Maintenance and Capital Costs of Locomotives

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On the basis of 1975 Interstate Commerce Commission (ICC) data, repairs for some 22 000 diesel-electric locomotives in freight and passenger service totaled $680 845 000; thus the average maintenance cost for all classes of diesel-electric locomotives was $30 948/unit. The maintenance cost of particular diesel-electric locomotives will vary with age, distance traveled, duty cycle, and type (turbocharged or nonturbocharged), as well as by manufacturer and railroad.

Maintenance cost data for specific railroads will deviate considerably from the gross averages. For example, a railroad that used 202 modern 2.24-MW (3000-hp) diesel-electric units that had an average age of 3.42 years compiled the following maintenance cost data for 1975: average monthly distance traveled per unit = 17 512 km (10 945 miles), average monthly repair cost per unit = $1258, average repair cost per unit-kilometer = $0.072/unit·km ($0.115/unit-mile), average overhead per unit-kilometer = $0.128/unit·km ($0.205/unit-mile), total average repair cost per unit-kilometer = $0.20/unit·km ($0.320/unit-mile), and total average annual repair cost per unit = $42 028. This cost is $12 000 more per unit per year than the U.S. average because of (a) a higher than average distance traveled per unit and (b) a lower percentage of branch-line and switcher operation.

Because of the difficulty of obtaining maintenance cost data for operating diesel-electric locomotives on a large number of railroads, we have constructed an average annual maintenance cost on the basis of the required ICC inspection and the manufacturers' recommended periodic maintenance procedures for the engine, electrical, and running gear and major overhauls over a 25-year life. The cost data refer to a typical turbocharged, six-axle 2.24-MW locomotive in heavy-duty service that accumulates 20 100 km (12 500 miles) each month. A typical breakdown of maintenance costs into major categories is shown below.

Item	Cost ($)	Percentage
Engine	13 400	31.3
Lube oil	3 500	8.2
Electrical	5 800	13.5
Running gear	20 000	47.0
Total	42 700	

Using 1975 dollars and the annual distance traveled of 240 000 km (150 000 miles), the maintenance cost is 17.8 cents/km (28.5 cents/mile). A locomotive that accumulated more kilometers would reflect lower costs per kilometer.

There is no established data base for modern electric locomotives in the United States at the present time, so comparisons are difficult to make. However, an estimate can be obtained by constructing a cost on the basis of the required ICC inspection and manufacturers' recommendations for periodic maintenance of electrical equipment running gear. If the annual distance traveled is 240 000 km, the expected maintenance cost would be $26 000 for a six-axle electric locomotive. This is 11 cents/km (17 cents/mile), or 61 percent of the corresponding cost for a six-axle diesel-electric locomotive.

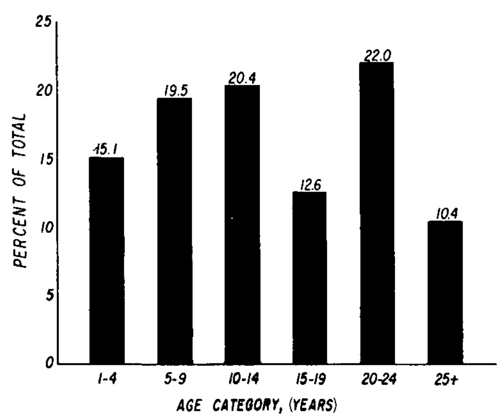
Typical maintenance cost values for the Swedish State Railway fleet of 43 ASEA RC locomotives is about 9 cents/km (15 cents/mile), which is close to the value computed for a six-axle 4.47-MW (6000-hp) electric locomotive. The Swedish locomotive, however, is only in passenger service, which differs considerably from the freight service for which the foregoing figures were developed. The electric locomotive entails about 60 percent of the maintenance cost of an equivalent-weight diesel-electric locomotive in the heavy-duty drag freight service that is characteristic of most U.S. freight operations. If tractive effort is not a limiting factor and locomotive units can be assigned on the basis of the total power needed for the train, it is possible to use a smaller number of electric units than diesel units, thereby achieving a further maintenance cost advantage. For example, if two 4.47-MW electric units can replace four 2.24-MW diesel units, the maintenance cost ratio (electric to diesel unit) would become 0.3.

The capital costs of diesel-electric and electric locomotives are much more difficult to compare, since very few modern electric locomotives have been constructed recently in the United States. On the basis of tractive effort, the price of a six-axle 4.47-MW electric locomotive is estimated to be two to three times the price of a six-axle 2.24-MW diesel-electric locomotive. On the basis of horsepower, the price of the electric is comparable to that of the diesel electric.

