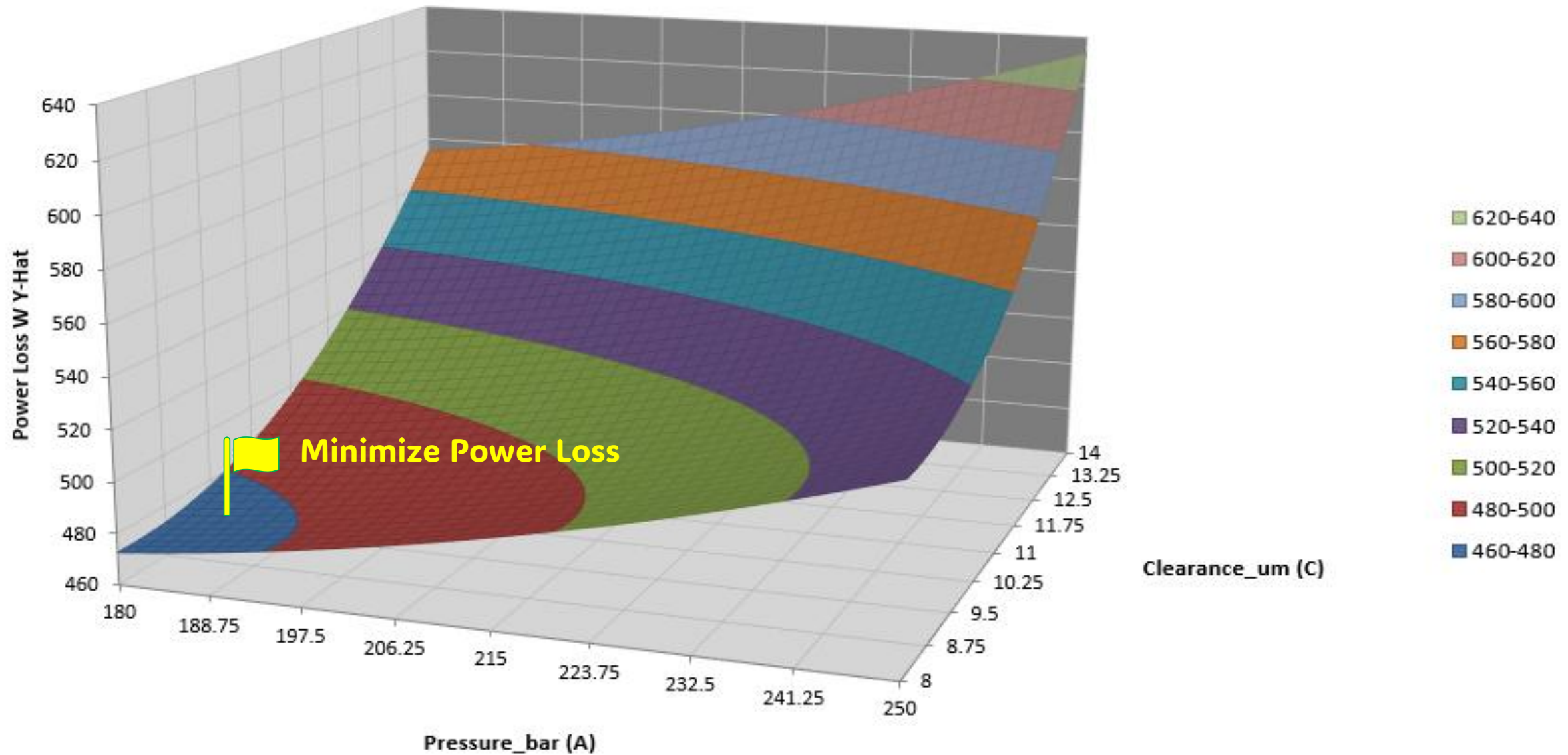
Power Loss W Y-Hat

Power Loss W Y-Hat



Pressure_bar (A) vs. Clearance_um (C)

Power Loss W Y-Hat Surface Plot Pressure_bar (A) vs. Clearance_um (C)

