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RAILWAY RESEARCH AND DEVELOPMENT and THE REALITIES OF THE 1980's

by

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1.0 Introduction

The railways of Canada will, in the remaining years of this decade be facing a set of realities in the commercial, operating and regulatory environment in which it exists, which will have significant impact on its Research and Development activities. In the following paper an attempt will be made to show how the realities will shape CP Rail's R&D efforts and in some part the R&D efforts of the industry in general.

2.0 The Realities

The immediate future is rapidly shaping up as one which will see Canadian railways under tremendous financial pressure. This will be the result of a number of factors.

- A major erosion of revenues resulting from the implementation of the new National Transportation Act as it was outlined in Freedom to Move.

- The erosion of the markets for, and the price of, Canadian agricultural and resource products which are shipped primarily by rail from their origin to tide water or the Great Lakes system.

In addition to the financial pressures, the Canadian railways will be called upon to improve their already high safety performance as well as improve their service standards. If we roll into this the impact of the "Via Act" and Free Trade the implications for the railways becomes clear: If the environment in which railways operate, through legislative and other means, results in major reductions in revenue while demanding better levels of service the railway must reduce costs or go out of business.

3.0 Cost Reduction

There are a limited number of ways that costs can be reduced. The most obvious is a rationalization of the plant. Beyond this the railways must find ways to increase productivity both in terms of obtaining more units of transportation for each unit of variable input and by increasing the useful life, in terms of transport units, of capital components. It is these latter items which will drive R&D in CP Rail during the next few years and it is suspected in the other railways as well.

Broadly speaking CP Rail is focusing R&D on five areas.

- reducing energy consumption
- improving useful life of major capital and non-capital components
- improving the productivity of all units of the operation by the application of new and evolving technology
- improving upon the inherent safety of the system
- creating a condition that by better defining our needs to the supply industry we will obtain better products.

Like all things R&D must function within budget constraints. CP Rail does not carry out R&D simply for the sake of doing it. It expects that overall the programs will lead to developments which when implemented will not only cover the costs of development but reduce operating and capital costs over the longer term. Research programs therefore are examined carefully before they begin as to probable costs and expected benefits. In doing this, it is appreciated that by the very nature of R&D not all programs will be successful. In order to minimize the cost of unsuccessful programs a system of milestone reviews is used which allows decisions to stop or proceed to be made at appropriate points in the programs.

The evaluation of probable potential benefits is at times difficult when eventual implementation requires approval from the regulatory agencies. The approval process can lead to serious lags in the implementation schedules and can materially affect subsequent benefits.

It should be noted, before anyone accuses railways of spending inadequate sums on R&D, that railways are a service industry. We do carry out R&D in the classical sense in that we are developing a better understanding of the complex forces that exist in our working environment and are using this data to aid in the development of better equipment. It is generally this effort that our critics address. However we spend considerable sums in developing new or improved services. Examples of this being the introduction of robot power and the introduction of domestic containers. While these are not viewed as R&D, they do require development and do present considerable financial risk.

4.0 Some Programs Presently Underway

To illustrate the principal thrusts of CP Rail's efforts and that of the industry in general three particular programs will be described. These have been selected to illustrate the diversity of the R&D effort and to demonstrate some of the problems faced in carrying it out. The three programs are:

- the testing and introduction of self-steering railway freight car trucks
- tangent track lubrication
- development and testing of a locomotive using AC traction motors and associated electronic control equipment.

4.1 Self-Steering Trucks

In the late 1960's the railways were becoming more knowledgeable of the behaviour of the standard three-piece truck; its tendency to parallelogram, to hunt when running under light cars, and the relatively high rate of wheel wear, which is inherent in the operation of these trucks, in highly curved track territory.

In response to these concerns, a number of solutions were brought forward. These involved either some means to have the axles steer around a curve, devices for stiffening the trucks, changes in wheel profile or a combination of all of these. In 1975 CP Rail made the decision to proceed on a carefully phased program to test and eventually implement an improved truck for bulk train service. The program would include:

- preliminary testing of up to five different truck configurations
- extended "in service" testing of at least two types of trucks
- implementation on an entire trainset of radial trucks

These steps were taken so that we could evaluate costs and benefits before further commitments were made. There was also at the time considerable conflicting evidence as to what we could expect from the various designs that were available.

The initial testing examined lateral wheel/rail loads, angle-of-attack under curving conditions and truck stability in operation. These tests led to "in service" testing of two types of radial trucks.

