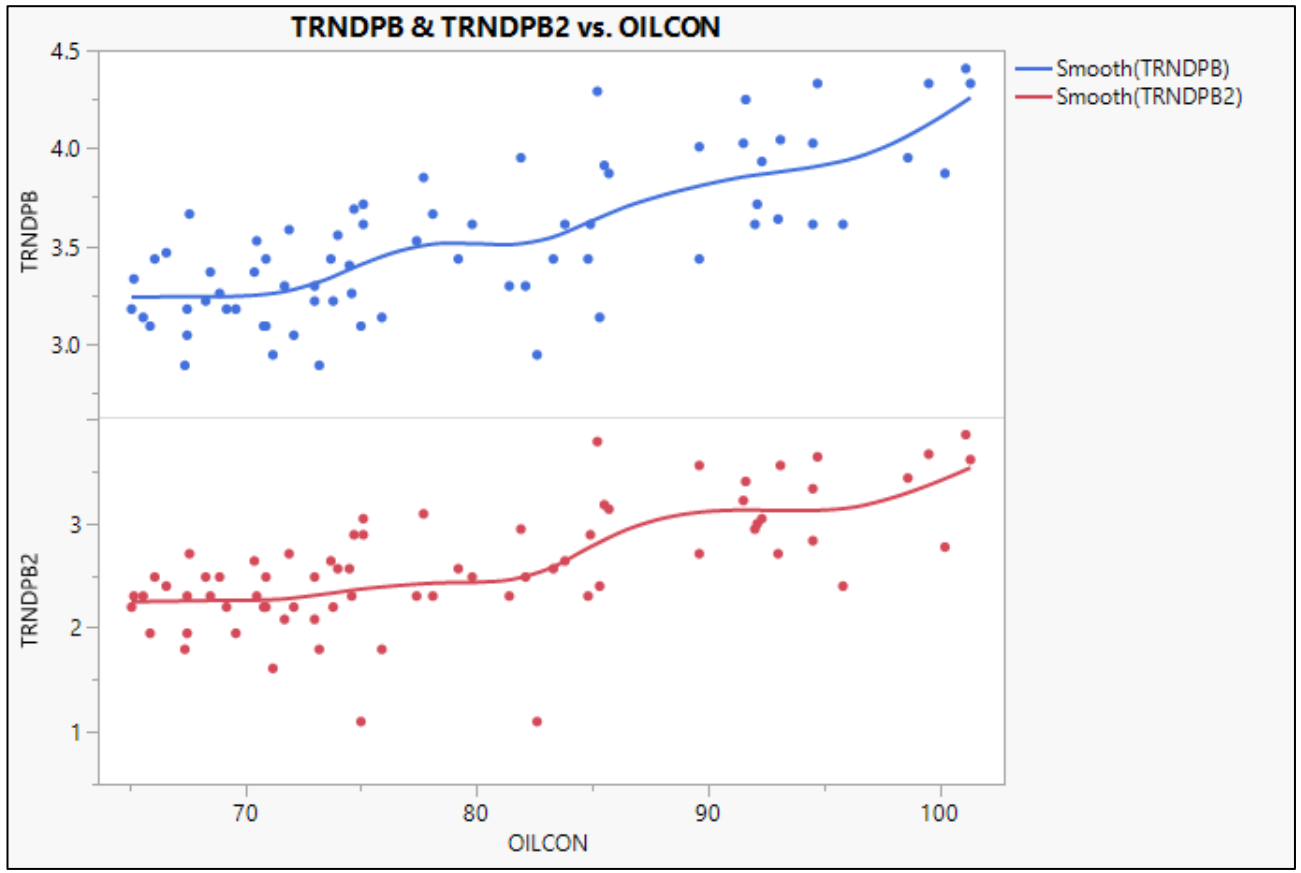
T12 – Data Review with ICF Option

01/29/25

Historical Review of Delta OilCon DPB ICF (2016)

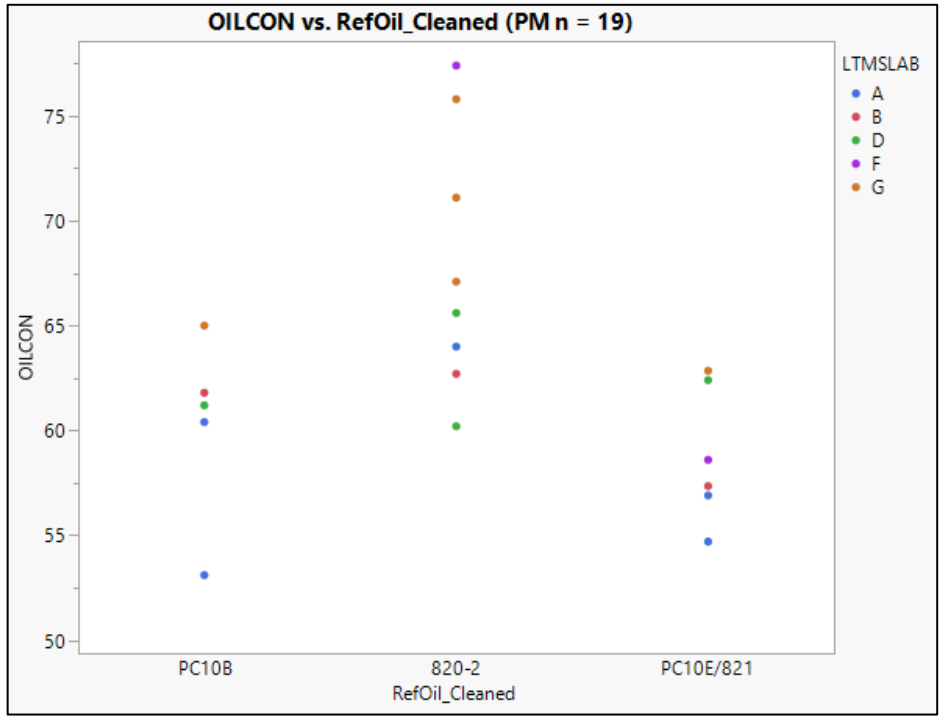
Historical Review of Delta PB OilCon ICF (2016)

- Rationale for oil consumption based dela DPB ICF:
  - As oil consumption increases, TRNDPB and TRNDPB2 levels correspondingly increase



Historical Review of Delta PB OilCon ICF (2016)

- What is the target Oil Consumption for the correction?
  - Original oil consumption target (PM) estimate is ~ 60g/hr for 821-X blends
  - If Oil Consumption > 65, ICF corrects Delta PB to levels at OilCon = 65g/hr



