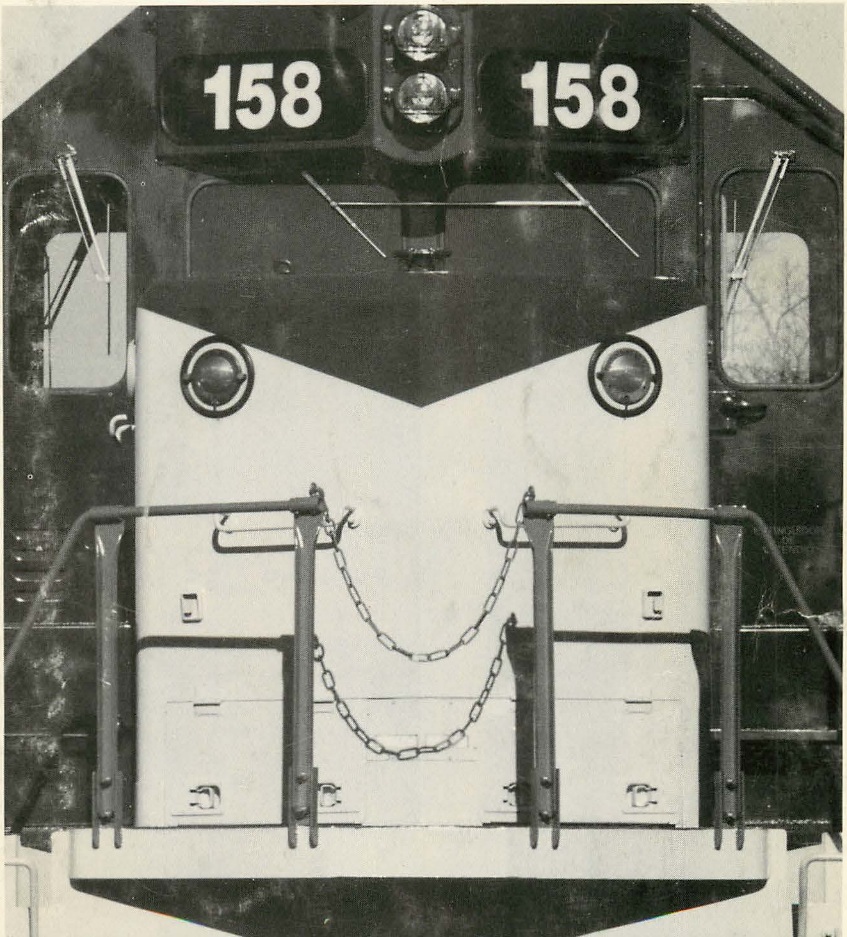
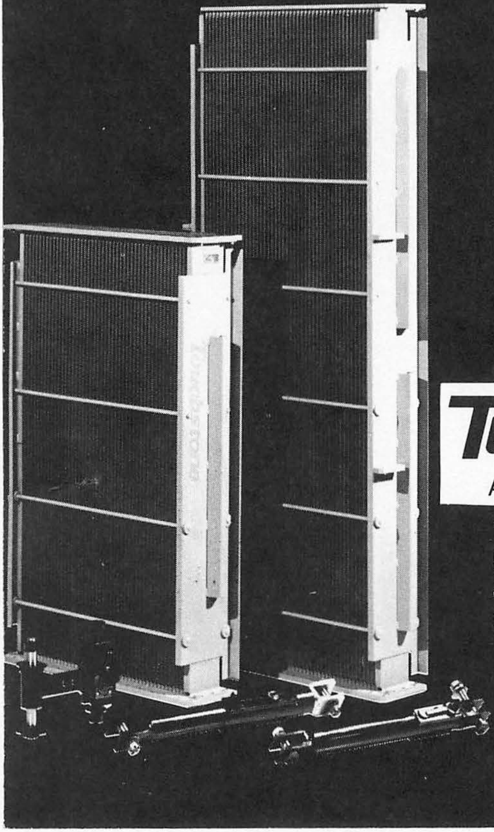
LMOA

Locomotive Maintenance Officers Association

Proceedings of the 56th Annual Meeting
Chicago, September 19-21,1994





1994 ADVERTISERS INDEX

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TECHNICAL PAPERS

JOINT MEETING OF COORDINATED ASSOCIATIONS WITH R.S.A.

Monday Morning
September 19, 1994

Keynote Address:
Harris Wagenseil
VP - Purchasing & Materials
Union Pacific RR

The Joint Meeting of the Coordinated Associations with the Railway Supply Association held at the 1994 Technical Conference of the Coordinated Mechanical Associations convened at 9:00 o'clock a.m. in the International Ballroom of the Chicago Hilton & Towers, Chicago, Illinois, with Mr. Herman T. Jones, President of The Air Brakes Association and Senior Instructor, Union Pacific Railroad, presiding as the Chairman.

Chairman Herman T. Jones: Good morning, ladies and gentlemen. Welcome to this session of this conference.

At this time I would like to introduce the gentlemen seated at the speakers table.

First, on my left is Reverend Charles J. Brunick of the Old St. Mary's Catholic Church.

Next to him is Mark Coles, President of the Locomotive Maintenance Officers Association.

Next is Chuck Funesti, Secretary and Treasurer of the Car Department Officers Association.

Next to Gary Grffiths, President of the Car Department Officers Association.

Next is Henry Christie, Secretary of The Air Brake Association, and next is Ron Pondel, Secretary of the Locomotive Maintenance Officers' Association.

To my right is Harris Wagenseil, Vice President, Maintenance Operations, Union Pacific Railroad.

Billy Sanders, President of The International Association of Railway Operating Officers.

Then Gary Hickey, Vice President of The International Association of Railway Operating Officers, and Joseph Stark, President of the Railway Supply Association, and Dale Gaeth, Director of the Railway Supply Association.

Rev. Brunick: Let's bow our heads briefly for a moment of silence, each in our own way, in our own heart, to ask God's blessings and the guidance of God's spirit on the deliberations over the next few days.

All Mighty God, we come here today from different places, different countries, states, cities and towns. We come, too, from different ethnic, cultural and religious backgrounds. In our separate faith communities we know you and often call you by different names, yet individually and together, despite our diverse backgrounds, we acknowledge you as the author of life, the creator of us all.

Bless this gathering, bless the organizations gathered here, send your spirit to guide us. Bless all who have come for these annual meetings. Make our discussions productive, our learning sessions informative, and may the fellowship we share over the next few days increase our love for each other and for you. Bless us all know and forever. Amen.

Chairman Herman T. Jones: Thank you, Father Brunick.

My name is Herman Jones, Senior Instructor, Union Pacific Railroad, and this year's President of The Air Brake Association.

At this time it is my pleasure to introduce our keynote speaker, Mr. Harris Wagenseil.

Harris Wagenseil is Vice President

of the Maintenance Operations of the Union Pacific Railroad. Harris joined the railroad in July 1989.

Harris was born in Alton, New York, and grew up in Los Angeles, California. He received a Bachelors Degree from Dartmouth College in 1967, Summa Cum Laude and Phi Beta Kappa. After college he attended Oxford University on a Rhodes Scholarship and took an MA Degree in the Honors School of Politics, Philosophy and Economics, with emphasis on Economics. Then Harris received a JD Degree from Harvard Law School, after which he practiced law in various public interest and private capacities. After practicing law for several years, Harris received an MBA from the Wharton School.

Harris joined the Cummins Engine Company in 1983. At Cummins, Harris was responsible for Cummins sales of engines worldwide for government applications and later became Vice President, Automotive. In that position he was responsible for North American marketing and sales of heavy and medium duty diesel engines for truck applications. The customers were major OEM's like Navistar and trucking companies located throughout North America.

Harris' last assignment at Cummins was as Vice President of Business Development. In that capacity he investigated and negotiated opportunities for diversification.

Upon joining Union Pacific in 1989, Harris served as assistant to the chairman. In that capacity he was responsible for Union Pacific's business with Mexico and for installation of an integrated planning and control system to improve the railroad's management systems which is still in use today.

Harris was appointed Vice President, Supply, in June 1990. In this position Harris was responsible for all railroad purchases and also materials distribution through 12 warehouses located on the 19,000 mile Union Pacific system.

In February 1991, the Maintenance Operations Department became Harris' responsibility also. This included locomotive repair and maintenance shops, car repair and maintenance shops, parts remanufacturing facilities, equipment engineering and the research and development laboratory.

Early this year Union Pacific realigned operations and added 2,000 people from the field to Maintenance Operations and transferred the Supply Department. Currently, Maintenance Operations has 5,000 employees and a yearly budget of 500 million in addition to capital expenditures of 300 million per year.

Over the years Harris has served on boards of several public interest associations and also corporations. He has been a speaker and lecturer at various conferences and meetings throughout his career.

Harris lives on Loveland Drive in Omaha with his wife, Clayton Wilshire, and two children, Kathleen Wallace and William Harrison. Three other children live most of the year out of state where they attend school.

I give you Mr. Harris Wagenseil.

Mr. Wagenseil: Thank you, Herman.

Good morning. I'm honored to be with you here this morning and flattered by the invitation to make your keynote address.

The last time that suppliers asked me to speak it was roughly four years ago and I had just been given responsibility for the Purchasing and Materials Department at Union Pacific Railroad. I gave a short speech at a luncheon at the Union League Club, and since then I have not talked to any industry associations.

Since the invitation here followed very closely on the heels of the last reorganization at Union Pacific

Railroad, I'm kind of curious about how the industry selects its speakers.

Since receiving the invitation I have spent some time thinking about what I wanted to say. And I thought about doing the vision thing, but that seemed like a very broad brush for a group that has a lot of engineers in it. And then I thought about just focusing on technical issues, and that frankly just seemed to be downright boring.

So if you'll bear with me, I'm going to do some of both. I'm going to do a mix of industry vision and I'm going to get into some technical details also. And I'll give you along the way my thoughts about where we are as an industry and what I think we need to be doing.

Over the past few years, we railroads have had a pretty good run. This slide shows operating income since 1987. The eastern and western major railroads are grouped separately. All Class I's are also shown.

Although the industry has had its ups and downs, it's generally strengthened for the major roads which are up 23 percent from 1987 to 1993, and some of the regional roads that were not shown here have done significantly better.

As this next slide shows, in the last couple of years the operating ratio for major roads has declined generally, although some Class I's have seen their operating ratio steadily decline since 1987. The upward trend from 1989 to 1991 in the west and for the Class I's is strongly influenced by the Southern Pacific. In particular the Union Pacific, however, the Sante Fe, Conrail and Norfolk Southern have noticeable downward trends if you look at them individually. Overall the Class I's have declined two percent, although in the east the operating ratio is down three percent.

So that's what's happened over the last few years, and how have we accomplished these results?

Surveying the past ten years or so, the analysts for Donaldson-Lofton noted in their July 1994 report on rails as follows.

"The industry has significantly and permanently reduced its cost of production by eliminating excess capacity and unproductive work rules carried over from more than 100 years of government regulation. Since 1980 the railroad have accessed 80,000 miles of track or approximately one-third of the original line, reduced rolling stock by 50 percent and eliminated more than 50 percent of the employees positions."

So where are we now? Let's turn to the analysts again. Jack Cawa of Dean Witter wrote in June: "The industry enters a new era of expansion, hiring and shortages, uncharted territory after 15 years of surpluses. Not sure of the impact, there will be some. After 15 years of downsizing, we wonder what impact and expansionary mind set will have on overall profitability. This is clearly an unknown for both management and analysts."

CS First Boston is even stronger:

"As we have discussed in numerous previous reports, we believe the easy cost cutting for the railroad industry is largely behind it. Rail cost reduction opportunities are becoming more limited."

Let me repeat that.

"The easy cost cutting for the railroad industry is largely behind it. Rail cost reduction opportunities are becoming more limited."

So the bottom line is that we railroads have had a pretty good run and the suppliers have seen good times return also.

The situation we face now, however, is that we have squeezed out much of our excess line capacity, our excess equipment capacity, and a lot of our excess people. Consequently, we will not be able to use the same tools in the future that we have used in the past at least to the same degree.

Now, the picture that I have just painted is a familiar one to most of

you. There's one more critical element, however, that has to do with our cost of capital. Mercer Management in an excellent series on the industry observed in Progressive Railroading recently:

"Since 1986 the cost of capital -- with the cost of capital consistently pegged at around 11.5 percent by the ICC, the industry's rate of return on net investment has never exceeded 8.1 percent and only a handful of individual railroads have earned more than their cost of capital."

I asked our finance department to look at the same issue in preparation for this speech and here's a composite graph that they've prepared for me.

It shows on the top line the industry cost of capital and on the bottom line the industry return on investment. That's quite a gap between the two. It confirms what Mercer reported. And by the way, in 1991 the big dip there was the result of a lot of railroads taking a writeoff in that year. It wasn't that bad a year. But nonetheless the gap is there very decidedly.

Now, the next graph here shows the industry cost of capital up there at the top as the yellow line and a host of lines are charted representing the seven big railroads and only a few of these break the yellow line in any years, and very few rise above the yellow line consistently.

The message here is that despite our excess capacity, despite our recent successes, we have had trouble earning the cost of the capital invested in us. Over the long term this will result in depressed stock prices and lack of investment.

Frankly, I personally think that this is the number one strategic issue facing the industry. We can justify buying a locomotive or some freight cars based on the return on investment, but as we become more capacity constrained and investment in several inputs are required simultaneously, how and when will we earn our costs for that capital? These are very serious questions and I'll talk about them in a second.

I hope, however, the answer to when is not the same one that God gave the physician that went to him. The doctor said to God, "You know, I just have one question I'm curious about. Will health care reform ever occur?" And God replied, "I have good news and bad news. The answer is yes, but not in my lifetime."

Now, the folks at Mercer Consulting have their answer as to how to earn our cost of capital and it's worth reading. This morning I'll put my spin on it.

I think we need to do three things that are all related. We need to improve utilization of the assets that we have, we need to shorten the cycle time for introducing new technology, and we need to cooperate and work together better than ever. What does this all mean? How can we improve asset utilization?

First, I think we cannot shrink ourselves further into prosperity. I suspect and I fear that some railroads have become accustomed to cost cutting and the vision is now becoming short sided. I know we have a lot of technology out there that's coming, AC locomotives, electronic freight car brakes and so forth, and I'll return to those topics in a minute. But I'm afraid we may have become too short term in our focus.

One author writing about Ford Motor Company in the 1960's talked about their approach to cost control. As far as he was concerned, their idea was to take one inch off the tail pipe very year.

My view is that need to instead put more resources, new resources possibly, or a realignment of our current sources into a better understanding of how to use our assets more effectively. We must join with suppliers, use a common approach and language based on rational analysis, and we must use the same approach where interchange standards are concerned. We cannot afford to use a little thinner casting in our components or a little shorter air hose if we're to be successful in the long run. We have to find other ways to cut our costs and to improve our asset utilization.

Let me illustrate. We've had a problem recently in our railroad with gear cases coming loose on a particular group of locomotives. We asked the manufacturer if they were aware of any problems with the design and they indicated that in general there had been no problems and as long as their maintenance schedules were followed, we wouldn't have the problem.

So we looked at the maintenance manual for these locomotives and indicated that the bolts should be retorqued every 92 days. That's a pretty tall order. Six motors per locomotive, three bolts per gear case, roughly 500 locomotives, 9,000 retorques every 92 days, 36,000 retorques in a year. You know, it reminds me of that saying, a million here, a million there, pretty soon you're talking real money.

Then we started to investigate how we would go about doing this. In order to do all the bolts, we discovered it would be necessary to remove part of the brake rigging. In addition to the time required for this task and the safety of having people under a locomotive tightening bolts to 460-odd foot pounds was also going to be difficult if not impossible.

So we asked the manufacturer how they accomplished this task and there was a long silence because, in fact, they don't actually do that kind of work.

Here's another example from our interchange rules. I don't know if anyone has taken a look at the field manual and the Manual of Standards and Recommended Practices to see if there's anything in there indicates when a freight car roller bearing has exceeded its useful life or when it is at least in need of reconditioning.

Well, there isn't anything in there of that nature. What it does say is that if an axle is removed for any reason, for example worn out wheel or shell tread, then the bearings must be reconditioned. In short, although we would all agree that at some point bearings are in need of reconditioning, our own field manual and standards state that wheel or axle condition is going to signal the right time for reconditioning that bearing.

My question for all of us is how do we decide that the wheel or axle condition would be the right time for that bearing to be reconditioned? Or rephrasing the question from the other side, why should a bearing be in need of reconditioning if it's just been applied to a wheel set which happens to be set out due to a handbrake being left on inadvertently? By our own rules, we're required to remove and recondition those bearings which are just applied.

Now, this rule reminds me of what the French Revolutionary said about laws which is that they're like sausages. You never really want to watch them being made.

Now, here's one more example and this is a controversial one. If you have the field manuals in your pocket, you can turn to Rule 41, Sections A and E on Pages 234 and 263. If you don't have them with you, I've put them on the slides.

Here you can see the rule on removal of thermal cracked wheels. The only explanation given in the field manual regarding thermal cracked wheels are these two photographs and the following explanation from the manual:

"Thermal or heat checks are often caused by brake shoe heating and appears a fine network of superficial lines and checks running in all directions on the surface of the wheel tread. This condition should not be confused with thermal cracking and is not cause for wheel removal."

Then if you look at the Manual of

Standards and Recommended Practices, you'll find this explanation. It says that thermal cracking is a serious defect.

Anyway, it says it's a serious defect and in any stage of development it is cause for immediate removal. On the other hand heat checks should not be confused with true thermal cracking and is normally not the cause for wheel removal.

Basically, what I need to know is if you look at these pictures and you listen to those explanations , do you think that our people in the field have an adequate basis to distinguish between thermal cracking and thermal checks?

This is an important issue since broken wheel derailments are extremely expensive and hazardous. If you were in the field could you really make that call every day with certainty and precision?

And, of course, remember that thermal cracks are also caused by brake shoe heating.

So the checks and the cracks are both caused by the same thing. It's just up to your interpretation whether or not the cracks are superficial as to whether or not you remove the wheel.

So there are three examples where I think we need to understand and manage our equipment much better. Doing so would improve our equipment reliability and our financial performance.

Incidentally, we've only been told about a million times by our customers that they want more reliable error free transportation. Failing to understand the reliability characteristics of our assets or ending up with a camel from the committee when we wanted a horse are not the paths to follow.

At the core of better asset utilization, at the core of my comments in the interchange rules, lies a need for better tools and better data.

Now, here's a real life example from Union Pacific. The example concerns traction motor support bearings. First, the wrong way to address the issue.

The manufacturer suggests that we change our motor support oil annually. We don't do that. We don't do it because we found that the more we fool around with removing and replacing the support bearing wicks, the more failed bearings we have. On some motors, however, we just get by by sweetening the oil a little bit and waiting for the wheels to wear out.

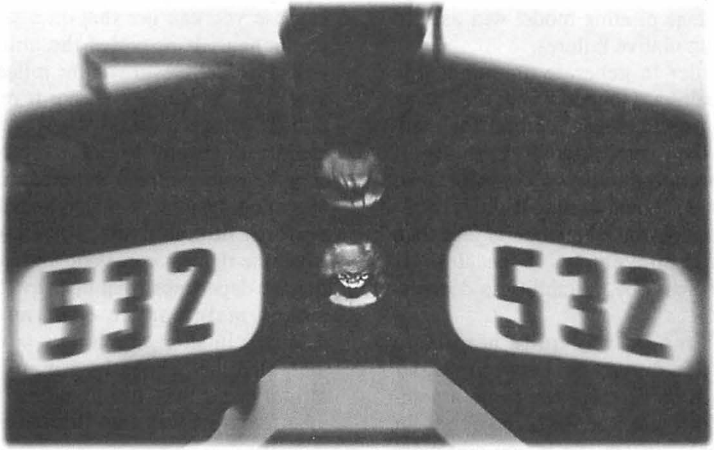
When we asked for technical advice from our supplier, they responded that the greatest factor influencing our failure rate was not following their recommendation to change out the motor support bearing oil on the schedule they required as other railroads do.

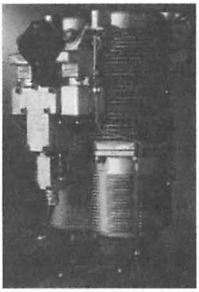
Now, we scratched our heads over this because, like I said, we do get by with it on some motors but not on others. However, for a long time instead of objectively analyzing this situation, we clouded the picture more by experimenting with an oil additive. We heard it was being used at another railroad when one of our shop directors talked with his contact and one of our general directors talked to another contact. They heard the additive was a good solution. And then when one of our engineers talked to his contact he heard, yes, the additive is being used but there's some other things that they did also that may have made a difference.

Anyway, these conversations, these information conversations, were enough for us. So we tried the oil additive and waited to see what happened. Well, we couldn't tell what happened. In short, as a result of searching for a quick fix, we lost valuable time, we confused ourselves, and we continued to have the same failures as before.

Let me illustrate a better way which eventually we did, and these are the type of tools that could be used to achieve more understanding of our reliability issues.

We used tools called Duane & Weibull Analysis to evaluate the useful life and failure modes of our traction





motors. The results of our tests, by the way, were that it appears that the oil additive has no effect on support bearing reliability.

A Duane plotting model was used to chart cumulative failures.

In order to generate a straight line both scales are logged. What the Duane model provides is a method for measuring the overall system reliability. If the system reliability is constant, then the slope is equal to one. If the reliability is improving, the slope is less than one, and conversely, if the slope is greater than one, reliability is decreasing.

This model was quite helpful in identifying differences between various facilities performing the same assembly tasks. Note that this technique is for the whole system. So if you add more people or more train and you want to measure if there is an effect, you can do this using the Duane plots.

In the plot that's shown here, what can be seen is a change in the failure rates right here at the point of inflection.

Right there at the inflection point of 10,000 cumulative days. This corresponds to when we made a change in the locations where we build our traction motor combos. So, although we made a change in the locations in order to be more cost effective, in fact it was a decrease in our reliability.

Kind of straight line right there. That's the plot from one shop. And then if you compare with this one, this one actually is a better shop. The line extends further along the right-hand scale and it's straight all the way. And then this one is actually the worst shop. You can see the plot goes up here and then it turns north very sharply, actually somewhere, I think, around three to 4,000 hours.

The point is that you can really see the differences in the different facilities as to the reliability of the traction motor combo that they produce.

Now, the next step in our analysis was to perform what's called a Weibull Analysis on the support bearing motors for the different motors. A Weibull Analysis can go one step further because you can use that on a specific component. It provides the ability to probablistically estimate the mileage or time of a component before it reaches failure. It's very useful when trying to identify the useful life of a component as well as to estimate the effect on the operating system. It's also possible to perform this analysis, for example, when the request comes down from the finance department that in order to save money maintenance costs must be deferred. In short, it's a very powerful tool. One that's been long used by the military and the aircraft industry and then found its way into the automotive industry.

Here is a Weibull plot of two different traction motor types. There are two separate slopes to each of these graphs. There's one slope which turns north and then the bottom line here is a parallel slope. Well, that turns north also.

This type of plot is called a Bi-Weibull distribution, and what is shows is that there are two failure modes associated with the component. The lower slope down here is the first stage of failure, and the second steeper slope here is the final wear out mode. Now, since the slope is basically one down here, it's referred to as an infant mortality failure mode, and then here where the slope is very steep, that's referred to as a rapid wear out failure mode. On the Y axis is the probability of failure and the percent, and on the X axis are the miles of the components.

So the way to interpret this line is to say that if you run these motors 200,000 miles you'll get about a two percent failure rate, and if you run them at 350,000 miles, this top motor here will have a failure rate of about five percent. Now, that's pretty good if you think about it until you look at the next motor, the one here, the bottom line. With this motor type you can go

370,000 miles at a two percent failure rate and 435,000 for a five percent probability of failure. That's a difference between the two motor types of around 100,000 miles or more.

Now, the slopes of these two lines down here are basically similar, so the failure modes are the same. The difference then you can conclude must be in design. So if you're trying to run a two percent failure rate, on the one motor you would stop at 220,000 miles and on the other motor you would stop at 350,000.

Now, the problem is that we don't do that and we didn't do it. We maintained the motors the same and consequently we had different failure rates and were always surprised when this motor up here fails before the one below.

Anyway, by using this tool you can see that you can determine the probability of failure for a variety of components and you can tailor your maintenance practices accordingly.

These are the types of tools that I think we need to use more often. We really can't afford to test a new component any more by installing it on a freight car, running it around for a while, and seeing how it does. And we've done that a lot.

Both the railroads and the suppliers need to use these kind of tools so that we can sharpen our dialogue and talk more factually about our problems. We'll also gain a better understanding of what maintenance practices we need in order to improve the overall reliability of our transportation product.

Now, frankly, this little simple recommendation, I think, is a pretty tough one for the railroads. It sound simple. Put a few more people on Duane & Weibull Analysis, move some resources around. But, in fact, many people recognize this is a very difficult situation.

As Donald Frey, the CEO of Bell & Howell has said: "Nothing puts a greater drag on innovation then the inertia in your own organization. It is especially difficult to have manufacturing reforms for the politics surrounding the security of people's jobs." So we've got our work cut out here.

My second recommendation is to shorten the cycle time for the introduction of new technology. It's related to the first point regarding tools and techniques. The tools Duane & Weibull Analysis can be powerful aids in shortening the product introduction cycle. With just a few points of data, you can identify defects or flaws in a new component.

Now, shortening the cycle time for new technology is not going to happen without a clearer dialogue around interchange standards also. You can see that from the earlier example.

How, for example, do you evaluate a new bearing design with the change out rule as it is currently written? You don't. In fact, I think we proved that recently with premium bearings. Not mentioned earlier, many railroads are afraid to make the initial investment in a premium bearing. They fear that the investment will be lost in the first bearing change.

Now, maybe you know the story of the man that went to the fortune teller and asked him to see his future. The fortune teller looked into her crystal ball and said, "You will be poor and unhappy until you are 45 years old." "Then what will happen," asked the man. Replied the fortune teller, "Well, then you'll get used to it."