The "in service tests" chiefly were directed to measuring rate of wear of the wheels while carefully monitoring other components, particularly the steering mechanism for deterioration. All wear measurements were to be made with reference to wear on a standard truck which was run under the exact same conditions as the test trucks. After more than 250,000 service miles we have recorded a reduction in tread wear of 39% and of flange wear of 75%, this is illustrated in Figs. 1 and 2. No major deterioration of the steering mechanism has been noticed nor significant deterioration of other truck components.

The data on wheel wear, angle-of-attack and lateral forces were used to estimate potential reduction in rail and wheel wear and in energy consumed on selected train runs. Based on the results an entire coal train of 108 cars has been equipped with radial trucks and entered revenue service in January 1986. The performance of the truck components will be monitored over time. Specific tests also will be carried out, in order that, rail wear, wheel wear and energy consumption can be more specifically measured.

In carrying out these tests CP Rail made use of facilities and instrumentation of the Railway Laboratory of the National Research Council. CP Rail also developed a number of instruments, in particular, devices to obtain a precise measure of wheel and rail wear and for measuring the angle-of-attack of wheelsets. This particular program is at the present time stimulating us to develop a method to measure rail wear resulting from the passage of a single train.

4.2 Tangent Track Lubrication

In 1984 tests carried out at the Association of American Railroads (AAR) test facility at Pueblo indicated that when lubricant was applied on tangent track segments significant reductions in the energy required to move a fully laden train were experienced. Reductions of the order of 30% were reported.

Many railways in North America have been using lubricators on curves for a number of years principally as a means of reducing rail wear due to wheel flange contact. It was always considered that flange contact on tangent track was negligible. The energy reduction from lubrication however indicated that this was not so or that there was some other energy loss mechanism at work.

In order to try to establish a better understanding for the energy reduction CP Rail agreed, as part of its participation in an industry wide Research and Development activity, to examine the angle-of-attack of a large number of wheelsets on its coal trains on tangent track. Using a laser based device which CP Rail developed some years earlier a sample of 444 carsets was observed at 3 separate locations on the track. The result of the observations on loaded cars is shown in Fig. 3.

At first these results were thought to confirm the notion that there was no significant skewness of the axles. However, analysis carried out by the Research & Test Dept. of AAR indicates that a skewness of as small as 2 milli radians and in the proportions indicated in the sample taken, would account for the change in energy consumption.

In order to obtain further confirmation of the phenomena on its own track, CP Rail ran tests on actual coal trains both loaded and empty. Using a lubricator car and instrumentation supplied by AAR which allowed for correction of different weights in the cars, effects of wind and different train handling, we experienced a saving of 3 to 8.5% on track over a distance of 125 miles. On this section of track curves in excess of 4° are already lubricated and these constitute a significant segment of the track miles.

The conclusion that can be drawn from these tests is that there is potentially an opportunity for a significant reduction in energy consumption. However implementation of full tangent track lubrication illustrates in a classic manner the problems which are inherent in introducing this type of development on a railway. Implementation would present a new set of problems to which there are no immediate answers. Specifically the most important of the problems involves uncertainties of what will happen to the rail. Since lubrication reduces rail wear the principal mechanism governing the life of the rail will probably be some form of fatigue. Incipient failure of a rail due to fatigue is somewhat more difficult to detect than visually observing head wear. Furthermore the presence of the lubricant on the rail might also increase the rate of propagation of surface cracks as well as possibly reduce the available tractive effort of the locomotive.

As a consequence, implementation on a wide scale must be carefully examined with respect to creation of new conditions which might cancel or result in negative benefits. This kind of conumdrum occurs quite often and because the railways must proceed cautiously, it makes railway research appear casual and slow.

4.3 AC Powered Diesel Electric Locomotives

One of the principal causes of locomotive unreliability is the electric traction motors. The present direct current motors have undergone considerable development in terms of improved robustness over the past 25 years, however, they still represent a major portion of our cost of locomotive maintenance. For example, CP Rail renews on the average 215 traction motors per month on a fleet of approximately 1200 locomotives. In winter months the number can exceed 350.

In 1981 it was decided to proceed, with the participation of Bombardier Inc., Brown Boveri Canada Inc. and shared cost funding supplied by the Canadian Department of Industry, Trade and Commerce, with the development of a locomotive using AC Traction Motors.

The principal benefits which we could foresee from AC traction were:

- adhesion levels that are above the levels now available from DC traction units
- dynamic brake capability down to near zero speed
- improved locomotive reliability and a significant reduction in maintenance costs.

This program has resulted in the conversion of a 4000 HP locomotive (CP 4744) using four 1000 HP, 3-phase asynchronous traction motors. The locomotive has undergone extensive performance testing and is performing very close to its design objectives. It is presently in limited revenue service and will shortly be entering regular revenue service where it will be monitored for about a two year period.