Original PM – Oil Consumption

T-12 Reference Oil Targets

Oil	Level	n	Effective Dates From	Effective Dates To[1]	Cylinder Liner Wear $\bar{X}$	Cylinder Liner Wear s	Top Ring Weight Loss $\bar{X}$	Top Ring Weight Loss s	Oil Consumption $\bar{X}$	Oil Consumption s	ΔPB @ End of Test $\bar{X}$	ΔPB @ End of Test s	ΔPB 250-300 Hours $\bar{X}$	ΔPB 250-300 Hours s
820-2	Stand	4	2-19-05	3-20-05	23.2	4.5	102.0	15.0	4.2770	0.0950	3.0269	0.2034	2.1647	0.1074
820-2	Lab	4	2-19-05	3-20-05	23.2	4.5	102.0	15.0	4.2770	0.0950	3.0269	0.2034	2.1647	0.1074
820-2	Stand	8	6-13-05	12-31-05	18.2	3.5	54.6	24.9	4.2040	0.0610	2.9250	0.2880	2.0020	0.3630
820-2	Lab	8	6-13-05	12-31-05	19.2	1.6	54.6	24.9	4.2040	0.0610	2.9250	0.2880	2.0020	0.3630
831 (PC10B)	Stand	5	6-13-05	12-31-05	12.8	3.2	54.5	24.9	4.1240	0.0610	3.3770	0.2880	2.2450	0.3630
831 (PC10B)	Lab	5	6-13-05	12-31-05	12.5	1.6	54.5	24.9	4.1240	0.0610	3.3770	0.2880	2.2450	0.3630
821 (PC10E)	Stand	6	6-13-05	3-12-08	15.1	3.4	66.4	24.9	4.0830	0.0610	3.2590	0.2880	2.2510	0.3630
821 (PC10E)	Stand	25	3-13-08	***	16.2	3.7	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821 (PC10E)	Lab	6	6-13-05	3-12-08	14.6	1.6	66.4	24.9	4.0830	0.0610	3.2590	0.2880	2.2510	0.3630
821 (PC10E)	Lab	25	3-13-08	***	15.1	2.8	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821-1[2]	Stand	--	3-13-08	***	16.2	3.7	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821-1[2]	Lab	--	3-13-08	***	15.1	2.8	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821-2[3]	Stand	--	9-27-11	***	16.2	3.7	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821-2[3]	Lab	--	9-27-11	***	15.1	2.8	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821-3[3]	Stand	--	8-21-12	***	16.2	3.7	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821-3[3]	Lab	--	8-21-12	***	15.1	2.8	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821-4[3]	Stand	--	4-29-14	***	16.2	3.7	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821-4[3]	Lab	--	4-29-14	***	15.1	2.8	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330

1 *** = currently in effect
2 Targets based on oil 821
3 Targets based on 25 tests on 821

Oil Con Target Summary

(Source: LTMS Manual)

Historical Review of Delta PB OilCon ICF (2016)

- Original oil Consumption PB ICF models shown below
  - Models are based on *n* = *72* & include Chartable, OC > 65, & RO821-X results

Response TRNDPB

Whole Model

Actual by Predicted Plot

Effect Summary

Source	Logworth	PValue
OILCON	10.055	0.00000
IND	1.441	0.03619
LTMSLAB	0.967	0.10783

Remove Add Edit FDR

Residual by Predicted Plot

Summary of Fit

RSquare	0.656277
RSquare Adj	0.593261
Root Mean Square Error	0.245172
Mean of Response	3.520775
Observations (or Sum Wgts)	72

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	11	6.886061	0.626006	10.4145
Error	60	3.606549	0.060109	Prob > F
C. Total	71	10.492610		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.1224769	0.304036	3.69	0.0005*
IND[821]	-0.079444	0.156976	-0.51	0.6146
IND[821-1]	0.0897298	0.076915	1.17	0.2480
IND[821-2]	0.0540575	0.083851	0.64	0.5216
IND[821-3]	-0.000367	0.092124	-0.00	0.9968
IND[821-4]	-0.186688	0.075766	-2.46	0.0166*
LTMSLAB[A]	-0.077571	0.07929	-0.98	0.3318
LTMSLAB[B]	0.0694986	0.095941	0.72	0.4716
LTMSLAB[D]	-0.156915	0.106558	-1.47	0.1461
LTMSLAB[F]	-0.087265	0.29616	-0.29	0.7693
LTMSLAB[G]	0.1190194	0.094534	1.26	0.2129
OILCON	0.030883	0.003934	7.85	<.0001*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
IND	5	5	0.7704396	2.5635	0.0362*
LTMSLAB	5	5	0.5708003	1.8992	0.1078
OILCON	1	1	3.7045223	61.6299	<.0001*

Response TRNDPB2

Whole Model

Actual by Predicted Plot

Effect Summary

Source	Logworth	PValue
OILCON	6.343	0.00000
IND	0.286	0.51764
LTMSLAB	0.275	0.53053

Remove Add Edit FDR

Residual by Predicted Plot

Summary of Fit

RSquare	0.502664
RSquare Adj	0.411486
Root Mean Square Error	0.442901
Mean of Response	2.592825
Observations (or Sum Wgts)	72

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	11	11.895787	1.08144	5.5130
Error	60	11.769687	0.19616	Prob > F
C. Total	71	23.665474		<.0001*

