

FORD 6.7 VALVETRAIN WEAR TEST

Overview

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TEST OVERVIEW

- MY2019 Ford Powerstroke 6.7L 8 Cylinder Diesel Engine with EGR Removed, closed crankcase
- Turbocharged, charge air cooled, 8-cylinder, direct injection, pressure ignition engine
- In-block camshaft, dual push tube per cam-follower, 4 valve per cylinder arrangement
- Disassembled down to short block prior to each test and rebuilt with measured test components
- Valvetrain Wear
 - Rocker Arms (Main Focus)
 - Push Rods
 - Roller-Followers
- Approximately 30 gallons of oil needed
- Approximately 16200L of an approved PC10 Fuel



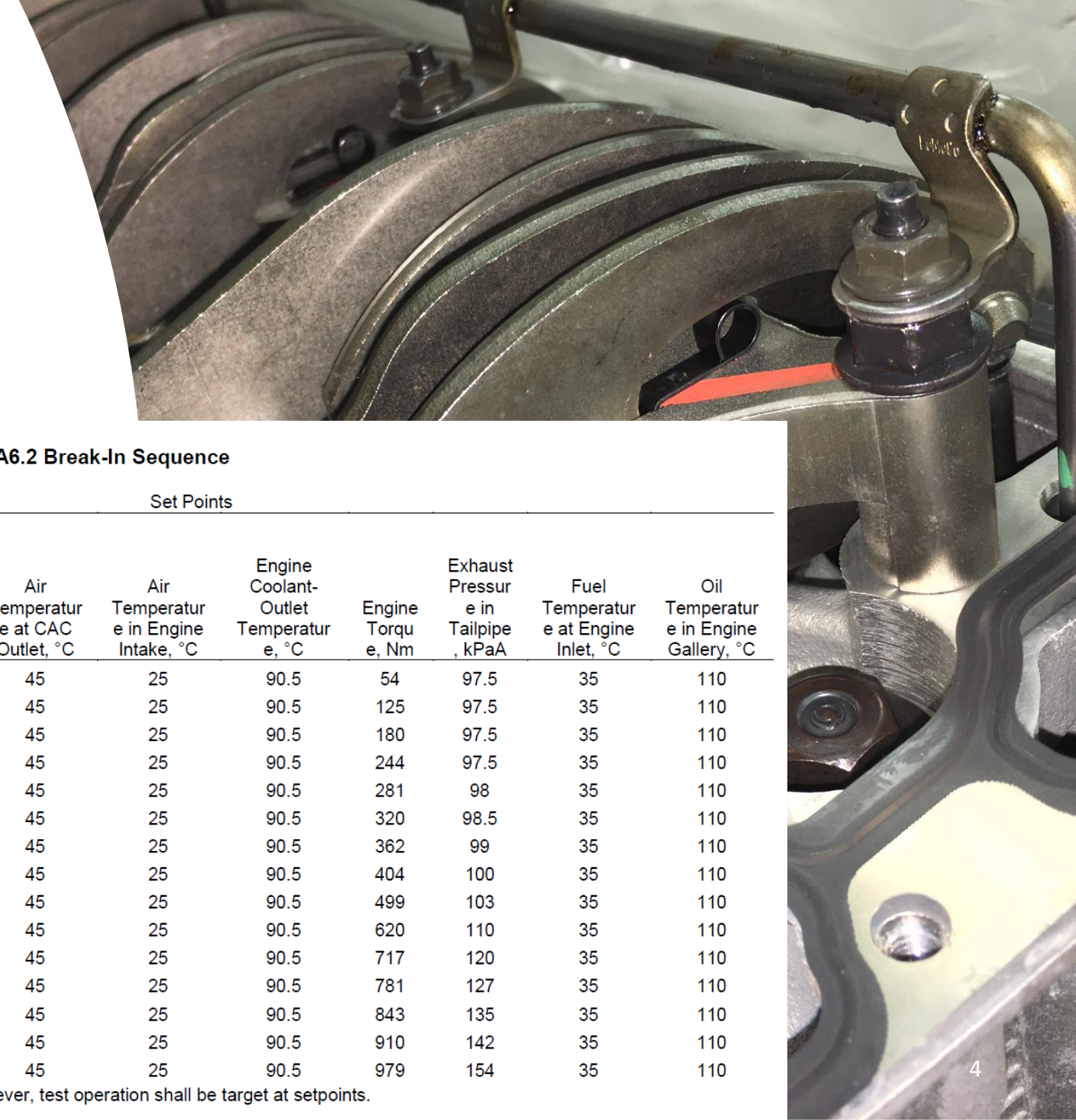
TEST OVERVIEW

- First Flush (14.5 kg oil charge)
 - 15 min, 1000 rpm no load
- Compression/Leakdown Check
- Break-In (14.5 kg oil charge)

TABLE A6.2 Break-In Sequence

Step	Time h:min	Setpoint Ramp Time, s	Engine Speed r/min	Set Points									
				Air Pressure in CAC Coolant System, kPag	Air Pressure in Engine Coolant System, kPag	Air Pressure in Engine Intake, kPaA	Air Temperature at CAC Outlet, °C	Air Temperature in Engine Intake, °C	Engine Coolant- Outlet Temperature, °C	Engine Torque, Nm	Exhaust Pressure in Tailpipe , kPaA	Fuel Temperature at Engine Inlet, °C	Oil Temperature in Engine Gallery, °C
