TECHNOLOGY DIGEST

Timely Technology Transfer

Comparative Adhesion Testing of the SD60MAC Locomotive

by A. J. Peters
and
G. B. Anderson

TD 92-014

Summary

The "all weather" dispatch adhesion of a locomotive is a measure of its train hauling capability and therefore an indication of its productivity. One of the anticipated benefits of using three-phase AC propulsion systems in mainline freight locomotives is their ability to be dispatched at higher adhesion ratings than their DC counterparts. A major goal of the AAR participation with EMD in the SD60MAC testing at the Transportation Test Center (TTC) was to establish realistic dispatch adhesion targets for mainline freight locomotives equipped with AC propulsion systems, so that the input data for recent economic analyses could be validated.

A comparative adhesion test was performed on the Train Dynamics Track at the TTC to measure the adhesion utilization of the SD60MAC locomotive with a radial truck design (HTCR) relative to a pair of GP40-2 locomotives equipped with a Positive Traction Control (PTC) wheelslip control and conventional truck design (HTC). As a second comparison, the SD60MAC was also tested against a SD60 (DC) locomotive with a conventional truck design (HTC). In this context the SD60MAC was considered to be representative of a state-of-the-art AC propulsion system. The test method used for the comparison was an "oiled rail" procedure developed by the Canadian National Railway.

The test results indicated that the adhesion utilization of the SD60MAC was approximately 43% better than the GP40-2 locomotives with PTC wheelslip control and 20% better than the SD60. Based on current "all weather" dispatch adhesion ratings of 22% for the PTC equipped 40 series locomotives and 24% to 26% for the SD60 locomotives, it was concluded that the SD60MAC can be assigned an "all weather" dispatch adhesion of 30% to 32%. It was also concluded that the 32% target value used in the recent AAR economic analysis done in the evaluation of a possible test fleet of AC traction locomotive was realistic.

Association of American Railroads
Research and Test Department

September 1992

INTRODUCTION AND CONCLUSIONS

One of the major benefits anticipated from the use of three-phase AC propulsion systems on mainline freight locomotives is improved utilization of the available adhesion between the wheel and the rail. An economic analysis was recently performed by the AAR as part of a proposal to establish a pilot fleet of AC propulsion equipped locomotives for in-service evaluation.

The results of this analysis indicated that a substantial life cycle cost benefit should accrue from the increased productivity resulting from the combination of improved adhesion utilization and a modest increase in engine horsepower.

A performance specification for the pilot fleet locomotives stipulates a starting adhesion level of 45%, with an "all-weather" dispatch adhesion level of 32%. This represents a 25% to 33% increase over current DC locomotives, which are dispatched at 24% to 26% by most railroads who use an "all-weather" dispatching policy.

During a recent series of tests, which were co-sponsored by the AAR and the Electro-Motive Division (EMD) of General Motors, the adhesion utilization level of the SD60MAC (a locomotive representative of the state-of-the-art in AC propulsion systems) was compared to two designs of DC traction motor equipped locomotives.

The main objective of this test from the AAR's perspective, was to confirm that the levels of adhesion proposed in the pilot fleet locomotive specification were achievable. The test was carried out using an "oiled rail" methodology developed by the Canadian National Railway (CN) during the 1970's and successfully used by them and others for similar comparisons in the past.

The two baseline DC locomotives used for the comparisons were a pair of CN GP40-2 locomotives equipped with PTC wheelslip control (developed by CN) and a single SD60 locomotive equipped with a "super-series" wheelslip control system.

As a result of the tests, it was concluded that:

- The SD60MAC consistently produced higher tractive effort over the full range of rail conditions covered by the test methodology.
- The average adhesion utilization improvement of the SD60MAC over the GP40-2 locomotives with PTC wheelslip control was 43% and over the SD60 was 20%.
- Based on the present "all weather" dispatch adhesion rating of 22% adopted by the CN for their 40 series locomotives with PTC wheelslip control and a rating of 25% for the SD60 test locomotive, the SD60MAC can be assigned an "all weather" dispatch adhesion rating of 30% to 32%.
- The target "all weather" dispatch adhesion of 32%, called for in the pilot fleet locomotive specification, is realistic.