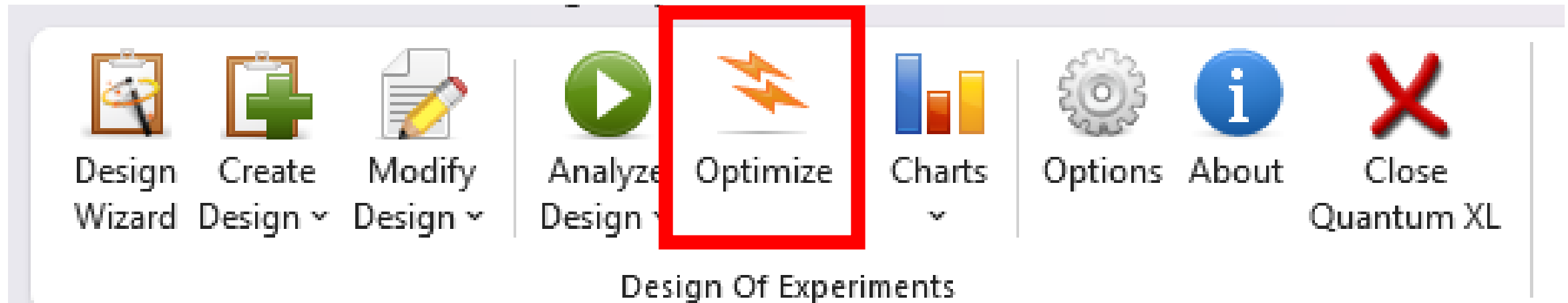


Regression in Coded Units (Only): QXL DOE >Optimize

Quantum XL Regression Analysis

Design sheet: DOE Design

Regression in coded units



Regression in Coded Units (Only): QXL DOE >Optimize

Quantum XL Regression Analysis

Design sheet: DOE Design

Regression in coded units

Optimizer

Enter low and high values for factors

Pressure_bar	Low	<input type="text" value="180"/>	High	<input type="text" value="250"/>	<input checked="" type="checkbox"/> Continuous
BackPressure_bar	Low	<input type="text" value="0.5"/>	High	<input type="text" value="2"/>	<input checked="" type="checkbox"/> Continuous
Clearance_um	Low	<input type="text" value="8"/>	High	<input type="text" value="14"/>	<input checked="" type="checkbox"/> Continuous

Help Cancel Next >

Regression in Coded Units (Only): QXL DOE >Optimize

Quantum XL Regression Analysis

Design sheet: DOE Design

Regression in coded units

The screenshot shows a software window titled "Optimizer" with a standard Windows-style title bar (minimize, maximize, close buttons). The main content area is titled "Optimization goal and constraints" in blue text. Below this title, there are two sections:

- Set the optimization goal:** A text box containing the text "Maximize the Power Loss W - Y-Hat" in blue, with "Min=458.342; Max=650.107" below it.
- Set the optimization constraints (optional):** An empty text box.