Parameter Estimates

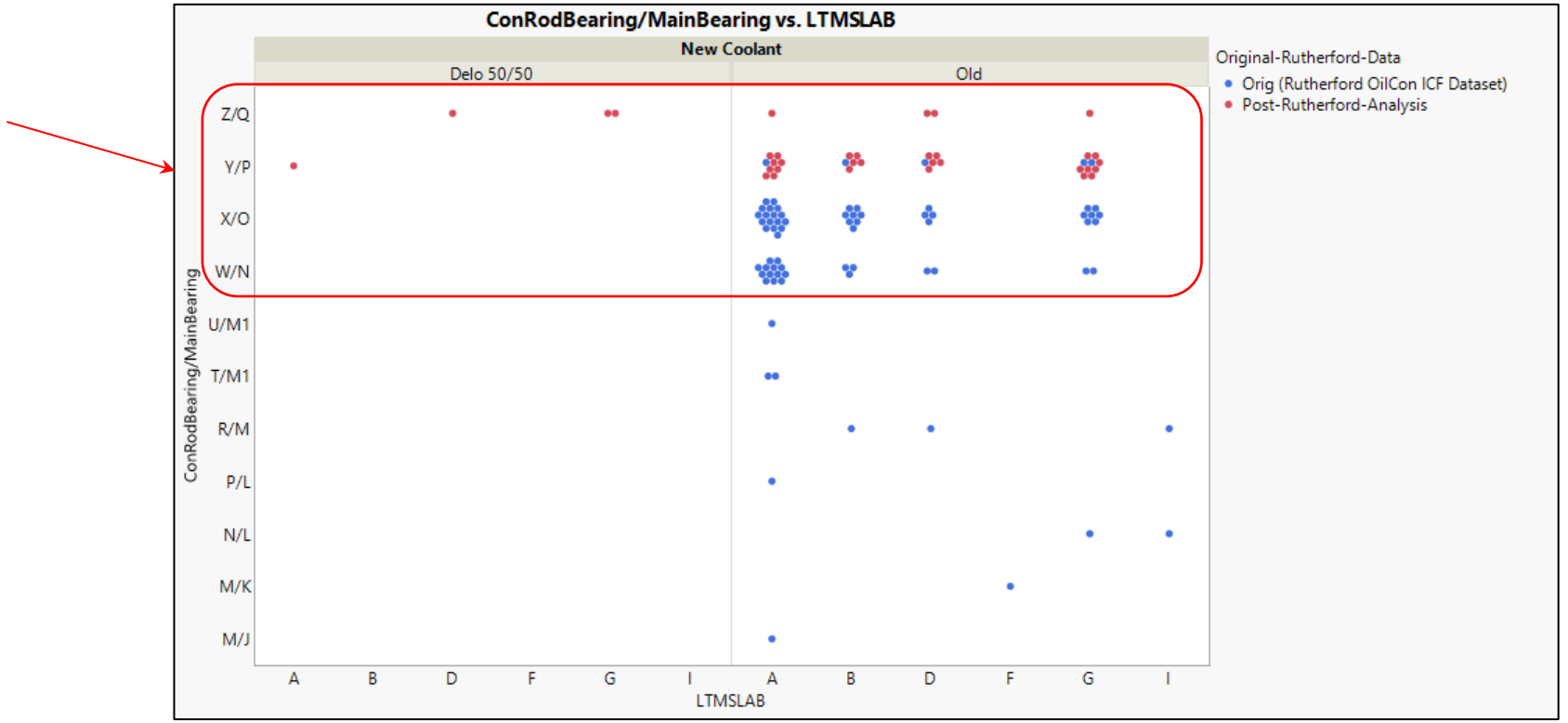
Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.48565	0.54924	-0.88	0.3801
IND[821]	-0.091116	0.283576	-0.32	0.7491
IND[821-1]	0.0572062	0.138946	0.41	0.6820
IND[821-2]	0.0146567	0.151477	0.10	0.9232
IND[821-3]	0.0167864	0.166422	0.10	0.9200
IND[821-4]	-0.208081	0.136871	-1.52	0.1337
LTMSLAB[A]	-0.145256	0.143236	-1.01	0.3146
LTMSLAB[B]	0.0555404	0.173317	0.32	0.7497
LTMSLAB[D]	-0.207315	0.192497	-1.08	0.2858
LTMSLAB[F]	-0.049148	0.535011	-0.09	0.9271
LTMSLAB[G]	0.0615736	0.170775	0.36	0.7197
OILCON	0.0402083	0.007107	5.66	<.0001*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
IND	5	5	0.8370983	0.8535	0.5176
LTMSLAB	5	5	0.8183123	0.8343	0.5305
OILCON	1	1	6.2794843	32.0118	<.0001*

Historical Review of Delta PB OilCon ICF (2016)

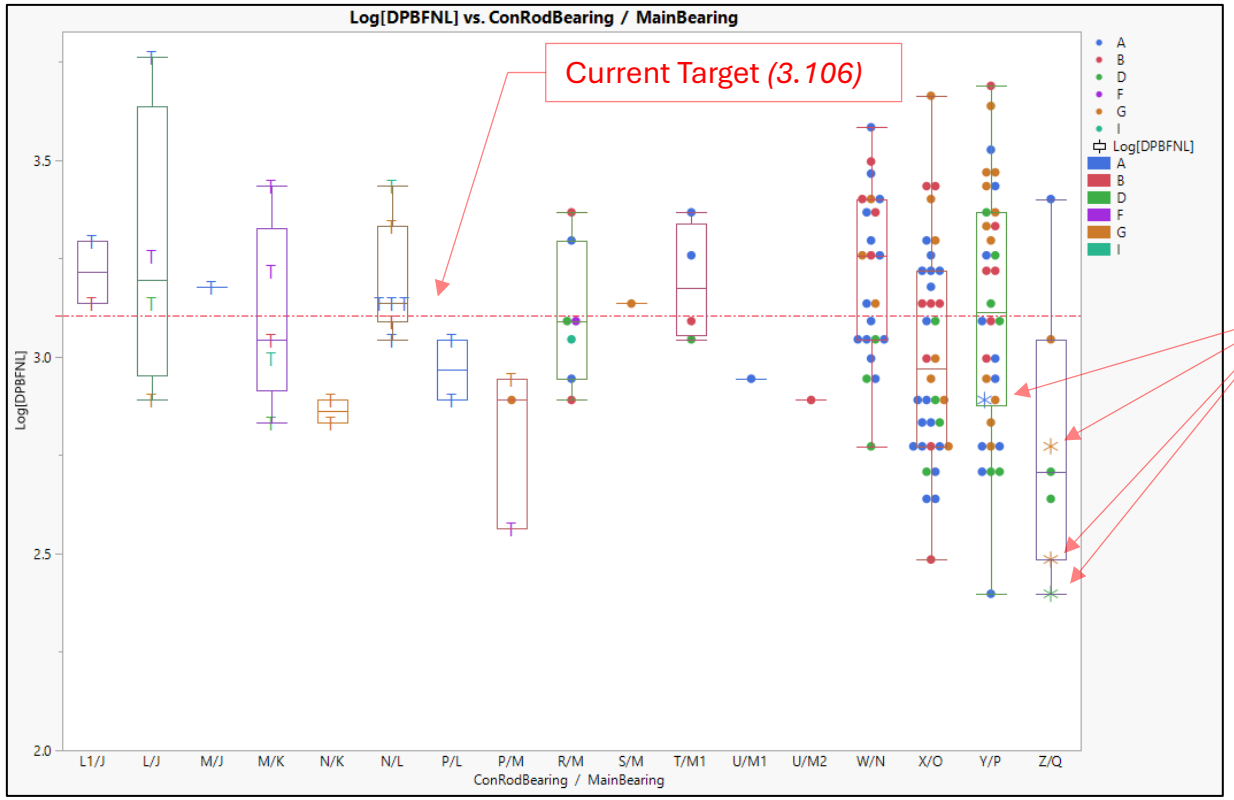
- Updated oilcon ICF model will include rod & main bearing factor
  - Due to confounding, the revised analysis will include recent hardware batches {Z/Q, Y/P, X/O, W/N} with ICF correction to 65g/hr oil consumption
  - Data available for analysis: *n* = 95