TEST DETAILS

The testing was performed on the Train Dynamics Track (TDT) at the TTC. The section of track selected for this test was 2000 feet long, containing a 300 foot spiral into a 1.5 degree curve, with an approximately equal length of tangent and constant curvature on either end. The whole test section and its approaches were on a constant upgrade of 0.9%. The combination of tangent and curved track was consistent with the recommendations made in the CN test methodology, as published in ASME paper No. 75-RT-8, "Locomotive Traction Performance Measurement" (April 1975), by W. M. Scott, R. B. Skene and B. A. Biglow.

The test consist was made up of the test locomotive in the lead, connected to the EMD test

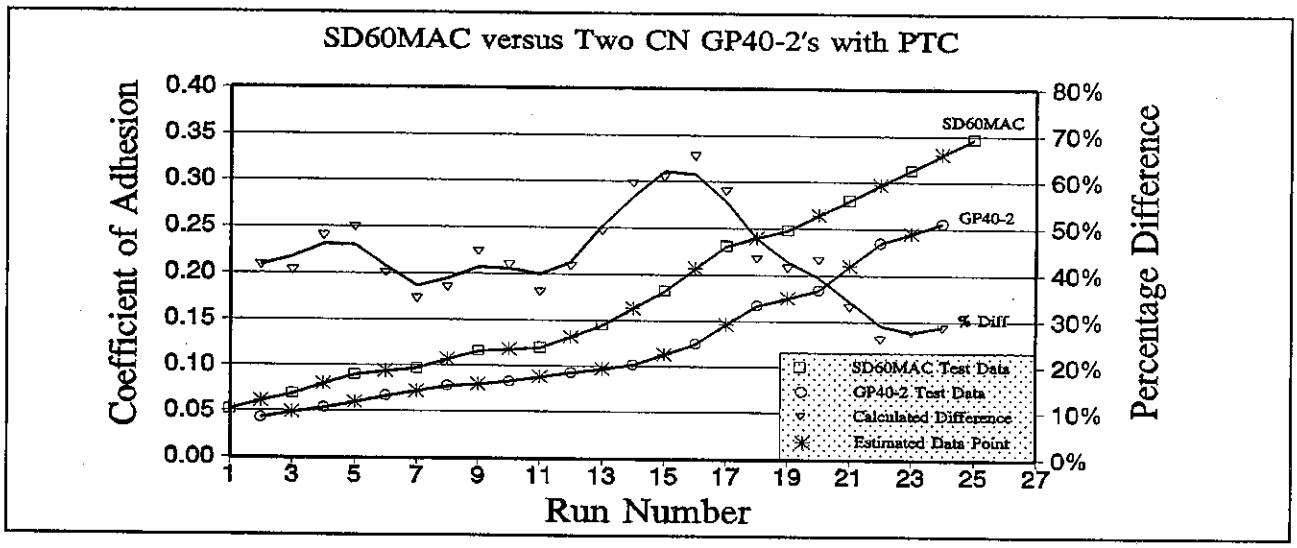

Exhibit 1. Results Summary for Test Series #1

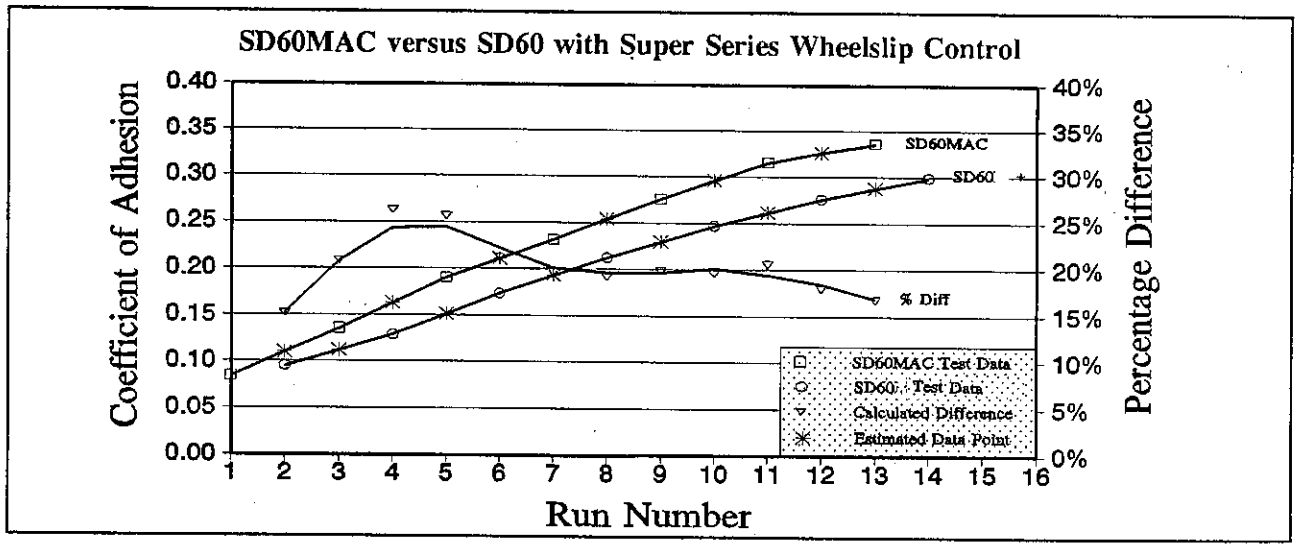

Exhibit 2. Results Summary for Test Series #3

car by an instrumented coupler. The test car was followed by three six-axle locomotives (two SD60MAC units and one SD60 unit) in dynamic brake to provide the necessary drag to control the consist speed. The sanding equipment on all locomotives in the test consist was turned off.

The instrumentation, measuring the instrumented coupler force, the speed and a test zone marker channel, was located in the EMD test car.

At the start of each test sequence, the test section was prepared as described in the CN methodology. A small quantity of 10w 30 (light lubricating) oil was applied intermittently to the head of each running rail through the test zone and for approximately one rail length beyond on either side of the test zone. The test consist was operated repeatedly over the test zone at a target speed which would keep the locomotive under power within the tractive effort limit range of its characteristic (generally within the 7 - 10 mph range).

Power was provided for alternate runs by the selected baseline locomotive and the test locomotive. Pairs of runs were repeated until the baseline locomotive had exceeded its dispatch adhesion rating and the rail was restored to a near dry condition. This state was indicated by a drop off in the rate of improvement in adhesion coefficient between runs.

For the initial test series, in which the SD60MAC was tested against the pair of GP40-2 units with PTC wheelslip control, the test units were alternated by switching them in and out of the consist between each run. This was done to follow the original test method as closely as possible. This was found to be time consuming, so for each subsequent test series both units were kept in the consist. Traction power from each unit was then simply cut in and out between runs to alternate the source of traction.