1 ^A	0:06	10	650	34	131	97	45	25	90.5	54	97.5	35	110
2 ^A	0:06	10	1000	34	131	96.75	45	25	90.5	125	97.5	35	110
3 ^A	0:30	30	1200	34	131	96.5	45	25	90.5	180	97.5	35	110
4 ^A	0:30	30	1400	34	131	95.75	45	25	90.5	244	97.5	35	110
5 ^A	0:30	30	1500	34	131	95.25	45	25	90.5	281	98	35	110
6 ^A	0:30	30	1600	34	131	95	45	25	90.5	320	98.5	35	110
7 ^A	0:30	60	1700	34	131	95	45	25	90.5	362	99	35	110
8 ^A	0:30	60	1800	34	131	95	45	25	90.5	404	100	35	110
9 ^A	0:30	60	2000	34	131	95	45	25	90.5	499	103	35	110
10 ^A	0:30	120	2200	34	131	95	45	25	90.5	620	110	35	110
11 ^A	0:30	120	2400	34	131	95	45	25	90.5	717	120	35	110
12 ^A	0:30	120	2500	34	131	95	45	25	90.5	781	127	35	110
13 ^A	0:30	120	2600	34	131	95	45	25	90.5	843	135	35	110
14 ^A	0:30	120	2700	34	131	95	45	25	90.5	910	142	35	110
15 ^A	0:54	120	2800	34	131	95	45	25	90.5	979	154	35	110

^ATemperatures and pressure may not reach setpoint during conditions; however, test operation shall be target at setpoints.



TEST OVERVIEW

- Power Check (Straight after Break-In)
 - 5 min, 2800 rpm, 100% Throttle
 - If 1050 Nm is obtained, proceed to flush 2
- Flush 2 (14.5 kg oil charge)
- Flush 3 (14.5 kg oil charge)
- Soot Phase (14.5 kg test charge)
 - 10 hours
 - $2.25 \pm 0.5\%$ soot at 10 hrs
 - False fuel temperature signal supply to ECM to change the amount of soot generated