Delta PB Data Analyses - with Bearing & OilCon Factor ICF

PBFNL Parameter - Data Review

- Ln[PBFNL] (with current ICF) data plot shown below
  - Includes RO821-X data, exclusively
  - Delo 50/50 coolant results on the current Bearing batch (Z/Q) appear lower



Current PB ICF Equation:

If $OC_{100\text{-}300} > 65.0$*:*

$$PBFNL_{cor} = exp(Ln(PB) + (65 - OC_{100\text{-}300}) \times 0.\ 0.03234)$$

else:

$$PBFNL_{cor} = exp(Ln(PB))$$

TRNDPB with Bearing & OilCon Factor ICF

- TRNDPB Parameter Summary with revised ICF:
  - Includes RO821-X, OC > 65, and connecting Rod/Main Bearing batch {Z/Q, Y/P, X/O, W/N} data
  - Bearing batch and Coolant factors are significant

Response TRNDPB

Whole Model

Actual by Predicted Plot

Lack Of Fit

Residual by Predicted Plot

Summary of Fit

RSquare	0.633454
RSquare Adj	0.589817
Root Mean Square Error	0.265521
Mean of Response	3.674105
Observations (or Sum Wgts)	95

Analysis of Variance

Parameter Estimates

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
LTMSLAB	3	3	0.9369129	4.4298	0.0061*
RefOil_Cleaned	3	3	0.2193156	1.0369	0.3806
OilCon-65	1	1	6.0534705	85.8633	<.0001*
ConRodBearing/MainBearing	3	3	1.0783844	5.0987	0.0027*

Expanded Estimates

Nominal factors expanded to all levels

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	3.0564229	0.096069	31.81	<.0001*
LTMSLAB[A]	-0.055192	0.046828	-1.18	0.2419
LTMSLAB[B]	0.1083917	0.056672	1.91	0.0592
LTMSLAB[D]	-0.168511	0.058677	-2.87	0.0052*
LTMSLAB[G]	0.1153116	0.051371	2.24	0.0274*
RefOil_Cleaned[821-1]	0.0150465	0.114934	0.13	0.8962
RefOil_Cleaned[821-2]	-0.012396	0.09103	-0.14	0.8920
RefOil_Cleaned[821-3]	0.0807828	0.092195	0.88	0.3834
RefOil_Cleaned[821-4]	-0.083434	0.100002	-0.83	0.4065
OilCon-65	0.033238	0.003587	9.27	<.0001*
ConRodBearing/MainBearing[W/N]	0.1431113	0.152154	0.94	0.3496
ConRodBearing/MainBearing[X/O]	-0.093788	0.061568	-1.52	0.1314
ConRodBearing/MainBearing[Y/P]	0.1346525	0.073473	1.83	0.0704
ConRodBearing/MainBearing[Z/Q]	-0.183975	0.101944	-1.80	0.0747

LTMSLAB | RefOil_Cleaned | OilCon-65

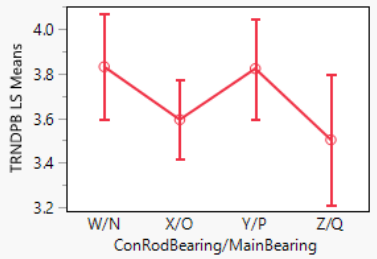
ConRodBearing/MainBearing

Leverage Plot

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
W/N	3.8303216	0.11941780	3.44105
X/O	3.5934221	0.08819698	3.67441
Y/P	3.8218628	0.11300408	3.85044
Z/Q	3.5032348	0.14795569	3.53230

Least Squares Means Plot



Corrected TRNDPB Equation with Z/Q Hardware and OILCON corrected to 65g/hr:

$TRNDPB\_ICF = RO\ Target_{821\text{-}X\,[3.106]} - TRNDPB2_{Model(Bearing\ \&\ OilCon\ Factors)}$

If $OILCON_{100\text{-}300} > 65.0$:

$TRNDPB\_ICF = 3.1060 - (3.0564 + (OILCON_{100\text{-}300} - 65) \times 0.0332 - 0.1840\ [Z/Q\ Bearings])$

$TRNDPB\_ICF = 0.2336 - (OILCON_{100\text{-}300} - 65) \times 0.0332$

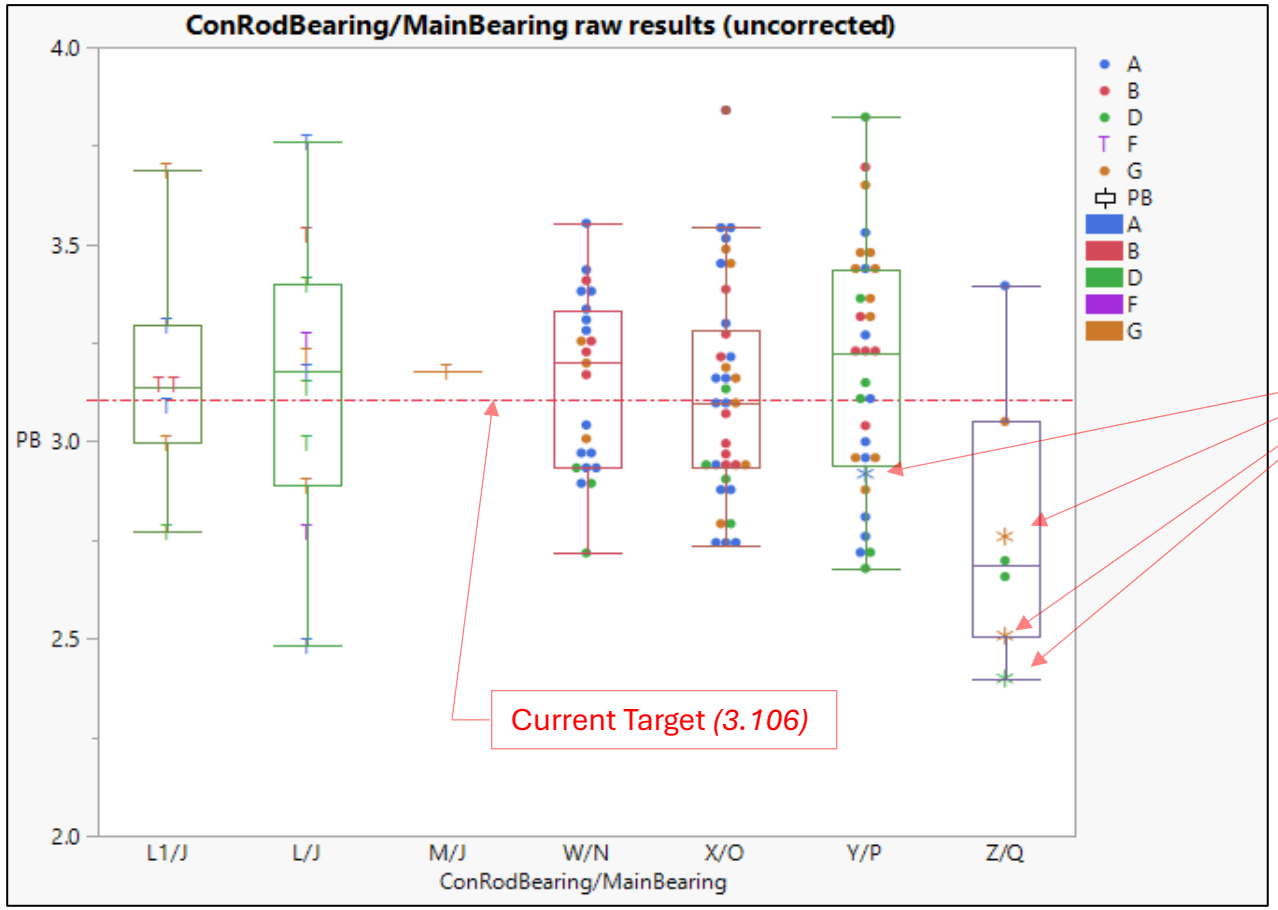
$TRNDPB_{cor} = TRNDPB + 0.2336 - (OILCON_{100\text{-}300} - 65) \times 0.0332$

