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Light-Duty Vehicle Transmission Benchmarking, 2017 Ford F-150 With 10R80 and 2018 Honda Accord With Earth Dreams CVT

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16. Abstract This report documents the benchmarking testing of two vehicle transmissions, the Ford F150 10-speed 10R80 transmission, and the Honda "Earth Dreams" continuously variable transmission used in many Honda models manufactured in 2017 and later.		
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Foreword

The objective of this project was to test, evaluate, and characterize different transmission architectures currently available in North American light-duty vehicles. The NHTSA task order includes the reverse engineering and costing of advanced transmissions offered in MY2017 or newer vehicles produced for the North American market. SwRI has worked with NHTSA and project partners to provide NHTSA with empirical data collection, technical support, and data analysis on the transmissions identified for benchmarking consideration. Evaluation of each benchmark transmission consisted of component efficiency mapping, torque converter mapping and engagement strategy, oil pump testing, parasitic loss determination, shift schedule identification, laden and unladen shift algorithm mapping, transmission teardown and component level costing. General ratio spread and packaging envelope of each transmission has also been documented while completing the Task Order. Throughout the duration of the project, attention has been paid to identify individual components of the transmissions that advance fuel economy and quantify their benefit. Each benchmark transmission underwent a teardown and cost analysis that was subcontracted by SwRI to Roush Industries.

This report follows the Specific Requirements or SRs outlined by the original NHTSA task order. Each SR section addresses unique objectives of the overall project. SR-1 was the project kick-off meeting held at the award of the program and did not generate any technical content. Therefor e, SR-1 has been omitted from the final report. SR-2 deliverables were generated with the fully assembled transmission at the component level. The transmission efficiency, torque converter performance, and in-gear inertia maps were all a part of the SR-2 tasks. Overall component level characterization took place within SR-3. The SR-3 tasks included parasitic measurements of the assembled transmissions, oil pump mapping, ratio determination, and physical dimensioning. SR-4 examined the in-vehicle performance of each transmission. The SR-4 data sets characterized shifting and converter strategies. Shift timing and CVT pulley ratio were examined with respect to road conditions and driver demand within SR-4. The transmission teardown and costing information was performed through the execution of SR-5 and has been reported separately.

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List of Acronyms

ANL	Argonne National Laboratory
ATF	Automatic Transmission Fluid
CVT	Continuously Variable Transmission
DCT	Dual Clutch Transmission
EPA	Environmental Protection Agency
NVH	Noise Vibration and Harshness
PWM	Pulse Width Modulation
SwRI	Southwest Research Institute
ULV	Ultra Low Viscosity (as it pertains to transmission fluid)

1 Project Introduction

The objective of this project was to evaluate and characterize different transmission architectures available for use in light duty vehicles produced for the North American market. The first two transmissions benchmarked for this effort included a 10-speed, longitudinal automatic transmission and a push-belt continuously variable transmission. The evaluation of each benchmarked transmission consisted of in-gear efficiency mapping, torque converter mapping, torque converter engagement strategy characterization, oil pump testing, parasitic loss determination, shift schedule identification with laden versus unladen shift algorithm mapping, characterization of ratio spread and packaging envelope, and finally, transmission teardown and costing.

The Ford 10R80 was the first of two benchmark transmissions evaluated for the FY2019 effort. The 10R80 is a 10-speed automatic transmission developed as part of a joint venture between General Motors and Ford that produced a 9-speed transaxle and a 10-speed, longitudinal transmission. Ford championed development of the longitudinal 10-speed and has deployed the transmission, widely, in the F- 150 line of pickup trucks. Claimed feature improvements for the new transmission include increasing the forward gears from six to ten speeds with the limited addition of a single planetary gearset and two clutches. The new transmission fits within the same package dimensions at the same assembled weight as the Ford 6-speed transmission the 10R80 replaces. Clutch engagement schemes are designed to minimize the number of disengaged (open) clutches in any gear, reducing the viscous drag during operation.

The Honda Earth Dreams transmission is a continuously variable transmission (CVT) produced by Honda that is available in the 2017 and up Accord. This was the second of the two benchmark transmissions evaluated during the FY2019 portion of the project. The Honda Earth Dreams CVT is the second generation CVT available in the Accord and is equipped with several updates over the previous generation to improve shifting performance and efficiency. The Honda CVT is a push-belt style CVT with a reversing planetary and a helical reduction gear train between the secondary variator and the output carrier.

The transmission benchmarking efforts undertaken as part of this project sought to provide NHTSA with powertrain data that improves vehicle modeling and standard writing activities. The report details the technological advancements of each benchmark transmission and the empirical data collected as part of the project.

1.1 Introduction to Ford 10R80

Transmissions contribute significantly in modern powertrains to the overall vehicle fuel economy achievable. Several strategies have been used across manufacturers and transmission types to extract maximum efficiency without negatively affecting the drivability of the vehicle. These powertrain strategies include several prevailing trends: increased number of drive gears, large ratio spread, more aggressive torque converter lockup strategies, material and finish selection for friction reduction, design for low viscous drag including reduced transmission fluid viscosity, and integrated powertrain control strategies. With a gear ratio spread of 7.39:1 and a maximum overdrive of 0.63:1, Ford noted the 10R80 provides closer ratio steps for smoother shifting and optimal use of each available gear.

1.1.1 Application and Platforms

The Ford 10R80 transmission is used in rear-wheel drive, 4-wheel drive, and all-wheel drive vehicles with longitudinal engine configurations. Ford uses the "R" designation for their longitudinal transmissions and an "F" designation for their transaxles. The "10" preceding the R indicates the number of forward gears, while the 80 indicates the torque capacity the transmission can receive from an engine in tens of Newton-meters. The transmission is currently installed in the following Ford Motor Company vehicles:

- 2017-present Ford F-150
- 2018-present Ford Mustang
- 2018-present Ford Expedition/Lincoln Navigator
- 2019-present Ford Ranger
- 2020-present Ford Explorer/Lincoln Aviator
- 2020-present Ford Transit

1.1.2 Areas of Efficiency Improvement

Following the Ford and GM partnership announcement, several press releases and articles were written describing the new features, efficiency gains, and refinements of the new transmissions. of interest to this report is efficiency and performance improvements, which can be categorized based on the component/feature that contributes to the efficiency gain. These bin categories are transmission architecture, control strategy, functional improvements, and internal frictional losses. Some features may cross over multiple categories but are discussed in the area of the final report they best fit within. Fluid testing, valve body layout, and internal torque converter dimensions were outside the scope of the teardown portion of this project.

1.1.3 Transmission Features

Increasing the available forward gears allows for greater torque multiplication to reduce engine load with high demand vehicle operation while retaining final drive ratios that provide fuel efficient cruise operation. Larger overall ratio spreads keep the engine in its most efficient operating range for a wider range of vehicle maneuvers. The 10R80 transmission fits four more forward speeds in a package size matching that of the outgoing 6-speed transmission, without adding weight. This is accomplished by using a one-piece aluminum case and a novel clutch packaging structure in the center of the transmission. Overall, the transmission has four gearsets, two brake clutches, and four rotating clutches. This is only one more clutch than the class leading ZF 8HP transmissions for two additional forward speeds. The packaging dimensions, weight, and clutch quantity highlight the efficient case and component design of the 10R80. No cast iron parts are used in the 10R80. The switch to cast aluminum or weight-optimized steel parts throughout the transmission results in no weight penalty with the increase in part count.

Ford and GM have developed their transmission control software separately on the joint venture transmissions. Notable deviations in the Ford and GM transmissions include the torque converter, case structure, and valve body. The architecture of the transmission introduces efficiency gains that can be exploited through controls strategy and selected shift hardware. Skip-shift algorithms and reduced shift time results in smooth and efficient operation with minimal wasted energy during ratio changes. Ford and GM have elected to optimize the controls of their transmissions, separately, to better suite each manufacturers powertrain and vehicle applications. Closely spaced transmission gear ratios allow for shifting without unlocking the torque converter. This allows a more aggressive torque converter lockup strategy, decreasing driveline losses prior to the input shaft of the transmission. The torque converter is unlocked during starts to provide torque multiplication at launch and engine-to-transmission fluid dampening at low vehicle speeds. Once a target speed, based on driver demand, is reached in first gear, the torque converter initiates a partial slip strategy that continues until the transmission is locked for the bulk of operation. Partial slip of the converter clutch is allowed during portions of vehicle operation. This is likely done to reduce driveline shock or mitigate objectionable NVH performance from the powertrain. The torque converter clutch is available to lock in all gears and has been observed to remain locked over a large portion of the standard drive cycles. by reducing the amount of time the torque converter is unlocked, a smaller torque converter can be used. a larger diameter torque converter is normally used to increase the efficiency of open converter operation across the range of pump and turbine speed ratios. a smaller converter reduces assembly weight, required fluid capacity, system inertia, and helps retain the packaging size of the outgoing six speed transmission.

The Ford 10R80 allows for idle fuel economy improvement strategies by including start/stop technology. An electric stop/start pump within the transmission allows engine stop/start functionality. Further fuel economy improvement is attributed to the use of Mercon ULV transmission fluid. The fluid is an ultra-low viscosity fluid for mulated to minimize pumping losses and viscous drag.

1.2 Introduction to Honda Earth Dreams CVT

CVTs differ from traditional automatic transmissions in that they provide a range of infinite gear ratios with no fixed steps between them. Rather than planetary gear sets with clutches and brakes to link the planetary elements together, CVTs use a set of pulleys whose effective diameters can be varied by means of hydraulic pressure. This allows any gear ratio between the low and high range of the transmission. by continually adjusting the ratio without interrupting power delivery, the engine can be kept in its optimal range based on the driver demand and economic operation.

Most automotive CVTs use a belt or chain with conical pulleys. by moving the halves of one pulley closer together, the effective diameter of the belt on the pulley is increased. Conversely, moving the halves further apart allows the belt to track inward to the center of the pulley, decreasing the effective diameter. The belt connects the drive pulley on the engine axis to the driven pulley connected to the transmission output. The effective diameters of the belt riding on the drive and driven pulley determines the ratio between pulleys. The belt for the Honda CVT is made of thin plate metal elements attached by laminate steel bands. Power transmission relies on friction generated by the CVT fluid between the element edges and the pulley surfaces. Most automotive CVTs use either link chains or push-belts to transmit power. One unique design among CVTs is Nissan's EXTROID CVT, which uses a toroidal design with power rollers situated between input and output rotors with various diameters along their axis. The power rollers can change angles to modify gear ratios. Nissan's EXTROID CVT was not part of this study.

1.2.1 Honda Earth Dreams CVT

Honda's Earth Dreams Technology is a group of developments aimed at improving both driving performance and fuel efficiency for internal combustion engines, transmissions, and electric-powered vehicles. to date, a variety of engines, hybrid powertrains, and transmissions have been produced under the Earth Dreams moniker. Honda deems the CVT in this study to be the company's mid-size class CVT.

Honda's Earth Dreams CVT is an evolution of the CVT found in the previous generation Honda Accord and other mid-size vehicles. The new transmission was released with idle stop capability, allowing the engine to shut off when the vehicle is stopped in traffic or at a stop signal. a new "G-Design Shift" system seeks to enhance driver feel by attempting to eliminate the disconnected feel that is a common complaint among drivers of CVT equipped vehicles. This system is purported to immediately transfer torque to the wheels when acceleration is desired, while adjusting to a lower gear ratio for increased acceleration. This contrasts the momentary freewheel of a stepped transmission as it undergoes a downshift during acceleration. at full throttle, the "G-Design Shift" logic uses stepped ratio emulation to recreate the feel of a traditional transmission.

1.2.2 Areas of Efficiency Improvement

Honda has introduced a variety of features in the Earth Dreams CVT to achieve their goals of increased fuel economy and improved driving experience. Honda claims a 10% fuel efficiency gain with the CVT compared to the automatic in the previous generation Accord. The CVT has a 10% lower gear ratio for improved launch. The G-Design Shift logic in the transmission provides some stepped-ratio feel reminiscent of an automatic transmission, while maintaining optimal acceleration. Acceleration is intended to be smooth and linear as the engine remains in its powerband during acceleration without excessive engine speed change. The Earth Dreams CVT claims a friction reduction by moving the pulleys above the fluid level to reduce fluid stirring and viscous drag. a variable displacement pump is present in the Earth Dreams CVT. This two-chamber pump with sequencing valve reduces power consumption at higher pump speeds. The dual chamber ensures necessary system pressure is available for proper operation and belt clamping force at lower pump speeds. CVTs operate at higher pressures than traditional stepped-gear automatic transmissions (6 MPa versus 2 MPa of peak pressure, respectively), so reducing pump output when possible can create further fuel savings.

2 SR-2 Deliverables – Gear Efficiency Maps

2.1 Gear Efficiency Mapping

2.1.1 Component Level Testing Setup

Component efficiency maps were completed outside the vehicle for each of the transmissions tested under the FY2019 task order. The transmissions were operated through steady-state conditions using a system of controls that directly interact with the shift control solenoids to mimic the calibration observed in the vehicle. The empirical data collected on each benchmark transmission was intended to improve upon the "Main Component Assumptions" tables that feed the Autonomíe model used by NHTSA and Argonne National Laboratory vehicle simulation. Figure 1 shows the assumed efficiency values at the start of this project for the high feature, stepped automatic, 10-speed transmission.

AU10 ++

AU10pp - 1st		rpm										
		500	750	1000	1250	1500	1750	2000	2500	3000	4000	5000
Torque ratio	0.0	0.78	0.80	0.81	0.81	0.81	0.80	0.79	0.77	0.73	0.67	0.67
	0.1	0.78	0.80	0.81	0.81	0.81	0.80	0.79	0.77	0.73	0.67	0.67
	0.2	0.88	0.89	0.89	0.90	0.90	0.89	0.89	0.87	0.87	0.83	0.83
	0.3	0.91	0.92	0.92	0.93	0.93	0.92	0.92	0.91	0.90	0.88	0.88
	0.4	0.93	0.93	0.93	0.94	0.94	0.94	0.94	0.93	0.92	0.90	0.90
	0.6	0.94	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.94	0.93	0.93
	0.8	0.94	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.94	0.94
	1.0	0.95	0.96	0.95	0.96	0.96	0.96	0.96	0.96	0.95	0.95	0.95

AU10pp - 2nd		rpm										
		500	750	1000	1250	1500	1750	2000	2500	3000	4000	5000
Torque ratio	0.0	0.79	0.81	0.82	0.82	0.82	0.81	0.80	0.78	0.74	0.68	0.68
	0.1	0.79	0.81	0.82	0.82	0.82	0.81	0.80	0.78	0.74	0.68	0.68
	0.2	0.89	0.90	0.91	0.91	0.91	0.90	0.90	0.89	0.88	0.84	0.84
	0.3	0.92	0.93	0.93	0.94	0.94	0.94	0.93	0.93	0.92	0.89	0.89
	0.4	0.94	0.95	0.95	0.95	0.95	0.95	0.95	0.94	0.94	0.92	0.92
	0.6	0.95	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.95	0.94	0.94
	0.8	0.96	0.96	0.97	0.97	0.97	0.97	0.97	0.96	0.96	0.95	0.95
	1.0	0.96	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.96	0.96

Figure 1. Assumed Efficiency for a Premium Model 10 Speed Stepped Automatic Transmission

Vehicle data and controls logic determination was required to build the test condition matrix and control schedule for each transmission component test. This instrumentation and vehicle control characterization was undertaken as a part of the SR-4 In-Use testing efforts and are discussed in detail in the SR-4 section of this report. SwRI tested the benchmark transmissions at the component level using the immediately adjacent vehicle hardware. This included using the vehicle flexplate or drive plate that mates to the transmission's torque converter and the vehicle output shaft. SwRI created mounting plates to emulate the engine block surface. Bellhousing dimensions for each mounting plate were taken using a FARO™ CMM probe. Then the mounting plate for the component level testing was created from Blanchard ground material with the bellhousing mounting holes. The mounting plate joined the transmission to the SwRI head stand that housed an input spindle and the transmission input torque flange. SwRI used a collection of appropriately sized HBM™ T10FS, T12, and T40 torque meters for inline torque measurement during the component level work. Figure 2 shows the Ford 10R80 installation from headstand to output torque meter. for the Ford 10R80 the output torque meter was placed between the prop-shaft and the absorbing dynamometer. This was done to increase the radial support of the inline torque meter and reduce the potential for a noisy torque signal caused by radial loading of the meter through transmission main-shaft movement. Prop-shaft angles were kept at zero degrees to minimize any shaft losses. This placement of the torque meter is allowed within the EPA GEM II procedures governed by CFR1037.

Figure 2. Ford 10R80 Component Test Setup

Figure 3 depicts the specific adaptations used for the Ford 10R80 component testing. The benchmark transmission evaluated was from a four-wheel drive vehicle. The mainshaft of the transmission mates to the transfer case that bolts directly to the transmission in the vehicle. SwRI procured an input carrier element for the vehicle's transfer case and created the pictured flange. The welded and post-machined adapter sealed the transmission's output shaft and created a flange for a propshaft connection. Figure 3 further shows the wiring harness adaptation used in the component level testing. The transmission bulkhead connector was used as the benchmark transmission has an external transmission/powertrain controller. for units with internal transmission controllers, a component testing harness must be connected to the control solenoids within the valvebody of the transmission and routed external to the transmission. The harness on the Ford 10R80 shown in Figure 3 routes out of case above the transmission pan surface and into a blade connecter terminal block where control signals were applied to the solenoids within the transmission.

Figures 4, 5, and 6 illustrate the specifics of the component testing installation for the Honda Earth Dreams CVT. Figure 4 shows the full transmission assembled for component testing. Matched gearboxes are used for transaxle configurations to link both output shafts to the absorbing dynamometer. No differential speed between the driver and passenger side output shafts is allowed using this configuration. Figure 5 shows the input driver that SwRI manufactured to adapt the inline torque flange to the transmission's flexplate. This adapter mimicked the vehicle's crankshaft flange and reproduced the in-vehicle torque converter pull-up measurement.

Proper pull-up dimensions are critical for torque converter sealing and avoidance of transmission pump damage. Figure 6 shows the deconstruction of the vehicle wheel hub bearing used to create an adapter flange for the output torque meters. The hub bearing was removed from the stub spindle and the wheel studs pressed out to allow a through-bolted joint directly to the output torque meter.

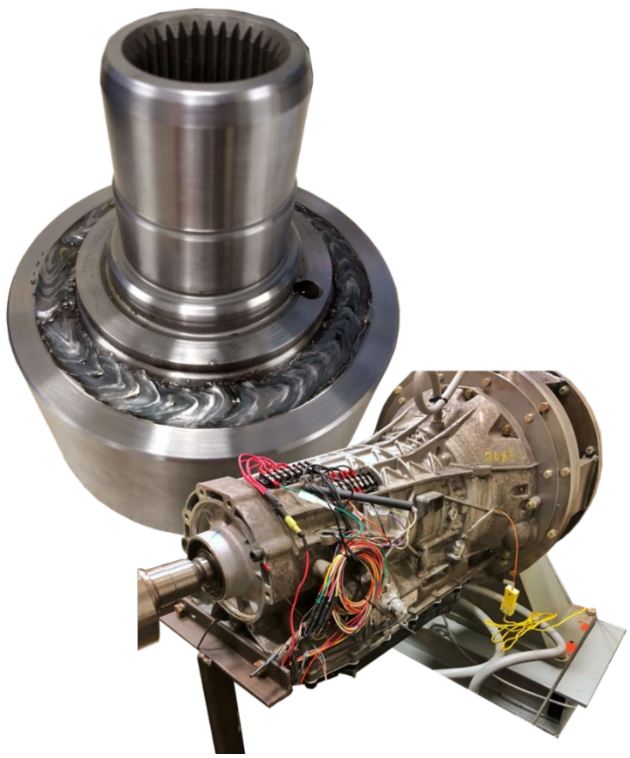


Figure 3. Ford 10R80 Component Test Adaptations

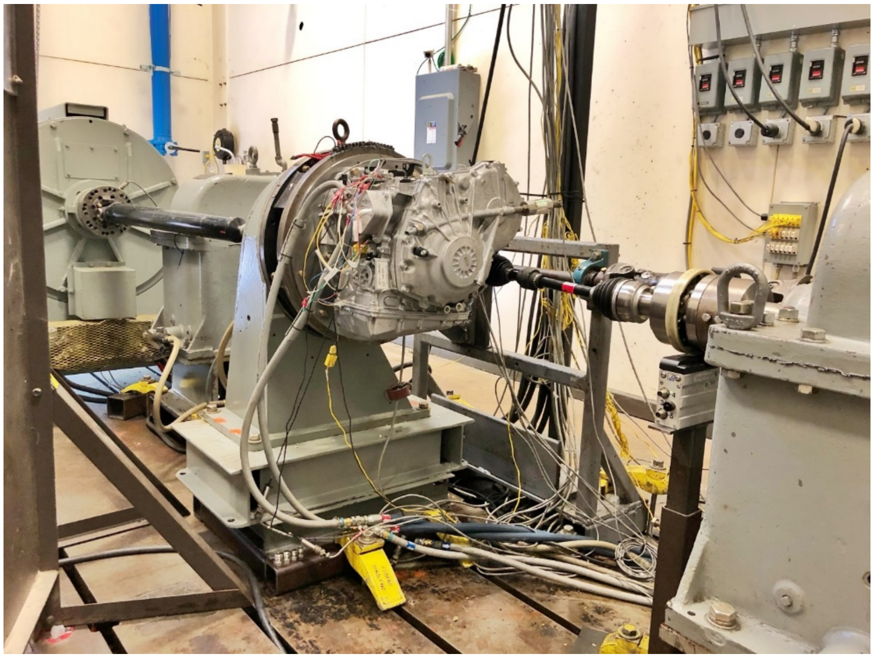


Figure 4. Honda Earth Dreams CVT Component Test Installation

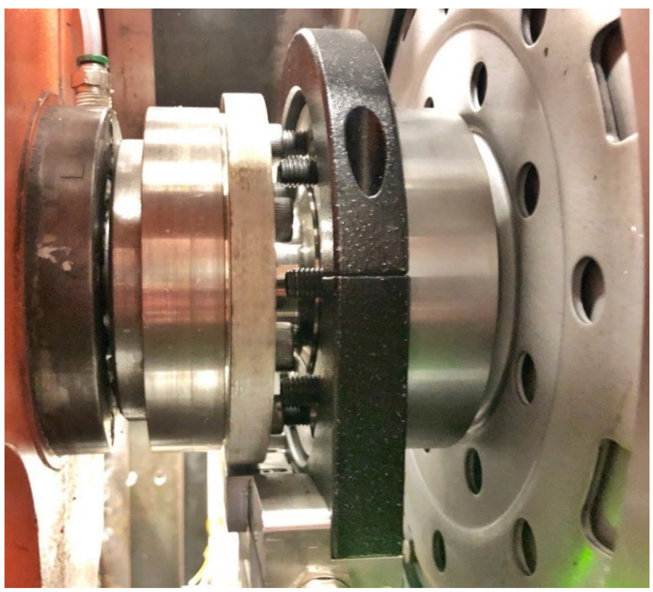


Figure 5. Honda CVT Input Adapter

Figure 6. Transaxle Output Adapters

2.1.2 Calibrations

HBM flange type torque meters were used to measure input and output torque. Information regarding each torque meter used can be found in Table 1. a representative dead weight calibration of the output torque meter used in the Ford 10R80 testing can be found in Figure 7. Each torque meter was calibrated by means of a deadweight calibration. The torque meter rotor and antenna were mounted on a calibration stand with the appropriate mounting hub. a torque arm was mounted to the hub. a load hanger and weights were placed on the torque arm. Weights were placed on the load hanger in an incremental pattern until the target torque was applied. The applied weight, calculated torque (F x d), and torque from the data acquisition system (DAQ) were recorded. The two zero-torque measurements from the DAQ were averaged to obtain the calibrated torque meter offset. The calibrated torque meter offset was then subtracted from each of the DAQ torque measurements to correct the DAQ channel offset for each torque measurement. The measurement errors at each applied load point were recorded to find the maximum meter measurement error value. This maximum error value was checked against the stated meter accuracy to ensure that the meter adheres to the accuracy and linearity requirements set forth by the manufacturer. The four torque meters used for testing had measurement errors within the tolerance for each meter.

Table 1. Torque Meter Information

	Input	10R80 Output	Left Output	Right Output
Model	HBM T40B	HBM T12	HBM T40B	HBM T40B
Scale	500 Nm	3000 Nm	3000 Nm	3000 Nm
Accuracy	± 0.25 Nm	± 1.5 Nm	± 1.5 Nm	± 1.5 Nm
Calibrated Offset	0.32 Nm	-2.18 Nm	-6.28 Nm	-0.05 Nm
Mean Installed Offset	0.32 Nm	-2.57 Nm	-3.27 Nm	0.58 Nm

				Subtract zero offset here:	
Applied Weight	Calculated Torque (Nm)	DAQ Reading (Nm)	Calibrated Offset (Nm)	Corrected DAQ Torque (Nm)	Corrected Error (Nm)
0	0.00	-6.36	-6.28	-0.09	0.09
50	-387.57	-393.93		-387.66	0.08
100	-670.21	-676.64		-670.37	0.15
150	-952.85	-959.31		-953.04	0.19
200	-1235.48	-1242.31		-1236.04	0.55
250	-1518.12	-1524.86		-1518.59	0.47
300	-1800.76	-1807.68		-1801.41	0.65
350	-2083.39	-2090.46		-2084.19	0.79
300	-1800.76	-1807.68		-1801.41	0.65
250	-1518.12	-1525.01		-1518.74	0.62
200	-1235.48	-1242.30		-1236.03	0.54
150	-952.85	-959.63		-953.36	0.51
100	-670.21	-676.85		-670.58	0.36
50	-387.57	-394.06		-387.79	0.21
0	0.00	-6.19		0.09	-0.09
				Min Error	-0.09
				Max Eror	0.79
				Error +/-	0.44

Figure 7. HBM T12 3000 NM Output Torque Meter Calibration for Ford 10R80 Testing

K-type thermocouples were used to measure sump temperature, relevant circuit temperatures, and ambient temperature. SwRI used graded thermocouples; sump temperature instrumentation used the lowest error thermocouples as those thermocouples served as the process variable for the fluid temperature conditioning circuits. Figure 8 details the bath-calibration information for the two of the thermocouples.

Sump Temperature (°C)				Ambient Temperature (°C)		
Nominal Value (°C)	DAQ Reading (°C)	Error		Nominal Value (°C)	DAQ Reading (°C)	Error
-50	-49.70	0.3		-50	-48.8	1.2
38	38.30	0.3		38	39.1	1.1
125	125.20	0.2		125	126.1	1.1
213	213.20	0.2		213	214.1	1.1
300	300.20	0.2		300	301.1	1.1

Figure 8. Thermocouple Calibration

Calibration of the speed channels was a tiered process. First, a frequency generator was used to calibrate the input and output speed readings in the DAQ by providing an ideal square wave of known frequencies. The frequency generator itself was calibrated and tracked through the SwRI calibration laboratory against proven standards. Figure 9 details the frequency calibration of the DAQ channels for the input and output speed. The DAQ speed channels were corrected for offset and linearity based on the error measured against the frequency calibrator, prior to testing. This corrected the gate/timing error characteristics of the DAQ frequency card. Speed measurement and speed control to setpoint were then verified for accurate reproduction according to CFR 1065.305 and equation 1065.602-4. Reproducibility for 10 repeats of each speed set point can be found in Figure 10.

Input Speed Channel						Output Speed Channel				
Supplied Frequency [Hz]	DAQ Speed (rpm)	Measured Error	Corrected Speed (rpm)	Corrected Error (rpm)		Supplied Frequency [Hz]	DAQ Speed (rpm)	Measured Error	Corrected Speed (rpm)	Corrected Error (rpm)
100	100.2	-0.2	99.9816	0.0184		100	99.9	0.1	100.0028	-0.0028
1000	1000.2	-0.2	1000.027	-0.0266		1000	999.8	0.2	999.9658	0.0342
2000	2000.1	-0.1	1999.977	0.0234		2000	1999.8	0.2	2000.0358	-0.0358
3000	3000.1	-0.1	3000.027	-0.0266		3000	2999.7	0.3	3000.0058	-0.0058
4000	4000	0	3999.977	0.0234		4000	3999.6	0.4	3999.9758	0.0242

Figure 9. Speed Calibration With Frequency Generator

Set Point	Target Accuracy (%)	1	2	3	4	5	6	7	8	9	10	Accuracy defined by eq. 1065.602-4, mean to set point	Target
50	0.05%	49.796	49.790	49.772	49.741	49.764	50.301	50.281	50.208	50.236	50.259	0.015	0.025
150	0.05%	149.832	149.815	149.791	149.807	149.744	150.381	150.442	150.271	150.217	150.141	0.044	0.075
250	0.05%	249.929	249.926	249.817	249.876	249.816	250.086	250.011	250.017	249.951	249.996	-0.057	0.125
350	0.05%	349.836	349.730	349.710	350.046	349.903	350.013	349.994	350.444	350.449	350.562	0.069	0.175
450	0.05%	449.730	449.582	449.687	450.025	449.992	449.900	449.825	450.576	450.593	450.602	0.051	0.225
550	0.05%	549.812	549.793	549.849	549.872	549.926	550.317	550.172	550.226	550.158	550.108	0.023	0.275
650	0.05%	650.131	649.792	650.117	649.890	649.861	650.262	650.140	650.081	650.100	650.104	0.048	0.325

Figure 10. Speed Reproduction Accuracy

Efficiency calculations were based upon the measured input torque, input speed, designed torque ratio of the transmission, and output torque. SwRI used the designed torque ratio to limit the error in efficiency calculations based on input and output speed disagreement. Slow output speeds can introduce error in calculated ratio due to the counting fidelity at low linear speeds for the in-use hall effect speed sensors.

2.1.3 Matrix Determinations

Testing boundaries for the component level work were developed using FTP75, HWFET and US06 drive cycle data. SwRI limited the component level envelope with the laden engine speeds and torques observed during SR-4 In-use testing. The FY2019 benchmark vehicles did not require wide-open throttle operation to meet any of the in-use testing, and therefor e, the input speed range captured for the component level testing was short of full throttle shift speed. As a result, the speed increments tested within SR-2 are smaller and provide greater efficiency data resolution for transmission input speed ranges that are represented in drive cycle usage. for the Ford F-150, the maximum engine speed observed during any drive cycle test was recorded as 3,715 rpm, so the efficiency matrix peak speed was limited to 4,000 rpm. Output shaft speeds were limited to equivalent vehicle speeds in the range of 80-to 85 mph for all component testing.

Table 2. Ford F150 Component Testing Envelope

Top Speed (mph)	80		
Trans Out Speed (rpm)	2775		
Wheel Speed (rpm)	838		
Gear	Ratio	Engine rpm @80 MPH	**Max Input Speed Tested (rpm)**
1	4.7	<4000	4000
2	2.99	<4000	4000
3	2.14	<4000	4000
4	1.8	<4000	4000
5	1.54	<4000	4000
6	1.29	3524	**3000**
7	1.00	2775	**2750**
8	0.85	2359	**2500**
9	0.69	1887	**2000**
10	0.64	1748	**1750**

The tractive effort for the drive cycles was used to bound input torque on the Ford10R80 testing. Few points exceeded 200 Nm with the vehicle at normal curb weight for the drive cycles tested. The rated peak torque of Ford's engine is stated as 637 Nm. The 350 Nm torque limit for the component testing allowed for the use of smaller output torque meters that improved torque measurement accuracy. As the efficiency results showed, the efficiency of the 10R80 became asymptotic with increasing torque. Target input torque conditions were biased to the lower torque values where small increases in torque resulted in considerable efficiency improvement. Figure 11 outlines the condition range and increments that the 10R80 was evaluated over for SR-2 component work.

Efficiency - 93C													
1st		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	Spin												
	25												
	50												
	75												
	100												
	150												
	200												
	250												
	300												
	350												

Figure 11. Test Matrix for Ford 10R80 Efficiency

The Honda Accord was similarly evaluated over the FTP75, HWFET and US06 drive cycles. Transmission input speed was limited between 650 and 3,000 rpm for the Earth Dreams CVT. 650 rpm represents vehicle idle speed and only 0.5% of the drive cycle conditions exceed 3,000 rpm. SwRI had planned to evaluate the Earth Dreams CVT above 3,000 rpm, but the ratio instability above 3,000 rpm created an unstable component system and efficiency numbers measured during the instability were not representative of the transmission. The output shaft stability allowed the component matrix to be extended to an equivalent vehicle speed of 93 mph. The Figure 12 histogram shows the dominant speed ranges over the drive cycles were tested. Table 3 calculates the input shaft speed for the vehicle cut points in the component test matrix at the discrete ratio targets. Shaded cells represent engine speeds that exceed measured values within in-use testing. SwRI expanded the speed cut-points to include 25 and 50 mph due to drive cycle speed histogram shown in Figure 12.

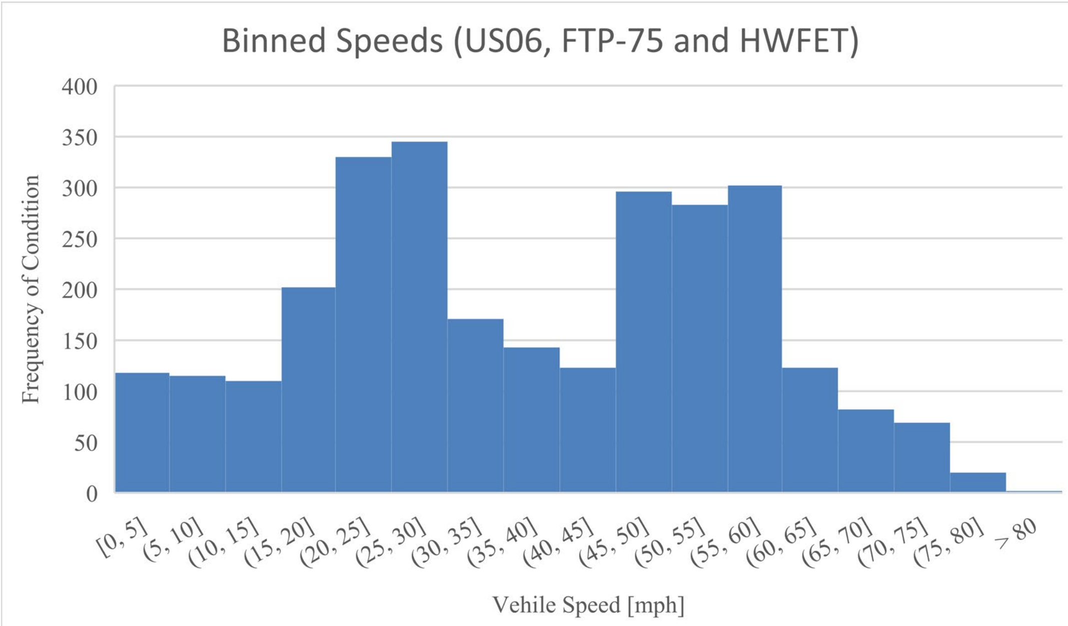


Figure 12. Histogram of Accord Vehicle Speed Over Drive Cycles

Table 3. Honda Earth Dreams CVT Test Speed Limits

		Ratio							
		2.645	**2.05**	**1.70**	**1.45**	**1.00**	**0.85**	**0.55**	**0.41**
Vehicle Speed (MPH)	16	2775	2151	1784	1521	1049	892	577	425
	25	4336	3361	2787	2377	1639	1394	902	664
	37	6418	4974	4125	3518	2426	2062	1335	983
	50	8673	6722	5574	4754	3279	2787	1803	1328
	62	10754	8335	6912	5895	4066	3456	2236	1647
	93	16131	12502	10368	8843	6099	5184	3354	2470

2.1.4 Control Pressure Generation

Control pressures required for running the transmisison at the component level were characterized during the vehicle in-use testing. As shown by the matrix selection process, the operating conditions of the engine and transmission can be narrow compared to the desired range of input conditions. This held true for the control pressures of the transmission. In order to create a line pressure schedule for the planned efficiency matrix, SwRI conducted steady state mapping tests. The vehicle was run at steady vehicle speeds with increasing pedal percent and at steady speed increasing load points. This steady state mapping extended the range of empirical data collected for the control pressures. Figure 13 illustrates the map extension process on the 10R80.

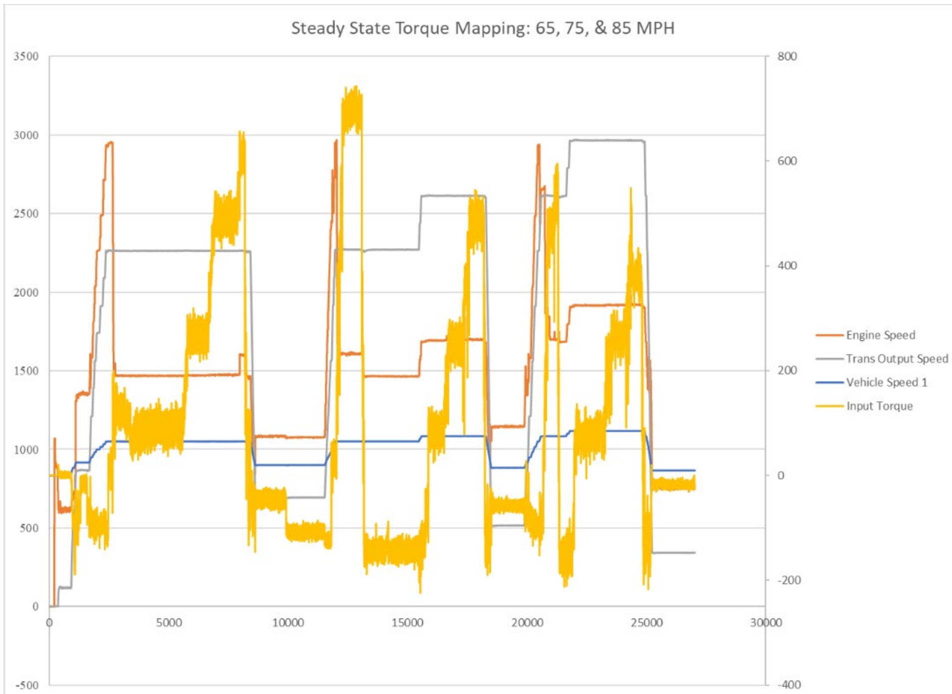


Figure 13. Steady Speed Torque Mapping in Ford F-150

Table 4. Empirical Line Pressure Measurement

UD Clutch Pressure, 1st Gear [kPa]		Engine Speed [RPM]										
		500	750	1000	1250	1500	1750	2000	2500	3000	4000	4500
Turbine Shaft Torque [Nm]	0	552	555	559	772	750	604	593		887		
	30	706	592	594			602	602		894		
	60		642	621			733	644	1201	907		
	90		764	783	851	1177	1192	779	1160	905	1068	
	120	1394	1090	965	963	957	969	928	1119	920		
	150	1403	1314	1095	1097	1051	1069	1080	1119	1063		
	200			1398	1404	1409	1350	1255		1290		
	250											
	300											

Table 4 shows representative data collected through the drive cycles and extended steady state mapping. The pockets of absent data are common from the vehicle mapping and additional work was required to complete a pressure schedule for the desired matrix. SwRI excluded pressure data that was inconsistent with other surrounding schedule data; transient operation and shift events affected the binning of certain cells. Trends with speed and torque guided the exclusions. The remaining points underwent an XYZ gridding process at the desired test conditions. a thin plate spline fit was performed over the desired grid for the empirical data. Figure 14 is the resultant contour plot following the fit of line pressure for the 5th gear data in Table 4. The contour plot is the graphical representation of the matrix generated at the XYZ grid points. The line pressure schedules for first and second gear of the 10R80 as generated by this method are presented in Table 5.

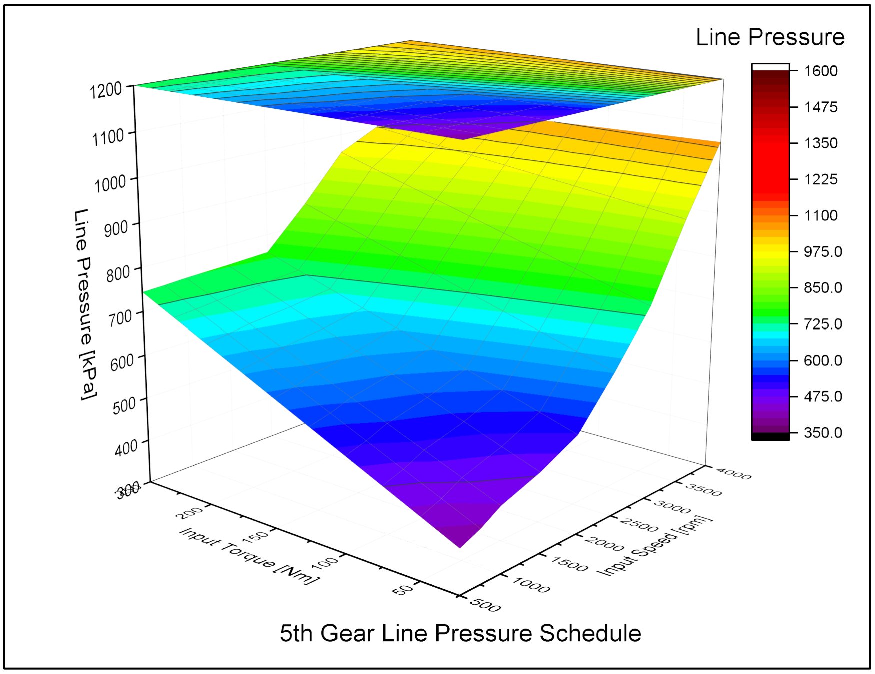


Figure 14. Surface Contour Plot for 5th Gear Line Pressure Schedule

Table 5. Line Pressure Fit for Ford 10R80 1st and 2nd Gear

1st		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	Spin												
	25	395	390	385	383	375	363	359	355	350	346	341	335
	50	412	409	406	406	402	393	390	387	383	380	377	372
	75	429	429	428	429	429	422	421	419	417	415	413	410
	100	446	448	450	452	456	452	452	451	450	450	449	448
	150	480	487	494	498	510	511	513	515	517	519	521	523
	200	515	526	538	544	565	571	575	579	584	588	592	599
	250	549	565	581	590	619	630	637	643	650	657	664	675
	300	583	604	625	636	673	689	698	708	717	726	736	750
	350	617	643	669	681	727	749	760	772	784	796	808	826

2nd		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	Spin												
	25	439	439	438	400	447	448	449	449	436	435	435	433
	50	451	451	451	412	460	461	463	464	451	451	451	451
	75	462	463	463	425	472	474	476	478	466	466	467	469
	100	474	474	475	438	485	487	490	493	480	482	484	487
	150	496	498	500	464	510	513	517	522	510	513	516	523
	200	519	522	524	489	535	540	544	550	539	544	549	559
	250	542	546	549	515	561	566	571	579	569	575	582	595
	300	565	569	573	541	586	592	598	608	598	606	615	631
	350	588	593	598	566	611	618	625	637	628	637	647	667

The component level mapping of a CVT required characterizing the clamping force of the secondary pulley against the measured output torque from the belt section of the CVT. The pulley clamping force is governed by the formula below, where d_2 is the effective diameter of the secondary pulley, μ is the tractive coefficient of the belt/pulley/fluid combination, and α is the belt angle.

$$F_{Driven} \approx \frac{Torque_{Out}}{\mu d_2}[\cos(\alpha)]$$

The formula can be reduced such that force is a scaled function of secondary pulley output torque. The vehicle-level CVT data acquired from the Accord was empirically fit for secondary pulley pressure versus output torque. a linear relationship was developed for secondary pressure with increasing output pulley torque (Figure 15). Data points shown in red on Figure 15 were not included as part of the data fit.

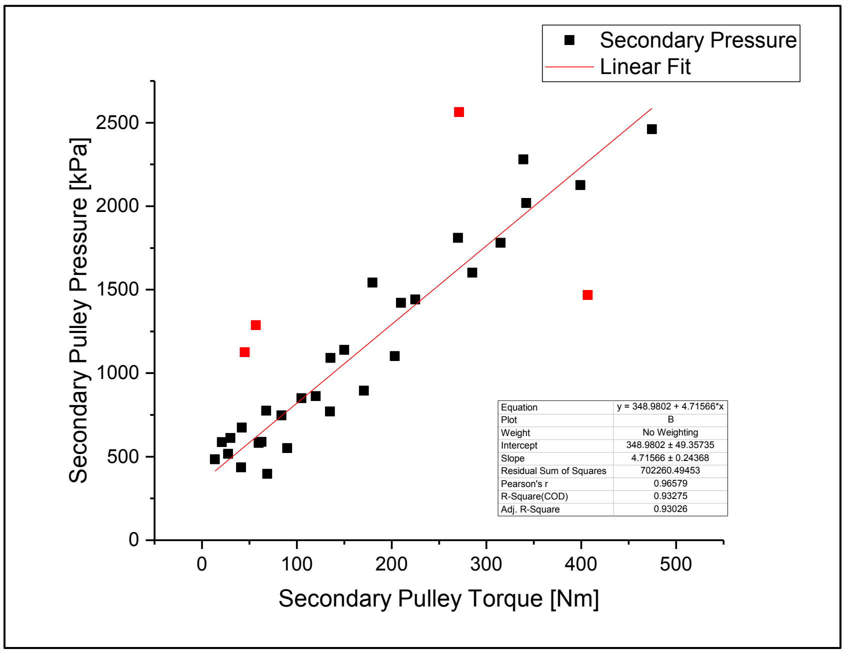


Figure 15. Secondary Pulley Pressure Relationship With Output Torque

During the component level testing, primary pulley pressure control was driven by logic within the SwRI data acquisition system. by specifying a desired pulley ratio and target input torque value, steady state component mapping was possible. The component system controls were observed to continuously affect one another. Increasing the output torque created an increasing thrust vector that opposes the secondary pulley pressure. Pulley ratio changed as a result of speed and torque command changes. SwRI used closed-loop controls on output torque load and pulley ratio during the steady state mapping. Controlling the CVT in this manner allowed for discrete pulley ratios to be evaluated. Critical to stable operation of the CVT was avoiding belt slippage and causing damage to the belt and pulleys. Building the secondary pressure relationship with measured output torque ensured the secondary pulley pressure creates adequate clamping on the belt to prevent slippage. Figure 16 diagrams the control methods used to map benchmark CVTs at SwRI.

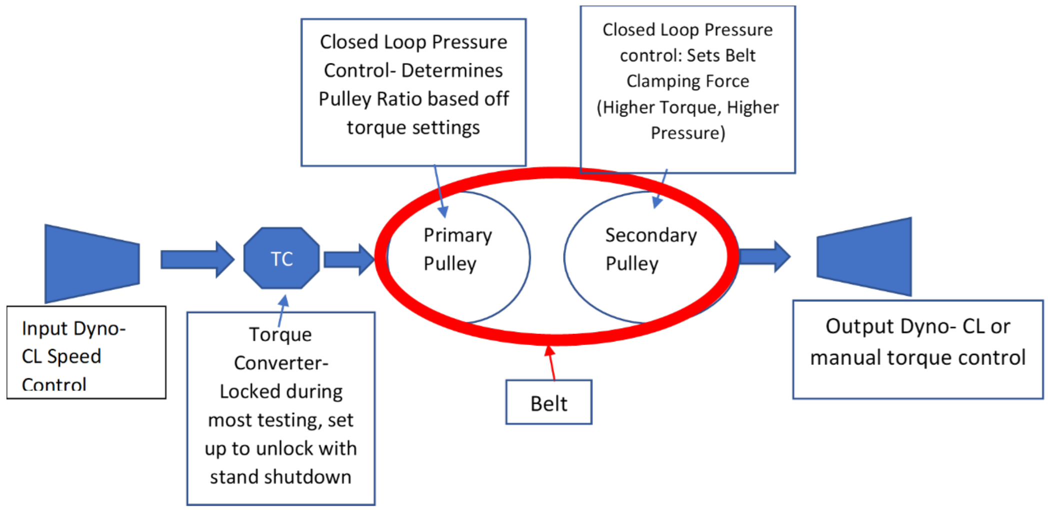


Figure 16. Component Level CVT Control Strategy

Point clouds of secondary pressure versus output torque were collected from drive cycle and steady state mapping. This point map was used to generate the secondary relationship with output torque. Line of best fit is shown in Figure 17, and shows the relationship for secondary pressure and output torque that was used in the SwRI control logic for efficiency mapping of the Honda Earth Dreams CVT.

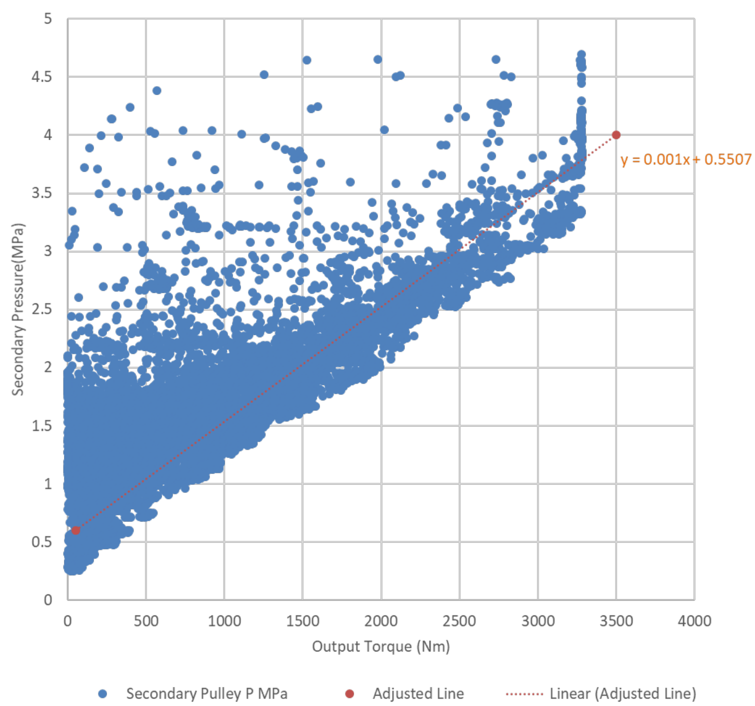


Figure 17. CVT Point Cloud for Secondary Pressure Relationship

2.2 Ford 10R80 Test Results

Full tabular efficiency results are available in Appendix B. Figures 18 to 27 present the 93 °C efficiency results for the Ford 10R80 with increasing speed and constant torque lines. The efficiency results showed minimal sensitivity to increasing input speed for each gear. The 10R80 utilizes separator springs between the steel reaction plates within the clutch packs. The small separator springs are wave plates of narrow cross section that package concentric to the friction plates and sandwich between adjacent reaction plates in each clutch pack. The separator springs served to equidistantly space the reaction and friction plates of an open clutch to reduce open clutch pack drag. Clutch packs that do not include separator springs require lube and apply oil to flow outward in the transmission barrel and create oil channels that buffer the friction plates from contact with the reaction plates. Transmissions that do not utilize separating springs tend to exhibit more speed sensitivity. Without separating springs, a stepped automatic transmission relies, solely, on fluid flow through the open clutch pack to keep separated the friction and reaction plates. In many cases, lube flow and/or pump output will be increased to promote friction and steel plate separation in open clutch packs. The increase in pump output and fluid shear within the open clutch carries a parasitic penalty, reducing overall efficiency. Efficiency may suffer at lower speeds as fluid flow entering the clutch pack fails to adequately separate the friction and reaction plates. Where incidental contact between the friction and steel plates occurs, efficiency and durability will suffer. SwRI has observed that transmissions using separating springs often utilize a lower line pressure schedule which further reduces parasitic loss. Equipping an open clutch pack with separating springs, may require less lube oil through the open clutch to keep friction and steel plates from incidental contact. This allows line pressure schedules to be a function of torque holding capacity, lubrication, and cooling needs and not of open pack plate separation.

The 10R80 showed some sensitivity to input shaft torque, but efficiency increased rapidly beyond 25 Nm of input torque and became nearly asymptotic at 75 Nm. The rate at which the 10R80's efficiency became asymptotic with increasing torque could be attributable to the design of the clutches. The line pressure rise from 25 Nm to 350 Nm for most gears is less than 300 kPa. This seemed comparatively low to legacy units, but on par with other current-technology longitudinal transmissions. Torque capacity is achieved without excessive line pressure rise in the 10R80 through apply plate area, frictional area, release spring tension, and managed leakage rates. Output shaft speed was limited for 10R80 component testing, so the input speed range tested decreases with increasing gear for Figures 18 through 27.

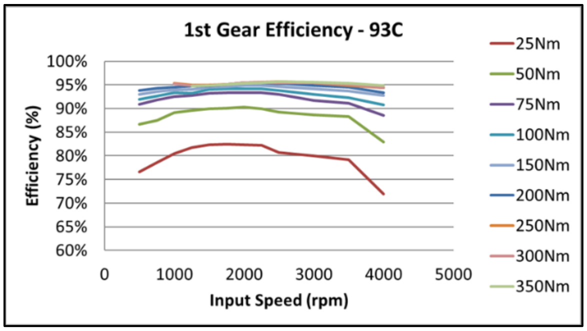


Figure 18. First Gear Efficiency for Ford 10R80 at 93 °C

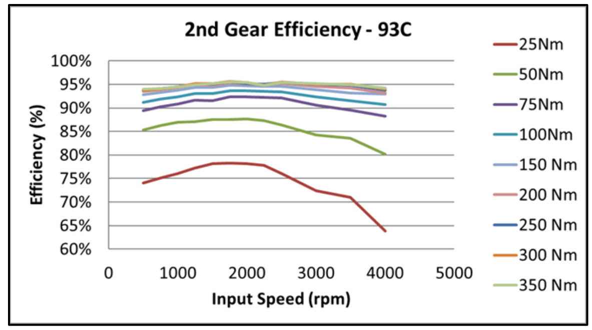


Figure 19. Second Gear Efficiency for Ford 10R80 at 93 °C

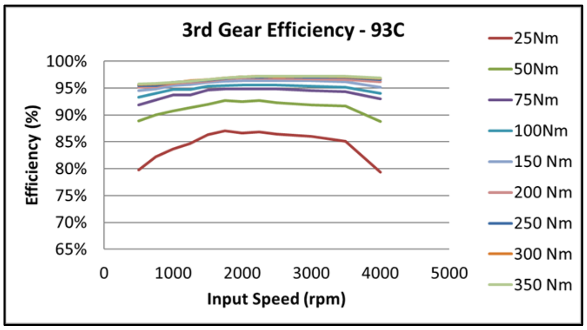


Figure 20. Third Gear Efficiency for Ford 10R80 at 93 °C

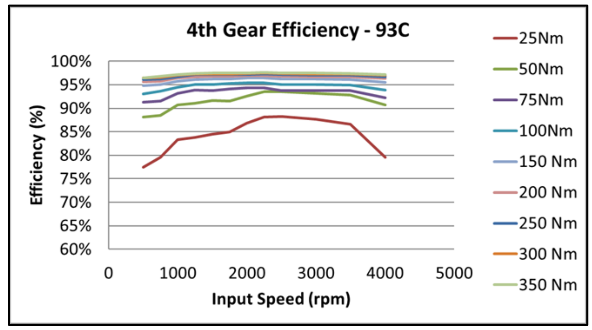


Figure 21. Fourth Gear Efficiency for Ford 10R80 at 93 °C

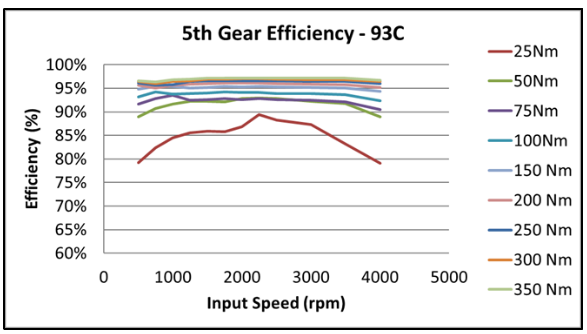


Figure 22. Fifth Gear Efficiency for Ford 10R80 at 93 °C

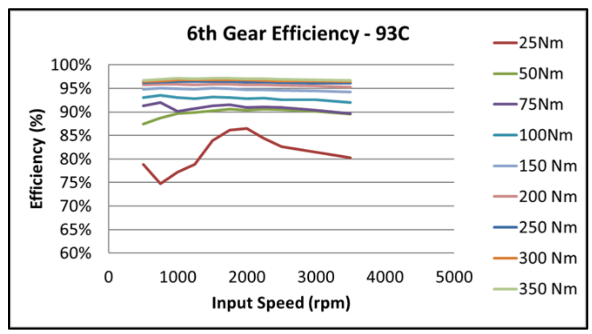


Figure 23. Sixth Gear Efficiency for Ford 10R80 at 93 °C

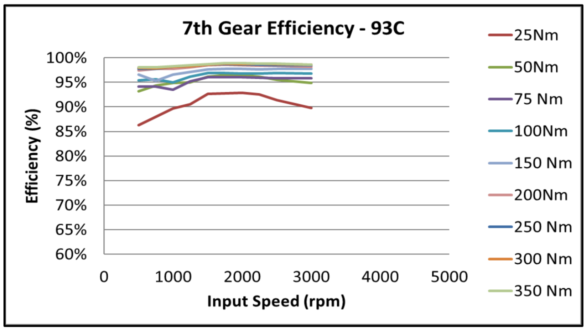


Figure 24. Seventh Gear Efficiency for Ford 10R80 at 93 °C

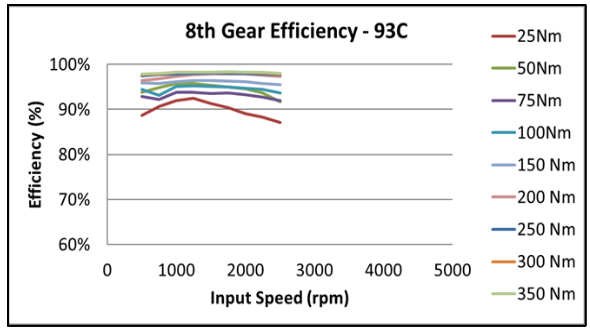


Figure 25. Eighth Gear Efficiency for Ford 10R80 at 93 °C

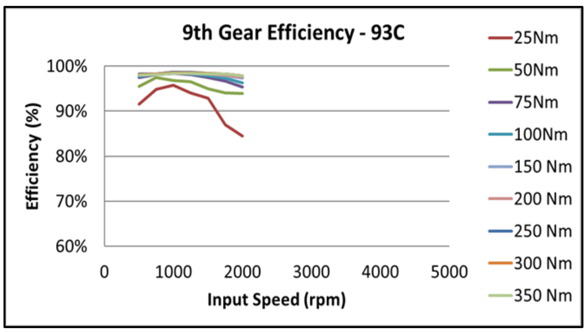


Figure 26. Ninth Gear Efficiency for Ford 10R80 at 93 °C

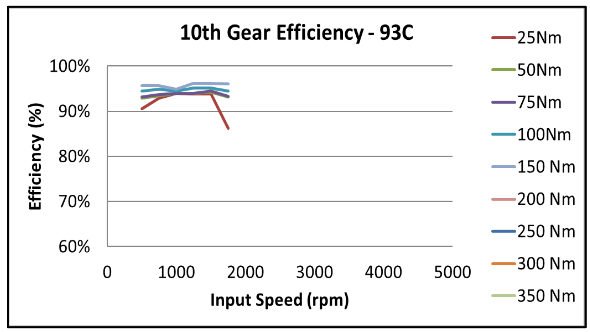


Figure 27. Tenth Gear Efficiency for Ford 10R80 at 93 °C

Figures 28 – 32 show the constant torque efficiency lines as a function of temperature from the efficiency data generated at 2000 rpm for the odd numbered gears of the 10R80. The efficiency was minimally affected by temperature. The lower torque set points showed a slight upward trend in efficiency with increased temperature. The limited sensitivity to temperature observed in the 10R80 and the limited time the vehicle cycles spend around 25 °C sump temperature reduced the importance of capturing data at the low temperature point. Full data sets were captured at 38 °C and 65 °C in lieu of limited data sets at 25 °C. The lack of temperature sensitivity could be attributed to the ULV fluid used within the 10R80 as well as the implementation of clutch separating springs. The open clutch pack parasitic losses that would normally dominate the lower temperature parasitic losses were not observed in the data collected on the Ford 10R80 due to the clutch pack architecture described previously.