The results of the first test sequence is presented in graphical form in Exhibit 1. Three curves are shown in the graph, all displayed against a common base of run number. Note that increasing run number represents a gradual improvement in rail condition.

The first two curves represent the adhesion performance of the SD60MAC test locomotive and the two baseline GP40-2 locomotives, presented in the form of an adhesion coefficient versus run number.

It is necessary to use the adhesion coefficient, defined as the ratio of the corrected tractive effort to the total weight on drivers, as the basis of comparison because of the difference in axle configuration and weight between the two locomotive consists. For each run, the measured adhesion coefficient for the locomotive providing the power is compared with an estimated value for the unit not providing the power.

The estimated value is the average of the pair of measured values on either side of the current run, representing a prediction of how the non-powered locomotive would have performed on the prevailing rail condition. The estimated data points are also included on the graphs for completeness.

The third curve indicates the difference between the test locomotive and the baseline locomotives (expressed as a percentage), based on the current measured value and the equivalent estimated value. Note that these data are presented in the form of the actual data points and a curve based on a moving average smoothing function so that the trends can be more clearly illustrated.

The data indicate an improved performance of the SD60MAC over the two GP40-2's ranging from 25% to 65%, with an average of 43%. Similar data, presented in Exhibit 2 for the SD60MAC

and SD60 comparison (Test Series #3), indicate a 20% advantage for the SD60MAC. The enhanced performance level of the SD60MAC is derived from three distinct factors. These are: the inherent benefit of the steep torque/speed characteristic of the AC motor, the independent control of wheelslip on each truck, and the use of a radial steering truck design.

Further analysis would be necessary to identify the relative contribution of each. However, the test results clearly demonstrate that 32% dispatch adhesion level is attainable from a combined application of these technologies and is therefore an achievable target for the near future, while the longer range goal of a 35% "all weather" dispatch adhesion is also realistic.

Note: Contact A. J. Peters at (312) 808-5820 with questions or comments about this document.