else $(OILCON_{100\text{-}300} \leq 65.0)$:

$TRNDPB_{cor} = TRNDPB + 0.2336$

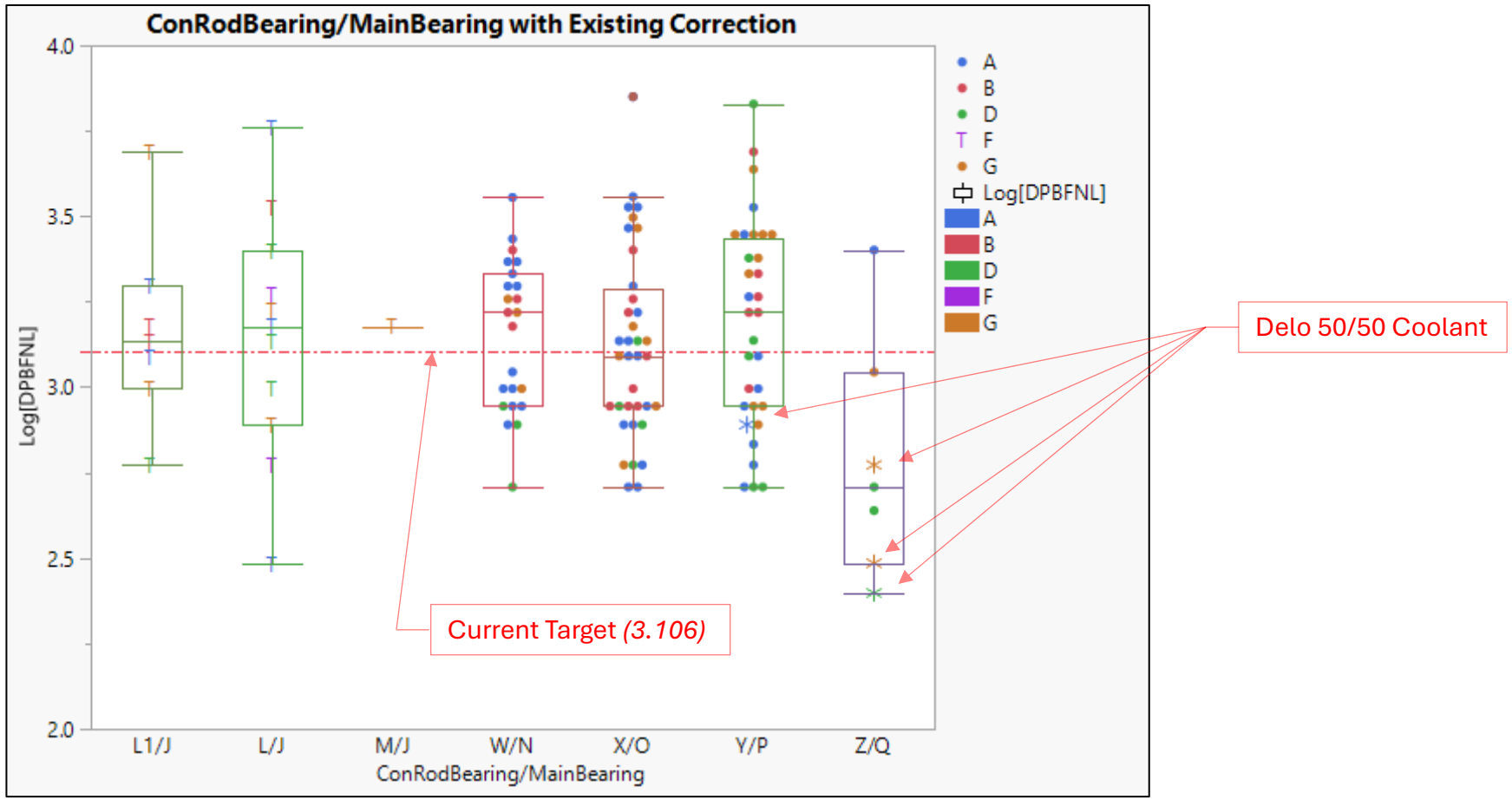
Uncorrected Log(DPB) Data

- Log(DPB) uncorrected (raw) data plot:
  - Includes PM (T) and Bearing batch {W/N, X/O, Y/P, Z/Q} data