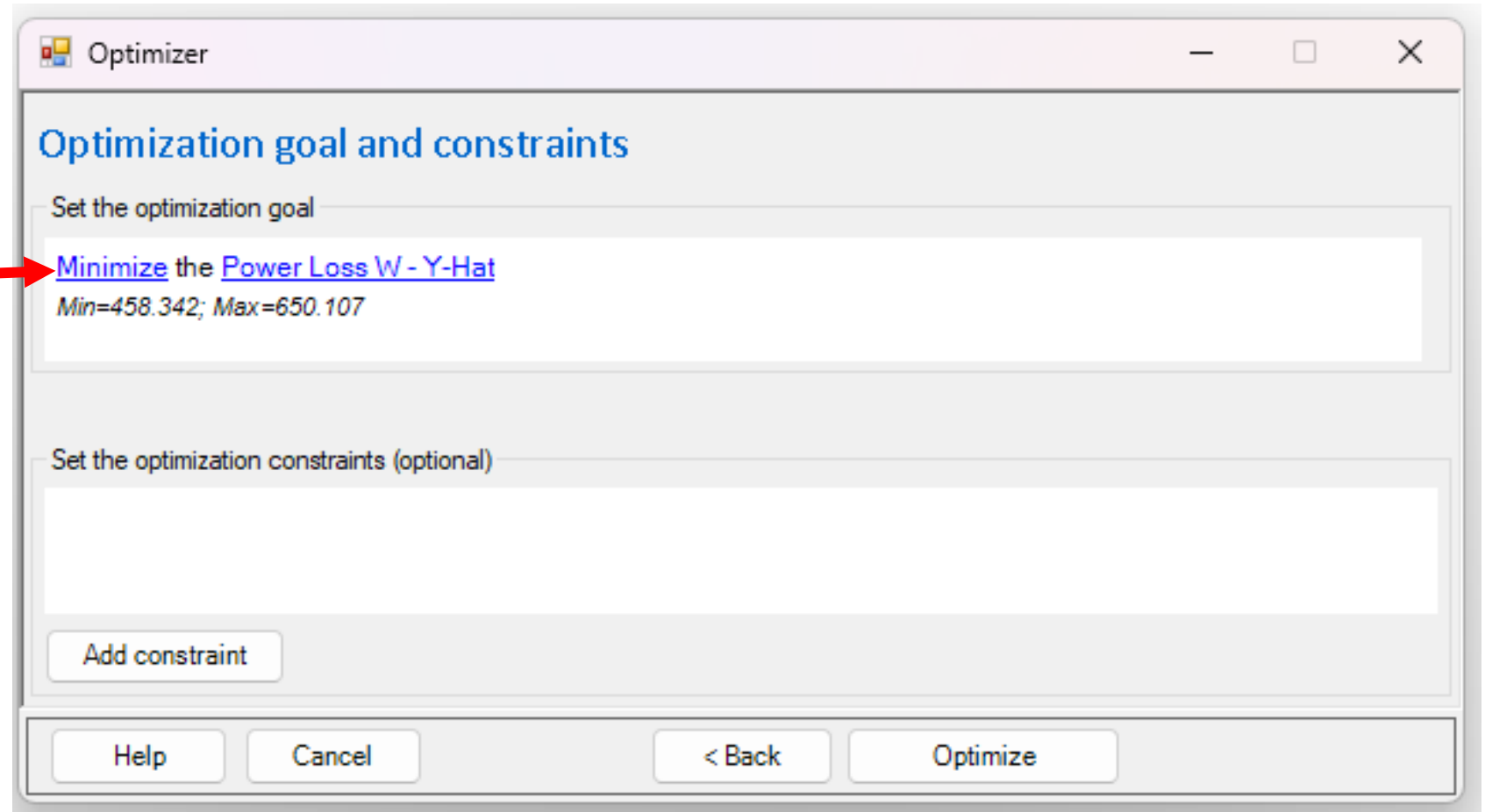
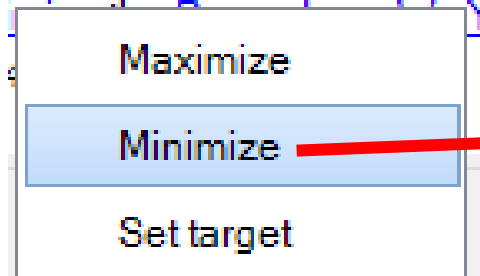
Below the constraints section is a button labeled "Add constraint". At the bottom of the window, there is a row of four buttons: "Help", "Cancel", "< Back", and "Optimize".