5.0 What Do These Programs Demonstrate

The programs described above are but three of a number that CP Rail has underway. They were selected to demonstrate the following characteristics of todays railway research.

- Because the operating environment contains so many variables, replication of this environment in a laboratory is very difficult. While laboratory facilities which are capable of replicating some parts of the operating environment have increased dramatically in the last 10 years, in service testing is still the final criteria for successful development.

- The operating environment is a complex interactive system. Development in one part of the system must take into account the potential effects on the other parts of the system. Since the nature and degree of many of the interactive elements are not yet fully understood, we must proceed in a manner which allows progress but does not give rise to deterioration in other parts of the system which could impact upon costs and safety.

- In order to shorten the development time the railways must continue their efforts to better understand and to quantify the forces at work in their environment.

- The railways are and will continue to increasingly demonstrate that when they become dissatisfied with equipment which is being produced by their "traditional" suppliers, they will actively encourage development by others and where necessary will support this development in the testing phases.

6.0 Industry Wide Programs

The programs described above are but three of several being pursued within CP Rail. While the programs are of direct interest to CP Rail they are also part of a much broader effort which is being pursued by the industry as a whole. This effort includes such programs as:

- analysis of alternate fuels

- extensive wind tunnel testing of rail car and train configurations to reduce aerodynamic resistance

- extensive testing of components such as rail, ties, ballast etc. at the Facility for Accelerated Testing at Pueblo and in various laboratory facilities

- extensive development of rolling stock to be used for hazardous materials

- development of laboratory facilities for environmental, shock, vibration and component wear testing.

The research activity is being carried out by the AAR in their own facilities or in affiliated University and Research Institutes and by the various major railways in the U.S. and Canada.

A major program also underway is the development of an

Automatic Train Control System (ATCS). This program originated with Canadian Railways and is now being supported on both sides of the border. At present some six million dollars Canadian have been committed to the development of system architecture and component specification. Half of this sum has come from the Canadian Railways.

7.0 Significance for the Railway Supply Industry

The Railways are in the business of providing transportation. We are not in the business of manufacturing major components for our own use. The railways, however, have traditionally carried out considerable design work and then had manufacturers produce to that design. There is at present, a definite change in emphasis. Today the railways are thinking more in terms of defining the performance which they want and of defining, in measurable terms, their operating environment. While we still have some way to go, research work by the industry over the past dozen years has led to a greater understanding of the forces at work which makes the definition of the parameters of the operational environment much more possible.

It can be foreseen that the railways will, in the near future, begin specifying acceptance criteria which will require, on the part of suppliers, the production of documentation that the particular item has met physical, environmental and performance specifications before the railway takes delivery of the item. It is expected that laboratory testing will become more definitive with "in service" testing only being used when there are no alternatives.

As the performance criteria and the operating environment become known, and the railways are able to more precisely define their requirements, the longer term impact on the industry is that it may be practical for a broad spectrum of industries to enter the market for the supply of railway material. It is certainly our hope that this will occur.

8.0 Constraints on Railway R&D

Large as the needs are for continuing or expanding R&D within the railways and its supply industry there are a number of constraints which tend to limit and in some ways direct the effort. There is the ever present financial restraint that all industrial R&D must live with. However, beyond this there are issues which are peculiar to railways, included are:

- The railways have a large capital investment. Consequently changes in components of this investment which are not compatable with the rest of the system are not acceptable. Therefore before any serious development resource is committed, it is incumbent upon the developer to examine the impact that the eventual product or system would have on the existing infrastructure or operations of the railways. There have been in the past far too many solutions chasing perceived problems.

- The capital write-off imposed upon the railways for taxation purposes does not encourage the replacement of working components unless the cost savings are dramatic. As an example, a 15% reduction in fuel consumption would, at present, not economically justify the replacement of an existing locomotive by a new locomotive.