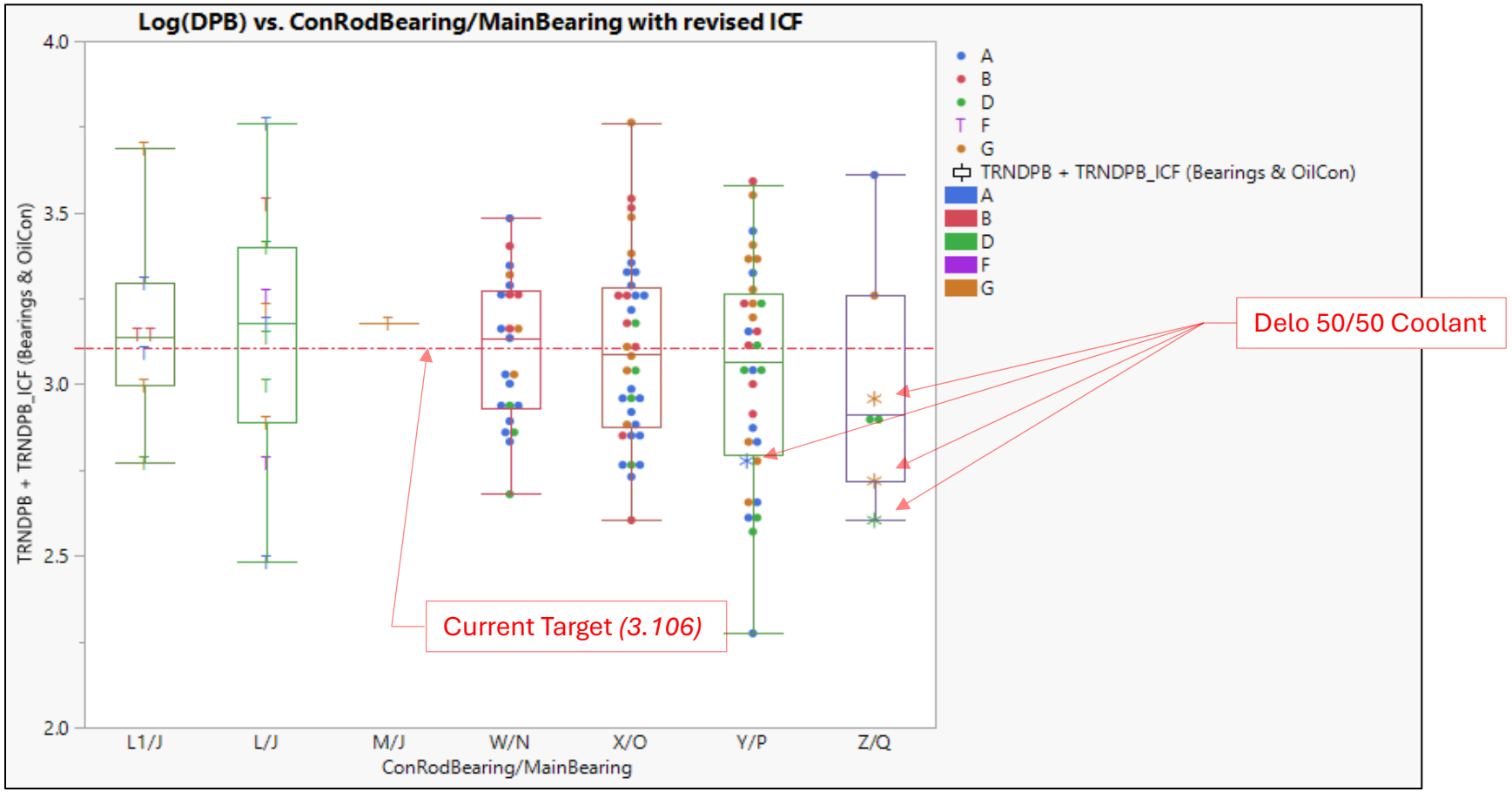
Log(DPBFNL) Correction (Current)

- Log(DBPFNL) with existing correction
  - Plot includes PM (T) and Bearing batch {W/N, X/O, Y/P, Z/Q} data, exclusively



TRNDPB with OilCon & Bearing Factor ICF

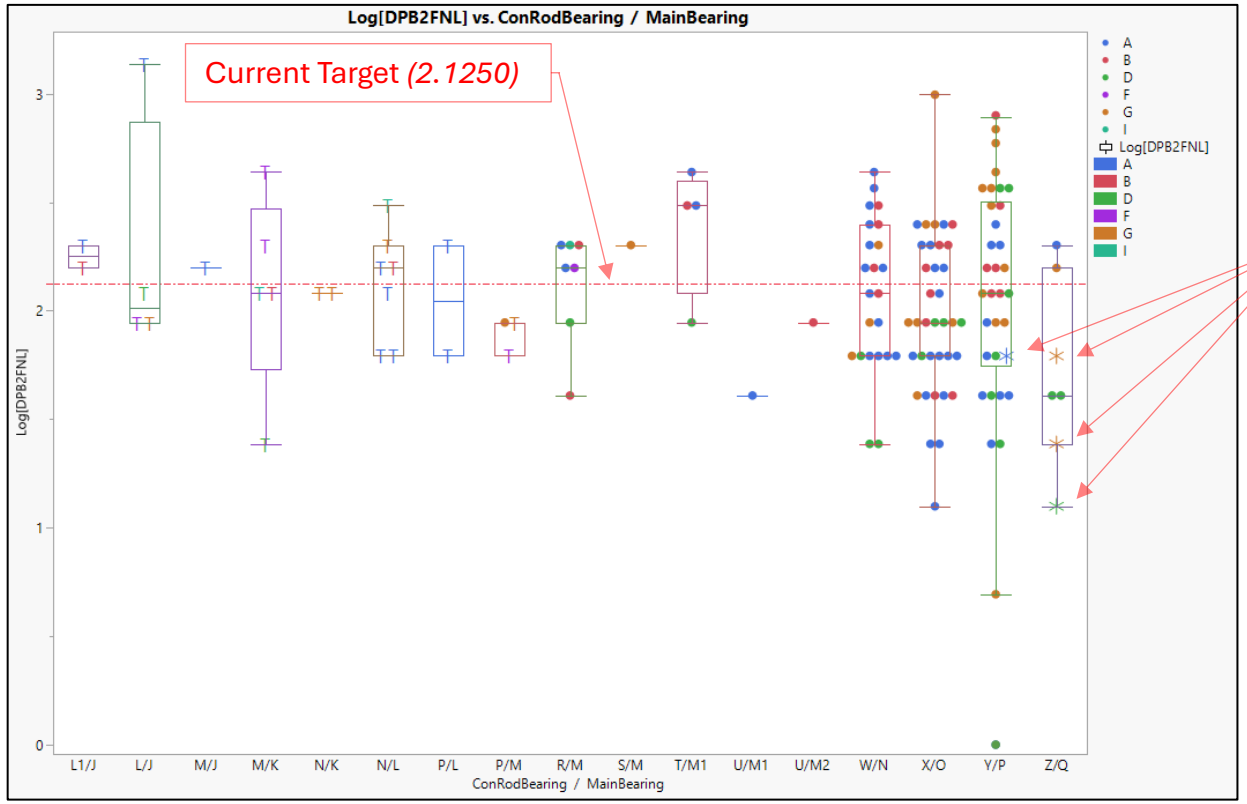
- TRNDP with revised ICF shown below
  - Includes ICF function based on OilCon and Bearing batch