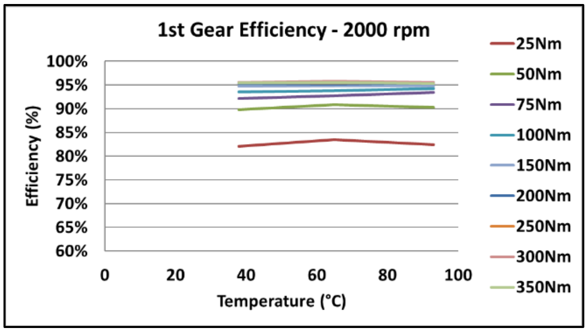


Figure 28. First Gear Efficiency for Ford 10R80 at 2000 rpm

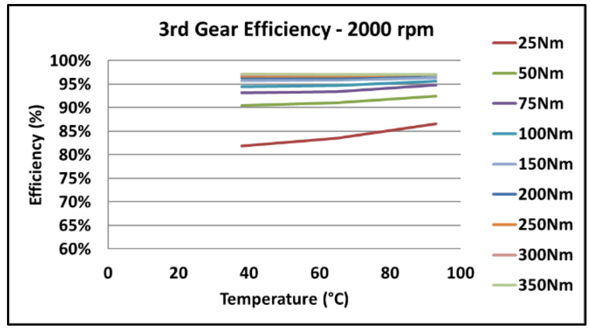


Figure 29. Third Gear Efficiency for Ford 10R80 at 2000 rpm

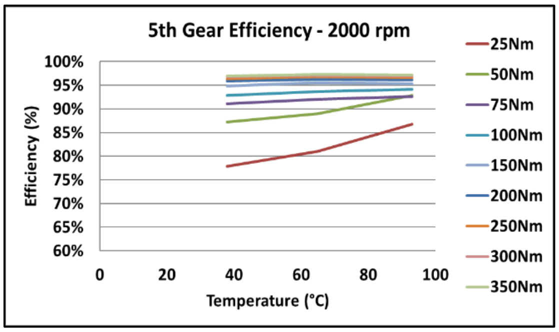


Figure 30. Fifth Gear Efficiency for Ford 10R80 at 2000 rpm

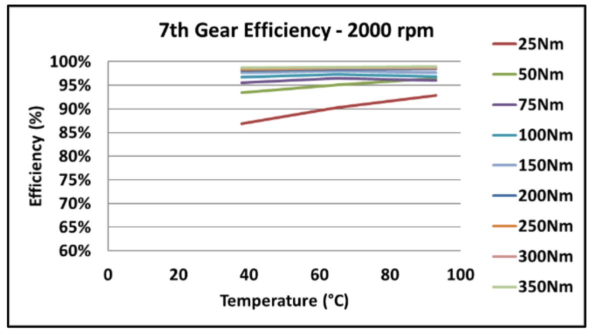


Figure 31. Seventh Gear Efficiency for Ford 10R80 at 2000 rpm

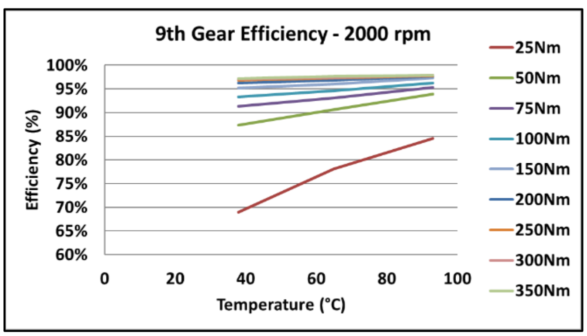


Figure 32. Ninth Gear Efficiency for Ford 10R80 at 2000 rpm

2.3 Honda Earth Dreams CVT Test Results

The efficiency testing of the Honda Earth Dreams CVT added another independent variable to a discrete-condition data collection. Gear selection was not a constant system parameter as it would be for an automatic transmission. CVT pulley ratio was controlled in addition to input speed and torque. The desired CVT test conditions influenced each other constantly and, in some conditions, moved the CVT through pulley ratios quickly while collecting data. a nested control loop was used to enable discrete pulley ratio testing. However, lines of constant torque over the transmission's pulley ratio range exhibited more variability than comparable data on stepped automatics. Figures 33 - 38 show inconsistent trends in adjacent data and attributed to unstable operation of the CVT at those points. Theoretical peak efficiency for a CVT occurs at a 1:1 pulley ratio; Figures 33 – 36 confirm peak efficiency occurred at a 1:1 pulley ratio for the Honda CVT. As target vehicle speed increased during testing, the 30 Nm input torque points became difficult to achieve as the drive torque for the transmission and the downstream output gearboxes and dynamometer began to exceed 30 Nm. The measured efficiency for the transmission decreased rapidly as the system drive torque approached the 30 Nm setpoint torque value, so these points as shown in Figure 36 are not representative of the true efficiency behavior of the transmission for low drive torques.

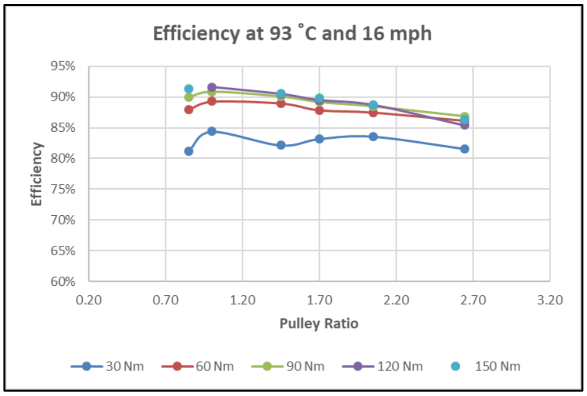


Figure 33. Honda CVT 16 MPH Efficiency

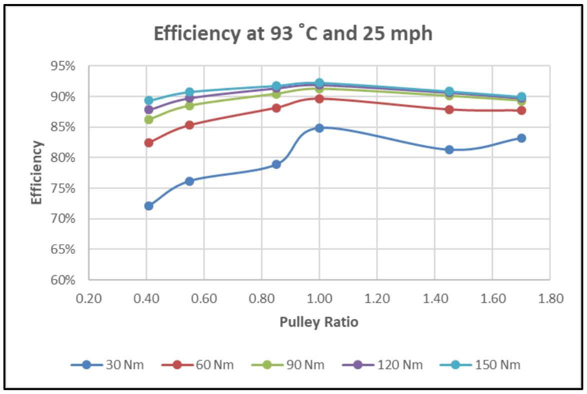


Figure 34. Honda CVT 25 MPH Efficiency

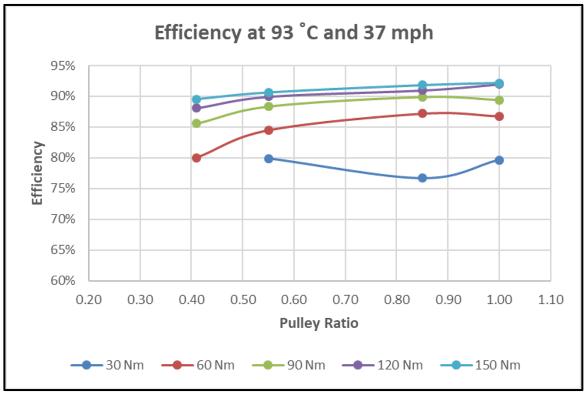


Figure 35. Honda CVT 37 MPH Efficiency

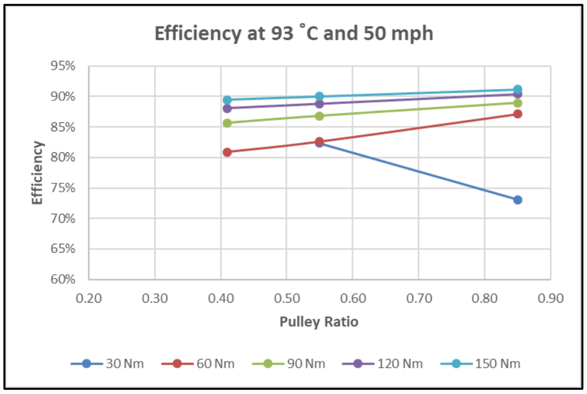


Figure 36. Honda CVT 50 MPH Efficiency

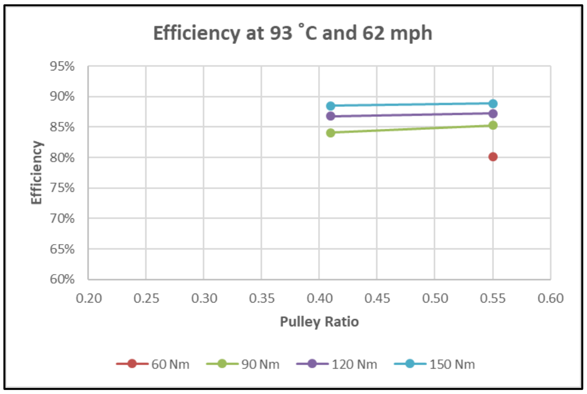


Figure 37. Honda CVT 62 MPH Efficiency

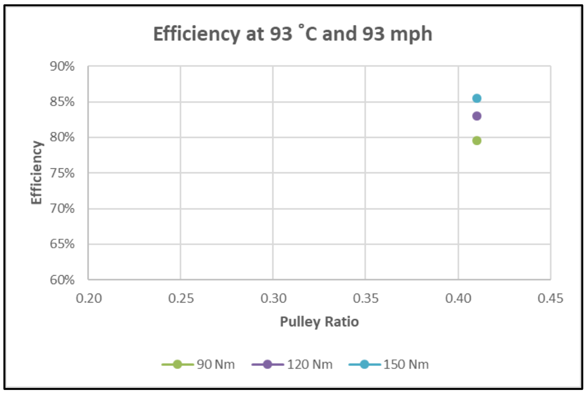


Figure 38. Honda CVT 93 MPH Efficiency

The same CVT efficiency data can be represented with lines of constant pulley ratio with input torque as the independent variable. This approach offered an alternative graphical representation that may better facilitate comparisons with stepped transmissions. Figures 39 – 44 are the constant pulley ratio plots for the same 93 °C data presented in Figures 33 – 38. The efficiency sensitivity to pulley ratio and input torque are illustrated in Figures 39 - 44.

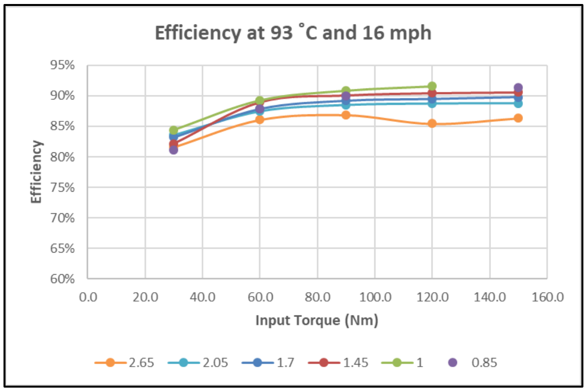


Figure 39. Honda CVT Constant Ratio Efficiency – 16 MPH

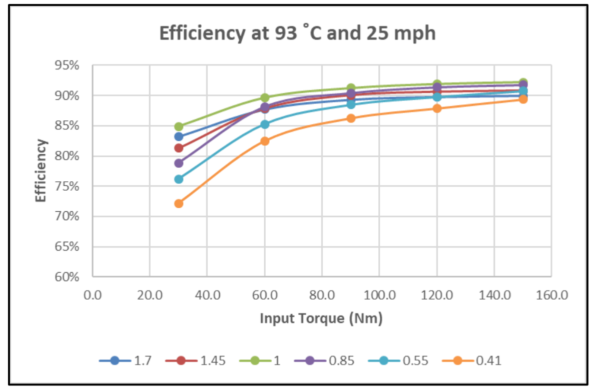


Figure 40. Honda CVT Constant Ratio Efficiency – 25 MPH

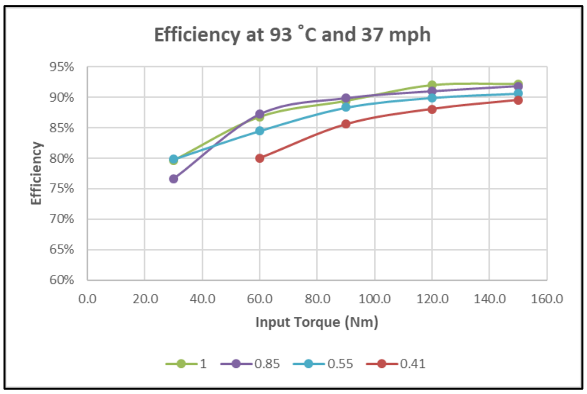


Figure 41. Honda CVT Constant Ratio Efficiency – 37 MPH

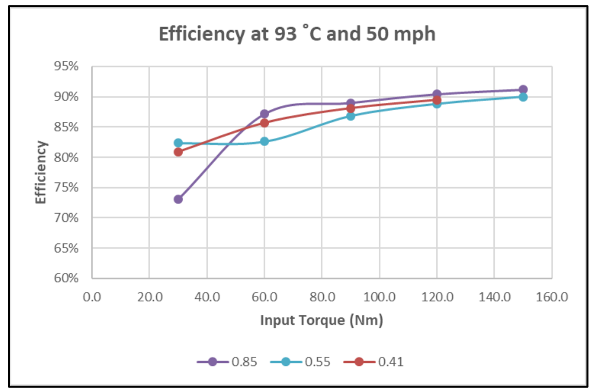


Figure 42. Honda CVT Constant Ratio Efficiency – 50 MPH

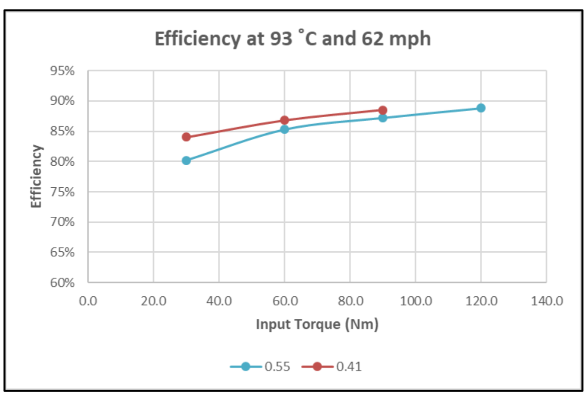


Figure 43. Honda CVT Constant Ratio Efficiency – 62 MPH

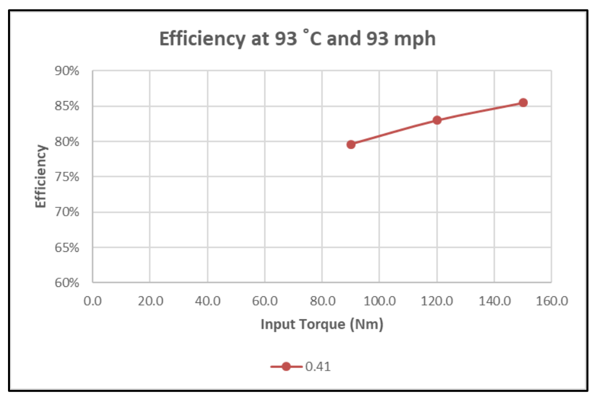


Figure 44. Honda CVT Constant Ratio Efficiency – 93 MPH

The temperature sensitivity of the Honda CVT was less clear than the results of the 10R80. Alternative temperature data and full tabular efficiency results for the Honda Earth Dreams CVT are available in Appendix C.

2.4 Torque Converter Characterization - Converter Efficiency, Torque Ratio, and K-Factor (Capacity Factor) Mapping

The torque converter characterization tests generated data sets that describe open torque converter performance. The torque converter clutch was not applied during these evaluations. SwRI performed the characterizations with assembled transmissions at constant input speed while reducing output speed to create a differential speed across the torque converter. Gear selection was targeted at a 1:1 ratio where possible. The default underdrive pulley ratio was used for CVT transmissions as the change in differential speed across the converter drives an output torque change that cannot be differentiated from the torque change generated by the converter. Sufficient secondary pressure was applied to hold ratio and prevent belt slippage during the converter speed ratio sweep. Using measured efficiency data, the in-gear torque loss was removed from the measured output torque allowing turbine shaft torque to be determined. Figure 45 graphs the operation of the Ford 10R80 converter characterization test. The figure shows the speed control of the input and output dynamometers and the reaction of output torque with decreasing speed ratio across the converter.

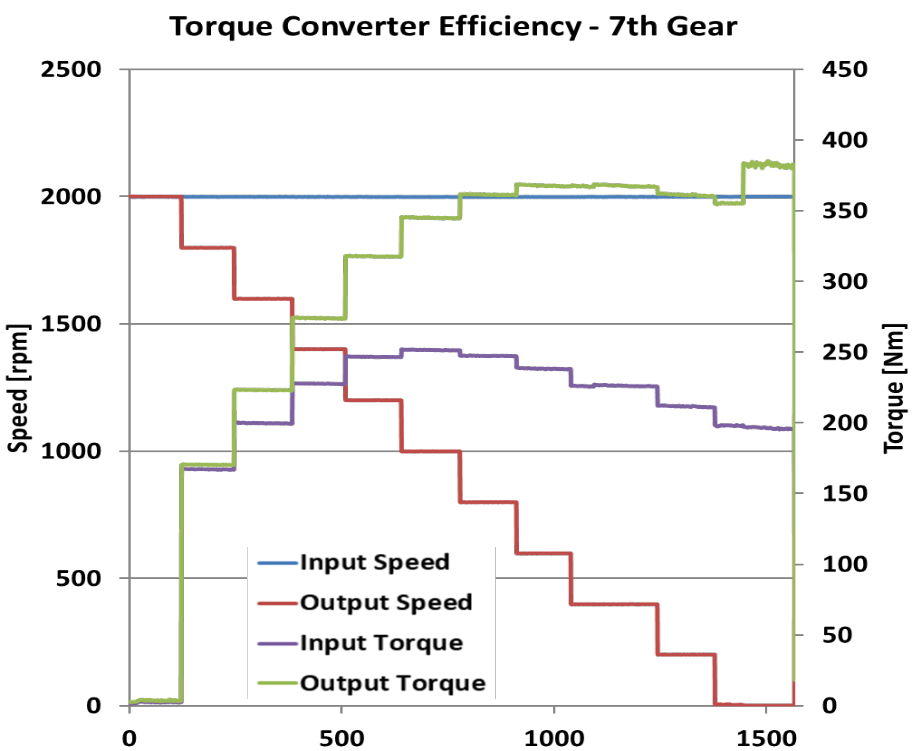


Figure 45. Recorded Torque and Speed Traces for 10R80 Torque Converter Characterization

The tabular data for the Ford 10R80 torque converter characterization is available in Table 6. The data table collects the measured input and output speed and torque, calculates the speed ratio across the converter, queries the measured efficiency data for the expected torque loss across the gear-train, and then calculates the torque at the converter turbine. Torque converter clutch drag was calculated as the difference between measured transmission input torque and the calculated turbine shaft torque near a 1:1 converter speed ratio. Figures 46 and 47 are the resultant performance graphs for the 10R80 converter test. The converter efficiency climbed above 90% as the speed ratio approached 0.8 across the converter. The linear increase in efficiency above 0.9

speed ratio depicts the torque converter clutch engagement and proved the benefit of torque converter clutches. Application of the converter clutch removed the losses across the converter as the clutch linked the pump side of the converter to the turbine shaft. In partial slip strategies, the converter clutch controlled the speed ratio across the converter to move the converter into a more efficient portion of the converter map.

Table 6. Ford 10R80 Torque Converter Characterization Worksheet

Avg Speed Ratio	Average Input Speed	Average Output Speed	Average Input Torque	Average Output Torque	Transmission Torque Loss	Calc. Turbine Shaft Torque	Torque Conv. Turbine Torque	Cf	K	Torque Ratio	TCC drag	Efficiency
1.001	1999.3	2000.4	2.1	-0.5	3.450	3.0	4.5	5.15E-07	1393.4	2.195		2.196
0.990	1997.6	1977.6	20.1	15.0	3.450	18.5	20.1	5.03E-06	446.0	1.000	1.57	0.990
0.893	1999.5	1785.4	169.0	170.0	3.450	173.4	175.0	4.23E-05	153.8	1.036		0.925
0.799	1999.5	1598.5	199.4	219.2	3.450	222.6	224.2	4.99E-05	141.6	1.124		0.899
0.701	1999.3	1400.6	227.3	270.0	3.000	273.0	274.6	5.69E-05	132.6	1.208		0.846
0.600	1999.2	1200.1	246.3	313.8	3.000	316.8	318.4	6.16E-05	127.4	1.293		0.776
0.500	1998.9	999.4	251.1	341.0	3.500	344.5	346.1	6.28E-05	126.1	1.378		0.689
0.400	1998.9	800.0	246.9	357.3	3.000	360.3	361.9	6.18E-05	127.2	1.466		0.587
0.299	1999.0	598.6	237.9	363.8	3.500	367.3	368.9	5.95E-05	129.6	1.550		0.464
0.199	1999.3	398.6	225.8	363.6	3.000	366.6	368.1	5.65E-05	133.0	1.630		0.325
0.100	1999.6	200.9	211.2	357.2	3.000	360.2	361.7	5.28E-05	137.6	1.713		0.172
0.001	1999.9	1.9	196.5	368.7	3.450	372.2	373.7	4.91E-05	142.7	1.902		0.002

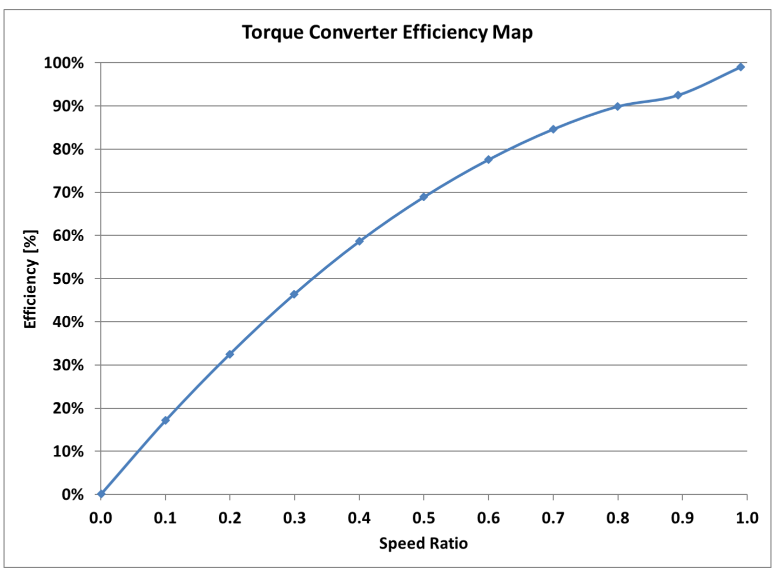


Figure 46. Ford 10R80 Torque Converter Efficiency

Figure 47 graphs the calculated torque ratio and capacity factor for the 10R80 transmission. The torque ratio for the 10R80 converter increased all the way to stall speed ratio and peaked near 1.9 multiplication. The capacity factor describes the relationship of required input torque to achieve the driven input speed for the converter. K-factor is the inverse of the square root of capacity factor. Capacity factor peaked when no additional input torque is required with further reduction of speed ratio. This trend is visible in Figure 45.

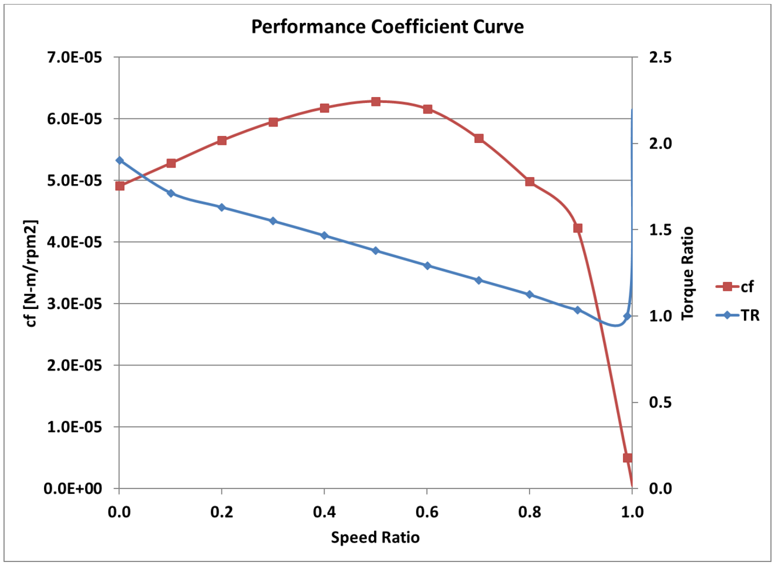


Figure 47. Ford 10R80 Torque Converter Performance Curves

The torque converter characterizations of the CVT required the output dynamometer in torque mode. This allowed the secondary pressure control to adjust and match the output torque measured and maintain pulley ratio without belt slip. Figure 48 illustrates the difference between the discrete speed ratio approach on the Ford 10R80 and the sweeping torque control necessary on the CVT evaluation.

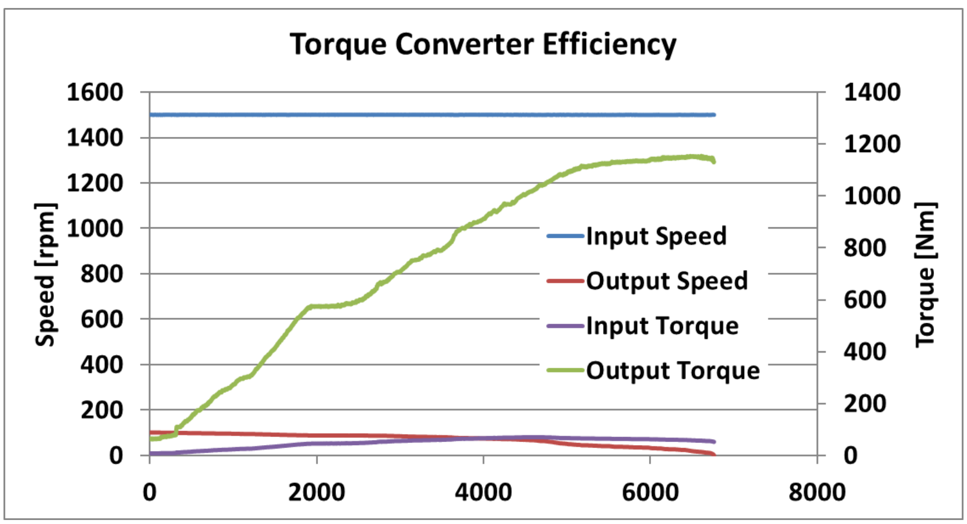


Figure 48. Recorded Torque and Speed Traces for Honda CVT Torque Converter Characterization

Data bins were created around target speed ratios to use the same converter worksheet as a stepped automatic. Since the CVT pulley ratio and final drive contribute to the torque multiplication measured at the output torque meters, the transmission ratio was accounted for in the turbine torque determinations. Table 7 shows the results of the Honda Earth Dreams CVT converter characterization.

Table 7. Honda CVT Torque Converter Characterization Worksheet

Avg Speed Ratio	Average Input Speed	Average Output Speed	Average Input Torque	Average Output Torque	Average Trans Ratio	Transmission Torque Loss	Calc. Turbine Shaft Torque	Torque Conv. Turbine Torque	Cf	K	Torque Ratio	TCC drag	Efficiency
0.948	1500.3	100.7	9.8	54.1	14.1	3.330	7.2	9.8	4.36E-06	479.1	1.000	2.65	0.948
0.846	1500.2	89.9	41.1	483.8	14.1	5.391	39.6	42.3	1.83E-05	234.1	1.029		0.871
0.708	1500.4	75.2	67.3	895.1	14.1	8.982	72.4	75.0	2.99E-05	182.9	1.115		0.789
0.568	1500.1	60.3	70.7	1047.9	14.1	8.982	83.2	85.8	3.14E-05	178.4	1.214		0.690
0.495	1500.1	52.6	68.7	1072.0	14.1	8.982	84.9	87.5	3.05E-05	181.0	1.275		0.631
0.422	1500.1	44.8	67.0	1102.9	14.1	8.982	87.1	89.7	2.98E-05	183.3	1.340		0.565
0.355	1500.1	37.7	65.0	1121.3	14.1	8.982	88.4	91.0	2.89E-05	186.1	1.400		0.496
0.284	1499.9	30.1	62.9	1133.6	14.1	8.982	89.2	91.9	2.80E-05	189.1	1.460		0.414
0.212	1500.0	22.5	60.6	1140.2	14.1	8.982	89.7	92.4	2.69E-05	192.7	1.525		0.323
0.142	1499.9	15.1	58.2	1138.1	14.1	7.061	87.6	90.3	2.59E-05	196.6	1.551		0.221
0.071	1500.2	7.5	55.5	1130.6	14.1	7.061	87.1	89.8	2.47E-05	201.3	1.616		0.114
0.009	1500.2	5.9	55.0	1128.1	14.1	7.061	86.9	89.6	2.44E-05	202.3	1.629		0.015

Figures 49 and 50 graph the efficiency and performance curves for the Honda CVT. The Accord's converter also produced peak torque ratio at stall speed. Peak torque ratio does not always occur at stall speed. The torque ratio curve is a function of the converter geometry. Smaller diameter converters with more elliptical, "squashed," torus sections may develop peak torque ratio at speed ratios above stall. The Honda CVT's capacity factor peaked at a marginally higher speed ratio than the Ford 10R80. Figures 51 and 52 plot the resultant efficiency and performance curves for both torque converters for comparison.

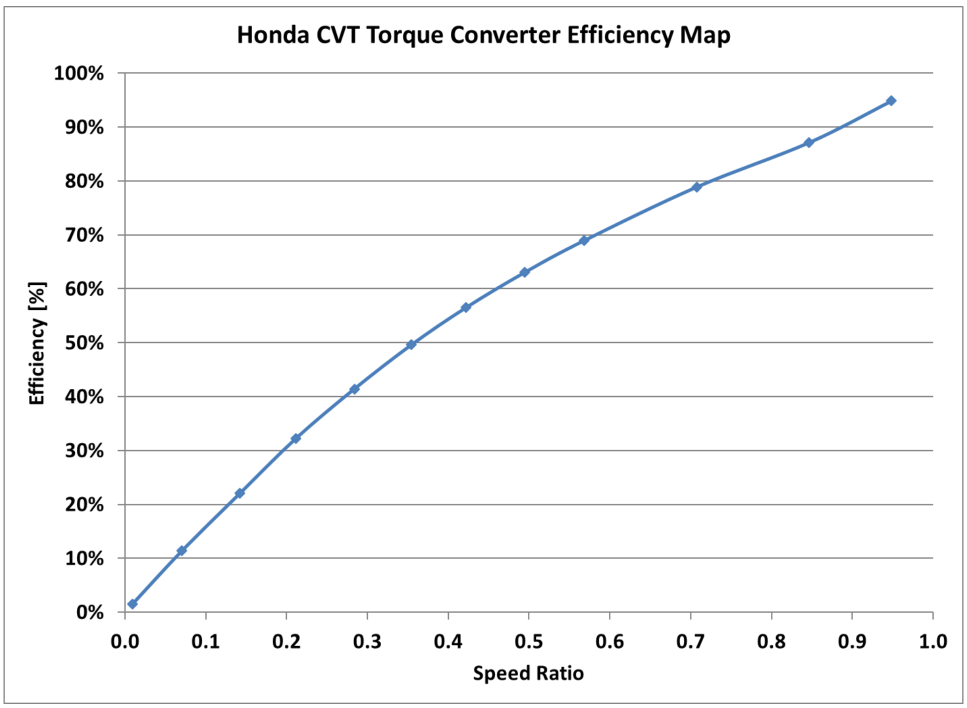


Figure 49. Honda Earth Dreams CVT Converter Efficiency

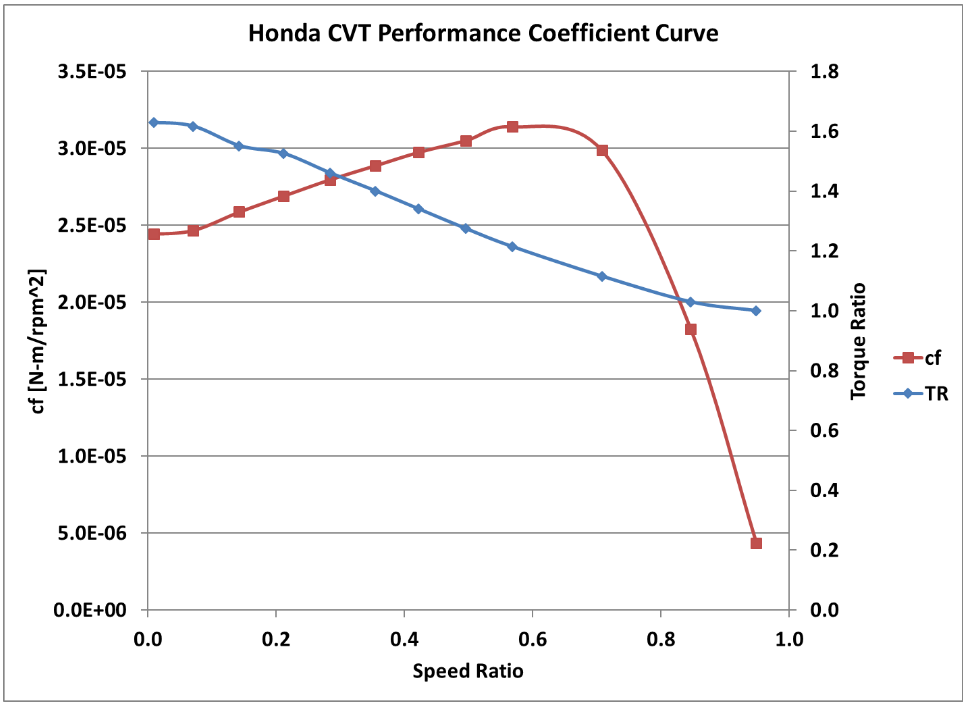


Figure 50. Honda CVT Torque Converter Performance Curves

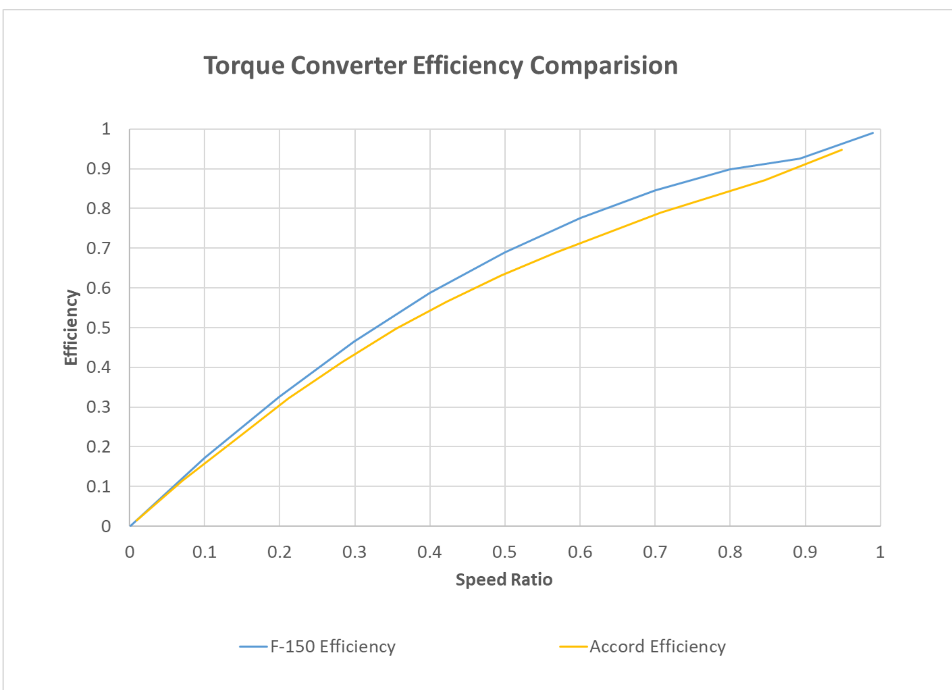


Figure 51. FY2019 Transmissions Converter Efficiency Comparison

The efficiency advantage of the 10R80's converter over the Honda CVT is attributable to size. With a larger diameter converter and likely less vehicle package constraints, fewer compromises in the 10R80's torque converter geometry allowed the unit to be more efficient and generate a greater torque ratio than the Honda's unit.

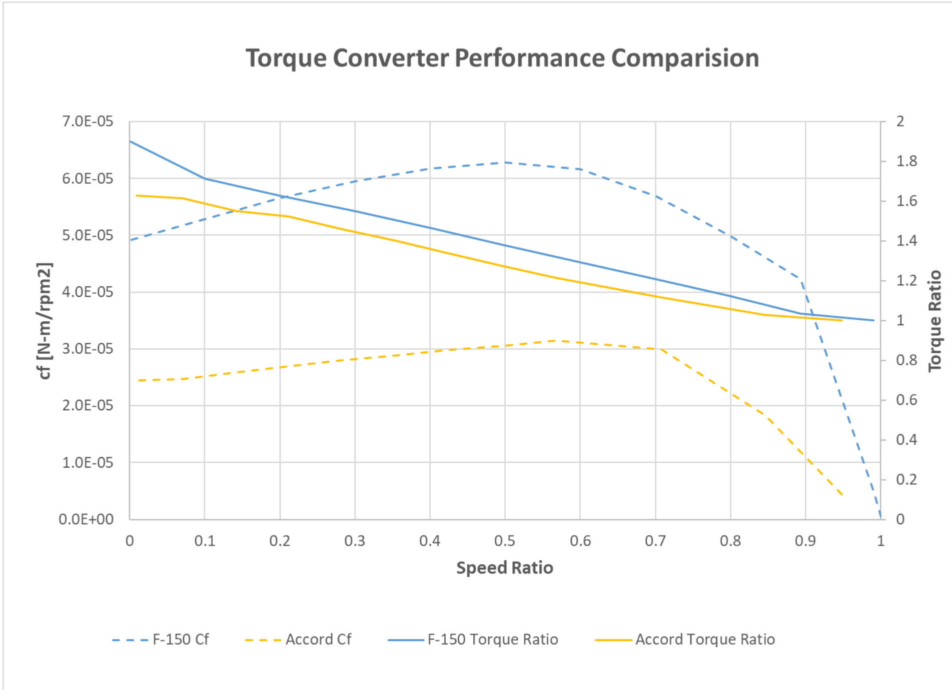


Figure 52. FY2019 Transmissions Converter Performance Comparison

The capacity factor curves indicated the difference in converter geometry. The magnitude of difference between the capacity factors proved the 10R80 converter is suited for a larger, heavier vehicle where the Honda CVT converter is from a smaller vehicle. The torque ratio curve exhibited by the Honda converter rose steadily to stall speed and peaks above 1.6 multiplication. The torque converter exists to aid vehicle launch and low speed acceleration, and the achievable torque ratio from the Honda CVT's converter reduced the need for greater pulley ratio spread with a lower underdrive ratio.

2.5 Transmission Inertia Mapping Per Gear

The assembly inertia was mapped for each of the benchmark transmissions. The inertia mapping was completed with a fully assembled transmission in the parasitic loss configuration. The output dynamometer was disconnected and only drive torque was measured at the input of the transmission. The torque converter clutch was locked for the inertia measurement tests. Prior to the fully assembled inertia testing, component inertia measurements were taken for the torque converter, flexplate, and the input driver that connects the input torque meter to the flexplate. These are the elements between the input torque meter and the turbine shaft of the transmission. The component inertia was solved for using the below equations:

$$I_{TC} = I_o\left(\frac{T_{TC}^2}{T_0^2} - 1\right)$$

$$I_{TC} = 0.0086kg - m^2\left(\frac{2.36s^2}{0.486s^2} - 1\right)$$

$$I_{TC} = 0.194kg - m^2$$

The period measurement was corrected for the table inertia and period constants. The torque converter was filled with fluid to complete the inertia measurement on the bench. a rotary table and oscilloscope were used to characterize the period of oscillation for each component (Figure 53). Figure 54 depicts the Ford converter on the rotary table for measurement. Period of oscillation was determined by measuring the table's tone wheel pulses on an oscilloscope. for the 10R80 torque converter the period measurement period was found to be T_TC = 2.36 seconds.

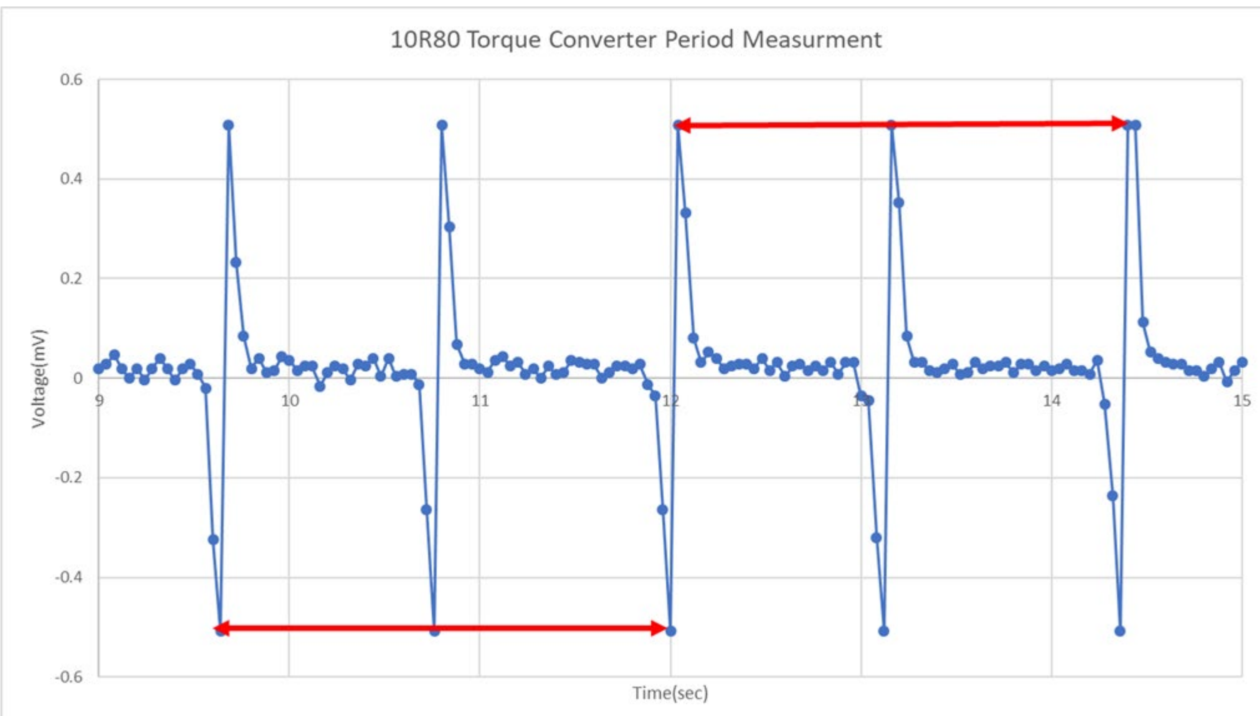


Figure 53. Period Measurement for Rotary Table Tests

Figure 54. Ford 10R80 Torque Converter on the Rotary Table

Once the component inertias were known, the system inertia was determined for each gear using the following equation:

$$I\_Sys = \tau\_Sys/\alpha$$

- Where α is the acceleration rate during the measurements

to determine transmission inertia (I_Trans), the inertia contribution from the torque converter, flexplate, and input driver were subtracted from the system. System inertia was determined through constant rate accelerations of the transmission assembly. Drive torque values for the transmission were measured during the constant acceleration and then at steady state speeds. The difference between the measured system torque and the steady speed torque values calculated the torque to accelerate the system. Removing the steady state torque subtracted the drive torque needed to overcome the transmission's parasitic losses. The tenth gear inertia test profile is shown in Figure 55. The input speed profile shows the constant acceleration and the steady speed operation on deceleration. The input torque during the constant acceleration took a portion of the ramp to become linear, so the torque to accelerate the system was characterized during the most linear segment of the acceleration. Figure 56 shows the acceleration, torque, and calculated inertia for first gear on the 10R80 at 93 °C versus the range of input speed.

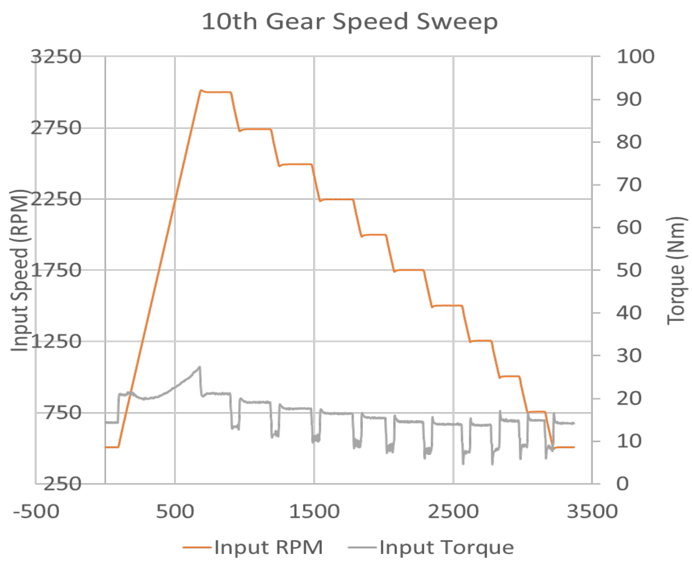


Figure 55. Inertia Measurement Test Profile

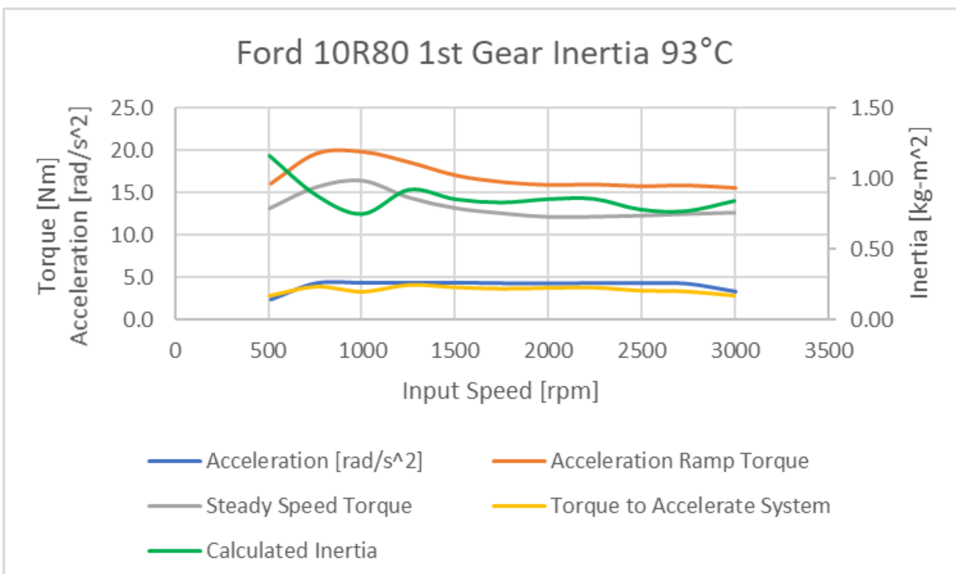


Figure 56. Ford 10R80 Inertia Test Results for 1st Gear Versus Speed

The per-gear inertia was reported from the most stable section of the speed range. In Figure 56 the stable range settled between 1,250 and 2,250 rpm. a complete map of inertia by gear was assembled across the tested temperature ranges using the per-gear reported values. The per-gear inertia for the 10R80 is shown in Figure 57. Fluid temperature influenced the measured inertia. The fluid temperature sensitivity was unique to each gear with some gears having a stronger dependency on fluid temperature and viscosity (Gears 2, 7, 9, and 10 have more sensitivity to fluid temperature). Achievable shift speeds will be affected by fluid temperature as a result of the fluid temperature sensitivity.

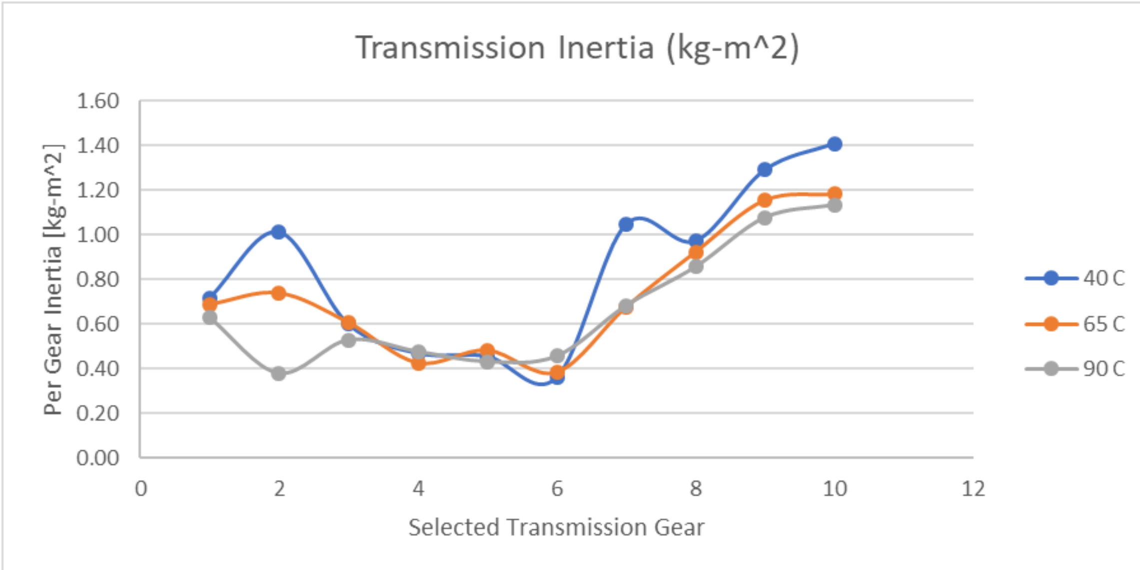


Figure 57. Measured Transmission Inertia by Gear – Ford 10R80

Inertia evaluations on CVTs required modification to the process outlined for stepped automatics. Pulley ratio became unstable upon deceleration, so the CVT was allowed considerable time to slow to rest after each constant ramp acceleration. The acceleration ramps each started with the target pulley ratio stabilized before commencement of the ramp. Figure 58 depicts the testing process, and also illustrates the narrow portions of linear input torque increase for the CVT evaluations. This caused a reduction in the amount of data acquired over the discrete ramps and pulley ratios for the inertia calculations.

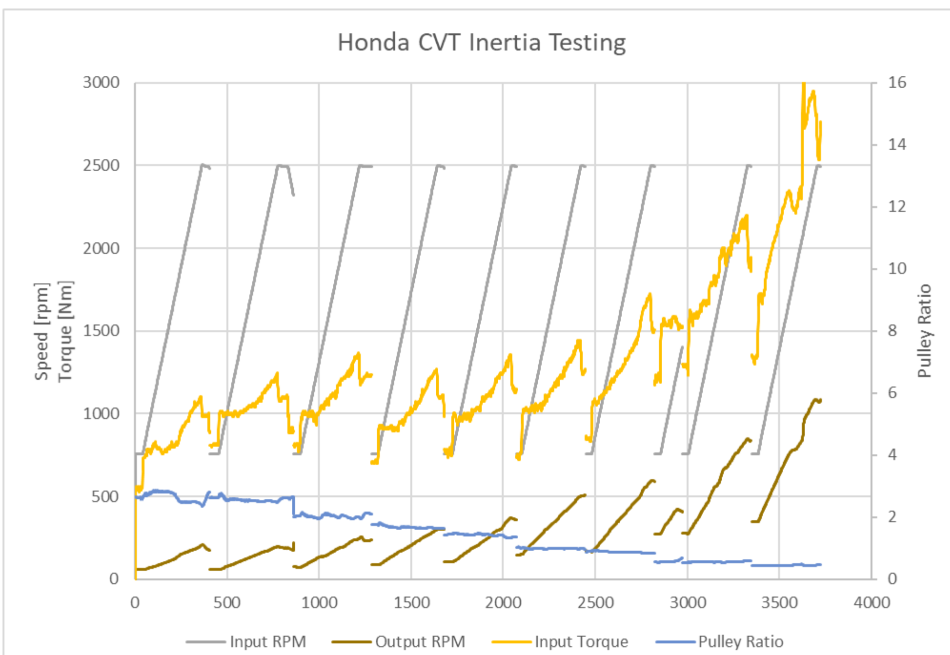


Figure 58. CVT Inertia Test Profile

Table 8. Honda Earth Dreams CVT Inertia Characterization Table

Input Speed (rpm)	Target Ratio	Sump Termperature	Input Torque	Spinloss Torque	Pulley Ratio	Primary Pressure	Secondary Pressure	Acceleratioin	Inertia
1000	2.645	91.8	8.5	2.2	2.63	311.5	985.5	4.49	1.27
1250	2.645	92.1	8.5	2.1	2.56	304.7	975.1	4.43	1.30
1500	2.645	92.3	8.5	2.6	2.53	298.5	979.6	4.42	1.19
1750	2.645	92.3	8.8	2.8	2.52	299.0	1001.9	4.42	1.20
2000	2.645	92.3	8.9	3.3	2.51	295.4	1008.6	4.43	1.11
2250	2.645	92.6	9.6	3.6	2.54	288.7	1080.2	4.43	1.21
2500	2.645	92.7	9.2	4.0	2.54	288.6	1090.8	2.64	1.81

The torque measured over the acceleration ramps was reduced by the drive torque measured during separate steady state spinloss measurements. Table 8 includes the average torque, pulley ratio, circuit pressures, spinloss torque, and the calculated values for ramp acceleration and system inertia. The compiled data in Table 8 used all the recorded data at the target input speed ± 100 rpm. The inertia values shown in table accounted for the input driver, flexplate, and torque converter inertias. The moment of inertia for the torque converter (I_{TC}) and input driver (I_{Driver}) were measured using the rotary table. 2.038 seconds (T_{TC}) was measured for the period of the rotary table and input driver combination, giving an inertia of 0.14263 $kg - m^2$. The rotary table and torque convertor combination measured 0.626 seconds (T_{Driver}) for the period yielding an inertia of 0.14263 $kg - m^2$.

$$I_{Driver} = I_o\left(\frac{T_{Driver}^2}{T_0^2} - 1\right) = 0.0086\ [kg - m^2]\left(\frac{0.626s^2}{0.486s^2} - 1\right) = 0.00567\ [kg - m^2]$$

$$I_{TC} = I_o\left(\frac{T_{TC}^2}{T_0^2} - 1\right) = 0.0086\ [kg - m^2]\left(\frac{2.038s^2}{0.486s^2} - 1\right) = 0.14263\ [kg - m^2]$$

Mean values of inertia were calculated for the pulley ratio using the bulk of the speed points. Visible in Table 8 is the acceleration decay as the transmission reached the end of the speed ramp. Inconsistencies in system acceleration were present near the start and end of the acceleration ramp. The inertia calculation was sensitive to acceleration rate and pulley ratio changes. Figure 59 presents the calculated inertia for the Honda CVT across four temperatures. The inertias found between 2.05 and 0.85 pulley ratios showed an increasing trend with temperature. This is finding was interesting and unexpected. Though the 38 °C and 65 °C results inverted, a decided increase was shown between 25 °C and 93 °C in the measured inertia values. SwRI hypothesizes that the trend may be due to rising fluid level within the transmission case or from the pulley piston leakage creating greater windage. The circuit leakage would increase with increasing fluid temperature and reduced fluid viscosity. The inertia values calculated at the extremes of pulley ratio were less conclusive. The results may be evidence of the dynamic nature of CVT transmissions and suggest greater restriction in the data points considered for the inertia calculations is needed. Full tabular results for the inertia testing are available in Appendix E. The Honda CVT data include the primary and secondary pressures observed during the acceleration ramps.