Regression in Coded Units (Only): QXL DOE >Optimize

Quantum XL Regression Analysis

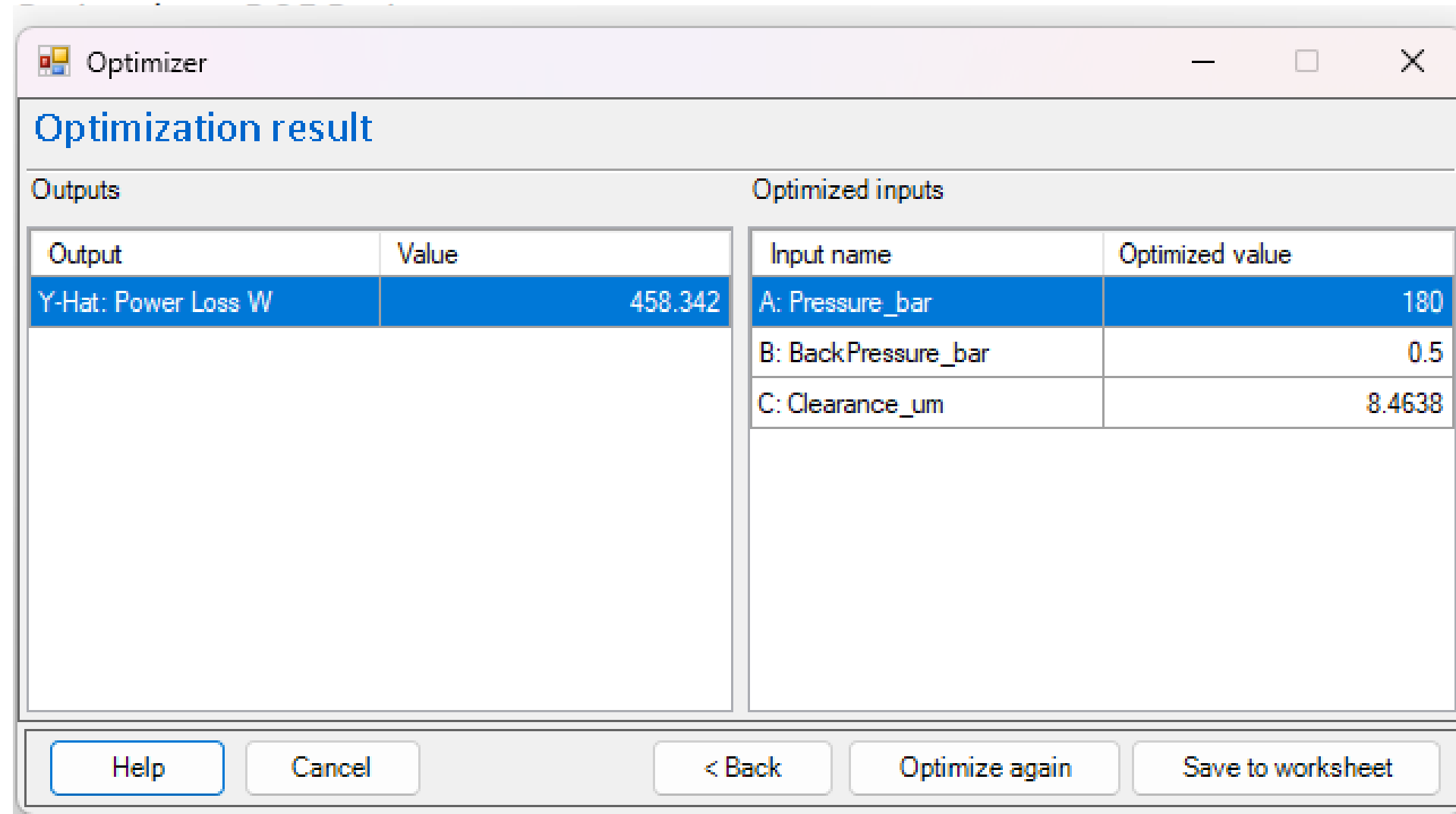
Design sheet: DOE Design

Regression in coded units



Regression in Coded Units (Only): QXL DOE >Optimize

Quantum XL Regression Analysis



The screenshot shows the 'Optimizer' window with the following data:

Outputs		Optimized inputs	
Output	Value	Input name	Optimized value
Y-Hat: Power Loss W	458.342	A: Pressure_bar	180
		B: BackPressure_bar	0.5
		C: Clearance_um	8.4638

Buttons at the bottom: Help, Cancel, < Back, Optimize again, Save to worksheet

Optimal Set Points to Minimize Power Loss

Quantum XL Regression Analysis

Design sheet: DOE Design

Regression in coded units

Factors				
Name	Factor	Range		Set point
		Low	High	
Pressure_bar	A	180.00	250.00	180.00
BackPressure_bar	B	0.50	2.00	0.50
Clearance_um	C	8.00	14.00	8.46

Prediction	
Power Loss W	
Y-Hat	458.34
S-Hat	5.16
PI Lower	442.85
PI Upper	473.83
USL	
LSL	
C_p	NA
C_{pk}	NA
DPM estimate	NA

Summary

- The Plackett-Burman (PB) design required only 12 runs to evaluate 11 factors, while a full-factorial design would have needed 2,048 runs ($2^{\text{number-of-factors}}$).
- In three out of the four cases studied, the main effects were sufficient for accurately predicting the critical quality performance metric.
- The PB design eliminated 8 out of the 11 factors that were suspected to influence Power Loss.
- The coefficient of determination for the Power Loss model increased from 66% to 99% when a response surface design was used.