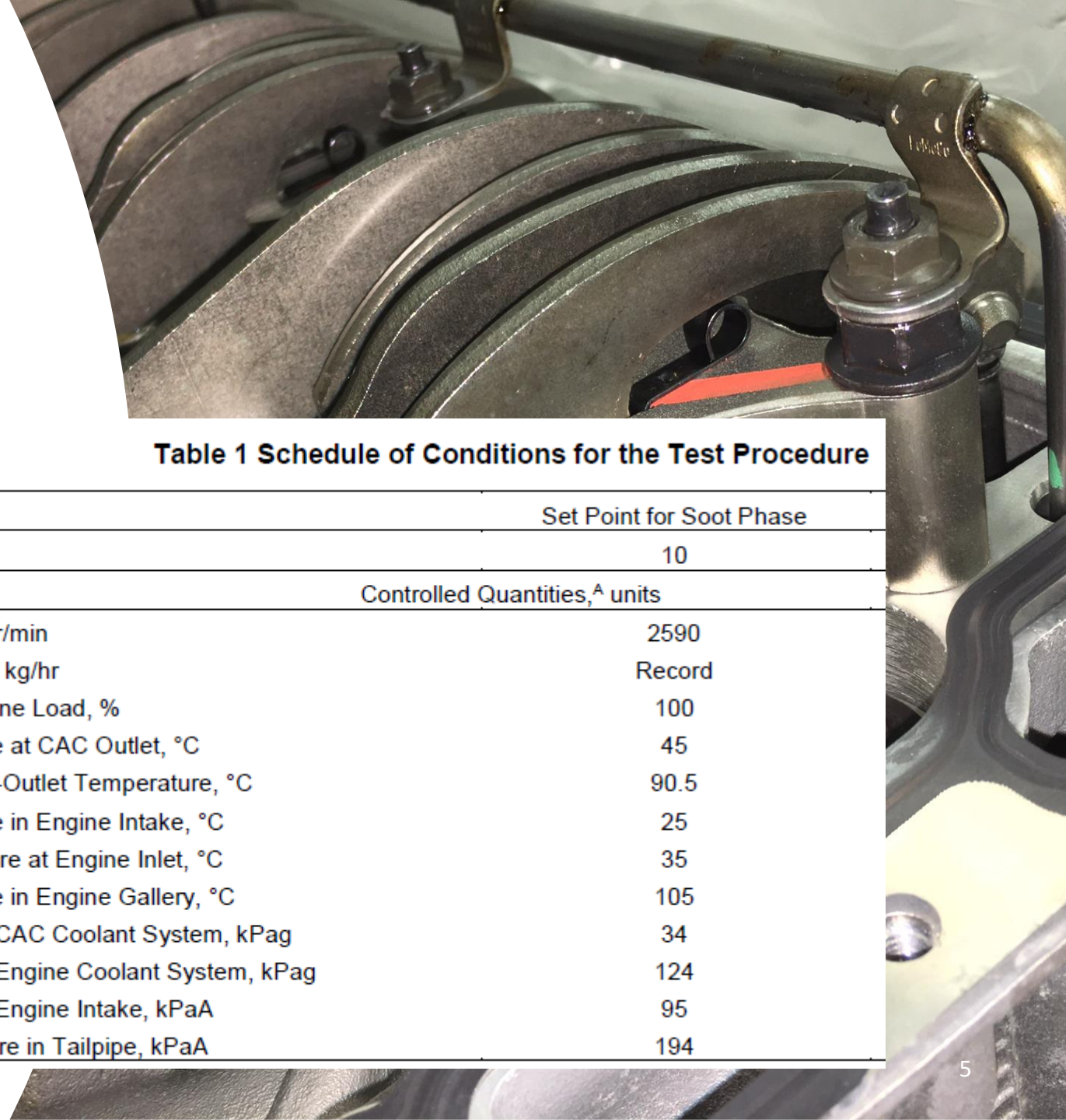


Table 1 Schedule of Conditions for the Test Procedure

	Set Point for Soot Phase
Time, h	10
Controlled Quantities, ^A units	
Engine Speed, r/min	2590
Fuel Flow Rate, kg/hr	Record
Calculated Engine Load, %	100
Air Temperature at CAC Outlet, °C	45
Engine Coolant-Outlet Temperature, °C	90.5
Air Temperature in Engine Intake, °C	25
Fuel Temperature at Engine Inlet, °C	35
Oil Temperature in Engine Gallery, °C	105
Air Pressure in CAC Coolant System, kPag	34
Air Pressure in Engine Coolant System, kPag	124
Air Pressure in Engine Intake, kPaA	95
Exhaust Pressure in Tailpipe, kPaA	194

TEST OVERVIEW

- Wear Phase
 - 200 hours
 - 5.25 ± 0.5% 110 hour soot window
 - 8.25 ± 0.5% 210 hour soot window
 - Soot controlled using **engine coolant temperature** sensor signal which in turn adjusts engine fuel timing
 - 1.4 kg Oil Adds every 25 hours (forced drain, fill to full)
- Post Test Compression Test/Leakdown