I'm afraid that we have gotten used to some methods of practices that don't make a lot sense. We've gotten used to some obstacles in the industry that we think are just part of the industry. We've ultimately gotten used to a pace of technology change that is just too slow for our competitive environment. Our record for introducing new technology in interchange is not enviable. For the ABDX or DB60 stabilized valve, it took us roughly four to five years to adopt it. That's even though we knew that UUDE's were a chronic problem on most railroads.

I think to some extent we're like the U.S. automobile manufacturers who were accustomed to a 60-month cycle for new product introduction. Unfortunately, as you know, the Japanese manufacturers held to a 48-month cycle, and you know who gained market share.

Over the past few years, the U.S. manufacturers have brought their cycle down to 48-months. Recent automotive trade magazines report that Ford and GM are now using processes to lower the cycle time to 35 months. Now, that's 35 months for an entire new car, but how long does it take us to get just one component accepted in the industry?

The Research and Test Committee of the AAR composed of representatives from the major railroads, recently voted to give the electronic train brake high priority in the R&T scheme of things.

Now, here's a picture of the key portion of the electronic brake as proposed by one manufacturer. The productivity and reliability benefits of the electronic brakes are undeniable.

This is a slide from the AAR which describes some of the advantages to the advanced electronic brake. You can see we're talking about potential fleet savings of $38 million. We're talking about reducing brake inspection and testing. We're talking about faster trains. Personally, I think this is just an enormous opportunity for the industry.

Now, my question to the audience, however, is whether anyone would like to place a bet about whether or not the electronic brake will be available in the industry -- that's just one component -- will it be available in the industry 35 months from today, the same length of time it takes U.S. manufacturers to introduce a completely new version of an automobile.

We need to understand that outside of our industry technological change is speeding up faster and faster. Photography took 112 years from discovery to development as a commercial product. Telephone took 56 years, radio 15, television 12. But it took six years to develop a working atomic bomb and five years for the first transistors.

Now, we can get a mip of computing power in one mass produced chip and it will be obsolete in a matter of months.

I think we need to be part of the technology revolution or we are in danger of being left behind.

Now, the only thing more difficult than making change in your own organization, perhaps is to cooperate more with other railroads whom you see as competitors. But that is in fact my third recommendation.

We at the Union Pacific often feel competitive towards other roads, but if you look at the top ten interchange railroads with the Union Pacific you'll find they rank as follows: first, the WRB no surprise, CNW no surprise, but then come Burlington Northern, Sante Fe, Norfolk Southern, Southern Pacific CSX and CR. These railroads, even the western railroads are not our competition, they are our partners.

Part of the problem as I see it has been discussed in literature what's called the prisoner's dilemma. I'm sure you know this model over two prisoners can each implicate the other and cut a deal for a shortened sentence or they can both say nothing and have a good chance of beating the rap. When each prisoner is approached separately, what choice do they make?

Now, the prisoner's dilemma can be generalized through any two person non-zero sum game, for example where one player can receive $1,000 for himself regardless of what the other player does, but if each player chooses a favorable payoff for the other player, then they each end up with more money, $3,000 or something like that.

In short, this model evaluates the circumstances under which people cooperate or fail to cooperate for their mutual benefit.

Now, the prisoners' dilemma game can be played one time or numerous times. Given the number of interactions that we have in the industry, I suggest that every day we're playing this game numerous times. And what we need to do, I think, is for each of us to keep this model in mind and to strive for pattern of friendly outcomes. In this way we'll each get a greater payoff in the long run.

Frankly, I'm not sure if we'll be able to overcome the prisoner's dilemma. There are some hopeful signs. UP and Burlington Northern have developed a common standard for grain cars. UP and Burlington Northern are working on a pilot project for positive train separation.

In the intermodal arena, the enormous pressure from the market has led to modifications of traditional interchange rules and the evolution of bilateral agreements to operate specific types of equipment. Maybe market pressures in the end will force us to work together better.

I'm not sure that we'll work together closely enough. I'm not sure if we'll improve our asset utilization or do the other things necessary to earn our cost of capital in the future.

In the prisoners' dilemma remember it' not irrational to select the $1,000 option, it's just not the optimal solution.

If we don't change our behavior, I personally think we're going to see more mergers in the industry. With an end to end merger usually there's some cost to drive out. So we will improve our return on investment one way or the other.

Over time we may become like the airline industry with United, Delta and American developing large networks to cover the entire country. In that way each airline has a lot of flexibility, and perhaps we're going to end up that way also.

In closing, let me ask you to do just three things over the next couple of days of meetings.

First, openly share the successes and failures that you have had with your suppliers, your customers, your fellow colleagues and other railroads. Use the information to make logical smart decisions, not just politically correct ones. Stay away, of course, from any information that could run afoul of the antitrust laws, but I believe, and this is not a legal opinion, that exchanges of technical information are generally okay.

Second, if you're not already familiar with the techniques of reliability centered maintenance and design practices, please become so. There are a lot of industries out there that we can learn from that use these techniques on a regular basis and have done so for years.

Thirdly, think about how to accelerate the pace of change in our industry. We've had a good run, but we're still not earning our cost of capital. Let's prove that a mature, capital intensive industry, a dinosaur even to some, can be nimble, flexible and innovative.

Thank you very much.

Chairman Herman T. Jones: Thank you, Mr. Wagenseil.

Now we'll hear from Mr. Lee Lang, Vice President of Police and Special Projects with the AAr.

Mr. Lang: Thank you very much. I'm delighted to be here this morning. Having arrived late, I can tell you that the experience of the Kennedy is enough to convince anyone that America needs a stronger rail alternative as part of its transportation system.

When I inquired about the length of the presentation that was appropriate here this morning, I was basically told, "Lee, talk as long as you want. Of course, all of us are leaving at 10:00 sharp." So obviously brevity is at a premium and I will in fact be very brief basically because I think there's a very simple message.

I know that businessmen do not like to hear that to a considerable degree the fate and the prospects of their industry remains dependent on what happens in the political system in Washington. Nevertheless, to a very substantial degree that's true.

And the first of the two things that I have to say here this morning is that the prospect of future growth for the railroad industry and for the railroad supply industry are at significant risk as a result of actions that our political system will be considering during the course of the next three years. I refer specifically to the threat of a change in policy at the federal level that would lead to higher truck weight and size limits and that would put the United States back onto the course of policy of ever increasing truck sizes and weights and the diversion of rail freight to the highway system that goes with that policy of relentless truck size and weight limit increases.

We're at a point now where we have basically got about one year to prepare for the political decisions about future truck size and weight policy. I don't think, given the existing political prospects, that anything very decisive will happen in 1995. That does not mean that we can remain inactive during 1995. On the contrary, we desperately need to mobilize soon in order to be prepared for the coming crises in '96 or '97. Why do I say that?

Basically, the trucking industry in dealing with truck size and weight limit increases has got a tremendous advantage. Their political strength is really founded on the very large political contributions the trucking industry makes and on the tremendous lobbying clout that the trucking industry gets as a result of those political contributions. And that's a resource that you can call upon just like flipping a switch. It's available instantly. You throw a switch and the voltage of all that political clout begins to flow and it can be started up very quickly.

But to defeat truck size and weight limit increases, and I know that many of you were very active in the effort in 1991 in which we did decisively defeat proposals for higher truck size and weight limits, for us to be effective, as I think many of you now from that experience, it's very important to mobilize the broad constituencies in the American public who, along with railroads and along with rail suppliers, are adamantly opposed to higher truck and weight limits. I'm sure you're all familiar with the data.

When you ask people about whether they want bigger trucks, whether they want heavier trucks, the answer come back 80 and 90 percent of the public are opposed to those policy changes. And yet without the time to mobilize that public opinion and to bring it to bear in the political process, there is still every likelihood that we can end up with a policy that increases truck weights and sizes and thaws the freeze that we succeeded in putting in place on the expansion of super large trucks in the 1991 legislation.

So what we need is time and preparation. 1995 is the year in which we have to lay the groundwork to be able to deal with the threats of 1996 and 1997. What threats are those?

Very quickly, first, Congress in 1996 will reconsider and will re-enact the so-called ice tea legislation. This is a perfect opportunity for the trucking industry to revisit the issue of truck size and weight limits and there are plenty of signs that they intend to do so. They will furthermore have the advantage of a number of government studies seeming to validate their claims. The threat is a very real and serious one.

If we survive that exercise, there is a second threat in 1997 as a result of the North American Free Trade Agreement. There is currently meeting a NAFTA committee on land transportation standards. That committee is very likely to produce a report in 1997 calling for the United States to both increase single combination vehicle weight limits and to authorize the operation of long combination vehicles in corridors linking Canada and Mexico across the U.S. highway system.

We've talked to the U.S. negotiating team in these negotiations, in these talks, and been told candidly that that's the outcome they expect. Frankly, that's the outcome that the highway bureaucrats who are doing the negotiating for the United States actually expect and want.

Thus, we've got these two challenges immediately before us. Our great resource is the opposition of the American public to higher truck sizes and weights.

In the past, the rail supply industry has played an absolutely vital role in helping to mobilize that public opinion. Their support of grass roots mobilization efforts in the 1991 legislative battle was, in my judgement and I think I was about as close an observer of this process as anybody, in my judgement your efforts were absolutely the key to success.

What we've got to do is to face the reality that the problem hasn't gone away and that we're going to need to make a similar effort in 1995, '96 and '97. I believe that the railroad industry and the rail supply industry can again work together successfully to stave off this challenge. But to succeed we are going to need to work together and we are going to need to start very soon.

I'd be glad to entertain any questions if we have a minute or so.

Hearing none, thank you very much.

Chairman Herman T. Jones: Thank you, Mr. Lang.

As we conclude this session, you're asked to go to your respective association meeting rooms. There locations are in your brochure or program. And this meeting is now adjourned.

Editor's Note: Mr. Wagenseil referred to a number of slides of graphs, charts, etc. We were unable to obtain these documents. We apologize. If you would like to view these graphs, please contact Mr. Wagenseil's office in Omaha, NE. Thank You.

Charlie Miller's Acceptance Speech
Tuesday, September 20, 1994

Good morning fellow railroaders. It is with pride and some reservations that I follow Mark Coles as President of LMOA.

In my time with the LMOA, I have met many, many people; I have made some good friends; and I have made a lot of resourceful connections that have helped me to do whatever good job I can do for the Union Pacific Railroad. In turn other railroads and suppliers have called upon us as a resource so that we can help them to do a better job for the industry.

I believe that the LMOA itself, as an organization, is embodied in that we help each other. I guess that's the value of the LMOA. I want especially to thank Past President Mark Coles sincerely for a superb job and the fortitude it takes to try and effect change in an organization like the LMOA. This movement began with Weylin Doyle and then with Mark, and I hope to continue the job to try and bring some change and effect some growth in this organization, to become more customer-oriented.

Please join me in thanking Mark Coles for a good job. (Applause)

A phrase that I will always remember is "There has never been a more energy efficient form of transportation device than the steel wheels to the steel rail."

We have all heard it. I believe this is still true, and it will continue to be true through our combined efforts.

When deregulation hit us a few years ago, the future appeared gloomy and dismal, and perhaps the industry was not going to be as strong, but we must all now agree that we are stronger, leaner and more aware of our position with respect to worldwide competition. We have grown through that experience and will continue to grow through all adversity. I believe the old adage, "You ain't seen nothing yet," is really our cornerstone, and we are going to continue to work on that through this organization.

We heard yesterday that the investment analysts say that our industry has taken advantage of the easy cost cutting and that now it will be harder to effect savings in the industry and that further gains must come from increased productivity and new technology improvements.

That probably wasn't a big surprise to us. We have felt that cut, and we are working with the improvements. Our keynote speaker, Harris Wagenseil, said yesterday that one of the major problems for us will be, first, to improve equipment utilization. I say to Harris, that most of are aware of that.

We are buying new units with new technology. We are applying new technology to our existing fleet. We are now seeing AC units come on the rails. We are testing condition monitoring for our units. We are experiencing alternate fuel on several railroads at this time, and we will be seeing and using electronic fuel injection in the next generation of locomotives.

We are repositioning our older fleet into lesser service. We are rebuilding generation 2 and generation 3 locomotives with new technology. Our old standby units are becoming increasingly more reliable. Harris, that's another way that we are improving asset utilization.

Harris then addressed the builders and the supply people. He said, it's time for you to reduce cycle time; the cycle time it takes for you to introduce new technology. He pointed out that the auto industry came to compete with the Japanese market, and they are now down to 36 months to produce a new model car bumper to bumper. He pointed out that we in the railroad industry take 3 to 4 times that long to introduce new innovations and models for our industry.

Harris challenged us all to improve cooperation between each other; sharing our achievements, sharing our failures, so as not to have to made the same mistakes that some other member roads made. We must share ideas. I say to Mr Wagenseil, and I tell you, especially the CMOs, our LMOA Members, the Executive Committee, and the Technical Committee Members, the OEMS and the Suppliers, we, the LMOA as an organization, is the embodiment of cooperation in the rail industry.

We must continue to work together. We must continue to share our ideas not worrying about A. being further ahead than B. and so forth and so on. We are not competitors. We are partners.

Mark's speech yesterday alluded to changes that we are proposing for the LMOA organization. We must continue to grow. The Executive Board got together several times and discussed: 1) How can we change? 2) What should we do? 3) How do we make this organization grow? And 4) What do we need to do?

First, we devised a list of who our customers are. Who are the customers, and primarily what do they want? What do they need? What can we do for you?

We prioritized this list of 12 customers after much debate, much argument, and much discussion and we came up with the following list:

The Locomotive Staff/Upper Management are perhaps number one. Shop Management, number two, and we really argued that point. We feel we need to get to the top management primarily. The third line was the Front Line Supervisor who really effects the work that we do have to have done. Then the Railroad Training Department to take and spread the information that we can put together to the rest of organization.

We acknowledge that all of our customers are important, and that list of 12 includes everyone. Answers to questions such as which customers are more important for LMOA growth and which customers are to be served that we are not currently serving?

Then we asked: 1) How do we reach these people? 2) How do we reach our customers? 3) How do we find out what they want? 4) How do we give them what they want? 5) Do they need to be members of the LMOA to receive the benefits?

Again there was much debate and a lot of argument, and we decided on these two concepts: 1) Railroad Upper Management will support the LMOA if the LMOA provides value products, services, and ideas to the railroad and its employees - that's novel. 2) The vendor community will support LMOA if LMOA provides exposure to products and people, and LMOA identifies product development requirements.

How do we improve our product? Well, what is our product? At this point in time it's this forum (the annual meeting). It's the papers that we see. The papers that you read in our books from past years.

What other services can we give you? We talked about videos. We talked about best practices at some of our shops to be shared on a video or tape making them available through this organization.

There are other things to consider about our product: 1) How many do we present each year? (Papers, tapes for example). 2) What subjects do we cover? 3) How do we avoid duplication with other associations? 4) How do we balance the education versus the entertainment portion of the presentation? 5) How long should a presentation be? 6) Who should present the paper? 7) What method or format should be used? 8) How should papers be scheduled, developed, and presented? 9) How shall papers be selected? 10) Where shall they be presented? (At conventions or pre-conventions or you name it) and 11) Should there be a yearly fee?

Again there were many hours of debate, suggestions, etc. and finally this is what we are going to put into effect this year, and hopefully will be accepted and will work throughout the organization. We will put together a better program and a better product from the LMOA to you folks.

A committee of Regional Execs will develop surveys for the following groups of customers: the shop supervisors; shop management; railroad material, safety and training department; the vendor community; the short line railroads; and the AAR.

You will all be contacted with the surveys hopefully before spring of next year to get your ideas and input. The Committee of Regional Executives will develop this list of questions to be covered during one-on-one interviews. Each committee member of the LMOA must conduct at least one, one-on-one interview with a member of at least one of the customer groups identified.

We want to get the personal touch of a member talking to someone who is categorized as our customer, and what they would like us to do for them. The results of the surveys and the one-on-one interviews will be used to develop a pool of ideas for future LMOA presentations, products, and services.

As I said, it is very difficult for this group to try and effect a change in an organization that we give only a portion of our time to each year. We can see the number going down in the group. We can see that our product perhaps needs to be improved greatly, and so this group (The LMOA Executive Board and Committee Chairmen and committee members) will do what we can to improve the LMOA organization for you, our customers.

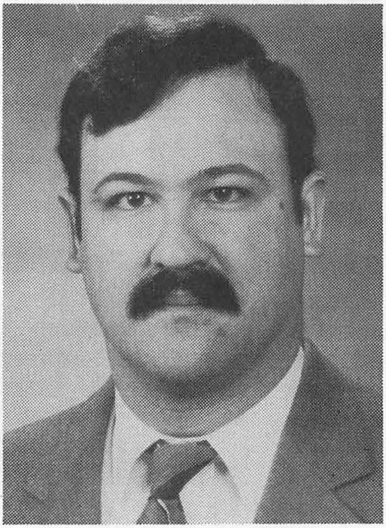
This doesn't go without pain and suffering. There is going to be a little more time required of our executive board, the Regional Execs, and Committee Chairmen, and as President, I hope to spend a little more time dealing with each of the Committee Chairmen and seeing if there is anything I can offer to help.

1995 will be a great year in our railroad industry. It's in our hands. We have to do our best with the cooperation of the suppliers, the OEMs, and each and every railroad. We need to take our improved maintenance methodoly to the Front Line Supervisor and have him do a better job so that we can increase productivity and reliability.

I want to thank you very much. I hope you continue to enjoy this show. Please get to the exhibit halls today. This afternoon will be open for you. Spend some time in the exhibit halls tomorrow.

Thank the suppliers for coming to visit with us, and thank your bosses for letting you come. Thank you all very much. (Applause)

OUR OFFICERS



President
MR. MARK COLES
Dir. - Loco. Maint. Planning
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1st Vice President
MR. CHARLES MILLER
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2nd Vice President
MR. GILBERT BRUNO
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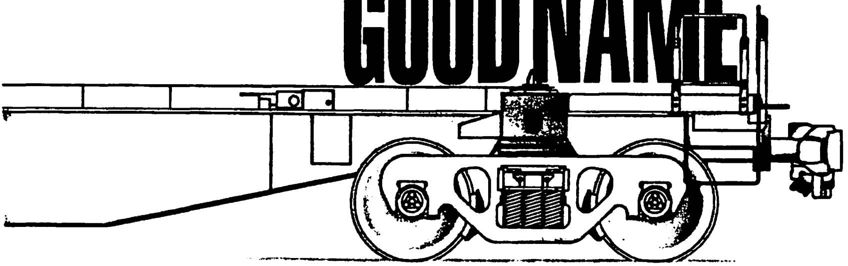
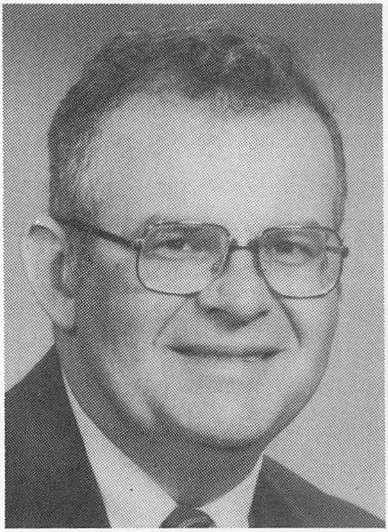


OUR PAST PRESIDENTS

Chairman of the Board
MR. WEYLIN R. DOYLE
Mgr.-Maint. Control Systems
Union Pacific Railroad
Omaha, NE 68179



MR. ALLEN KELLER
Dir.-Loco. Projects
Reading Railroad
Cleona, PA 17042

MR. DAVE GOEHRING
Supt.-Loco. Maint.
Amtrak
Philadelphia, PA 19104

OUR PAST PRESIDENTS

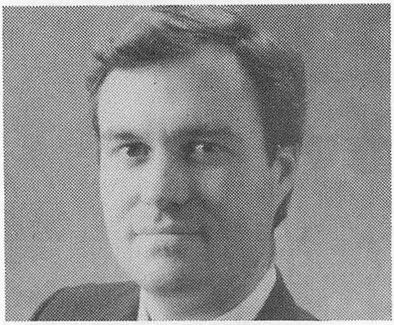
MR. DALE H. PROPP
Gen. Supt.-Loco. Opns.
Burlington Northern Railroad
Fort Worth, TX 76102

MR. DARRELL M. WALKER
Asst. Shop Mgr.
Norfolk Southern Corp.
Atlanta, GA 30315

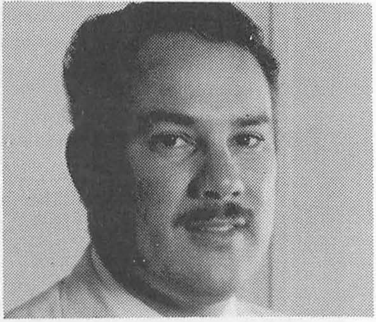
OUR REGIONAL EXECUTIVES

MR. DAVID M. WETMORE
Mgr.-Production
CSX Transportation
Cumberland, MD 21502

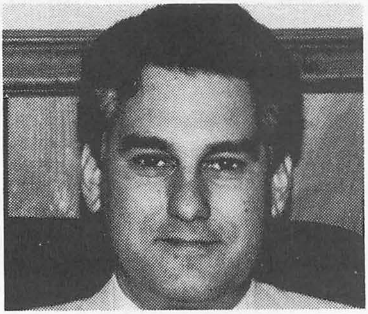
MR. MIKE PENNELL
Director-Materials
Burlington Northern Railroad
Fort Worth, TX 76180



MR. DOUG CORBIN
Mgr. Syst. Assy. Shop
Norfolk Southern Corp.
Chattanooga, TN 37403

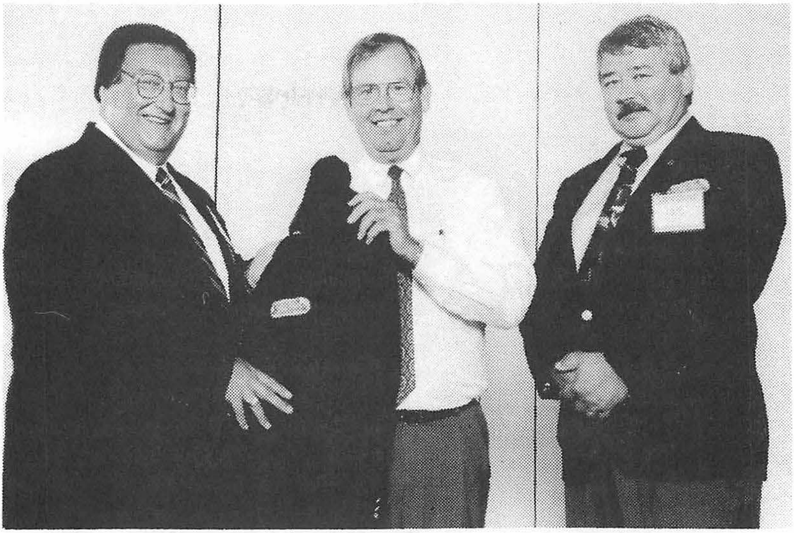


MR. JAKE VASQUEZ
Mgr. of Opns.
GWI Switching Services
Dayton, TX 77535



MR. LOU CALA
Mgr.-Reman. Components
Conrail
Altoona, PA 16603

LMOA Executive Officers: Seated left to right - Chairman of the Board, Weylin Doyle, UP; Past President, Dave Goehring, Amtrak; Past President, Darrell Walker NS; Past President Tom Harley, retired; Standing (left to right) President Mark Coles, UP; Past President, Dale Propp. BN; Honorary Life Member, Jack Kuhns, retired; 2nd V.P., Charlie Miller, UP; Newly elected 3rd V.P. Mike Pennell, BN; Newly elected 2nd V.P., Dave Wetmore, CSX; Past President, Bill Brown, BN (now with L & M Radiator).



Incoming President Charlie Miller, UP, presents LMOA Blazer to newly elected 3rd V.P., Mike Pennell, BN, which was witnessed by 1st V.P. Gil Bruno, Amtrak.

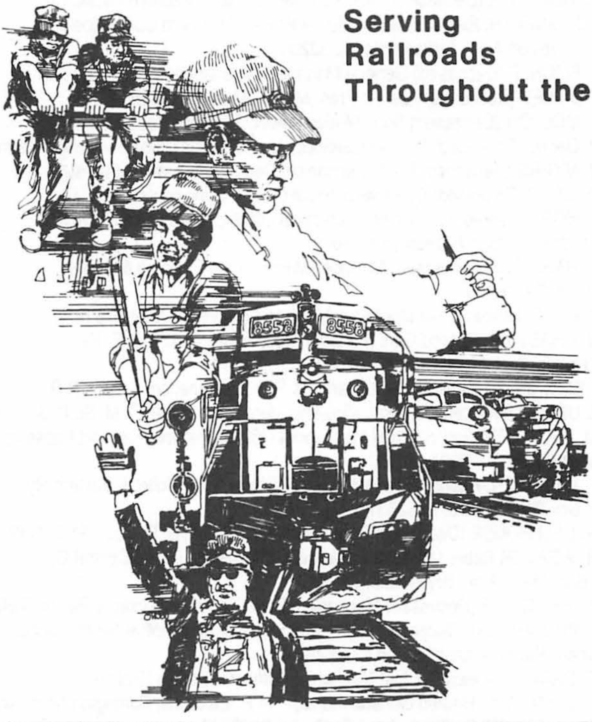
Outgoing President Mark Coles, UP, presents gavel to newly elected President Charlie Miller, UP. Dave Goehring, Amtrak, attended the transition.

Past President Dale Propp, BN, presents Past President pin to outgoing President Mark Coles, UP, which was done in Bill Brown's presence.

1st V.P. Gil Bruno, Amtrak, assists newly elected 2nd V.P. Dave Wetmore, CSX, in putting on his LMOA Blazer. President Charlie Miller, UP, attended the ceremony.


