CRC Report No. ACES-1a

Creation of the 16-hour Engine Test Schedule from the Heavy Heavy-Duty Diesel Engine Test Schedule

Final Report

July, 2007

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ACES-1a Final REPORT

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Submitted to the Coordinating Research Council

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Test Schedule Creation

The program objective was to create a 16-hour test schedule based on the ACES-1 modes for use in diesel engine health effect studies. Two requirements were that the engine schedule had a 16 hour length and a 50/50 time split for urban and rural operation. Urban operation was considered to include transient, creep, and FTP modes. Rural operation was considered to include cruise and high-speed cruise modes.

Candidate Modes

The ACES-1 project created four engine test modes. The modes included transient, creep, cruise, and HHDDTS (high-speed cruise). The ACES-1 final report should be referenced for specific details of the development and statistics of these modes. The 16-hr cycle developed in this program used three complete engine test modes (transient, cruise, and HHDDTS), one adjusted test mode (Creep), and the FTP. Transient, cruise, and HHDDTS each represent unique portions of typical truck activity. Creep was created from the creep chassis test mode, which, unlike the other three modes, required the vehicle to run four repeated microtrips. A microtrip is a subdivision of a given engine or vehicle mode, which usually starts and ends at engine idle or a period where the vehicle is stopped. However, for the rural modes, microtrip divisions were not aligned with any idle portions, since there was no idle break available during the cruise time.

In this ACES-1a program, instead of using a complete creep mode, the first microtrip of the creep mode was chosen because it best represented creep mode database statistics when compared to the other three creep microtrips. Therefore, the candidate modes chosen were transient, creep-mt1 (where “mt” denotes microtrip), cruise, HHDDTS, and FTP. Table 1 on page 4 shows their time durations.

Modes Repetitions and Sequence

The CAFEE researchers manipulated different combinations of the four modes, developing a 16-hour cycle duration with a 50/50 urban/rural time split. In additional, the mode sequence ensured no back-to-back testing of any mode. The 16-hour cycle consisted of four repetitions of a 4-hour sub-cycle. The sub-cycle included sixteen modes. Figure 1 shows the mode sequence.

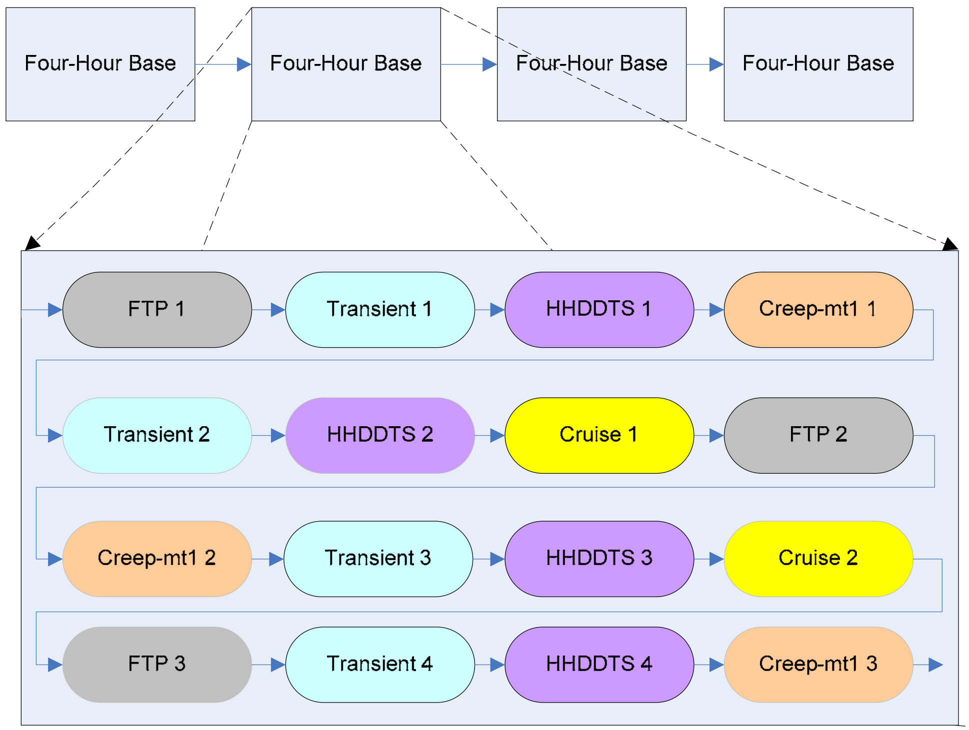

Figure 1: 16-hour Test Sequence

Schedule Time Duration and Average Values

Table 1 lists the time duration and repetitions of the five modes in the sub-cycle segment. The total time of the sub-cycle was 14,385 seconds (3.996 hours). The combination shown in Table 1 provided 49.95% of 14,385 seconds (7,185 seconds) as urban operation and 50.05% of 14,385 seconds (7,200 seconds) as rural operation. The 16-hour schedule had 57,540 second time duration. If the time is desired to be exactly 16 hours (57,600 seconds), the CAFEE researchers suggested adding 60 seconds of engine idle to either the beginning or the end of the complete 16-hour schedule.