Table 1 Schedule of Conditions for the Test Procedure

	Set Point for Soot Phase	Set Point for Wear Phase
Time, h	10	200
Controlled Quantities, ^A units		
Engine Speed, r/min	2590	2800
Fuel Flow Rate, kg/hr	Record	70.5
Calculated Engine Load, %	100	Record
Air Temperature at CAC Outlet, °C	45	50
Engine Coolant-Outlet Temperature, °C	90.5	90.5
Air Temperature in Engine Intake, °C	25	25
Fuel Temperature at Engine Inlet, °C	35	35
Oil Temperature in Engine Gallery, °C	105	109
Air Pressure in CAC Coolant System, kPag	34	34
Air Pressure in Engine Coolant System, kPag	124	131
Air Pressure in Engine Intake, kPaA	95	95
Exhaust Pressure in Tailpipe, kPaA	194	194

TEST OVERVIEW

Table 8 Minimum Requirements for Oil Sampling and Testing

Quantity/Test Method											Comments
Phase	Test Hour ^B	Sample Size, mL	Perform Oil Add	Fuel Dilution	KV at 100 °C	Oxidation IR Peak Height Method	Soot by TGA	Wear Metals	Base Number	Acid Number	
				D3524	D445	Based on E168	D5967	D5185	D4739	D664	
	0	120		X	X	X	X	X	X	X	From fresh oil drum
Soot	0-10 ^A	7.4 max each					X				
Soot	10	120		X	X	X	X	X	X	X	
Wear	35	120	X		X	X	X	X			
Wear	60	120	X	X	X	X	X	X	X	X	
Wear	85	120	X		X	X	X	X			
Wear	110	120	X	X	X	X	X	X	X	X	
Wear	135	120	X		X	X	X	X			
Wear	160	120	X	X	X	X	X	X	X	X	
Wear	185	120	X		X	X	X	X			
Wear	210	120		X	X	X	X	X	X	X	

^AOptional samples

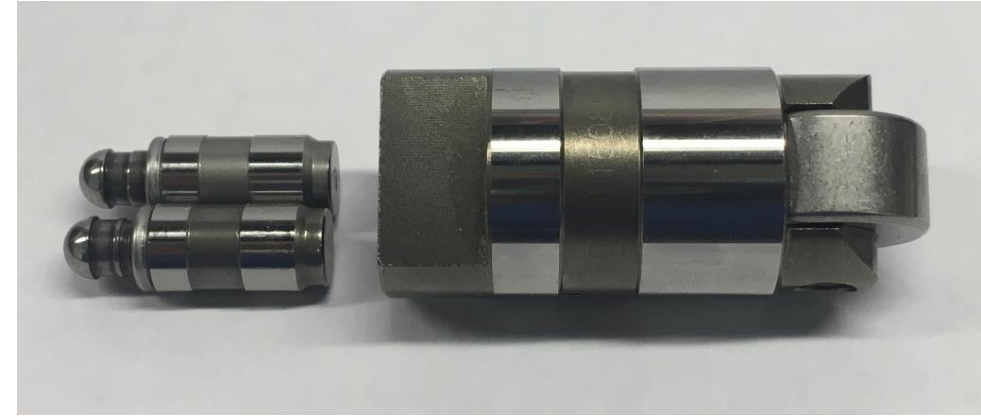
^BMaximum of 30 mL of combined sample may be taken from start of Soot Phase up to the 10-hour sample.