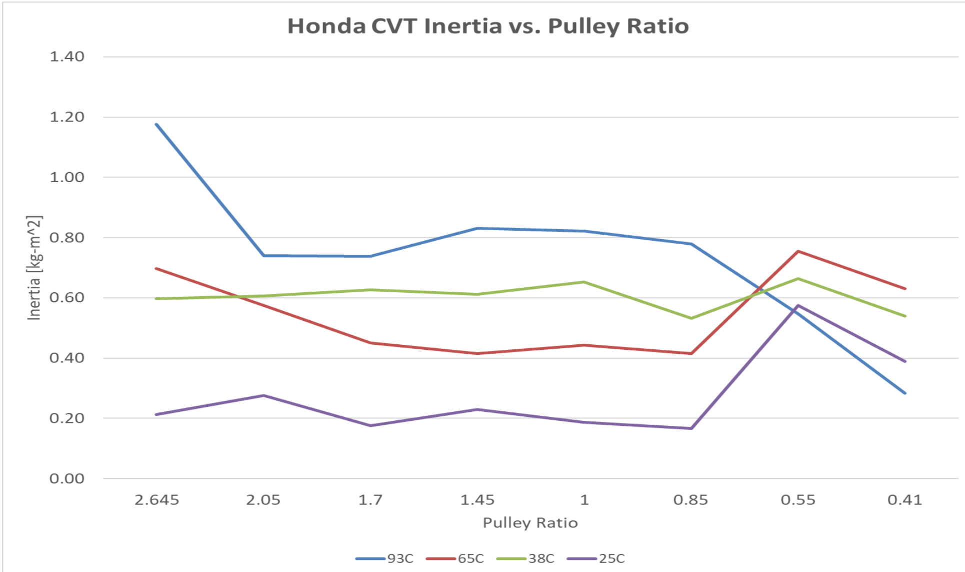
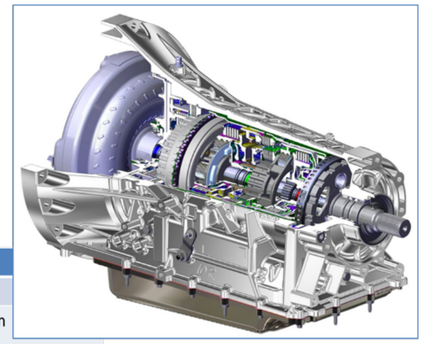


Figure 59. Honda CVT Inertia Testing Results

3 SR-3 Deliverables – Overall Transmission Characterization

The SR-3 task focused on overall transmission characterization for the chosen benchmark units. This task intended to provide additional information on each benchmark transmission to aid in comparisons between available technologies and highlight features of the benchmark transmissions that contribute to fuel efficiency. Figures 60 and 61 provide overview information for each benchmark transmission and vehicle tested as part of the FY2019 portion of the project.



Vehicle	2017 Ford F150
VIN	1FTEW1EGXHKC32685
Engine	3.5L Ecoboost V6
Drive Type	Four Wheel Drive
Transmission	10R80 10 Speed Automatic

10 Speed Automatic	
Model	10R80
Oil Pump(s)	1 - Chain Driven 2 - Electric
Gear Ratios	1^{st} – 4.69 2^{nd} – 2.98 3^{rd} – 2.14 4^{th} – 1.76 5^{th} – 1.52 6^{th} – 1.27 7^{th} – 1.00 8^{th} – 0.85 9^{th} – 0.68 10^{th} – 0.63 Rev – 4.86
Rear Axle Ratio	3.31
Tire Size	275/65R18

Figure 60. Test Vehicle Summary – Ford F150 – 10R80 Transmission

Vehicle	2018 Honda Accord
VIN	1HGCV1F14JA0 56668
Engine	1.5T I4 DOHC 16V Turbocharged VTEC
Drive Type	Front Wheel Drive
Transmission	CVT

CVT	
Model	
Oil Pump(s)	Chain Driven Oil Pump
Gear Ratios	Lowest – 2.68 Highest – 0.46 Span – 5.83 Rev – 4.86
Final Drive Ratio	5.044048
Tire Size	225/50R17

Figure 61. Test Vehicle Summary – Honda Accord – Earth Dreams CVT

3.1 Ratio Determination and Physical Packaging Dimensions

3.1.1 10R80 Ratio and Package Information

The gear ratios for the 10R80, as quoted by Ford, are represented in Table 9. The individual gear ratios and final drive ratio were verified during the in-use vehicle testing using a Rotec high speed rotational measurement system. The gear ratio spread for the 10R80 transmission was 7.44:1. This span represented an improvement over the outgoing six speed transmissions and was a small increase in span over the current market ZF 8HP 8-speed transmissions, previously benchmarked by NHTSA.

Table 9. Ford 10R80 Quoted Gear Ratios

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Reverse	Span
Ford 10R80	4.69	2.98	2.14	1.76	1.52	1.27	1.00	0.85	0.68	0.63	4.86	7.44
Ford 6R80	4.17	2.34	1.52	1.14	0.87	0.69					3.40	6.04
ZF 8HP70	4.71	3.14	2.11	1.67	1.29	1.00	0.84	0.67			3.30	7.07

In 2016, upon the release of the transmission, Ford's 10R program manager Kevin Norris stated that the 7.44 ratio spread is the maximum usable on the road, with limited returns past 10 speeds. The transmission fits four more speeds in a package size matching that of the outgoing 6-speed transmission, without adding weight. This was accomplished by a single-piece aluminum case, and novel clutch packaging in the center of the transmission. Overall, the transmission has four gearsets, two brake clutches, and four rotating clutches. This is only one more clutch than the ZF

8HP eight-speed, making maximum use of available package dimensions. Additionally, no cast iron parts were used in the 10R80. The switch to cast aluminum and optimized steel parts throughout the transmission results in no weight gain for the increase in internal hardware.

3.1.2 Ford 10R80 Efficiency Improvement Features

Following the Ford and GM partnership announcement, several press releases and articles were written describing the features, efficiency gains, and refinements of the new transmissions. of interest to this report was efficiency and performance adders, which can be sorted into categories based on the component or feature that contributes to the efficiency gain. Many of these features and elements are discussed at length within teardown segments of the SR-5 section.

The Ford 10R80 hydraulic pump circuit was a departure from the six-speed transmission it replaces. The transmission has two pumps: the primary pump and an electric stop/start pump. The primary, mechanical pump has been moved off the turbine shaft axis and is now a gear driven pump. The mechanical pump was found to be a variable-displacement vane pump used to optimize pressure based on pump speed and required system pressure. As pressure demand builds, the pump slide moved the stator to be more concentric with the pump rotor, reducing displacement until the system pressure balanced with demand. This displacement reduction decreased the drive torque requirements of the pump at higher speeds and lower system pressure demands. The electric stop/start pump allowed engine stop/start functionality. The stand-alone electric pump removed the need for a hydraulic accumulator. Using an electric pump in place of an accumulator eliminated the amount of time needed to charge the accumulator prior to engine stop and increases the time the engine can be off.

Hydraulic passages in the transmission have been shortened where possible to minimize filling time and reaction time during shifts. Moving the pump near the pickup point reduced fluid travel distance from the pickup to the pump. The pump is situated immediately between the pickup and the delivery passages. Reduction in shift times decreased the energy lost during shifts and the heat generated within the shift elements over the course of a shift. The 10R80 uses Ford's latest ATF specification Mercon ULV transmission fluid, an ultra-low viscosity fluid designed to improve fuel economy by minimizing pumping losses and viscous drag. Mercon ULV has a viscosity of 4.5 cSt at 100 °C, compared to 6.0 cSt at 100 °C for the previous Mercon LV ATF, which was recommended for the 6R80 and 6R140 6-speed transmissions.

Parasitic loss was improved in the 10R80 by only having two open clutches in any given gear. The brake clutches, which are normally grounded to the case structure, were located in a brake housing on the input side of the transmission. This elevated the brake clutches away from the fluid level and allowed the fluid to be expelled from the brake clutches while disengaged. This minimized viscous drag in the open brakes that typically have high relative velocities and large surface areas between the rotating and stationary elements. Separating spring plates inside these brake clutches helped further separate clutch elements while disengaged.

3.1.3 Honda CVT Ratio and Packaging Information

The input pulley in the Earth Dreams CVT was the primary controller of gear ratio, containing pistons to move the pulley in and out. The output pulley contained a single piston pressing the sheaves together and an opposing spring that defaulted the transmission into its lowest ratio (largest reduction) when no pressure is applied to the input sheave. The Honda CVT achieved pulley ratios between 2.645:1 to 0.405:1. The helical reduction gearset downstream of the driven pulley included an idler gear and the differential drive gear that provided further reduction of 5.044:1. This provided an overall ratio in the underdrive arrangement of 13.341:1 and an overdrive ratio of 2.042:1. That overall ratio span compared favorably to stepped transaxles, providing useable reduction at vehicle launch and economic operation at cruising speeds. The overall envelope of the Honda CVT was comparable to market transaxles. a variant of the ZF 9HP has been available in other trim levels of the Accord, so both units package within the Accord chassis.

3.1.4 Honda CVT Efficiency Improvement Features

Honda elected to equip the Earth Dreams CVT with a torque converter. Alternative approaches on CVTs see the transmission equipped with a start clutch that sometimes includes a torsional damper. The torque converter provided for a smooth start without the need to control the engagement of a clutch pack. Start clutches can be subject to driver complaints similar to DCTs, exhibiting "shudder" when starting. Once the Accord CVT shifts beyond the underdrive default ratio, the torque converter locked, and the engine was directly coupled to the transmission. The torque converter also provided additional torque multiplication for launch and gradeability, which reduced the need for wider pulley ratio span. As pulley ratio moves to either end of the ratio envelope away from a 1:1 ratio, greater efficiency losses were observed.

CVTs operate with higher hydraulic pressure than typical automatic transmissions because of the axial force needed to prevent belt slippage. Pressure capability up to 6 MPa is common in CVTs. Hydraulic pressure within the Honda CVT was provided through a positive displacement, dual-discharge vane pump driven by chain from the input shaft. The chain drive located the pump at the fluid level within the transmission sump, allowing it to integrate directly into the filter and hydraulic control body. In addition to the high pressure needs, ratio response time is dictated by hydraulic flow, so the hydraulic pump must be large enough to provide adequate flow when large ratio changes are needed. In the Earth Dreams CVT, the pump was capable of 100 L/min of flow at full discharge and full speed. The Honda CVT used a pushbelt to enable greater load carrying and limit deflection between the pulleys. The CVT belt used in the Earth Dreams CVT is 30mm wide with 12-ring construction and is specified to handle 350 - 400 Nm of engine torque.

3.2 Parasitic Loss Mapping

The parasitic loss mapping consisted of unloaded spinloss testing. This transmission evaluation characterized the speed-based losses of the transmission with no load applied. The tests were conducted using the vehicle line pressure and control pressure schedules from the lowest load point of the efficiency mapping tests. The torque converter clutch was locked during the spinloss testing to remove any losses across an open converter. Input torque meters were sized and calibrated for additional fidelity during the spinloss testing. The propshaft was removed for longitudinal transmission testing, and the output CV shafts were removed for transaxle testing. SwRI manufactured sealing plugs that fit the output shaft bores to retain the transmission fluid during testing.

3.2.1 Ford 10R80 Parasitic Results

The spinloss testing on the 10R80 encompassed three temperatures and input speed range observed in the in-use testing. The10R80 parasitic results mirrored the findings of the loaded efficiency testing. The transmission exhibited small amounts temperature sensitivity between 40 °C and 65 °C with the drive torque decreasing for the bulk of conditions across all gears. However, between 65 °C and 93 °C, only marginal differences were observed. Figures 62, 63, and 64 show the per-gear trends of spinloss at the three test temperatures.

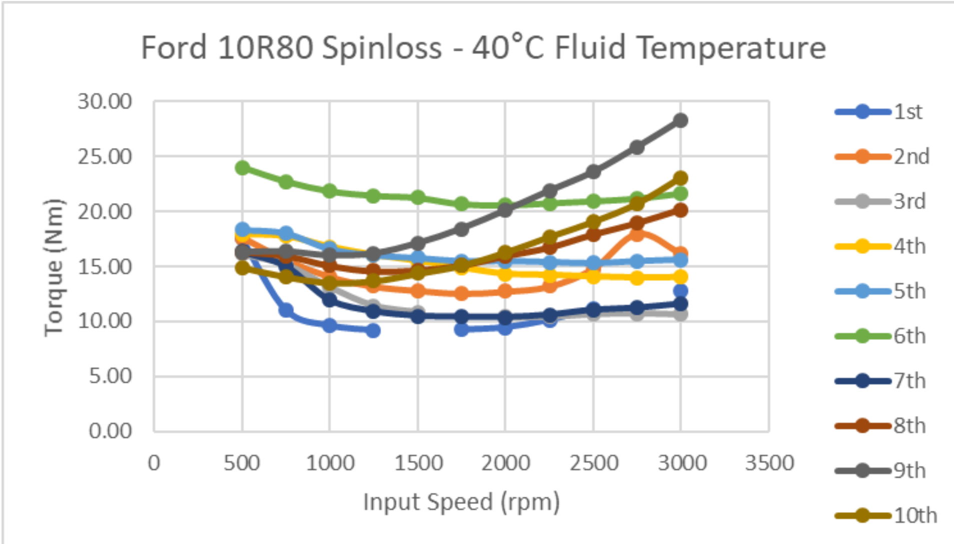


Figure 62. Ford 10R80 Spinloss at 40 °C Fluid Temperature

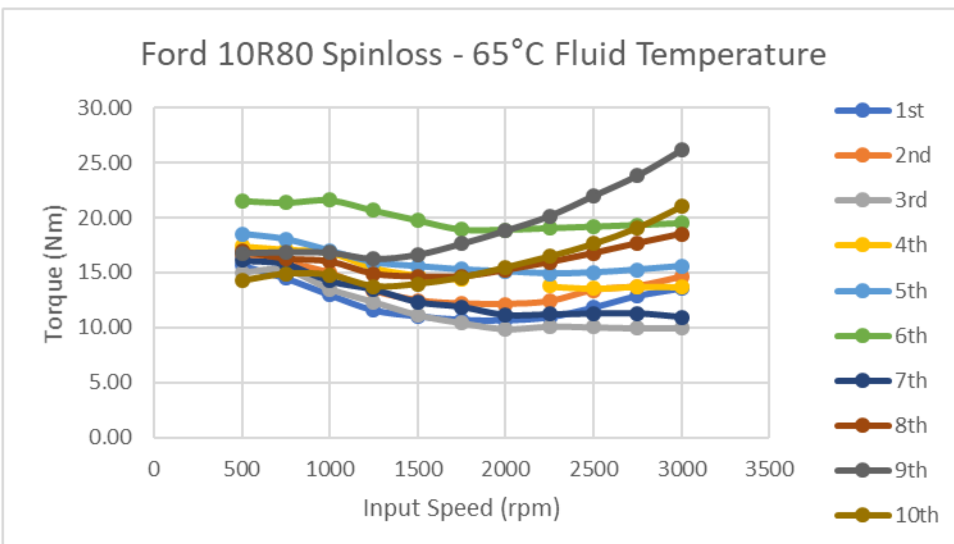


Figure 63. Ford 10R80 Spinloss at 65 °C Fluid Temperature

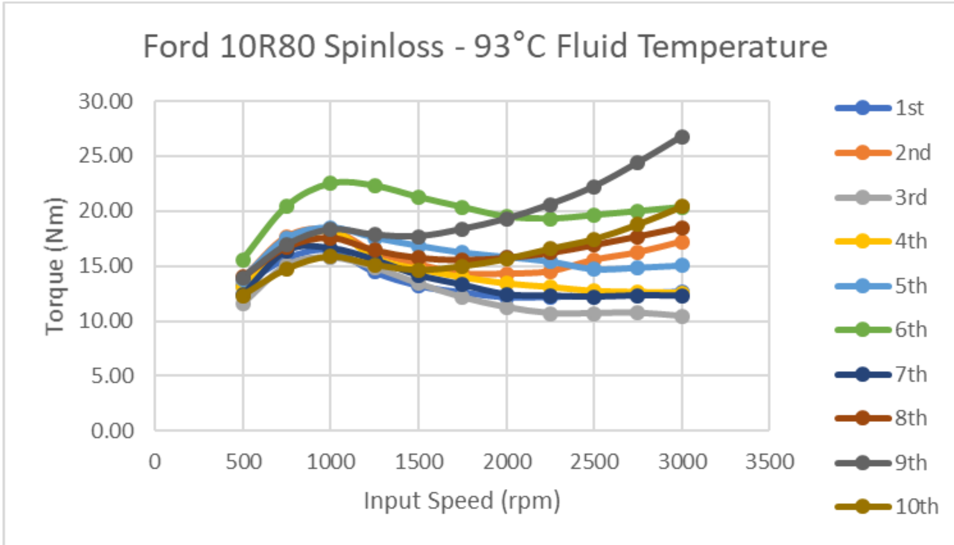


Figure 64. Ford 10R80 Spinloss at 93 °C Fluid Temperature

The plots illustrate minimal speed dependency for a number of gears. Only 2nd, 8th, 9th and 10th gears exhibit strong speed dependency at 93 °C fluid temperature.

3.2.2 Honda CVT Parasitic Results

The spinloss results for the Honda CVT provided a comparison for the expected trends between the parasitic losses of a CVT versus a stepped automatic transmission. Where the stepped automatic had input speed dependency, the CVT showed minimal sensitivity to input speed. Figures 65-67 illustrate the CVT's sensitivity to pulley ratio at all temperatures. When the pulley ratio moved into overdrive pulley ratios the mechanical losses began to follow output speed / belt speed.

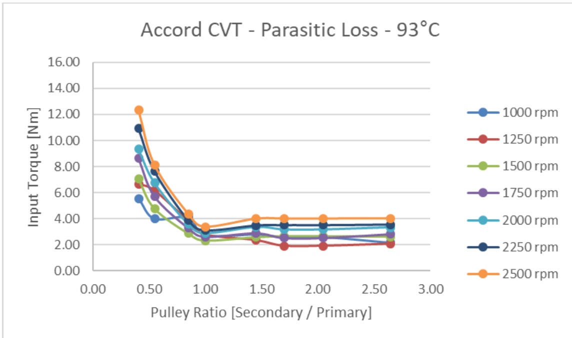


Figure 65. Honda CVT Spinloss at 93 °C Fluid Temperature

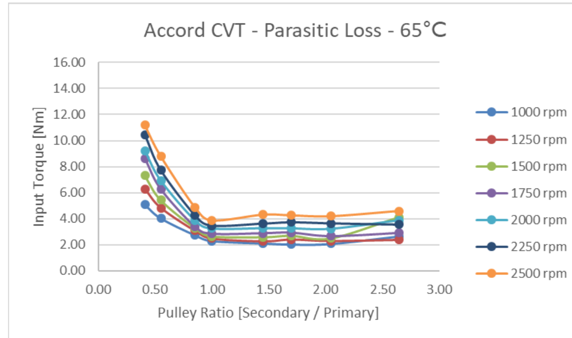


Figure 66. Honda CVT Spinloss at 65 °C Fluid Temperature

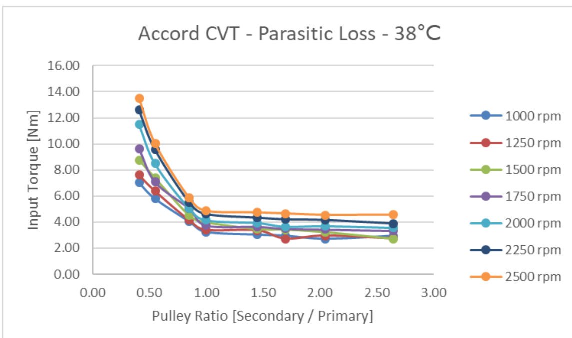


Figure 67. Honda CVT Spinloss at 38 °C Fluid Temperature

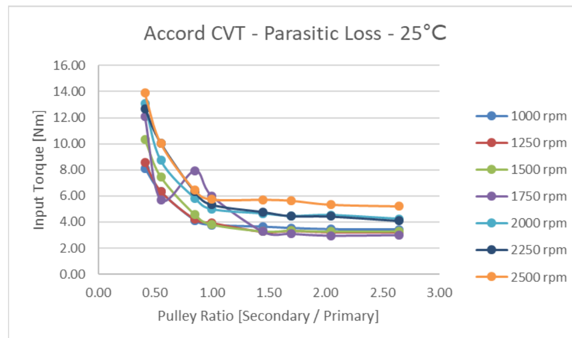


Figure 68. Honda CVT Spinloss at 25 °C Fluid Temperature

In the underdrive ratios, the mechanical losses were low, and the CVT's parasitic losses were tied to the torque to drive the hydraulic pump. The pump torque followed input speed to some extent, and temperature sensitivity was evident between 25 °C and 93 °C. Pump testing on the Honda CVT showed the mechanical pump dominates the parasitic losses measured in the underdrive pulley ratios.

3.3 Transmission Pump Testing

3.3.1 Ford 10R80 Pump Testing

The off-axis pump of the 10R80 was gear driven from the turbine shaft of the transmission. The pump is a variable vane pump with pressure feedback control of the pump displacement. The pump is a seven-vane pump with input and outputs on the same cast endplate of the pump. Internal and external pictures of the pump, including instrumentation, can be seen in Figures 69, 70, and 72. The variable displacement pump was feedback controlled based off the line pressure demand.

The oil pump testing included differential pressure measurement across the pump, fluid temperature, pump speed and drive torque measurements. The oil pump testing was conducted in the assembled transmission. The 10R80 pump outlet mounts directly to the valvebody with the pump displacement feedback control being referenced from the valvebody. The line pressure control solenoid changed pump displacement through the control pressure chamber, as seen in Figure 71. The feedback port from the valve body to the pump control chamber can be seen in Figure 69.

As control chamber pressure increased, the pump volume decreased. The line pressure solenoid was a normally high type, so with no control signal, the pump defaulted to its max displacement. The figures illustrate how truncated the filter-to-pump and pump-to-valvebody circuits are within the 10R80. This packaging precluded in-transmission flow rate measurements that would have allowed volumetric and hydraulic efficiency measurements of the pump.

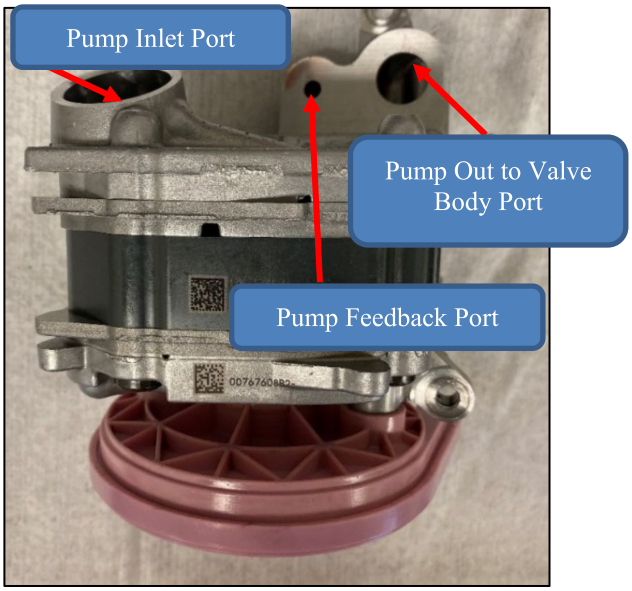


Figure 69. Off-Axis Ford 10R80 Gear Driven Pump

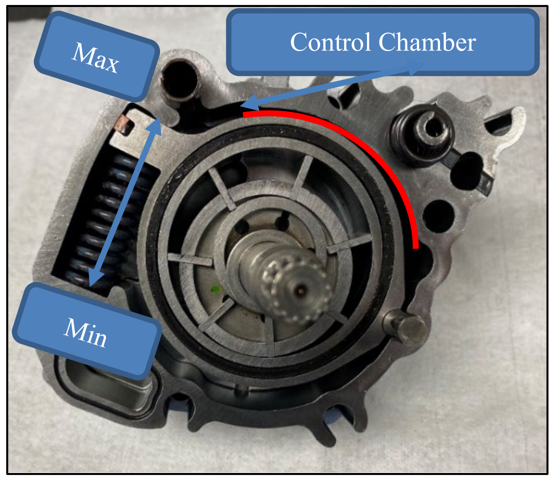


Figure 70. Ford 10R80 Variable Displacement Pump

Figure 71. Ford 10R80 Valvebody Elevated to Show Pump Outlet Channel Into Valvebody

The transmission was tested in neutral with no clutches applied and the torque converter locked to reduce any contributions to measured drive torque other than the torque required to turn the mechanical oil pump. The oil pump measurements were taken over a speed and a range of line pressure command as illustrated in Table 10. The pump speed and drive torque served to calculate the mechanical power consumption of the pump.

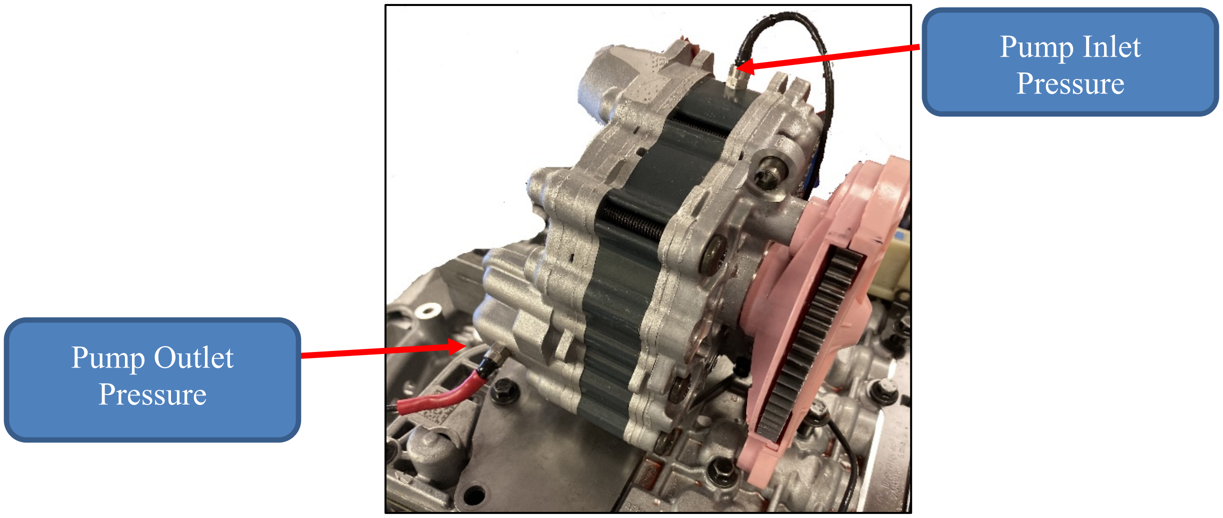


Figure 72. Picture of 10R80 Pump Exterior and Instrumentation

Table 10. 10R80 Oil Pump Test Conditions

	Input Speed [rpm]						
	750	**1000**	**1500**	**2000**	**2500**	**3000**	**3250**
Min. Line Pressure							
25% Line Pressure Command							
50% Line Pressure Command							
75% Line Pressure Command							
Maximum Line Pressure Command							

System pressures were measured from input speeds between 750 to 3,250 rpm. Transmission motoring torque was measured at each speed setpoint while sweeping line pressure solenoid control. The difference in drive torque required between minimum and maximum pump displacement was characterized. Maximum current supplied to the line pressure control solenoid resulted in ~400 kPa line pressure. Measured motoring torque corresponds, inversely, to solenoid command. Reduced solenoid command gave greater pump displacement and increased the required torque to drive the system. The pump performance had very little dependency on speed, as seen in Figure 73. Below 1,500 rpm, less peak output pressure was attainable. This indicated that the pump lacks enough output to engage the pressure relief circuit below 1,500 rpm. From 1,500 up to 3,250 rpm, the peak pressure remained consistent with command. The relationships between the pressure, input torque, and line pressure solenoid command can be seen in Figure 73, 74, and 75.

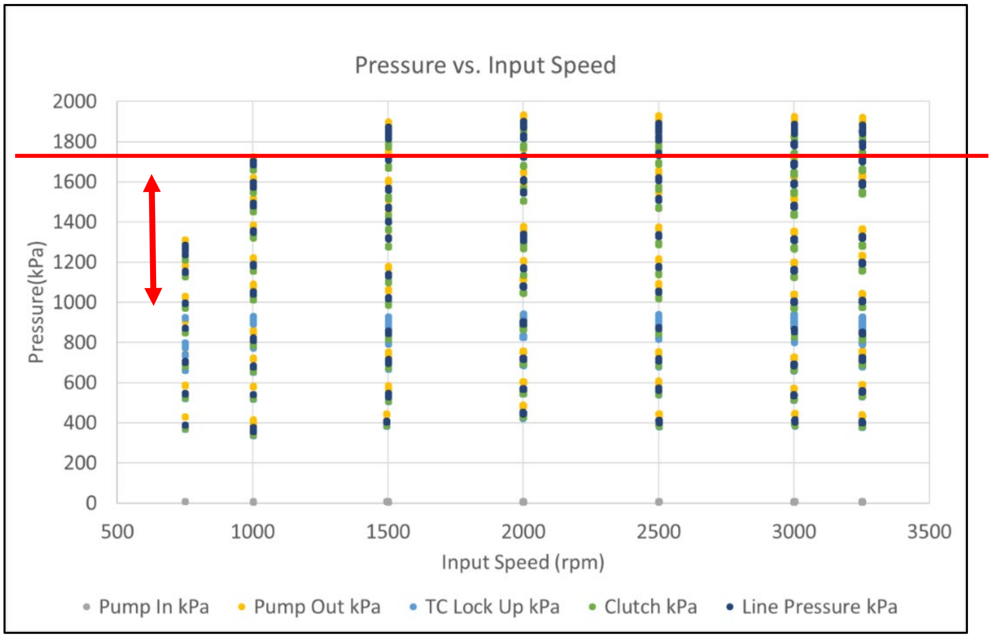


Figure 73. Input Speed Vs. Pressure of 10R80 Pump

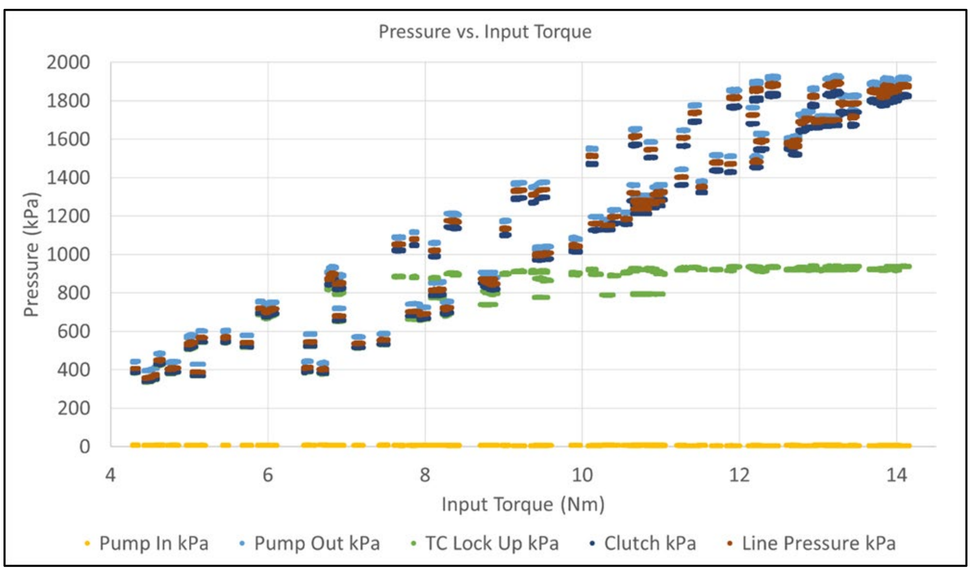


Figure 74. Input Torque Vs. Pressure of 10R80 Pump

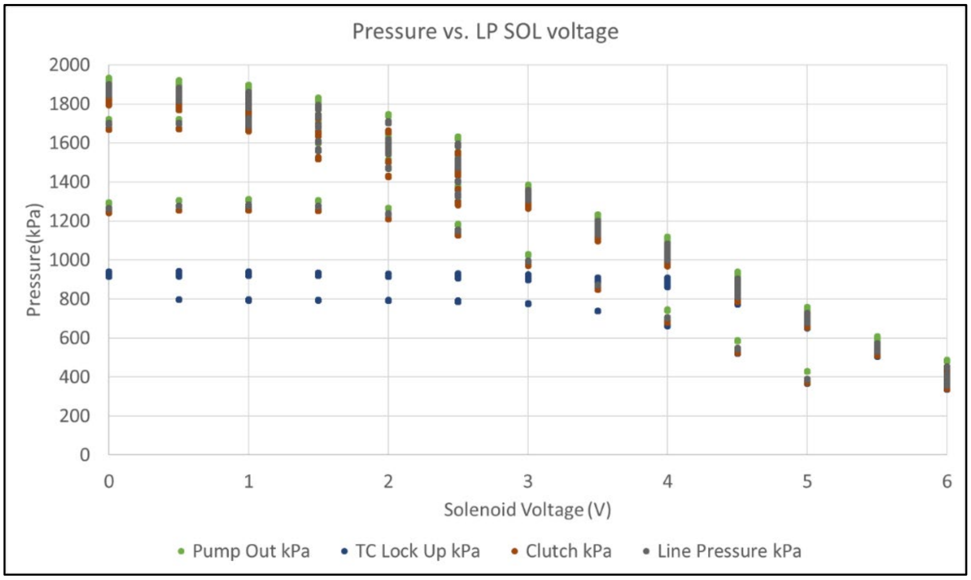


Figure 75. Line Pressure Solenoid Voltage Vs. Pressure of 10R80 Pump

This electric pump in the 10R80 utilized during engine start/stop operation keeps the valvebody primed while the primary mechanical pump is not supplying fluid to the transmission. The pump is a gerotor pump that contains its own filter as it draws fluid directly from the transmission sump during normal operation. Figure 76 and 77 show the filter and gerotor partially disassembled. The characterization of the 10R80 start/stop, electric pump included measuring the pump speed, displacement, and power draw for the auxiliary, electrically driven oil pump. The start/stop pump used a brushless DC motor. SwRI used a PWM signal to vary the speed of the electric oil pump for testing. Downstream valving was used to create pump load during the evaluation. The pump was not observed to vary speed during in-vehicle operation. Figure 78 presents the electric power consumption of the start/stop pump for a partial load and full, no-flow load cases. The overall power consumed by the pump was below 100 Watts during all the observed operation.

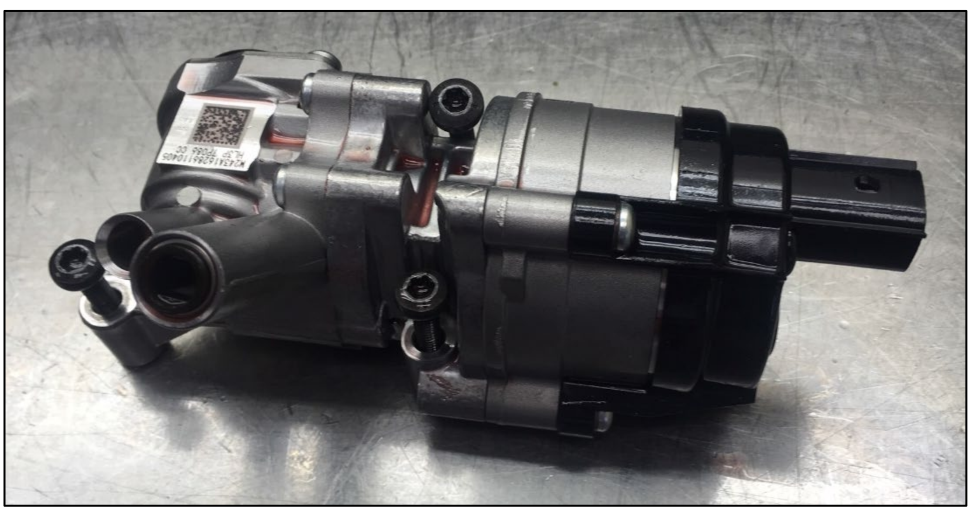


Figure 76. Electric Auxiliary Oil Pump

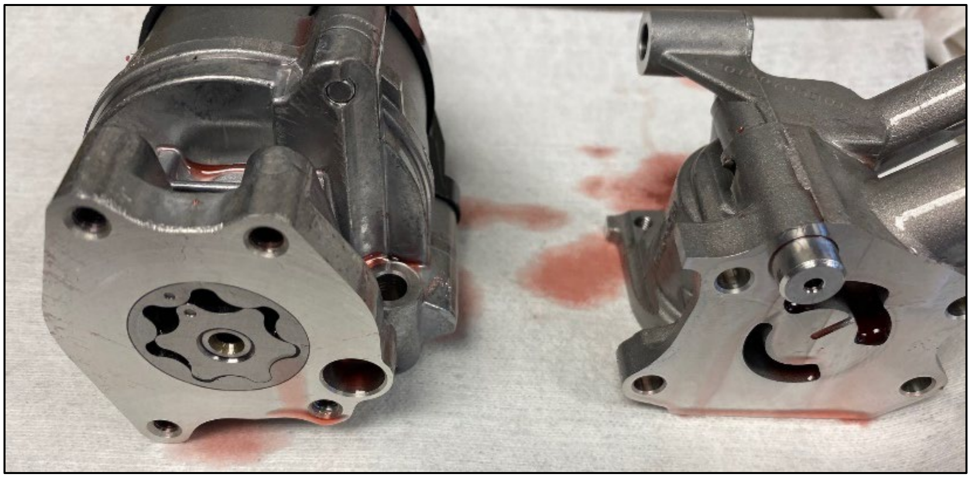


Figure 77. Gerotor Pump and Filter Housing Separated

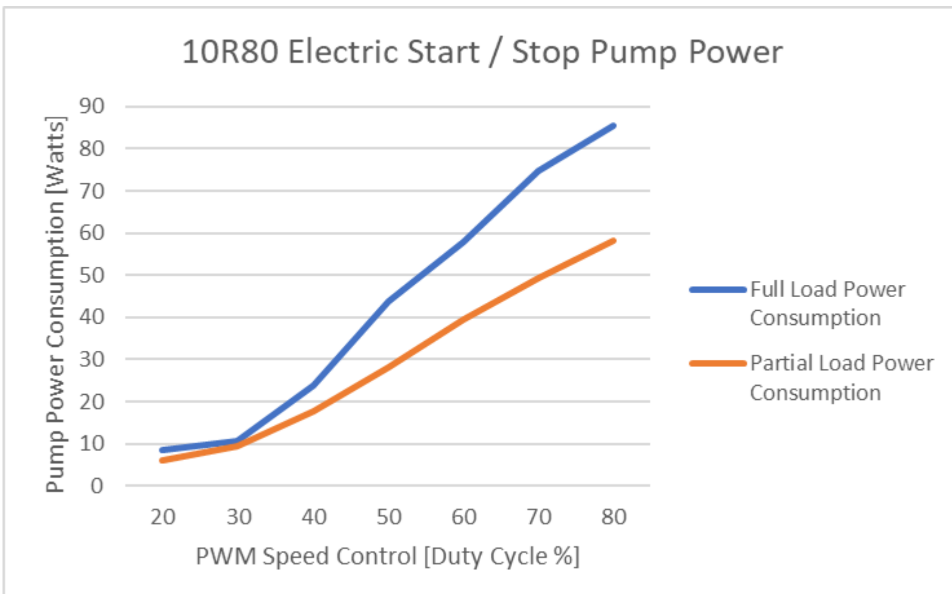


Figure 78. Ford 10R80 Electric Start/Stop Pump Characterization

3.3.2 Honda Earth Dreams CVT Pump Testing

The Honda Earth Dreams CVT used a dual chamber pump with the capability of using the chambers in parallel for large volume output or using the chambers in series to reduce output and elevate the pump inlet pressure. The pump used an on/off solenoid control valve to dam the balance oil pressure from acting on the displacement control spool valve. The lack of balance oil allowed the displacement control valve to shuttle and block one of the discharge passageways. This bypassed one of the pump chambers back into the inlet side of the pump housing. at this point, only one of the pump chambers contributed fluid output to the valvebody. This mode of operation allowed for drive torque reductions at high pump speeds. With the balance oil on both sides of the displacement control spool valve, both pump chambers contributed to the pump output. This allowed the pump to supply ample pressure and flow to the variators even at low oil pump shaft speeds. Figure 79 is a technical document provided by the pump supplier. The illustration of function aided in understanding both modes of operation. Figures 80 and 81 show the pump rotor and the twin chambers of the pump. Figure 81 illustrates the output channels of both chambers and the link between them at the displacement control spool valve.

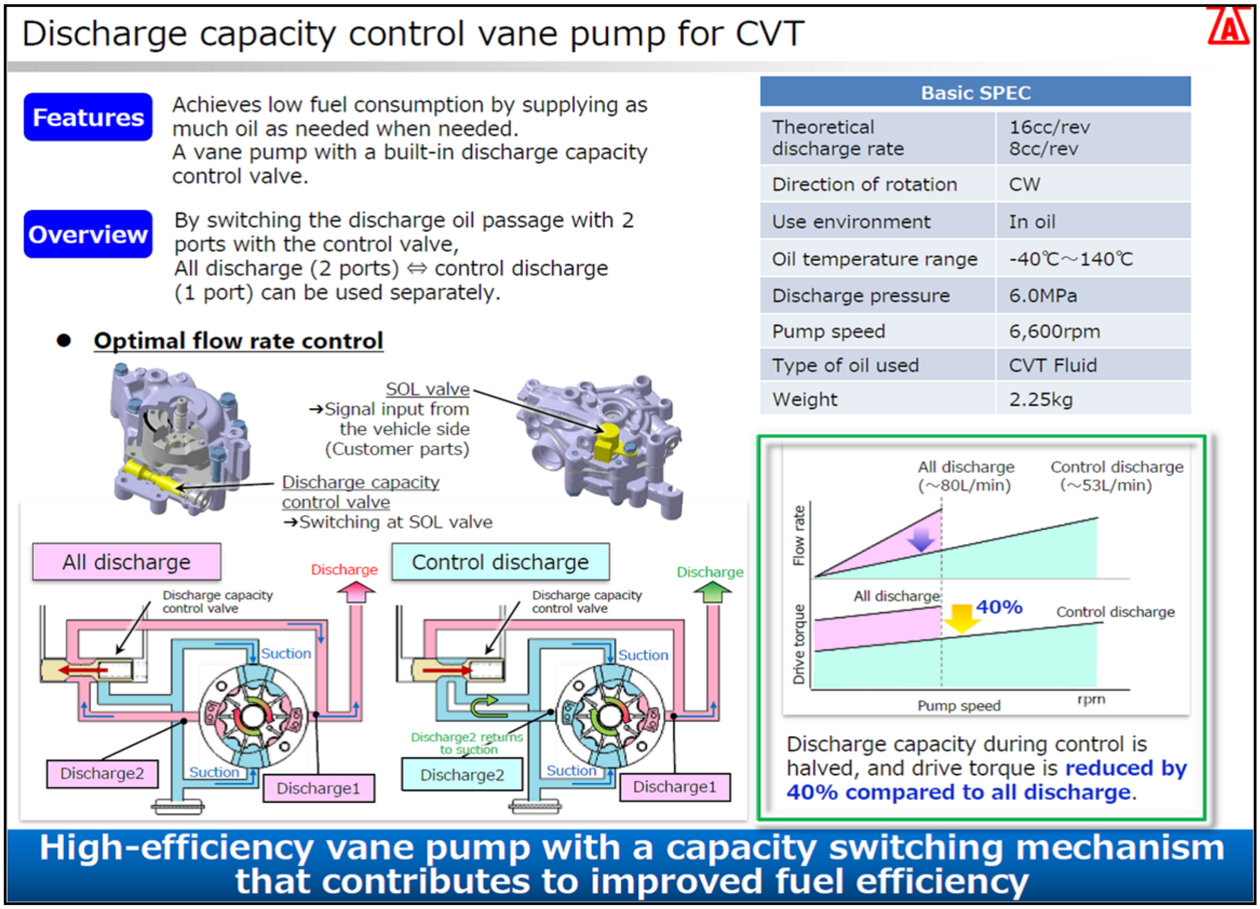


Figure 79. Honda CVT Pump Description From Pump Supplier

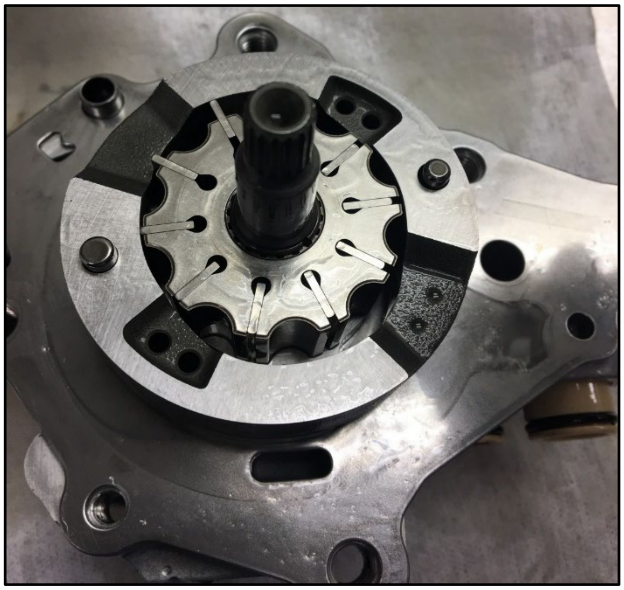


Figure 80. Honda CVT Dual Chamber Pump

Figure 81. Honda CVT Displacement Control Valve

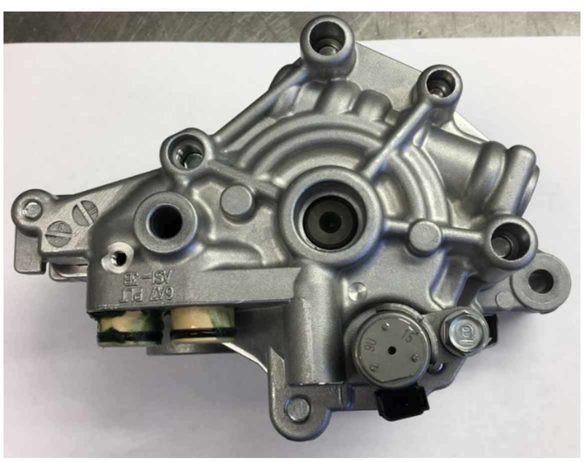


Figure 82. Honda CVT Pump Outlet Pressure Port

Figure 83. Honda CVT Pump Inlet Pressure Port

Figures 82 and 83 provide the locations for mini-Kulite pressure transducers used in instrumenting the Honda CVT pump. The instrumented pump was reassembled into the Honda CVT for testing. Functionally, the pump outlet pressure was determined by the maximum demand pressure between the primary pulley circuit, secondary pulley circuit, and the forward clutch circuit. Secondary pressure was used to elevate the pump outlet pressure over the desired test range, so no rotation or pulley movement occurred during testing. The primary pulley was not driven during the pump testing as the forward clutch was not applied and the neutral range was selected on the transmission shift lever. The pump testing was conducted with the torque converter clutch locked, so the torque converter did not contribute any loss in the measured drive torque values. The design of the pump was not observed to be sensitive to fluid temperature. Small drive torque differences were only apparent at low input speeds. Figures 84 -87 present the fluid comparison results on the Honda CVT pump experiment with the pump in the reduced displacement mode.

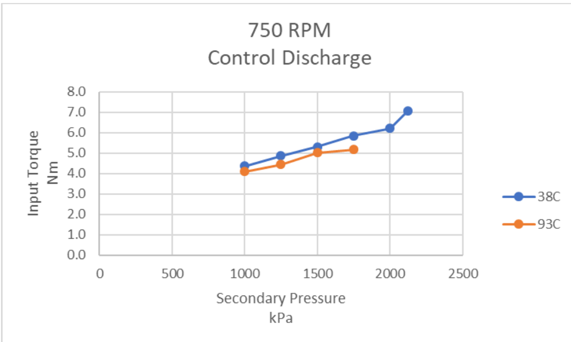


Figure 84. Honda CVT Fluid Temperature Comparison – 750 rpm

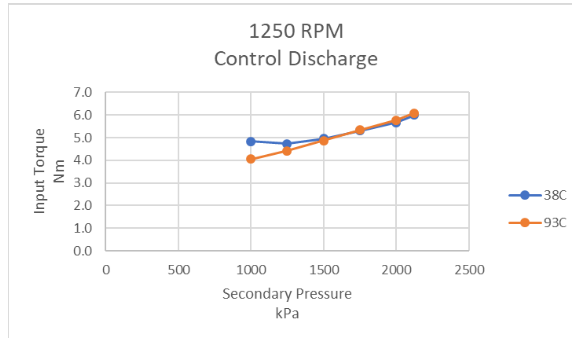


Figure 85. Honda CVT Fluid Temperature Comparison – 1,250 rpm

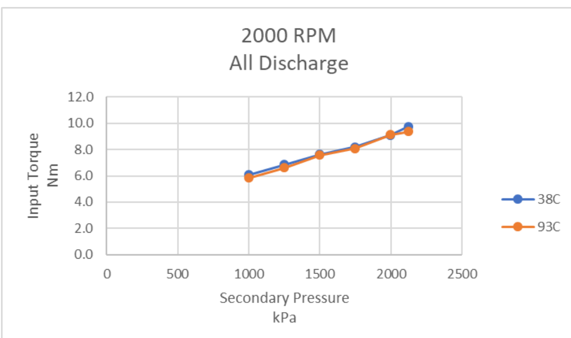


Figure 86. Honda CVT Fluid Temperature Comparison – 2,000 rpm

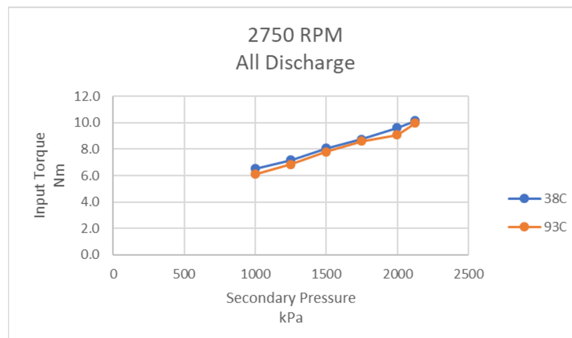


Figure 87. Honda CVT Fluid Temperature Comparison – 2,750 rpm

The displacement control valve on the pump reduced the drive torque significantly. The displacement control was observed to save between two to four newton meters of drive torque depending on the pump output pressure. All efficiency and spinloss testing on the Honda CVT was conducted with the control valve providing full pump discharge as this proved to be the safest and most robust means of testing with the closed loop system used for secondary pulley pressure and pulley ratio control. Figures 88 – 91 show the drive torque reduction when the pump displacement control valve decreases output.

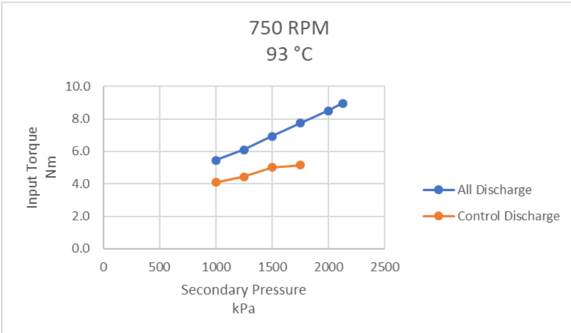


Figure 88. Figure 88. Honda CVT Pump Displacement Comparison – 750 rpm

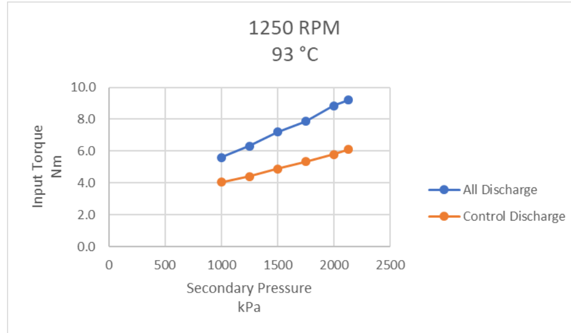


Figure 89. Honda CVT Pump Displacement Comparison – 1,250 rpm

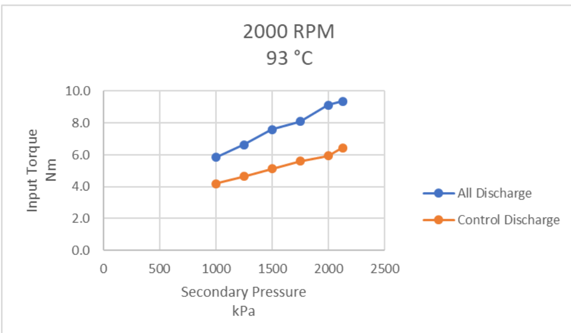


Figure 90. Honda CVT Pump Displacement Comparison – 2,000 rpm

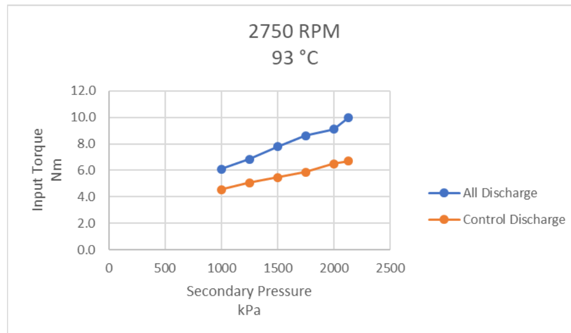


Figure 91. Honda CVT Pump Displacement Comparison – 2,750 rpm

4 SR-4 Deliverables – In-Use Performance Testing

4.1 Vehicle Level Instrumentation and Setup

4.1.1 Ford 10R80 Instrumentation

The first steps taken upon receipt of the benchmark transmission vehicles included removing the transmission and installing discrete instrumentation in the transmissions of each vehicle. The instrumentation for the 10R80 transmission included three pressure transducers, four speed signal splices, a flexplate speed pickup for crankshaft speed, and sump thermocouple. Table 11 shows the instrumented circuits for the 10R80 transmission.

Table 11. 10R80 Discrete Instrumentation

Preussures		
TCC Apply	mini Kulite Transducer	
Secondary Line	mini Kulite Transducer	
1-3-5-6-7-8-9 Clutch	mini Kulite Transducer	
Speeds		
Turbine Shaft Speed	Native Hall Effect pickup	40 tooth
Intermediate Speed A	Native Hall Effect pickup	50 tooth
Intermediate Speed A	Native Hall Effect pickup	50 tooth
Output Shaft Speed	Native Hall Effect pickup	68 tooth
Temperature		
Sump Temperature	K-type Thermocouple	

The secondary line and 1-3-5-6-7-8-9 clutch pressures were externally accessible on the case of the transmission and allowed for the line pressure schedule characterization in the 10R80 during in-use testing. Torque converter clutch apply pressure required disassembly of the valvebody and machining of a valvebody channel to facilitate the instrumentation of the circuit. Figures 92 and 93 show the location of the drilling and pressure transducer, respectively, in the lower valvebody of the Ford 10R80. SwRI used a small-bodied Kulite pressure transducer with in-line amplifier to measure internal system pressures. The transducer body allowed for in-channel packaging of pressure transducers without disrupting adjacent valvebody circuits.