2000

Chairman of the Board Weylin Doyle, UP, presents General Desk Set to outgoing President Mark Coles, UP. The presentation was attended by Past President Darrell Walker, NS.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PAST PRESIDENTS

1939 & 1949 - F. B. DOWNEY (Deceased) Shop Supt., C & O Ry.
1941 - J. C. MILLER (Deceaed), MM, N.Y.C. & St. L.R.R.
1942-1946, Inc. - J. E. GOODWINN (Deceased) Exec. Vice President, C. & N.W. Ry.
1947 - S. O. RENTSCHILLER (Deceased) Chief Mechanical Officer, Bessemer and Lake Erie R.R.
1948 - C. D. ALLEN (Deceased) Asst. C.M.O. - Locomotive, C. & O. Ry. & B. & O. R.R.
1949 - J. W. HAWTHORNE (Deceased) Asst. Vice-Pres.- Equipment, Seaboard Coast Line R.R.
1950 - G. E. BENNET (Deceased) Vice-Pres.-Gen. Purchasing Agent, C. & E. I. Ry.
1951 - P. H. VERD (Deceased) Vice-Pres.-Personnel, E. J. & E. Ry.
1952 - H. H. MAGILL (Deceased) Master Mechanic, C. & N. W. Ry.
1953 - S. M. HOUSTON (Deceased) Gen. Supt. Mech. Dept. Southern Pacific Co.
1954 & 1955 - F. D. SINEATH, Retired Chief of Motive Power, Seaboard Coast Line R.R.,
1061 Nelson Ave., Jacksonville, FL 32205
1956 - T. T. BLICKLE (Deceased) General Manager - Mechanical, A .T. & S. F. Ry.
1957 - J. T. DAILEY (Deceased) Asst. to Pres.-Mech., Alton & Southern R.R.
1958 - F. E. MOLLOR (Deceased) Supt. Motive Power, Southern Pacific Co.
1958 - F. R. Denny (Deceased) Mechanical Supt., New Orleans Union Passenger Terminal
1959 - E. V. MYERS (Deceased) Supt. Mechanical Dept., St. Louis-Southwestern Ry.
1960 - W. E. LEHR (Deceased) Chief Mechanical Officer, Pennsylvania R.R.
1961 - O. L. HOPE, Retired Asst. Chief Mechanical Officer, Missouri Pacific R.R.,
523 Hidden Harbor, Houston, TX 77079
1962 - R. E. HARRISON (Deceased) Manager-Maintenance Planning & Control,
Southern Pacific Co.
1963 - C. A. LOVE, Retired Chief Mechancial Officer, Louisville & Nashville R.R.
1964 - H. N. CHASTAIN, Retired Gen. Manager-Mechanical, A. T. & S. F. Ry.
909 Connecticut, Manhattan, KS 66502
1965- J. J. EKIN, JR. (Deceased) Supt. Marine & Pier Maintenance, B. & O. R.R.
1966 - F. A. UPTON II (Deceased) Asst. Vice-President-Mechanical, C. M. St. P. & P. R.R.
1967 - G. M. BEISCHER, Retired Chief Mechancial Officer, National Railroad Passenger Corp.
Washington, D.C. 20024
1968 - G. F. BACHMAN, Retired Chief Mechanical Officer, Elgin Joilet & Eastern Ry.
Rt. 1 Box 28010, Albia, IA 52531
1968 - T. W. BELLHOUSE (Deceased) Supt. Mechanical Dept., S. P. Co., - St. L. S.W. Ry.
1970 - G. R. WEAVER Retired Director Equipment Engineering, Penn Central Co.,
516 Bryn Mawr Ave., Bryn Mawr, PA 19010
1971 - G. W. NEIMEYER (Deceased) Mechanical Superintendent, Texas & Pacific Railway
1972 - K. Y. PRUCHNICKI (Deceased) General Supervisor Locomotive Maintenance,
Southern Pacific Transportation Company
1973 - W. F. DADD, (Deceased) Chief Mechanical Officer, Chessie System
1974 - C. P. STENDAHL, Retired General manager M.P.-Electrical, Burlington Northern
Railroad, 1052 W. California Ave., St. Paul, MN 55117
1975 - L. H. BOOTH, Retired Assistant C.M.O.-Locomotive, Chessie System,
906-13th Ave., Huntington, W.V. 25701
1976 - J. D. SCHROEDER, Retired Assistant C.M.O.-Locomotive Burlington Northern,
Railroad, 244 Carrie Drive, Grass Valley, CA 95942
1977 - T. A. TENNYSON (Deceased) Asst. Manager Engineering-Technical, Southern Pacific
Transportation Co.
1978 - E. E. DENT, Retired Superintendent Motive Power, Missouri Pacific Railroad,
13500 S. Outer 40 Rd., Apt. 116 East, Chesterfield, MO 63017
1979 - E. T. HARLEY, Retired Senior Vice President Equipment, Trailer Train Company,
289 Belmont Road, King of Prussia, PA 19406
1980 - J. H. LONG, Retired Manager Locomotive Dept., Chessie System
5454 Cleander Drive, Cincinnati, OH 45238
1981 - R. G. CLEVENGER, Retired General Electrical Foreman, Atichison, Topeka & Sante Fe
Rwy., 5802 W. 157th Terrace, Overland Pk., KS 66223
1982 - N.A. BUSKEY (Deceased) Asst. General Manager-Locomotive, Chessie System
1983 - F. D. BRUNER (Deceased) Asst. Chief Mechanical Officer-R. & D. Union Pacific Railroad
1984 - R. R. HOLMES, Retired Director Chemical Labs and Environment, Union Pacific

PAST PRESIDENTS (Con't)

1985 - D. M. WALKER, Asst. Shop Manager, Norfolk Southern Corp., 793 Windsor St., Atlanta, GA 30315
1986 - D. H. PROPP, Gen. Supt.-Loco. Opns., Burlington Northern, 777 Main St., Ft. Worth, TX 76102
1987 - D. L. WARD, (Deceased) Coord.-Quality Safety & Tech. Trng. Burlington Northern R.R.
1988 - D.G. GOEHRING, Retired, Supt. Loco. Maint., National RR Passenger Corp.
1989 - WILLIAM A. BROWN (Retired) General Foreman, Burlington Northern RR, 2630 Evergreen, Burlington, IA 52601
1990 - P. F. HOERATH, Retired Sr. Mech, Engr. Shops, Conrail, Box 134, R.R. 4, Hollidaysburg, PA 16648
1991 - D. D. HUDGENS, (Retired) Sr. Mgr. R & D, Union Pacific, 16711 Pine St., Omaha, NE 68130
1992 - K. ALLEN KELLER, Reading, R.R., Cleona, PA
1993 - W. R. DOYLE, Mgr.-Maint. Control Systems Union Pacific RR, 1416 Dodge St., Omaha NE 68179

HONORARY LIFE MEMBERS

KJELL AXELSON, Retired Superintendent Motive Power, Burlington Northern, 36-716 Bluebird Ave. Rancho Mirage, CA 92270
F. W. BUNCE, Retired Chief Mech. Officer, Milwaukee Road.
J. J. BUTLER, Retired Chief Mech. Officer, Consolidated Rail Corp., 158 Woodgate Ln., Paoli, PA 19301
OWEN CLARKE, Retired Vice-President, Chesapeake & Ohio Ry., Cleveland, Ohio
B. A. CUMBEA, Reitred Mgr. Loco. Maint.-Engr., Chessie System, 310 Cherokee Trail, Huntington, WV 25705
N. C. ECKERLE, Sales Mgr. Specialty Chem., Nalco Chem. Co., 2901 Butterfield Rd., Oak Brook, IL 60521
W. EWING, Retired, Altoona Gear Co., Calbassas, CA
W. T. FARICY, Retired Chairman of the Board, A.A.R.
J. G. GERMAN, Retired V. Pres.-Engr. Missouri Pacific Railroad Co.
J. J. GREGORY, Retired Project Mgr.-Heavy Repair Shop, Consolidated Rail Corp., 603 Ruskin Drive, Altoona PA 16602
S. GRAHAM HAMILTON, President, Global Group, Inc., P.O. Box 2024, Winter Park, FL 32790
E. R. HAFLING, Retired Engineering Assist., Santa Fe Rwy., 2711 James St., Topeka, KS 66614
W. J. HARRIS, Retired V. Pres., Research & Test Dept., Assn. of American Railroads, Washington, D.C.
H. W. HAYWARD, Retired Chief M.P. & R. S., CP Rail, Montreal 101, Quebec, Canada
D. W. HENDERSON, V.P.-Technology, Engr. & Maint. Burlington Northern RR, 9401 Indian Creek Pkwy., Overland Park, KS 66210
JOHN H. HERTOG, Retired V. Pres. Operations, Burlington Northern, Inc., St. Paul, MN 55101
JOHN W. INGRAM, Retired Pres. and Chief Executive Officer, Chicago, Rock Island and Pacific Railroad Co.
A. W. JOHNSON, Retired, V. Pres. of Opns. and Maint., Assoc. of American RR, Washington, D.C.
JOSEPH J.T. KOERNER, Sec'y-Treas. (Retired), LMOA, 3144 Brereton Cr., Huntington, WV 25705
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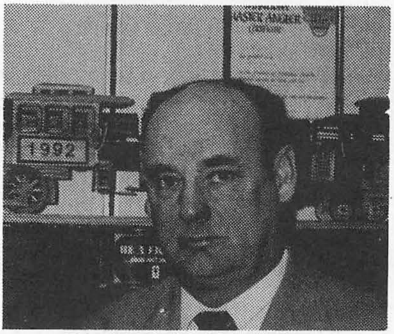
REPORT OF THE COMMITTEE ON DIESEL MECHANICAL MAINTENANCE

MONDAY, SEPTEMBER 19,1994

10:00 A.M.

Pre-Convention
Presentation
Conrail



May 10, 1994
Ramada
Altoona, PA

E.L. (LEE) OVIATT, Chairman
Manager-Loco. Maint.
DM&IR Rwy.
Proctor, MN

Vice Chairman
T. H. VOLKMANN
Supt. MP-GE
C&NW Transp.
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PERSONAL HISTORY

Eugene L. Oviatt

Eugene L. Oviatt (Lee) was born in Glasgow, Montana on June 2, 1940.

Lee began his railroad career in June of 1959 as a signalman helper for the Great Northern Railroad in Superior, Wisconsin. Lee worked various other jobs and in 1962 started an electrical apprenticeship.

After being promoted to electrician he moved to Minot, N.D. In 1968 Lee was transferred to Havre, Montana and promoted to foreman and worked various jobs in the Havre shop in the nine years he was there.

He left the Burlington Northern in January, 1977 and went to work for the DM&IR Ry as a foreman in the locomotive shop in Proctor, MN.

He was instrumental in the setting up of the locomotive rebuild program on DM&IR locomotives, and served a Foreman, Diesel Supervisor, Assistant General Foreman, and Manager of Locomotive Maintenance in the DM&IR Locomotive Shops.

Lee is married and has two daughters, one son, and three step daughters. His hobbies include hunting, fishing, boating, and woodworking.

LMOA wishes to express its thanks to Conrail for hosting the Pre-Convention Presentation in Altoona, PA.

Our Diesel Mechanical Maintenance Committee was well received in what we trust was a mutually beneficial experience.

I. ELECTRONIC FUEL INJECTION

Presented by: Rick Gates - AT & SF

Early in the 1990's GE and EMD started design of an electronic fuel injection system (EFI) for their respective series of diesel engines. In 1993, GE put the EFI system into production and as of September 1994 will have approximately 350 locomotives in operation in North America. EMD has recently placed EFI into production.

Some of the major benefits of EFI on a locomotive are:

- Fuel economy improvement
- Improved emission
- Reduced maintenance
- Improved reliability
- Improved engine diagnostics.

In addition some of the key features of EFI are:

- Variable fuel injection timing
- High injection pressure
- Electronically controlled
- Elimination of mechanical components
- Automatic injection pop tests (GE).

With the variable injection timing control, specific fuel consumption and/or emission levels can be controlled to the optimum.

With the change to EFI there are some system changes that take place. The following components are eliminated from the diesel engine:

- Main governor
- Overspeed governor (GE)
- Fuel linkages
- Fuel racks
- Overspeed link
- Governor gear box
- Load regulator
- Engine low water protector (EMD).

In addition to the components that are eliminated, the following components are changed:

- Electronic controller
- Sensors
  - Oil pressure and temperature
  - Water pressure
  - Manifold air pressure
  - Water temperature
  - Manifold air temperature (GE)
  - Fuel temperature and pressure (EMD).

By optimizing electronic components, maintenance will be reduced and reliability will increase.

In addition to the generic system changes mentioned above, some configuration changes also take place in both the GE and EMD systems. We will explore the particulars of the EMD system first; then we will cover the GE system.

A. EMD EFI System Configuration

The EMD EFI system, termed EMDEC for Electro-Motive Diesel Engine Control, is based on proven technology and will be retrofittable on all 645 and 710 model diesel engines.

The EMDEC fuel injection system consists of three major subsystems:

- The electronic control module (ECM)
- Electronic unit injectors (EUI)
- The sensors.

The electronic control module is the heart of the system and controls all fuel injection parameters. Two ECM's are used on a 16-cylinder engine, with one mounted on each side of the engine crankcase. The ECM also stores all fault data and diagnostic information.

The electronic unit injector design is based on the mechanical unit injector that has been historically used in all EMD engines. The solenoid operated control valve performs the injection timing and metering events, allowing direct electronic control of the injection process. EMDEC eliminates the adjustments of injector timing and fuel rack settings required by the mechanical injection system. The EUI can be installed in the current design cylinder head, making this system easy to retrofit into existing engines.

The EMDEC system sensors gather the feedback signals that the ECM requires to control the fuel injection process and protect the engine. The system sensors measure:

- Oil temperature
- Oil pressure
- Fuel temperature
- Fuel pressure
- Airbox pressure
- Both water pump pressures
- Engine RPM.

EMDEC will aid the mechanic when troubleshooting engine problems. Individual cylinders can be cut out to determine if a weak or non-firing cylinder exists. The engine computer can automatically perform this function and report suspect cylinders with the push of a button. Low horsepower and smoking problems can be isolated within minutes instead of hours. Electronic unit injection offers computer diagnostics not available on mechanical fuel injection engines. The onboard engine computer will store faults recorded during over-the-road operation similar to the central locomotive computer on existing microprocessor controlled locomotives. This information is accessed through the use of a handheld reader.

The EMDEC system has been designed for retrofitability and flexibility. The ability to install EUI's in existing cylinder heads impacts retrofit economics significantly. The microprocessor controlled fuel injection system offers unprecedented flexibility. For example, if the horsepower rating of the engine is modified, there is no longer a need to remove and rebalance a governor. A simple software upgrade will accomplish a horsepower and/or engine speed modification.

We will now examine the General Electric EFI system configuration.

B. GE EFI System Configuration

The previous mechanical 18-mm fuel injector pumps now become 22-mm electronically controlled injector pumps with 18,000 psi injection pressure.

The camshaft lift is now a 22-mm with separate journal and a new sleeve bearing.

Now let's take a more detailed look at the changes mentioned previously. EFI equipped engines do not have an electro-hydraulic control governor. The functions of the control governor are now performed by solid state controllers. The governor oil trip pressure sensor and the water trip pressure sensors are now located in the same box with the manifold air pressure (maps) and crankcase overpressure sensor (COPS), which box is located by the start station.

The GE diesel engine speeds are now controlled by a Bryce CPC controller. Feedback for actual engine RPM is via a tachometer that is located on the right side of the diesel engine barring - over gear box. Engine RPM can be monitored by using the Diagnostic Information Display (DID) panel or through the Integrated Function Computer (IFC) display, using monitor level #2 with parameter #2005.

The overspeed governor has been eliminated on the diesel engine. This function is now provided by the solid state controller.

An optical encoder is now used for timing the firing order of the GE diesel engine. This encoder sends signals to the CPC controller by use of an LED pickup. This encoder is set in time with the diesel engine using the left bank cam gear. You can access the encoder drive by removing the left bank cam gear cover.

The GE diesel engine with EFI has undergone several changes in the camshaft/camshaft bearing area. The camshafts are heavier, and now require 8 bolts to assemble. The additional weight and bolts are required due to the increased loading forces developed by the new style fuel pumps. Also, the #8 right and left cams are different from the rest of the cam sections and cannot be interchanged.

The GE EFI diesel engine also used a different type of cam bearing. Unlike the split aluminum bearing presently being used, the EFI diesel engine uses a steel sleeve-type bearing and a steel journal. The bearing is notched for alignment. The use of a hydraulic ram with special ends is required to replace this bearing.

A GE diesel engine with EFI does not have a mechanical fuel linkage. The functions of the fuel linkage are performed by electrical solenoids on the fuel pump.

"Pop" testing the cylinders by pulling out the fuel linkage is not possible. This function is now controlled by the Bryce controller through computer software. There is a switch located near the start station that activates the pop test sequence starting with the cylinder closest to the switch, then works around the diesel engine. There is a pause between the left to right bank to allow the craftsman to go around to the other side of the locomotive. You can also select a certain cylinder for pop testing by using the same switch. Each cylinder pop test will be from 3 to 5 seconds in length.

GE EFI diesel engines require higher injection pressure than mechanical systems, (18,000 vs 12,000 psi), consequently utilizing a larger injection pump. The larger pump creates more heat, which in turn requires a different fuel hose supply and return line to obtain proper heat injection and lubrication of the plunger. The top line is the return and the bottom line is the supply.

Available through your local GE representative is an EFI training video and a running maintenance manual (section 9), which will provide you with more detailed reference information.

Requests for further information on EFI should be directed to your respective EMD or GE representative.

II. ICAV - THE PHYSICAL ASPECTS OF INSTANTANEOUS CRANKSHAFT ANGULAR VELOCITY TECHNOLOGY

Presented by: Leslie E. Olson - BN

A. Abstract

The work conducted to develop a useful tool to effectively pressure balance the internal combustion engine has been reported by many investigators over along period of time. The effort to succeed has not been limited geographically or ethnically in any respect. However, this effort appears to have been somewhat limited to the technically developed world. It has been highly successful when applied to the spark ignition engine. The typical engine tune-up "scope" with which most people are familiar is a primary example of the successful application of these efforts. Of late, this technology has progressed from periodic application – the six-month tune-up at the garage – to the constantly monitored and controlled systems of the modern automobile of today. This is all a result of the equipment miniaturization explosion of the past three decades.

The application of this technology to the diesel, pressure ignition engine has also been tried. In most cases, the efforts have been unsuccessful, or only very limited success has been achieved.

This paper will present the concept, history, field tool, and current status of using dynamics of the combustion event and its associated dynamic impact to the engine crankshaft as a translatable data event for engine performance, health, or power output as a shop diagnostic tool. This method is known as "Instantaneous Crankshaft Angular Velocity," or the ICAV approach. A brief discussion of the physical aspects of the technology is presented. The mathematics requiring evaluation are briefly explained as well.

B. Introduction

There exist a multitude of reasons to desire a means by which the locomotive diesel engine can be effectively assured to be in pressure balance. Management concerns would say that the effectively balanced engine will ultimately last longer since wear to all the subject components will be equalized. This can ultimately be translated to dollars for use in other valuable areas. Shop forces, responsible for providing quality operational equipment, would potentially save many valuable repeat repair hours if they could be certain that when a locomotive left the shop, the engine was in pressure balance. Additionally, a sizable diagnostic labor saving could be achieved if locomotive loading problems could readily be allocated to either the engine not providing sufficient output or directing labor hours immediately to the highly complex electrical controls systems of today's locomotives. The electronically controlled fuel injection systems with their attendant computer controls just coming into use on today's locomotives can and are addressing this problem. The fuel purchasing departments would certainly like to know that the locomotive fleet is pressure balanced, since any under- or over-fueled cylinder is operating inefficiently as a consumer of fuel dollars. The material department provides a storage house of fuel injectors for replacement in the engines. The number of fuel injectors being changed out every year in a locomotive fleet represents a significant amount of operating dollars. With a tool to perform effective pressure balancing of the locomotive engine, unnecessary fuel injector change-outs could be eliminated.

Effective pressure balancing of the locomotive fleet is possible today without ICAV. If this statement is true, then why is ICAV needed or even desirable? Today's effective means of pressure balancing the engine is through one of two means. First, we can install in-cylinder pressure transducers. This is engine-invasive, costly, prone to very short life, and requires specialized calibration for each event use. The pressure transducers (PT's) related to in-cylinder use are generally long-lived, as long as they do not remain subject to cylinder pressure and heat fluctuation. In other words, install, use and remove the PT's. Second, the engine can be pressure-balance verified by using the familiar Kiene adapter to a simple gauge. This approach requires one-cylinder-at-a-time verification. Significant labor hours are required to properly verify the balance using the Kiene adapters pressure gauge technique. Generally, the Kiene gauge approach, when properly calibrated, is an individually accurate system.

C. History

The ICAV approach was developed by the National Research Council of Canada (NRC) under contract to the Canadian Department of National Defense (DND). By 1987, the economy in Canada was such that the government was making strong inferences of major cutbacks in government funded basic research. NRC had to make some strategic decisions regarding direction of their overall efforts. ICAV became a topic of possible cutback and curtailment. By early 1988, NRC had determined that without some form of non-government sponsorship, ICAV would have to go. After all, the basic research was completed, data acquisition hardware (Figure 1) and software had been developed and verified, nothing more seemed needed to complete NRC's mission task under its charter. At this time, NRC offered the technology to the Association of American Railroads' Research and Test (AAR R&T), Locomotive Research Subcommittee for consideration to be developed as a locomotive diagnostic tool. The AAR decided not to participate in developing a tool using this technology.

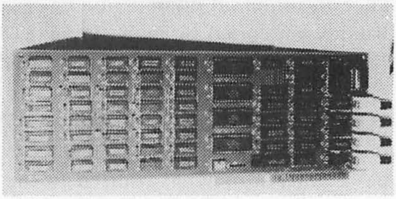
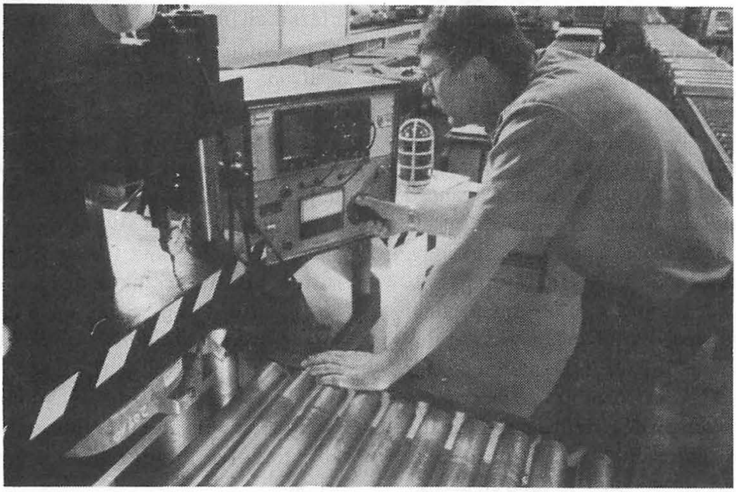


Figure 1.
National Research Council's
ICAV Data Acquisition board for the
PC based system of 1987

Subsequently, Burlington Northern Railroad (BN), together with the Canadian Pacific Railway (CP), agreed to a limited funding program to demonstrate the ICAV technology on locomotives. NRC was to demonstrate the ability to detect small imbalances in the locomotive diesel engine in a BN unit after determining the specific diesel engine's characteristics on CP's locomotives. The demonstration proved to be impressive. However, NRC was under continuing pressure from the government to reduce its budget. ICAV was chosen to be deleted from the NRC programs. CP was experiencing a down-sizing concurrently with the NRC's down-sizing and elected to withdraw from further ICAV development for the immediate future. ICAV appeared to be a promising technology for wide use in railroad locomotive engine diagnostic assistance, but it also looked like the technology would be put on a shelf and never developed for use.



Burlington Northern was unable to discover effectively competing technology to ICAV on the horizon and worked with both NRC management and the technology staff developers at NRC to save the technology from the "curiosity storage shelf." The lab personnel at NRC who had been principally working with ICAV desired to try to keep the technology alive and continue development on it. They left NRC and formed a new company which would center its activities on the development of ICAV. BN teamed with Advanced Engine Technology of Ottawa, Canada to continue to develop this technology. By the end of 1992, the system was largely developed with only major field testing needed to be conducted. At this time, AAR's R & T Department was offered the opportunity to become a participant in the field testing of the ICAV technology. A proposal was made by BN to R&T to fund field testing on the various member railroads to expedite the introduction of the repair diagnostic tool (RDT) into the marketplace. R&T again decided not to participate. BN continues to work toward the eventual market availability of this technology.

D. Technology Concept

Instantaneous Crankshaft Angular Velocity–ICAV–is ultimately the mathematically precise solution of the overall engine torque equation. The overall engine torque is the sum of the individual cylinder torques at any particular angle in the crankshaft rotation with their cranks correspondingly offset:

$$\mathrm{TORQUE}_{\mathrm{overall}} = \sum_{i=1,}^{16} \mathrm{TORQUE}\,(\theta + \mathrm{OFFSET}_i)$$

In the general approach to designing and even building an engine, the design group will often assume the crankshaft is an infinitely stiff member. This approach is sound and with very few exceptions works quite well. To make an engine work, produce power at design levels, keep everything timed, etc., one can almost always use the classical infinitely stiff crankshaft assumption.

If one wishes to precisely solve the above equation for overall torque, then the classical infinitely stiff crankshaft is not acceptable. To solve this equation, we must first understand what is happening dynamically at the crankshaft for each crank throw. The true stiffness or true crank deflection must be understood to precisely solve for the torque overall at any angular rotational position of the crankshaft. Thus, to ultimately solve the torque equation precisely at any position, we must also be able to solve the question of virtual work:

$$\Sigma Tn \bullet \Omega n + \Sigma Fn \bullet Vn + \Sigma(-M_n A_{G_n} V_{G_n}) + \Sigma(-I_n \alpha_n \bullet \Omega_n) = 0,$$

which is the sum of the dot products of torque and angular velocity; gas forces on the piston and velocity; mass acceleration and velocity due to gravity, and inertia and angular velocity on each and every component in the system at the given point where one desires to look. This precision solution is necessary because we wish to physically look at the real time result of this mathematical equation and decide if the real time event is occurring in concurrence with the mathematical model, although all this must occur within some tolerance limit to be universally acceptable for this work in general. By assigning 90% confidence limits about the stiffness aspect of the crankshaft in applying the mathematical solution, the ICAV method repeatedly shows a pressure variance of only seven percent in the peak pressure of any one cylinder output in the engine.