In heavy-duty freight service, locomotives are normally sized on the basis of continuous tractive effort to ensure operation over the maximum grade on the line. Therefore, locomotive costs on the basis of tractive effort provide the best comparison between diesel-electric and electric locomotives. In passenger service or special high-speed freight service, in which tractive effort is not a limiting factor and power is the basis for sizing locomotives, comparative locomotive costs should be based on power ratings.

It has frequently been stated that the diesel-electric locomotive has an economic life of 15 years. While the allowable tax depreciation life of the diesel locomotive can be taken to be as short as 11 years, the actual useful operating life can exceed 25 years, although technical obsolescence will dictate savings by replacing locomotives before this time in order to benefit from improve-

Figure 1. Distribution by age of 17 911 diesel-electric locomotives in service on U.S. railroads as of January 1976.



ments. Figure 1 shows the distribution by age category of 17 911 locomotives built by General Motors Corporation and in service as of January 1976. Twenty-two percent of this fleet has been in service for 20 to 24 years and 10.4 percent for more than 25 years. The average age is 13.7 years.

With the current rate of technological development in the electric locomotive field, it seems likely that new electric motive power introduced into the field will exhibit a life expectancy similar to that of current diesel-electric locomotives.

In summary, the maintenance costs of electric and diesel-electric locomotives will vary widely with the type of service. The maintenance costs of electric locomotives in heavy-duty freight service are expected to be in the neighborhood of 60 percent of the maintenance costs of equivalent-weight diesel-electric locomotives with the same number of axles. The maintenance-cost ratio can be reduced to 30 percent or less in lighter freight operations.

The life expectancy of diesel-electric and electric locomotives is expected to be similar—about 25 years. Both types of motive power are subject to technological obsolescence.

The price of electric locomotives is considerably higher than that of diesel-electric locomotives of similar weight and tractive-effort ratings. It is expected that electric locomotives for passenger service or for special high-speed freight service in which tractive effort is not a limiting factor will have prices closer to those of diesel electrics of comparable power.

Maintenance of Diesel and Electric Motive Power

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Numerous investigations of the capital and maintenance costs of railway electrification have been carried out since electrification became a practical traction system almost a century ago. Any further studies are unlikely to reveal new factors, but there is a wealth of information available on which to base judgments.

Consideration of the statistics derived from international experience in the field of maintenance can only be meaningful if the costs can be compared with those from an alternative form of motive power that performs similar duties. Since my experience has been principally in Britain, I propose to compare the costs, results, and problems of electric locomotives operating in the United Kingdom with diesel-electric locomotives operating under similar conditions.

Competition from air and road has intensified the demand for the shortest possible journey times by rail that are compatible with the increased cost of maintaining the track at a level suitable for the higher speeds involved, the cost and social acceptability of the increased energy consumption, and the more expensive motive power and passenger cars.

Premier passenger services in many of the developed countries of the world operate at maximum speeds of at least 160 km/h (100 mph) and in many cases at 200 km/h (125 mph). With these high speeds, impact forces must be kept low if rail failures and heavy track maintenance are to be avoided. This is usually achieved by restricting the unsprung mass of the vehicle trucks, and the resulting total maximum axle loading for high-speed operation is normally 16 to 17 Mg. Such traction units are not ideal for freight-hauling purposes so far as adhesive weight and gearing are concerned. Head-end power facilities for train heating, braking characteristics, and aerodynamic shape are just some of the features that make high-speed power units unsuitable for freight locomotive applications. Relatively few cases can be found in which mixed-traffic locomotives can now be efficiently employed; it is therefore proposed to separate passenger and freight statistics in comparing diesel-electric and electric alternatives.

COMPARISON OF ELECTRIFICATION AND DIESEL-ELECTRIC TRACTION

The examination of many cases in which electrification was one of the alternative forms of traction being considered has led to the clear conclusion that, if financial return is the main criterion for decision making, only exceptionally intense operating conditions justify the high capital costs of electrification. There are a number of benefits to be obtained from the use of electric traction, some of which can be quantified in financial terms; they include

1. Smaller fleet of locomotives to achieve comparable service,
2. Lower capital cost of each locomotive,
3. High reliability,
4. Greater availability,
5. Lower maintenance costs,
6. Lower operating costs,
7. Lower levels of atmospheric pollution in built-up areas, and
8. Ability to use energy from sources that do not deplete the valuable and finite natural oil reserves.

Among the key factors that must be recognized on the opposite side of the account are (a) higher overall capital cost of electrification and (b) reduction in operating flexibility.

Although all the above factors are relevant and there are many others, it is interesting to note the areas in which change is taking place.

1. Ten years ago there was a significant difference between the capital cost of electric and diesel-electric locomotives; in approximate terms a diesel-electric locomotive designed to carry out duties similar to those of an electric locomotive was then 50 percent more costly. Developments to improve performance and reliability and at the same time to reduce maintenance and track damage have increased the cost of those elements that are common to all types of power units. The resulting sophistication has narrowed the difference in initial