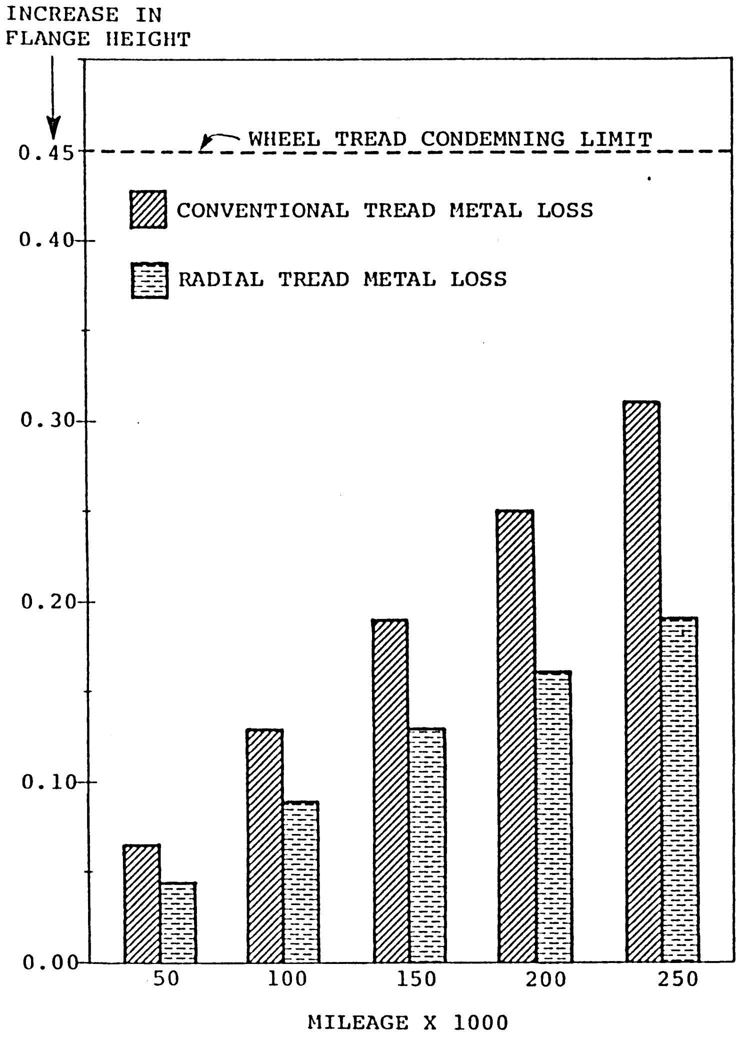
- The implementation of a new or improved technology is at times restricted by the regulatory regime under which railways operate. If the implementation requires any change to regulations or orders then we can find ourselves in an extended period of discussions which can sometimes include public hearings. This process and its inherent delays, represents a serious risk to anyone who sets out to develop new devices for use on the railroad.

9.0 Conclusion

Research and Development is very much alive in the Canadian Railway Industry. Its directions are being shaped by the financial pressures which deregulation will create, by the world market for Canadian products and by and by a desire on the part of the railways to improve service and safety. The programs underway cover both applied and basic research. The applied research is directed at improving the products and systems that we already have in place and developing new products or systems to do our job better. The basic research is a continuing effort to better understand the interrelationship of the multitude of forces at work in the rail operating environment.

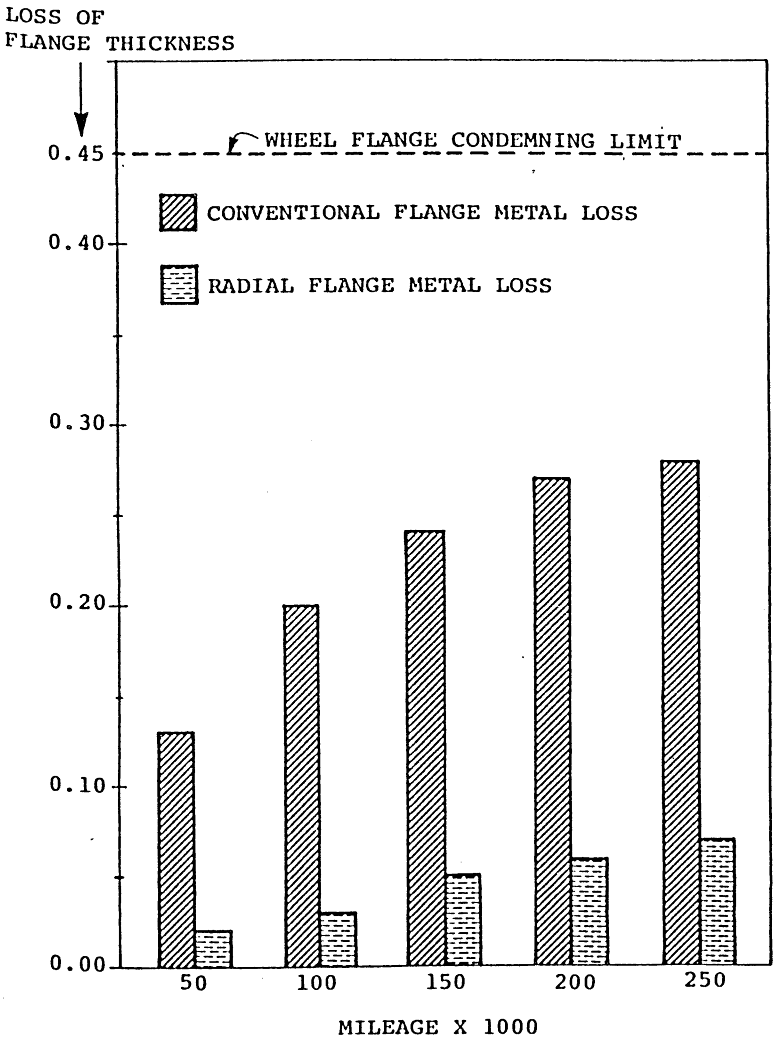
The combined affect of the research efforts will, in time, impact on suppliers of railway equipment and systems because they will be working to performance specifications which will give them some flexibility in design but will also expose them to increased competition.