Table 1: Modes Time Duration and Repetitions in 4-hour Sub-Cycle

Mode	Duration (sec)	Repetitions	Total Time (sec)	Total Time (hrs)
Cruise	2082	2	4164	1.157
Transient	687	4	2748	0.763
Creep-mt1	280	3	840	0.233
HHDDTS	759	4	3036	0.843
FTP	1199	3	3597	0.999
		Total:	14385	3.996
		Repeated 4 Times:	57540	15.983

Percent of engine speed (%Speed) and percent of engine torque (%Torque) for the 4-hour cycle is shown in Figure 2 and Figure 3. Definitions of %Speed and %Torque are shown in the following formulas.

$$\%Speed = \frac{Actual\ \ Engine\ \ Speed - Idle\ \ Engine\ \ Speed}{Rated\ \ Engine\ \ Speed - Idle\ \ Engine\ \ Speed}$$

$$\%Torque = \frac{Actual\ \ Torque_{At\ the\ Given\ Engine\ Speed}}{Maximum\ \ Torque_{At\ the\ Given\ Engine\ Speed}}$$

The cycle did not include accessory loads (a reasonable estimate of average accessory loads is 3%). However, if it is desired, the cycle could be corrected to include the loads by (a) not altering any motoring points and (b) rescaling the command load percent range of 0% to 100% to be 3% to 100% for all remaining points, so that idle load becomes 3% in the revised schedule. The following formula for all points other than full motoring points implied the recalling action.

$$New\ \ \%Load = 0.97 \times (Old\ \ Load) + 3\%$$

The average %Speed was 48% and the standard deviation was 32%. The average %Torque was 26% and the standard deviation was 30%. The FTP had an average %Speed of

42% and standard deviation of 41%. The average %Torque for the FTP was 24% and the standard deviation was 33%. All FTP and ACES 1a calculations excluded motoring points. In Figure 3 a red dot was displayed on x axis to denote each point that is to be considered closed rack motoring. These calculations show that the 16-hour cycle had higher average %Speed and %Torque than the FTP, but lower standard deviation for both percent speed and percent torque. However, the difference between the statistics was small, making the two cycles comparable.