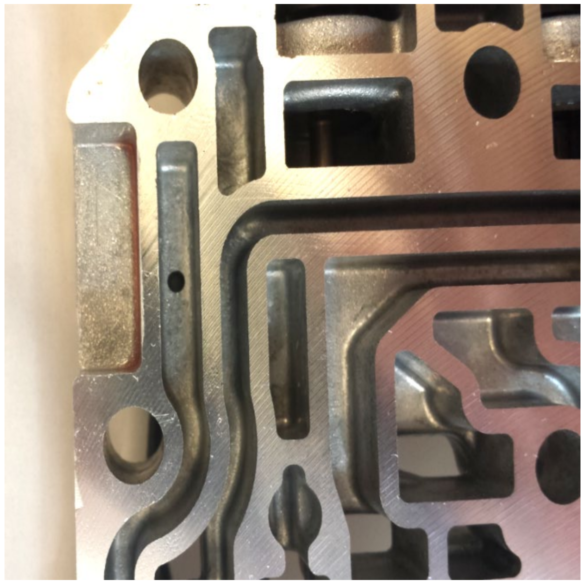


Figure 92. Valvebody Drilling Location for TCC Apply Circuit – Lower Valve Body of 10R80

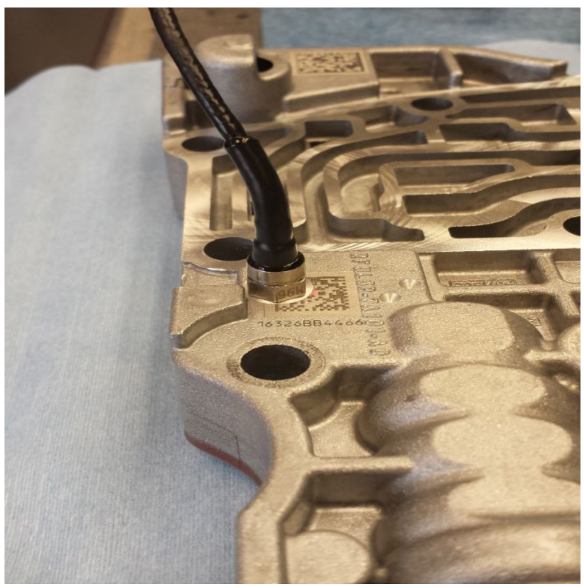


Figure 93. Mini-Kulite Pressure Transducer Installed in TCC Apply Circuit

The pressure transducer in the TCC Apply circuit was used to map the torque converter clutch state during in-use vehicle testing. Figure 94 shows TCC pressure traces for driveaway maneuvers on the Ford F-150. The pressure signal was essential in timing the torque converter clutch events when used with the flexplate and turbine shaft speed pickups. SwRI used the native hall-effect speed pickups for the turbine shaft, intermediate speed sensor A, intermediate speed sensor B, and the output shaft speed pickup. SwRI used an opto-isolator in line with the speed signals tapped external to the transmission to leave transmission function unaffected by the piggy-back instrumentation. The native speed signals were post conditioned with a TTL digitizer for accurate speed measurements collected at 20 GHz with a Rotec RASnbk system. Figure 95 depicts the four speed pickups in the 10R80.

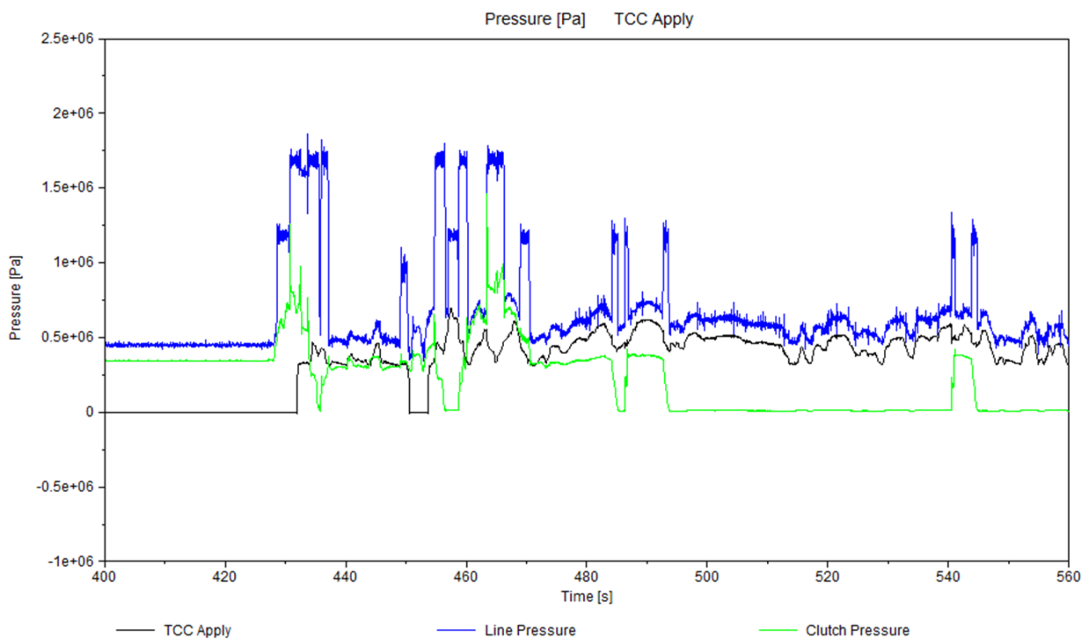


Figure 94. Ford 10R80 Discrete Pressure Instrumentation Trace

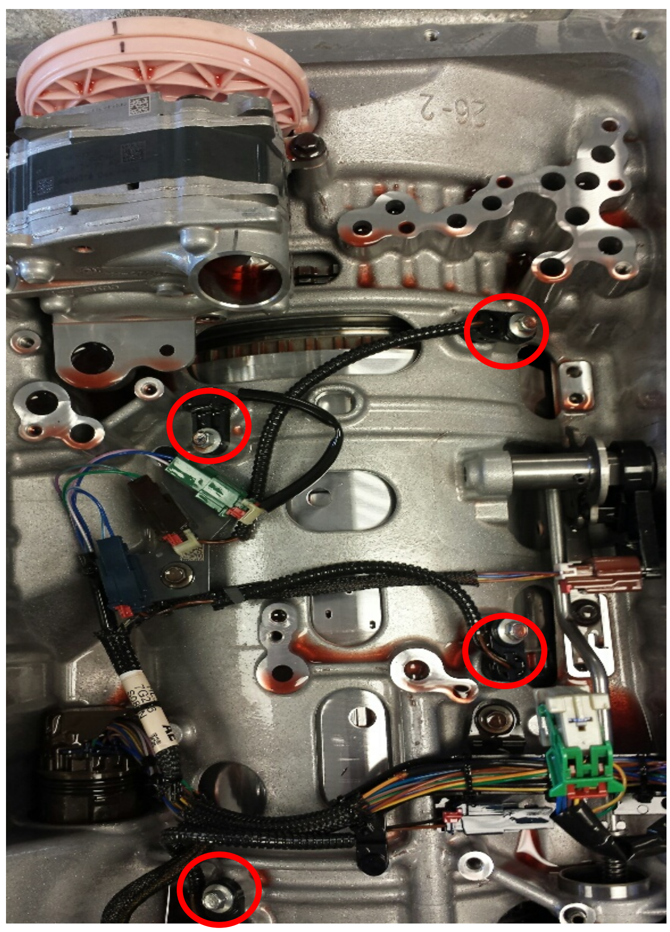


Figure 95. Native Hall Effect Speed Pickups, Ford 10R80

A loss in speed signal amplitude with the flywheel speed channel during in-use testing disrupted the logging of the native speed sensors for the turbine, intermediate 1, intermediate 2, and output speed signals from the transmission. to alleviate this disruption, SwRI moved the flexplate to a standalone power supply and migrated the flexplate to speed channel two on the measurement system. The measurement system was then triggered from the native Hall-effect turbine speed sensor within the 10R80. The in-use testing also logged CAN data to monitor/collect certain engine parameters and transmission control signals during the multiple repeats of the drive cycles. Fuel flow instrumentation was added to each vehicle prior to testing.

Figure 96. Power Supply and TTL Circuitry Enclosure

Figure 96 depicts the power supply enclosure used to power the discrete instrumentation and house multiple TTL digitizers that create speed pickup isolation for the transmission's native speed sensors. The digitizers are low current switching transistors that create ideal square waves from a native frequency input. These elements allowed unaffected operation of the transmission during in-use testing while sampling native sensors.

4.1.2 Honda Earth Dreams CVT Instrumentation

Discrete pressure instrumentation was added to the Accord CVT for the forward and reverse clutch pressure, primary pulley, secondary pulley, and torque converter apply pressure circuits. The primary, secondary, engine, and output shaft speeds used native speed pickups like the F-150 instrumentation. on the Accord CVT, the native speed pickups and the secondary pulley pressure sensors are external to the transmission. The primary and secondary pulley speeds characterized the pulley ratio real-time during cycle and maneuver testing. The list of discrete instrumentation for the Accord in-use testing is shown in Table 12.

Table 12. Honda Accord SR4 In-Use Daq Hardware

Channel	Instrumentation
Drive Pulley Pressure	Kulite transducer
Driven Pulley Pressure	Kulite transducer
Clutch Pressure Control	Kulite transducer
Lock-up Pressure	Kulite transducer
Pump Control	Kulite transducer
Sump Control	K-type thermocouple
Turbine Speed Sensor	Native w/digitizer
Drive Pulley Speed	Native w/digitizer
Driven Speed Sensor	Native w/digitizer
Flexplate speed	CAN OBD

Figure 97 shows the Honda Accord CVT instrumentation. The primary pulley speed sensor and secondary pulley pressure sensor are visible in the foreground of the figure. The transmissions coolant-to-oil heat exchanger is shown on the left side of Figure 98. The plate and fin heat exchanger functions as both a fluid heater and a cooler dependent on the temperature gradient between engine coolant and the transmission fluid. Below the heat exchanger there is a casting feature that is not in use for the Accord transmission but exists to adapt an electric oil pump in applications with start/stop capability.

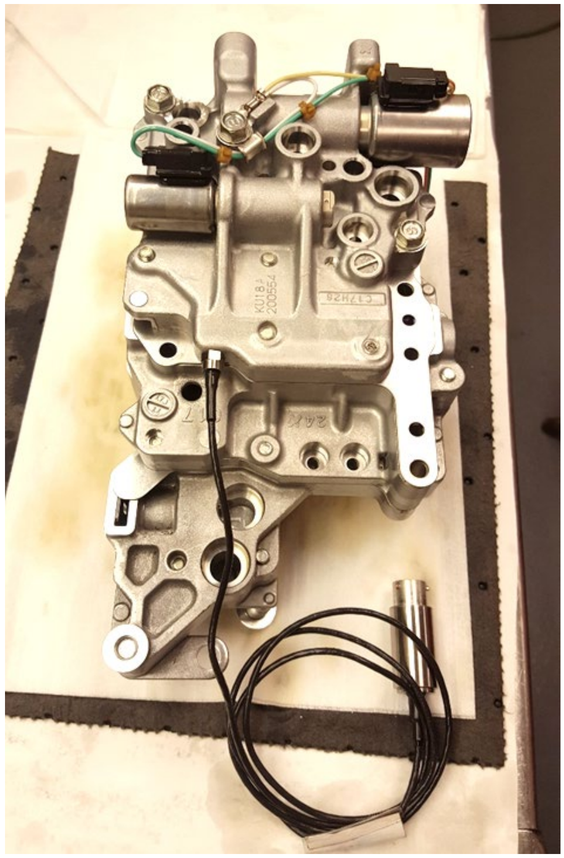


Figure 97. Honda CVT Valvebody With Torque Converter Clutch Pressure Transducer

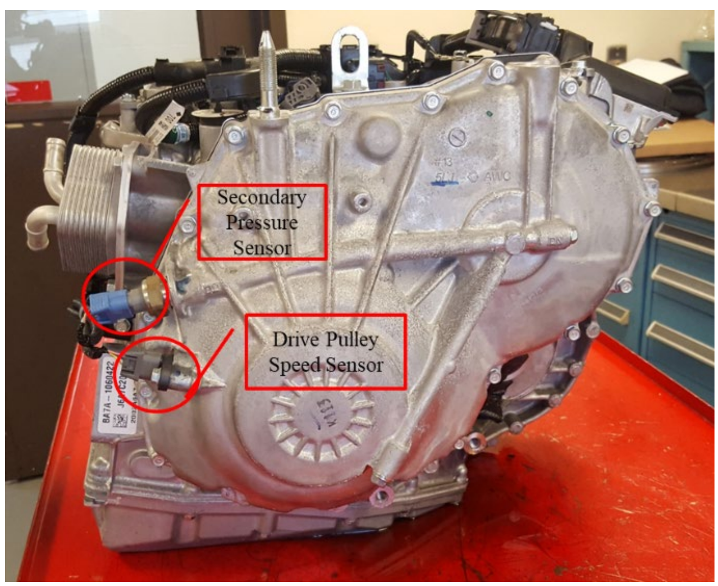


Figure 98. Honda CVT External Sensor Locations

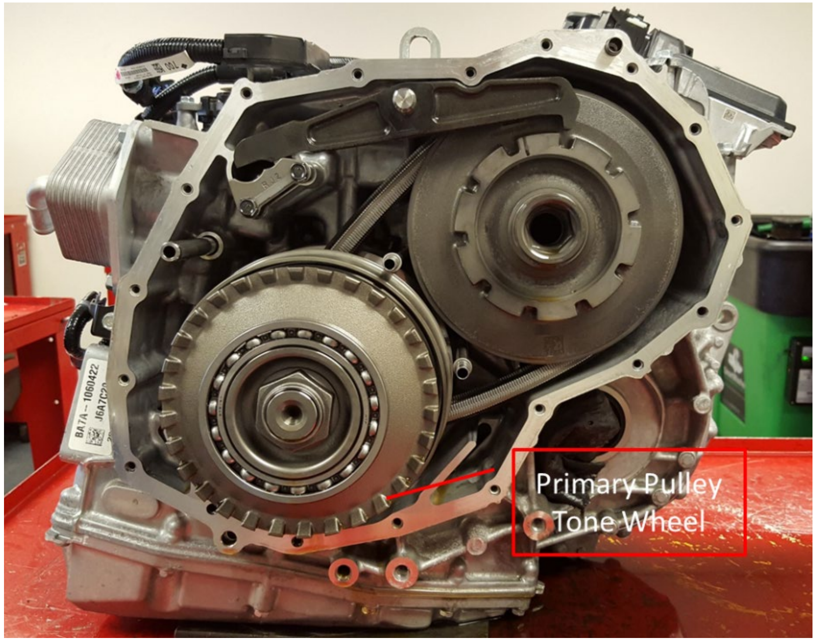


Figure 99. Honda CVT Internal Tone Wheel on Primary Pulley

Figure 99 depicts the drive pulley, driven pulley, and belt arrangement within the Honda CVT. Visible on the drive pulley is the tone wheel that incorporated 30 raised-tooth profiles that the external Hall-effect sensor triggers from. Drive pulley speed was measured directly from the pulley using this hardware feature and native speed pickup. The driven pulley connects to a reduction gearset. The driven pulley connects immediately to a 32-tooth gear that starts the final drive reduction geartrain. The driven speed pickup reads the idler shaft's 53-tooth gear that is driven by the pulley's 32-tooth gear, in constant mesh. The output idler shaft speed measured was corrected back to the driven pulley speed via the 53:32 tooth ratio. SwRI calculated real-time pulley ratio through the measured drive pulley speed and calculated driven pulley speed.

4.2 Drive Cycle Characterization

Each benchmark vehicle underwent in-use testing on SwRI's dynamometer cell-7. The cell is a two-wheel drive chassis roll arrangement within a temperature-controlled environment. All vehicle testing was completed at a target ambient temperature of 73 °F. The cell used a variable speed fan to recreate on-road air flow across the front of the vehicle. Figure 100 shows a vehicle prepared to begin cycle work with anchors and variable speed fan in place. Each vehicle test began with determination of the dyno coefficients. Vehicle coast-downs generated the rolling and frictional coefficients for each benchmark vehicle. EPA aerodynamic coefficients were used for the cycle and mapping work.

Figure 100. Honda Accord Undergoing In-Use Testing

The in-use testing began with drive cycle characterization of each vehicle. Standard bag measurements were taken for each cycle. Coriolis flow meters were fitted to each vehicle to quantify fuel flow during in-use testing. SwRI completed three repeats of each drive cycle to ensure transmission behavior was consistent and to average out cycle-to-cycle variance. Figure 101 and 102 summarize the drive cycle emissions and fuel economy measurements collected on the F-150 and the Honda Accord.

					Weighted FTP-75				
		THC	CO	NOx	CO2	CH4	NMHC	FE	Trans. Temp
Test	Date	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	°C
F150#2685-FTP-T1	21-Feb-19	0.04	0.80	0.02	427.3	0.014	0.03	20.66	60.33
F150#2685-FTP-T2	22-Feb-19	0.04	0.83	0.02	430.4	0.015	0.03	20.51	60.85
F150#2685-FTP-T4	27-Feb-19	0.04	0.58	0.02	429.0	0.013	0.02	20.60	59.96
Average		0.04	0.74	0.02	428.9	0.01	0.03	20.59	60.38
St.Dev		0.00	0.14	0.00	1.6	0.00	0.00	0.08	0.45
COV		10.26%	18.92%	13.93%	0.37%	7.14%	11.11%	0.37%	0.74%

					Phase 1				
		THC	CO	NOx	CO2	CH4	NMHC	FE	Trans. Temp
Test	Date	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	°C
F150#2685-FTP-T1	21-Feb-19	0.145	3.01	0.05	466.3	0.033	0.116	18.78	33.72
F150#2685-FTP-T2	22-Feb-19	0.160	3.45	0.05	472.4	0.036	0.129	18.51	33.73
F150#2685-FTP-T4	27-Feb-19	0.119	2.11	0.05	472.1	0.028	0.095	18.61	33.46
Average		0.14	2.86	0.05	470.28	0.03	0.11	18.64	33.64
St.Dev		0.02	0.68	0.00	3.43	0.00	0.02	0.14	0.16
COV		14.68%	23.93%	2.13%	0.73%	12.50%	15.14%	0.73%	0.46%

					Phase 2				
		THC	CO	NOx	CO2	CH4	NMHC	FE	Trans. Temp
Test	Date	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	°C
F150#2685-FTP-T1	21-Feb-19	0.008	0.04	0.01	430.6	0.008	0.002	20.56	67.06
F150#2685-FTP-T2	22-Feb-19	0.008	0.03	0.01	430.3	0.007	0.001	20.58	67.75
F150#2685-FTP-T4	27-Feb-19	0.006	0.01	0.01	428.8	0.007	0.001	20.58	66.79
Average		0.01	0.03	0.01	429.91	0.01	0.00	20.57	67.20
St.Dev		0.00	0.02	0.00	0.95	0.00	0.00	0.01	0.49
COV		15.75%	72.51%	19.92%	0.22%	7.87%	43.30%	0.04%	0.73%

					Phase 3				
		THC	CO	NOx	CO2	CH4	NMHC	FE	Trans. Temp
Test	Date	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	°C
F150#2685-FTP-T1	21-Feb-19	0.018	0.58	0.01	391.6	0.012	0.008	22.56	80.21
F150#2685-FTP-T2	22-Feb-19	0.021	0.38	0.02	399.0	0.013	0.010	22.16	81.07
F150#2685-FTP-T4	27-Feb-19	0.026	0.50	0.03	396.7	0.014	0.013	22.28	79.64
Average		0.02	0.49	0.02	395.74	0.01	0.01	22.33	80.31
St.Dev		0.00	0.10	0.01	3.77	0.00	0.00	0.21	0.72
COV		18.65%	20.85%	31.07%	0.95%	7.69%	24.35%	0.92%	0.90%

					HwFET				
		THC	CO	NOx	CO2	CH4	NMHC	FE	Trans. Temp
Test	Date	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	°C
F150#2685-FTP-T1	21-Feb-19	0.001	0.04	0.00	294.9	0.002		30.02	81.86
F150#2685-FTP-T2	22-Feb-19	0.001	0.04	0.00	297.2	0.002		29.79	82.95
F150#2685-FTP-T4	27-Feb-19	0.001	0.03	0.00	295.6	0.002		29.96	81.64
Average		0.00	0.04	0.00	295.89	0.00	0.00	29.92	82.15
St.Dev		0.00	0.01	0.00	1.16	0.00	0.00	0.12	0.70
COV		0.00%	18.07%	34.64%	0.39%	0.00%	#DIV/0!	0.39%	0.85%

					US06				
		THC	CO	NOx	CO2	CH4	NMHC	FE	Trans. Temp
Test	Date	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	°C
F150#2685-FTP-T1	21-Feb-19	0.14	1.23	0.02	513.9	0.03	0.114	17.15	85.09
F150#2685-FTP-T2	22-Feb-19	0.15	1.32	0.03	525.4	0.03	0.125	16.77	85.66
F150#2685-FTP-T4	27-Feb-19	0.15	1.28	0.03	530.8	0.03	0.121	16.61	85.33
Average		0.15	1.28	0.03	523.39	0.03	0.12	16.84	85.36
St.Dev		0.01	0.05	0.00	8.64	0.00	0.01	0.28	0.29
COV		4.52%	3.62%	12.69%	1.65%	3.69%	4.64%	1.67%	0.34%

Figure 101. Summary of Ford F-150 Drive Cycles

		Weighted FTP-75							
		THC	CO	NOx	CO2	CH4	NMHC	FE	Micromotion
Test	Date	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(mpg)	ccm
ADC668_FTP_PT1	8/5/2019	0.011	0.191	0.000	247.41	0.003	0.008	34.80	4.16
ADC668_FTP_T1	8/7/2019	0.015	0.188	0.001	247.53	0.004	0.011	34.78	4.27
ADC668_FTP_T3	8/9/2019	0.014	0.195	0.001	242.04	0.004	0.010	35.57	4.21
Average		0.01	0.19	0.00	245.66	0.00	0.01	35.05	4.21
St.Dev		0.00	0.00	0.00	3.14	0.00	0.00	0.45	0.05
COV		15.61%	1.84%	86.60%	1.28%	15.75%	15.80%	1.28%	1.29%

		Phase 1							
		THC	CO	NOx	CO2	CH4	NMHC	FE	Micromotion
Test	Date	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(mpg)	ccm
ADC668_FTP_PT1	8/5/2019	0.051	0.421	0.001	260.00	0.011	0.040	33.05	7.53
ADC668_FTP_T1	8/7/2019	0.062	0.342	0.004	263.23	0.014	0.047	32.66	7.70
ADC668_FTP_T3	8/9/2019	0.059	0.396	0.003	253.61	0.013	0.045	33.88	7.48
Average		0.06	0.39	0.00	258.95	0.01	0.04	33.20	7.57
St.Dev		0.01	0.04	0.00	4.89	0.00	0.00	0.63	0.12
COV		9.92%	10.45%	57.28%	1.89%	12.06%	8.19%	1.88%	1.58%

		Phase 2							
		THC	CO	NOx	CO2	CH4	NMHC	FE	Micromotion
Test	Date	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(mpg)	ccm
ADC668_FTP_PT1	8/5/2019	0.000	0.115	0.000	252.88	0.000	0.000	34.07	4.06
ADC668_FTP_T1	8/7/2019	0.001	0.105	0.000	251.79	0.001	0.000	34.21	4.17
ADC668_FTP_T3	8/9/2019	0.001	0.109	0.000	246.59	0.001	0.000	34.93	4.15
Average		0.00	0.11	0.00	250.42	0.00	0.00	34.40	4.13
St.Dev		0.00	0.01	0.00	3.36	0.00	0.00	0.46	0.06
COV		86.60%	4.59%	#DIV/0!	1.34%	86.60%	#DIV/0!	1.35%	1.41%

		Phase 3							
		THC	CO	NOx	CO2	CH4	NMHC	FE	Micromotion
Test	Date	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(mpg)	ccm
ADC668_FTP_PT1	8/5/2019	0.001	0.162	0.000	227.66	0.001	0.000	37.82	6.08
ADC668_FTP_T1	8/7/2019	0.006	0.229	0.000	227.73	0.003	0.004	37.79	6.25
ADC668_FTP_T3	8/9/2019	0.004	0.205	0.000	224.74	0.002	0.002	38.30	6.24
Average		0.00	0.20	0.00	226.71	0.00	0.00	37.97	6.19
St.Dev		0.00	0.03	0.00	1.71	0.00	0.00	0.29	0.09
COV		68.63%	17.09%	#DIV/0!	0.75%	50.00%	100.00%	0.75%	1.52%

		HwFET							
		THC	CO	NOx	CO2	CH4	NMHC	FE	Micromotion
Test	Date	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(mpg)	ccm
ADC668_FTP_PT1	8/5/2019	0.001	0.173	0.000	177.35	0.001	0.000	48.53	8.76
ADC668_FTP_T1	8/7/2019	0.001	0.207	0.000	174.95	0.001	0.001	49.18	8.85
ADC668_FTP_T3	8/9/2019	0.001	0.191	0.000	170.89	0.001	0.000	50.36	8.76
Average		0.00	0.19	0.00	174.39	0.00	0.00	49.36	8.79
St.Dev		0.00	0.02	0.00	3.27	0.00	0.00	0.92	0.05
COV		0.00%	8.94%	#DIV/0!	1.87%	0.00%	173.21%	1.87%	0.60%

		US06							
		THC	CO	NOx	CO2	CH4	NMHC	FE	Micromotion
Test	Date	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(g/mi)	(mpg)	ccm
ADC668_US06_PT1	8/5/2019	0.022	1.208	0.004	296.47	0.008	0.014	28.89	14.13
ADC668_US06_T1	8/7/2019	0.017	1.556	0.002	288.81	0.006	0.011	29.59	14.38
ADC668_US06_T3	8/9/2019	0.016	0.885	0.002	291.80	0.006	0.010	29.40	13.55
Average		0.02	1.22	0.00	290.30	0.01	0.01	29.50	36.84
St.Dev		0.00	0.47	0.00	2.12	0.00	0.00	0.14	0.43
COV		4.29%	38.87%	0.00%	0.73%	0.00%	6.73%	0.47%	1.16%

Figure 102. Summary of Honda Accord Drive Cycles

In-use testing was conducted at vehicle curb weight and at GVWR to produce the respective un-laden and laden strategies. The peak input speed and torque values used in the component level testing were enveloped using the laden in-use testing. Figures 103 and 104 demonstrate the in-use laden drive cycles for the F-150. The maximum tractive effort in each drive cycle was less than two thousand pounds-force. for the shift schedule mapping of the laden weight of the F-150, a tractive effort ceiling equal to 3,500 Nm of output torque at the drive wheels was used. Figures 105 and 106 illustrate the operating envelope for engine speed and torque for the drive cycles. Maximum engine speed observed for the Accord was approximately 3,500 rpm. Tractive effort was lower than 1,300 $lb_{f..}$

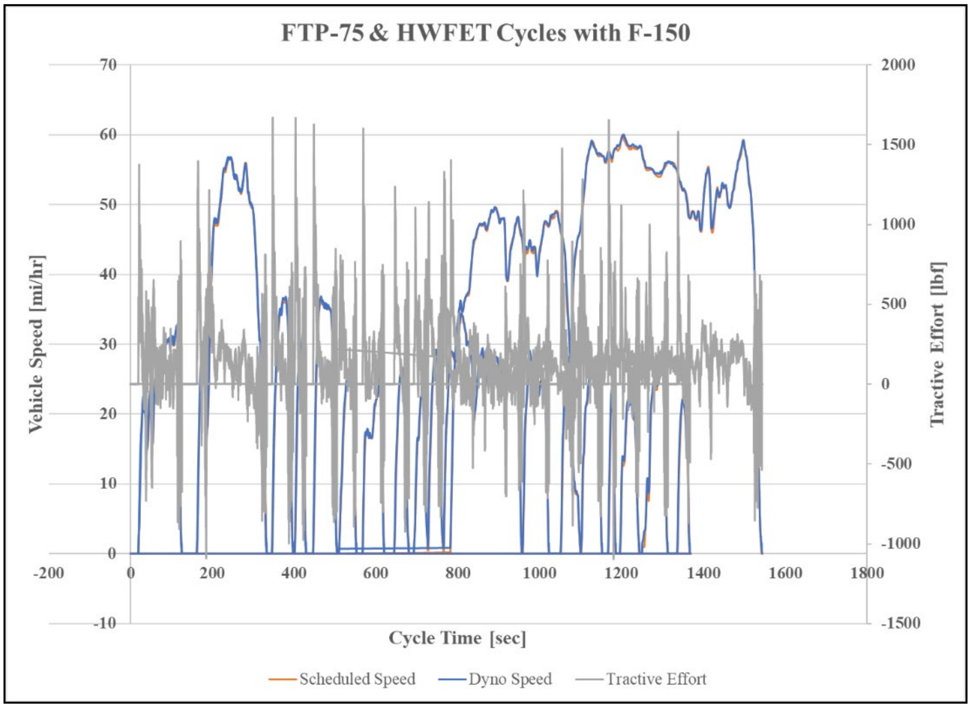


Figure 103. Ford F-150 FTP75 and HWFET Drive Cycle Trace

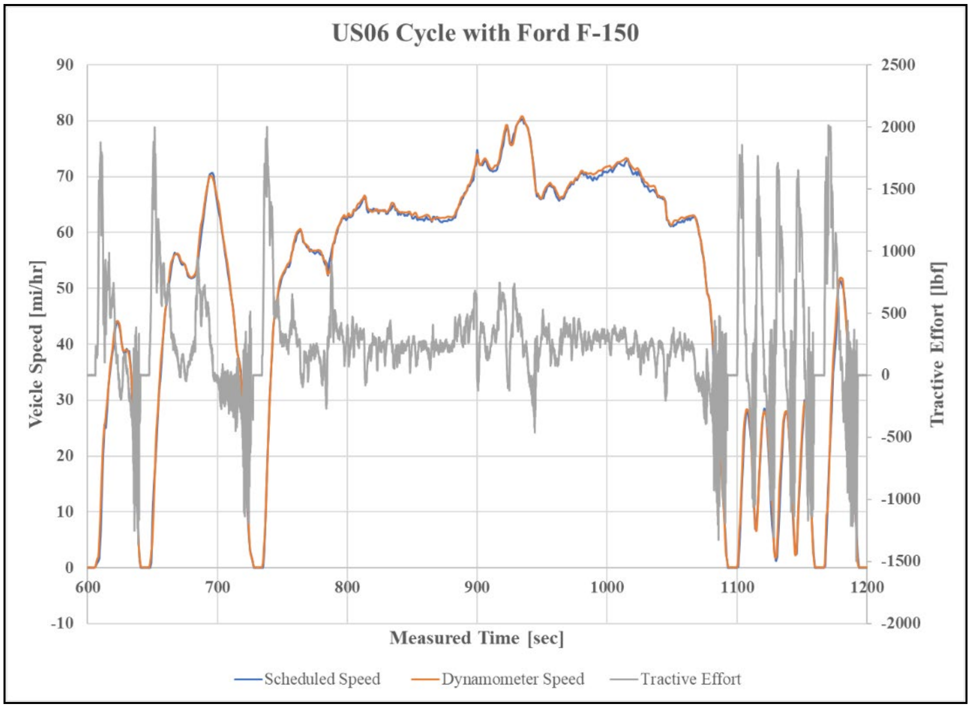


Figure 104. Ford F-150 US06 Drive Cycle Trace

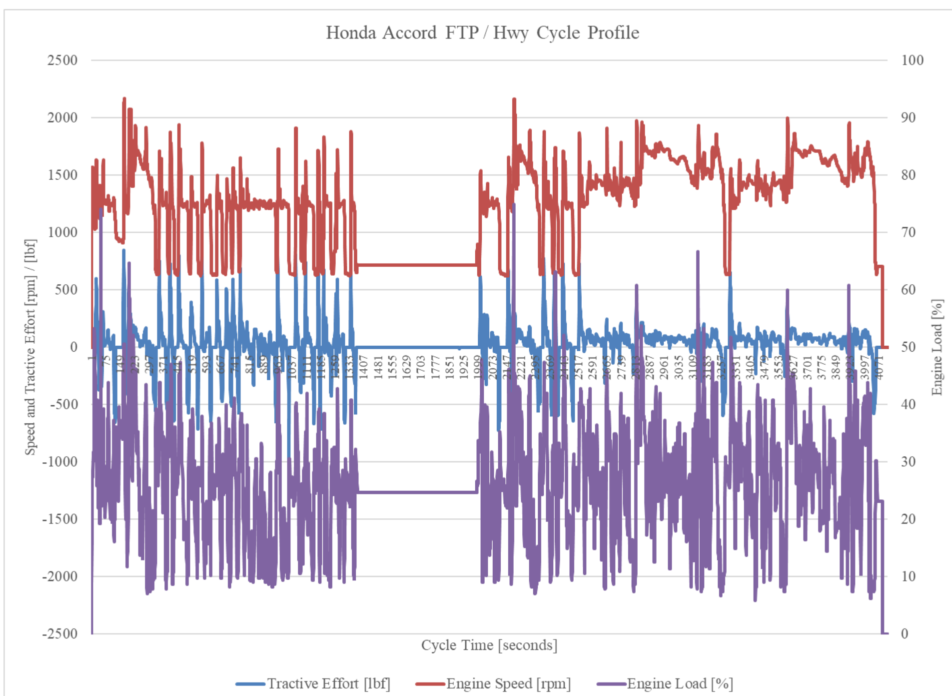


Figure 105. Honda Accord FTP75 and HWFET Drive Cycle Trace

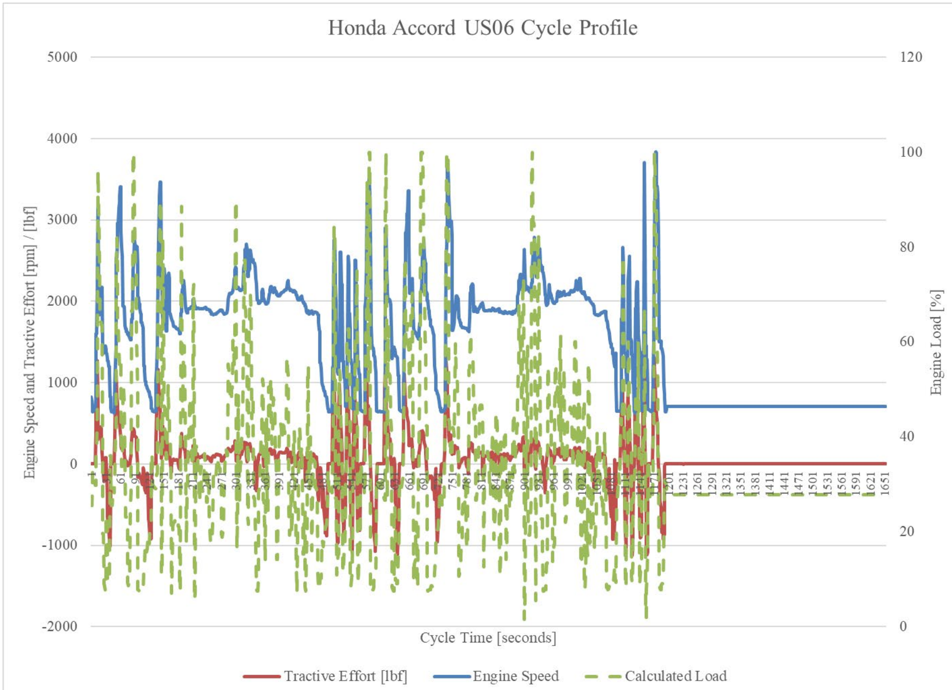


Figure 106. Honda Accord US06 Drive Cycle Trace

4.3 Shift Map and Converter Strategies

In addition to the standard cycle work, shift speed curves, pressure schedules, and torque converter strategies were generated in both unladen/laden vehicle trims on the chassis dynamometer. Steady-state vehicle mapping was necessary for logic mapping and data collection over a broad range of vehicle conditions. Combinations of fixed-pedal-percentage transient-speed and fixed-speed transient-pedal operations were performed to map transmission behavior in both laden and unladen conditions. The mapping exercises used the dynamometer grade function to induce severe conditions. This operation extended the recorded vehicle conditions to build shift and pressure arrays versus vehicle speed and torque demand. All in-use vehicle maps are available in Appendixes H and I for the Ford 10R80 and Honda CVT, respectively.

5 SR-5 Deliverables

The teardown and costing activities that comprised SR-5 have been submitted to NHTSA in a separate report.

Appendix A: Ford 10R80 Line Pressure Schedule

1st		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	Spin												
	25	395	390	385	383	375	363	359	355	350	346	341	335
	50	412	409	406	406	402	393	390	387	383	380	377	372
	75	429	429	428	429	429	422	421	419	417	415	413	410
	100	446	448	450	452	456	452	452	451	450	450	449	448
	150	480	487	494	498	510	511	513	515	517	519	521	523
	200	515	526	538	544	565	571	575	579	584	588	592	599
	250	549	565	581	590	619	630	637	643	650	657	664	675
	300	583	604	625	636	673	689	698	708	717	726	736	750
	350	617	643	669	681	727	749	760	772	784	796	808	826

2nd		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	Spin												
	25	439	439	438	400	447	448	449	449	436	435	435	433
	50	451	451	451	412	460	461	463	464	451	451	451	451
	75	462	463	463	425	472	474	476	478	466	466	467	469
	100	474	474	475	438	485	487	490	493	480	482	484	487
	150	496	498	500	464	510	513	517	522	510	513	516	523
	200	519	522	524	489	535	540	544	550	539	544	549	559
	250	542	546	549	515	561	566	571	579	569	575	582	595
	300	565	569	573	541	586	592	598	608	598	606	615	631
	350	588	593	598	566	611	618	625	637	628	637	647	667

3rd		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	Spin												
	25	435	435	434	434	434	434	434	433	433	433	433	432
	50	466	467	467	467	467	467	468	468	468	468	469	469
	75	497	498	500	500	501	501	501	503	504	503	504	506
	100	528	530	532	533	534	534	535	537	539	538	540	543
	150	590	594	598	599	600	601	603	607	609	608	612	617
	200	652	658	663	665	667	668	671	676	680	678	684	691
	250	715	721	728	732	734	734	738	745	751	748	755	765
	300	777	785	793	798	800	801	806	814	821	819	827	839
	350	839	849	859	864	867	868	874	884	892	889	899	914

4th		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	Spin												
	25	470	470	479	480	507	490	490	490	500	505	510	515
	50	479	480	490	490	516	500	500	500	510	515	520	525
	75	488	489	500	501	525	510	511	511	520	525	530	534
	100	497	499	511	511	533	520	521	521	530	535	540	544
	150	514	518	532	532	551	540	542	542	550	555	560	563
	200	532	537	553	553	568	560	563	563	570	575	580	582
	250	550	557	574	573	585	580	583	583	590	595	600	602
	300	567	576	595	594	603	600	604	604	610	615	620	621
	350	585	595	616	615	620	620	625	625	630	635	640	640

5th		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	Spin												
	25	450	455	460	465	470	470	475	475	480	485	485	490
	50	460	465	471	476	481	481	486	488	493	499	500	505
	75	471	476	482	487	491	492	497	500	506	513	515	521
	100	481	486	492	497	502	502	508	513	519	528	530	536
	150	502	507	514	519	523	524	531	538	545	556	560	567
	200	523	528	535	540	544	545	553	564	572	585	590	598
	250	543	548	557	562	565	567	575	589	598	613	620	628
	300	564	569	578	583	586	588	598	615	624	642	650	659
	350	585	590	600	605	607	610	620	640	650	670	680	690

6th		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	Spin												
	25	450	455	460	465	470	470	475	475	480	485	485	
	50	462	467	472	477	481	481	487	488	493	498	499	
	75	474	478	483	488	492	492	499	500	506	512	513	
	100	486	490	495	500	503	504	511	513	519	525	527	
	150	510	513	518	523	526	526	535	538	545	552	554	
	200	533	536	541	546	548	549	558	564	572	579	582	
	250	557	559	564	569	570	571	582	589	598	606	610	
	300	581	582	587	592	593	594	606	615	624	633	637	
	350	605	605	610	615	615	616	630	640	650	660	665	

7th		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	Spin												
	25	375	380	390	400	405	415	430	440	450	450		
	50	405	410	420	429	434	443	1001	467	478	479		
	75	434	440	450	458	463	471	1572	494	505	508		
	100	464	470	480	488	492	499	2142	521	533	537		
	150	523	530	540	546	549	556	3284	575	588	594		
	200	582	590	600	605	607	612	4425	628	644	652		
	250	642	650	660	663	665	668	5567	682	699	710		
	300	701	710	720	722	722	725	6708	736	755	767		
	350	760	770	780	780	780	781	7850	790	810	825		

8th		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	Spin												
	25	337	375	380	390	400	405	415	430	440			
	50	358	393	398	408	418	423	433	448	458			
	75	379	412	417	426	435	441	451	465	477			
	100	400	430	435	444	453	459	469	483	495			
	150	442	467	472	480	488	495	505	518	532			
	200	484	504	509	517	524	530	542	554	569			
	250	526	541	546	553	559	566	578	589	606			
	300	568	578	583	589	595	602	614	625	643			
	350	610	615	620	625	630	638	650	660	680			

9th		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	Spin												
	25	440	440	440	440	440	440	440					
	50	450	450	450	450	450	450	450					
	75	480	480	483	484	484	485	485					
	100	490	490	490	495	495	495	500					
	150	520	520	525	525	525	530	530					
	200	548	550	555	559	560	565	570					
	250	575	580	580	585	590	595	600					
	300	640	645	650	655	660	665	670					
	350	710	712	715	720	724	730	735					

10th		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	Spin												
	25	440	450	450	450	470	490						
	50	475	485	485	485	504	524						
	75	509	519	519	520	538	558						
	100	544	554	554	554	573	592						
	150	613	623	623	624	641	659						
	200	682	692	692	693	710	727						
	250	752	762	762	763	778	795						
	300	821	831	831	832	847	862						
	350	890	900	900	902	915	930						

Appendix B: Ford 10R80 Loaded Efficiency – Tabular Data

Efficiency - 38C

1st – Input Torque (Nm)	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
25	77.4%	80.3%	82.4%	83.5%	83.3%	82.0%	82.1%	81.0%	77.3%	76.8%	74.8%	70.8%
50	87.3%	88.6%	89.8%	90.3%	90.2%	89.8%	89.8%	89.1%	87.7%	87.0%	86.5%	84.7%
75	90.6%	91.5%	92.2%	92.5%	92.6%	92.2%	92.2%	91.9%	91.2%	90.1%	90.3%	88.3%
100	92.3%	93.0%	93.6%	93.7%	93.7%	93.4%	93.5%	93.1%	92.7%	92.1%	91.7%	90.6%
150	93.8%	94.2%	94.6%	94.8%	94.8%	94.6%	94.7%	94.5%	94.2%	93.9%	93.5%	92.9%
200	94.4%	94.8%	95.1%	95.4%	95.3%	95.2%	95.3%	95.2%	94.9%	94.6%	94.5%	93.8%
250	94.7%	95.1%	95.4%	95.6%	95.6%	95.5%	95.6%	95.5%	95.2%	95.1%	94.8%	94.4%
300	95.0%	95.3%	95.6%	95.6%	95.6%	95.7%	95.6%	95.6%	95.1%	95.4%	95.2%	94.7%
350	95.1%	95.3%	95.4%	95.6%	95.6%	95.7%	95.4%	95.6%				

Input Speed (rpm)

2nd – Input Torque (Nm)	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
25	69.0%	76.9%	77.4%	80.7%	78.9%	78.2%	78.6%	76.2%	73.0%	71.9%	73.0%	61.3%
50	82.7%	85.9%	87.1%	88.7%	88.2%	87.8%	88.0%	86.5%	85.5%	83.0%	84.2%	79.6%
75	87.4%	89.4%	90.4%	91.2%	90.9%	90.9%	91.2%	90.3%	89.8%	87.5%	88.8%	85.7%
100	89.8%	91.4%	92.1%	92.6%	92.4%	92.3%	92.6%	92.1%	92.0%	90.2%	91.0%	89.7%
150	92.2%	93.2%	93.8%	94.2%	93.9%	94.0%	94.2%	93.7%	93.6%	92.4%	92.9%	92.1%
200	93.1%	94.0%	94.5%	94.7%	94.7%	94.8%	94.9%	94.6%	94.5%	93.8%	94.1%	93.2%
250	93.6%	94.5%	94.9%	95.0%	95.2%	95.2%	95.4%	95.2%	95.0%	94.7%	94.7%	93.9%
300	94.0%	94.8%	94.9%	95.2%	95.4%	95.4%	95.6%	95.3%	95.3%	95.0%	95.1%	94.4%
350	94.4%	94.9%	95.1%	95.3%	95.5%	95.6%	95.7%	95.5%	95.5%	95.3%	95.3%	94.7%

Input Speed (rpm)

3rd Gear – Input Torque (Nm)	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
25	76.7%	80.3%	81.5%	84.3%	82.3%	83.1%	81.9%	82.8%	82.4%	82.6%	83.0%	77.1%
50	87.2%	88.5%	89.9%	91.0%	90.4%	90.6%	90.5%	90.6%	90.4%	90.3%	90.2%	87.3%
75	90.3%	91.6%	92.5%	93.2%	93.0%	93.1%	93.2%	93.1%	93.0%	92.9%	93.0%	90.2%
100	92.2%	93.3%	94.0%	94.4%	94.3%	94.4%	94.5%	94.4%	94.3%	94.2%	94.3%	92.7%
150	93.9%	95.0%	95.5%	95.5%	95.6%	95.7%	95.8%	95.8%	95.6%	95.5%	95.6%	94.6%
200	94.8%	95.7%	96.1%	96.2%	96.2%	96.3%	96.4%	96.4%	96.3%	96.3%	96.1%	95.4%
250	95.2%	95.9%	96.4%	96.6%	96.6%	96.7%	96.7%	96.7%	96.7%	96.7%	96.6%	96.1%
300	95.7%	96.2%	96.6%	96.7%	96.8%	96.9%	97.0%	97.0%	97.0%	96.9%	96.8%	96.5%
350	95.9%	96.3%	96.7%	96.9%	96.9%	97.0%	97.2%	97.2%	97.1%	97.0%	97.1%	96.8%

Input Speed (rpm)

4th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	25	71.0%	75.7%	76.5%	76.0%	76.4%	78.2%	77.2%	78.2%	77.5%	78.4%	77.4%	69.9%
	50	84.6%	86.0%	87.0%	87.2%	87.0%	87.7%	87.8%	88.1%	88.1%	87.8%	87.8%	84.6%
	75	89.2%	90.4%	90.9%	91.0%	90.9%	91.4%	91.7%	91.7%	91.6%	91.6%	91.5%	89.5%
	100	91.6%	92.5%	92.8%	93.0%	92.9%	93.3%	93.5%	93.5%	93.4%	93.5%	93.4%	91.9%
	150	94.0%	94.6%	94.7%	94.7%	94.9%	95.1%	95.3%	95.2%	95.2%	95.3%	95.2%	94.3%
	200	95.2%	95.5%	95.6%	95.7%	95.7%	96.0%	96.0%	96.1%	96.1%	96.2%	96.2%	95.4%
	250	95.8%	96.1%	96.3%	96.3%	96.3%	96.5%	96.6%	96.7%	96.7%	96.5%	96.8%	96.1%
	300	96.3%	96.4%	96.5%	96.7%	96.8%	96.9%	97.0%	96.9%	97.0%	96.9%	96.8%	96.5%
	350	96.6%	96.5%	96.8%	96.9%	97.0%	97.1%	97.2%	97.2%	97.3%	97.1%	97.1%	96.8%

5th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	25	74.4%	73.8%	77.6%	78.3%	78.3%	76.9%	77.9%	78.1%	70.6%	72.0%	71.9%	66.4%
	50	86.6%	86.1%	87.7%	87.7%	87.1%	86.6%	87.2%	86.5%	85.8%	85.8%	85.3%	82.6%
	75	90.5%	90.1%	91.4%	91.3%	91.0%	90.4%	91.1%	90.3%	90.0%	89.9%	89.7%	87.7%
	100	92.5%	92.3%	93.2%	93.4%	92.8%	92.8%	92.9%	92.4%	92.2%	92.2%	91.7%	90.4%
	150	94.6%	94.4%	94.9%	95.2%	94.8%	94.7%	94.8%	94.6%	94.4%	94.1%	94.0%	93.0%
	200	95.6%	95.4%	95.8%	96.0%	95.8%	95.8%	95.9%	95.6%	95.4%	95.3%	95.2%	94.5%
	250	96.1%	96.0%	96.4%	96.4%	96.4%	96.3%	96.4%	96.3%	96.2%	96.0%	95.8%	95.3%
	300	96.4%	96.5%	96.7%	96.8%	96.8%	96.8%	96.8%	96.6%	96.4%	96.4%	96.3%	95.9%
	350	96.7%	96.7%	96.9%	97.1%	96.7%	97.0%	97.0%	97.0%	96.7%	96.8%	96.6%	96.2%

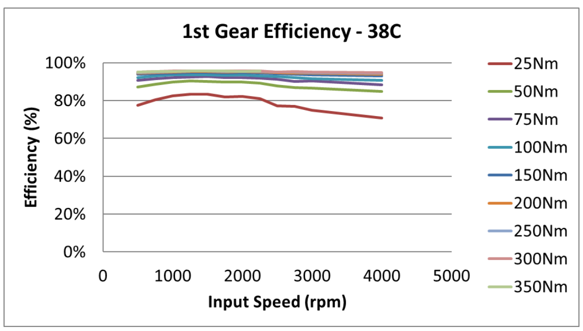
6th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	25	61.3%	63.6%	66.5%	66.9%	69.8%	67.6%	67.9%	67.2%	66.9%	67.6%	68.2%	
	50	83.0%	82.2%	84.0%	83.9%	83.7%	83.2%	83.5%	83.5%	82.3%	81.6%	79.9%	
	75	88.4%	87.6%	88.8%	88.6%	88.5%	88.2%	88.5%	87.9%	87.9%	87.0%	86.4%	
	100	91.0%	90.1%	91.2%	91.1%	91.1%	90.9%	90.8%	90.6%	90.5%	90.1%	89.5%	
	150	93.3%	93.1%	93.8%	93.6%	93.6%	93.4%	93.5%	93.4%	93.3%	92.7%	92.6%	
	200	94.8%	94.6%	94.9%	94.9%	95.0%	94.9%	94.8%	94.7%	94.5%	94.3%	94.1%	
	250	95.3%	95.4%	95.6%	95.7%	95.7%	95.7%	95.6%	95.5%	95.4%	95.3%	94.9%	
	300	95.8%	95.7%	96.1%	96.2%	96.2%	96.1%	96.1%	96.1%	96.0%	95.7%	95.7%	
	350	96.2%	96.1%	96.5%	96.5%	96.5%	96.3%	96.5%	96.5%	96.4%	96.2%	96.1%	

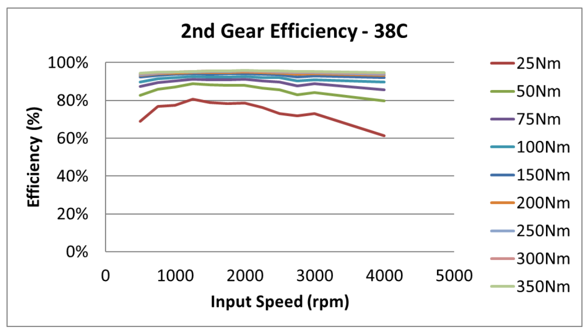
7th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)													
	25	82.0%	83.4%	87.2%	88.7%	85.8%	84.8%	86.9%	87.0%	87.1%	81.5%		
	50	91.1%	92.5%	93.9%	93.7%	92.8%	92.4%	93.4%	93.5%	93.1%	92.9%		
	75	93.7%	95.0%	96.0%	95.8%	95.2%	95.0%	95.6%	95.6%	95.3%	95.0%		
	100	95.0%	96.1%	96.9%	96.8%	96.4%	96.2%	96.7%	96.6%	96.3%	96.1%		
	150	96.4%	97.1%	97.5%	97.7%	97.5%	97.4%	97.6%	97.6%	97.3%	97.1%		
	200	97.1%	97.6%	97.9%	98.0%	97.9%	97.9%	98.1%	98.1%	97.9%	97.7%		
	250	97.5%	97.8%	98.2%	98.3%	98.3%	98.3%	98.4%	98.4%	98.2%	98.0%		
	300	97.8%	98.0%	98.4%	98.5%	98.5%	98.4%	98.6%	98.6%	98.4%	98.3%		
	350	98.0%	98.2%	98.5%	98.6%	98.6%	98.6%	98.7%	98.7%	98.6%	98.4%		

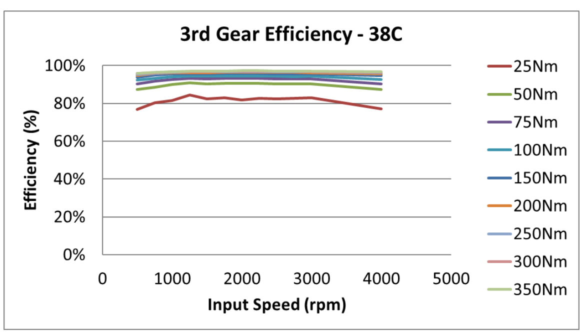
8th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)													
	25	86.5%	88.1%	87.8%	87.1%	85.5%	85.5%	87.1%	71.5%	79.9%			
	50	92.9%	93.6%	93.4%	93.1%	92.3%	92.2%	91.9%	88.3%	83.5%			
	75	94.9%	95.6%	95.1%	95.3%	94.9%	94.0%	93.6%	92.3%	90.8%			
	100	96.0%	96.5%	96.1%	96.0%	95.8%	95.2%	94.9%	94.1%	93.8%			
	150	96.8%	97.3%	97.0%	97.0%	96.9%	96.6%	96.5%	95.9%	95.6%			
	200	97.3%	97.6%	97.6%	97.5%	97.4%	97.2%	97.2%	96.8%	96.6%			
	250	97.6%	97.8%	97.8%	97.8%	97.7%	97.5%	97.7%	97.1%	96.9%			
	300	97.8%	98.0%	98.0%	98.0%	97.9%	97.8%	97.8%	97.5%	97.3%			
	350	97.9%	98.1%	98.1%	98.1%	98.1%	98.0%	98.0%	97.6%	97.6%			

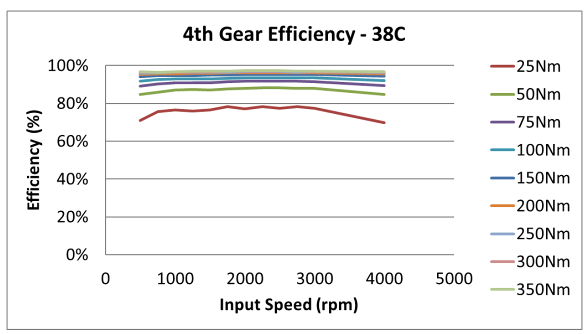
9th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)													
	25	85.8%	89.9%	89.9%	87.4%	87.4%	77.2%	69.0%					
	50	92.6%	94.6%	93.9%	90.5%	90.5%	88.9%	87.3%					
	75	94.9%	95.7%	95.2%	94.3%	94.3%	93.0%	91.3%					
	100	96.0%	96.7%	96.1%	95.6%	95.6%	94.4%	93.3%					
	150	97.0%	97.2%	97.1%	96.8%	96.8%	95.8%	95.2%					
	200	97.4%	97.7%	97.5%	97.2%	97.2%	96.6%	96.2%					
	250	97.7%	97.4%	97.7%	97.6%	97.6%	97.2%	96.8%					
	300	97.7%	97.8%	97.8%	97.7%	97.7%	97.4%	97.1%					
	350	97.7%	98.0%	97.9%	97.8%	97.8%	97.6%	97.2%					

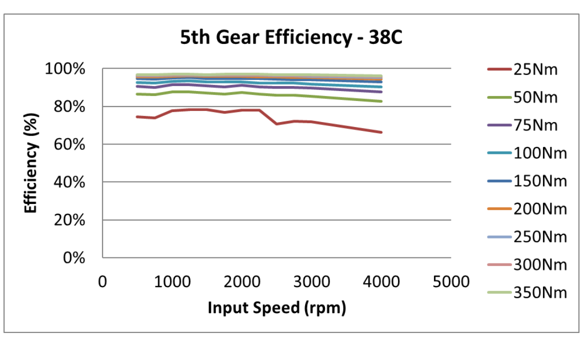
10th Gear	Input Speed (rpm)											
Input Torque (Nm)	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
25	89.1%	90.3%	90.2%	83.4%	75.0%	79.0%						
50	93.7%	94.1%	92.2%	92.5%	91.9%	91.2%						
75	95.2%	94.8%	95.0%	95.3%	94.9%	93.8%						
100	96.2%	96.0%	96.2%	96.1%	95.8%	94.9%						
150	96.7%	96.9%	97.0%	96.9%	96.5%	96.3%						
200	97.3%	97.4%	97.4%	97.4%	97.2%	96.9%						
250	97.5%	97.6%	97.8%	97.6%	97.5%	97.3%						
300	97.6%	97.6%	97.9%	97.8%	97.7%	97.5%						
350	97.9%	97.7%	97.9%	98.0%	97.8%	97.7%						