Research and Development, therefore, will play a significant role in helping the railways to address the challenges of the future;challenges that will be overcome just as those of the past were overcome.



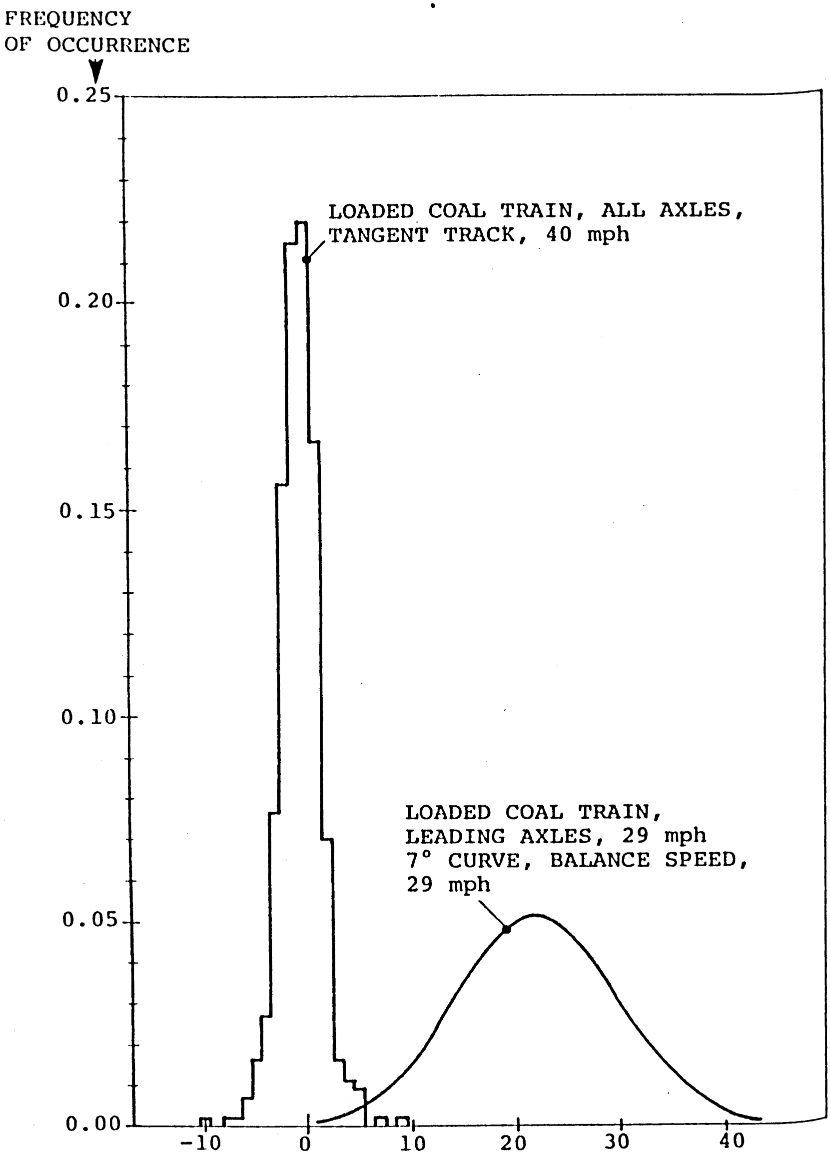
INCREASE IN FLANGE HEIGHT VS MILEAGE

Figure 1



LOSS OF FLANGE THICKNESS VS MILEAGE

Figure 2



ANGLE-OF-ATTACK DISTRIBUTION FOR
A LOADED COAL TRAIN

Figure 3