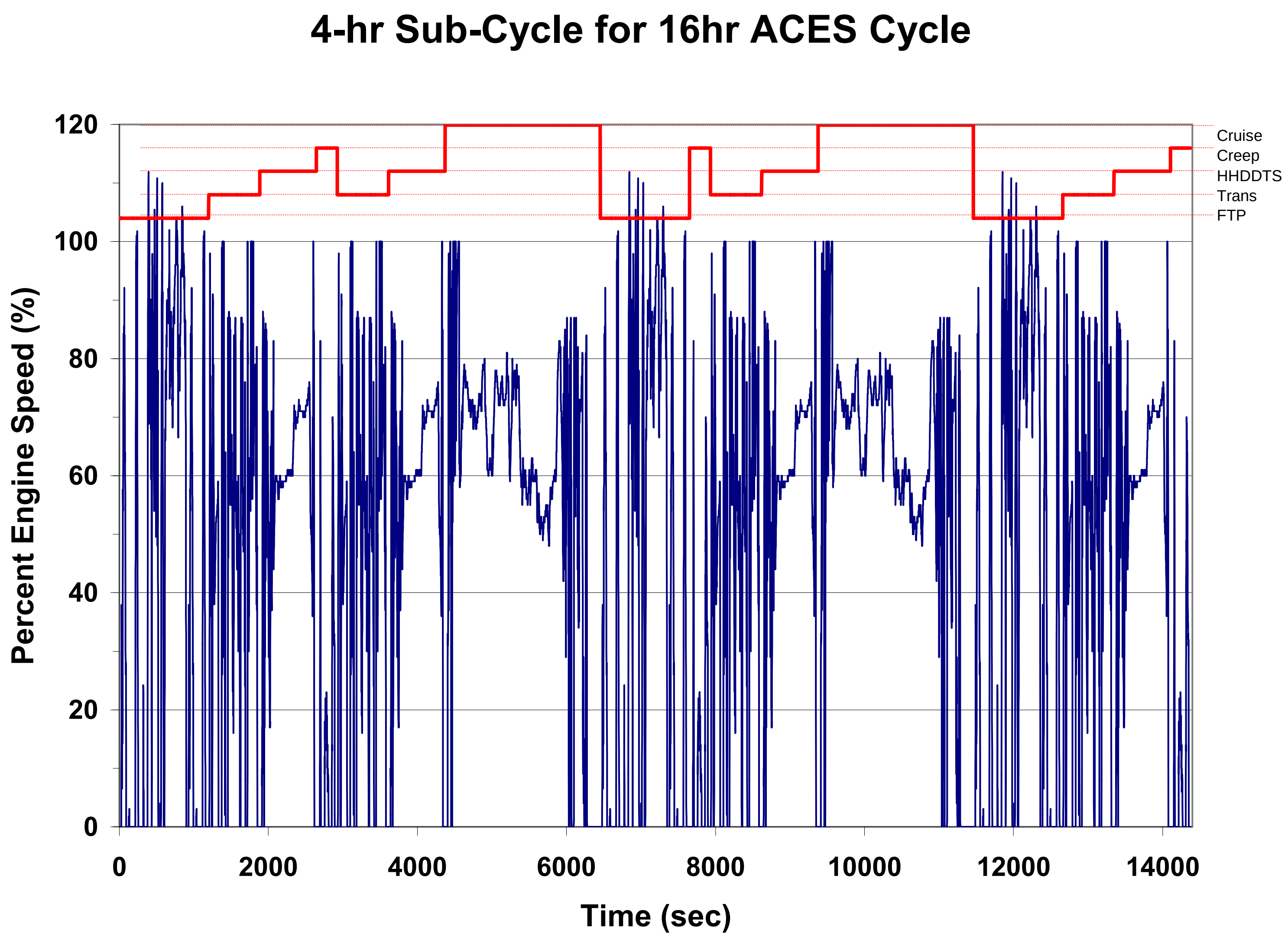

Figure 2: Engine Speed for 4-hour Sub-Cycle

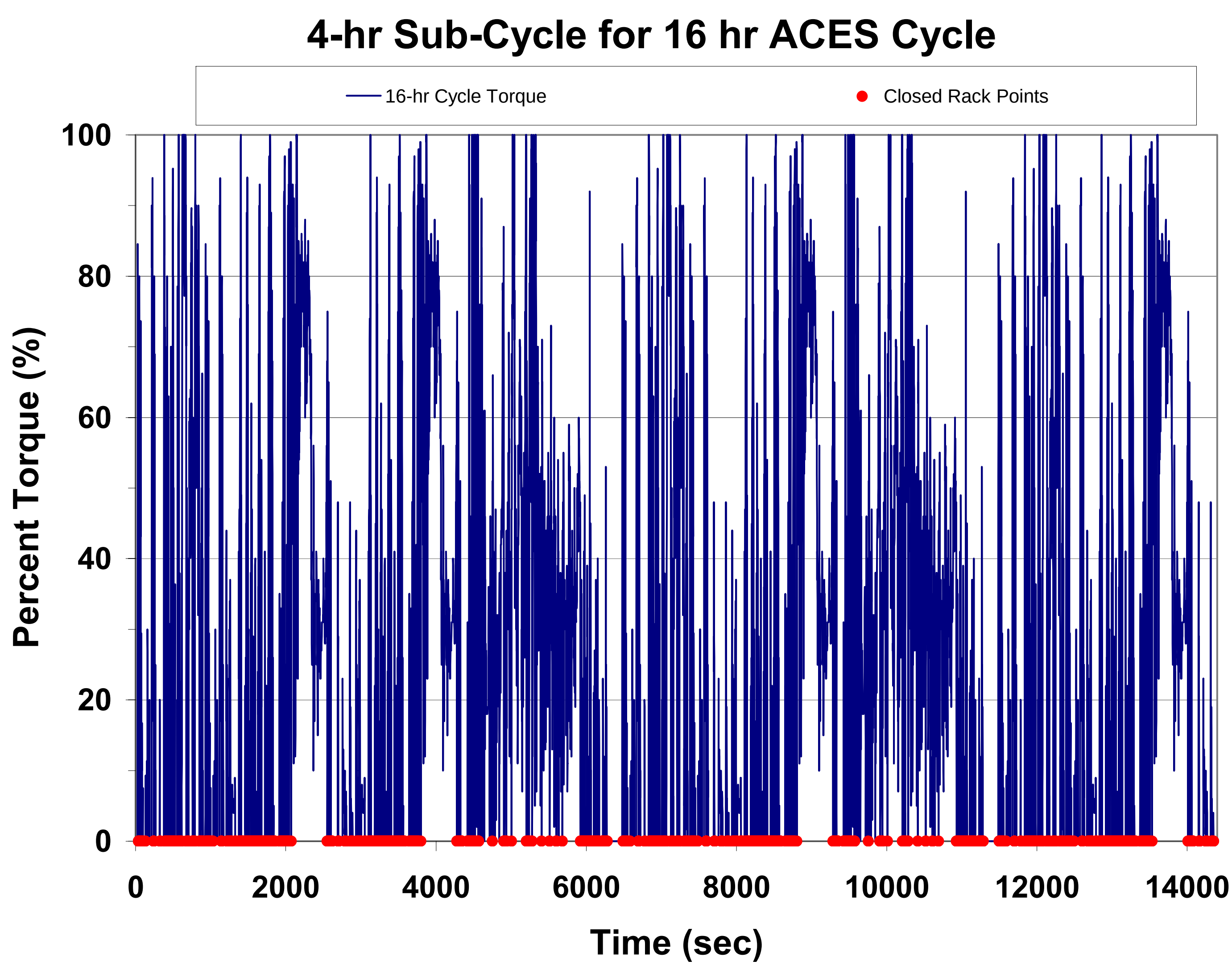

Figure 3: Engine Torque for 4-hour Sub-Cycle