Delta PB2 Data Analyses - with Bearing & OilCon Factor ICF

Ln[PB2FNL] Parameter Data Review

- Ln[PB2FNL] data plot shown below
  - Includes existing ICF function based on Oil Consumption
  - Delo 50/50 results on the current Con-Rod-Bearing [Z/Q] batch appear lower



Delo 50/50 Coolant

Current PB2 ICF Equation:

If $OC_{100\text{-}300} > 65.0$:

$$PB2FNL_{cor} = exp(Ln(PB2) + (65 - OC_{100\text{-}300}) \times 0.04089)$$

else:

$$PB2FNL_{cor} = PB2$$

TRNDPB2 with OilCon & Bearing Factor ICF

- TRNDPB2 Parameter Summary with revised ICF :
  - Includes RO821-X, OC > 65, and connecting Rod/Main Bearing batch {Z/Q, Y/P, X/O, W/N} data
  - OilCon factor is significant
  - Connecting Rod/Main Bearing batch factor is not significant

Response TRNDPB2

Whole Model

- Actual by Predicted Plot
- Lack Of Fit
- Residual by Predicted Plot

Summary of Fit

RSquare	0.504023
RSquare Adj	0.444978
Root Mean Square Error	0.44172
Mean of Response	2.779291
Observations (or Sum Wgts)	95

- Analysis of Variance
- Parameter Estimates

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
LTMSLAB	3	3	1.964812	3.3567	0.0226*
RefOil_Cleaned	3	3	0.259562	0.4434	0.7226
OilCon-65	1	1	10.067948	51.5997	<.0001*
ConRodBearing/MainBearing	3	3	0.901101	1.5394	0.2103

Expanded Estimates

Nominal factors expanded to all levels

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.9533899	0.15982	12.22	<.0001*
LTMSLAB[A]	-0.124119	0.077903	-1.59	0.1149
LTMSLAB[B]	0.1546049	0.094279	1.64	0.1048
LTMSLAB[D]	-0.202011	0.097614	-2.07	0.0416*
LTMSLAB[G]	0.1715258	0.085461	2.01	0.0480*
RefOil_Cleaned[821-1]	-0.051706	0.191204	-0.27	0.7875
RefOil_Cleaned[821-2]	-0.059273	0.151438	-0.39	0.6965
RefOil_Cleaned[821-3]	0.136321	0.153375	0.89	0.3766
RefOil_Cleaned[821-4]	-0.025342	0.166364	-0.15	0.8793
OilCon-65	0.042865	0.005967	7.18	<.0001*
ConRodBearing/MainBearing[W/N]	0.229719	0.253123	0.91	0.3667
ConRodBearing/MainBearing[X/O]	-0.064488	0.102424	-0.63	0.5307
ConRodBearing/MainBearing[Y/P]	0.0827494	0.122229	0.68	0.5003
ConRodBearing/MainBearing[Z/Q]	-0.24798	0.169594	-1.46	0.1474

LTMSLAB | RefOil_Cleaned | OilCon-65

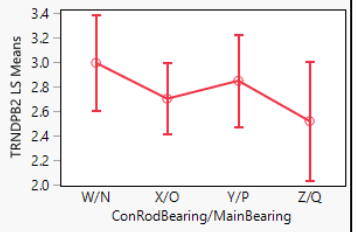
ConRodBearing/MainBearing

- Leverage Plot

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
W/N	2.9965972	0.19866313	2.41138
X/O	2.7023900	0.14672427	2.84428
Y/P	2.8496275	0.18799328	2.96498
Z/Q	2.5188981	0.24613869	2.64741

Least Squares Means Plot



Corrected TRNDPB2 Equation with Z/Q Hardware and OILCON corrected to 65g/hr:

$TRNDPB2\_ICF = RO\ Target_{821\text{-}X\ [2.125]} - TRNDPB2_{Model(Bearing\ \&\ OilCon\ Factors)}$

If $OILCON_{100\text{-}300} > 65.0$:

$TRNDPB2\_ICF = 2.1250 - (1.9534 + (OILCON_{100\text{-}300} - 65) \times 0.0429 - 0.2480\ [Z/Q\ Bearings])$

$TRNDPB2\_ICF = 0.4196 - (OILCON_{100\text{-}300} - 65) \times 0.0429$

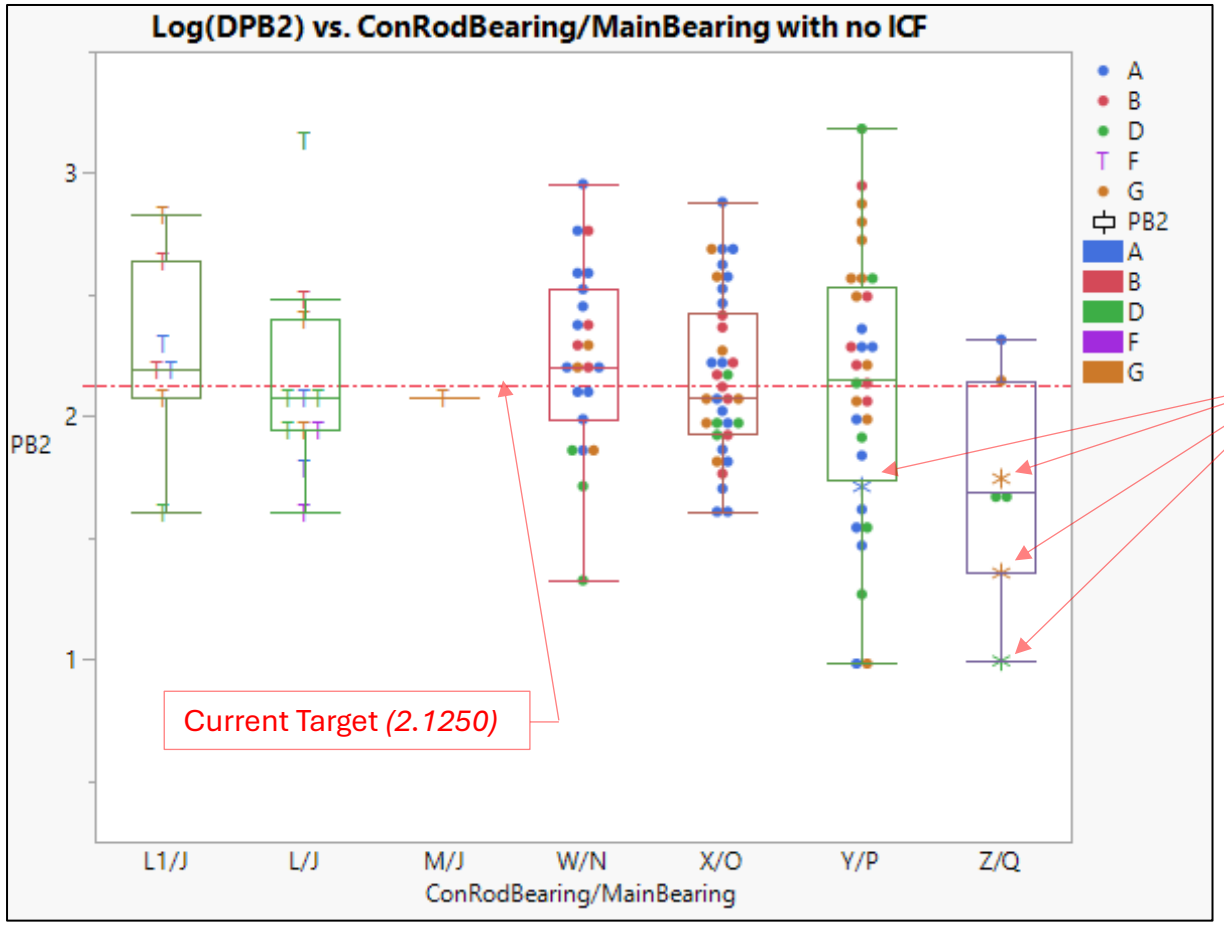
$TRNDPB2_{cor} = TRNDPB2 + 0.4196 - (OILCON_{100\text{-}300} - 65) \times 0.0429$