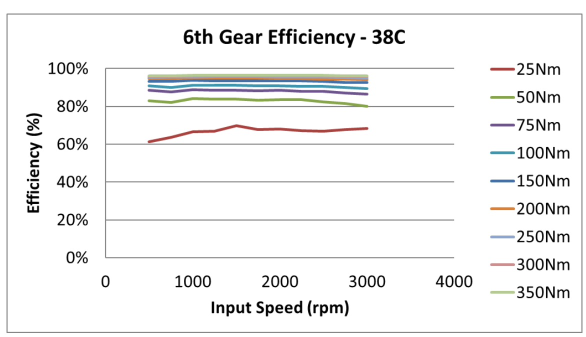


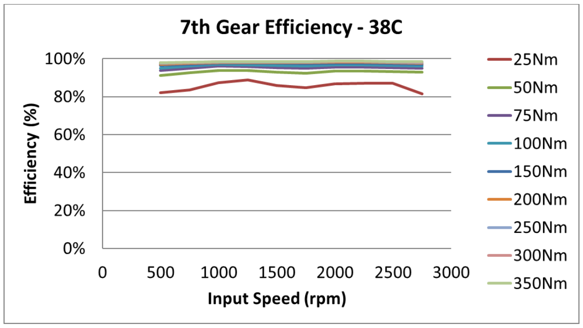


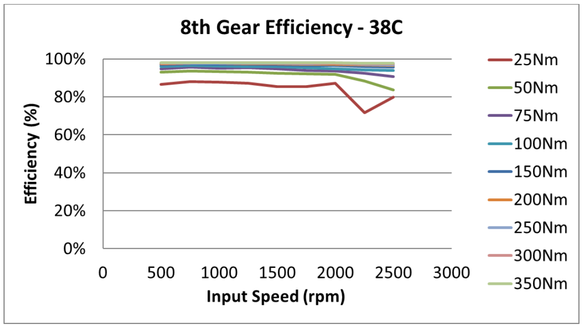


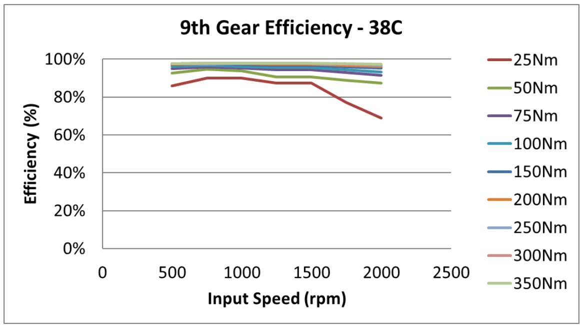


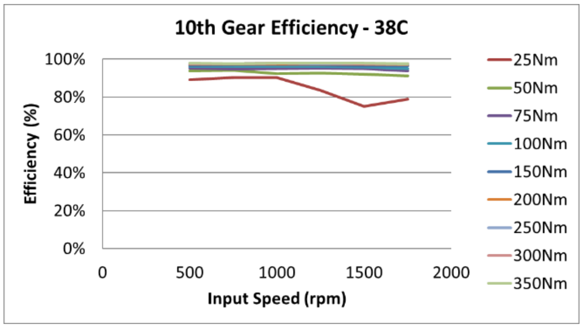





7th Gear Efficiency - 38C
100%
80%
60%
40%
20%
0%
Efficiency (%)
0
500
1000
1500
2000
2500
3000
Input Speed (rpm)
25Nm
50Nm
75Nm
100Nm
150Nm
200Nm
250Nm
300Nm
350Nm


8th Gear Efficiency - 38C
100%
80%
60%
40%
20%
0%
Efficiency (%)
0
500
1000
1500
2000
2500
3000
Input Speed (rpm)
25Nm
50Nm
75Nm
100Nm
150Nm
200Nm
250Nm
300Nm
350Nm


9th Gear Efficiency - 38C
100%
80%
60%
40%
20%
0%
Efficiency (%)
0
500
1000
1500
2000
2500
Input Speed (rpm)
25Nm
50Nm
75Nm
100Nm
150Nm
200Nm
250Nm
300Nm
350Nm


10th Gear Efficiency - 38C
100%
80%
60%
40%
20%
0%
Efficiency (%)
0
500
1000
1500
2000
Input Speed (rpm)
25Nm
50Nm
75Nm
100Nm
150Nm
200Nm
250Nm
300Nm
350Nm

Efficiency - 65C

1st	Input Speed (rpm)											
Input Torque (Nm)	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
25	75.9%	81.1%	83.5%	84.4%	83.5%	83.9%	83.5%	84.1%	84.1%	80.7%	79.9%	73.9%
50	86.2%	89.4%	90.7%	91.0%	90.8%	91.0%	90.9%	91.2%	90.9%	88.7%	88.0%	85.4%
75	90.6%	92.3%	92.8%	93.0%	93.0%	92.9%	92.7%	93.3%	93.2%	91.4%	91.4%	89.6%
100	91.7%	93.1%	93.7%	94.0%	94.0%	94.0%	93.8%	94.3%	94.3%	93.0%	92.7%	91.6%
150	92.9%	94.0%	94.6%	94.6%	94.7%	94.7%	94.8%	95.3%	95.3%	94.5%	94.2%	93.5%
200	93.6%	94.6%	94.9%	95.2%	95.2%	95.2%	95.2%	95.7%	95.7%	95.2%	94.9%	94.3%
250	94.3%	95.1%	95.3%	95.5%	95.3%	95.7%	95.5%	95.9%	95.8%	95.5%	95.2%	94.8%
300	94.3%	95.0%	95.3%	95.5%	95.2%	95.6%	95.8%	95.9%	95.8%	95.7%	95.5%	95.2%
350	94.2%	94.8%	95.3%	95.3%	95.4%	95.6%	95.6%	95.7%	95.7%	95.7%	95.3%	95.3%

2nd	Input Speed (rpm)											
Input Torque (Nm)	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
25	75.2%	77.6%	79.3%	82.0%	83.3%	82.9%	81.9%	81.3%	81.1%	78.9%	74.8%	70.9%
50	85.4%	87.3%	88.4%	89.8%	89.8%	89.9%	89.8%	89.4%	89.1%	87.6%	86.1%	83.9%
75	90.1%	90.5%	91.3%	92.1%	92.3%	92.3%	92.0%	91.9%	91.9%	90.6%	89.4%	86.9%
100	91.8%	92.2%	92.5%	93.4%	93.5%	93.7%	93.5%	93.3%	93.3%	92.3%	91.5%	89.9%
150	93.3%	93.6%	93.9%	94.5%	94.8%	94.7%	94.7%	94.6%	94.6%	94.0%	93.3%	92.9%
200	94.1%	94.3%	94.4%	95.1%	95.1%	95.3%	95.3%	95.2%	95.2%	94.8%	94.3%	94.0%
250	94.5%	94.6%	94.8%	95.4%	95.5%	95.6%	95.6%	95.6%	95.5%	95.2%	94.8%	94.5%
300	94.7%	94.7%	95.0%	95.4%	95.7%	95.8%	95.8%	95.7%	95.7%	95.5%	95.1%	94.8%
350	94.8%	94.9%	95.1%	95.1%	95.7%	95.9%	95.9%	95.9%	95.8%	95.6%	95.4%	95.0%

3rd Gear	Input Speed (rpm)											
Input Torque (Nm)	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
25	77.8%	82.5%	83.0%	84.9%	83.5%	84.7%	83.5%	84.1%	83.4%	83.5%	84.3%	81.6%
50	88.3%	90.0%	90.6%	91.6%	91.1%	91.9%	91.0%	91.4%	90.7%	90.8%	91.2%	88.4%
75	91.1%	92.6%	93.1%	93.7%	93.5%	93.9%	93.4%	93.6%	93.1%	93.3%	93.6%	91.5%
100	92.8%	93.9%	94.4%	94.9%	94.7%	95.0%	94.7%	94.7%	94.4%	94.5%	94.7%	93.1%
150	94.3%	94.9%	95.5%	95.8%	95.8%	95.9%	95.9%	95.9%	95.7%	95.8%	95.9%	95.0%
200	95.0%	95.5%	96.0%	96.3%	96.3%	96.5%	96.4%	96.5%	96.4%	96.4%	96.5%	95.8%
250	95.4%	95.8%	96.2%	96.6%	96.6%	96.8%	96.7%	96.8%	96.7%	96.7%	96.8%	96.3%
300	95.7%	96.0%	96.3%	96.6%	96.7%	96.9%	97.0%	97.0%	96.9%	96.9%	97.0%	96.6%
350	95.8%	96.0%	96.5%	96.8%	96.8%	97.0%	97.1%	97.1%	97.1%	97.2%	97.1%	96.8%

4th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	25	74.1%	77.3%	78.4%	79.1%	79.7%	80.8%	82.2%	81.8%	81.6%	80.1%	80.2%	73.7%
	50	86.7%	88.1%	88.7%	88.8%	88.8%	89.4%	90.1%	90.4%	90.1%	89.6%	89.5%	87.1%
	75	90.4%	91.5%	91.8%	92.1%	92.1%	92.6%	93.0%	93.1%	92.9%	92.8%	92.6%	91.1%
	100	92.4%	93.2%	93.5%	93.6%	93.7%	94.2%	94.4%	94.5%	94.3%	94.3%	94.1%	93.0%
	150	94.4%	95.0%	95.2%	95.2%	95.3%	95.6%	95.8%	95.9%	95.8%	95.7%	95.6%	95.0%
	200	95.4%	95.8%	96.0%	96.0%	96.1%	96.4%	96.5%	96.5%	96.5%	96.4%	96.3%	95.9%
	250	96.0%	96.3%	96.5%	96.5%	96.6%	96.8%	96.9%	96.9%	96.9%	96.8%	96.8%	96.4%
	300	96.3%	96.6%	96.8%	96.8%	96.9%	97.2%	97.2%	97.2%	97.2%	97.1%	97.1%	96.8%
	350	96.6%	96.8%	97.0%	97.1%	97.1%	97.4%	97.4%	97.4%	97.4%	97.3%	97.3%	97.0%

5th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	25	75.6%	78.8%	79.3%	79.5%	80.6%	81.2%	81.0%	82.7%	76.5%	76.4%	76.1%	72.4%
	50	86.8%	88.6%	88.9%	89.0%	89.0%	89.0%	89.0%	89.4%	89.3%	88.6%	88.1%	85.3%
	75	90.6%	91.9%	92.2%	92.3%	92.2%	92.2%	92.0%	92.3%	92.2%	92.0%	91.5%	89.8%
	100	92.5%	93.6%	93.7%	94.0%	93.8%	93.8%	93.7%	93.9%	93.7%	93.6%	93.3%	92.0%
	150	94.4%	95.2%	95.3%	95.5%	95.4%	95.5%	95.5%	95.4%	95.4%	95.2%	95.1%	94.2%
	200	95.4%	95.9%	96.1%	96.2%	96.2%	96.2%	96.3%	96.2%	96.2%	96.0%	95.9%	95.2%
	250	96.0%	96.4%	96.6%	96.7%	96.7%	96.6%	96.8%	96.7%	96.7%	96.5%	96.4%	95.9%
	300	96.4%	96.6%	96.9%	97.0%	97.0%	97.0%	97.1%	97.0%	97.0%	96.9%	96.8%	96.3%
	350	96.6%	96.9%	97.1%	97.2%	97.2%	97.2%	97.3%	97.2%	97.2%	97.1%	97.0%	96.6%

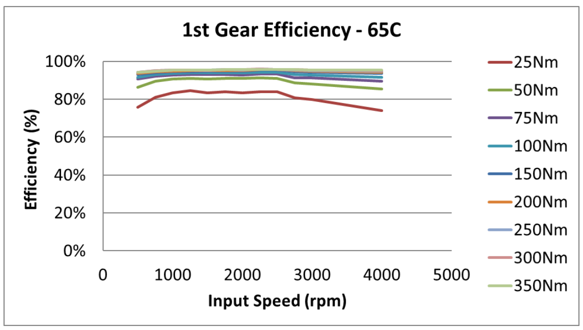
6th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	25	68.8%	68.9%	74.5%	72.8%	72.9%	74.4%	74.6%	74.4%	72.9%	69.8%	68.0%	
	50	84.7%	86.3%	85.6%	84.7%	87.1%	87.2%	86.8%	86.7%	85.7%	84.7%	84.4%	
	75	89.2%	90.4%	89.6%	88.9%	90.9%	90.8%	90.7%	90.5%	90.2%	89.2%	88.8%	
	100	91.4%	92.3%	91.6%	91.3%	92.8%	92.8%	92.7%	92.3%	92.2%	91.8%	91.2%	
	150	93.7%	94.4%	94.7%	94.4%	94.6%	94.7%	94.6%	94.4%	94.2%	94.0%	93.8%	
	200	94.9%	95.4%	95.6%	95.4%	95.6%	95.7%	94.4%	95.5%	95.3%	95.2%	95.1%	
	250	95.6%	96.0%	95.8%	96.0%	96.3%	96.3%	96.3%	96.2%	96.0%	95.9%	95.8%	
	300	96.1%	96.4%	95.0%	96.5%	96.7%	96.7%	96.7%	96.6%	96.5%	96.3%	96.2%	
	350	96.4%	96.6%	95.1%	96.7%	96.9%	97.0%	96.9%	96.9%	96.8%	96.6%	96.5%	

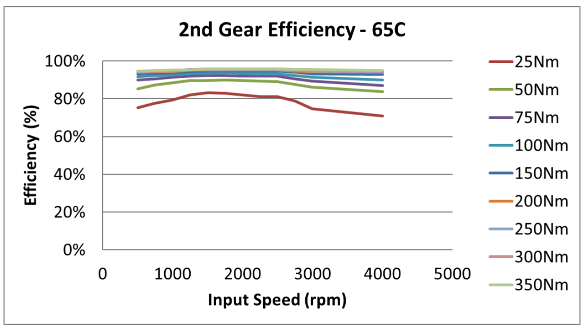
7th Gear	Input Speed (rpm)											
Input Torque (Nm)	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
25	87.9%	87.1%	89.4%	91.3%	91.3%	89.7%	90.3%	89.9%	89.4%	88.9%		
50	92.6%	93.9%	94.7%	95.2%	95.5%	95.1%	95.1%	94.7%	94.3%	94.1%		
75	94.6%	95.8%	96.5%	96.5%	96.6%	96.5%	96.5%	96.3%	96.0%	96.0%		
100	95.7%	96.6%	97.2%	97.1%	97.2%	97.1%	97.3%	97.1%	96.8%	96.9%		
150	96.7%	97.5%	97.9%	97.9%	98.0%	97.9%	98.0%	97.9%	97.7%	97.6%		
200	97.4%	97.9%	98.1%	98.3%	98.3%	98.3%	98.3%	98.3%	98.2%	98.1%		
250	97.8%	98.1%	98.4%	98.5%	98.5%	98.5%	98.6%	98.5%	98.4%	98.4%		
300	98.0%	98.2%	98.4%	98.6%	98.6%	98.7%	98.7%	98.7%	98.6%	98.6%		
350	98.1%	98.3%	98.6%	98.7%	98.7%	98.7%	98.8%	98.8%	98.7%	98.7%		

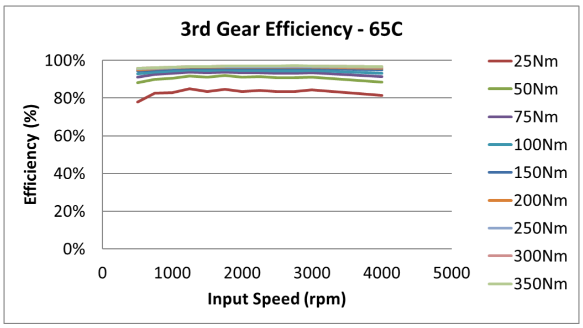
8th Gear	Input Speed (rpm)											
Input Torque (Nm)	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
25	87.2%	91.9%	91.3%	92.4%	91.0%	89.7%	89.5%	87.5%	86.8%			
50	93.8%	95.2%	95.2%	95.7%	94.9%	94.4%	94.5%	93.0%	92.0%			
75	95.4%	96.5%	96.5%	96.5%	96.3%	95.9%	95.4%	94.6%	93.9%			
100	96.4%	97.0%	97.0%	97.1%	96.9%	96.6%	96.2%	95.8%	95.3%			
150	97.1%	97.6%	97.7%	97.7%	97.5%	97.4%	97.1%	96.8%	96.5%			
200	97.5%	97.9%	97.9%	97.9%	97.9%	97.8%	97.6%	97.4%	97.1%			
250	97.7%	98.1%	98.1%	98.2%	98.1%	98.1%	97.8%	97.7%	97.5%			
300	97.9%	98.2%	98.2%	98.3%	98.3%	98.2%	98.1%	97.9%	97.8%			
350	98.0%	98.2%	98.3%	98.3%	98.3%	98.3%	98.2%	98.1%	97.9%			

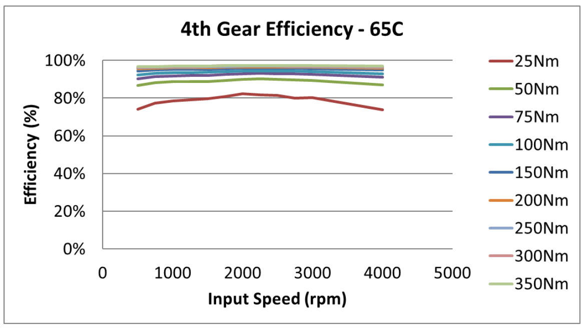
9th Gear	Input Speed (rpm)											
Input Torque (Nm)	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
25	91.1%	92.8%	90.7%	90.6%	84.9%	83.7%	78.1%					
50	94.9%	95.8%	95.0%	93.1%	93.9%	92.4%	90.6%					
75	96.2%	96.7%	96.4%	95.9%	95.4%	94.4%	93.1%					
100	96.8%	97.1%	97.0%	96.7%	96.3%	95.5%	94.6%					
150	97.4%	97.5%	97.7%	97.5%	97.2%	96.7%	96.0%					
200	97.6%	97.9%	97.9%	97.8%	97.5%	97.2%	96.8%					
250	97.9%	98.1%	98.1%	98.1%	97.9%	97.6%	97.3%					
300	97.9%	98.0%	98.0%	98.1%	97.9%	97.7%	97.4%					
350	97.9%	97.9%	98.1%	98.1%	98.0%	97.8%	97.6%					

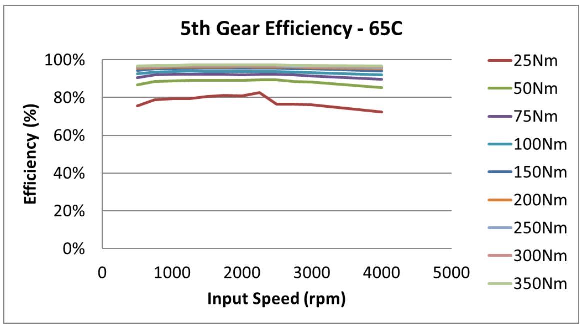
10th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)													
	25	89.3%	93.9%	93.2%	94.4%	90.1%	87.0%						
	50	94.7%	95.7%	96.2%	95.5%	95.2%	94.0%						
	75	96.0%	96.6%	97.0%	96.8%	96.7%	95.3%						
	100	96.7%	97.0%	97.5%	97.4%	97.1%	96.4%						
	150	97.2%	97.4%	98.0%	97.9%	97.6%	97.2%						
	200	97.5%	97.6%	97.9%	98.1%	97.9%	97.6%						
	250	97.7%	97.8%	98.1%	97.8%	98.1%	97.8%						
	300	97.9%	97.8%	98.0%	98.2%	98.1%	98.0%						
	350	97.9%	97.8%	98.1%	98.2%	98.2%	98.1%						

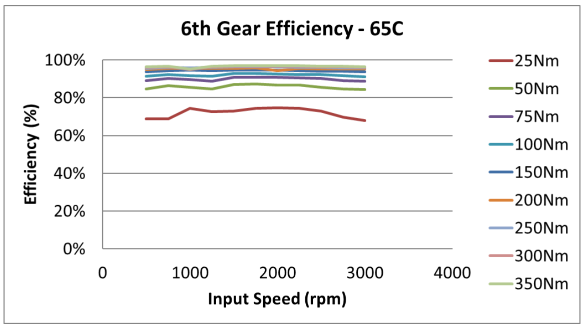


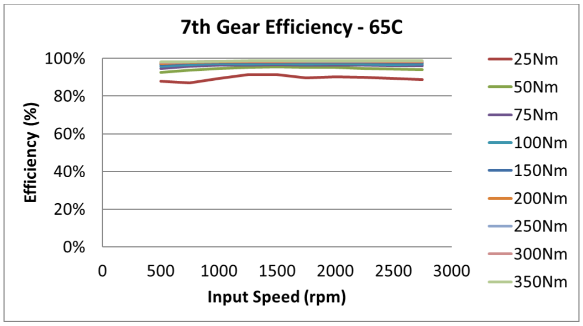


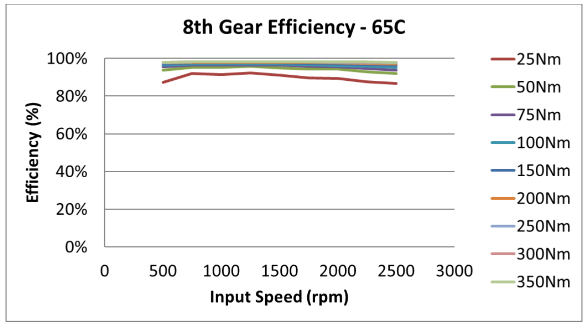


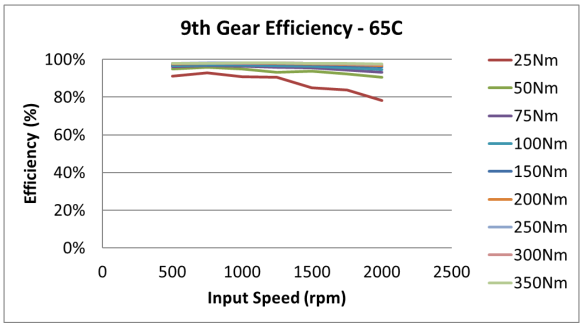


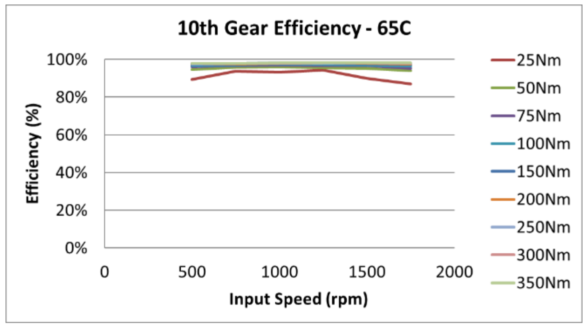





7th Gear Efficiency - 65C
Efficiency (%)
Input Speed (rpm)
25Nm
50Nm
75Nm
100Nm
150Nm
200Nm
250Nm
300Nm
350Nm


8th Gear Efficiency - 65C
Efficiency (%)
Input Speed (rpm)
25Nm
50Nm
75Nm
100Nm
150Nm
200Nm
250Nm
300Nm
350Nm


9th Gear Efficiency - 65C
Efficiency (%)
Input Speed (rpm)
25Nm
50Nm
75Nm
100Nm
150Nm
200Nm
250Nm
300Nm
350Nm


10th Gear Efficiency - 65C
Efficiency (%)
Input Speed (rpm)
25Nm
50Nm
75Nm
100Nm
150Nm
200Nm
250Nm
300Nm
350Nm

Efficiency - 93C

1st	Input Speed (rpm)											
Input Torque (Nm)	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
25	76.6%	78.6%	80.5%	81.8%	82.4%	82.5%	82.4%	82.2%	80.7%	80.0%	79.2%	71.9%
50	86.7%	87.5%	89.1%	89.6%	90.0%	90.1%	90.3%	90.0%	89.2%	88.7%	88.3%	82.9%
75	90.9%	91.8%	92.5%	92.8%	93.2%	93.4%	93.4%	93.4%	93.0%	91.7%	91.1%	88.6%
100	91.9%	92.6%	93.3%	93.2%	94.0%	94.2%	94.2%	94.2%	93.8%	93.0%	92.3%	90.8%
150	93.0%	93.6%	93.9%	94.1%	94.5%	94.6%	94.9%	94.9%	94.6%	94.2%	93.7%	92.8%
200	93.8%	94.3%	94.5%	94.7%	94.8%	95.1%	95.4%	95.4%	95.3%	94.9%	94.5%	93.3%
250			95.3%	95.0%	95.0%	95.1%	95.5%	95.6%	95.7%	95.4%	94.9%	94.4%
300			95.2%	94.9%	94.9%	95.1%	95.5%	95.6%	95.5%	95.5%	95.1%	94.4%
350				94.7%	94.9%	95.1%	95.3%	95.5%	95.7%	95.6%	95.3%	94.9%

2nd	Input Speed (rpm)											
Input Torque (Nm)	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
25	74.0%	75.1%	76.0%	77.2%	78.2%	78.3%	78.1%	77.8%	76.0%	72.4%	71.0%	63.8%
50	85.3%	86.3%	87.0%	87.1%	87.5%	87.5%	87.7%	87.3%	86.4%	84.3%	83.6%	80.2%
75	89.4%	90.2%	90.8%	91.7%	91.5%	92.4%	92.4%	92.2%	92.1%	90.6%	89.5%	88.2%
100	91.2%	91.9%	92.4%	93.0%	93.0%	93.6%	93.6%	93.5%	93.4%	92.3%	91.5%	90.7%
150	92.8%	93.3%	93.7%	94.3%	94.3%	94.8%	94.7%	94.6%	94.6%	93.9%	93.2%	92.9%
200	93.5%	93.9%	94.3%	94.9%	94.8%	95.3%	95.1%	95.0%	95.2%	94.6%	94.2%	93.2%
250	93.8%	94.1%	94.5%	95.1%	95.1%	95.5%	95.2%	95.1%	95.4%	95.0%	94.8%	93.7%
300	93.8%	94.0%	94.5%	95.2%	95.2%	95.6%	95.4%	94.8%	95.5%	95.0%	95.1%	94.0%
350	94.0%	94.1%	94.5%	94.9%	95.2%	95.5%	95.4%	94.8%	95.4%	95.2%	94.9%	94.2%

3rd Gear	Input Speed (rpm)											
Input Torque (Nm)	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
25	79.8%	82.2%	83.7%	84.7%	86.3%	87.0%	86.6%	86.8%	86.4%	86.0%	85.1%	79.3%
50	88.9%	90.0%	90.7%	91.4%	92.0%	92.7%	92.5%	92.7%	92.3%	91.9%	91.7%	88.8%
75	91.9%	92.8%	93.7%	93.7%	94.6%	94.8%	94.8%	94.8%	94.8%	94.5%	94.3%	93.0%
100	93.3%	94.0%	94.7%	94.7%	95.4%	95.5%	95.6%	95.6%	95.6%	95.4%	95.2%	94.0%
150	94.5%	94.8%	95.5%	95.7%	96.1%	96.3%	96.4%	96.4%	96.4%	96.4%	96.2%	95.2%
200	95.2%	95.3%	95.9%	96.1%	96.3%	96.7%	96.9%	96.8%	96.8%	96.7%	96.6%	96.2%
250	95.5%	95.5%	96.1%	96.3%	96.5%	96.8%	97.1%	97.0%	97.1%	97.0%	97.0%	96.6%
300	95.7%	95.8%	96.0%	96.4%	96.6%	96.9%	97.1%	97.2%	97.1%	97.2%	97.1%	96.8%
350	95.8%	95.9%	96.1%	96.3%	96.6%	96.9%	97.1%	97.2%	97.2%	97.2%	97.2%	96.9%

4th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	25	77.4%	79.6%	83.3%	83.8%	84.5%	84.9%	86.8%	88.1%	88.3%	87.6%	86.6%	79.6%
	50	88.1%	88.5%	90.7%	91.1%	91.6%	91.5%	92.6%	93.5%	93.5%	93.2%	92.8%	90.7%
	75	91.3%	91.5%	93.2%	93.9%	93.8%	94.1%	94.3%	94.3%	93.8%	93.8%	93.7%	92.2%
	100	93.0%	93.6%	94.5%	95.0%	95.0%	95.3%	95.4%	95.4%	95.1%	95.1%	94.9%	93.9%
	150	94.8%	95.1%	95.7%	96.1%	96.2%	96.2%	96.4%	96.4%	96.2%	96.2%	96.1%	95.5%
	200	95.6%	95.8%	96.4%	96.7%	96.8%	96.8%	96.9%	96.9%	96.8%	96.7%	96.7%	96.3%
	250	96.1%	96.2%	96.7%	97.1%	97.1%	97.1%	97.2%	97.3%	97.1%	97.0%	97.0%	96.7%
	300	96.4%	96.6%	97.0%	97.3%	97.3%	97.3%	97.4%	97.5%	97.4%	97.3%	97.3%	97.0%
	350	96.5%	96.8%	97.1%	97.4%	97.5%	97.5%	97.5%	97.6%	97.5%	97.5%	97.4%	97.2%

5th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	25	79.2%	82.4%	84.5%	85.5%	85.9%	85.8%	86.8%	89.4%	88.3%	87.3%	83.2%	79.1%
	50	89.0%	90.7%	91.7%	92.2%	92.2%	92.1%	92.8%	92.9%	92.8%	92.2%	91.8%	89.0%
	75	91.6%	92.8%	93.5%	92.5%	92.6%	92.8%	92.6%	92.8%	92.6%	92.5%	92.1%	90.5%
	100	93.2%	94.2%	93.7%	93.9%	94.0%	94.2%	94.1%	94.1%	93.9%	93.9%	93.6%	92.4%
	150	94.8%	95.4%	95.4%	95.1%	95.2%	95.4%	95.3%	95.4%	95.3%	95.2%	95.0%	94.3%
	200	95.6%	95.0%	95.6%	95.9%	96.0%	96.1%	96.1%	96.1%	96.0%	95.9%	95.8%	95.2%
	250	96.1%	95.6%	95.8%	96.4%	96.6%	96.6%	96.6%	96.6%	96.6%	96.5%	96.4%	96.0%
	300	96.4%	96.0%	96.4%	96.6%	96.9%	96.9%	97.0%	97.0%	96.9%	96.8%	96.8%	96.4%
	350	96.6%	96.3%	96.8%	96.9%	97.1%	97.2%	97.2%	97.2%	97.1%	97.1%	97.1%	96.7%

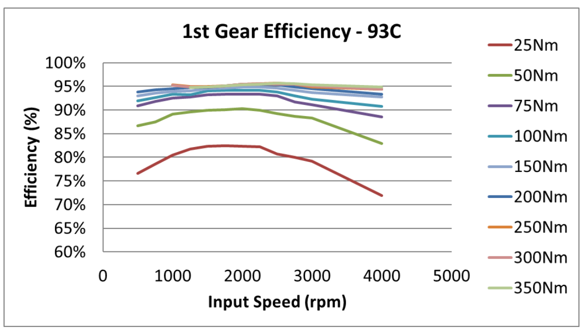
6th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)	25	78.9%	74.7%	77.2%	78.8%	83.9%	86.1%	86.5%	84.4%	82.6%	81.4%	80.3%	
	50	87.4%	88.7%	89.7%	89.9%	90.2%	90.6%	90.4%	90.6%	90.5%	90.1%	89.5%	
	75	91.3%	92.0%	90.1%	90.7%	91.3%	91.5%	90.9%	91.0%	90.9%	90.3%	89.7%	
	100	93.1%	93.5%	93.1%	92.8%	93.2%	93.0%	92.8%	92.9%	92.6%	92.6%	92.0%	
	150	94.8%	95.0%	94.9%	94.8%	95.0%	94.9%	94.7%	94.7%	94.6%	94.5%	94.2%	
	200	95.7%	95.9%	95.9%	95.8%	95.9%	95.9%	95.7%	95.7%	95.6%	95.5%	95.3%	
	250	96.2%	96.3%	96.5%	96.4%	96.4%	96.4%	96.3%	96.3%	96.2%	96.1%	96.1%	
	300	96.5%	96.6%	96.8%	96.8%	96.8%	96.8%	96.8%	96.7%	96.6%	96.6%	96.5%	
	350	96.7%	96.9%	97.1%	97.0%	97.1%	97.1%	97.0%	97.0%	96.9%	96.8%	96.7%	

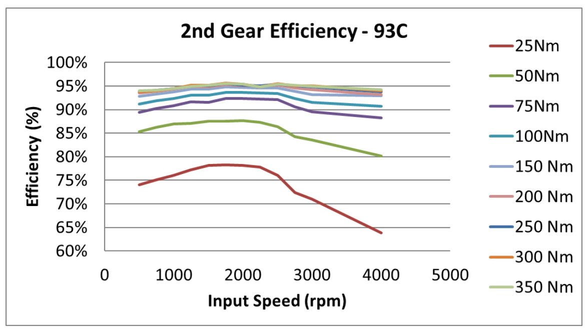
7th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)													
	25	86.3%	88.0%	89.7%	90.5%	92.6%	92.8%	92.9%	92.5%	91.4%	89.8%		
	50	93.2%	94.4%	94.9%	95.0%	96.2%	96.5%	96.5%	96.2%	95.5%	94.9%		
	75	94.1%	94.1%	93.5%	95.2%	96.0%	96.1%	96.0%	95.9%	95.8%	95.8%		
	100	95.4%	95.6%	95.0%	96.2%	96.9%	96.9%	96.8%	96.8%	96.9%	96.8%		
	150	96.6%	95.3%	96.6%	97.1%	97.6%	97.7%	97.7%	97.6%	97.7%	97.7%		
	200	97.4%	97.7%	97.8%	98.1%	98.5%	98.6%	98.5%	98.4%	98.4%	98.2%		
	250	97.7%	97.7%	98.2%	98.3%	98.6%	98.7%	98.6%	98.6%	98.5%	98.5%		
	300	98.0%	97.9%	98.2%	98.3%	98.6%	98.8%	98.7%	98.8%	98.7%	98.6%		
	350	98.1%	98.1%	98.3%	98.5%	98.7%	98.9%	98.9%	98.8%	98.8%	98.6%		

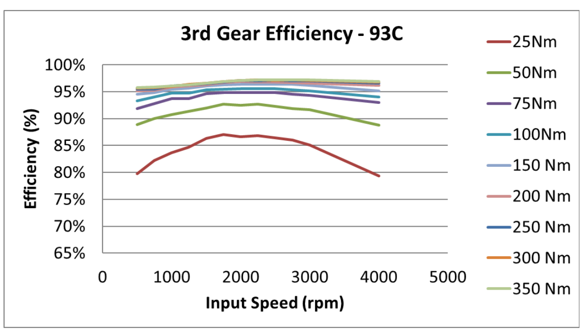
8th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)													
	25	88.7%	90.7%	92.0%	92.5%	91.3%	90.4%	89.1%	88.3%	87.1%			
	50	93.8%	94.9%	95.7%	95.8%	95.4%	95.0%	94.6%	93.7%	91.7%			
	75	92.9%	92.2%	93.8%	93.8%	93.6%	93.7%	93.3%	92.7%	91.9%			
	100	94.4%	93.2%	95.1%	95.2%	95.1%	95.0%	94.7%	94.4%	93.7%			
	150	95.9%	95.7%	96.2%	96.4%	96.4%	96.3%	96.1%	95.8%	95.5%			
	200	96.4%	96.8%	97.4%	97.7%	97.8%	97.8%	97.8%	97.6%	97.4%			
	250	97.5%	97.7%	97.9%	98.0%	98.1%	98.0%	98.0%	97.9%	97.7%			
	300	97.7%	97.9%	98.2%	98.2%	98.2%	98.2%	98.2%	98.1%	97.9%			
	350	97.8%	98.0%	98.2%	98.3%	98.3%	98.4%	98.3%	98.2%	98.0%			

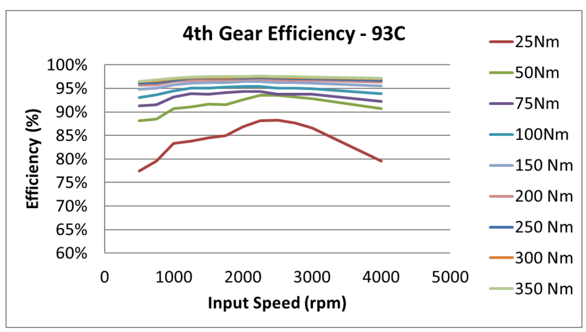
9th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)													
	25	91.5%	94.8%	95.8%	94.0%	92.9%	86.9%	84.5%					
	50	95.5%	97.4%	96.8%	96.5%	94.9%	94.0%	93.9%					
	75	97.5%	98.1%	98.4%	98.1%	97.5%	96.7%	95.3%					
	100	97.7%	98.3%	98.6%	98.3%	97.9%	97.3%	96.3%					
	150	98.0%	98.3%	98.6%	98.4%	98.2%	97.8%	97.3%					
	200	98.0%	98.3%	98.6%	98.5%	98.3%	98.0%	97.6%					
	250	98.2%	98.3%	98.6%	98.6%	98.4%	98.2%	97.8%					
	300	98.1%	98.2%	98.5%	98.5%	98.4%	98.2%	97.9%					
	350	98.0%	98.1%	98.4%	98.4%	98.3%	98.2%	97.9%					

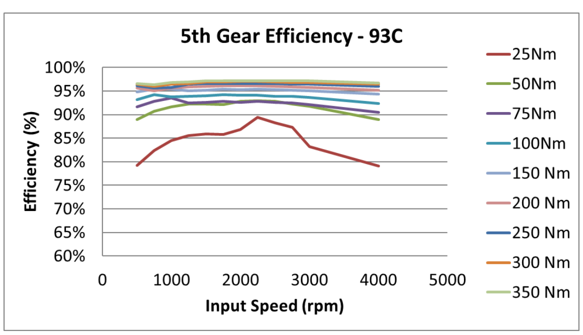
10th Gear		Input Speed (rpm)											
		500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	4000
Input Torque (Nm)													
	25	90.5%	92.9%	93.9%	93.8%	93.8%	86.2%						
	50	92.9%	93.4%	94.0%	93.9%	94.2%	93.1%						
	75	93.2%	93.7%	94.0%	93.9%	94.5%	93.3%						
	100	94.5%	94.8%	94.5%	95.1%	95.1%	94.5%						
	150	95.7%	95.7%	94.9%	96.2%	96.2%	96.0%						
	200	97.3%	97.6%	97.9%	98.0%	97.9%	97.6%						
	250	97.5%	97.6%	97.9%	98.1%	98.0%	97.9%						
	300	97.6%	97.7%	97.9%	98.1%	98.1%	97.9%						
	350	97.7%	97.8%	97.9%	98.1%	98.2%	98.0%						

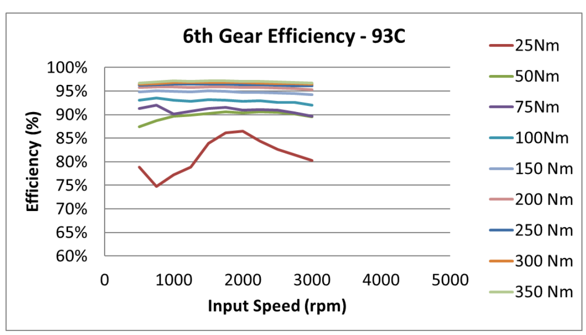


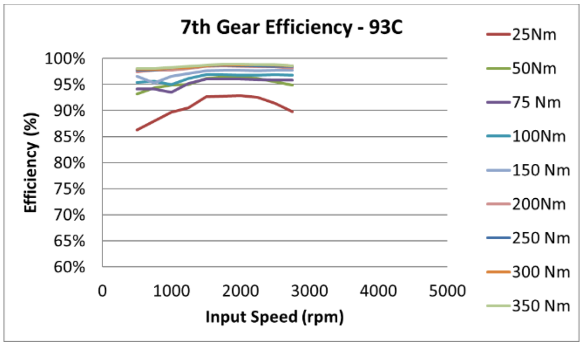


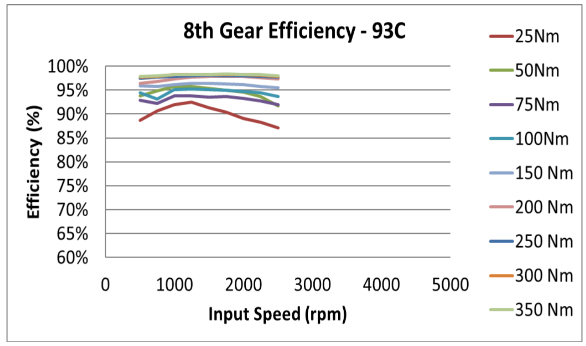


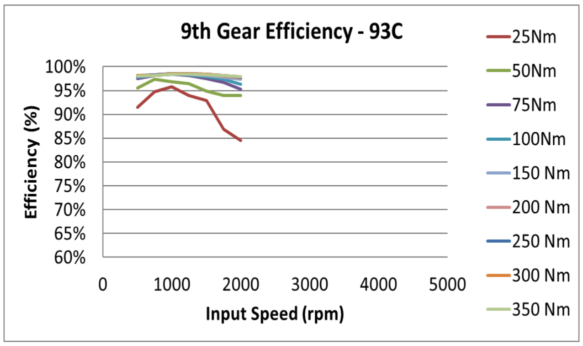


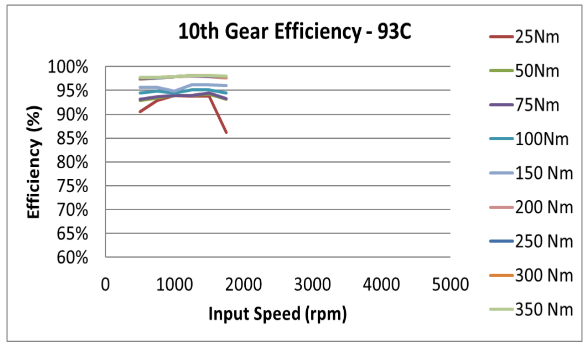





7th Gear Efficiency - 93C
Efficiency (%)
100%
95%
90%
85%
80%
75%
70%
65%
60%
0
1000
2000
3000
4000
5000
Input Speed (rpm)
25Nm
50Nm
75 Nm
100Nm
150 Nm
200Nm
250 Nm
300 Nm
350 Nm


8th Gear Efficiency - 93C
Efficiency (%)
100%
95%
90%
85%
80%
75%
70%
65%
60%
0
1000
2000
3000
4000
5000
Input Speed (rpm)
25Nm
50Nm
75Nm
100Nm
150 Nm
200 Nm
250 Nm
300 Nm
350 Nm


9th Gear Efficiency - 93C
Efficiency (%)
100%
95%
90%
85%
80%
75%
70%
65%
60%
0
1000
2000
3000
4000
5000
Input Speed (rpm)
25Nm
50Nm
75Nm
100Nm
150 Nm
200 Nm
250 Nm
300 Nm
350 Nm


10th Gear Efficiency - 93C
Efficiency (%)
100%
95%
90%
85%
80%
75%
70%
65%
60%
0
1000
2000
3000
4000
5000
Input Speed (rpm)
25Nm
50Nm
75Nm
100Nm
150 Nm
200 Nm
250 Nm
300 Nm
350 Nm

Appendix C: Honda CVT Loaded Efficiency

Honda Accord CVT-93C

CVT - mech eff @ 16mph

Torque, Nm	ratio: 2.65	2.05	1.70	1.45	1.00	0.85
30.0	0.82	0.84	0.83	0.82	0.84	0.81
60.0	0.86	0.87	0.88	0.89	0.89	0.88
90.0	0.87	0.88	0.89	0.90	0.91	0.90
120.0	0.85	0.89	0.89	0.90	0.92	
150.0	0.86	0.89	0.90	0.91		0.91

CVT - mech eff @ 25mph

Torque, Nm	ratio: 1.70	1.45	1.00	0.85	0.55	0.41
30.0	0.832	0.813	0.849	0.789	0.762	0.72
60.0	0.877	0.879	0.896	0.881	0.853	0.82
90.0	0.893	0.901	0.912	0.904	0.885	0.86
120.0	0.897	0.906	0.919	0.914	0.897	0.88
150.0	0.900	0.908	0.922	0.917	0.907	0.89

CVT - mech eff @ 37mph

Torque, Nm	ratio: 1.00	0.85	0.55	0.41
30.0	0.80	0.77	0.80	[redacted]
60.0	0.87	0.87	0.85	0.80
90.0	0.89	0.90	0.88	0.86
120.0	0.92	0.91	0.90	0.88
150.0	0.92	0.92	0.91	0.90

CVT - mech eff @ 50mph

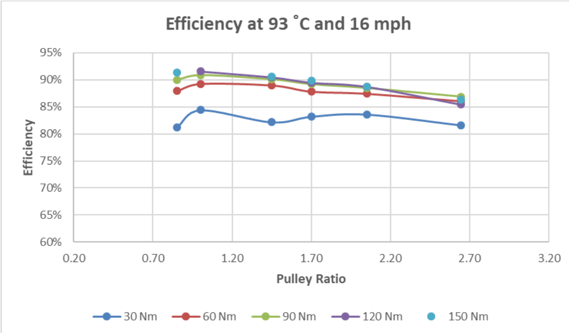
Torque, Nm	ratio: 0.85	0.55	0.41
30.0	0.73	0.82	[redacted]
60.0	0.87	0.83	0.81
90.0	0.89	0.87	0.86
120.0	0.90	0.89	0.88
150.0	0.91	0.90	0.89

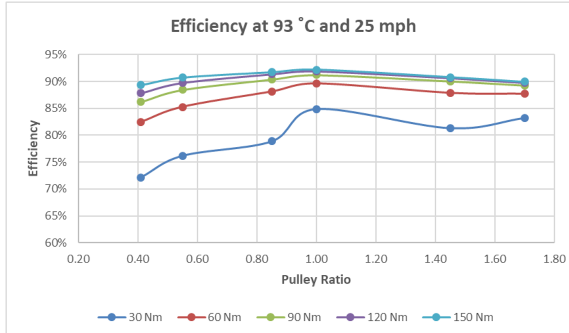
CVT - mech eff @ 62mph

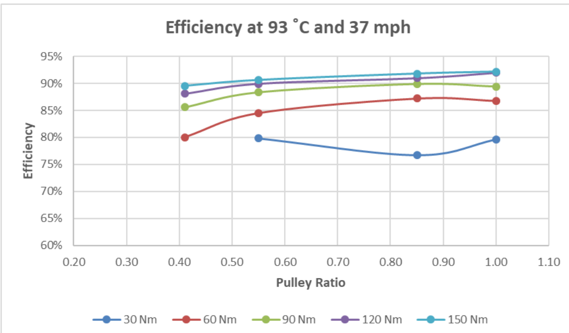
Torque, Nm	ratio: 0.55	0.41
30.0	[redacted]	[redacted]
60.0	0.80	[redacted]
90.0	0.85	0.84
120.0	0.87	0.87
150.0	0.89	0.89

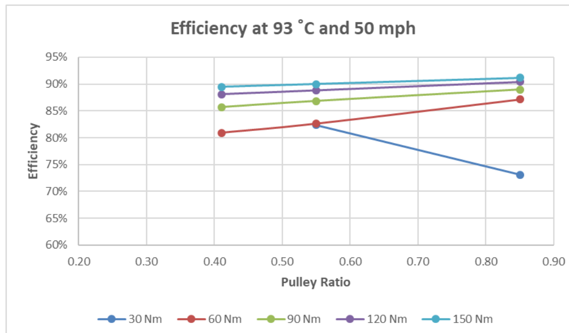
CVT - mech eff @ 93mph

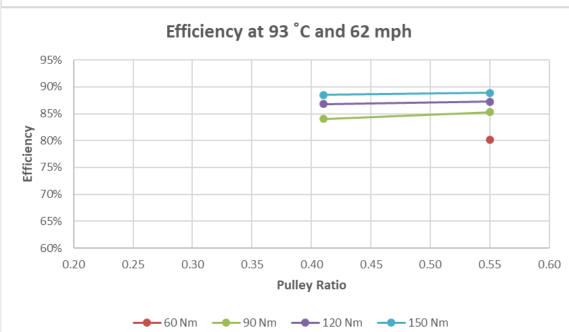
Torque, Nm	ratio: 0.41
30.0	[redacted]
60.0	[redacted]
90.0	0.80
120.0	0.83
150.0	0.86

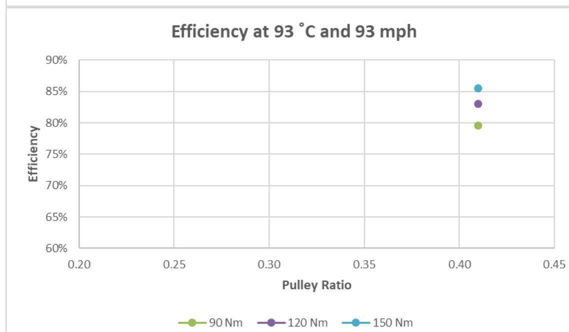

Efficiency at 93 ˚C and 16 mph
Efficiency
Pulley Ratio
30 Nm
60 Nm
90 Nm
120 Nm
150 Nm

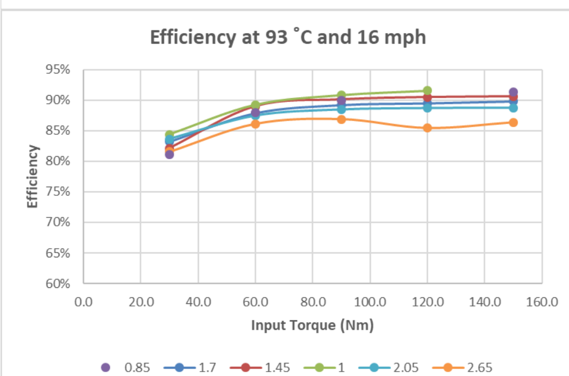

Efficiency at 93 ˚C and 25 mph
Efficiency
Pulley Ratio
30 Nm
60 Nm
90 Nm
120 Nm
150 Nm

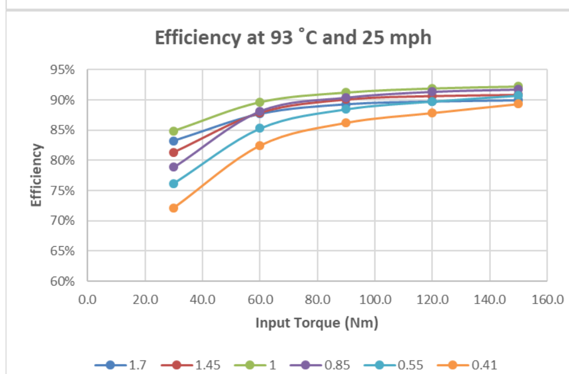

Efficiency at 93 ˚C and 37 mph
Efficiency
Pulley Ratio
30 Nm
60 Nm
90 Nm
120 Nm
150 Nm

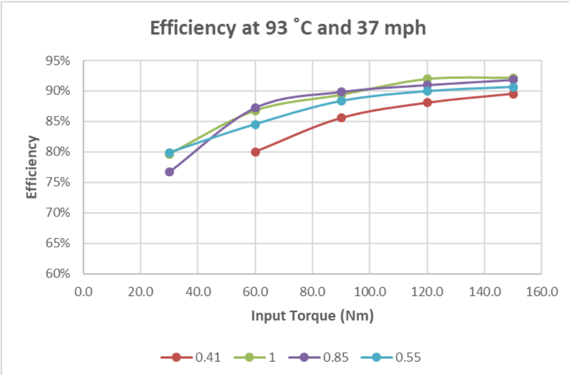

Efficiency at 93 ˚C and 50 mph
Efficiency
Pulley Ratio
30 Nm
60 Nm
90 Nm
120 Nm
150 Nm

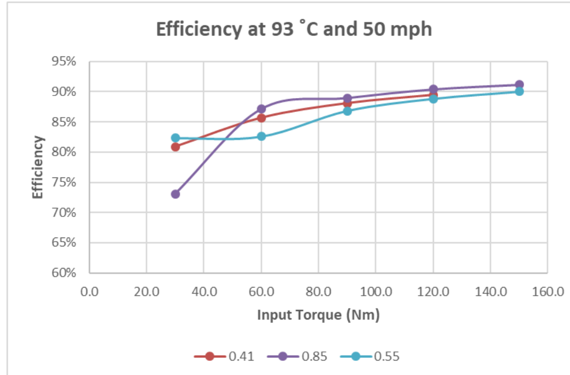

Efficiency at 93 ˚C and 62 mph
Efficiency
Pulley Ratio
60 Nm
90 Nm
120 Nm
150 Nm

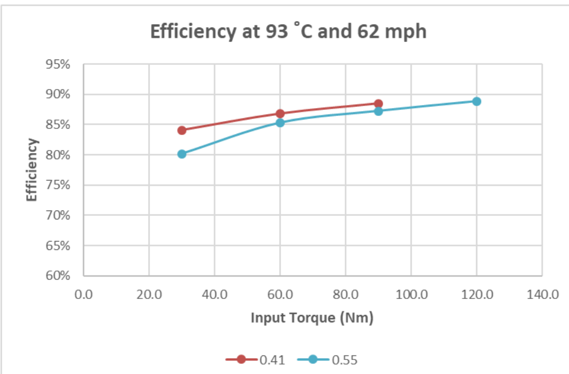

Efficiency at 93 ˚C and 93 mph
Efficiency
Pulley Ratio
90 Nm
120 Nm
150 Nm

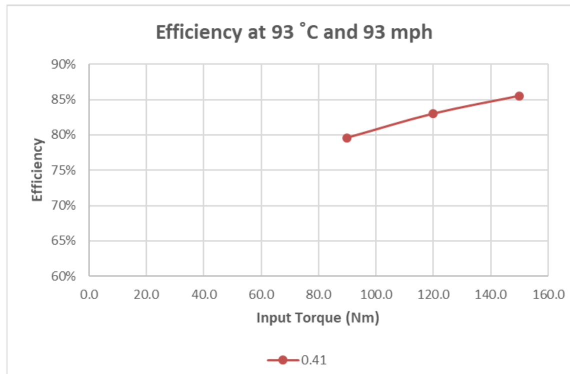

Efficiency at 93 ˚C and 16 mph
Efficiency
Input Torque (Nm)
0.85
1.7
1.45
1
2.05
2.65


Efficiency at 93 ˚C and 25 mph
Efficiency
Input Torque (Nm)
1.7
1.45
1
0.85
0.55
0.41


Efficiency at 93 ˚C and 37 mph
Efficiency
95%
90%
85%
80%
75%
70%
65%
60%
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
Input Torque (Nm)
0.41
1
0.85
0.55


Efficiency at 93 ˚C and 50 mph
Efficiency
95%
90%
85%
80%
75%
70%
65%
60%
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
Input Torque (Nm)
0.41
0.85
0.55


Efficiency at 93 ˚C and 62 mph
Efficiency
95%
90%
85%
80%
75%
70%
65%
60%
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
Input Torque (Nm)
0.41
0.55


Efficiency at 93 ˚C and 93 mph
Efficiency
90%
85%
80%
75%
70%
65%
60%
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
Input Torque (Nm)
0.41

Honda Accord CVT-65C

CVT - mech eff @ 16mph

Torque, Nm	ratio 2.65	2.05	1.70	1.45	1.00	0.85
30.0	0.82	0.83	0.83	0.86	0.85	0.84
60.0	0.86	0.88	0.89	0.89	0.90	0.89
90.0	0.85	0.89	0.90	0.90	0.92	0.91
120.0	0.87	0.89	0.90	0.91	0.92	0.92
150.0		0.89	0.90	0.91	0.92	0.92

CVT - mech eff @ 25mph

Torque, Nm	ratio 1.70	1.45	1.00	0.85	0.55	0.41
30.0	0.834	0.833	0.841	0.825	0.782	0.81
60.0	0.880	0.890	0.899	0.888	0.862	0.832
90.0	0.895	0.904	0.915	0.908	0.887	0.884
120.0	0.898	0.909	0.922	0.917	0.903	0.888
150.0	0.900	0.910	0.925	0.921	0.911	0.902

CVT - mech eff @ 37mph

Torque, Nm	ratio 1.00	0.85	0.55	0.41
30.0	0.82	0.80	0.76	
60.0	0.88	0.88	0.85	0.84
90.0	0.91	0.90	0.88	0.87
120.0	0.91	0.91		0.89
150.0	0.92	0.92		0.90

CVT - mech eff @ 50mph

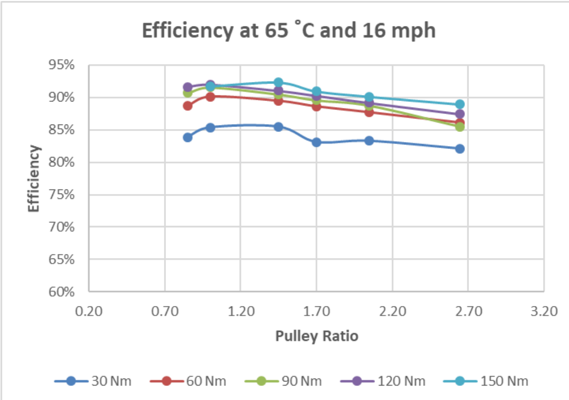
Torque, Nm	ratio 0.85	0.55	0.41
30.0	0.74		
60.0	0.85	0.83	0.81
90.0	0.89	0.87	0.86
120.0	0.90	0.89	0.88
150.0	0.91	0.90	0.90