E. Development Efforts

During the testing conducted in both the laboratory and the field testing ICAV, consistency became the primary concern for the investigating team. The work with CP's engines proved to be some of the most rewarding undertaken. The first engine tested for waveform generation showed that the system worked as well on the locomotive engine as had been predicted by the lab "white coats." CP's engines were looked at for balance on first arrival for the test, data were recorded on the as-arrived condition. Then the locomotive engine was tuned by a CP shop machinist and again the engine data were recorded. At this point, pressure perturbations were introduced at 1%, 3%, 5%, 10%, and 18% on one cylinder with data being recorded for each perturbations level. This data base has continued to provide new information to the development team throughout the investigations.

When BN's locomotives were first looked at (Figure 2) with the ICAV system, the course data were good but, there were very few find data that corresponded with the CP data and the BN data. This presented a major problem to the investigation team and were were fraught with doubt about the universality of the system. It was that CP data which gave the team the clue to what was seemingly erroneous data or basic waveform difference. The team spent the next eight months working on software and development of the mathematical solutions for the overall torque equations to bring ICAV together again.

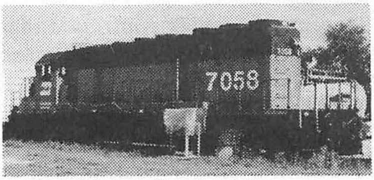


Figure 2.
BN's ICAV investigations underway at West Burlington overhaul facility.

Again, the system was transported to BN's West Burlington overhaul facility for data gathering on locomotives. AET felt BN wold gain significant information if inbound locomotives to be overhauled were looked at and tested. This was accomplished; however, no significant decisions have been addressed with the data results at this time. The West Burlington shop support during the data gathering efforts was extensive and the job literally could not have been completed without this support.

The engines under test seemed always to be in the shops' way just when a 30-minute test had been initiated. The locomotive under test could not be moved for as much as three hours when this would happen. The locomotive under test requires stable engine operating conditions to do data acquisition for development purposes. With the amount of specialized data acquisition cabling handing off the locomotive that required prior removal, locomotive moves took significant time (Figure 3).

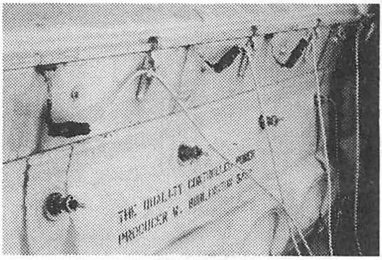


Figure 3.
Data acquisition cables on the locomotive engine.

One of the cables controlled the adjustable rack links used to perform remote adjustments to change the individual cylinders' fuel supply. This method allowed precise, known changes in cylinder peak pressure (Figure 4).

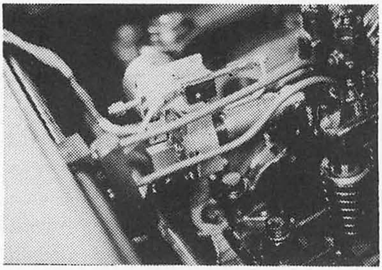


Figure 4.

F. Repair Diagnostic Tool

The repair diagnostic tool (RDT) is a portable computer based system. The system detects small pressure variances in cylinder power outputs and assigns locations to these output variances. The tool uses a non-contact magnetic effect transducer, Hall effect transducers, to carry out the tack. The RDT is connected to the transducers via a simple Canon type connector, which is envisioned to be on the electrical equipment wall located in the locomotive cab (Figure 5).

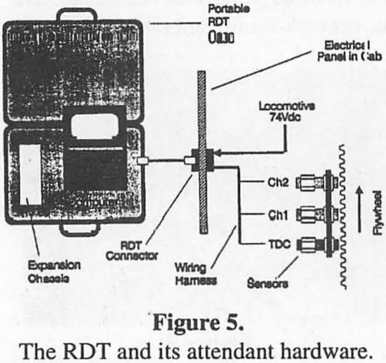


Figure 5.
The RDT and its attendant hardware.

Two engine test speeds are required for the RDT to detect power variance and assign locations. This is accomplished by operating the locomotive in self-test position at throttle notch (TN) 2 and at TN 8. The RDT's diagnostic screen is formatted to present three areas of concern to the user (Figure 6). The central left area is a rectangle that fixes a switch position to allow the user quick reference to what function the RDT is currently set on. The switch position must be changed by the user so that the system does not finish a task and automatically proceed to the next task. The central right rectangle is larger and visually indicates the time remaining of the task underway. The rectangle also gives the user a running average of the rpm during the tasking.

Across the bottom of the screen are the results of the test. The power balance is displayed as a grouping of vertical bars about a zero center line. If the engine were perfectly balanced there would not be any bars, merely a rectangular grid pattern. The power balance bars are currently displayed as three different color bars, indicating levels of seriousness. Variance from 0 to 6% indicated with a green bar, 7 - 15% imbalance is indicated by a yellow bar and anything greater than 15% is indicated by red. It was felt by the designers that clear representation of color level would enhance the user friendliness of the system.

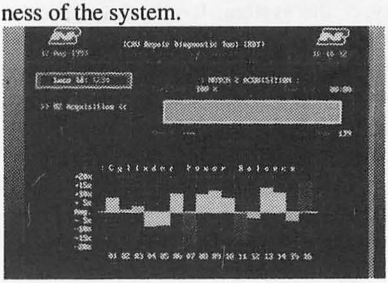


Figure 6.
The RDT screen as the user will see it during the diagnosis process.

Current thinking believes that small imbalance is best allowed to remain unchanged, since changing these small imbalances may only cause other imbalances in other cylinders. Attempts to correct small imbalances will ultimately lead the RDT user to expend unproductive repair time. Yellow imbalances may need to corrected. However, depending on the amount and extent of the yellow the decision will generally be user specific. Red imbalances, it is felt, are serious and should be corrected while the unit is at the shop. Significant fuel savings can be expected by correcting imbalances of 15% or more, even on one cylinder.

The RDT is expected to be used by the engine overhaul facility upon final engine trimming to ensure maximum balance, power output, and minimum fuel consumption. This can also represent a shop validation procedure for record keeping and product quality at transfer. The running repair shop where the locomotive is assigned will also use the RDT. At every 90 day inspection interval the unit will be tested for proper balance to ensure continued peak operating efficiency and overall engine health.

The ICAV wave form (Figure 7) is generated every time the flywheel completes a revolution. This waveform is completely transparent to the user. The magnetic transducers located on the engine structure about the flywheel gear-teeth (Figure 8) generate a time interval between teeth accurate to one part in 65,000. The system uses two pickups at a predetermined spacing, which allows the speed of the flywheel teeth to be examined. This in turn, allows the change in speed to be determined. The ICAV data acquisition board performs the data gathering and essentially does the speed rate-of-change calculation in an ongoing manner. Because of the fineness of the data acquisition process a very accurate waveform is generated. This characteristic is the allowing element of the waveform to develop pressure balance simulation.

G. Current Status

The IVAC RDT will accurately detect and assign location to small pressure imbalances in the EMD 16-645E3B engine. The RDT software package has been completed for the field prototype stage. A users' manual has been completed and reviewed by BN shop personnel for usability. The NRC staff and DND consultants are in the final testing stages on a self-learning pattern recognizer software package. The pattern recognizer is expected to be available for insertion into the RDT by November of 1994. When the RDT with the integrated pattern recognizer is completed and ready for use, BN will initiate field testing at an already designated running repair shop, Glendive, Montana.

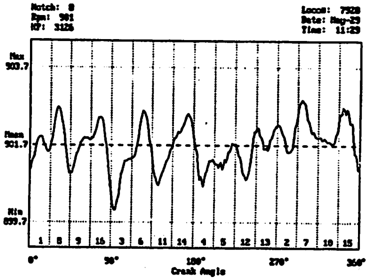


Figure 7.
The ICAV waveform as used by the RTD.

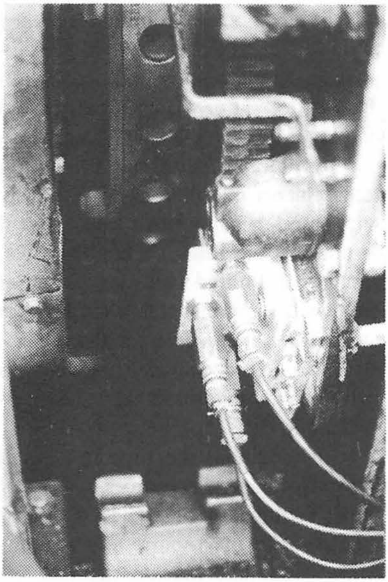
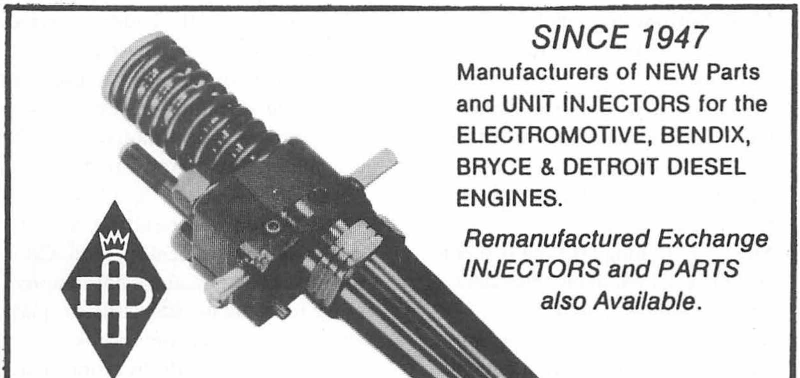


Figure 8.
The Hall Effect tranducers on the mounting bracket located about the flywheel.



III. REGIONAL RAILROADS VERSUS CLASS I RAILROADS

Presented by: Joe Calvey
Wisconsin Central

We from the regional railroads represented on this committee, would like to compare our practices with what takes place on a Class I railroad.

As the regionals/shortlines began to develop from spin-offs of Class I railroads, there were a lot of surplus locomotives purchased which, for the most part, were cast off from the Class I's, or purchased from the locomotive junk yards. These locomotives are naturally somewhat unreliable and contain lots of outdated components. With little financing available, and a lesser degree of technical and mechanical expertise, the regionals/shortlines have nevertheless operated, using these locomotives.

The regionals/shortlines of necessity have a different outlook on the required maintenance and components that keep their horses running and earning their keep. As a comparison, some of the major differences are as follows:

1. Most shortlines/regionals have no back shop facility to remanufacture components.
2. Most have to use contract shops or their Class I counterparts to change major components, i.e. prime mover/main generator/heavy accident damage.
3. Most use running take out components (TM's, PM, main generators, wheels, radiators, etc.)
4. Most have their own M.I., which governs their preventive maintenance programs.
5. Most have no overhaul program.
6. Most use the policy "run until failure."
7. Most use consultants to audit their maintenance procedures.

The Class I's have time frames by type of locomotive for the mileage they accumulate, to determine which components should be renewed before failure occurs. This varies greatly from one to the next on the Class I railroads.

The regionals/shortlines have FRA requirements that they have to comply with, undergoing the same federal scrutiny as the Class I's do. This fact, along with limited facilities, if any at all, results in problems that can become more difficult to solve for the regionals/shortlines mechanical people, who strive to maintain these older, less reliable units.

If the regional/shortline roads had the staff, financial resources and major repair facilities that the Class I's do, it would make the repairs and maintenance of our units much easier.

The regionals/shortlines rely on the Class I's for research and development, then they piggyback on information supplied by the Class I's.

The regionals/shortlines also have difficulty purchasing repair parts in sufficient quantities or volume to qualify for lower prices, while discounts are routinely given to the Class I roads. The vendors hardly budge on price to the small volume purchaser.

Regionals/shortlines must use discretion when selecting vendors to supply components for locomotive use. There are many definitions to the words "basic", "rebuilt", "qualified", and "overhauled", depending on which company you are dealing with. Criteria for repair specifications are required in order to maintain standards of quality, and to make cost comparisons.

To this effect, the regionals/shortlines would like to appeal to vendors and the Class I railroads, to develop a component catalog, with full description of each part, so an actual cost comparison could be made, which would in turn alleviate the confusion as to what our budgeted maintenance dollar is

actual buying.

Some shortline and regional railroads are fortunate in having the ability to hire experienced locomotive maintenance personnel. Most, however, are faced with protracted on-the-job-training programs when they must hire inexperienced help locally.

As apprenticeship programs are almost non-existent on smaller roads, the mechanical supervisors must be innovative in the training of new hires. Several of the regionals/shortlines utilize correspondence courses, pairing new hires with experienced maintenance personnel, using vendor supplied videos or training videos obtained from our Class I counterparts. Smaller staff levels require cross-training in all areas of locomotive maintenance in order for the smaller roads to survive.

In closing, we, the regional/shortline group, look to the Class I railroads for a lot of help. We would be unable to operate without the benefit of their Research and Development departments, and the knowledge we receive through our membership in the LMOA.

IV. AMTRAK DOCUMENT MANAGEMENT

Presented by: Glen A. Stickler, Amtrak

July 1992, Amtrak embarked on developing electronic media distribution of mechanical service manuals and schematics. This dissertation explains the challenges that the Amtrak Document Management program encountered. This program is now known by the acronym of ADM.

The need for a system which provides quick, on demand, support information for our shop employees, became acute with the arrival of the high tech, computer controlled locomotive equipment that Amtrak has recently purchased. The Training department researched the possible options for distribution of large manuals electronically. The criteria for the desired system had to include the following features:

- Easily and quickly handle large electronic media publications;
- Provide for importing various electronic media formats from different vendors;
- Cabability to handle advance desktop publishing functions;
- Upgradeable to provide multimedia training applications.

After extensive research, which included visiting various companies using different publishing software, the decision was made that Interleaf software operating within a Unix operating system, would be the best solution.

ADM Set Up

Once the choice of options was made, an alliance between the Training and Mechanical departments was formed. Funding was provided through training funds allocated by a C.A.R. for the GE equipment acquisition.

Originally, the scope of this project was only to provide electronic distribution of documents. However, early in the project's development, multimedia possibilities were included in the program objectives. The implementation of this project was in two phases. Phase One began with setting up the authoring station. The Wilmington Training Center was selected to be the site for the ADM authoring center.

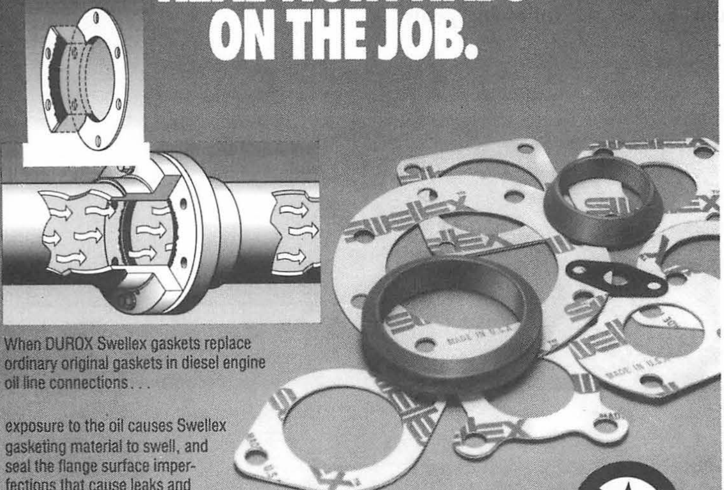
A Sun IPX workstation was set up, with a two gigabyte hard drive, three types of tape drives, and loaded with Interleaf 5. The authoring center is also equipped with scanning capability, a CD mastering studio and a Matrox digital editing studio.

The objective of the pilot program, Phase Two, was to test the acceptance of the concept for electronic distribution of material within the shop environment. The New Orleans, Los Angeles and Chicago Maintenance facilities were chosen for the pilot program. Kiosks equipped with Sun's LX computers were placed on the shop floors. Manuals are viewable with the use of WorldView software package, operating on a Solaris 2.3 operating system.

Multimedia

The ADM Program presently employs a video application which is a five minute introduction to the A.S.K. Kiosks. This introduction video shows the employee how to use the WorldView software to access the manuals and schematics. This video is 100% software driven, using software produced by Paradise Inc. The goal of this video was to test the technology with regard to running videos in this environment. Amtrak is extremely pleased with the video application and its reception by the employees.

Based on the success of the video implanted in the documentation, the



next step for the ADM program is to develop interactive video training programs that reside in the distribution system. Amtrak is presently evaluating different multimedia author software for this application.

ADM Program Cost

The cost of this type of program is always front loaded. The initial purchase of equipment, software licenses and labor were:

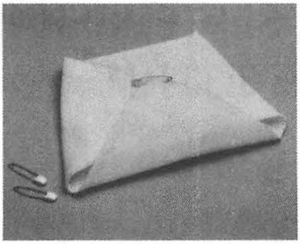
• Software Licenses	$35,000
• Hardware	60,000
• Labor Cost	37,000

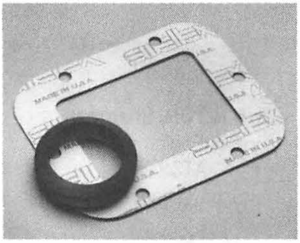
Future For ADM

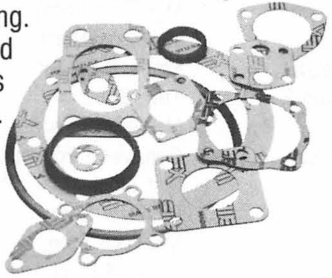
Amtrak has set the following goals for the ADM project:

- Continue to enlarge the library on the ADM program.
- Increase training application available on the facility kiosk through multimedia.
- Use the A.S.K. kiosk to automate the material acquisition process.
- Incorporate management control systems within the ADM Program.
- Automate the maintenance forms.

Amtrak is challenged by the opportunities that this new technology presents. We believe it is the future for supporting employees who are being challenged by new technology in their work places. The investment in the ADM Program is an investment in our employees and their future.







REPORT OF THE COMMITTEE ON DIESEL ELECTRICAL MAINTENANCE

MONDAY, SEPTEMBER 19,1994
3:30 P.M.

Pre-Convention
Presentation
Southern &
Southwestern Rwy.
Club

July 8, 1994
Hyatt Regency
Hilton Head, SC

JOHN NIXON, Chairman
Dir. Equipment
AT&SF
Schaumburg, IL

Vice Chairman
J. POPP
Mgr.-Quality Control
Amtrak
Wilmington, DE

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J. Youngwirth	Sr. ServiceTech. Engr.	Electro-Motive	La Grange, IL

PERSONAL HISTORY

John Nixon

John was born March 15, 1949 in Marshall, MO. He was raised in Kansas City and graduated from Wyandotte High School in 1967. He served three years in the US Army and received an honorable discharge.

John attended three years of college and pursued a business degree. He completed a two year course at an industrial electronics school and received a 2nd class FCC license. He started working on the Santa Fe in 1972 as a laborer. He completed a four year apprenticeship and was promoted to ASDE in 1979. He has worked as a travel lift foreman, mechanical training instructor, Asst. to the Manager of Locomotive Maintenance and Performance, Engineering Assistant, Asst. Manager of Locomotives, General Equipment Supervisor. He was recently promoted to Director of Equipment.

John is married and has four children.

THE SOUTHERN AND SOUTHWESTERN RAILWAY ASSN.

717 Pinecliffe Drive
Chesapeake, Virginia 23320

PURPOSE

The purpose of the Southern and Southwestern Railway Association is to promote customer and supplier relationships and provide an educational opportunity. The Association is aimed at middle management including shop, service, engineering, purchasing and sales personnel. Meetings are held to discuss current and developing trends in the industry. Presentations are made by railroad and supply representatives. The meetings also provide opportunities to cultivate ideas and personal relationships in social atmosphere.

The Southern and Southwestern Railway Association holds four (4) meetings per year at important railroad cities in the southeast.

Please drop our Secretary a line for an application for further information.

J. S. Mastrangelo
Secretary
717 Pinecliffe Drive
Chesapeake, Virginia 23320

I. SAFETY FIRST

Presented by: John Nixon - AT & SF

Over the years, the Diesel Electrical Maintenance Committee has concentrated on maintenance and quality issues. We feel the committee has done a very good job in these areas. One area that we have not covered adequately is safety. All railroads have a safety rule book. Employees are required to read the rule book and sign accordingly. Most railroads require the employee to take written test on these safety rules.

Safety or lack of a good safety process is very costly in terms of human suffering and cost. The effect of an injury on the work force is devastating. Morale is adversely effected. Production suffers and quality takes a dramatic drop. One Western railroad estimated injuries cost them a minimum of $55 million in 1992.

Our customers also view our safety records as a means of determining if it is a quality organization. Our safety record also is an indicator of how much shipment damage they can expect from us.

Accident prevention is the only logical approach towards safety. Eliminate the root cause of an accident and your prevent the accident from occurring again. Accident prevention will eliminate human suffering. Ask yourself when was the last time your railroad went the whole year without at least one of your employees being fatally injured. If you can say last year and this year, you are going the right direction with your safety program. A Western railroad has never gone a complete calendar year without at least one of its employees being fatally injured. It is working hard to eliminate fatalities in the work place and I am sure all of you are doing likewise.

The first six months of 1994 AAR safety standings are as follows:

TOTAL RAILROAD	
1. NS	1.88
2. CSX	2.37
3. ATSF	2.90
4. BN	4.06
5. UP	4.69
6. SP	4.72
7. AMTRAK	5.45
8. CR	5.71

MECH. DEPT.	
1. CSX	2.01
2. ATSF	2.30
3. NS	2.97
4. BN	4.22
5. SP	4.60
6. UP	4.99
7. AMTRAK	5.08
8. CR	6.57

Editor"s Note: A video on electrical safety depicting graphic scenes of actual electrocutions was shown at the conclusion of oral presentation. If you would like a copy of this video, please contact our Secretary-Treasurer, Ron Pondel, (312) 772-4600, and he can arrange for you to show your Mechanical department staff.

II. LOCOMOTIVE HEALTH MONITORING SYSTEMS

Presented by: John Chionchio
Technical Services &
Marketing, Inc.

A. Introduction

Railroads have worked hard to maintain core business and attract new business, and that effort is resulting in every-increasing traffic volume. This higher level of traffic has increased the demands on locomotive fleets, and Mechanical departments are being asked to improve locomotive availability significantly. Much of this new business carries a lower profit margin, so this increased availability must be accomplished through efficient maintenance practice improvements without staffing increases. How can the rail industry accomplish this?

B. Locomotive Health Monitoring

There are many ways to approach this goal. One option is to reduce locomotive down time by reducing unscheduled maintenance and increase the efficiency of performing required maintenance, through the use of "locomotive health monitoring".

What items on the locomotive are worth monitoring? At one extreme, every performance parameter could be monitored and an "expert system" could decide what was wrong with the locomotive, leaving mere parts changing to shop personnel. While this option has an innate appeal and may be possible someday, it would be very expensive and it is probable that the monitoring system required would become a large maintenance item on its own. The old "Search" system is an example of a monitoring system that, as it aged, required more maintenance than it saved. In fact, it is imperative that the monitoring systems be orders of magnitude more reliable than the systems that are monitored, or the system will never be trusted, and the goal never accomplished.

A more direct, cost effective approach would be to employ a modular system which could monitor a basic package of items now, and be expanded to solve specific problems in the future. This approach would minimize the cost of learning what is worth monitoring while providing substantial benefit immediately.

This simple, modular system approach was chosen by TSM for a test "LocoHealth" system developed and installed on a GP60 locomotive in 1992. This system monitored the following parameters based on guidelines established by the AAR dynamic tag committee:

Fuel Level – To reduce unnecessary fueling stops and prevent running out of fuel. Also useful for correct interchange billing. Displays were provided on either side of the fuel tank. Cab displays and IFC or ICE interfaces are optional.

Cumulative Kilowatt Hours – Provides for accurate interchange billing. Kilowatt hours provide an excellent measure of how much work the locomotive has done, which is certainly a better indication of the need for maintenance than miles traveled or time.

Horsepower – The TSM system monitors horsepower to verify that proper horsepower is being achieved during throttle 8 operation over a 10 minute period. This feature alerts maintenance personnel to a decline in performance before it might otherwise be noticed, and allows the dispatching of locomotives based on true horsepower.

Oil and Air Filters – Detection of plugged or dirty oil and air filters

allows changeout as required, prevents potential engine damage, and ensures top fuel economy.

Status Indicators – The following status indicators are also monitored, providing information on the locomotives true operating status to both maintenance and operating personnel:

"Ground Relay" – Is the ground relay tripped?

"Traction Motor Cut Out" - Have any traction motors been cut out by the crew?

"Dynamic Brake Cut Out" – Have the dynamic brakes been cut out according to Operating department guidelines?

"Hot Engine Count" – A cumulative count of hot engine trips.

"Isolation Switch Position" – Is the locomotive "on line"?

"Locomotive Running" – Is the locomotive engine running or shut down?

These items provide feedback to maintenance and operating personnel on general locomotive condition on a continuous basis, facilitating preventive, rather than defective maintenance. Many other items may be monitored at customer request, but this group provides a minimum of coverage at a reasonable cost.

C. Data Transmission

The TSM LocoHealth system allows data to be transferred to wayside by data radio or Amtech dynamic tag. Data may also be downloaded into a laptop computer or memory card. A laptop computer may also be used to display live performance data on the locomotive during troubleshooting.

Which method of downloading data to use depends on the individual railroad's situations and preferences. If there are substantial numbers of locomotives equipped with data radio on a particular railroad and the wayside radio network is in place, then the cost of the radio option is greatly reduced. Cellular connections have been used for work order reporting in some areas, but this is an expensive proposition with limited coverage areas.

The implementation of AEI tagging has resulted in the installation of hundreds of Amtech tag reader sites in the U.S. While not continuous in the ability to download data, like the data radio may be in some areas, the Amtech Dynamic tag option is much less expensive than radio for railroads that are not already using a data radio network. Both methods may also be used on the same locomotive, which provides the benefit of Amtech interchange information even when a locomotive is on another railroad's property.