else ($OILCON_{100\text{-}300} \leq 65.0$):

$TRNDPB2_{cor} = TRNDPB2 + 0.4196$

Uncorrected Log(DPB2) Data

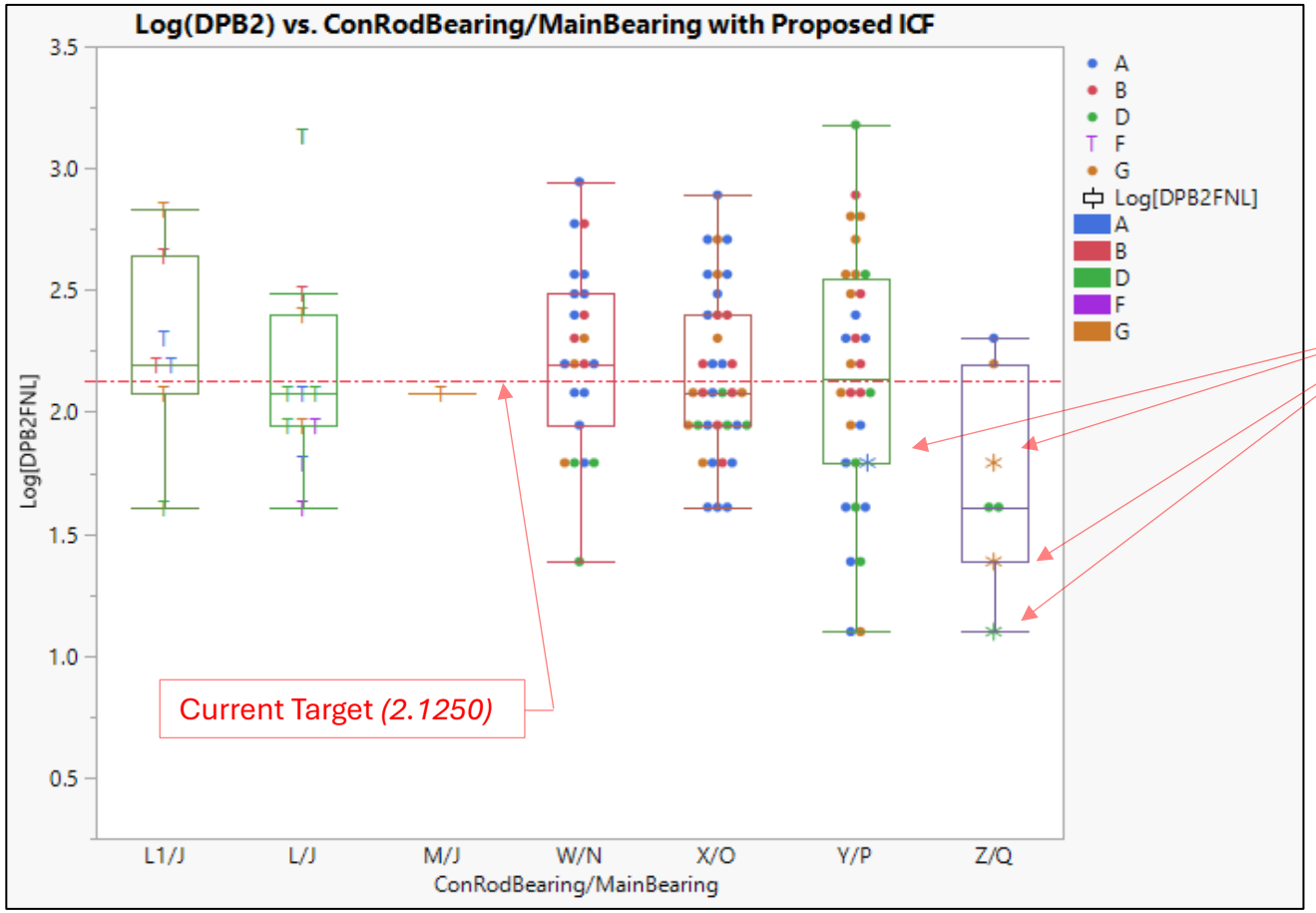
- Log(DPB2) uncorrected (raw) data plot:
  - Includes PM (T) and Bearing batch {W/N, X/O, Y/P, Z/Q} data



Delo 50/50 Coolant

Log(DPB2FNL) Correction (Current)

- Log(DBP2FNL) with existing correction
  - Includes PM (T) and Bearing batch {W/N, X/O, Y/P, Z/Q} data



Delo 50/50 Coolant

Log(DPB2FNL) Correction (Current)

- Log(DBP2FNL) with proposed bearing & Oilcon correction
  - Plot includes PM (T) and Bearing batch {W/N, X/O, Y/P, Z/Q} data, exclusively