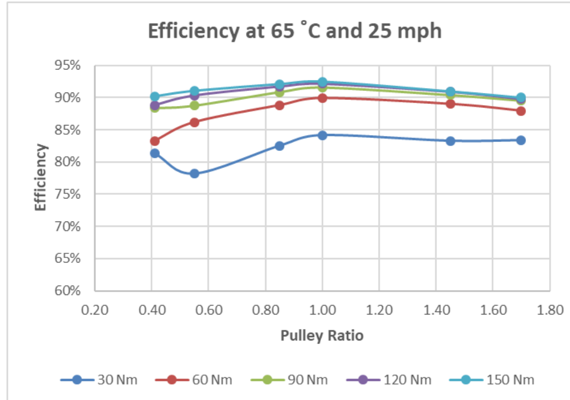
CVT - mech eff @ 62mph

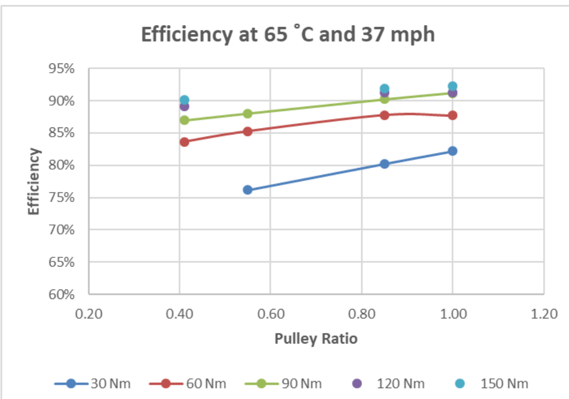
Torque, Nm	ratio 0.55	0.41
30.0		
60.0	0.80	
90.0	0.85	0.84
120.0	0.87	0.86
150.0	0.88	0.89

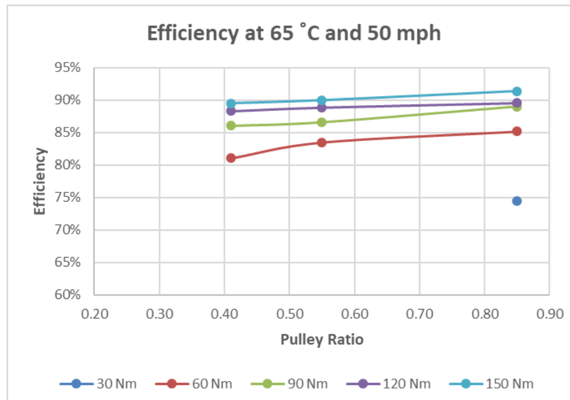
CVT - mech eff @ 93mph

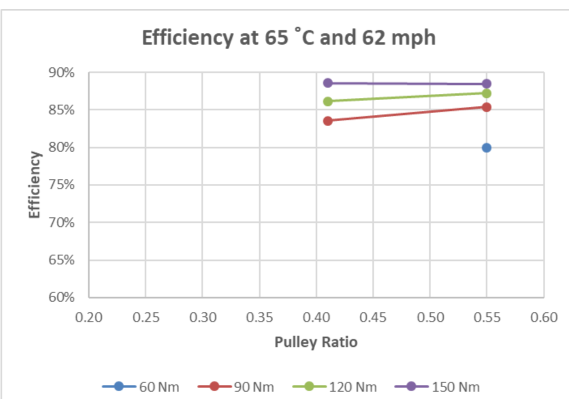
Torque, Nm	ratio 0.41
30.0	
60.0	
90.0	0.77
120.0	0.82
150.0	

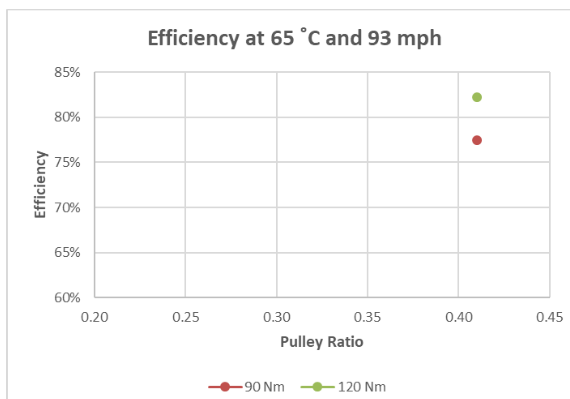

Efficiency at 65 ˚C and 16 mph
95%
90%
85%
80%
75%
70%
65%
60%
Efficiency
0.20
0.70
1.20
1.70
2.20
2.70
3.20
Pulley Ratio
30 Nm
60 Nm
90 Nm
120 Nm
150 Nm

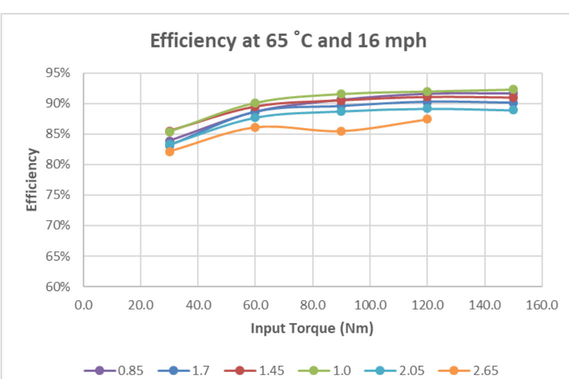

Efficiency at 65 ˚C and 25 mph
95%
90%
85%
80%
75%
70%
65%
60%
Efficiency
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
Pulley Ratio
30 Nm
60 Nm
90 Nm
120 Nm
150 Nm

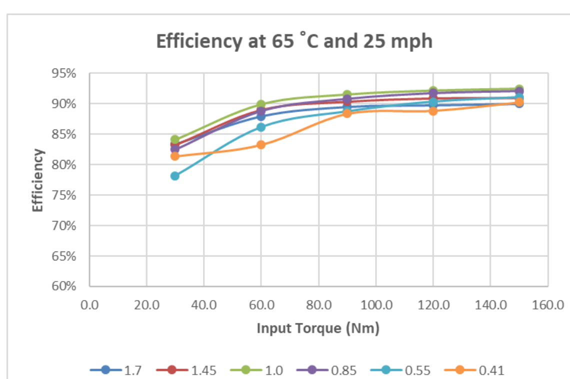

Efficiency at 65 ˚C and 37 mph
95%
90%
85%
80%
75%
70%
65%
60%
Efficiency
0.20
0.40
0.60
0.80
1.00
1.20
Pulley Ratio
30 Nm
60 Nm
90 Nm
120 Nm
150 Nm

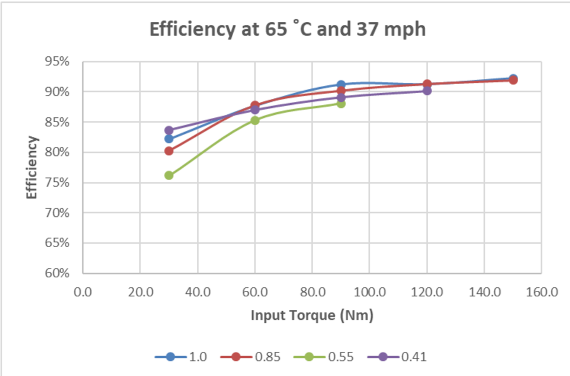

Efficiency at 65 ˚C and 50 mph
95%
90%
85%
80%
75%
70%
65%
60%
Efficiency
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Pulley Ratio
30 Nm
60 Nm
90 Nm
120 Nm
150 Nm

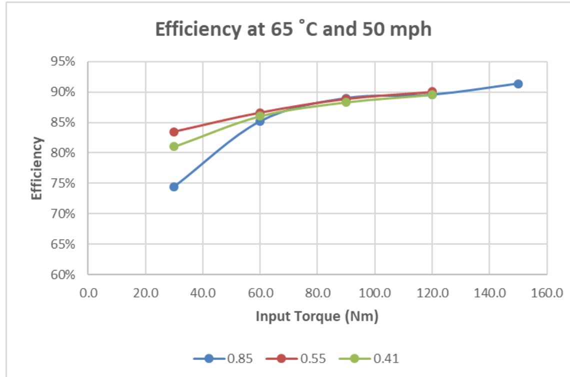

Efficiency at 65 ˚C and 62 mph
90%
85%
80%
75%
70%
65%
60%
Efficiency
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.55
0.60
Pulley Ratio
60 Nm
90 Nm
120 Nm
150 Nm

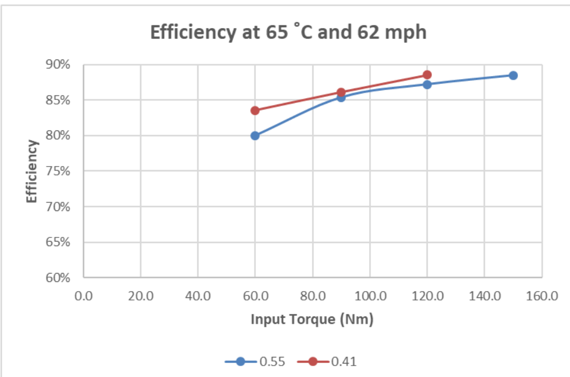

Efficiency at 65 ˚C and 93 mph
85%
80%
75%
70%
65%
60%
Efficiency
0.20
0.25
0.30
0.35
0.40
0.45
Pulley Ratio
90 Nm
120 Nm

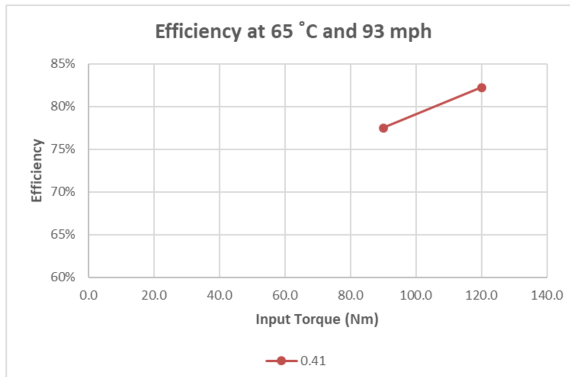

Efficiency at 65 ˚C and 16 mph
95%
90%
85%
80%
75%
70%
65%
60%
Efficiency
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
Input Torque (Nm)
0.85
1.7
1.45
1.0
2.05
2.65


Efficiency at 65 ˚C and 25 mph
95%
90%
85%
80%
75%
70%
65%
60%
Efficiency
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
Input Torque (Nm)
1.7
1.45
1.0
0.85
0.55
0.41


Efficiency at 65 ˚C and 37 mph
Efficiency
Input Torque (Nm)
95%
90%
85%
80%
75%
70%
65%
60%
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
1.0
0.85
0.55
0.41


Efficiency at 65 ˚C and 50 mph
Efficiency
Input Torque (Nm)
95%
90%
85%
80%
75%
70%
65%
60%
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
0.85
0.55
0.41


Efficiency at 65 ˚C and 62 mph
Efficiency
Input Torque (Nm)
90%
85%
80%
75%
70%
65%
60%
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
0.55
0.41


Efficiency at 65 ˚C and 93 mph
Efficiency
Input Torque (Nm)
85%
80%
75%
70%
65%
60%
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
0.41

Honda Accord CVT-38C

CVT - mech eff @ 16mph

Torque, Nm	ratio 2.65	2.05	1.70	1.45	1.00	0.85
30.0	0.80	0.80	0.84	0.84	0.85	0.82
60.0	0.84	0.86	0.88	0.89	0.90	0.89
90.0	0.85	0.87	0.90	0.91	0.92	0.91
120.0		0.88	0.90	0.91	0.92	0.92
150.0	0.85	0.88	0.90	0.91	0.93	0.92

CVT - mech eff @ 25mph

Torque, Nm	ratio 1.70	1.45	1.00	0.85	0.55	0.41
30.0	0.757	0.770	0.797	0.779	0.754	0.78
60.0	0.850	0.861	0.876	0.868	0.846	0.83
90.0	0.878	0.886	0.900	0.896	0.879	0.87
120.0	0.892	0.896	0.913	0.908	0.895	0.89
150.0	0.893	0.899	0.916	0.915		0.90

CVT - mech eff @ 37mph

Torque, Nm	ratio 1.00	0.85	0.55	0.41
30.0	0.76	0.73	0.79	
60.0	0.86	0.85	0.83	0.82
90.0	0.89	0.88	0.87	0.86
120.0	0.91	0.90	0.89	0.88
150.0	0.91	0.91	0.91	0.90

CVT - mech eff @ 50mph

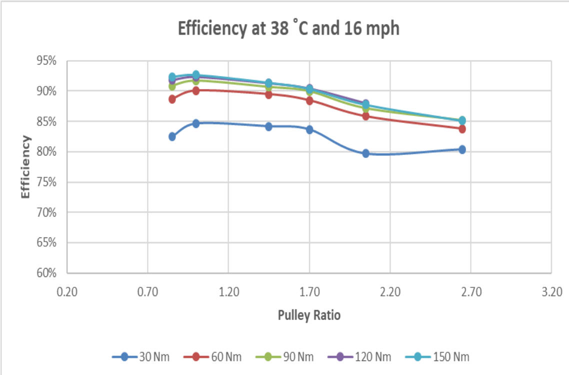
Torque, Nm	ratio 0.85	0.55	0.41
30.0	0.69		
60.0	0.83	0.80	0.78
90.0	0.87	0.86	0.84
120.0	0.89	0.88	0.87
150.0	0.90	0.90	0.89

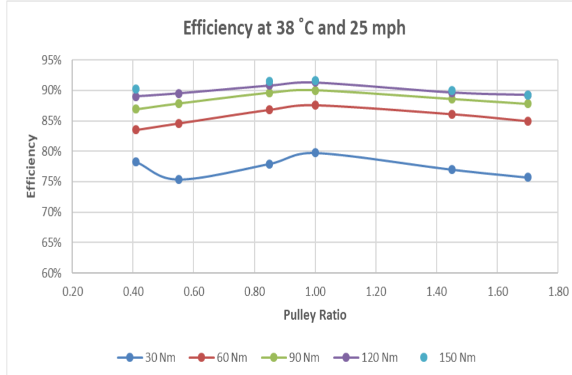
CVT - mech eff @ 62mph

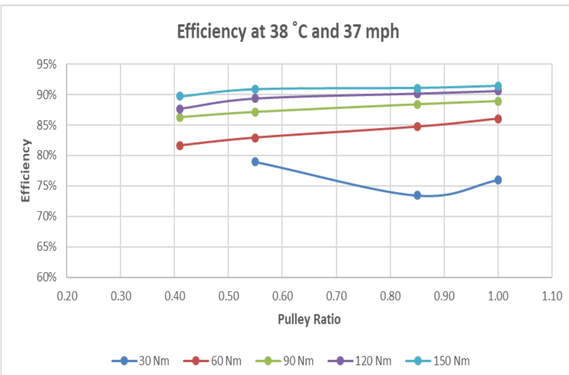
Torque, Nm	ratio 0.55	0.41
30.0		
60.0	0.78	
90.0	0.84	0.81
120.0	0.86	0.85
150.0	0.89	0.87

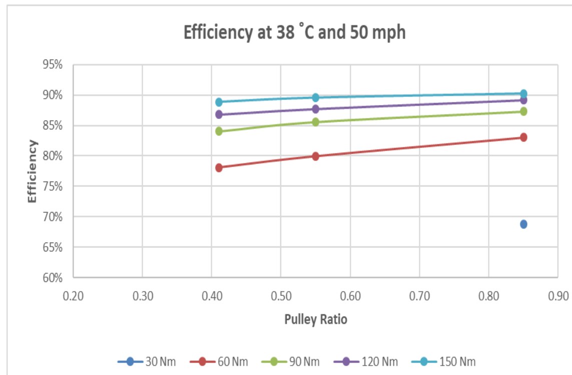
CVT - mech eff @ 93mph

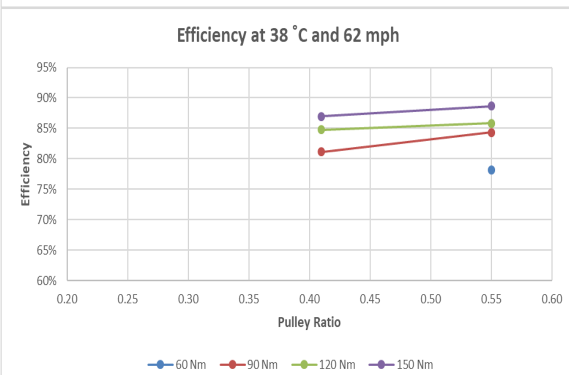
Torque, Nm	ratio 0.41
30.0	
60.0	
90.0	0.78
120.0	
150.0	

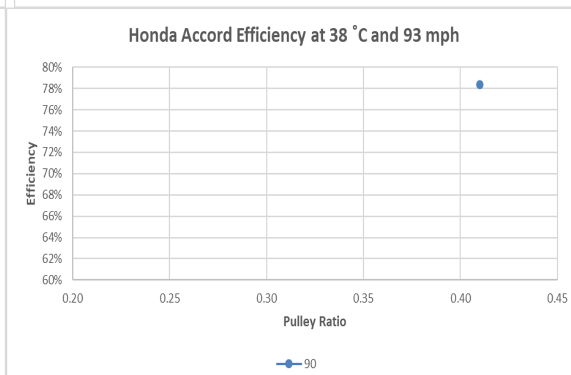

Efficiency at 38 ˚C and 16 mph
Efficiency
Pulley Ratio
30 Nm
60 Nm
90 Nm
120 Nm
150 Nm

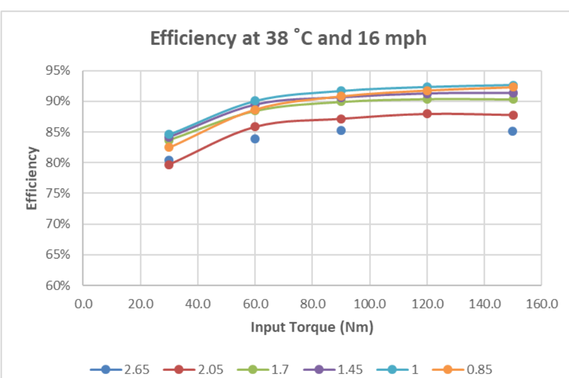

Efficiency at 38 ˚C and 25 mph
Efficiency
Pulley Ratio
30 Nm
60 Nm
90 Nm
120 Nm
150 Nm

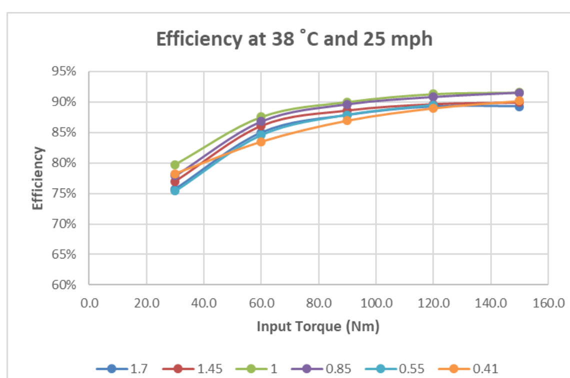

Efficiency at 38 ˚C and 37 mph
Efficiency
Pulley Ratio
30 Nm
60 Nm
90 Nm
120 Nm
150 Nm

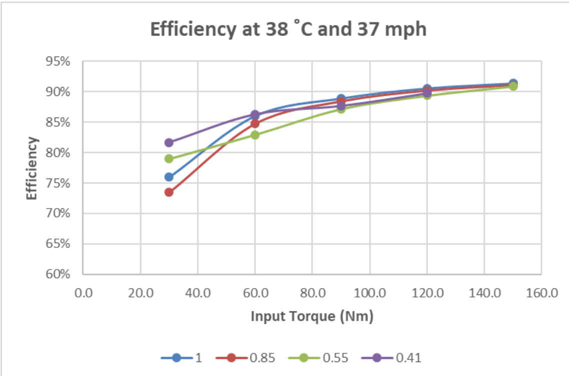

Efficiency at 38 ˚C and 50 mph
Efficiency
Pulley Ratio
30 Nm
60 Nm
90 Nm
120 Nm
150 Nm

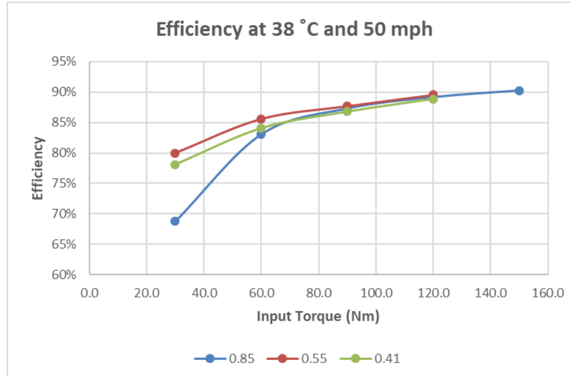

Efficiency at 38 ˚C and 62 mph
Efficiency
Pulley Ratio
60 Nm
90 Nm
120 Nm
150 Nm

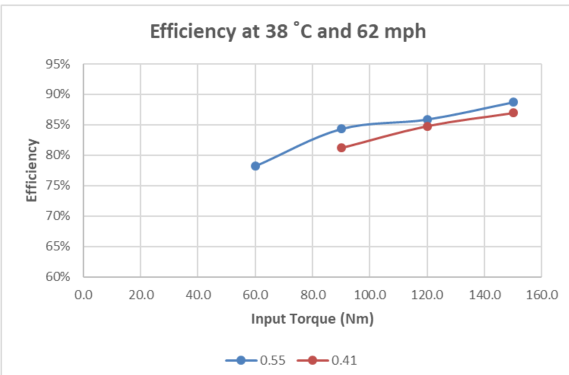

Honda Accord Efficiency at 38 ˚C and 93 mph
Efficiency
Pulley Ratio
90

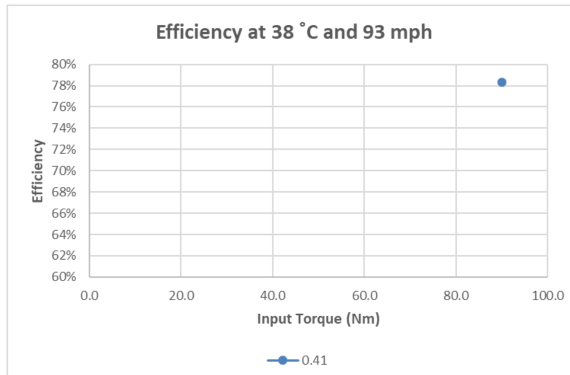

Efficiency at 38 ˚C and 16 mph
Efficiency
Input Torque (Nm)
2.65
2.05
1.7
1.45
1
0.85


Efficiency at 38 ˚C and 25 mph
Efficiency
Input Torque (Nm)
1.7
1.45
1
0.85
0.55
0.41


Efficiency at 38 ˚C and 37 mph
Efficiency
95%
90%
85%
80%
75%
70%
65%
60%
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
Input Torque (Nm)
1
0.85
0.55
0.41


Efficiency at 38 ˚C and 50 mph
Efficiency
95%
90%
85%
80%
75%
70%
65%
60%
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
Input Torque (Nm)
0.85
0.55
0.41


Efficiency at 38 ˚C and 62 mph
Efficiency
95%
90%
85%
80%
75%
70%
65%
60%
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
Input Torque (Nm)
0.55
0.41


Efficiency at 38 ˚C and 93 mph
Efficiency
80%
78%
76%
74%
72%
70%
68%
66%
64%
62%
60%
0.0
20.0
40.0
60.0
80.0
100.0
Input Torque (Nm)
0.41

Honda Accord CVT-25C

CVT - mech eff @ 16mph

Torque, Nm	ratio 2.65	2.05	1.70	1.45	1.00	0.85
30.0	0.75	0.78	0.80	0.80	0.79	0.76
60.0	0.83	0.85	0.85	0.87	0.87	0.86
90.0	0.85	0.87	0.88	0.89	0.89	0.89
120.0						
150.0		0.88				

CVT - mech eff @ 25mph

Torque, Nm	ratio 1.70	1.45	1.00	0.85	0.55	0.41
30.0	0.754	0.771	0.774	0.762	#DIV/0!	0.77
60.0	0.846	0.858	0.863	0.855	0.824	0.82
90.0	0.874	0.884	0.893	0.885	0.866	0.86
120.0	0.889		0.910			
150.0						

CVT - mech eff @ 37mph

Torque, Nm	ratio 1.00	0.85	0.55	0.41
30.0	0.75	0.73	0.68	[redacted]
60.0	0.85	0.84	0.82	0.79
90.0	0.89	0.88	0.86	0.85
120.0				
150.0				

CVT - mech eff @ 50mph

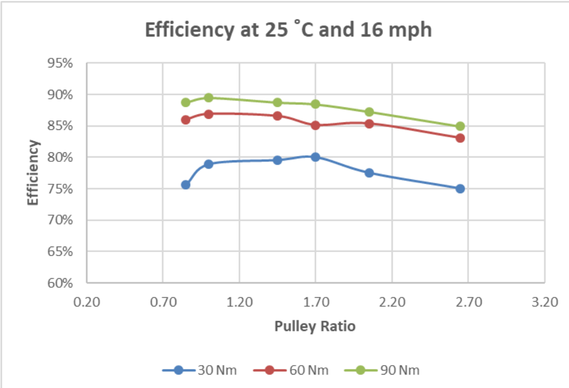
Torque, Nm	ratio 0.85	0.55	0.41
30.0	0.67	[redacted]	[redacted]
60.0	0.82	0.80	0.79
90.0	0.86	0.85	0.84
120.0			
150.0			

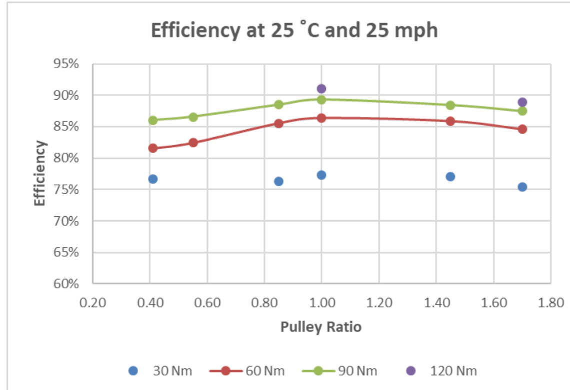
CVT - mech eff @ 62mph

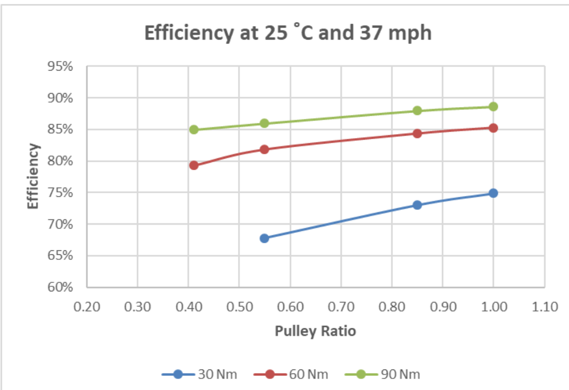
Torque, Nm	ratio 0.55	0.41
30.0	[redacted]	[redacted]
60.0	0.77	[redacted]
90.0	0.84	0.82
120.0	0.86	
150.0		

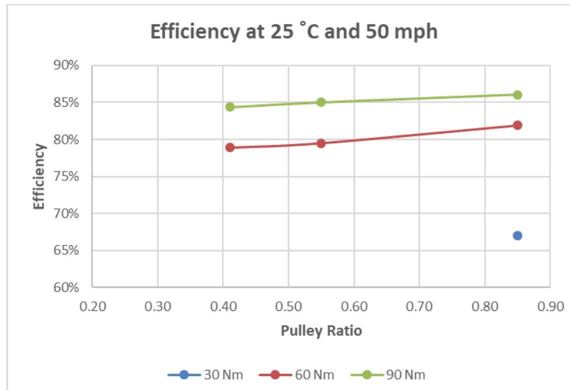
CVT - mech eff @ 93mph

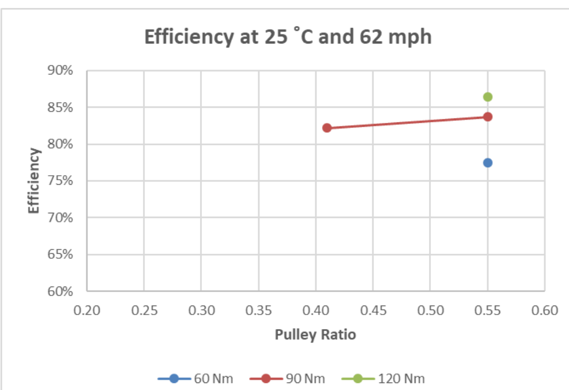
Torque, Nm	ratio 0.41
30.0	[redacted]
60.0	[redacted]
90.0	0.78
120.0	0.83
150.0	

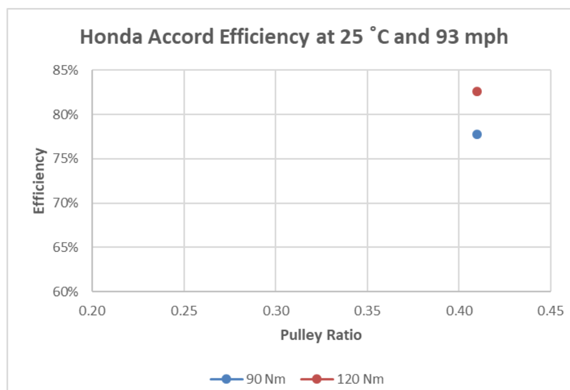

Efficiency at 25 ˚C and 16 mph
Efficiency
Pulley Ratio
30 Nm
60 Nm
90 Nm

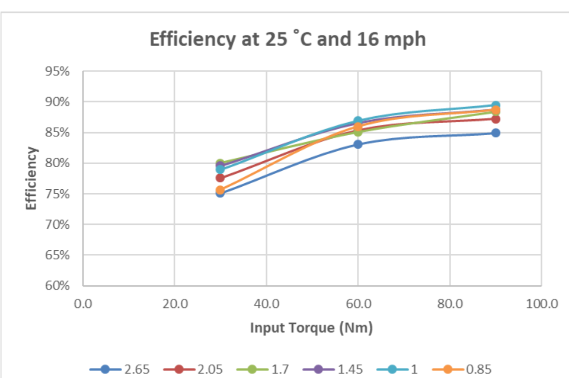

Efficiency at 25 ˚C and 25 mph
Efficiency
Pulley Ratio
30 Nm
60 Nm
90 Nm
120 Nm

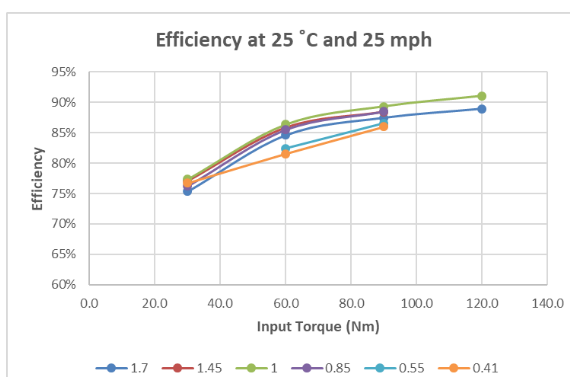

Efficiency at 25 ˚C and 37 mph
Efficiency
Pulley Ratio
30 Nm
60 Nm
90 Nm

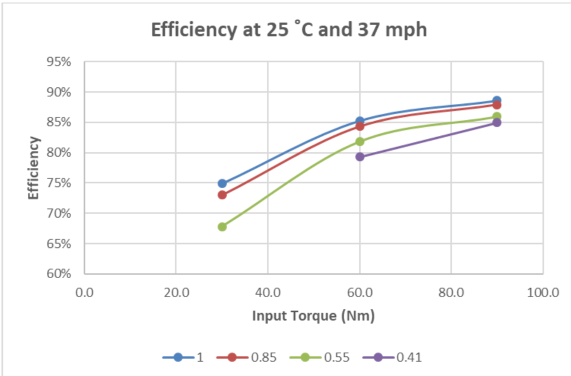

Efficiency at 25 ˚C and 50 mph
Efficiency
Pulley Ratio
30 Nm
60 Nm
90 Nm

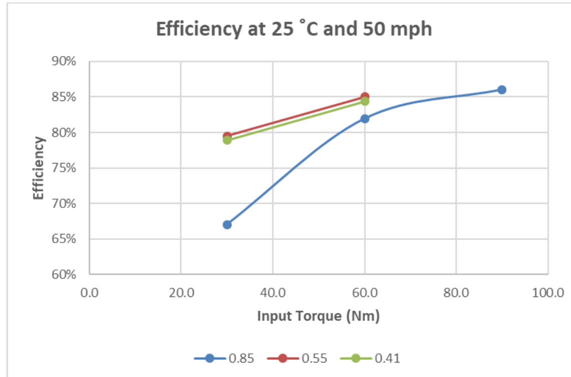

Efficiency at 25 ˚C and 62 mph
Efficiency
Pulley Ratio
60 Nm
90 Nm
120 Nm

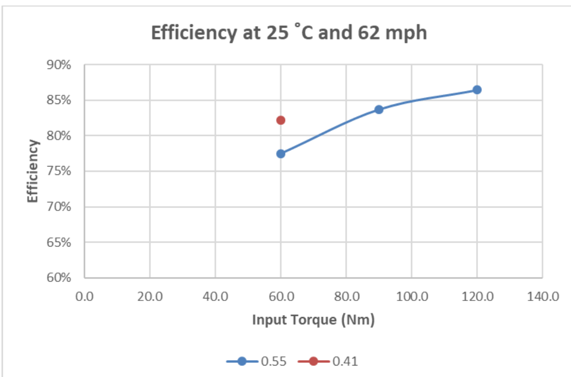

Honda Accord Efficiency at 25 ˚C and 93 mph
Efficiency
Pulley Ratio
90 Nm
120 Nm


Efficiency at 25 ˚C and 16 mph
Efficiency
Input Torque (Nm)
2.65
2.05
1.7
1.45
1
0.85


Efficiency at 25 ˚C and 25 mph
Efficiency
Input Torque (Nm)
1.7
1.45
1
0.85
0.55
0.41


Efficiency at 25 ˚C and 37 mph
Efficiency
Input Torque (Nm)
1
0.85
0.55
0.41


Efficiency at 25 ˚C and 50 mph
Efficiency
Input Torque (Nm)
0.85
0.55
0.41


Efficiency at 25 ˚C and 62 mph
Efficiency
Input Torque (Nm)
0.55
0.41

Appendix D: Torque Converter Tables

FORD 10R80 TORQUE CONVERTER

Avg Speed Ratio	Average Input Speed	Average Output Speed	Average Input Torque	Average Output Torque	Transmission Torque Loss	Calc. Turbine Shaft Torque	Torque Conv. Turbine Torque	Cf	K	Torque Ratio	TCC drag	Efficiency
1.001	1999.3	2000.4	2.1	-0.5	3.450	3.0	4.5	5.15E-07	1393.4	2.195		2.196
0.990	1997.6	1977.6	20.1	15.0	3.450	18.5	20.1	5.03E-06	446.0	1.000	1.57	0.990
0.893	1999.5	1785.4	169.0	170.0	3.450	173.4	175.0	4.23E-05	153.8	1.036		0.925
0.799	1999.5	1598.5	199.4	219.2	3.450	222.6	224.2	4.99E-05	141.6	1.124		0.899
0.701	1999.3	1400.6	227.3	270.0	3.000	273.0	274.6	5.69E-05	132.6	1.208		0.846
0.600	1999.2	1200.1	246.3	313.8	3.000	316.8	318.4	6.16E-05	127.4	1.293		0.776
0.500	1998.9	999.4	251.1	341.0	3.500	344.5	346.1	6.28E-05	126.1	1.378		0.689
0.400	1998.9	800.0	246.9	357.3	3.000	360.3	361.9	6.18E-05	127.2	1.466		0.587
0.299	1999.0	598.6	237.9	363.8	3.500	367.3	368.9	5.95E-05	129.6	1.550		0.464
0.199	1999.3	398.6	225.8	363.6	3.000	366.6	368.1	5.65E-05	133.0	1.630		0.325
0.100	1999.6	200.9	211.2	357.2	3.000	360.2	361.7	5.28E-05	137.6	1.713		0.172
0.001	1999.9	1.9	196.5	368.7	3.450	372.2	373.7	4.91E-05	142.7	1.902		0.002

HONDA CVT TORQUE CONVERTER

Avg Speed Ratio	Average Input Speed	Average Output Speed	Average Input Torque	Average Output Torque	Average Trans Ratio	Transmission Torque Loss	Calc. Turbine Shaft Torque	Torque Conv. Turbine Torque	Cf	K	Torque Ratio	TCC drag	Efficiency
0.948	1500.3	100.7	9.8	54.1	14.1	3.330	7.2	9.8	4.36E-06	479.1	1.000	2.65	0.948
0.846	1500.2	89.9	41.1	483.8	14.1	5.391	39.6	42.3	1.83E-05	234.1	1.029		0.871
0.708	1500.4	75.2	67.3	895.1	14.1	8.982	72.4	75.0	2.99E-05	182.9	1.115		0.789
0.568	1500.1	60.3	70.7	1047.9	14.1	8.982	83.2	85.8	3.14E-05	178.4	1.214		0.690
0.495	1500.1	52.6	68.7	1072.0	14.1	8.982	84.9	87.5	3.05E-05	181.0	1.275		0.631
0.422	1500.1	44.8	67.0	1102.9	14.1	8.982	87.1	89.7	2.98E-05	183.3	1.340		0.565
0.355	1500.1	37.7	65.0	1121.3	14.1	8.982	88.4	91.0	2.89E-05	186.1	1.400		0.496
0.284	1499.9	30.1	62.9	1133.6	14.1	8.982	89.2	91.9	2.80E-05	189.1	1.460		0.414
0.212	1500.0	22.5	60.6	1140.2	14.1	8.982	89.7	92.4	2.69E-05	192.7	1.525		0.323
0.142	1499.9	15.1	58.2	1138.1	14.1	7.061	87.6	90.3	2.59E-05	196.6	1.551		0.221
0.071	1500.2	7.5	55.5	1130.6	14.1	7.061	87.1	89.8	2.47E-05	201.3	1.616		0.114
0.009	1500.2	5.9	55.0	1128.1	14.1	7.061	86.9	89.6	2.44E-05	202.3	1.629		0.015

Appendix E: Inertia Results

Ford 10R80 Inertia Data

93 °C

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
1	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	510	91.4	2.5	16.05	505	90.8	13.17	2.88	1.16
750	755	91.3	4.4	19.59	756	91.5	15.68	3.91	0.88
1000	1004	91.1	4.4	19.79	1003	92.3	16.45	3.34	0.75
1250	1254	90.6	4.4	18.55	1253	92.7	14.44	4.10	0.92
1500	1501	90.7	4.5	17.02	1501	93.1	13.19	3.84	0.86
1750	1750	91.0	4.4	16.24	1750	93.6	12.57	3.67	0.83
2000	1997	91.1	4.4	15.90	1997	93.9	12.14	3.77	0.86
2250	2247	91.2	4.4	15.95	2246	94.0	12.16	3.79	0.86
2500	2492	91.4	4.4	15.75	2492	93.6	12.29	3.46	0.78
2750	2738	91.5	4.4	15.85	2739	93.0	12.48	3.37	0.77
3000	3000	91.5	3.4	15.55	3000	92.0	12.65	2.90	0.84

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
2	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	512	88.8	3.2	17.25	505	90.3	13.80	3.45	1.08
750	755	88.7	4.4	20.32	755	92.1	17.66	2.66	0.60
1000	1003	88.1	4.4	20.99	1003	92.1	18.26	2.72	0.62
1250	1252	87.3	4.4	19.16	1253	92.0	16.27	2.89	0.66
1500	1501	87.1	4.4	17.40	1501	91.9	15.15	2.25	0.51
1750	1750	87.0	4.4	16.66	1750	91.8	14.30	2.36	0.54
2000	1996	87.0	4.5	16.53	1997	91.5	14.27	2.26	0.51
2250	2245	87.3	4.8	18.34	2247	90.8	14.49	3.85	0.81
2500	2491	87.4	4.5	18.12	2492	90.1	15.54	2.58	0.58
2750	2741	87.4	3.9	17.94	2740	89.0	16.23	1.72	0.44
3000	2998	86.7	3.8	19.59	3000	87.0	17.21	2.38	0.62

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
3	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	511	91.7	2.7	14.16	505	92.5	11.53	2.62	0.98
750	756	91.7	4.4	18.25	755	93.0	15.06	3.19	0.72
1000	1003	91.7	4.4	19.09	1004	93.3	15.79	3.31	0.75
1250	1255	91.9	4.4	18.13	1254	93.6	14.86	3.28	0.74
1500	1500	92.0	4.4	16.62	1501	93.9	13.42	3.20	0.72
1750	1751	92.0	4.5	15.28	1750	93.8	12.16	3.12	0.69
2000	1998	92.0	4.4	14.43	1997	93.3	11.26	3.17	0.72
2250	2247	92.0	4.4	14.03	2246	92.9	10.70	3.32	0.75
2500	2492	92.0	4.4	13.97	2492	92.6	10.70	3.27	0.75
2750	2740	92.1	4.4	14.04	2739	92.2	10.74	3.30	0.75
3000	3002	92.2	3.4	12.96	3002	92.1	10.44	2.52	0.74

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
4	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	510	90.6	2.7	15.26	505	89.6	13.04	2.22	0.81
750	755	90.6	4.4	19.67	755	89.0	16.48	3.19	0.72
1000	1005	90.3	4.4	20.43	1003	88.9	18.34	2.09	0.48
1250	1254	89.7	4.4	19.80	1253	88.9	15.77	4.04	0.91
1500	1501	89.1	4.4	18.54	1501	88.9	14.71	3.83	0.86
1750	1750	88.7	4.5	17.46	1750	88.9	13.98	3.48	0.78
2000	1998	88.4	4.4	16.69	1996	88.8	13.39	3.29	0.74
2250	2245	88.1	4.4	15.39	2245	88.6	13.07	2.32	0.53
2500	2493	88.0	4.4	15.09	2492	88.5	12.70	2.40	0.54
2750	2738	87.9	4.4	15.11	2739	88.2	12.60	2.51	0.57
3000	2999	87.9	3.7	14.99	2999	88.0	12.52	2.47	0.67

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
5	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	513	88.1	3.2	16.83	505	90.4	13.84	2.99	0.92
750	756	88.0	4.5	20.94	755	92.6	17.55	3.38	0.75
1000	1003	87.9	4.4	21.59	1003	92.5	18.50	3.08	0.70
1250	1253	88.0	4.4	20.58	1253	92.4	17.59	3.00	0.68
1500	1502	88.1	4.4	19.67	1501	92.3	16.85	2.82	0.64
1750	1751	88.1	4.4	18.88	1750	92.0	16.22	2.65	0.60
2000	1996	88.1	4.4	18.37	1997	91.6	15.82	2.55	0.58
2250	2246	88.1	4.4	17.60	2246	91.0	15.40	2.19	0.50
2500	2491	88.1	4.4	17.49	2492	90.3	14.72	2.78	0.63
2750	2738	88.1	4.4	17.72	2739	89.4	14.83	2.89	0.65
3000	2999	88.2	3.5	17.28	2999	88.5	15.03	2.25	0.64

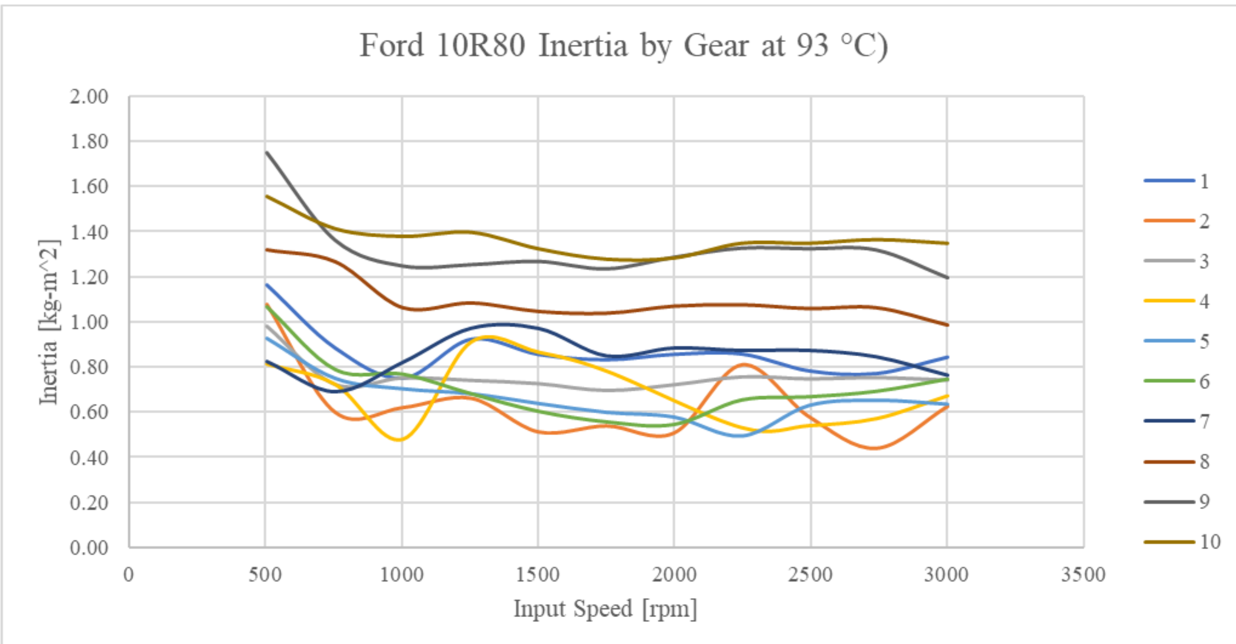
Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
6	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	511	91.9	2.9	18.72	505	93.3	15.57	3.15	1.07
750	756	91.8	4.4	23.90	755	94.2	20.43	3.47	0.79
1000	1003	91.2	4.4	25.89	1003	94.4	22.50	3.39	0.77
1250	1255	90.9	4.3	25.26	1253	94.8	22.31	2.96	0.68
1500	1499	91.1	4.4	23.92	1500	95.2	21.27	2.65	0.60
1750	1748	91.2	4.4	22.79	1750	95.4	20.36	2.43	0.56
2000	1997	91.2	4.4	21.90	1997	95.4	19.50	2.40	0.54
2250	2245	91.3	4.4	22.16	2245	95.0	19.30	2.85	0.65
2500	2492	91.5	4.4	22.59	2491	94.2	19.62	2.97	0.67
2750	2738	91.5	4.4	23.02	2738	93.1	19.98	3.04	0.69
3000	2999	91.7	3.7	23.11	3000	91.9	20.35	2.76	0.75

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
7	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	511	94.1	2.7	14.58	505	91.1	12.36	2.22	0.82
750	755	93.9	4.4	19.36	755	86.9	16.36	3.00	0.69
1000	1003	93.6	4.4	20.19	1003	87.0	16.61	3.58	0.82
1250	1254	92.8	4.4	19.87	1253	87.3	15.54	4.33	0.97
1500	1499	91.8	4.4	18.43	1501	87.6	14.15	4.28	0.97
1750	1750	91.2	4.4	17.01	1750	87.8	13.30	3.71	0.85
2000	1998	90.8	4.4	16.33	1997	88.0	12.42	3.91	0.88
2250	2247	90.5	4.4	16.15	2246	88.4	12.29	3.86	0.87
2500	2493	90.2	4.4	16.05	2491	88.9	12.20	3.84	0.87
2750	2738	90.0	4.4	16.09	2739	89.4	12.33	3.76	0.84
3000	3001	89.9	3.4	14.89	2999	89.8	12.30	2.59	0.76

Gear	Ramp				Steady State				
8	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	513	86.8	3.3	18.43	505	88.7	14.02	4.41	1.32
750	754	86.8	4.4	22.33	755	89.5	16.70	5.63	1.27
1000	1004	86.7	4.4	22.24	1003	89.6	17.55	4.69	1.06
1250	1253	86.3	4.4	21.20	1253	89.6	16.44	4.76	1.08
1500	1502	85.8	4.4	20.35	1501	89.5	15.76	4.59	1.04
1750	1751	85.5	4.5	20.18	1750	89.3	15.57	4.61	1.04
2000	1996	85.4	4.4	20.44	1997	89.1	15.75	4.69	1.07
2250	2246	85.3	4.4	20.90	2246	88.9	16.20	4.70	1.07
2500	2491	85.2	4.4	21.57	2492	88.3	16.90	4.68	1.06
2750	2740	85.3	4.4	22.38	2739	87.4	17.66	4.72	1.06
3000	2999	85.4	3.6	21.99	2999	86.0	18.47	3.52	0.98

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
9	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	511	89.2	2.7	18.59	505	91.1	13.92	4.67	1.75
750	755	89.1	4.4	22.96	755	92.8	16.90	6.06	1.36
1000	1004	89.0	4.5	23.90	1003	93.2	18.32	5.58	1.25
1250	1254	88.8	4.4	23.36	1253	93.6	17.82	5.54	1.25
1500	1500	88.6	4.4	23.28	1501	94.0	17.70	5.59	1.27
1750	1749	88.5	4.4	23.79	1750	94.1	18.35	5.44	1.23
2000	1996	88.6	4.4	24.96	1997	93.8	19.28	5.68	1.28
2250	2246	88.7	4.4	26.42	2245	93.4	20.60	5.83	1.33
2500	2491	88.9	4.4	28.04	2491	92.8	22.22	5.82	1.32
2750	2738	89.0	4.3	30.11	2738	91.7	24.40	5.71	1.32
3000	2999	89.2	3.6	31.07	2999	90.0	26.78	4.30	1.19

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
10	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	513	91.5	3.1	17.12	505	90.7	12.29	4.83	1.56
750	756	91.5	4.5	21.11	755	90.6	14.71	6.40	1.41
1000	1003	91.4	4.5	22.02	1003	90.8	15.85	6.17	1.38
1250	1253	90.6	4.4	21.24	1253	91.1	15.10	6.14	1.40
1500	1500	89.7	4.4	20.50	1500	91.2	14.63	5.87	1.32
1750	1747	89.6	3.8	19.81	1750	91.3	14.96	4.86	1.27
2000	1996	88.8	4.4	21.30	1997	91.3	15.62	5.68	1.28
2250	2244	88.6	4.4	22.52	2244	91.2	16.56	5.95	1.35
2500	2492	88.6	4.4	23.39	2491	91.0	17.43	5.96	1.35
2750	2737	88.7	4.4	24.81	2738	90.4	18.78	6.03	1.36
3000	3000	88.8	3.5	25.08	2999	89.2	20.40	4.68	1.35



65 °C

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
1	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	513	65.4	2.9	18.52	505	65.0	15.68	2.84	0.97
750	755	65.5	4.4	18.05	756	64.9	14.51	3.54	0.81
1000	1003	65.4	4.4	17.12	1004	64.9	12.99	4.12	0.93
1250	1254	64.1	4.3	15.69	1253	64.9	11.59	4.10	0.96
1500	1501	63.4	4.4	15.07	1501	65.0	11.04	4.03	0.92
1750	1750	63.1	4.4	14.82	1750	64.9	10.71	4.11	0.93
2000	1997	63.2	4.4	14.77	1997	64.8	10.66	4.12	0.94
2250	2247	63.4	4.4	14.84	2246	64.7	10.95	3.89	0.89
2500	2492	63.5	4.4	15.13	2492	64.5	11.84	3.30	0.75
2750	2740	63.5	4.4	15.47	2739	64.1	12.91	2.56	0.58
3000	3000	63.4	3.6	15.28	3000	63.5	13.59	1.69	0.47

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
2	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	511	63.7	2.6	19.37	505	64.9	16.64	2.73	1.04
750	755	63.8	4.4	20.04	755	65.8	15.93	4.11	0.93
1000	1004	63.7	4.4	19.07	1003	66.1	14.95	4.12	0.93
1250	1254	63.7	4.5	17.70	1253	66.4	13.34	4.37	0.98
1500	1501	63.7	4.4	16.70	1501	66.7	12.45	4.25	0.96
1750	1750	63.8	4.4	16.22	1750	67.0	12.16	4.06	0.92
2000	1997	63.8	4.4	16.27	1997	67.2	12.12	4.15	0.94
2250	2247	63.9	4.4	16.49	2246	67.1	12.37	4.12	0.93
2500	2492	64.1	4.4	16.71	2492	66.3	13.39	3.32	0.75
2750	2738	64.2	4.4	17.23	2739	65.5	13.75	3.49	0.78
3000	2999	64.4	3.7	17.75	3000	64.6	14.60	3.15	0.85

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
3	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	511	64.2	2.7	17.48	505	64.2	14.99	2.49	0.92
750	756	63.9	4.4	18.63	755	64.4	15.23	3.40	0.77
1000	1003	63.5	4.4	17.47	1003	64.5	13.51	3.96	0.90
1250	1254	63.2	4.4	15.60	1253	64.9	12.33	3.27	0.73
1500	1501	63.1	4.4	14.72	1501	64.9	11.16	3.56	0.81
1750	1751	63.2	4.4	13.97	1750	64.8	10.44	3.53	0.80
2000	1997	63.3	4.4	13.72	1997	64.8	9.90	3.82	0.87
2250	2247	63.4	4.4	13.73	2246	65.2	10.12	3.61	0.83
2500	2492	63.4	4.4	13.73	2492	64.5	10.05	3.68	0.83
2750	2739	63.5	4.4	13.31	2739	63.9	9.97	3.35	0.75
3000	3000	63.6	3.6	12.47	3000	63.7	9.98	2.49	0.69

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
4	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	512	64.3	3.2	20.41	505	65.1	17.39	3.02	0.95
750	755	64.2	4.5	20.69	755	65.5	17.10	3.59	0.80
1000	1002	63.7	4.4	20.81	1004	65.2	16.83	3.97	0.90
1250	1254	62.7	4.4	19.57	1254	65.2	15.45	4.12	0.93
1500	1501	62.6	4.3	17.73	1501	65.1	14.75	2.98	0.69
1750	1750	62.4	4.4	17.04	1750	64.9	14.39	2.64	0.60
2000									
2250	2247	62.2	4.4	16.57	2247	64.5	13.78	2.79	0.63
2500	2493	62.2	4.4	16.31	2493	63.9	13.59	2.72	0.62
2750	2740	62.2	4.4	16.48	2740	63.2	13.75	2.72	0.61
3000	2999	62.2	3.6	15.90	3000	62.4	13.72	2.18	0.60

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
5	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	511	66.6	2.9	21.00	505	66.0	18.51	2.49	0.87
750	756	66.4	4.5	21.72	755	65.1	18.03	3.69	0.82
1000	1003	66.1	4.5	21.46	1004	65.0	16.99	4.47	1.00
1250	1255	65.3	4.5	20.31	1253	65.3	15.96	4.35	0.98
1500	1500	64.9	4.4	19.74	1501	65.5	15.58	4.15	0.93
1750	1749	64.7	4.4	18.29	1750	65.6	15.29	3.00	0.68
2000	1998	64.5	4.4	18.17	1997	65.5	15.13	3.04	0.68
2250	2246	64.5	4.4	17.92	2246	65.3	14.93	2.99	0.68
2500	2491	64.4	4.5	18.10	2491	65.0	15.02	3.08	0.69
2750	2739	64.3	4.4	18.38	2739	64.8	15.28	3.10	0.70
3000	3000	64.3	3.6	18.12	3000	64.4	15.60	2.52	0.70

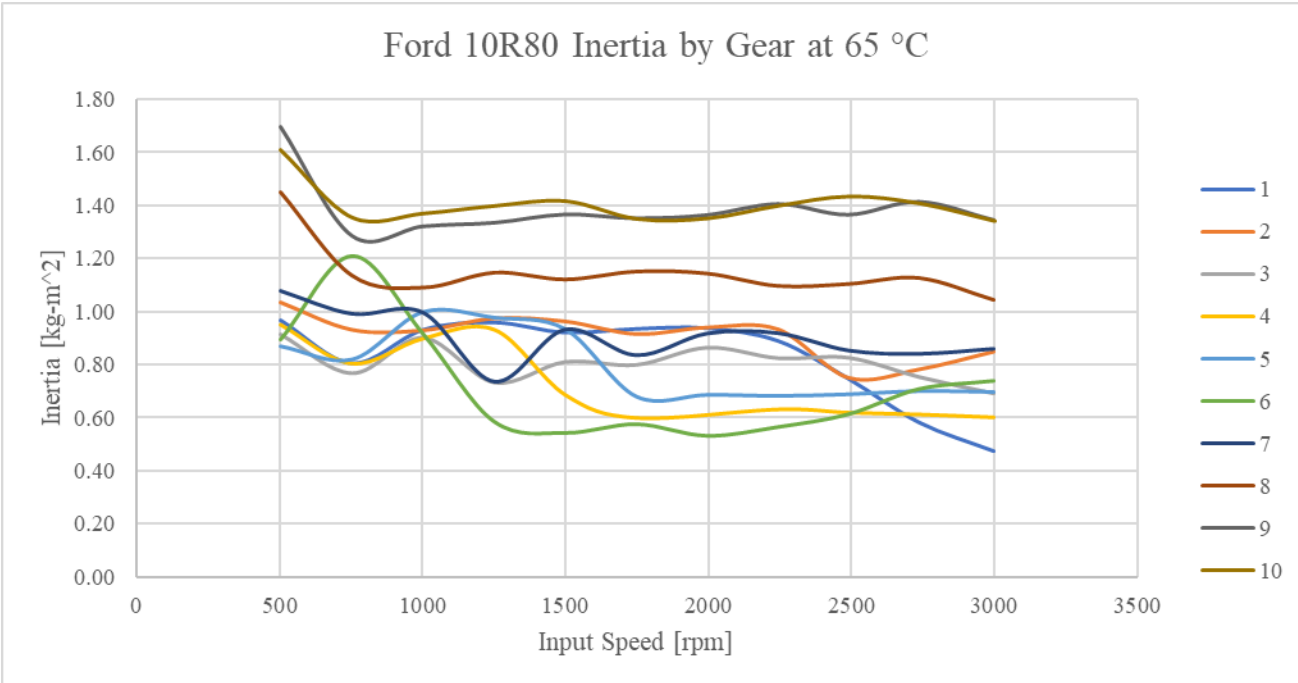
Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
6	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	512	62.2	3.1	24.29	505	64.7	21.57	2.72	0.89
750	757	62.2	4.4	26.71	755	66.3	21.40	5.31	1.21
1000	1002	62.1	4.4	25.67	1003	66.3	21.62	4.05	0.91
1250	1252	61.7	4.4	23.24	1253	66.4	20.66	2.58	0.58
1500	1501	61.4	4.4	22.12	1501	66.3	19.76	2.37	0.54
1750	1750	61.2	4.4	21.44	1750	65.9	18.90	2.54	0.57
2000	1997	61.2	4.5	21.28	1997	65.4	18.89	2.39	0.53
2250	2245	61.2	4.4	21.55	2246	64.8	19.04	2.51	0.56
2500	2490	61.3	4.4	21.89	2492	63.8	19.18	2.71	0.61
2750	2740	61.4	4.4	22.44	2739	62.9	19.33	3.11	0.71
3000	3001	61.6	3.5	22.08	3000	61.9	19.52	2.57	0.74