The TSM LocoHealth demonstration system currently in the field uses an Amtech dynamic tag to download the data to wayside. The advantage of this method is that the reader sites are already in place and the tags are much less expensive than radios, resulting in very inexpensive implementation. The tag option has the limitation of being able to download data only as it passes a reader site. This limitation will be less significant as more and more reader sites come on line, and since the data collected are targeted toward general locomotive health rather than real time problem analysis, this is not a serious issue. The tag may also be easily read in other areas with a hand held tag reader.

Amtech tags function by absorbing radio energy that is directed at them by a reader and using this energy to transmit the tag information back to the reader. This information is collected by a computer at the reader site, packaged, and sent to the railroad's mainframe computer.

The Amtech tags that have been installed on the rail car fleet in the U.S. are passive tags. They are programmed once prior to installation and send the pre-programmed information to tag readers for the life of the tag or car. The tags used in conjunction with the TSM LocoHealth system are known as "dynamic". The information in them can be constantly updated by an attached device such as a LocoHealth system. This allows the LocoHealth system to send current information to wayside readers, allowing the tracking of vital locomotive conditions. Passive tags have one "page" of information, similar to a page in a notebook. Dynamic tags may have up to 256 pages of information which are rapidly read as the tag passes a reader, allowing large volumes of information to be transmitted. The basic AAR locomotive health data described earlier all fit on the first "page", allowing for vast expansion of tag bases systems.

The number of pages that can be sent to any one reader is limited by the speed of the locomotive. Above 40 mph, at least two pages may be read and studies are ongoing to assess the maximum possible through put of these devices in real world operation.

Once acquired, the data may be used in many ways. Perhaps the most important benefit of the system for maintenance use is positive problem diagnosis, eliminating unnecessary shopping. This could potentially save the railroad industry millions of dollars per year.

One Western railroad veteran said that locomotives often require two hours of unscheduled service for every hour of scheduled repairs. Having a better idea of what to expect when the locomotive reaches the shop has proven to be beneficial where these types of systems have been employed. Efficiency of shop operations, through more accurate planning of required maintenance and shop forces, is a fundamental benefit of LHM. We all know how difficult it is to fix the locomotive shopped for "NOT LOADING PROPERLY" on the first shopping.

D. Data Storage

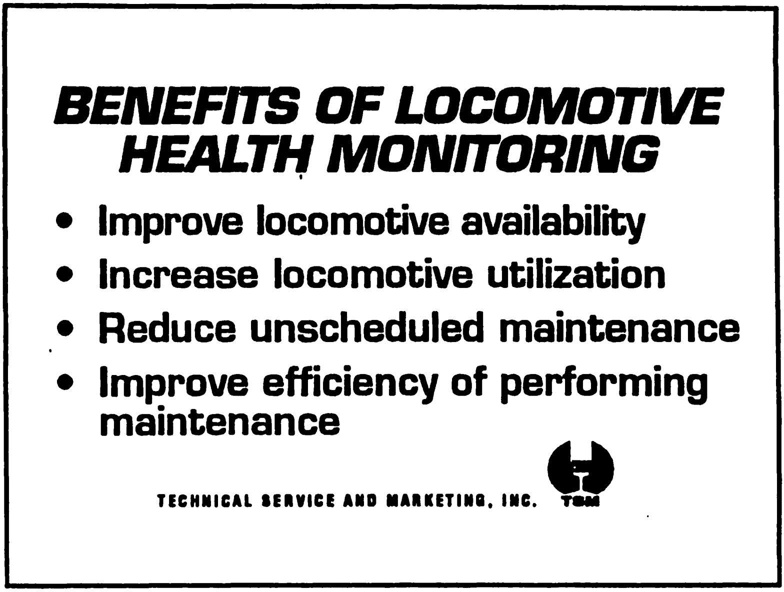
An area that requires attention is the cost benefit analysis regarding the storage of the downloaded locomotive health information. How long should it be saved? What is the cost of saving it? What is the benefit provided? These questions can only be answered after experience is gained with systems in the field. It is vital that quantifiable measuring systems be put into place now to assess the value of these potentially substantial investments.

The data storage question invites another; how much processing of information should take place on the locomotive before the data is downloaded? Analysis of the on-board data as it is generated can greatly reduce the amount of raw data that needs to be transmitted and kept in memory in the railroad mainframe. The TSM LocoHealth system is powerful enough to perform sophisticated on-board data analysis, or can also send out raw data if the customer prefers.

The data radio can be used to update the on-board software automatically as more powerful programs are developed, ensuring that the system can grow cost effectively with future innovations.

E. Summary

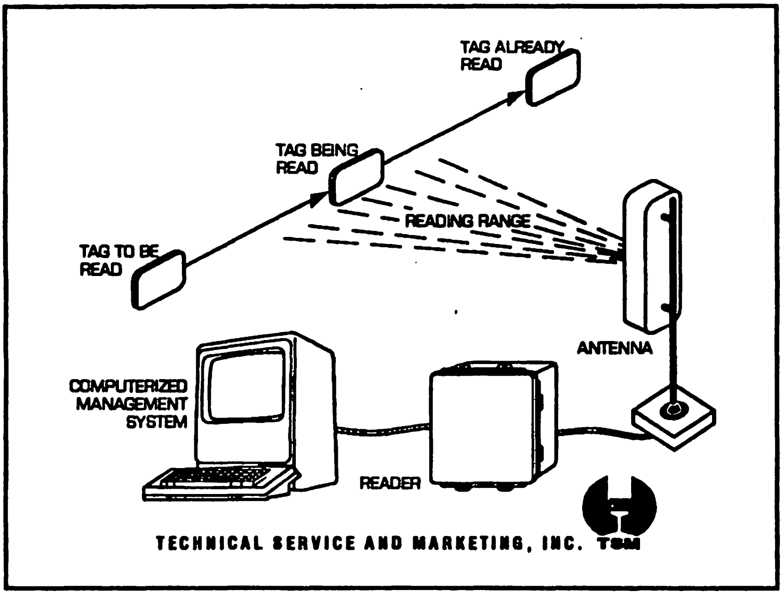
A global view of the benefit to the entire railroad is essential if locomotive health monitoring is to reach its full potential. LHM holds great promise to improve the transportation services offered by American Class I railroads through lower maintenance costs, increased locomotive availability, reduction of enroute defects, and more efficient train operations.



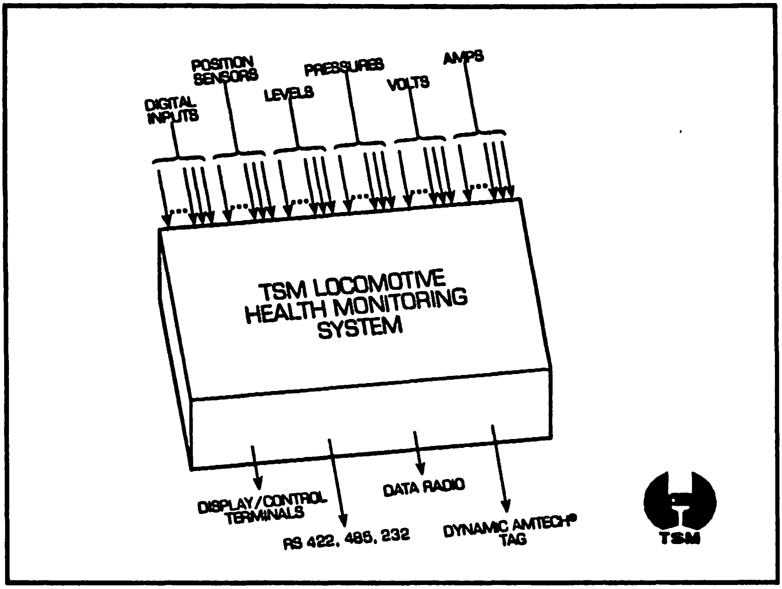
BENEFITS OF LOCOMOTIVE HEALTH MONITORING

- Improve locomotive availability
- Increase locomotive utilization
- Reduce unscheduled maintenance
- Improve efficiency of performing maintenance

TECHNICAL SERVICE AND MARKETING, INC. TSM



TECHNICAL SERVICE AND MARKETING, INC. TSM


POSITION SENSORS
PRESSURES
AMPS
DIGITAL INPUTS
LEVELS
VOLTS
TSM LOCOMOTIVE HEALTH MONITORING SYSTEM
DISPLAY/CONTROL TERMINALS
DATA RADIO
RS 422, 485, 232
DYNAMIC AMTECH® TAG
TSM

III. EVENT RECORDER UPDATE

Presented by Mike Fitzpatrick, Conrail

The locomotive event recorder is a valuable tool that is not always used to its fullest potential. Most Mechanical department employees are familiar with the ability of event recorders to provide valuable data for use in investigating incidents. How fast was the locomotive traveling? Was the engineer operating the horn at the crossing? When did the emergency brake application begin?

The potential is also there to utilize these same data to analyze locomotive performance. Some event recorder manufacturers offer software built into the playback unit to analyze fuel consumption, horsepower and other parameters by creating macro programs that look for certain conditions. But if the event recorder does not have this ability to analyze automatically, it is still possible to utilize the raw data. The information is already available and can be analyzed with a few charts or simple graphic overlays. Making use of this analysis can help our motive power fleets operate more efficiently.

Consider this scenario: The train dispatcher calls the engineer of train EX1, wanting to know why he isn't making track speed. The engineer replies that the locomotive, an SD50, is loading 470 amps in 8th notch, and will only make 40 mph.

This is not acceptable to the dispatcher. Forty miles per hour will cause delays to to all the trains behind EX1. The dispatcher routes the train to a siding, cuts the power and sends it to the shop.

The shop foreman assigns a mechanic to investigate the locomotive for Not Loading Properly. The mechanic checks the locomotive over, gives it a self load, and reports No Defects Found. The foreman dispatches the locomotive, not knowing whether or not there was indeed a defect.

If the dispatcher had known the proper loading and horsepower characteristics of the locomotive, he would not have shopped it. At 40 mph, and SD50 locomotive with 70/17 gear ratio, operating in 8th notch, should only load 470 amps.

While the locomotive was in the shop, if the event recorder information had been analyzed, a positive determination of locomotive performance could have been made. The data cover the entire last trip and several days worth of information.

There is a direct relationship between the amperage and speed of every locomotive. The graph of Fig. 1 shows this relationship for an EMD SD50. When speed is low the traction motor amperage is high. As speed increases, the amperage drops off. When operated in 8th notch, under normal conditions, the locomotive should be putting out its full rated horsepower. Therefore, any point on this curve also represents the locomotive's rated horsepower, in this case 3600 hp.

Plotting these same data points on a transparency of the event recorder graph would look like the graph of Fig. 2. As noted previously, in 8th notch there is a direct relationship between speed, amperage and full horsepower. Comparing the full horsepower data with the actual printed data from the event recorder will allow easy analysis of locomotive power output. At 10 mph, as shown in Fig. 3, the locomotive should be loading at about 1200 amps; at 20 mph about 780 amps; and at 50 mph about 400 amps.

Taking the example given earlier, we can see that at 40 mph the locomotive should have been putting out about 470 amps, as shown in Fig. 4, so there was actually no defect. The locomotive should not have been shopped. If it was mistakenly shopped, the event recorder data should have been analyzed, the locomotive released for service, and the dispatcher given the loading characteristics of the SD50.

In the event of a shopping for not loading or not loading properly, the following should be routine:

1. *Download the date.* Either pull the tape, download with a memory card or use a portable computer, depending on the type of equipment.

2. *Replay the data.* Using the appropriate equipment, reconstruct the event history.

3. *Analyze the data.* Either automatically or manually, compare speed, amperage and throttle notch.

Let's take one more close look at the analysis process.

For any given throttle notch, there is a discrete corresponding amperage for proper horsepower. These data can be charted on a transparency such as Fig. 2, which can be laid over the raw data. This can be done for all throttle positions, but these charts are made for 8th notch for ease of use.

Find a point on the graph where the locomotive has spent awhile in the 8th notch. Then align the speed from the event recorder chart with the same speed on the transparency and compare the amperage shown on the event recorder chart with the amperage shown on the transparency. If the recorder chart and the transparency don't align, the locomotive is not putting out the proper horsepower.

Now let's look at a few examples where the unit actually was not loading properly. The example in Fig. 5, another SD50, shows low horsepower. The event recorder trace is below the 470 amps that should be generated at 40 mph. The problem of low amperage exists over the entire speed range, and was found to be caused by a restriction in the fuel supply.

It is necessary to check over the entire speed range, as some problems may show up only at certain speeds. In the example in Fig, 6, still another SD50, the horsepower is OK at low speed -- 20 mph and 780 amps. But if we look further and check at a higher speed we see that the amperage is below normal. In this case the problem was traced to a defective voltage feedback circuit board.

The examples given in this paper were based on a single locomotive. For multiple units in a consist, each unit must be individually observed and analyzed, based on its own unique loading characteristics.

In summary, the event recorder when used to its full potential can help us maintain and operate locomotives more efficiently by reducing down time, thus contributing to the bottom line.

I am compiling the information detailing the type of recorder and its application by road number for all railroads. In this listing I also have information about event recorder playback and analysis, including the names and addresses of the people responsible for their operation. If a locomotive is on a foreign road and is involved in an incident, information as to downloading, playback and analysis can be obtained from these sources. Anyone with information to contribute, or wanting a copy of the information, may call me at (216) 268-7491.

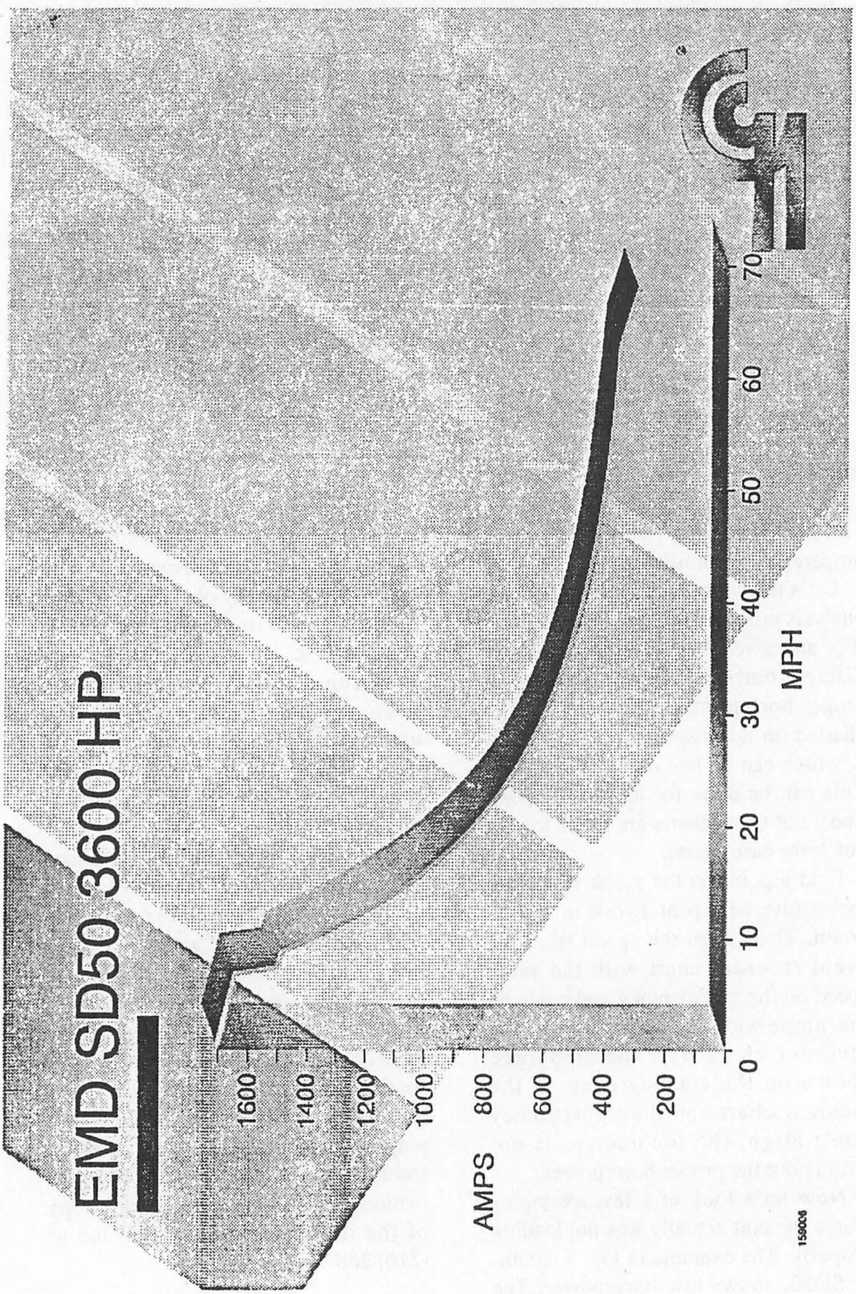

EMD SD50 3600 HP
AMPS
1600
1400
1200
1000
800
600
400
200
0
10
20
30
40
50
60
70
MPH
159006

Fig. 1

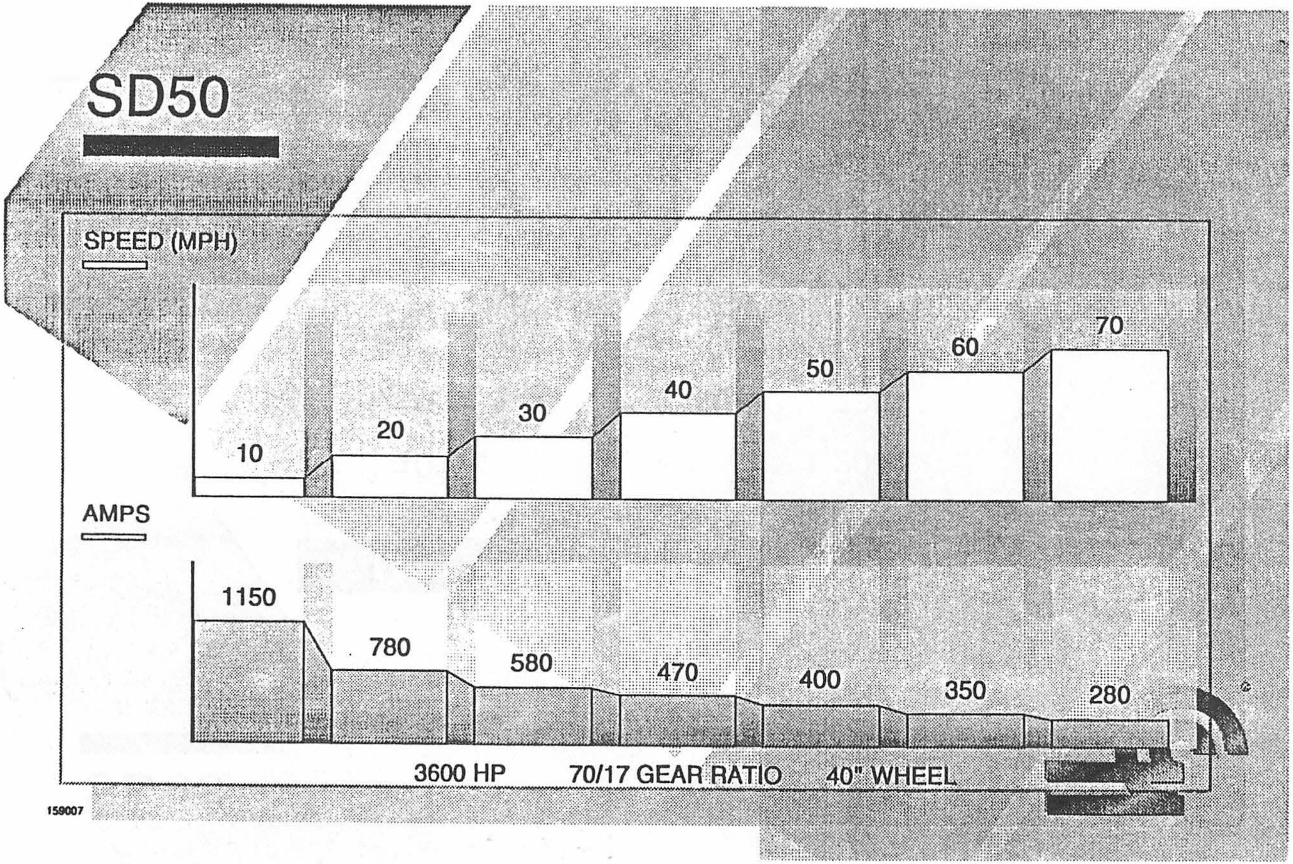
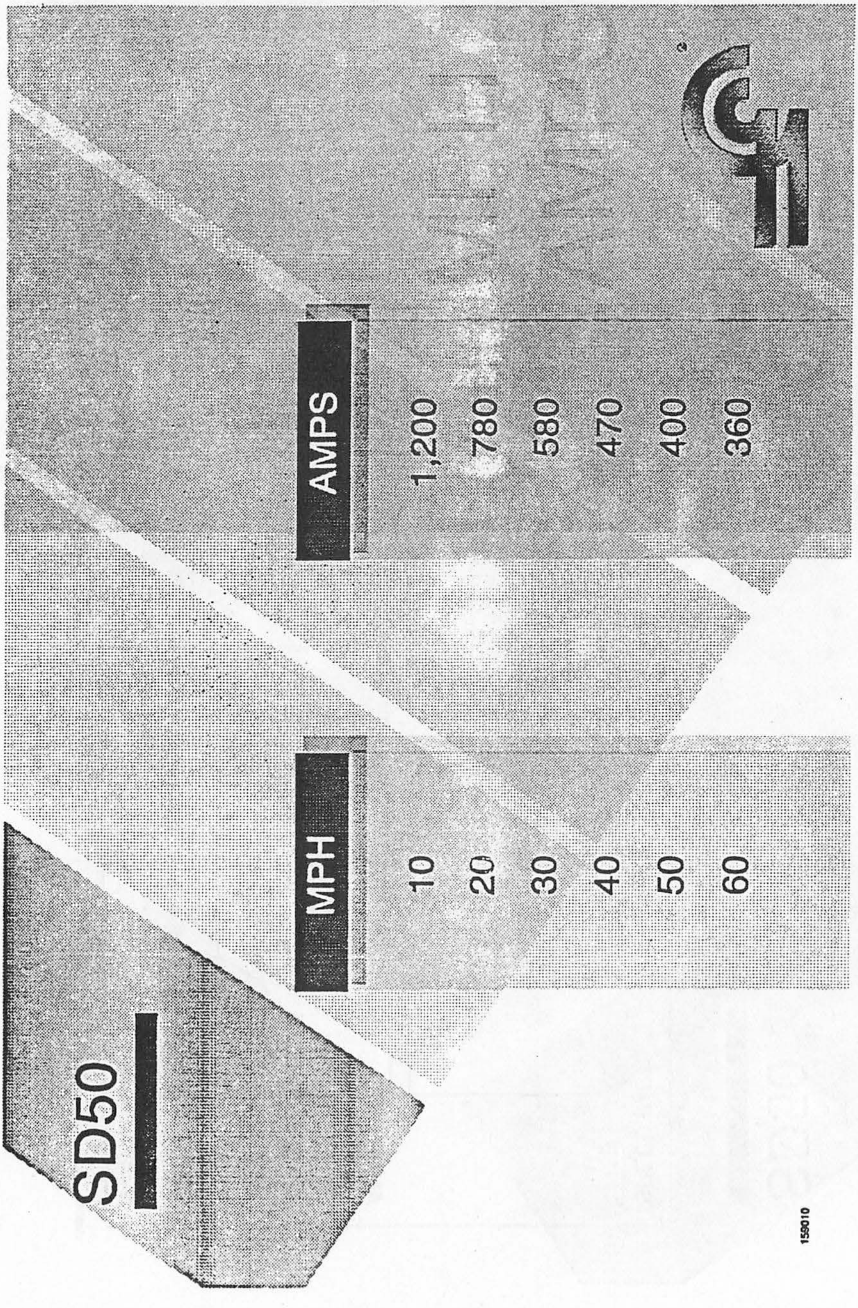