VALVETRAIN PARTS



Examined Valvetrain Parts

- Rocker Arms
- Push Rods
- Fulcrum Balls (not shown)
- Pedestals
- Roller-Followers (Trace on Shaft)



VALVETRAIN PARTS

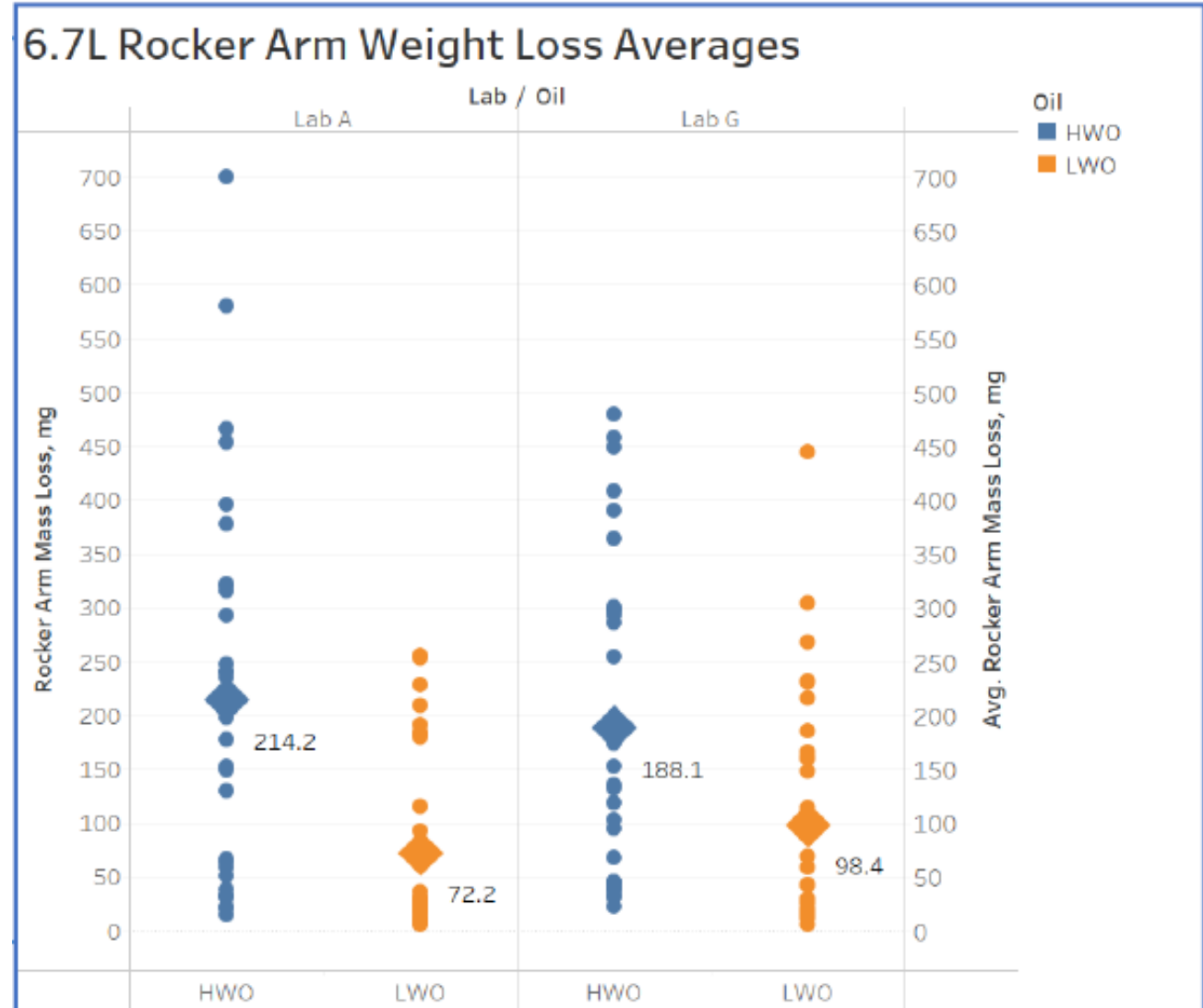
- Focus on Rocker Arm Wear (Weight Loss, mg)
- No discrimination between oils seen on other components during prove-out testing
- Will continue to monitor other components throughout precision matrix



PROVE-OUT TESTING RESULTS



- All tests ran on current procedure
- HWO (Blue) – 800 ppm Phosphorus, 5W-30, 3.0 HTHS150
- LWO (Orange) – CJ-4 Factory Fill, 1100 ppm Phosphorus, 10W-30, 3.5 HTHS150
- Acceptable oil discrimination



Questions?



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