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
7	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	513	64.7	3.0	19.34	505	65.4	16.12	3.22	1.08
750	754	64.6	4.4	20.19	756	65.6	15.78	4.41	0.99
1000	1004	64.5	4.5	18.68	1003	65.6	14.24	4.44	1.00
1250	1253	64.2	4.4	16.71	1254	65.8	13.48	3.23	0.73
1500	1502	64.0	4.4	16.45	1501	66.0	12.33	4.12	0.93
1750	1751	63.9	4.4	15.54	1750	66.1	11.89	3.65	0.83
2000	1997	63.9	4.4	15.20	1997	66.0	11.14	4.05	0.92
2250	2247	63.9	4.4	15.26	2246	65.8	11.20	4.06	0.92
2500	2492	63.9	4.4	15.03	2492	65.4	11.28	3.75	0.85
2750	2739	64.1	4.4	15.00	2739	65.0	11.30	3.70	0.84
3000	3000	64.2	3.6	14.02	3000	64.4	10.96	3.06	0.86

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
8	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	513	65.1	3.1	21.49	505	64.9	16.96	4.53	1.45
750	755	65.1	4.4	21.33	755	65.0	16.28	5.05	1.14
1000	1004	64.7	4.4	20.87	1003	64.9	16.01	4.86	1.09
1250	1254	63.6	4.5	20.05	1253	64.9	14.91	5.14	1.15
1500	1501	62.7	4.5	19.66	1501	64.9	14.65	5.01	1.12
1750	1752	62.0	4.4	19.75	1750	64.8	14.68	5.07	1.15
2000	1997	61.5	4.4	20.27	1997	64.7	15.24	5.03	1.14
2250	2247	61.3	4.4	20.84	2246	64.5	15.96	4.89	1.10
2500	2492	61.4	4.4	21.67	2492	64.1	16.77	4.89	1.11
2750	2740	61.5	4.4	22.65	2740	63.4	17.67	4.98	1.13
3000	3000	61.7	3.5	22.16	3000	62.2	18.52	3.65	1.05

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
9	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	512	66.9	2.7	21.39	505	66.0	16.78	4.61	1.70
750	756	67.0	4.4	22.58	756	65.9	16.88	5.70	1.29
1000	1003	66.7	4.4	22.68	1003	66.2	16.83	5.85	1.32
1250	1253	66.0	4.4	22.17	1254	66.6	16.27	5.91	1.34
1500	1502	65.2	4.5	22.75	1501	67.0	16.65	6.09	1.37
1750	1751	64.6	4.5	23.73	1750	67.3	17.65	6.08	1.35
2000	1996	64.4	4.4	24.83	1996	67.5	18.83	6.00	1.36
2250	2246	64.4	4.4	26.36	2246	67.4	20.18	6.18	1.41
2500	2491	64.5	4.5	28.08	2491	67.2	22.00	6.08	1.37
2750	2740	64.6	4.4	30.08	2739	66.7	23.85	6.22	1.41
3000	3001	64.8	3.5	30.87	3000	65.4	26.16	4.71	1.35

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
10	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	512	62.9	2.9	18.85	505	65.2	14.25	4.60	1.61
750	755	63.1	4.5	20.95	755	67.1	14.89	6.05	1.35
1000	1004	63.4	4.4	20.87	1004	67.4	14.78	6.09	1.37
1250	1254	63.8	4.4	19.93	1254	67.8	13.75	6.18	1.40
1500	1501	64.0	4.4	20.17	1501	68.3	13.96	6.21	1.42
1750	1750	64.2	4.5	20.54	1750	68.9	14.54	6.00	1.35
2000	1997	64.3	4.4	21.37	1997	69.2	15.46	5.90	1.35
2250	2247	64.4	4.4	22.63	2246	69.2	16.48	6.15	1.40
2500	2492	64.6	4.4	23.97	2492	68.9	17.63	6.34	1.43
2750	2740	64.9	4.4	25.32	2740	68.1	19.12	6.20	1.41
3000	3001	65.2	3.5	25.80	3001	66.1	21.05	4.75	1.34



40 °C

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
1	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	507	41.1	2.8	21.85	502	41.4	17.55	4.30	1.53
750	756	41.1	4.5	22.04	755	42.3	11.05	10.99	2.45
1000	1003	41.1	4.4	19.75	1004	42.5	9.62	10.12	2.31
1250	1255	40.6	4.4	13.27	1254	42.6	9.20	4.07	0.92
1500									
1750	1751	40.3	4.4	13.68	1751	42.6	9.25	4.44	1.00
2000	1998	40.1	4.4	13.83	1998	42.4	9.46	4.37	0.99
2250	2248	39.9	4.4	14.12	2247	42.3	10.15	3.97	0.90
2500	2493	39.9	4.4	14.60	2493	42.1	11.15	3.45	0.78
2750									
3000	2986	40.1	4.5	16.21	2986	41.5	12.75	3.46	0.77

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
2	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	512	38.0	2.8	20.98	505	39.3	17.62	3.36	1.21
750	754	38.1	4.5	21.13	755	41.2	15.58	5.55	1.25
1000	1004	38.2	4.5	19.50	1004	41.3	14.07	5.43	1.22
1250	1253	37.9	4.4	18.73	1254	41.3	13.20	5.53	1.25
1500	1502	37.8	4.4	18.20	1501	41.2	12.82	5.38	1.22
1750	1751	37.6	4.5	18.04	1750	41.1	12.56	5.49	1.23
2000	1998	37.6	4.5	18.20	1997	40.9	12.74	5.46	1.20
2250	2246	37.6	4.4	18.24	2247	40.5	13.20	5.04	1.14
2500	2493	37.6	4.5	18.31	2493	39.8	14.79	3.52	0.79
2750	2741	37.7	4.4	18.94	2740	39.0	17.94	1.00	0.23
3000	2987	37.8	3.4	18.84	2986	38.1	16.15	2.69	0.78

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
3	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	511	39.1	2.6	18.43	505	40.0	16.14	2.28	0.87
750	755	39.0	4.4	18.56	756	40.8	15.21	3.35	0.76
1000	1005	38.9	4.4	16.65	1004	40.6	13.15	3.50	0.79
1250	1254	38.8	4.4	15.17	1254	40.8	11.44	3.73	0.84
1500	1501	38.6	4.4	14.63	1501	41.1	10.86	3.77	0.85
1750									
2000	1998	38.8	4.4	13.89	1998	41.1	10.41	3.49	0.79
2250	2248	39.0	4.4	13.93	2247	41.0	10.41	3.52	0.80
2500	2504	39.2	4.4	14.25	2504	40.7	10.65	3.60	0.81
2750	2747	39.4	4.4	14.23	2748	40.3	10.74	3.50	0.79
3000	2995	39.5	3.8	13.53	2996	39.8	10.63	2.90	0.77

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
4	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	512	39.0	3.0	20.02	505	40.6	17.91	2.11	0.70
750	757	39.0	4.5	21.97	755	42.6	17.75	4.22	0.95
1000	1002	38.9	4.4	21.39	1003	42.7	16.79	4.60	1.05
1250	1254	39.1	4.5	18.98	1254	42.7	16.05	2.93	0.65
1500	1500	39.3	4.5	18.59	1501	42.7	15.52	3.07	0.69
1750	1750	39.6	4.5	17.88	1751	42.5	14.90	2.99	0.67
2000	1997	39.7	4.4	17.19	1997	42.2	14.34	2.84	0.65
2250	2244	39.8	4.4	17.15	2246	41.9	14.23	2.92	0.66
2500	2492	39.9	4.4	16.99	2492	41.6	14.09	2.91	0.66
2750	2740	39.9	4.3	17.21	2739	41.1	13.99	3.21	0.74
3000	3001	40.0	3.7	16.53	3000	40.4	14.03	2.50	0.67

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
5	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	511	39.8	2.9	20.58	505	41.3	18.33	2.25	0.77
750	756	39.7	4.4	22.12	756	43.4	18.01	4.11	0.94
1000	1003	39.7	4.4	21.62	1003	43.8	16.58	5.04	1.15
1250	1255	39.9	4.5	19.31	1253	43.7	16.01	3.30	0.74
1500	1500	40.2	4.4	18.67	1501	43.7	15.77	2.90	0.65
1750	1751	40.4	4.4	18.16	1750	43.5	15.48	2.69	0.62
2000	1998	40.5	4.5	18.05	1997	43.3	15.50	2.55	0.57
2250	2248	40.6	4.3	18.22	2246	42.9	15.41	2.81	0.65
2500	2493	40.7	4.4	18.34	2492	42.5	15.30	3.04	0.69
2750	2739	40.8	4.4	18.60	2739	41.8	15.50	3.10	0.70
3000	3001	40.8	3.5	18.13	3001	41.1	15.64	2.49	0.71

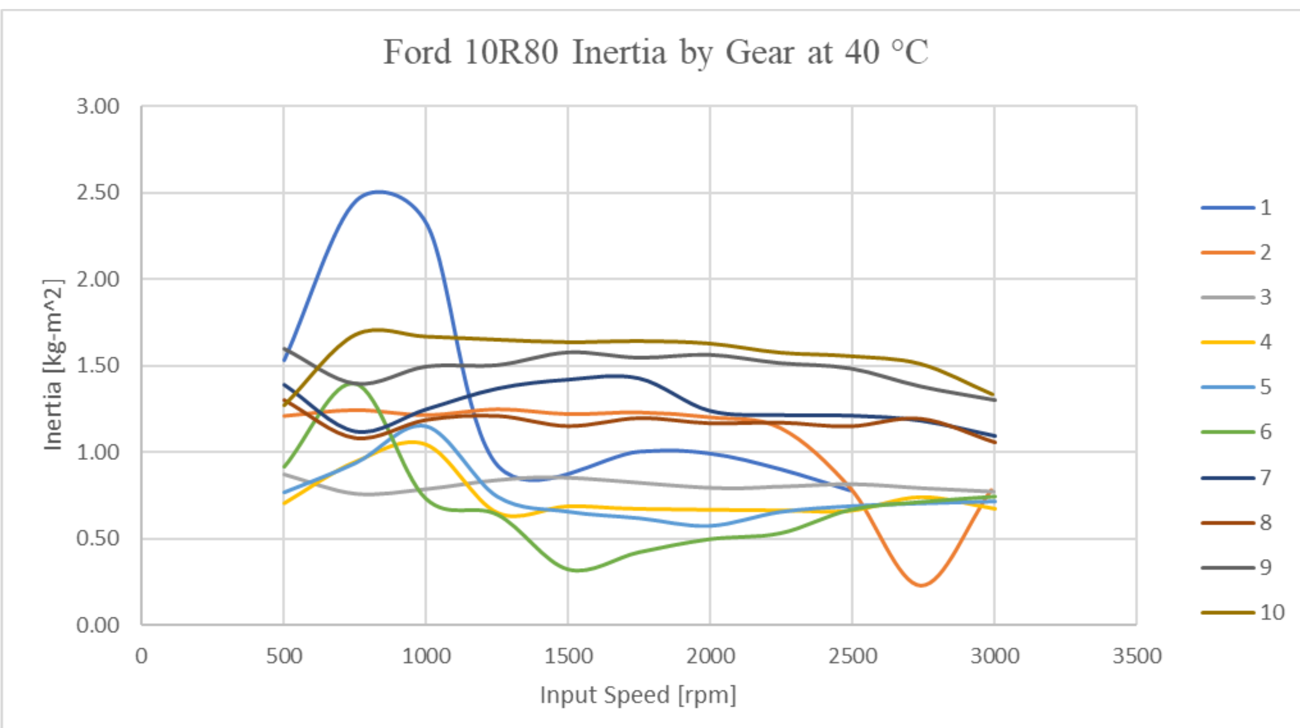
Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
6	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	511	41.6	2.7	26.54	505	44.4	24.03	2.51	0.91
750	756	41.6	4.4	28.92	755	47.9	22.73	6.18	1.40
1000	1001	41.8	4.4	25.07	1002	47.8	21.85	3.21	0.73
1250	1254	42.1	4.4	24.25	1254	47.8	21.45	2.80	0.64
1500	1501	42.2	4.5	22.68	1501	47.6	21.25	1.43	0.32
1750	1750	42.4	4.4	22.50	1750	47.4	20.67	1.83	0.42
2000	1997	42.5	4.4	22.76	1997	46.9	20.58	2.18	0.49
2250	2247	42.5	4.4	23.10	2246	46.3	20.76	2.34	0.53
2500	2492	42.6	4.4	23.91	2492	45.6	20.95	2.96	0.67
2750	2740	42.8	4.5	24.39	2740	44.7	21.19	3.20	0.71
3000	3001	42.9	3.6	24.29	3000	43.4	21.65	2.65	0.74

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
7	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	510	38.8	2.7	20.06	505	40.1	16.37	3.68	1.39
750	755	38.8	4.5	20.05	755	40.8	15.05	5.00	1.12
1000	1004	38.8	4.4	17.49	1004	40.8	11.95	5.54	1.25
1250	1253	38.9	4.4	16.97	1254	40.8	10.92	6.05	1.37
1500	1502	39.1	4.4	16.75	1501	40.7	10.51	6.24	1.42
1750	1751	39.1	4.4	16.74	1750	40.6	10.43	6.31	1.43
2000	1997	39.2	4.5	15.90	1997	40.7	10.39	5.51	1.24
2250	2246	39.2	4.4	15.98	2246	40.7	10.62	5.37	1.21
2500	2491	39.3	4.4	16.41	2492	40.6	11.06	5.35	1.21
2750	2739	39.4	4.4	16.47	2739	40.3	11.25	5.22	1.18
3000	3000	39.6	3.7	15.63	3001	39.9	11.62	4.01	1.09

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
8	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	512	39.3	3.1	20.35	505	41.8	16.33	4.02	1.30
750	753	39.3	4.4	20.79	754	43.4	15.99	4.80	1.08
1000	1003	39.3	4.4	20.30	1003	43.4	15.09	5.20	1.19
1250	1252	39.3	4.4	19.96	1254	43.5	14.60	5.36	1.21
1500	1502	39.3	4.4	19.80	1501	43.5	14.69	5.11	1.15
1750	1751	39.3	4.4	20.41	1750	43.5	15.13	5.29	1.20
2000	1996	39.4	4.4	21.13	1997	43.3	15.97	5.16	1.17
2250	2246	39.5	4.4	21.91	2245	43.1	16.74	5.17	1.17
2500	2491	39.6	4.5	23.03	2490	42.8	17.92	5.11	1.15
2750	2741	39.8	4.4	24.18	2740	42.0	18.94	5.24	1.19
3000	3000	40.1	3.7	24.05	3000	40.6	20.17	3.88	1.05

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
9	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	511	40.0	2.7	20.61	505	42.9	16.29	4.32	1.60
750	755	40.0	4.5	22.57	755	45.1	16.36	6.20	1.39
1000	1005	39.9	4.4	22.57	1004	45.3	15.99	6.57	1.49
1250	1254	39.9	4.4	22.83	1253	45.5	16.18	6.65	1.50
1500	1502	39.9	4.5	24.13	1501	45.5	17.11	7.02	1.58
1750	1750	40.0	4.4	25.30	1750	45.6	18.44	6.87	1.55
2000	1998	40.1	4.4	27.02	1997	45.4	20.09	6.93	1.56
2250	2246	40.2	4.5	28.76	2245	45.1	21.88	6.88	1.51
2500	2493	40.4	4.4	30.19	2492	44.5	23.59	6.60	1.48
2750	2739	40.8	4.4	31.95	2739	43.5	25.85	6.10	1.38
3000	3001	41.1	3.4	32.74	3001	41.8	28.30	4.44	1.30

Gear	Acceleration Ramp Torque				Steady State Torque			Inertia Calcs	
10	Speed (RPM)	Temp (°C)	Acceleration (rad/s^2)	Torque (Nm)	Speed (RPM)	Temp (°C)	Torque (Nm)	Accel Torque (Nm)	Inertia (kgm^2)
500	512	41.3	3.1	18.88	505	42.7	14.93	3.95	1.27
750	756	41.2	4.5	21.54	755	43.9	14.08	7.46	1.68
1000	1003	41.2	4.4	20.94	1003	44.1	13.54	7.39	1.67
1250	1254	41.4	4.4	21.00	1254	44.4	13.68	7.32	1.65
1500	1501	41.0	4.4	21.60	1500	44.6	14.37	7.23	1.63
1750	1751	41.2	4.5	22.40	1750	44.8	15.10	7.30	1.64
2000	1997	41.6	4.4	23.41	1997	45.1	16.28	7.13	1.63
2250	2246	41.5	4.4	24.70	2246	45.0	17.70	7.00	1.57
2500	2491	41.7	4.4	25.92	2492	44.6	19.07	6.85	1.55
2750	2740	41.8	4.4	27.42	2739	43.5	20.73	6.69	1.51
3000	2992	41.9	3.8	28.16	2993	43.1	23.09	5.08	1.33



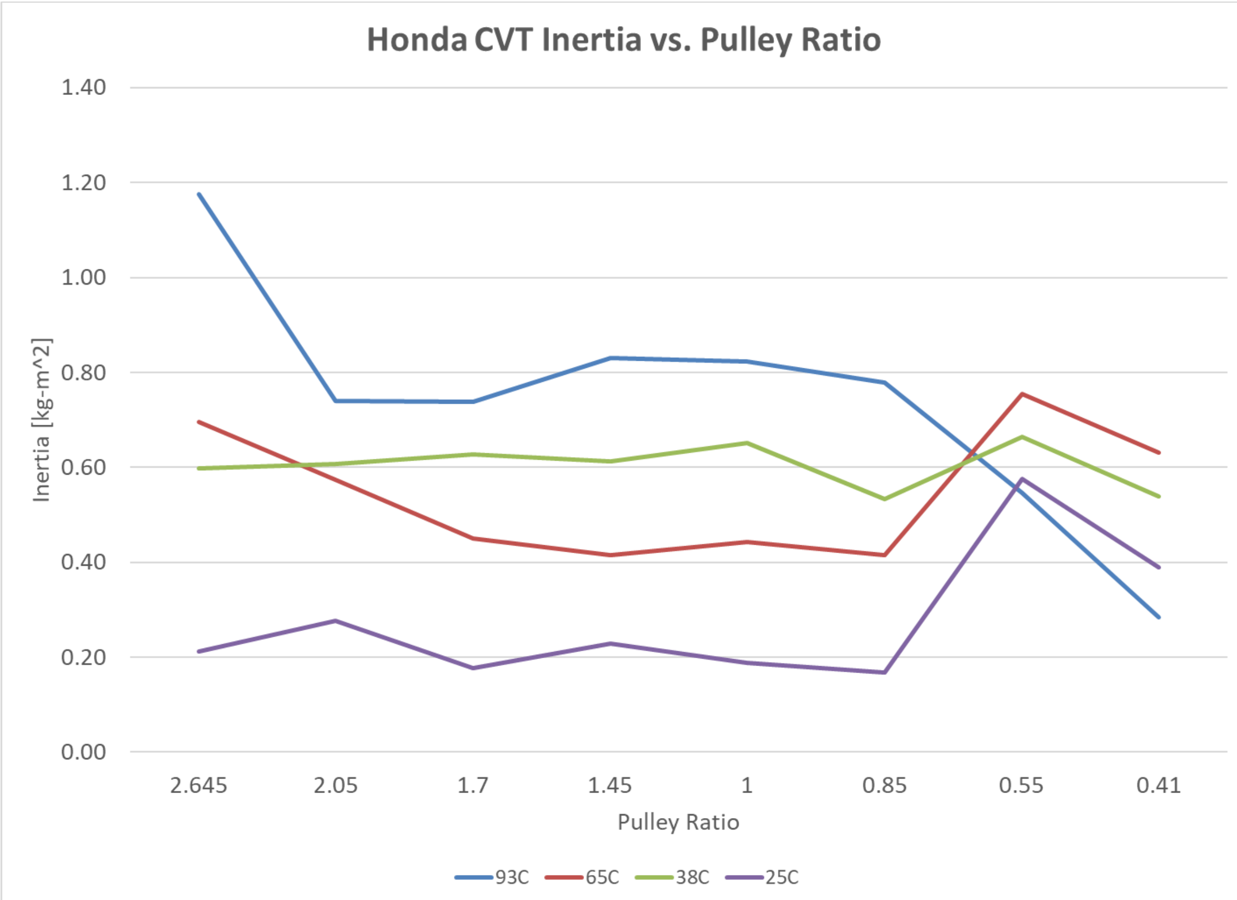
Honda Earth Dreams CVT – Inertia Data

Input Speed (rpm)	Target Ratio	Sump Termperature	Input Torque	Spinloss Torque	Pulley Ratio	Primary Pressure	Secondary Pressure	Acceleratioin	Inertia
1000	2.645	91.8	8.5	2.2	2.63	311.5	985.5	4.49	1.27
1250	2.645	92.1	8.5	2.1	2.56	304.7	975.1	4.43	1.30
1500	2.645	92.3	8.5	2.6	2.53	298.5	979.6	4.42	1.19
1750	2.645	92.3	8.8	2.8	2.52	299.0	1001.9	4.42	1.20
2000	2.645	92.3	8.9	3.3	2.51	295.4	1008.6	4.43	1.11
2250	2.645	92.6	9.6	3.6	2.54	288.7	1080.2	4.43	1.21
2500	2.645	92.7	9.2	4.0	2.54	288.6	1090.8	2.64	1.81
1000	2.05	85.8	5.5	2.6	1.91	123.1	468.0	4.55	0.49
1250	2.05	85.8	6.5	1.9	2.03	139.2	668.2	4.42	0.89
1500	2.05	86.0	6.7	2.7	2.19	167.8	627.8	4.42	0.75
1750	2.05	86.1	6.7	2.5	2.06	158.7	633.6	4.43	0.80
2000	2.05	86.6	7.0	3.2	1.97	151.3	660.0	4.43	0.71
2250	2.05	86.7	7.2	3.5	1.95	143.8	682.4	4.43	0.69
2500	2.05	86.7	7.0	4.0	1.96	136.2	693.4	2.82	0.91
1000	1.7	87.9	6.3	2.6	1.67	162.0	574.7	4.48	0.67
1250	1.7	88.2	6.3	1.9	1.65	160.8	582.3	4.43	0.85
1500	1.7	88.4	6.4	2.7	1.59	153.4	584.8	4.42	0.70
1750	1.7	88.2	6.7	2.5	1.59	153.7	629.6	4.42	0.79
2000	1.7	88.4	7.1	3.2	1.64	156.5	672.0	4.43	0.74
2250	1.7	88.7	7.4	3.5	1.74	156.5	693.1	4.43	0.72
2500	1.7	89.2	7.1	4.0	1.80	160.9	696.2	2.67	1.02
1000	1.45	91.1	7.1	2.8	1.42	221.6	704.2	4.49	0.81
1250	1.45	91.1	7.1	2.3	1.41	216.5	711.5	4.43	0.93
1500	1.45	90.3	7.0	2.6	1.46	191.7	674.7	4.42	0.85
1750	1.45	90.0	7.1	2.9	1.46	187.9	694.5	4.42	0.81
2000	1.45	91.1	7.7	3.4	1.39	207.5	765.5	4.43	0.83
2250	1.45	91.5	8.1	3.5	1.38	210.0	808.2	4.43	0.90
2500	1.45	92.5	7.9	4.0	1.40	212.5	841.1	2.17	1.65
1000	1	91.6	6.3	2.7	0.96	233.4	482.2	4.47	0.63
1250	1	90.9	6.4	2.8	0.96	233.6	510.2	4.43	0.68
1500	1	91.1	6.6	2.3	0.96	240.8	511.4	4.42	0.82
1750	1	91.1	6.9	2.6	0.95	242.2	513.7	4.42	0.81
2000	1	91.0	7.2	2.9	0.94	244.2	519.0	4.43	0.83
2250	1	91.5	7.4	3.1	0.95	243.0	531.3	4.43	0.82
2500	1	92.1	6.8	3.4	0.98	233.9	536.8	2.10	1.48
1000	0.85	88.6	6.9	4.1	0.85	249.6	492.4	4.49	0.47
1250	0.85	89.1	6.8	3.8	0.87	250.2	498.3	4.43	0.53
1500	0.85	89.6	7.0	2.9	0.88	251.1	496.8	4.42	0.78
1750	0.85	89.5	7.3	3.3	0.86	252.8	498.7	4.42	0.75
2000	0.85	89.3	7.7	3.6	0.86	255.9	505.7	4.43	0.77
2250	0.85	89.0	8.2	3.9	0.85	257.7	506.7	4.43	0.81
2500	0.85	90.4	7.3	4.4	0.90	240.8	511.3	2.15	1.21
1000	0.55	89.6	7.4	4.0	0.50	209.2	277.5	4.49	0.61
1250	0.55	89.9	7.9	6.2	0.51	211.1	271.8	4.43	0.24
1500	0.55	89.8	8.2	4.8	0.52	203.2	242.1	4.42	0.63
1750	0.55	89.9	8.7	5.7	0.51	210.3	224.6	4.42	0.53
2000	0.55	89.8	9.6	6.8	0.51	219.3	195.6	4.43	0.48
2250	0.55	89.2	10.0	7.7	0.52	224.8	177.7	4.43	0.37
2500	0.55	88.8	9.7	8.1	0.54	221.3	174.4	4.14	0.24
1000	0.41	90.8	7.6	5.6	0.43	205.0	198.4	4.49	0.31
1250	0.41	90.8	8.4	6.7	0.43	208.9	198.9	4.43	0.24
1500	0.41	90.5	9.0	7.1	0.44	212.8	199.6	4.42	0.30
1750	0.41	90.2	9.0	8.6	0.49	216.0	212.6	4.42	-0.07
2000	0.41	89.9	9.6	9.3	0.51	220.4	193.1	4.43	-0.09
2250	0.41	89.4	10.7	10.9	0.49	236.5	148.5	4.43	-0.21
2500	0.41	89.2	10.9	12.3	0.48	242.3	123.1	4.38	-0.47

Input Speed (rpm)	Input Torque (Nm)	Belt Ratio	Sump Termperature	Input Speed	Input Torque	Output Speed	Spinloss Torque	Pulley Ratio	Primary Pressure	Secondary Pressure	Acceleratioin	Inertia
1000	15	2.645	64.9	912.9	5.8	72.1	2.7	2.51	188.9	575.6	4.59	0.53
1250	15	2.645	64.7	1334.5	6.7	102.7	2.4	2.57	186.5	733.3	4.42	0.82
1500	15	2.645	64.6	1501.4	6.8	113.0	4.1	2.63	194.2	730.0	4.42	0.45
1750	15	2.645	64.4	1750.6	7.0	134.9	2.9	2.57	189.6	744.6	4.43	0.76
2000	15	2.645	64.3	1994.2	7.2	155.5	3.9	2.54	185.5	762.2	4.43	0.59
2250	15	2.645	64.3	2252.4	7.5	175.7	3.5	2.54	177.5	795.2	4.43	0.73
2500	15	2.645	64.4	2414.2	7.3	181.5	4.6	2.64	154.0	814.2	3.20	0.70
1000	15	2.05	63.1	1001.0	5.9	96.6	2.1	2.05	143.4	591.6	4.49	0.70
1250	15	2.05	63.2	1345.3	5.7	123.2	2.3	2.17	141.1	532.6	4.43	0.61
1500	15	2.05	63.3	1500.4	5.8	144.3	2.5	2.06	135.1	544.4	4.42	0.59
1750	15	2.05	63.4	1749.7	6.1	176.3	2.7	1.97	135.6	581.8	4.43	0.63
2000	15	2.05	63.5	1982.3	6.4	203.2	3.2	1.94	133.1	606.8	4.43	0.57
2250	15	2.05	63.5	2096.5	6.5	217.1	3.6	1.91	130.7	612.3	4.43	0.50
2500	15	2.05	64.1	2496.0	6.4	256.3	4.2	1.93	136.7	710.8	0.39	5.50
1000	15	1.7	63.1	1000.9	5.0	119.0	2.0	1.67	93.0	412.0	4.49	0.50
1250	15	1.7	63.0	1234.0	4.9	143.8	2.4	1.71	91.8	393.1	4.43	0.42
1500	15	1.7	62.6	1499.8	5.2	176.4	2.7	1.69	94.6	434.2	4.42	0.42
1750	15	1.7	62.6	1749.1	5.6	209.4	2.9	1.66	96.9	473.0	4.42	0.44
2000	15	1.7	62.6	1990.2	6.0	239.1	3.3	1.65	102.2	510.5	4.43	0.46
2250	15	1.7	62.8	2232.5	6.5	267.7	3.7	1.66	109.6	562.1	4.43	0.47
2500	15	1.7	63.1	2436.4	6.5	293.4	4.3	1.65	115.8	627.5	3.08	0.59
1000	15	1.45	62.7	962.2	5.1	121.3	2.1	1.57	102.5	441.3	4.52	0.50
1250	15	1.45	63.5	1272.4	4.8	162.9	2.3	1.55	82.4	360.1	4.43	0.42
1500	15	1.45	63.5	1500.6	5.0	201.9	2.6	1.48	84.1	383.7	4.42	0.40
1750	15	1.45	63.4	1749.9	5.3	249.0	2.9	1.39	84.4	412.9	4.43	0.40
2000	15	1.45	63.2	2019.1	5.9	280.8	3.3	1.42	92.3	475.0	4.43	0.44
2250	15	1.45	63.0	2276.9	6.4	308.2	3.6	1.47	101.6	538.1	4.44	0.49
2500	15	1.45	63.1	2391.7	6.6	324.8	4.3	1.46	106.3	569.8	4.28	0.38
1000	15	1	61.7	1001.7	4.7	204.9	2.3	0.97	140.9	288.5	4.49	0.37
1250	15	1	61.8	1238.5	5.1	265.7	2.5	0.93	150.7	306.9	4.43	0.44
1500	15	1	61.8	1508.5	5.3	309.4	2.7	0.97	139.9	334.8	4.42	0.44
1750	15	1	62.0	1728.6	5.4	339.4	2.9	1.01	136.6	334.1	4.43	0.44
2000	15	1	62.2	2009.8	5.9	399.9	3.3	1.00	141.7	340.2	4.43	0.45
2250	15	1	62.1	2282.2	6.5	478.1	3.5	0.95	144.0	336.2	4.44	0.53
2500	15	1	62.0	2429.4	6.4	519.4	3.9	0.93	145.4	335.6	3.32	0.61
1000	15	0.85	61.7	1001.7	4.7	204.9	2.8	0.97	140.9	288.5	4.49	0.27
1250	15	0.85	61.7	1250.5	5.1	271.1	3.1	0.92	150.7	306.2	4.43	0.32
1500	15	0.85	61.5	1474.9	5.5	332.8	3.3	0.88	150.4	311.4	4.42	0.36
1750	15	0.85	61.2	1749.5	6.2	417.5	3.4	0.83	153.2	300.9	4.43	0.47
2000	15	0.85	61.4	2026.0	6.5	474.0	3.9	0.85	155.1	316.9	4.43	0.44
2250	15	0.85	61.8	2272.1	6.6	500.1	4.3	0.90	147.9	328.5	4.44	0.38
2500	15	0.85	62.0	2416.4	6.4	521.7	4.9	0.92	145.6	333.3	3.42	0.30
1000	15	0.55	63.0	1001.7	8.7	409.2	4.0	0.49	318.8	400.8	4.49	0.89
1250	15	0.55	63.0	1251.6	9.0	498.9	4.8	0.51	308.9	408.1	4.43	0.80
1500	15	0.55	62.9	1500.9	9.7	579.1	5.4	0.53	309.5	396.0	4.42	0.81
1750	15	0.55	62.9	1750.2	10.1	670.0	6.3	0.53	311.0	368.1	4.43	0.71
2000	15	0.55	62.5	1999.6	10.9	767.3	6.9	0.52	315.5	329.2	4.43	0.74
2250	15	0.55	61.7	2251.4	11.7	873.2	7.7	0.52	320.4	288.8	4.44	0.75
2500	15	0.55	61.1	2450.6	11.3	954.6	8.8	0.52	317.1	243.3	1.84	1.23
1000	15	0.41	63.0	1001.7	8.7	409.2	5.1	0.49	318.8	400.8	4.49	0.65
1250	15	0.41	63.1	1230.4	9.5	530.4	6.3	0.47	315.8	377.9	4.43	0.58
1500	15	0.41	63.2	1501.1	10.9	684.0	7.3	0.44	318.5	330.2	4.42	0.65
1750	15	0.41	63.3	1750.3	11.1	770.9	8.6	0.45	323.2	312.5	4.42	0.41
2000	15	0.41	62.4	2000.2	11.8	847.8	9.2	0.47	329.9	281.5	4.43	0.44
2250	15	0.41	60.9	2249.5	13.1	972.9	10.4	0.46	340.1	221.8	4.44	0.45
2500	15	0.41	60.8	2455.6	12.5	1043.7	11.2	0.47	337.8	191.1	1.61	0.66

Input Speed (rpm)	Belt Ratio	Sump Termperature	Input Torque	Spinloss Torque	Pulley Ratio	Primary Pressure	Secondary Pressure	Acceleratioin	Inertia
1000	2.645	35.4	5.8	2.9	2.61	153.6	517.3	4.50	0.50
1250	2.645	#DIV/0!	#DIV/0!	2.7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1500	2.645	35.5	6.2	2.7	2.55	143.2	590.0	4.42	0.64
1750	2.645	35.5	6.5	3.3	2.57	141.7	612.2	5.72	0.40
2000	2.645	35.5	6.8	3.6	2.56	137.4	631.2	3.45	0.78
2250	2.645	35.5	7.1	3.9	2.56	135.0	657.8	4.44	0.57
2500	2.645	35.6	7.1	4.6	2.69	150.9	765.0	1.11	2.18
1000	2.05	36.7	5.9	2.7	2.03	151.0	538.3	4.49	0.55
1250	2.05	36.7	6.2	3.0	2.05	163.9	621.7	4.43	0.59
1500	2.05	36.7	6.4	3.2	2.06	163.1	604.3	4.42	0.56
1750	2.05	36.7	6.7	3.4	2.01	163.2	641.4	4.43	0.60
2000	2.05	36.7	7.1	3.7	1.98	160.6	661.8	4.43	0.62
2250	2.05	36.8	7.7	4.2	2.00	167.6	731.7	4.43	0.65
2500	2.05	36.9	7.6	4.5	2.05	181.5	796.3	1.71	1.66
1000	1.7	38.2	5.8	3.0	1.60	167.8	559.7	4.49	0.50
1250	1.7	38.4	6.2	2.7	1.76	181.6	629.7	4.43	0.65
1500	1.7	38.4	6.5	3.4	1.72	182.3	626.6	4.42	0.55
1750	1.7	38.3	6.9	3.5	1.65	178.8	651.5	4.43	0.62
2000	1.7	38.3	7.3	3.7	1.71	181.2	700.9	4.43	0.68
2250	1.7	38.3	7.8	4.2	1.70	176.0	715.5	4.43	0.65
2500	1.7	38.2	7.6	4.7	1.67	165.9	731.7	2.89	0.87
1000	1.45	38.3	5.9	3.0	1.49	175.2	568.4	4.47	0.50
1250	1.45	38.3	6.3	3.4	1.46	188.2	620.5	4.43	0.52
1500	1.45	38.3	6.6	3.5	1.47	187.8	624.2	4.42	0.56
1750	1.45	38.3	7.0	3.7	1.42	188.3	648.7	4.42	0.61
2000	1.45	38.2	7.5	3.9	1.41	193.4	698.1	4.43	0.67
2250	1.45	38.2	8.0	4.3	1.45	190.1	731.3	4.43	0.68
2500	1.45	38.3	7.9	4.7	1.48	182.9	733.5	3.27	0.81
1000	1	37.3	6.4	3.2	0.96	246.6	486.4	4.49	0.54
1250	1	37.3	6.6	3.4	0.96	250.7	490.2	4.43	0.58
1500	1	37.3	6.9	4.0	0.95	249.2	487.9	4.42	0.52
1750	1	37.2	7.4	3.8	0.96	256.8	511.1	4.43	0.67
2000	1	37.2	7.9	4.2	0.95	259.0	512.5	4.43	0.69
2250	1	37.2	8.5	4.6	0.94	261.6	520.5	4.44	0.72
2500	1	37.3	8.1	4.9	0.96	262.2	542.7	2.15	1.38
1000	0.85	37.1	6.8	4.1	0.86	261.8	477.4	4.49	0.46
1250	0.85	37.2	7.2	4.1	0.84	269.4	492.6	4.43	0.55
1500	0.85	37.3	7.7	4.5	0.82	268.6	475.2	4.42	0.57
1750	0.85	37.0	7.8	5.1	0.89	273.6	517.0	4.43	0.47
2000	0.85	37.1	8.1	5.1	0.92	265.6	515.4	4.43	0.55
2250	0.85	37.2	8.6	5.5	0.91	264.9	515.5	4.44	0.54
2500	0.85	37.2	8.5	5.9	0.90	270.7	530.4	1.49	1.59
1000	0.55	37.4	9.2	5.8	0.52	297.2	388.4	4.49	0.61
1250	0.55	37.4	9.6	6.4	0.52	290.8	377.1	4.43	0.58
1500	0.55	37.3	11.0	7.4	0.50	291.0	308.1	4.42	0.66
1750	0.55	37.4	11.1	7.1	0.52	294.3	301.8	4.43	0.75
2000	0.55	37.4	11.7	8.5	0.51	288.1	245.3	4.43	0.58
2250	0.55	37.2	12.0	9.6	0.52	281.7	213.8	4.44	0.41
2500	0.55	37.0	11.5	10.0	0.54	276.2	199.3	2.02	0.57
1000	0.41	37.1	10.1	7.0	0.43	302.9	327.6	4.49	0.54
1250	0.41	37.1	10.7	7.6	0.44	299.7	324.5	4.43	0.56
1500	0.41	37.1	11.7	8.8	0.44	296.9	281.9	4.42	0.51
1750	0.41	37.0	12.1	9.6	0.45	305.2	256.2	4.42	0.41
2000	0.41	37.3	12.0	11.5	0.50	290.9	229.2	4.43	-0.03
2250	0.41	37.2	12.2	12.6	0.51	286.2	209.4	4.44	-0.24
2500	0.41	36.7	12.5	13.5	0.50	293.7	170.4	2.48	-0.55

Input Speed (rpm)	Input Torque (Nm)	Belt Ratio	Sump Termperature	Input Speed	Input Torque	Output Speed	Spinloss Torque	Pulley Ratio	Primary Pressure	Secondary Pressure	Acceleratioin	Inertia
1000	15	2.645	25.5	983.4	6.2	74.0	4.8	2.64	135.1	531.4	5.78	0.11
1250	15	2.645	26.3	1247.9	6.7	96.1	4.8	2.57	166.7	630.6	5.66	0.18
1500	15	2.645	26.0	1517.0	6.6	116.7	4.6	2.58	145.2	597.3	5.65	0.20
1750	15	2.645	25.3	1743.3	6.4	133.8	4.3	2.59	110.2	522.3	5.66	0.22
2000	15	2.645	25.9	1976.1	7.0	155.6	5.6	2.52	128.0	605.7	5.66	0.10
2250	15	2.645	26.1	2265.8	7.1	176.5	5.6	2.54	129.1	659.0	3.18	0.33
2500	15	2.645	26.0	2434.2	7.0	186.2	6.6	2.59	123.3	683.5	0.75	0.39
1000	15	2.05	25.9	1003.2	6.6	98.2	4.8	2.03	165.5	587.5	5.76	0.17
1250	15	2.05	25.8	1250.0	6.6	125.4	4.8	1.98	154.5	584.2	5.68	0.17
1500	15	2.05	25.8	1501.4	7.0	143.5	4.6	2.07	168.1	649.9	5.65	0.28
1750	15	2.05	25.8	1750.1	7.3	170.5	4.3	2.04	166.0	661.7	5.66	0.39
2000	15	2.05	25.8	2002.0	7.7	196.2	5.9	2.02	162.5	689.4	5.67	0.18
2250	15	2.05	25.8	2252.2	8.1	223.6	5.9	2.00	155.9	709.1	5.54	0.26
2500	15	2.05	25.7	2444.3	8.1	238.1	6.7	2.04	160.9	759.1	2.70	0.36
1000	15	1.7	24.6	1000.1	6.2	115.5	4.9	1.72	138.2	482.2	5.76	0.08
1250	15	1.7	24.6	1252.2	6.2	148.9	4.9	1.67	128.6	470.8	5.67	0.08
1500	15	1.7	24.6	1501.1	6.5	177.8	4.7	1.67	131.0	507.6	5.66	0.17
1750	15	1.7	24.6	1752.5	6.8	208.4	4.4	1.67	127.2	512.8	5.66	0.26
2000	15	1.7	24.6	1998.8	7.2	239.9	5.8	1.65	123.9	534.7	5.67	0.09
2250	15	1.7	24.6	2248.2	7.7	269.9	5.8	1.65	121.1	564.3	5.67	0.18
2500	15	1.7	24.5	2431.6	7.6	293.2	7.0	1.64	118.8	585.4	3.66	0.02
1000	15	1.45	23.9	998.4	6.5	136.0	5.0	1.46	157.2	511.1	5.76	0.11
1250	15	1.45	23.9	1250.5	6.6	173.2	5.0	1.43	154.2	513.6	5.68	0.14
1500	15	1.45	23.9	1499.2	6.9	205.2	4.7	1.45	156.9	545.2	5.65	0.24
1750	15	1.45	23.9	1747.8	7.2	240.8	4.6	1.44	154.7	555.1	5.66	0.31
2000	15	1.45	23.8	1999.6	7.6	279.8	6.0	1.42	150.5	574.1	5.67	0.14
2250	15	1.45	23.8	2248.9	8.1	323.0	6.0	1.38	140.9	582.8	5.67	0.22
2500	15	1.45	23.8	2420.4	8.0	354.9	7.1	1.35	131.1	585.6	4.36	0.07
1000	15	1	23.1	998.9	7.0	209.7	5.1	0.95	239.3	420.0	5.75	0.18
1250	15	1	23.1	1249.7	7.2	266.0	5.1	0.93	236.4	418.7	5.68	0.22
1500	15	1	23.1	1498.4	7.6	323.3	5.2	0.92	239.1	426.8	5.65	0.27
1750	15	1	23.1	1749.7	8.0	375.6	7.3	0.93	242.6	436.9	5.66	-0.03
2000	15	1	23.1	2000.0	8.5	430.6	6.3	0.92	242.5	440.4	5.67	0.23
2250	15	1	23.1	2209.4	8.8	463.4	6.3	0.95	237.0	451.7	5.67	0.28
2500	15	1	23.1	2418.7	8.5	488.3	7.1	0.98	227.5	461.0	4.45	0.18
1000	15	0.85	23.1	998.9	7.0	209.7	5.5	0.95	239.3	420.0	5.75	0.11
1250	15	0.85	23.1	1249.7	7.2	266.0	5.5	0.93	236.4	418.7	5.68	0.16
1500	15	0.85	23.1	1498.4	7.6	323.3	5.9	0.92	239.1	426.8	5.65	0.14
1750	15	0.85	23.1	1749.7	8.0	375.6	9.3	0.93	242.6	436.9	5.66	-0.38
2000	15	0.85	23.1	2000.0	8.5	430.6	7.2	0.92	242.5	440.4	5.67	0.08
2250	15	0.85	23.1	2247.9	9.2	489.2	7.2	0.92	245.3	457.2	5.67	0.20
2500	15	0.85	23.1	2415.9	9.3	528.9	7.8	0.91	247.2	468.9	4.63	0.17
1000	15	0.55	23.4	1000.8	10.2	387.7	7.7	0.52	301.1	368.6	5.77	0.29
1250	15	0.55	23.4	1249.3	10.7	473.1	7.7	0.53	310.3	385.6	5.67	0.39
1500	15	0.55	23.4	1488.7	11.9	592.0	8.8	0.51	318.9	358.8	5.66	0.39
1750	15	0.55	23.4	1749.7	12.6	698.6	7.1	0.50	324.9	335.0	5.66	0.82
2000	15	0.55	23.4	1998.7	13.3	781.9	9.6	0.51	331.8	307.6	5.66	0.51
2250	15	0.55	23.4	2250.7	14.5	890.4	9.6	0.51	340.0	260.8	5.67	0.72
2500	15	0.55	23.4	2414.9	14.3	943.1	11.3	0.52	344.9	251.3	4.70	0.49
1000	15	0.41	23.4	975.6	10.4	401.8	9.4	0.49	311.1	356.0	5.80	0.02
1250	15	0.41	23.4	1251.3	12.3	570.6	9.4	0.43	335.0	329.0	5.67	0.35
1500	15	0.41	23.4	1494.3	12.3	620.9	11.6	0.48	323.1	342.1	5.66	-0.03
1750	15	0.41	23.4	1765.6	12.8	715.7	13.1	0.49	329.1	332.6	5.66	-0.21
2000	15	0.41	23.4	1980.4	13.4	785.0	11.4	0.50	334.5	303.9	5.66	0.21
2250	15	0.41	23.4	2219.9	15.7	954.1	11.4	0.47	361.7	219.8	5.67	0.61
2500	15	0.41	23.5	2415.6	16.3	1065.4	16.7	0.45	381.2	180.4	4.70	-0.25


Honda CVT Inertia vs. Pulley Ratio
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Inertia [kg-m^2]
2.645
2.05
1.7
1.45
1
0.85
0.55
0.41
Pulley Ratio
93C
65C
38C
25C

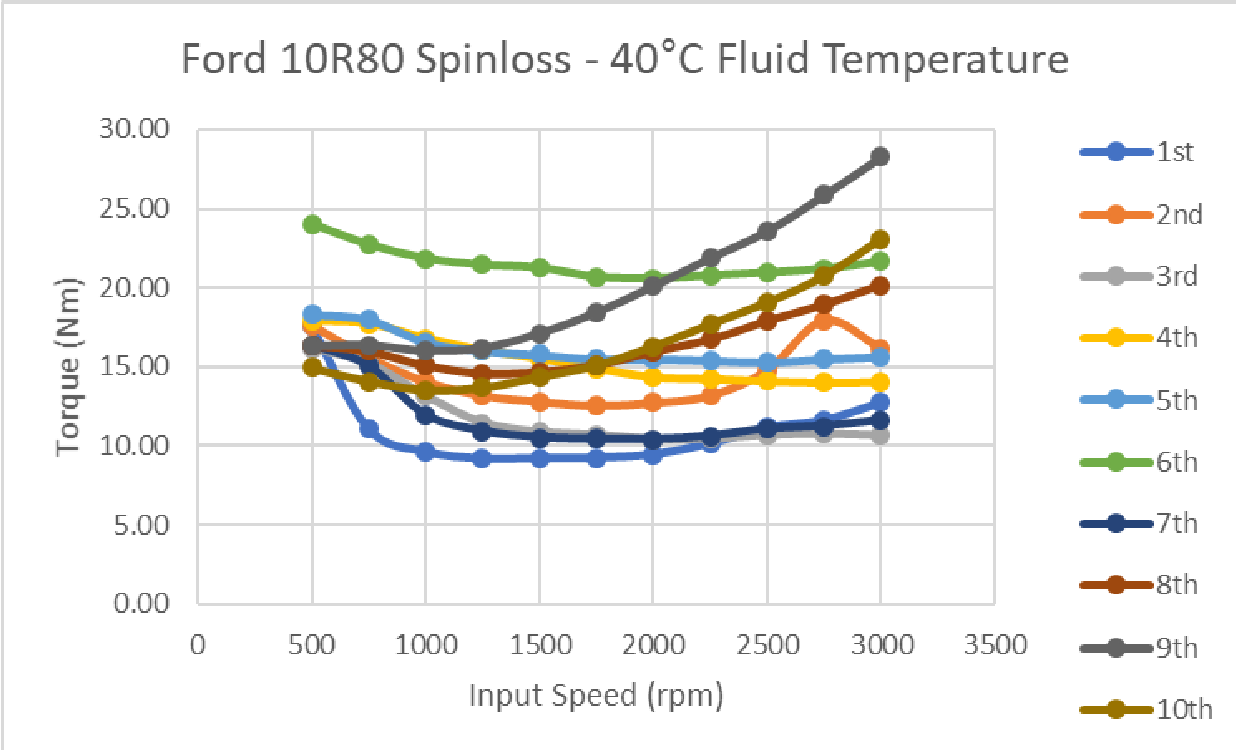
Appendix F: Spinloss Results

Ford 10R80 Spinloss DATA

40 °C	Spinloss Summary [Nm]										
Gear	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
1	17.55	11.05	9.62	9.20	9.22	9.25	9.46	10.15	11.15	11.64	12.75
2	17.62	15.58	14.07	13.20	12.82	12.56	12.74	13.20	14.79	17.94	16.15
3	16.14	15.21	13.15	11.44	10.86	10.67	10.41	10.41	10.65	10.74	10.63
4	17.91	17.75	16.79	16.05	15.52	14.90	14.34	14.23	14.09	13.99	14.03
5	18.33	18.01	16.58	16.01	15.77	15.48	15.50	15.41	15.30	15.50	15.64
6	24.03	22.73	21.85	21.45	21.25	20.67	20.58	20.76	20.95	21.19	21.65
7	16.37	15.05	11.95	10.92	10.51	10.43	10.39	10.62	11.06	11.25	11.62
8	16.33	15.99	15.09	14.60	14.69	15.13	15.97	16.74	17.92	18.94	20.17
9	16.29	16.36	15.99	16.18	17.11	18.44	20.09	21.88	23.59	25.85	28.30
10	14.93	14.08	13.54	13.68	14.37	15.10	16.28	17.70	19.07	20.73	23.09

40 °C	Input Speed Summary [rpm]										
Gear	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
1	501.64	755.28	1003.82	1253.71	1501.37	1750.59	1997.98	2246.54	2493.13	2739.80	2986.43
2	505.09	755.14	1003.58	1253.73	1501.45	1750.24	1997.39	2246.75	2492.70	2739.82	2986.32
3	504.97	755.60	1003.77	1253.85	1501.24	1750.33	1997.91	2247.01	2503.60	2748.27	2996.07
4	505.08	755.30	1002.55	1253.54	1500.77	1750.56	1996.73	2245.98	2491.67	2739.08	3000.49
5	505.13	755.72	1003.39	1253.41	1500.95	1750.46	1997.00	2246.12	2492.16	2739.35	3000.85
6	505.16	754.93	1001.59	1253.67	1501.12	1749.97	1997.45	2246.09	2492.14	2739.51	3000.30
7	505.13	755.17	1003.64	1253.53	1501.19	1750.43	1996.79	2246.03	2491.97	2739.05	3000.72
8	505.02	754.24	1003.01	1253.66	1501.02	1750.21	1996.59	2245.26	2490.35	2739.51	3000.32
9	505.15	755.49	1003.66	1253.30	1500.96	1750.15	1997.12	2245.19	2491.70	2738.81	3000.80
10	505.19	755.37	1002.97	1253.52	1500.37	1750.49	1997.23	2246.16	2491.90	2739.35	2993.27

40 °C	Sump Temperature Summary [°C]										
Gear	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
1	41.39	42.29	42.47	42.61	42.51	42.56	42.42	42.33	42.09	41.78	41.51
2	39.26	41.24	41.28	41.27	41.21	41.12	40.91	40.51	39.76	39.01	38.12
3	40.03	40.75	40.63	40.75	41.10	40.67	41.09	40.99	40.74	40.34	39.82
4	40.56	42.58	42.73	42.73	42.70	42.53	42.22	41.94	41.60	41.09	40.36
5	41.26	43.43	43.76	43.72	43.70	43.54	43.26	42.94	42.46	41.80	41.05
6	44.36	47.86	47.85	47.78	47.64	47.37	46.94	46.33	45.62	44.69	43.41
7	40.09	40.76	40.79	40.75	40.70	40.62	40.73	40.69	40.56	40.32	39.90
8	41.79	43.40	43.41	43.48	43.51	43.46	43.34	43.11	42.76	42.01	40.56
9	42.89	45.12	45.32	45.46	45.54	45.55	45.42	45.06	44.54	43.54	41.80
10	42.75	43.85	44.08	44.37	44.60	44.78	45.07	44.97	44.60	43.49	43.08

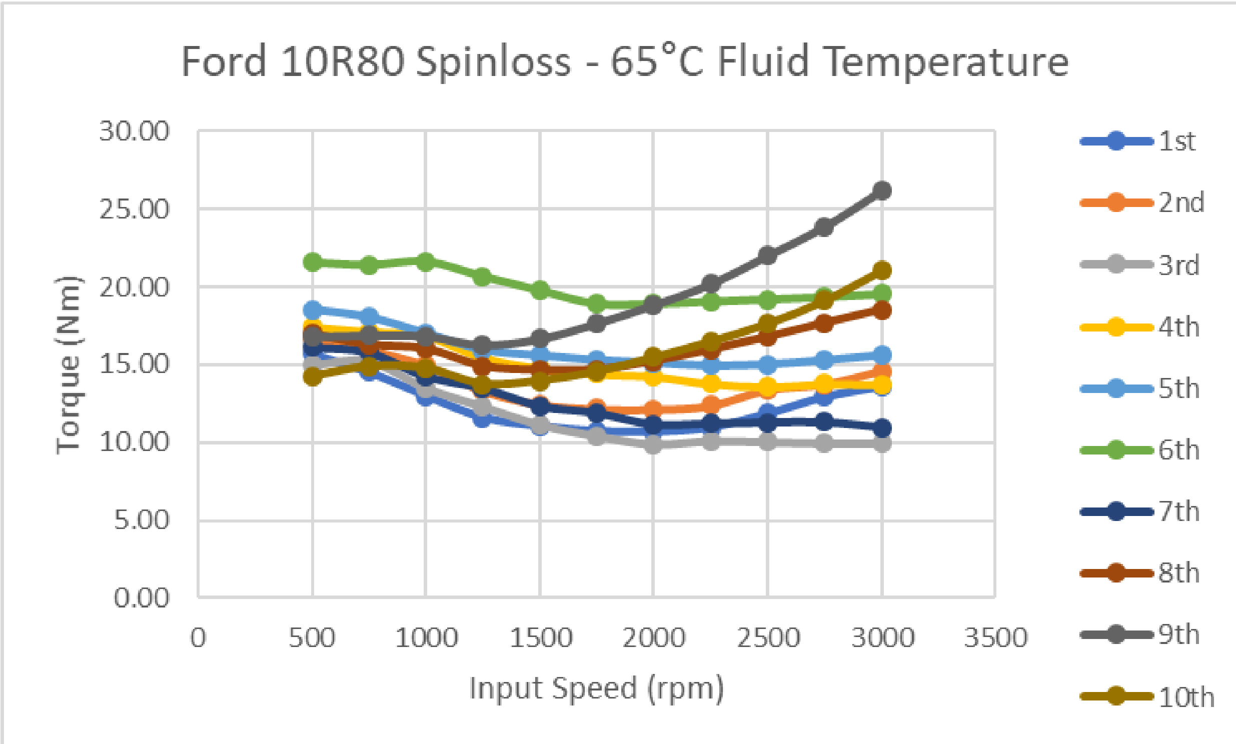


Ford 10R80 Spinloss - 40°C Fluid Temperature
Torque (Nm)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
500
1000
1500
2000
2500
3000
3500
Input Speed (rpm)
1st
2nd
3rd
4th
5th
6th
7th
8th
9th
10th