SD50
SPEED (MPH)
10
20
30
40
50
60
70
AMPS
1150
780
580
470
400
350
280
3600 HP
70/17 GEAR RATIO
40" WHEEL
159007

Fig. 2



SD50

MPH	AMPS
10	1,200
20	780
30	580
40	470
50	400
60	360

Fig. 3

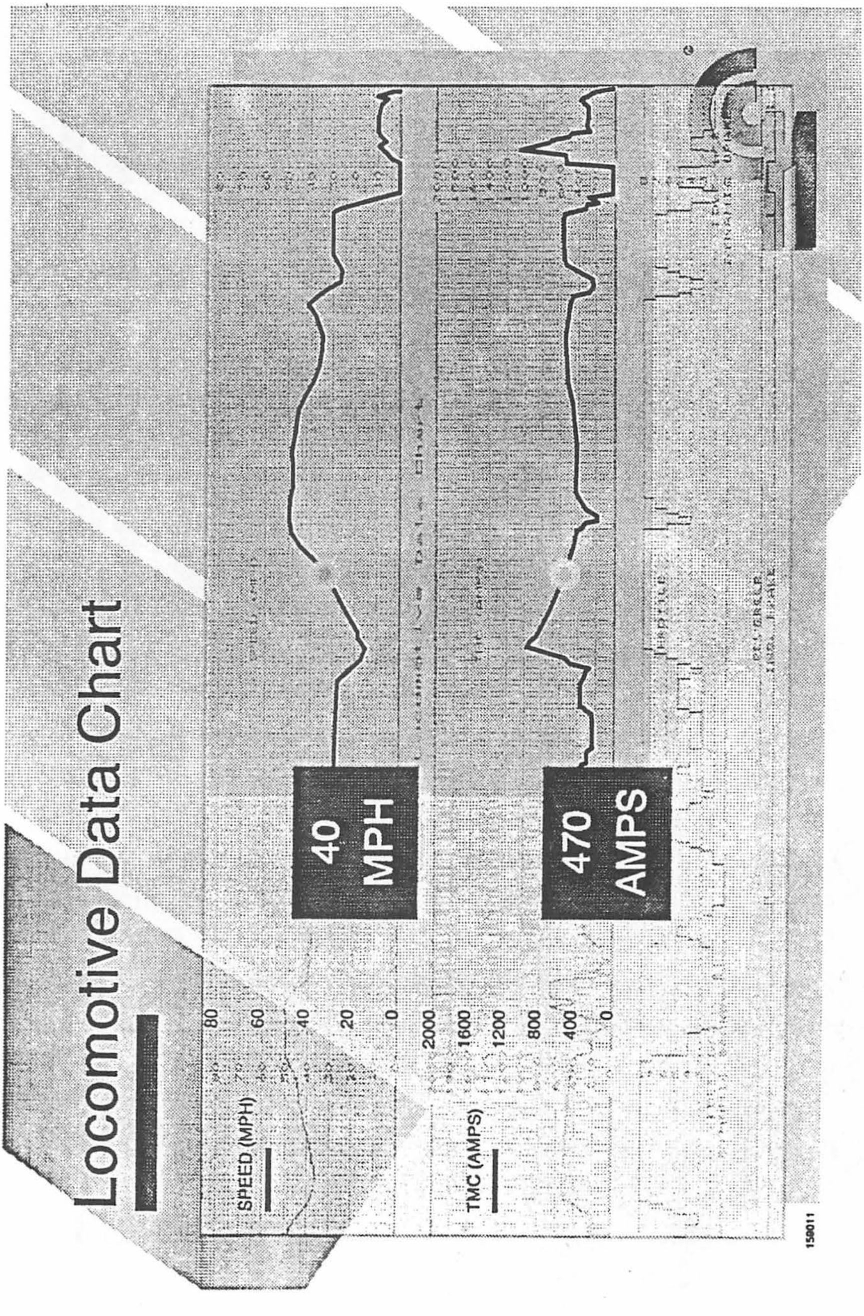
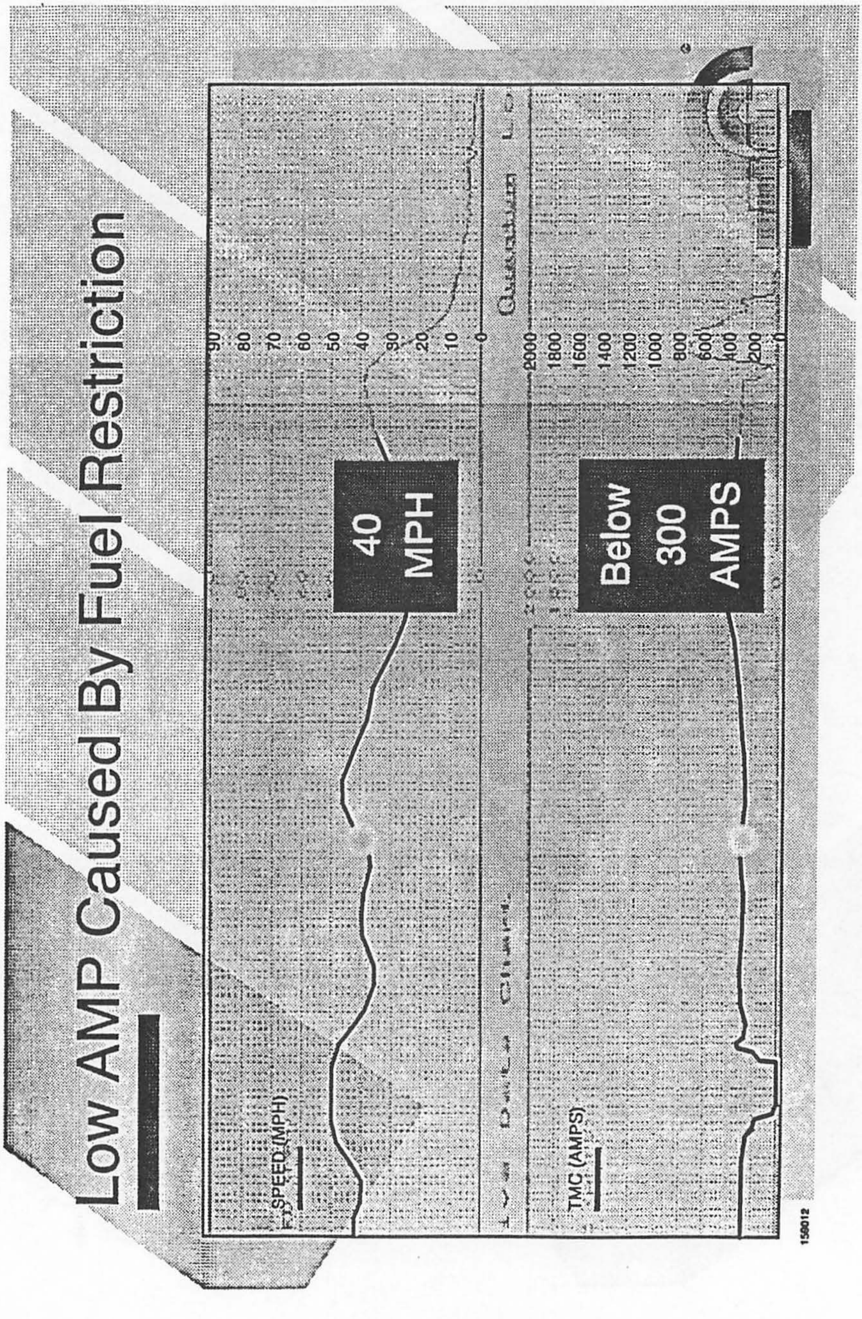

Locomotive Data Chart
SPEED (MPH)
80
60
40
20
0
TMC (AMPS)
2000
1600
1200
800
400
0
40 MPH
470 AMPS
150011

Fig. 4



Low AMP Caused By Fuel Restriction

Fig. 5

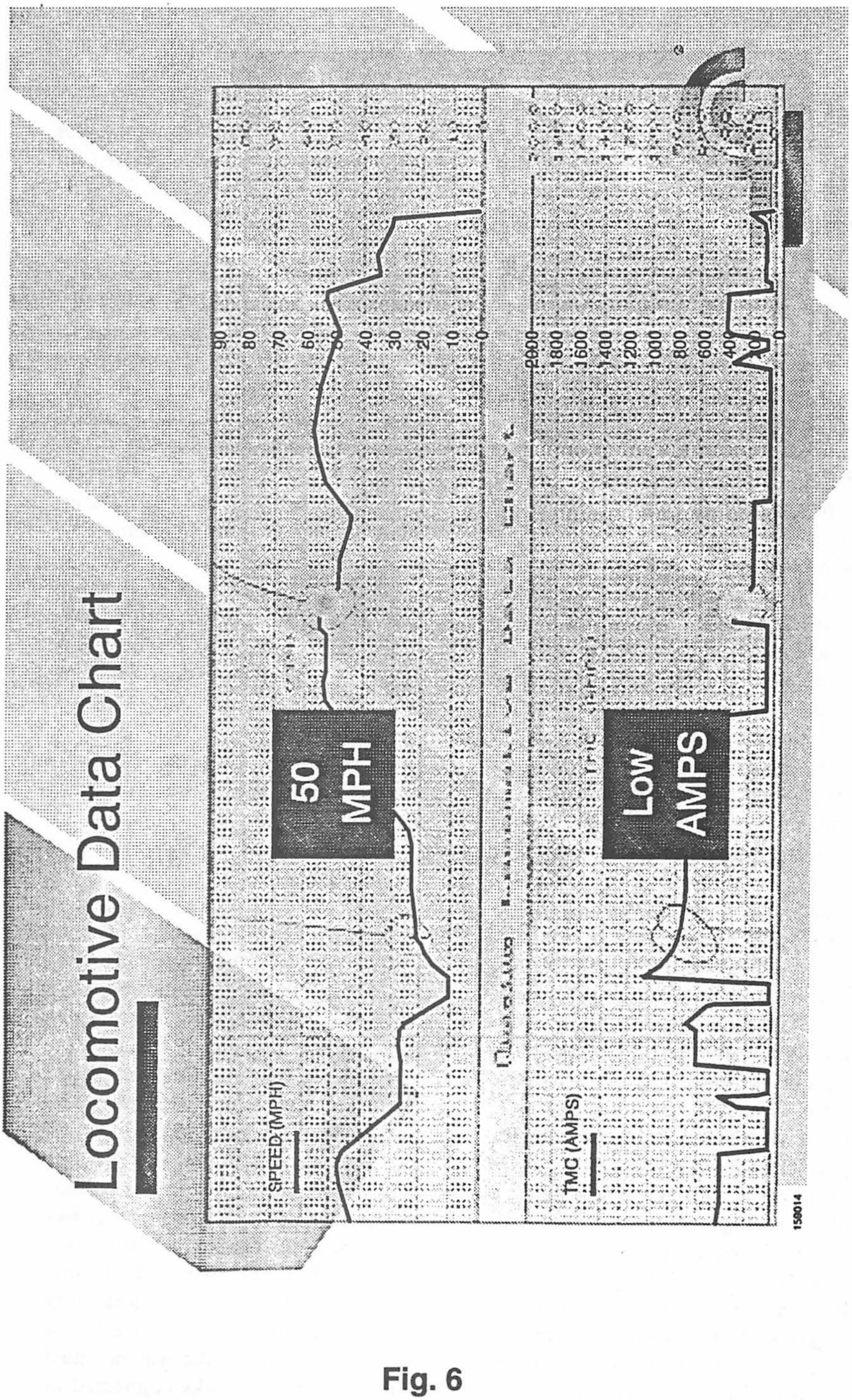

Locomotive Data Chart
SPEED (MPH)
90
80
70
60
50
40
30
20
10
0
50 MPH
TMC (AMPS)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Low AMPS
150014

Fig. 6

IV. SD60 DYNAMIC BRAKE IMPROVEMENTS

Presented by: Jerome W. Youngwirth
Electro-Motive Division

The addition of microprocessor technology into the locomotive control system has provided the railroads with a window to the future. This technology, for all intents and purposes, has reinvented the locomotive and brought it into the space age. Each software improvement serves to better harness the tremendous power of the modern locomotive and put that power to the rail. This paper will review one aspect of the locomotive control system: the control of dynamic brake. More specifically, ti will review the advances in dynamic brake control which Electro-Motive has attained on its SD60 series of locomotives.

Although dynamic brake has been in use as a vital part of train handling for more than half a century, a cursory review of its function is in order.

In its simplest form, control circuitry permits the engineer to turn the traction motors into generators by utilizing both the inertia of the moving train and excitation provided by the main generator (Figure 1). The power produced cannot be stored for future use and must be expended without damage to the electrical equipment. This is done by directing the current produced in dynamic braking to a large bank of resistors where the energy is dissipated to atmosphere in the form of heat. The dynamic brake removed much of the load from the air brake system and provides the engineer with better train handling characteristics.

Over the past several years, Electro-Motive has made several incremental changes to its dynamic brake controller to enhance the performance of the dynamic brake. To explaining how these changes affect the performance, one must first understand how dynamic brake regulation is controlled.

Figure 2 shows a simplified schematic of how the main generator and traction motors are configured for dynamic braking. For sake of discussion, the circuit can be broken down into two sections, control and output. The control portion consists of the microprocessor, the SCR assembly, the generator field circuit, the main generator output and the traction motor fields (Figure 3). These components tie together to make up the control portion of the dynamic brake (Figure 4).

The output portion of the circuit contains the traction motor armatures, brake grid resistors, and shorting contractors (Figure 5).

To control the amount of dynamic braking effort, the microprocessor varies the excitation to the generator field. The microprocessor accomplishes this by changing the firing angle of the SCRs. The earlier the SCRs are turned on, the more excitation the system provides, which increases the braking effort.

Series Operation

Perhaps the biggest change to improve dynamic brake performance was the simple reconfiguration of the main generator from a parallel to series configuration for dynamic brake operation. The SD60 series locomotive is equipped with a 3-phase alternator. This alternator is comprised of two independent sets of stator windings. The output from each of these two strators is rectified via its own rectifier bank assembly. The rectifier banks are connected in one of two fashions, series or parallel, which is dictated by the position of the SGC contractor. In the past, dynamic brake was operated with the rectifier banks connected in

parallel. By changing to a series configuration for dynamic brake operation, two benefits were realized:

1. Decreased generator time constant.
2. Moving the operating point to the linear portion of the generator excitation curve.

Decreased Generator Time Constant

Changing the electrical configuration of the generator from parallel to series configuration resulted in a substantially shorter generator time constant (Figure 6). This time constant is defined as the time it takes for an exponential quantity to change by 63.2% of the total change requested. Specifically, in this example, it is the time necessary for the generator field current to decrease by 63.2%. How did this change improve dynamic brake performance? This can best be explained by examining what happens during a wheel slip.

As soon as the wheel slip is detected, the microprocessor tries to reduce the generator field excitation. This is accomplished by increasing the firing angle of the SCRs. The greater the SCR firing angle, the later the SCRs are turned on, the less field excitation results. Removing field excitation, reduces brake effort. However, because of the inductance associated with the generator, an instantaneous change is not possible. The time it takes for the field current to decay by 63.2% is referred to as the generator time constant. The smaller the generator time constant, the faster the generator field will decay, the faster braking effort will be reduced. Therefore the faster the generator can respond to a change in excitation, the quicker a wheel slip correction can be made. Quicker wheel slip corrections provide a twofold benefit: a more stable system and a higher overall brake effort level. This gives the engineer better train control.

Moving the Operating Point to the Linear Portion of the Generator Excitation Curve

The second advantage in having the generator operate in series is that it allows the generator to operate in the linear portion of the curve for the field excitation (Figure 7). This means that for a discrete change in the firing angle, an equal and corresponding discrete change will occur at the output. This allows for more precise control of the output. This was not the case when the generator was connected in parallel. Consequently, by moving the field excitation point to the linear portion of the curve, a more stable control system was achieved.

Additional enhancements to the dynamic brake control system now became possible due to the increased stability of the system. This stability provided the capacity to increase system sensitivity levels. This provided additional enhancements as follows:

1. Increased wheel slip detection sensitivity;
2. Quicker wheel slip recovery;
3. Redefined recovery rates to minimize overshoots;
4. Improved control of extended range dynamic brake.

Wheel Slip Detection Levels

Electro-Motive wheel ship detection is broken into four stages. Stage 1 and stage 2 wheel slips are recognized by the rate of change of the difference between the highest and lowest traction motor currents. Stage 3 wheel slips are recognized by the instantaneous difference between the highest and lowest traction motor currents. Stage 4 wheel slips are recognized by summing the voltages in each of the dynamic brake paths.

Within the control system, both stage 1 and stage 2 wheel slip detection levels are used to keep the brake effort (references) at the highest level possible for the current track conditions. Stage 3 (level) and stage 4 (WSR) wheel slip detection levels are used to reduce the brake effort from a high level to a low level very quickly. This is necessary to recover from a severe wheel slip.

Because of the slow response time associated with the parallel configuration, stage 1 and stage 2 wheel slip corrections were less effective. The slower response allowed state 1 and stage 2 wheel slips to quickly degenerate into stage 3 or stage 4 wheel slips which are associated with large unloads. (loss of brake effort). These large unloads could severely affect train handling performance. By increasing the generator response time, stage 1 or stage 2 wheel slip corrections became more effective. This allowed the control system to make quick reductions in brake effort, before large wheel slips would occur, resulting in large system unloads.

Thus, the series configuration, because it provides a quicker response, increased the effort of both stage 1 and stage 2 corrections, improving train handling. The increased stability of the system also allowed an increase to the sensitivity level of stage 1 and stage 2 detection, making the system respond even sooner to potential wheel slips.

Wheel Slip Recovery

To reduce the unload time resulting from a wheel slip, improvements were required to the wheel slip recovery system. Once a wheel slip ends, a large error would typically exist between the references and the feedbacks. This lag, which is inherent to the system, leaves the references substantially lower than the feedbacks. Consequently, the system will continue to unload until the references were ramped back up past the feedbacks. This causes the unit to unload for a longer period of time than necessary. To reduce this, the references were set equal to the feedback levels once the wheel slip ended. This way the brake effort level was only reduced to the level required to stop the wheel slip. This allows quicker recovery up the maximum brake effort that the current track conditions can support.

Recovery Rates

An improvement was also made to the reference recovery slopes. These slopes determine how quickly braking effort will be reapplied after a wheel slip. With the previous system, these slopes were set excessively high causing the system to overshoot. These overshoots, depending on track conditions, would cause consecutive wheel slips, reducing train handling performance.

To correct this problem, the recovery slopes were set to levels which were slightly higher than that which the feedbacks were capable of rising. This kept the error between the feedbacks and the references to a minimum, allowing the control system to respond adequately, minimizing the overshoot. This change to the control system minimized the consecutive wheel slips that tended to occur subsequent to state 3 or stage 4 wheel slips.

Extended Range

The final change was made to extended range braking. Extended range is a process where grid resistance is reduced in order to maintain high levels of brake effort at lower speeds.

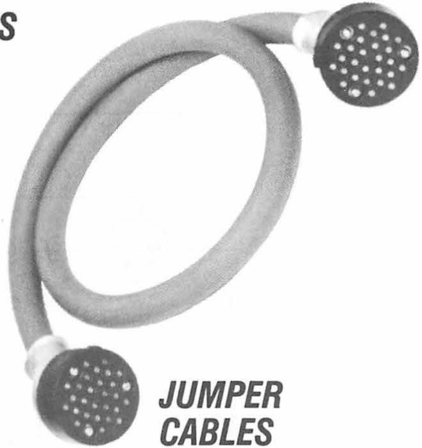
To accomplish this, two contactors are connected in parallel with the grid sections. These contactors pick up and drop out, shorting out portions of the grid resistors as locomotive speed decreases. This decrease in grid resistance increases brake effort. Because these contactors make discrete changes in the resistance instantaneous, bursts of grid currents are generated. These bursts of current were sufficient to cause momentary wheel slips.

The control system was modified to compensate for these types of wheel slips by reducing excitation, momentarily, just prior to initiating an extended range step. Although this change did not eliminate the bursts of grid current (brake effort) completely, it was significant enough to prevent the wheels from momentarily locking up.

Conclusion

Today's railroads are hauling more and more freight with fewer locomotives. This has placed an increasing demand on the dynamic brake system on a per-unit basis. The dynamic brake improvements described here today will help meet customer needs. It is important that the control system offer the customer the ability to work in adverse track conditions with minimal loss of power, such that trains meet the schedules, and thus enhance the revenue position of the railroad. The dynamic brake enhancements outlined above should be thought of as a snapshot in time, not the end of a process. The process of improving the product is an ongoing endeavor and the hardware is designed with ease of application in mind. As such, improvements to software that become available are easily retrofittable by simply reprogramming the microprocessor. This has removed the burden of tying up the customer's power for extended periods of time for hardware reconfigurations.

In summary, the new software package for Electro-Motive's SD60 locomotives has substantially improved dynamic brake performance. This was achieved by the increased generator response time, as a result of changing the generator from a parallel to a series configuration. This provides for a more stable system which allows for increased detection levels and quicker recovery from wheel slips. The net result is a control system that can provide the user with an overall higher level of brake effort under adverse track conditions.



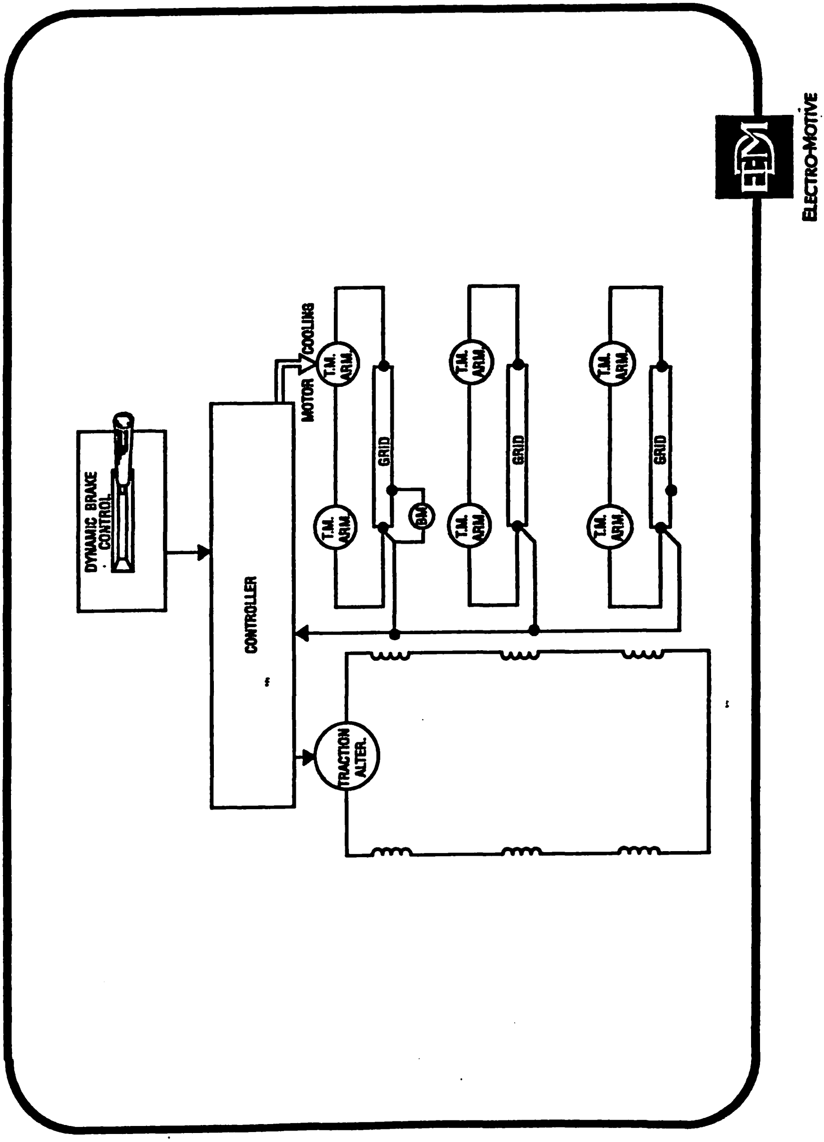

DYNAMIC BRAKE CONTROL
CONTROLLER
MOTOR COOLING
T.M. ARM.
T.M. ARM.
T.M. ARM.
T.M. ARM.
T.M. ARM.
T.M. ARM.
GRID
GRID
GRID
BM
TRACTION ALTER.
ELECTRO-MOTIVE

Figure 1

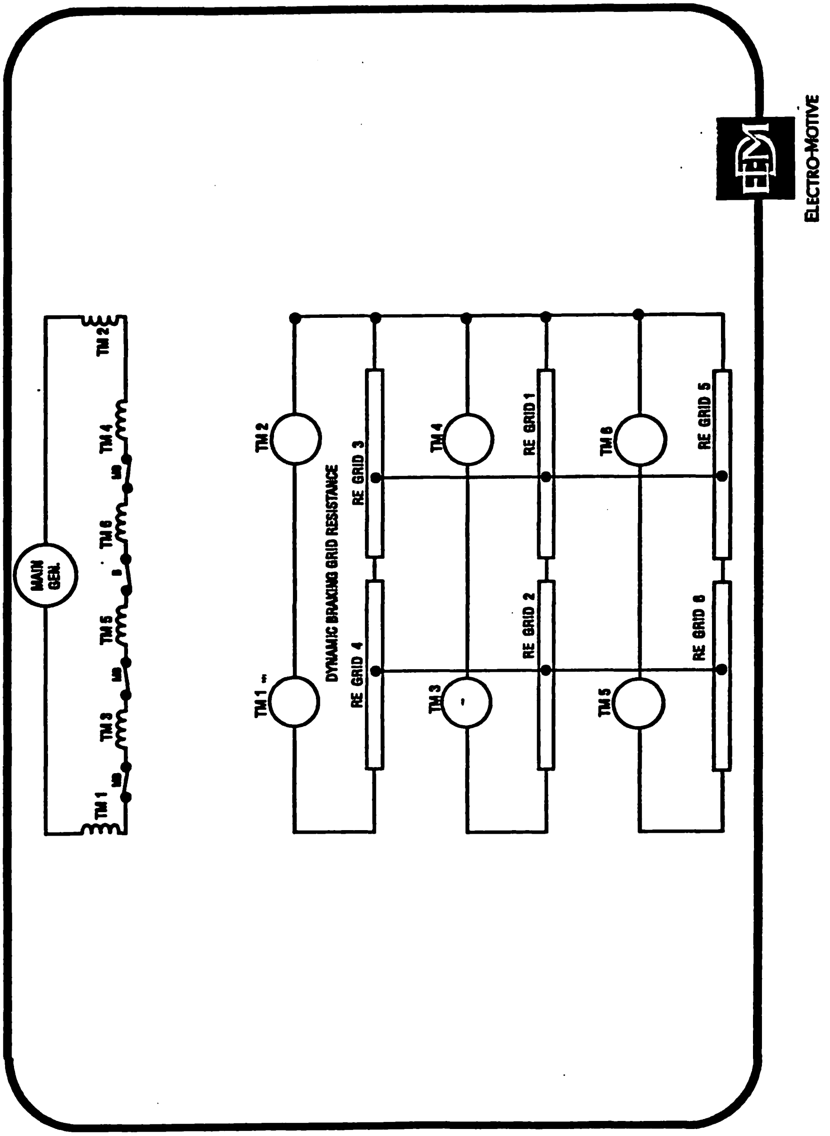

MAIN GEN.
TM 1
MB
TM 3
MB
TM 5
B
TM 6
MB
TM 4
TM 2
DYNAMIC BRAKING GRID RESISTANCE
TM 1
TM 2
RE GRID 4
RE GRID 3
TM 3
TM 4
RE GRID 2
RE GRID 1
TM 5
TM 6
RE GRID 6
RE GRID 5
ELECTRO-MOTIVE