65 °C	Spinloss Summary [Nm]										
Gear	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
1	15.68	14.51	12.99	11.59	11.04	10.71	10.66	10.95	11.84	12.91	13.59
2	16.64	15.93	14.95	13.34	12.45	12.16	12.12	12.37	13.39	13.75	14.60
3	14.99	15.23	13.51	12.33	11.16	10.44	9.90	10.12	10.05	9.97	9.98
4	17.39	17.10	16.83	15.45	14.75	14.39	14.24	13.78	13.59	13.75	13.72
5	18.51	18.03	16.99	15.96	15.58	15.29	15.13	14.93	15.02	15.28	15.60
6	21.57	21.40	21.62	20.66	19.76	18.90	18.89	19.04	19.18	19.33	19.52
7	16.12	15.78	14.24	13.48	12.33	11.89	11.14	11.20	11.28	11.30	10.96
8	16.96	16.28	16.01	14.91	14.65	14.68	15.24	15.96	16.77	17.67	18.52
9	16.78	16.88	16.83	16.27	16.65	17.65	18.83	20.18	22.00	23.85	26.16
10	14.25	14.89	14.78	13.75	13.96	14.54	15.46	16.48	17.63	19.12	21.05

65 °C	Input Speed Summary [rpm]										
Gear	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
1	505.29	755.50	1003.54	1253.50	1500.74	1750.09	1997.23	2246.27	2492.14	2739.39	2999.52
2	505.08	755.44	1003.41	1253.28	1500.83	1750.06	1997.01	2246.32	2491.97	2738.79	2999.65
3	505.13	755.46	1003.50	1253.39	1500.99	1750.27	1997.29	2246.45	2492.47	2739.49	2999.56
4	505.14	755.41	1003.55	1253.56	1501.15	1750.39	1997.34	2246.82	2492.77	2739.70	2999.51
5	505.04	755.40	1003.61	1253.39	1500.79	1750.19	1997.13	2246.28	2491.37	2738.94	3000.05
6	504.94	755.14	1003.28	1253.13	1500.79	1750.08	1996.77	2246.06	2491.55	2738.61	3000.11
7	505.23	755.52	1003.49	1253.58	1500.93	1750.16	1996.87	2245.95	2491.94	2738.99	2999.97
8	505.19	755.46	1003.50	1253.50	1500.80	1750.33	1997.33	2246.13	2492.33	2739.51	3000.16
9	505.29	755.65	1003.46	1253.53	1500.79	1749.85	1996.46	2245.97	2491.37	2738.96	3000.24
10	505.30	755.32	1003.65	1253.52	1501.06	1750.30	1997.35	2246.48	2492.47	2739.57	3000.61

65 °C	Sump Temperature Summary [°C]										
Gear	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
1	64.98	64.94	64.91	64.88	64.97	64.88	64.82	64.69	64.49	64.14	63.53
2	64.87	65.79	66.10	66.40	66.73	67.05	67.19	67.07	66.30	65.47	64.64
3	64.17	64.36	64.53	64.86	64.95	64.81	64.81	65.18	64.54	63.90	63.68
4	65.13	65.46	65.19	65.17	65.05	64.93	65.17	64.46	63.88	63.23	62.44
5	66.00	65.11	64.97	65.34	65.46	65.56	65.50	65.30	65.03	64.75	64.40
6	64.66	66.33	66.34	66.35	66.29	65.94	65.45	64.77	63.84	62.90	61.93
7	65.42	65.58	65.64	65.82	66.00	66.10	66.00	65.76	65.41	64.96	64.38
8	64.91	64.98	64.95	64.95	64.87	64.79	64.69	64.55	64.12	63.39	62.20
9	65.97	65.93	66.22	66.55	66.97	67.33	67.45	67.42	67.21	66.69	65.39
10	65.22	67.07	67.41	67.83	68.33	68.87	69.15	69.16	68.89	68.14	66.14

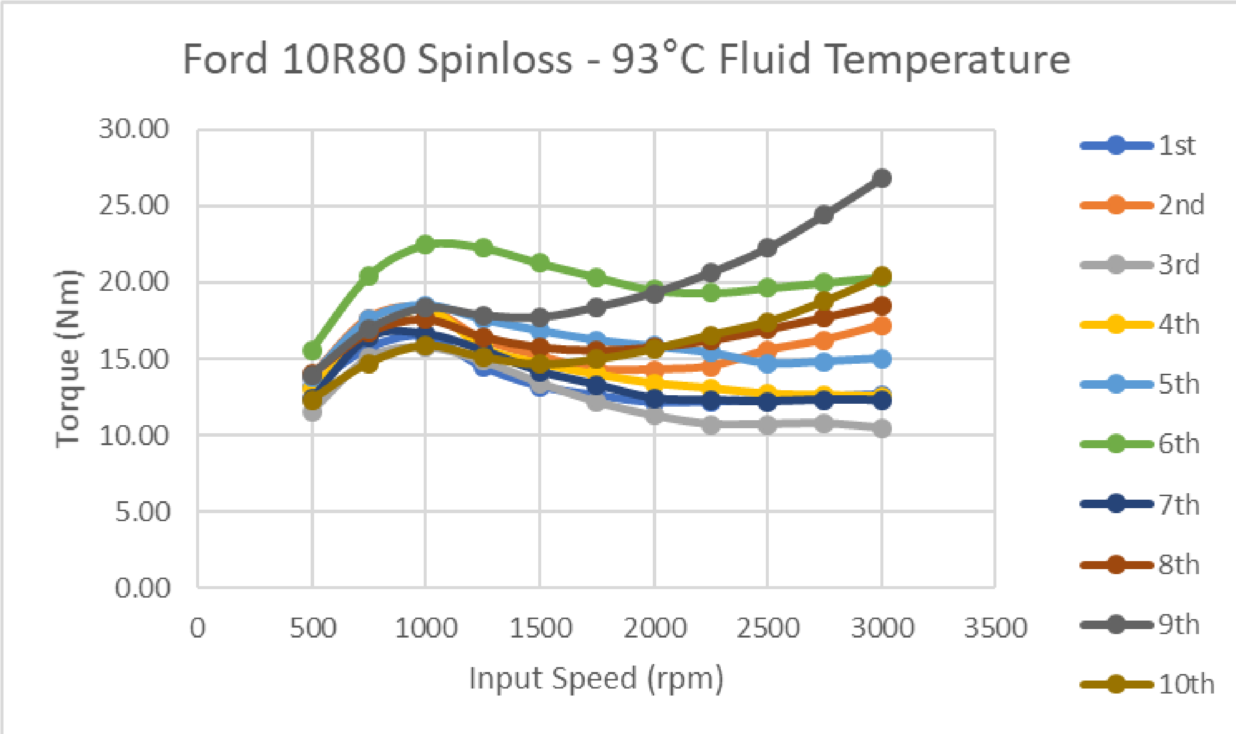


Ford 10R80 Spinloss - 65°C Fluid Temperature
Torque (Nm)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
500
1000
1500
2000
2500
3000
3500
Input Speed (rpm)
1st
2nd
3rd
4th
5th
6th
7th
8th
9th
10th

93 °C	Spinloss Summary [Nm]										
Gear	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
1	13.17	15.68	16.45	14.44	13.19	12.57	12.14	12.16	12.29	12.48	12.65
2	13.80	17.66	18.26	16.27	15.15	14.30	14.27	14.49	15.54	16.23	17.21
3	11.53	15.06	15.79	14.86	13.42	12.16	11.26	10.70	10.70	10.74	10.44
4	13.04	16.48	18.34	15.77	14.71	13.98	13.39	13.07	12.70	12.60	12.52
5	13.84	17.55	18.50	17.59	16.85	16.22	15.82	15.40	14.72	14.83	15.03
6	15.57	20.43	22.50	22.31	21.27	20.36	19.50	19.30	19.62	19.98	20.35
7	12.36	16.36	16.61	15.54	14.15	13.30	12.42	12.29	12.20	12.33	12.30
8	14.02	16.70	17.55	16.44	15.76	15.57	15.75	16.20	16.90	17.66	18.47
9	13.92	16.90	18.32	17.82	17.70	18.35	19.28	20.60	22.22	24.40	26.78
10	12.29	14.71	15.85	15.10	14.63	14.96	15.62	16.56	17.43	18.78	20.40

93	Input Speed Summary [rpm]										
	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
1	504.90	755.51	1003.43	1253.02	1500.65	1749.84	1996.95	2246.03	2491.92	2739.10	2999.51
2	504.92	754.89	1003.27	1253.39	1500.73	1749.99	1997.27	2246.64	2492.33	2739.92	2999.86
3	505.08	755.22	1003.59	1253.61	1500.66	1750.40	1997.19	2246.13	2491.83	2739.08	3001.62
4	505.08	755.19	1003.42	1253.34	1500.74	1749.51	1996.31	2245.10	2491.51	2738.70	2999.16
5	505.12	755.48	1003.49	1252.98	1500.51	1749.86	1996.78	2246.09	2491.88	2738.92	2999.18
6	505.03	755.27	1003.12	1253.33	1500.49	1749.72	1996.80	2245.32	2491.18	2738.37	2999.67
7	505.02	755.22	1003.37	1253.03	1500.65	1749.87	1996.74	2246.08	2491.50	2738.61	2999.46
8	505.05	755.36	1003.21	1253.14	1500.96	1750.30	1996.81	2246.04	2492.11	2739.01	2999.12
9	505.15	755.22	1003.12	1253.07	1500.67	1749.68	1996.93	2245.04	2491.44	2738.28	2999.47
10	505.03	755.37	1003.42	1252.88	1499.88	1749.59	1996.62	2244.11	2491.16	2737.94	2999.45

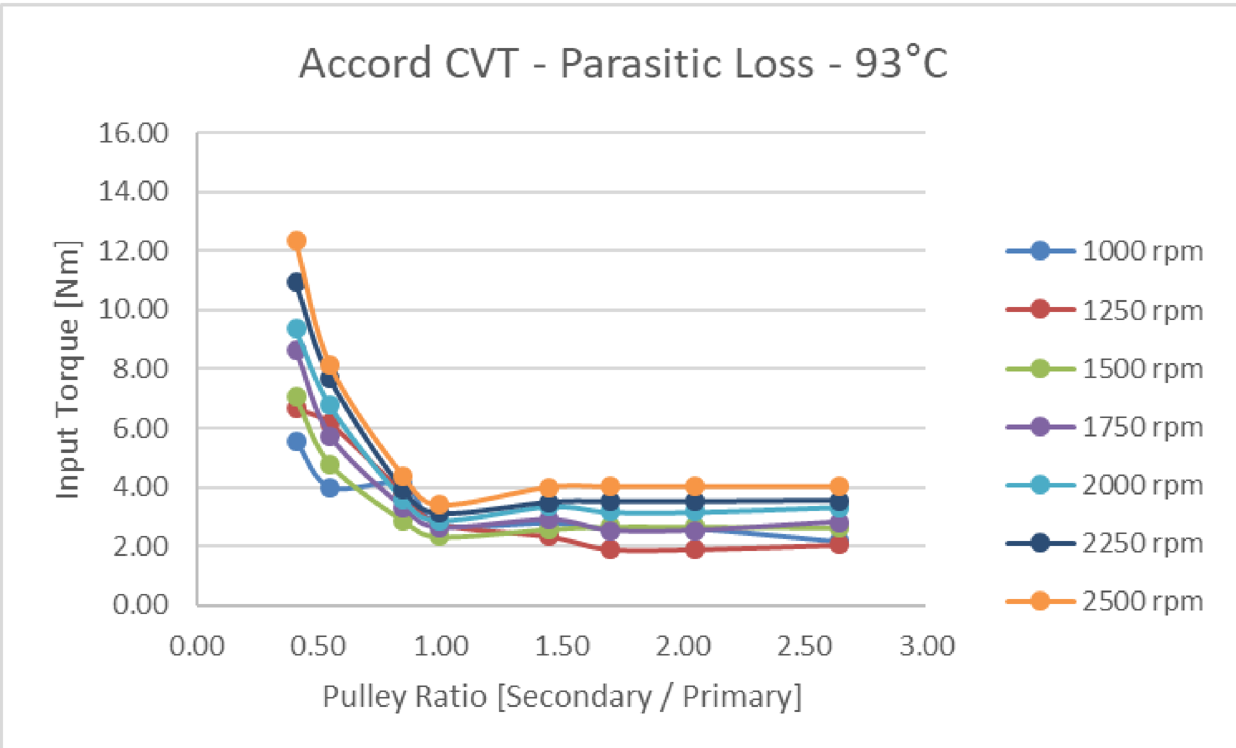
93	Sump Temperature Summary [°C]										
	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
1	90.81	91.51	92.25	92.74	93.13	93.57	93.94	93.99	93.59	92.97	92.00
2	90.33	92.13	92.08	92.00	91.91	91.80	91.48	90.76	90.05	88.99	87.00
3	92.53	93.02	93.30	93.56	93.88	93.77	93.34	92.91	92.57	92.22	92.11
4	89.61	89.04	88.95	88.94	88.92	88.86	88.76	88.62	88.47	88.24	87.97
5	90.38	92.59	92.51	92.45	92.28	92.00	91.63	91.04	90.27	89.40	88.49
6	93.28	94.24	94.36	94.80	95.19	95.41	95.43	95.01	94.24	93.11	91.91
7	91.12	86.92	87.02	87.27	87.55	87.79	88.00	88.37	88.95	89.40	89.83
8	88.75	89.51	89.65	89.60	89.48	89.29	89.13	88.86	88.27	87.36	86.02
9	91.06	92.82	93.22	93.57	93.96	94.14	93.85	93.35	92.76	91.72	89.96
10	90.70	90.55	90.83	91.08	91.21	91.32	91.33	91.24	90.97	90.36	89.18



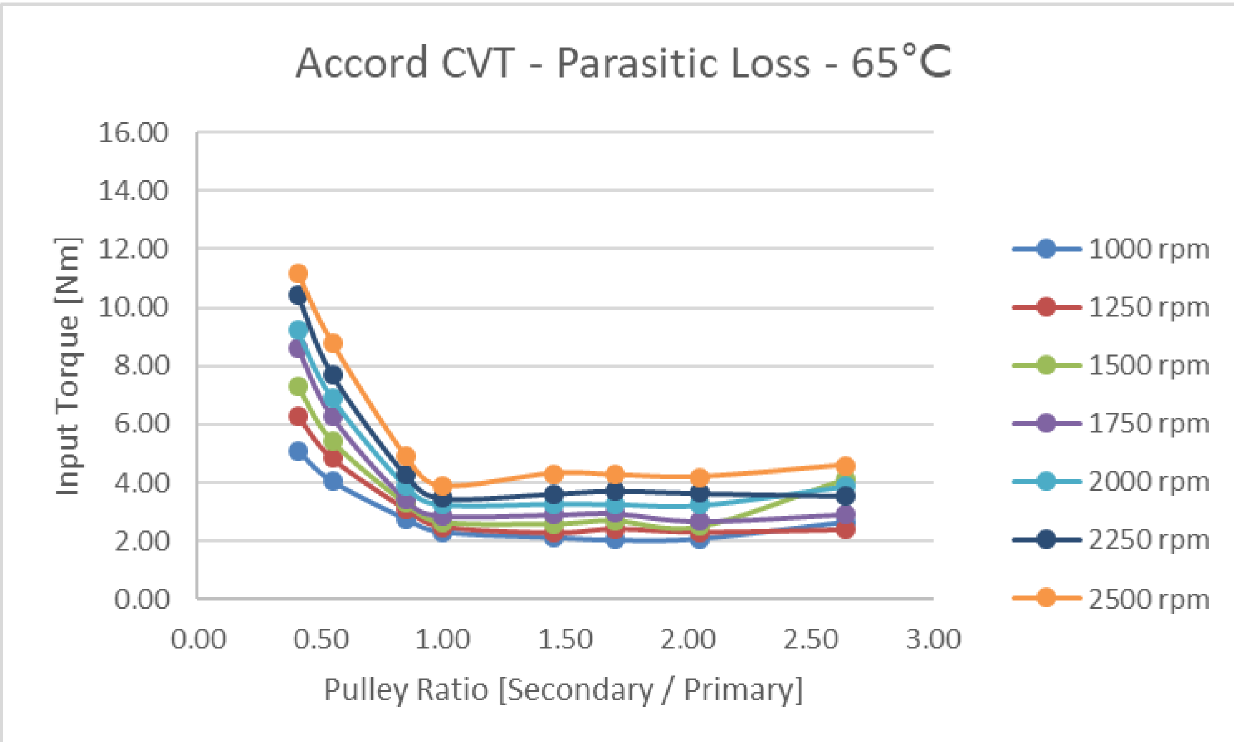
Ford 10R80 Spinloss - 93°C Fluid Temperature
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Torque (Nm)
0
500
1000
1500
2000
2500
3000
3500
Input Speed (rpm)
1st
2nd
3rd
4th
5th
6th
7th
8th
9th
10th

Honda Earth Dreams CVT Spinloss DATA

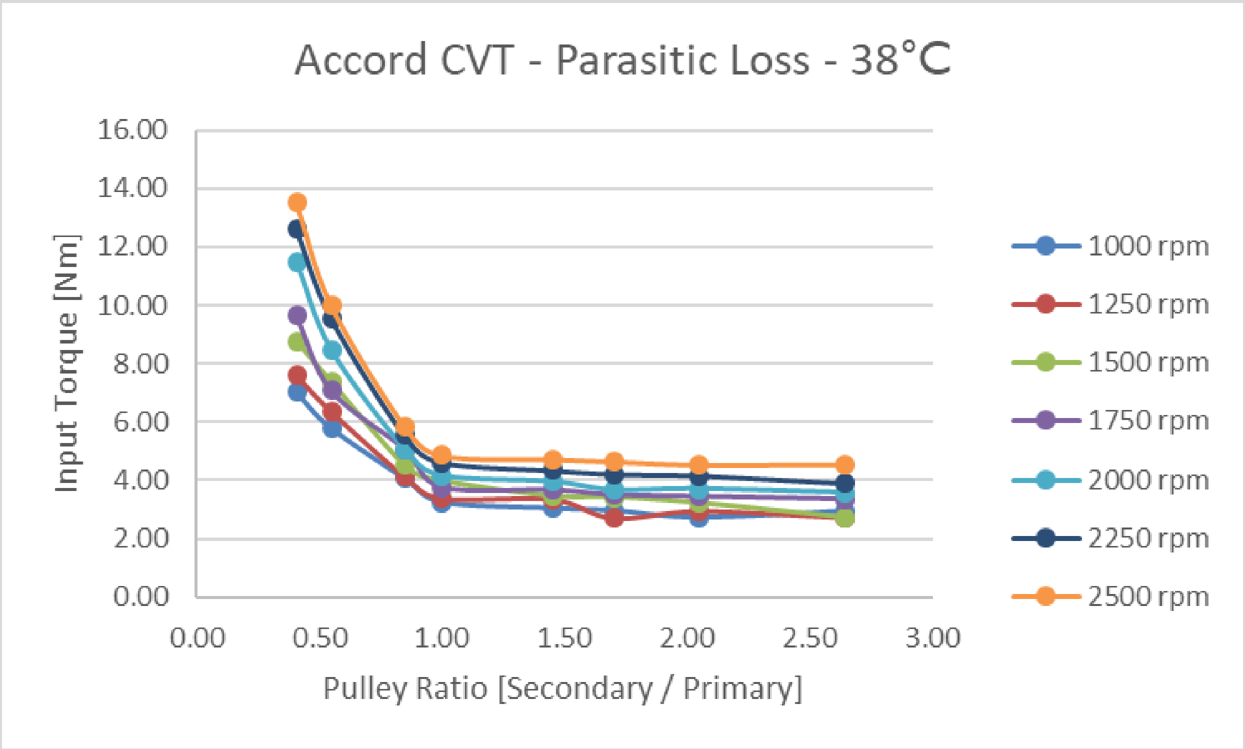
CVT - Drive Torque at 93°C		Pulley Ratio							
		2.65	2.05	1.70	1.45	1.00	0.85	0.55	0.41
Input Speed [rpm]	1000	2.17	2.60	2.60	2.79	2.75	4.11	4.00	5.56
	1250	2.06	1.92	1.92	2.35	2.79	3.83	6.17	6.66
	1500	2.63	2.66	2.66	2.58	2.32	2.87	4.79	7.06
	1750	2.83	2.53	2.53	2.89	2.63	3.30	5.74	8.65
	2000	3.33	3.17	3.17	3.36	2.88	3.59	6.77	9.35
	2250	3.56	3.52	3.52	3.49	3.12	3.90	7.67	10.93
	2500	4.03	4.02	4.02	4.00	3.39	4.38	8.14	12.33



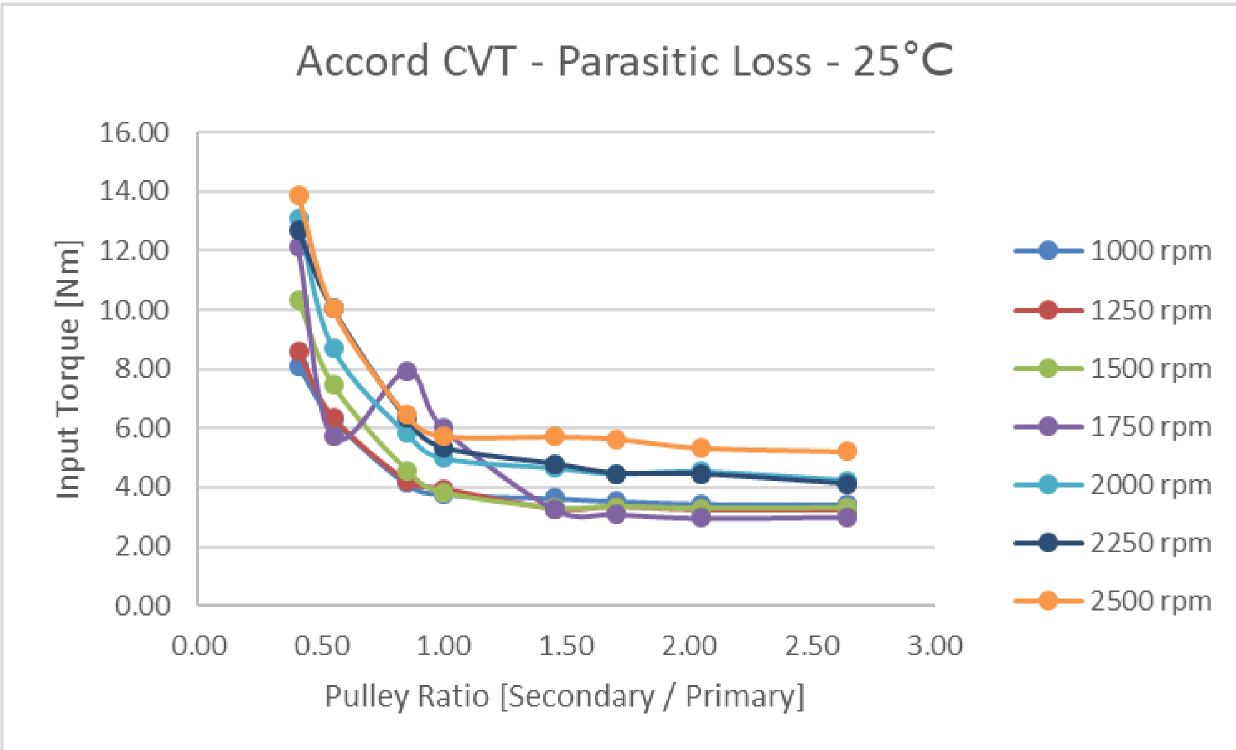
CVT - Drive Torque at 65 °C		Pulley Ratio							
		2.65	2.05	1.70	1.45	1.00	0.85	0.55	0.41
Input Sped [rpm]	1000	2.66	2.09	2.04	2.13	2.31	2.76	4.05	5.09
	1250	2.39	2.30	2.41	2.27	2.49	3.09	4.83	6.29
	1500	4.13	2.51	2.71	2.60	2.66	3.30	5.44	7.32
	1750	2.92	2.68	2.95	2.90	2.86	3.41	6.27	8.63
	2000	3.88	3.23	3.27	3.27	3.25	3.89	6.92	9.22
	2250	3.55	3.64	3.72	3.62	3.47	4.28	7.72	10.44
	2500	4.60	4.20	4.26	4.31	3.87	4.89	8.80	11.18



CVT - Drive Torque at 38°C		Pulley Ratio							
		2.65	2.05	1.70	1.45	1.00	0.85	0.55	0.41
Input Speed [rpm]	1000	2.94	2.72	2.96	3.04	3.25	4.06	5.81	7.04
	1250	2.74	2.96	2.72	3.37	3.40	4.14	6.38	7.60
	1500	2.73	3.22	3.43	3.46	3.98	4.52	7.38	8.76
	1750	3.34	3.44	3.49	3.66	3.75	5.06	7.08	9.65
	2000	3.57	3.70	3.66	3.94	4.16	5.06	8.48	11.49
	2250	3.90	4.16	4.22	4.34	4.62	5.53	9.55	12.59
	2500	4.56	4.54	4.65	4.73	4.86	5.85	10.02	13.52



CVT - Drive Torque at 25°C		Pulley Ratio							
		2.65	2.05	1.70	1.45	1.00	0.85	0.55	0.41
Input Speed [rpm]	1000	3.43	3.46	3.54	3.64	3.78	4.13	6.31	8.10
	1250	3.23	3.24	3.33	3.27	3.95	4.22	6.37	8.60
	1500	3.30	3.29	3.35	3.30	3.83	4.58	7.47	10.35
	1750	3.00	2.96	3.10	3.26	5.99	7.94	5.71	12.11
	2000	4.25	4.53	4.46	4.65	4.98	5.82	8.73	13.08
	2250	4.11	4.44	4.47	4.78	5.34	6.32	10.05	12.69
	2500	5.21	5.34	5.64	5.72	5.74	6.44	10.04	13.89



Appendix G: Honda Accord CVT Pump Testing

38 °C All Discharge

Secondary Pressure (kPa)	Average Input Torque (Nm) Input Speed (RPM)			
	750	1250	2000	2750
1000	6.1	6.3	6.1	6.5
1250	7.0	7.1	6.9	7.2
1500	7.8	8.0	7.6	8.1
1750	8.5	8.8	8.2	8.7
2000	9.3	9.5	9.1	9.6
2125	9.8	10.3	9.8	10.1

38 °C Control Discharge

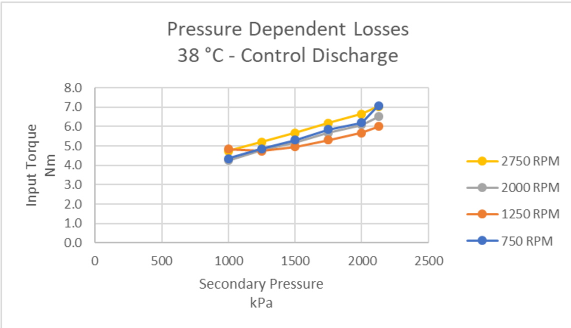
Secondary Pressure (kPa)	Average Input Torque (Nm) Input Speed (RPM)			
	750	1250	2000	2750
1000	4.4	4.8	4.3	4.8
1250	4.9	4.7	4.8	5.2
1500	5.3	4.9	5.2	5.7
1750	5.9	5.3	5.7	6.2
2000	6.2	5.7	6.1	6.7
2125	7.1	6.0	6.5	7.0

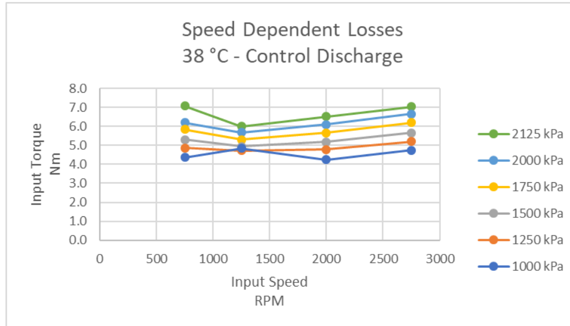
93 °C All Discharge

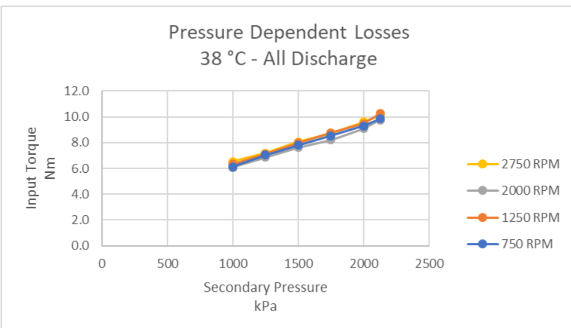
Secondary Pressure (kPa)	Average Input Torque (Nm) Input Speed (RPM)			
	750	1250	2000	2750
1000	5.5	5.6	5.8	6.1
1250	6.1	6.3	6.6	6.9
1500	6.9	7.2	7.6	7.8
1750	7.7	7.9	8.1	8.6
2000	8.5	8.8	9.1	9.1
2125	9.0	9.2	9.4	10.0

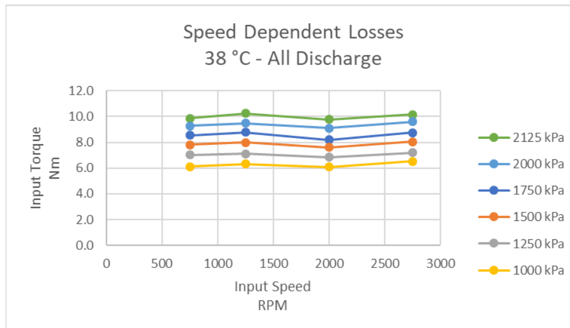
93 °C Control Discharge

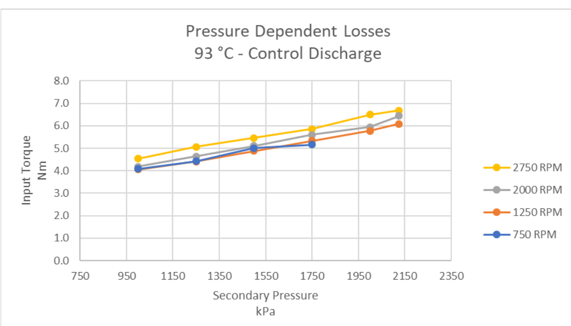
Secondary Pressure (kPa)	Average Input Torque (Nm) Input Speed (RPM)			
	750	1250	2000	2750
1000	4.1	4.1	4.2	4.5
1250	4.4	4.4	4.6	5.1
1500	5.0	4.9	5.1	5.5
1750	5.2	5.3	5.6	5.9
2000		5.8	5.9	6.5
2125		6.1	6.4	6.7

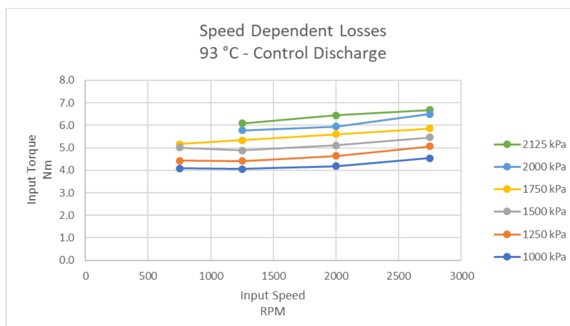

Pressure Dependent Losses
38 °C - Control Discharge
Input Torque
Nm
Secondary Pressure
kPa
2750 RPM
2000 RPM
1250 RPM
750 RPM

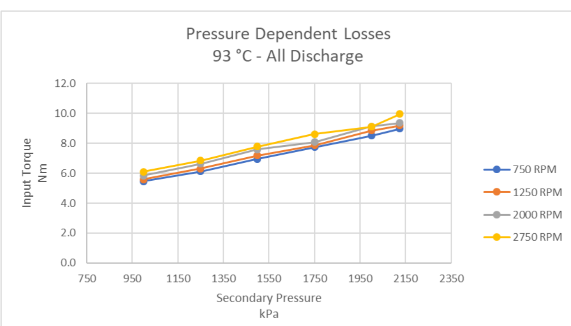

Speed Dependent Losses
38 °C - Control Discharge
Input Torque
Nm
Input Speed
RPM
2125 kPa
2000 kPa
1750 kPa
1500 kPa
1250 kPa
1000 kPa

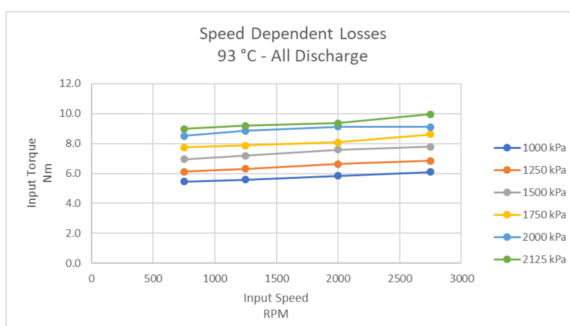

Pressure Dependent Losses
38 °C - All Discharge
Input Torque
Nm
Secondary Pressure
kPa
2750 RPM
2000 RPM
1250 RPM
750 RPM


Speed Dependent Losses
38 °C - All Discharge
Input Torque
Nm
Input Speed
RPM
2125 kPa
2000 kPa
1750 kPa
1500 kPa
1250 kPa
1000 kPa

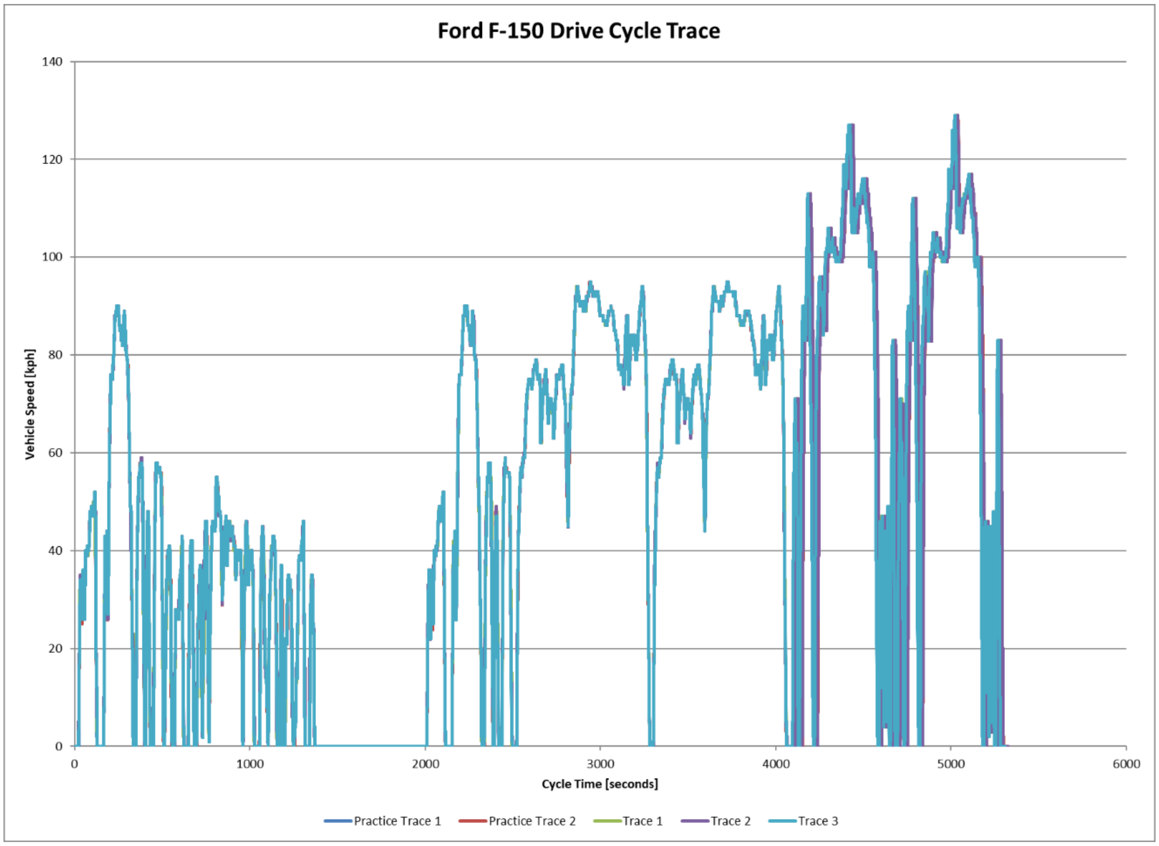

Pressure Dependent Losses
93 °C - Control Discharge
Input Torque
Nm
Secondary Pressure
kPa
2750 RPM
2000 RPM
1250 RPM
750 RPM

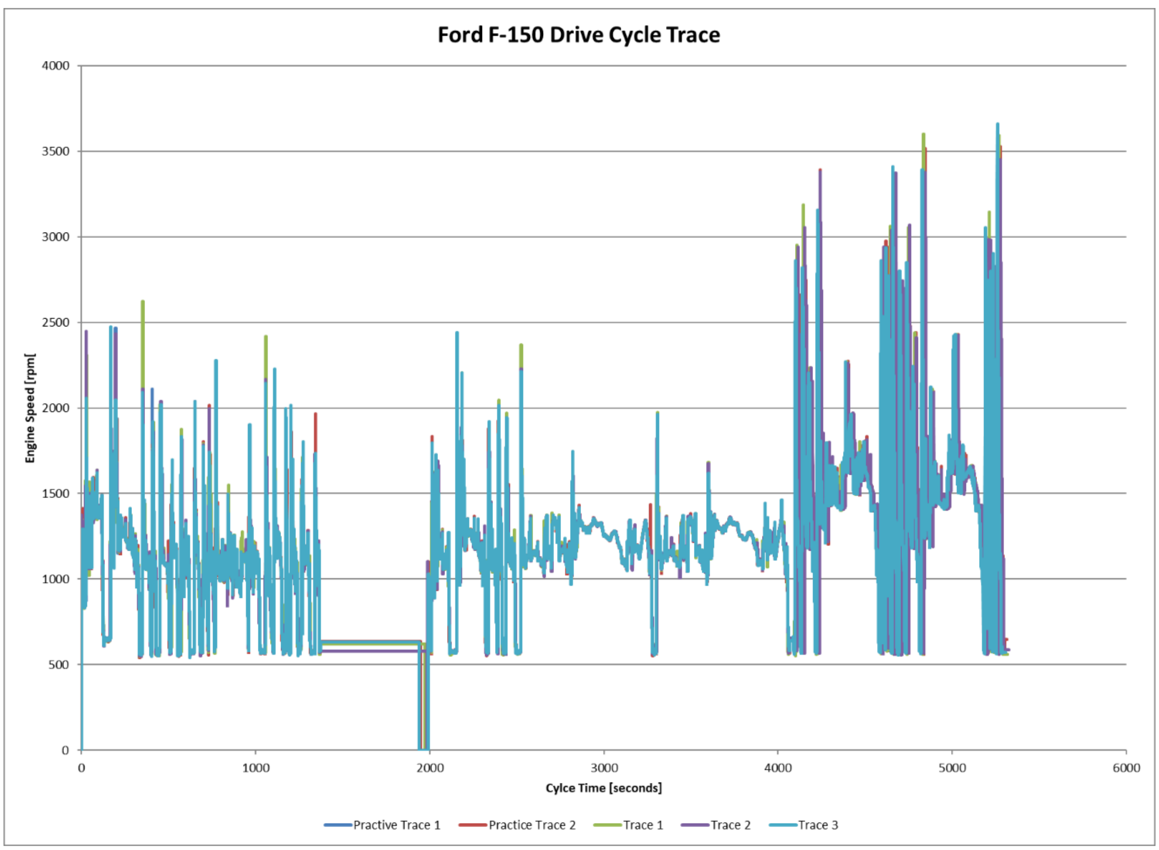

Speed Dependent Losses
93 °C - Control Discharge
Input Torque
Nm
Input Speed
RPM
2125 kPa
2000 kPa
1750 kPa
1500 kPa
1250 kPa
1000 kPa

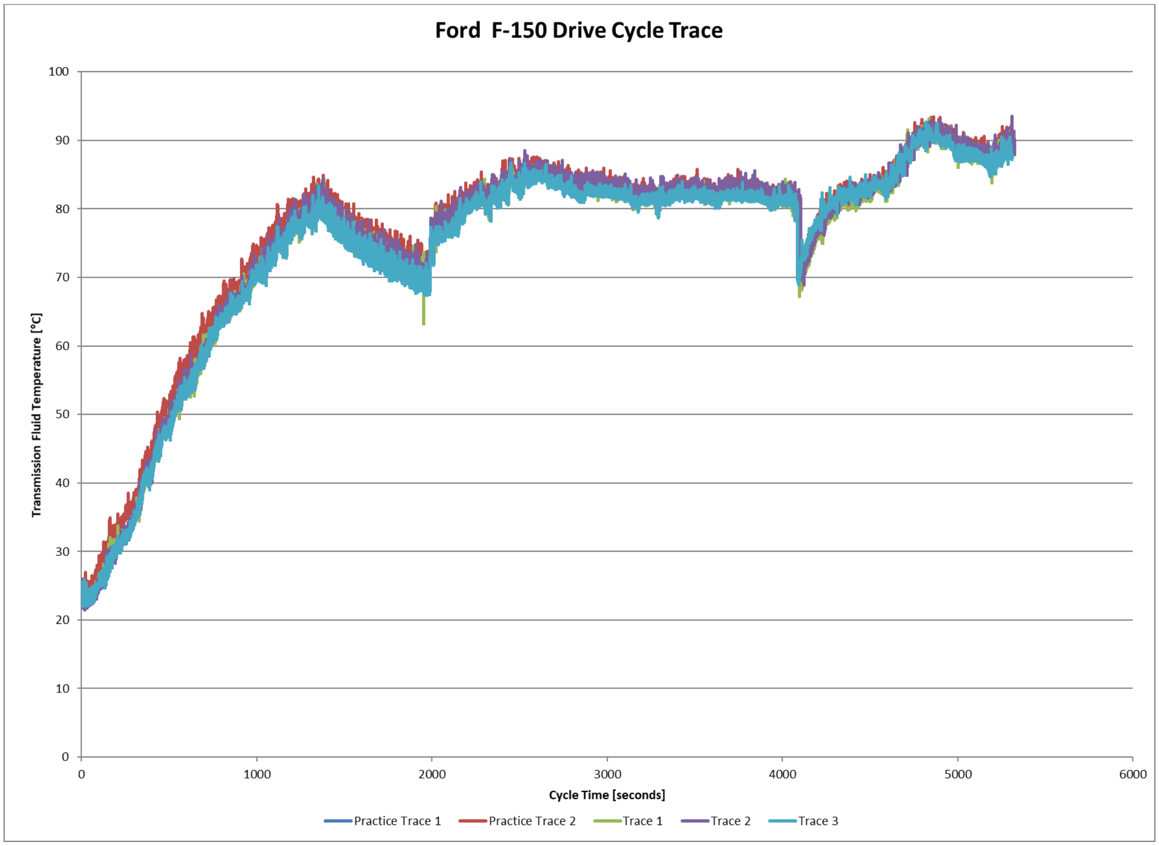

Pressure Dependent Losses
93 °C - All Discharge
Input Torque
Nm
Secondary Pressure
kPa
750 RPM
1250 RPM
2000 RPM
2750 RPM


Speed Dependent Losses
93 °C - All Discharge
Input Torque
Nm
Input Speed
RPM
1000 kPa
1250 kPa
1500 kPa
1750 kPa
2000 kPa
2125 kPa

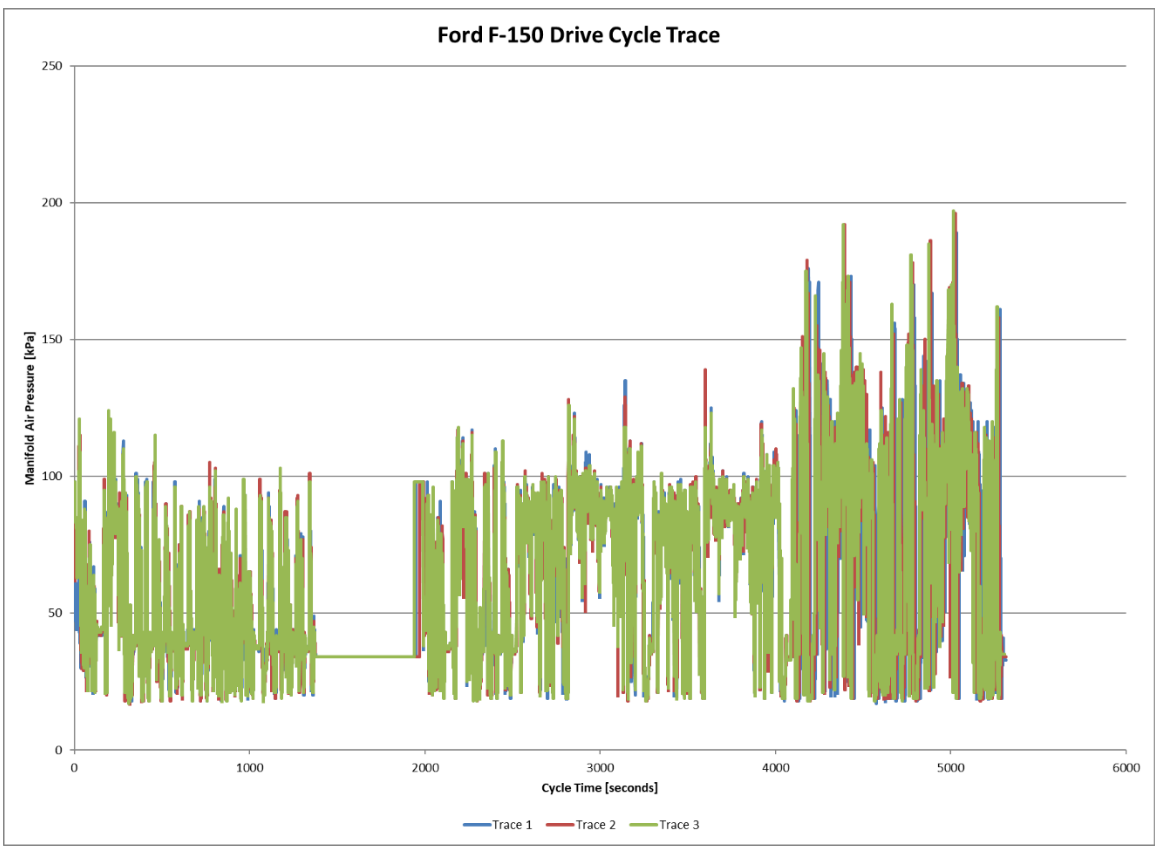
Appendix H: 10R80 In-Use


Ford F-150 Drive Cycle Trace
Vehicle Speed [kph]
0
20
40
60
80
100
120
140
0
1000
2000
3000
4000
5000
6000
Cycle Time [seconds]
Practice Trace 1
Practice Trace 2
Trace 1
Trace 2
Trace 3


Ford F-150 Drive Cycle Trace
Engine Speed [rpm[
0
500
1000
1500
2000
2500
3000
3500
4000
0
1000
2000
3000
4000
5000
6000
Cylce Time [seconds]
Practive Trace 1
Practice Trace 2
Trace 1
Trace 2
Trace 3

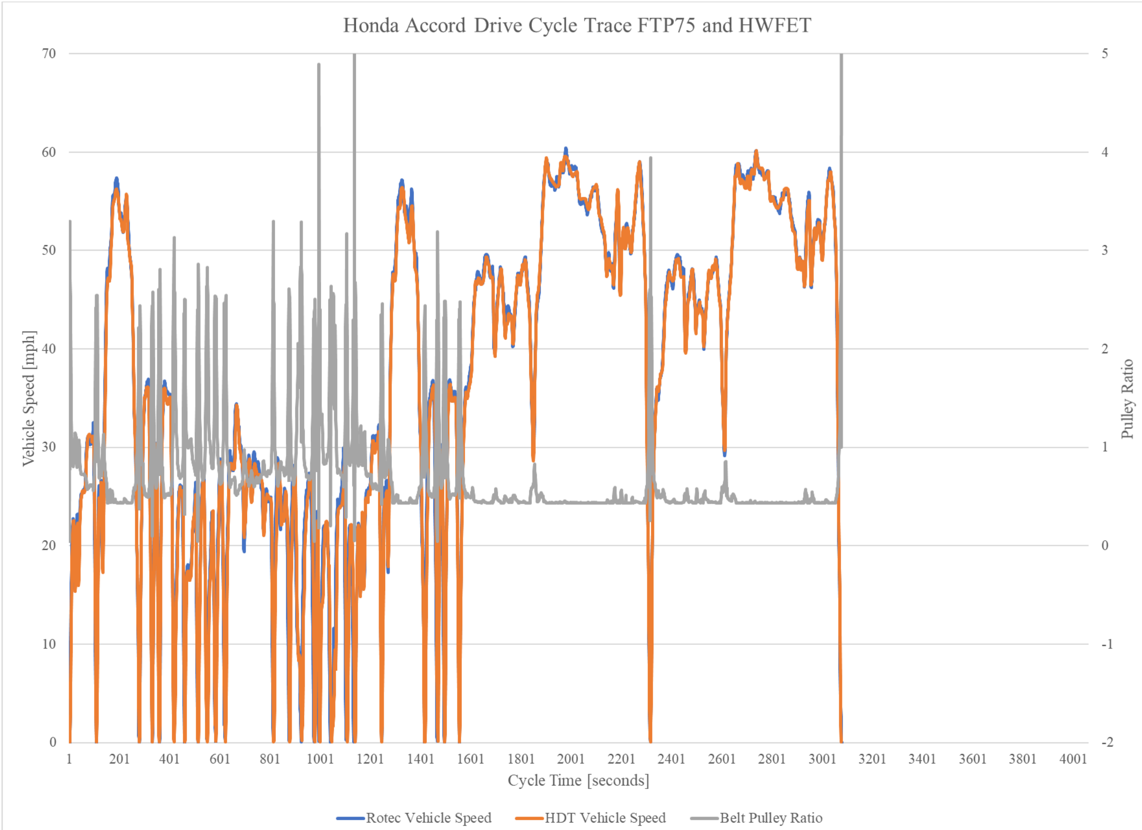


Ford F-150 Drive Cycle Trace
Transmission Fluid Temperature [°C]
Cycle Time [seconds]
Practice Trace 1
Practice Trace 2
Trace 1
Trace 2
Trace 3

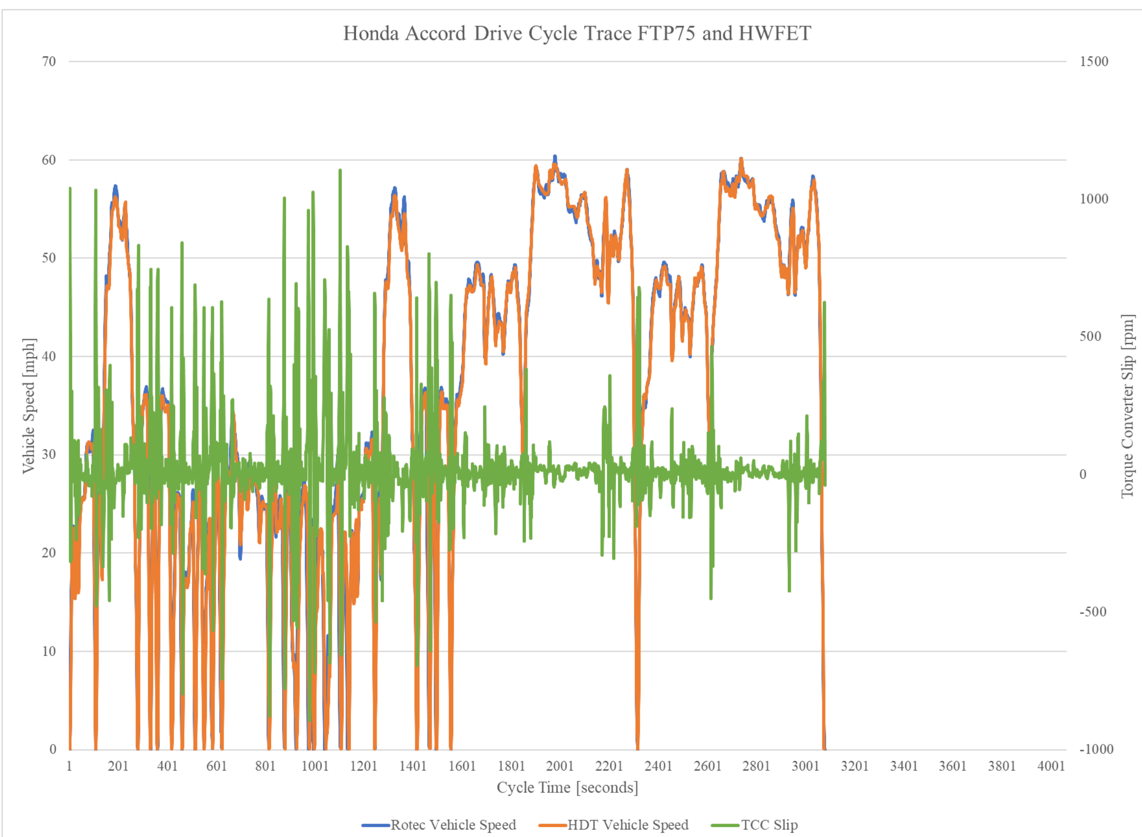


Ford F-150 Drive Cycle Trace
Manifold Air Pressure [kPa]
Cycle Time [seconds]
Trace 1
Trace 2
Trace 3

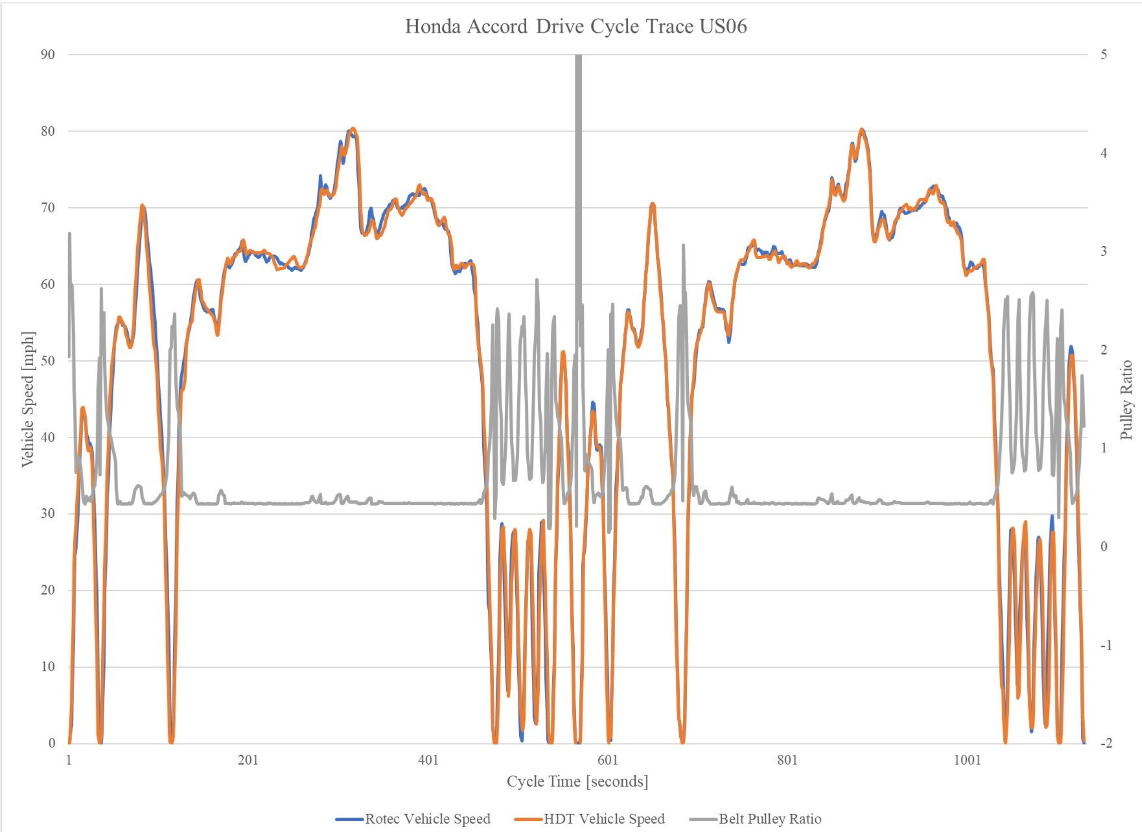
Appendix I: Accord In-Use



Honda Accord Drive Cycle Trace FTP75 and HWFET
Vehicle Speed [mph]
Pulley Ratio
Cycle Time [seconds]
Rotec Vehicle Speed
HDT Vehicle Speed
Belt Pulley Ratio



Honda Accord Drive Cycle Trace FTP75 and HWFET
Vehicle Speed [mph]
Torque Converter Slip [rpm]
Cycle Time [seconds]
Rotec Vehicle Speed
HDT Vehicle Speed
TCC Slip


Honda Accord Drive Cycle Trace US06
Vehicle Speed [mph]
Pulley Ratio
Cycle Time [seconds]
0
10
20
30
40
50
60
70
80
90
-2
-1
0
1
2
3
4
5
1
201
401
601
801
1001
Rotec Vehicle Speed
HDT Vehicle Speed
Belt Pulley Ratio


Honda Accord Drive Cycle Trace US06
Vehicle Speed [mph]
Torque Conver Slip [rpm]
Cycle Time [seconds]
0
10
20
30
40
50
60
70
80
90
-2000
-1500
-1000
-500
0
500
1000
1500
2000
2500
3000
1
201
401
601
801
1001
Rotec Vehicle Speed
HDT Vehicle Speed
TCC Slip

DOT HS 813 163
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U.S. Department
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National Highway
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