Figure 2

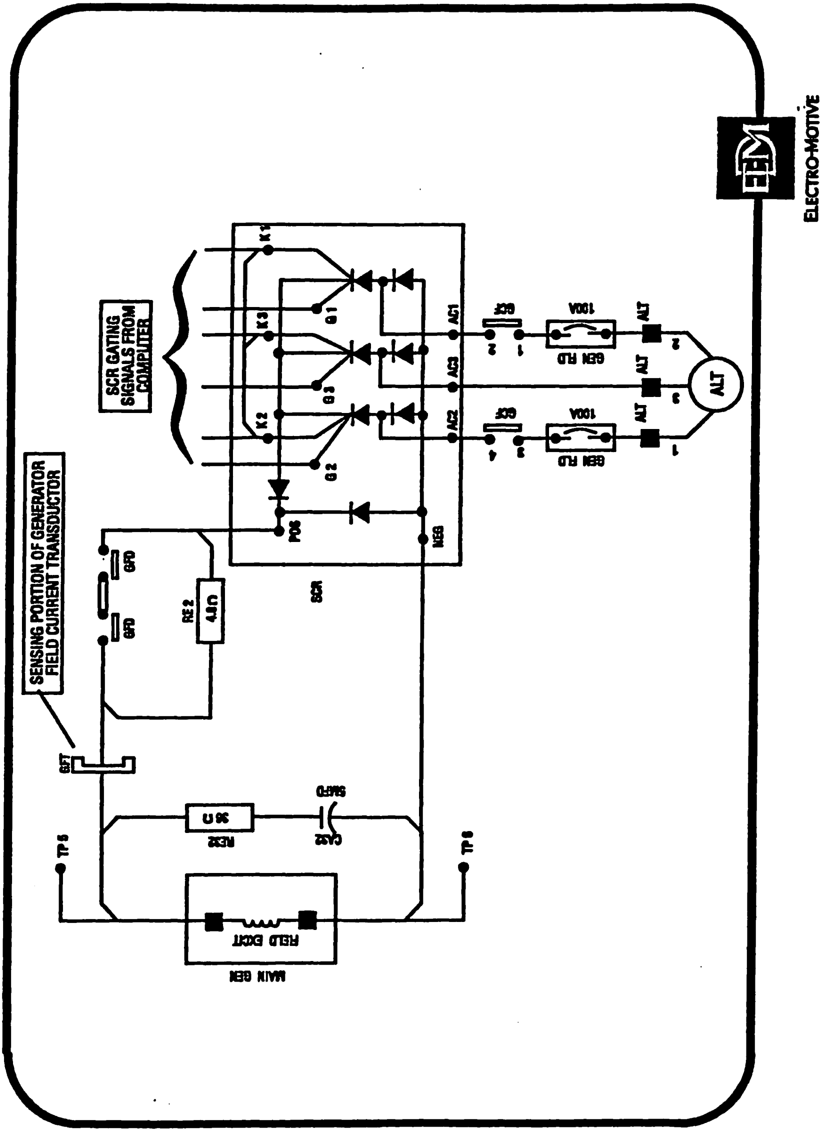

SCR GATING SIGNALS FROM COMPUTER
SENSING PORTION OF GENERATOR FIELD CURRENT TRANSDUCTOR
K1
K3
K2
G1
G3
G2
AC1
AC3
AC2
POS
NEG
SCR
GFD
GFD
RE2
4.0Ω
GFT
RE3
36Ω
CA52
5MFD
TP5
TP6
FIELD EXCIT
MAIN GEN
GCF
GCF
GEN FLD
GEN FLD
100A
100A
ALT
ALT
ALT
ALT
2
1
4
3
2
3
1
ELECTRO-MOTIVE

Figure 3

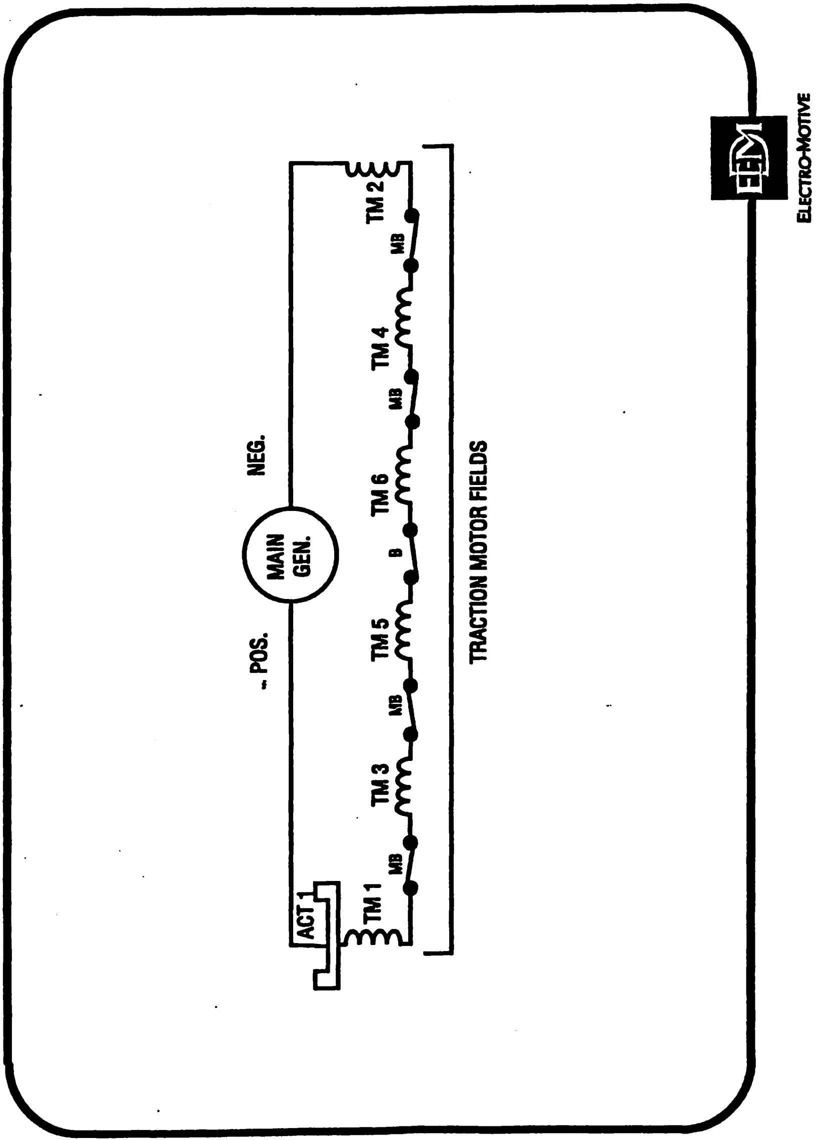
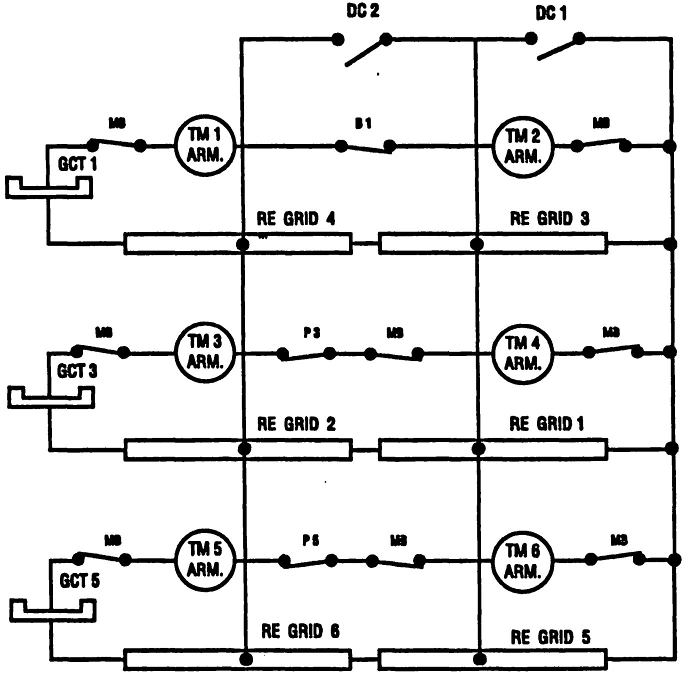

POS.
MAIN GEN.
NEG.
ACT 1
TM 1
MB
TM 3
MB
TM 5
B
TM 6
MB
TM 4
MB
TM 2
TRACTION MOTOR FIELDS
ELECTRO-MOTIVE

Figure 4



ELECTRO-MOTIVE

Figure 5

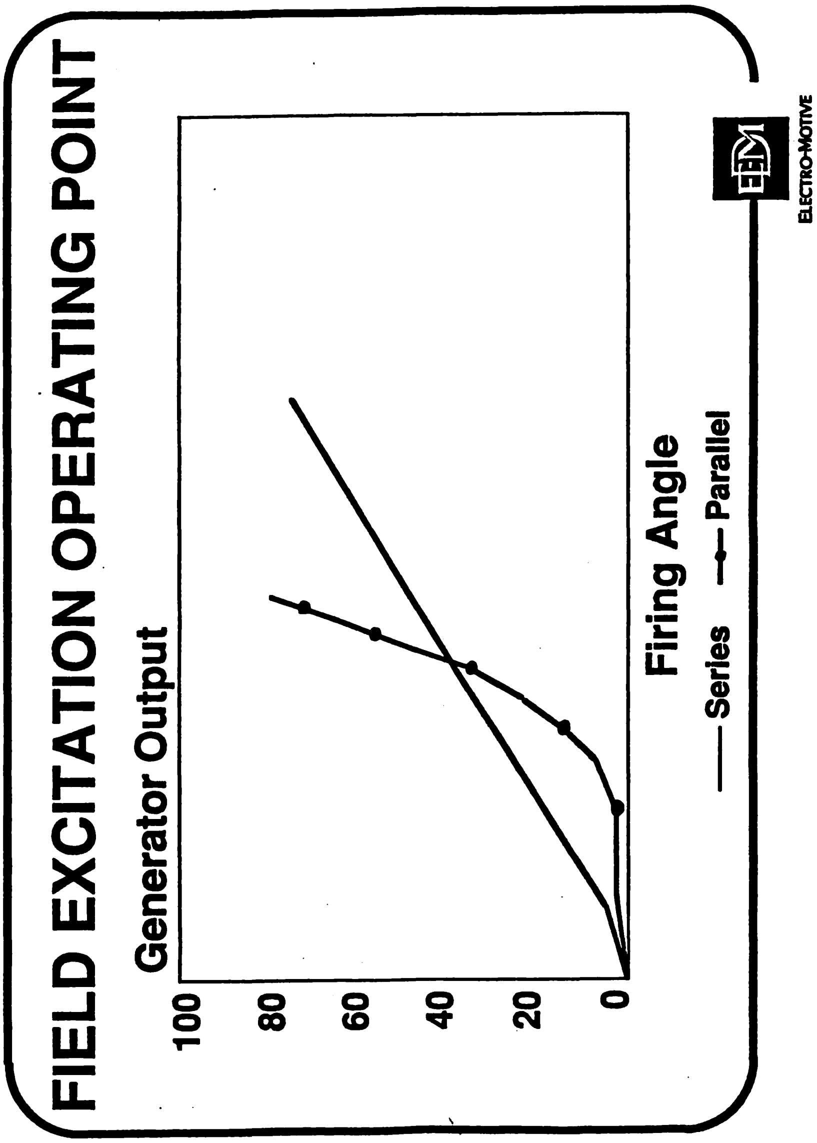
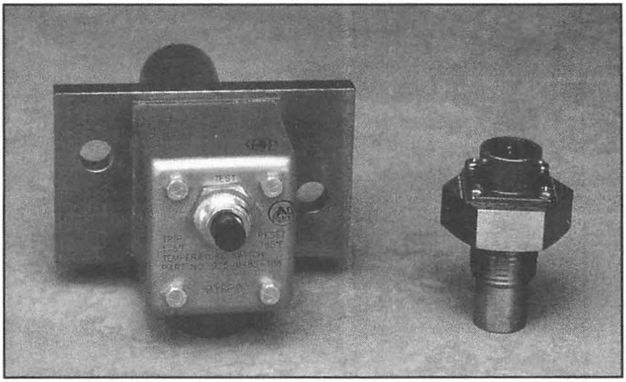
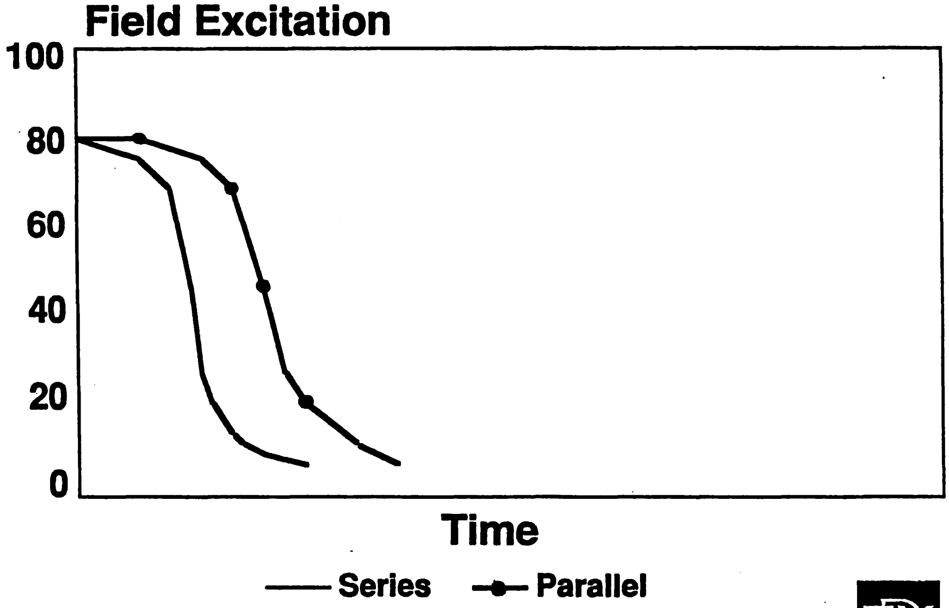

FIELD EXCITATION OPERATING POINT
Generator Output
100
80
60
40
20
0
Firing Angle
Series
Parallel
ELECTRO-MOTIVE

Figure 6



GENERATOR FIELD DECAY



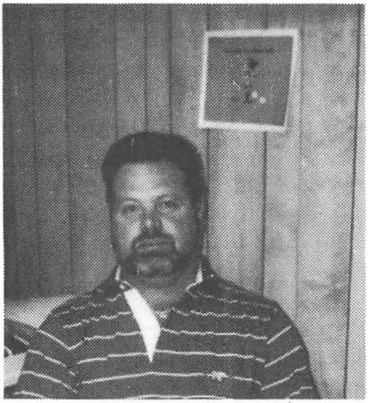
ELECTRO-MOTIVE

Figure 7

REPORT OF THE COMMITTEE ON DIESEL MATERIAL CONTROL

MONDAY, SEPTEMBER 19, 1994
1:45 P.M.

Pre-Convention
Presentation
Chg. RR.
Mech. Assn.



April 11, 1994
Union League Club
Chicago, IL

WILLIAM LECHNER, Chairman
General Foreman
Conrail
Altoona, PA

Vice Chairman
BOB CORDER
Director-Material
VMV
Paducah, KY

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PERSONAL HISTORY

William Lechner

Bill Lechner began his railroad career in 1977 as a clerk with Conrail in the Transportation Department at Trainmaster's Office in Hollidaysburg, PA. Later he transferred to Mechanical Division and held several positions in Stores Department and Promotions followed: Supervisor Production Control (1980); Manager of Material and Production Control (1992); General Foreman of Air Brake Shop (1993).

Bill graduated from Altoona Area High School (1966), also a graduate of Penn State University (1972). Attended many schools for computer training throughout career, and many technical schools for railroad training.

Bill and his wife Debbie have two children: Wendy Jo, 20, and Todd William (18) and both are currently attending Penn State University. They currently live in Altoona where Bill is Manager Material and Production Control and also General Foreman of Air Brake Shop for Conrail.

THE CHICAGO RAILROAD MECHANICAL ASSOCIATION
THE CHICAGO RAILROAD DIESEL CLUB
THE CHICAGO RAILROAD CAR ASSOCIATION

The Chicago Railroad Mechanical Association would like to introduce you to our organization. The Association exists "For Exchange of Ideas on Railroad Locomotives and Cars" which forms the basis for meetings that provide an excellent opportunity to learn of new product offerings and maintenance procedures as well as becoming better acquainted with others in the railroad industry.

The Association has 110 sustaining member companies and 600 individual members. Meetings are held on the SECOND MONDAY evening of each month during September through April with an additional "SPRING DINNER DANCE" on the FIRST FRIDAY EVENING OF MAY and a "GOLF OUTING" the FIRST FRIDAY OF JUNE. The meetings are located at the Union League Club, 65 West Jackson Blvd., in the Chicago Loop. Meetings are generally sponsored by one of our member Companies who then make a short presentation on a topic of current interest. Plenty of time is available for shop talk amongst the members.

Sustaining membership dues are $120.00 per year plus $30.00 for each individual from your company. Supply members are assessed $30.00 for dinner and refreshments for each individual attending a meeting.

If you have never been a member of our Club or Clubs and would like to see what we are about first hand, just contact our Secretary, Don Brooks (708-258-9660), and we will be happy to provide you with complimentary tickets for one of our meetings. We'll look forward to seeing you at the next meeting where you will find a friendly informal atmosphere in which to learn more about the railroad industry and its people.

The Board of Directors
The Chicago Railroad
Mechanical Association

I. CONSIGNMENT – FREE LUNCH OR GOOD BUSINESS SENSE?

Presented by: Lee Murphy - UP

Webster states that consignment is the giving over of material to the care of another; to entrust. It also states that it's to set apart for a special use. It further states that the consignee is expected to pay following sale.

Consignment is a word that can bring terror in the minds of some suppliers. On the railroad, we have an altogether different outlook. In many of our locations, running repair of locomotives is our business. Trying to make use of the "just in time" concept becomes a nightmare. Consignment and the many forms it can take becomes a shining star. Let's explore some of these forms.

The simplest form is found in the hardware area. Labor expended on the inventory of nuts and bolts and the handling of them is non-productive at today's rail labor costs. Many shops are set up with suppliers that will set up storage areas and routinely inventory and supply the needed hardware at predetermined levels. We trust the supplier to accurately count and maintain inventory while agreeing to pay on his counts. This allows us to use our labor more efficiently, while at the same time making sure we don't hold a locomotive for a nickel-dime item.

Other commodities such as turbos, brakeshoes, wheel blanks, injectors and filters, just to name a few, are consigned at pre-determined levels. The components are paid for after being applied to the units. The benefits are two-fold for the railroads: we are spared the inventory carrying costs, while at the same time we are assured of the availability of needed components to cover unusual material demands in running repairs.

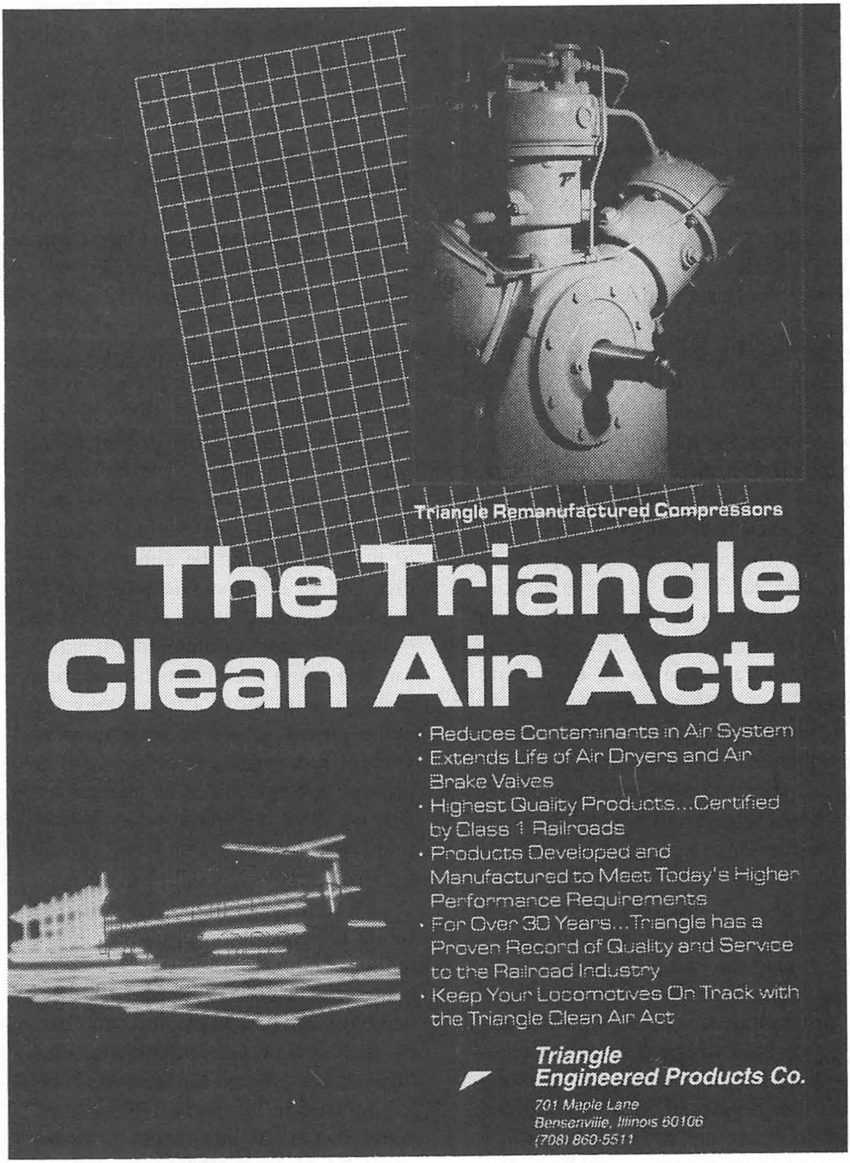
Dedicated warehousing is another form. Some of our suppliers have set up warehouses in strategic locations to react to our needs faster. Some are dedicated to a specific railroad location, while others are able to service several railroads from one location. This cuts transit times from two to three days down to overnight in many instances. Once again, this helps to keep our locomotives on the road instead of in the shop.

One of the more responsive forms of consignment are the customer service centers that are located in the locomotive shops themselves. These may carry an inventory for a specific locomotive or can cover all types. They are staffed with the suppliers' personnel. The material is paid for upon application to the units. This type of facility may include technical support and might also use railroad labor for parts handling.

Stretching consignment brings us to guarantees of delivery. In this form of consignment there is a penalty associated with non-performance. This helps the supplier plan and insures on time delivery.

The suppliers might be asking "what do I get out of this deal"? "Sounds like a free lunch for the railroads". Consignment can help you reduce your in-house inventory needs and space. It can reduce or eliminate those last minute emergency orders that have to be someplace yesterday. It can eliminate delayed receipts because of inclement weather. It can help you plan production. It also means that you and your product are there when opportunity knocks. It solidifies partnerships.

The most important thing about consignment is that it keeps the locomotives where they're supposed to be – on the track pulling freight. We challenge you to be innovative with your proposals. There are numerous opportunities, some in areas not yet considered. It may be a cliche' but it's still true: service is the name of the game.



II. THE NEXT STEP IN ELECTRONIC INFORMATION MANAGEMENT: INTERACTIVE TECHNICAL MANUALS

Prepared by: Bob Florczyk
John Minnie
Jennifer Szczesniak
Bill Wewers

Presented by: John Minnie - BN

Last September this LMOA Material committee gave a presentation entitled "Electronic Catalogs, The OEM/Supplier Point of View." The premise of that presentation was that technology in the form of electronic catalogues is available today. This technology will make everyone's job easier; from the mechanic on the floor, to the clerk in the Material department, to the purchasing manager in the office, even to the supplier across the country. Unfortunately, the response to our presentation was far less than anticipated. This committee would again like to challenge this audience to study the potential benefits of electronic technology in the rail industry.

If you remember, last year we painted a picture of the steps involved to get the correct materials ordered. A machinist thumbing through multi-volumed catalogs or looking through his "little brown book" trying to find the necessary part number. A materials person handling the requisition, cross referencing the part number to the railroad's identification number and finally processing an order. A purchasing manager reviewing the order and sending it on its way. A supplier receiving the order, interpreting what is needed and shipping the order. It was not a pretty picture when one realizes how much more efficient the process could be if current electronic technology is utilized. Each step has its pitfalls including outdated catalogs, invalid part numbers, transposed numbers, and incorrect prices. All of these discrepancies can cause delays that cost the railroad and suppliers unnecessary expense. The sheer number of people conducting manual operations within the normal ordering process increases the potential for error; this in turn causes production delays, units held, erroneous shipments, and eventually a reiteration of the whole process.

The potential for errors and confusion can be substantially reduced with the use of "electronic technologies". Whether you are a Class I railroad, a regional, or a short line, almost all of us have computers or have thought seriously about the benefits of having them. Instead of paging through volumes of catalogs, some of which are outdated, or incomplete, an individual could simply walk up to a terminal, call up a component such as a water pump or a generator and be automatically directed to the specific part that is needed. The next logical step would be to type the quantity required, hit a button and begin the automatic ordering process. With today's technology the entire process could be accomplished without ever writing a single word or printing a single piece of paper. Last year we showed a prototype of an electronic parts catalog developed jointly by EMD and EDS. This prototype could be a stepping stone into the future of electronic cataloging. As of today, catalogs on computer disc are being provided by the OEM's on a limited basis, for new locomotive purchases, such as with GE and Amtrak. One OEM is planning on having parts catalog available by early 1995 which could encompass information on locomotives built from 1988 to the present. The OEM's are moving toward the future but it is up to the railroads to help provide the direction and the incentive to push this program.

In addition to "electronic cataloging" there is also the potential to utilize electronic information in the field of diagnostics, much as we use maintenance manuals today. This diagnostic electronic catalog is more appropriately known as an interactive technical manual. Or perhaps it is easier to think of interactive technical manuals as artificial intelligence; you answer yes or no and the computer knows what to do next.

A short video was shown to explain more about interactive electronic technical manuals. Specifically the video addressed a system developed by Lockheed, Fort Worth Division. Although this video dealt with aircraft, the technology can be applied to locomotives.

Currently an interactive technical manual system is being implemented by the U.S. Navy for the maintenance of its F-16 fighter jets. Now while a Navy jet may seem unrelated to a locomotive, both machines share the commonality of thousands of both mechanical and electrical parts, as well as thousands of pages of technical information. In fact, when the system was developed, the Defense department requested that it be sufficiently flexible to accommodate any "machine" in the defense department including: planes, boats, submarines, tanks, and guns. You may also be surprised to hear that implementation of interactive technical manual systems is being considered by leaders in the fields of medical equipment, commercial heating and air conditioning, Society of Automotive Engineers, elevator manufacturing, and telecommunications. Interactive technical diagnostics is a flexible technology adaptable to any industry where maintenance functions are crucial to survival.

In much the same way that electronic catalog technology was developed to simplify the parts ordering process, interactive technical manual technology was developed to eliminate common maintenance problems. One such problem occurs when the mechanic cannot duplicate the same problem and/or symptom as reported by the locomotive engineer. A second type of problem occurs when the engineer reports an incorrect problem in the first place. In this case the mechanic tests for the incorrect problem, finds nothing wrong, and sends the locomotive back into the field with the actual problem unrepaired. How frustrating it is for the chief mechanical officer on down to the mechanic when revenue is lost when a locomotive is shopped because a problem cannot be diagnosed efficiently! This second type of problem costs the Navy on average $20,000 per occurrence.

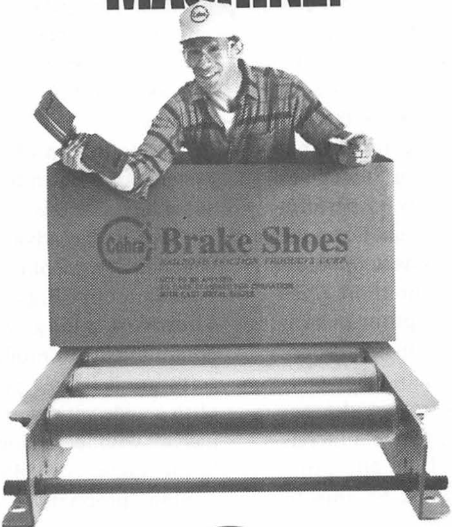
The interactive technical manual system developed for the Navy was designed to be used by the Army, Navy and Air Force. It is conceivable that this same system could be used by the locomotive industry simply by changing the technical data. Much of the logic is already in place. However, what makes this existing system so powerful is the cooperation of many vendors and/or government contractors in sharing technical data. For the rail industry it would appear that both GE and EMD would have to share data with the interactive technical manual creator. The interactive technical manual would be created with railroad industry standards in mind. Therefore, as new vendors and manufacturers are added to the data base, the user would see seamless technical data presented. This sharing of technical data with the interactive technical manual creator is necessary for it to succeed.

The software that creates the data

and presents the data was created for the United States government. The software is free to government contractors. However, the cost of authoring rail specific data and putting locomotive technical manual data into electronic form is unknown. Creating logic for yes or no questions in an interactive technical manual format is very time consuming. Creating the decision tree for maintenance logic is very time consuming as well. As a result of modifying existing technical publications to an interactive format, one third of the resultant data would be existing technical data and two thirds of the resultant data would be newly written information.

Whether it's a locomotive, a plane, an automobile, or earth moving equipment, the necessity for maintenance is omnipresent and the technology to provide this information needs to be as user friendly as possible. Using printed maintenance manuals results in many of the same problems associated with paper parts catalogs. These manuals are used in the workplace and are therefore exposed to the typical locomotive shop environment. They become dirty and worn, and they do not always get updated. All of the disorganization can be eliminated with the advent of electronic interactive technical manuals, similar to what Caterpillar and the Navy are using today.

While some of this technology is here today, more will become available between now and the 21st Century. We need to champion this cause now! The technology is out there. The railroad industry needs to educate itself by forming a committee to pursue the formats that will be necessary to advance into the electronics of the future. We challenge all of you to explore electronic cataloging and electronic technical diagnostics, and to decide what is needed for your future. We are all challenged on a daily basis to work more efficiently. Without a doubt, electronic technology can help. But the responsibility for bringing the future to today rests with no one but themselves . . . . . the railroads.


Cobra
Brake Shoes

III. ELECTRONIC CATALOG ALTERNATIVES

Presented and Presented by:
Marj Dinius - MRL
Bob Corder - WMV

Electronic catalogs and electronic interactive technical manuals look like the answer to many unsolved riddles for the major Class I railroads. Unfortunately, the vast majority of short lines and most regional railroads operate older model power that will never have this vast array of electronic information available. Most regional railroads operate on tight budgets with little or no extra money available for fancy computer systems. Since the revenue comes from hauling freight, not repairing locomotives, it is sometimes difficult to get the money to perform the routine maintenance functions; the futuristic aspects are almost impossible. Some of the smaller short lines don't even have computers, and, depending on the size of the operation, may not need one. For both the regionals and shortlines electronic alternatives must be cost effective and literally very inexpensive. Like any profitable business, we must be able to show a reasonable return of our investment before we can take the risk. The R.O.I. (return on investment) must be substantial and fast. We have to be able to justify any expense, as we should.

In this day of information, there are ways of getting affordable information to the people who need it the most. Data exchange or just the exchanging of information is fast becoming the norm in this country and the world. The term "information super highway" is becoming a common term in today's language. More and more networks and computer link-ups are being established in the business world and in our personal worlds. We can literally talk to people anywhere in the world with a relatively small cash investment. A personal computer, a modem and a telephone will tie even the most remote locations to the business centers of the world.

There are several "bulletin board" systems available at the present time, with information ranging from airplane parts to prospective husbands or wives. Just about anything an individual person really wants or needs can be located or at least discussed utilizing the "super information highway". Some systems just give you access to the information, while others allow a conversation between the interested parties (a good idea if it is a mate you're looking for).

The definition of a "bulletin board system" or BBS in today's language is something like this:

"Due to the advances of software, specifically graphics and Windows-based technology developed by Microsoft, along with advances in communication modems and related software, it is now possible to accomplish a wide variety of "electronic commerce" with technology called bulletin board systems, or BBS for short."

Both "proprietary" and "open" bulletin board systems are available at the present time. Proprietary systems restrict the information to specific people or companies connected to the field involved in the particular endeavor. Open systems or bulletin boards are available to anyone paying to be on the network.

Presently available in this country and around the world is a network call "Internet". The Internet was born about 20 years ago in an effort to tie the ARPAnet system together from the U.S. Defense Department and various other radio and satellite networks. The system was experimental and designed to help the military in the research and the building of a network that could be maintained with partial outages (like bomb attacks) and remain functional. This experiment by the U.S. government two decades ago now has millions of users connected and talking every day.

Today's Internet is, in reality, a large web of smaller regional networks. It has been described as a transcontinental superhighway system running to all of the major cities and towns, where residential streets get to the individual people. The "superhighway" is the high-speed Internet. Connected to this are computers that use a particular system of transferring data at high speeds. Smaller computers are networked into the larger system for specific geographic regions and personal computers are linked to the networks. The Internet system is not controlled by one central computer or even a group of computers. Its resources are made up of thousands of individual computers.

Since the number of link-ups changes by the day, no one really knows how many computers and networks actually make up the Net. Estimates put the numbers in the range of 350,000 computers on about 5000 networks serving over 3,000,000 people around the world.

Several parallel networks have been developed during the past decade. Today most of the parallel systems are becoming connected, thereby increasing the size by leaps and bounds.

A couple of companies involved in these systems are Digital Equipment Corporation and InterNIC Information Services. DEC is an example of a proprietary type system, while InterNIC is more of an open network.

Digital Equipment Corporation is in the computer business and has found that utilizing the Internet allows certain advantages over the "old" ways of doing business. The company sees Internet as a vital tool to get information quickly and directly to customers. Internet is used to let customers know what is available, answer questions about products and generally share information. Since the network is a two way street the customers may also talk to Digital and ask the questions important to them individually. The railroad industry will see benefits similar to those at DEC through better communication between railroads and suppliers.

Digital's long term objective in its use of the Internet is to develop new and better products based on improved communication and responsiveness to customers. Internet opens the door for small companies, as well as the giants. Communicating and interacting with customers on the network relies more on creativity, flexibility and responsiveness than on corporate muscle power. The Internet link allows the opportunity for small companies to get their message out and for customers (small companies or individuals) to find the products they need.

Internet is a cooperative effort between the government agencies, educational institutions and various commercial and non-profit organizations. It has a collection of over 10,000 computer networks around the world, all owned and operated separately. No one organization owns the Internet.

The major type of information in the Internet up until a year ago was basically in the research and education fields. Recently, several new areas have been expanding such as library catalogs, electronic journals, government information and news. It is very possible to add locomotive component availability from various suppliers to the data base in the future.

The Internet works with "open" standards. Open standards, as stated earlier, means the information is available to anyone with access to the system. The computer standards have been adapted for use on most common systems, such as a UNIX workstation, a PC, a Macintosh and a VAX.

The Internet is easy to use, menu driven and can be accessed from a standalone PC.

The Internet is not "free". There are certainly costs involved in getting the data from the suppliers and getting set up in the system. After the system has been set up, the users must have a computer, modem and a telephone. The users must pay a fee to tie into the system.

The Internet access can be purchased through network service providers around the country. There are several methods for accessing the system, ranging from dialing into a "host" computer to connecting entire corporate networks through high speed leased line circuits. Like everything else in life, you pay for what you get. The bigger systems cost more than the smaller inquiry systems. The more you get, the more the price goes up.

Another example, while not on the Internet per se, is the airline industry, which uses a network similar to a BBS/Internet structure. This example is probably the closest to our industry since airlines like us, are in the transportation business. And like the situation in the rail industry, the commercial airplane fleet is aging, making the need for quick delivery of repair parts critical.

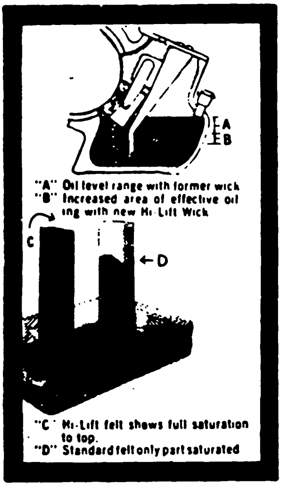
The ILS (Inventory Locator Service) Electronic Market is an inventory locator service with instant accessibility, 24 hours a day, seven days a week. ILS pioneered the electronic market concept in the aviation industry over a decade ago. The company began with just a few subscribers and several hundred thousand parts listed in a data base and grew rapidly. Today thousands of clients access millions of line items with over 45,000 computer transactions each day.

ILS is involved with computer service and does not actually sell the products. It is in the business of letting potential customers know where they can obtain the parts to get their planes off the ground and back into service. By reducing the lead times of critical items, it helps the airlines increase their revenue while reducing the dollars spent on inventory. The benefit to the sellers of the equipment is obvious, since their products can be sold quickly.

The first ILS customers in 1979 were all parts dealers. No carriers were in the original group of subscribers. As time went by most major carriers became involved with the organization. Today 65 domestic carriers and 60 foreign carriers are utilizing the service. These companies range in size from commuter operators to such major carriers as United, American, TWA, Air France and Swissair. Both new and rebuilt parts are displayed in the data base, allowing potential buyers to get a look at not only availability but price comparisons as well. The service costs customers between $450 and $750 per month. More than 10,000 calls per day are handled by the computer.

A similar data base is being built at the present time by Inventory Locator service that includes commercial and naval components. Participants include 10 U.S. naval installations and several private ship yards and repair facilities. The firm is also exploring the possibility of setting up data bases to include locating similar components for off shore oil drilling rigs. In the future components for repairs to nuclear and fossil-fueled power utilities may be placed in the locator system. The potential for expansion in this field is tremendous.

In closing, we feel that regional railroads and short lines will probably have access to the "information superhighway" in the future. This is certainly an alternative that, as time goes by will decrease in cost like all computer related products.



REPORT OF THE COMMITTEE ON NEW DEVELOPMENTS

TUESDAY, SEPTEMBER 20, 1994
9:15 A.M.

Pre-Convention
Presentation
Norfolk Southern

April 28, 1994
Airport Marriott
Roanoke, VA

ROBERT RUNYON, Chairman
Engineer-Loco. Design
Norfolk Southern Corp.
Roanoke, VA

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PERSONAL HISTORY

Robert Runyon

Bob Runyon was born in Williamson, W. VA on June 13, 1939, and resided in Belfry, KY throughout his early years. After graduating from high school, he attended Virginia Polytechnic Institute in Blacksburg, VA., graduating in 1961 with a BS degree in electrical engineering. He continued with post-graduate studies for another year and while on active duty in the Army, earning an MS degree in nuclear science and engineering in 1966.

For five years starting in 1962, Mr. Runyon served in the U.S. Army Artillery, assigned to various positions including a three-year stay in Germany and a year in Pittsburgh, eventually holding the rank of Captain. Upon leaving the Army in 1967, he moved to Roanoke, VA and joined ITT in an engineering capacity.

Mr. Runyon's railroad career began on April 16, 1970, when he joined Norfolk & Western Railway Co. as an assistant engineer in Roanoke, VA, with subsequent promotion to gang foreman in 1972. During most of this time he supervised the design and construction of a SEARCH locomotive test facility, which he operated through the end of 1974, and participated in the design of a fleet of slug locomotives to be used in yard and hump service. After spending a year as assistant foreman supervising one shift at Roanoke Shops, he was transferred to the Locomotive department staff to take on the electrical design phase of a new slug locomotive.

In 1977, Mr. Runyon was promoted to mechanical supervisor, replacing the retiring incumbent, and in 1982 was promoted to his present title of engineer locomotive design. During the years that followed, he has continued with responsibility for various projects to include repowered locomotives and additional slugs, fuel efficiency testing, and the continuing effort to computerize drawings and other records. He is presently active in his church, has served in the International Management Council from 1972, and is licensed to practice engineering in Virginia.

Bob has been married since 1962 and lives in Roanoke with his wife, Nancy. They have two daughters, both married, and one granddaughter.

LMOA wishes to express its thanks to the Norfolk Southern Corporation for hosting the Pre-Convention Presentation in Roanoke, VA.

Our New Developments Committee was well received in what we trust was a mutually beneficial experience.

I. ELECTRONIC FUEL INJECTION SYSTEMS

Presented by Timothy Frederick – Conrail

Electronic fuel injection has finally become a reality in the railroad industry. Once sought by many Class I railroads, electronic fuel injection has been made the standard for locomotive production by both OEM's. Although several mechanical problems have arisen during the initial applications, they have been taken in stride with the hope and expectation that EFI is a better, more reliable system.

Electronic fuel injection systems have smoothed out the operation of the diesel engine. Maintaining speed and changing throttle positions is sharp and crisp, unlike the operation of the mechanical governor and rack linkage. Although originally not a main concern for either the OEM's or the end users, electronic fuel injection has made the biggest contribution to emissions reduction for the rail industry with electronically controlled variable engine timing for NOx reduction and fueling limits for visible smoke reduction.

When we think of electronic fuel injection we think of the applications to automobiles and light trucks in the late 70's and early 80's -- new technology, right? Not quite. The first patent for an electro-magnetic operated fuel injection system was granted to an American, Thomas T. Gaff on April 22, 1913.

HIs patent centered on the idea of having a nozzle with an electro-matic poppet valve for each cylinder position (Fig. 1). The fuel was supplied from a constant pressure accumulator charged from a high pressure pump and regulated by a relief valve (Fig. 2). The timing of each nozzle was set by a distributor governor device utilizing conducting contacts and a hub driven off the crankshaft. As the speed of the engine increased, so did the rate and amount of fuel (Fig. 3).

Today, as with Thomas Gaff's design, the most important part of the electronic fuel injection system is the regulation or engine control. Both EMD with its EMDEC (Electro Motive diesel engine control) and GE have put great emphasis on their control systems (Fig. 4 & 5). That is not to take anything away from the role of the actual fuel injector.

Taking a look at the fuel injector

EMD's electronic fuel injector has remained much the same as the mechanical injector except for not having a rack and pinion and of course no helix on the plunger because of the addition of an electronic poppet valve on top of the injector body. The physical characteristics of fuel delivery and opening pressure have not changed and therefore the engine system has not changed. The engine utilizes the same camshafts, rocker arms, cylinder heads, liners, and pistons.

The engine governor has been eliminated along with the fuel rack and overspeed device. Retrofitability of the EMD system is a small task, which is cost effective when looking at the benefits of reduced maintenance, improved reliability, and lower emissions.

With the EMD unit injector, the pump and nozzle are housed together in the same injector body with no high pressure fuel lines that are exposed. The electronic portion of the injector controls the amount of fuel trapped using the poppet valve, which acts to close off a "spill port" in the injector. The controller activates the poppet valve based on the rotational position of the engine. Timing is determined and controlled electronically through the use of two speed pick-ups looking at timing targets on the flywheel. These signals indicate engine speed and angular position. The poppet valve closes to trap fuel and actually begin the injection of fuel to the cylinder, driven by the mechanical plunger.

Each injector has a "signature", that describes its own characteristics (Fig. 6). Voltage is applied to the coil and the current starts to increase until the plunger starts to move. At that point the current is lowered a small amount and again starts to rise and is modulated until injection ends.

This information can be loaded into the control computer, so that the fuel injector action is "customized" for each cylinder on each engine revolution.

The GE Electronic Fuel Injector system is substantially different from the previous mechanical system which results in changing the engine significantly. First, the pump and nozzle are larger. The nozzle is now 38 mm diameter and its opening pressure is set at 5400 psi. The pump now utilizes a 22mm diameter plunger, increasing the injection pressure to 18,000 psi. The injection system requires a new high pressure crossover line which is directionally positioned with the large bend on the pump side. Timing of the injector requires a special gauge which must be set before the installation of the pump. The injection pump requires a different fuel hose supply and return line. The larger pumps create more heat and need more fuel flow to cool and lubricate. The bottom fuel line is the supply and the top fuel line is the return line.

Due to the increased plunger size of the pump, the camshaft is now 7/16" larger in diameter with a separate stub shaft and bearing. The camshaft bearing is now a trimetal lead bronze design with steel backing material, which is now pressed into place on the block. The bearing is notched for alignment of the oil passages in the main frame; the notch goes at the 6:00 position.

The #8 right and left cam sections are different from the #1 through #7 cam sections and cannot be interchanged. The crosshead guide is shorter to account for the larger camshaft with a wider roller slot. The cam follower roller is wider to distribute the higher pump load over a wider area. The pump pushrod is now shorter.

Since the nozzle is larger in diameter, the cylinder head and cylinder jacket have been changed to account for the larger nozzle. The valve push rods are 2½" shorter on the EFI engine but the crossheads are the same.

EMD Control System

The EMD EMDEC control system has at its core an electronic controller. The "brains" of the system, it is fed all the appropriate information to know how to control the engine as well as how to protect it, by sensors mounted on the engine. The controller uses these sensors to determine how fast the engine is running, where the engine is (in crank angle degrees) at all times, when to fire the injectors, how much fuel is needed to hold speed, and other pertinent information about the engine itself (pressure and temperatures) and the engine environment (ambient temperature, barometric pressure).

Since the controller is microprocessor based, its knowledge of what actions to take is contained in the program in its memory. Herein lies a primary advantage of this type of control system - reprogrammability! Changes in engine timing to improve fuel economy, performance, and/or emissions can be implemented by simply reprogramming the controller. Also, within the confines of the controller's resident program, parameters such as injector timing can be varied in many different ways. For instance, if certain throttle notches operate best with special injection timing, this can be accomplished. Other examples include timing optimization during transients between throttle notches, or for better startability. Some performance parameters are even directly reprogrammable on the locomotive through the use of a hand-held reader, making system interaction much simpler and more versatile than the present mechanical version.

Engine protection now becomes part of the controller function. The controller constantly checks engine temperature, oil temperature and pressure as well as delta water pressure, for out of tolerance conditions, as well as making a separate check for failed senors. A crankcase pressure sensor is expected to be added later.

Some of the protection criteria are available for custom configuration, as either a warning only or to initiate an engine shutdown event.

Engine diagnostics are annunciated from the controller through an RS232 link to an external hand held reader. The system will, in the near future, be linked directly to the main control computer (EM2000), for data and fault logging, retrieval, and diagnostic activity.

GE CPC Controller

The GE CPC solid state controller has eliminated the functions of the engine governor, overspeed governor, rack, linkage, and more than 100 grease fittings. The diesel engine speeds are now controlled by the CPC controller. Feedback for actual engine RPM is via a tachometer that is located on the right side of the diesel engine barring-over gear box. The low oil and low water pressure diaphram function of the governor has been replaced by sensors. The oil pressure sensor and the water pressure sensor are in the same box with the manifold air pressure sensor and the crankcase overpressure sensor located at the start station.

An optical encoder is used for timing the firing order of the diesel engine. The encoder sends signals to the CPC controller by the use of an LED pickup point. For example, to start the locomotive turn on the breakers. The EXC, EIP (engine interface panel), CPC (control and protection card) and SDU (smart drive unit) power up, do a system and communication check and get ready for operation. Activating the start button causes the engine to rotate. The optical encoder provides a signal to the SDU of the engine. The SDU monitors the speed and once the encoder detects motion it looks for the 360 DEG signal. Once the 360 DEG signal is detected the firing sequence begins at right #1 position. Note that due to the mechanical limitations of the pump and nozzle, the pumps will not produce fuel until approximately 70-90 RPM is achieved. At this point the engine will only idle. The EXC takes throttle signals from the control stand and passes them to the EIP for locomotive engine speed control.

Conclusion

Certain advantages exist with the electronic fuel injection system:

1. Improved reliability - fewer moving parts (certain mechanical components have been replaced with electronics).

2. Electronic technology and increased diagnostics (self testing and logging of faults).

3. Retrofitability (for improved fuel economy and emissions).

4. Protection management systems

(controlling the engine in a fail-safe mode, with less need for special action or intervention by the crews.

5. Continuous quality improvement of the EUI system (ability to grow with technology).

Disadvantages of the system are:

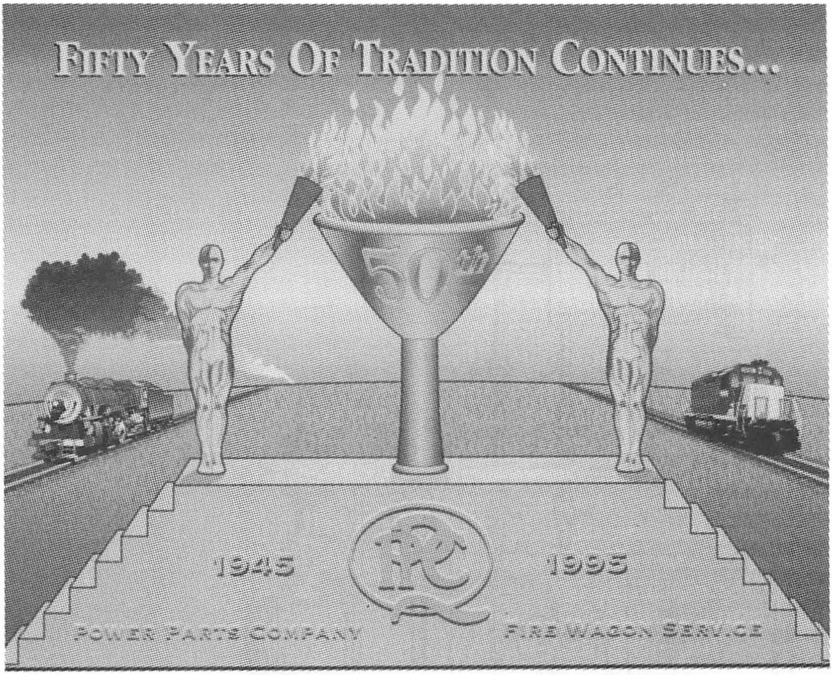
1. An emerging technology for locomotive applications (not fully matured, a need for training, new awareness of technology.

2. Sophistication of equipment has outpaced the standard maintenance procedures.

It is the responsibility of the railroads to acquire this new level of technology. Our mechanics as well as supervisors must become familiar with these new systems. New tools and gauges also must be obtained.

With electronic fuel injection, using alternate fuels is now possible. Conrail requested electronic fuel injection from the OEM's in the late 80's so that they could pursue using methanol, ethanol, LNG, and other alternate fuels. Electronic fuel injection allows the user to vary the timing enough to overcome the knock from various alternate fuels.

Now that the engine control systems have been developed for the present electronic fuel injection systems, both OEM's should consider going away from the jerk pump technology and move towards a common rail fuel delivery system. This would enable the engine to start faster and have reduced emissions in the lower throttle notches. A major limitation of the jerk pump fuel injection system is the limitation of pumping pressure based upon camshaft speed or crosshead lift velocity. The diesel engine has to be rotating fast enough to produce enough pressure to lift the nozzle valve from its seat. At low battery voltage starting is next to impossible. A common rail system would provide the same injection pressure independent of crankshaft speed. Providing higher injection pressures at the lower throttle notches would further reduce smoke or particulate emissions. This would make a good system even better.



For fifty years, Power Parts Company has supplied the railroad industry with quality products and on-time deliveries, known to the industry as "Fire Wagon Service," an axiom inscribed by the late owner and founder, Marty Hausman.

In March of 1945, Marty began the legacy of Power Parts Company and *Fire Wagon Service* with only six gaskets to offer. The persistence to excel led him to become the authorized distributor for a host of fortune 500 manufacturers of a wide variety of locomotive parts and railroad products.

This year marks a golden year of celebration to remember Power Parts and its Sign and Alert Divisions for past accomplishments and to help advance the torch into the future. The loyal employees of Power Parts have served their clientele with pride and *Fire Wagon Service*, which has become a hallmark of the trade.

MK Rail Corporation joins the Power Parts team in its commitment to continue to improve their business relationships by anticipating the future demands of our customers. The Power Parts Company pledges to continue the time honored tradition of providing *Fire Wagon Service* to the railroad industry. *Fire Wagon Service* is the benchmark by which all other suppliers will be measured.

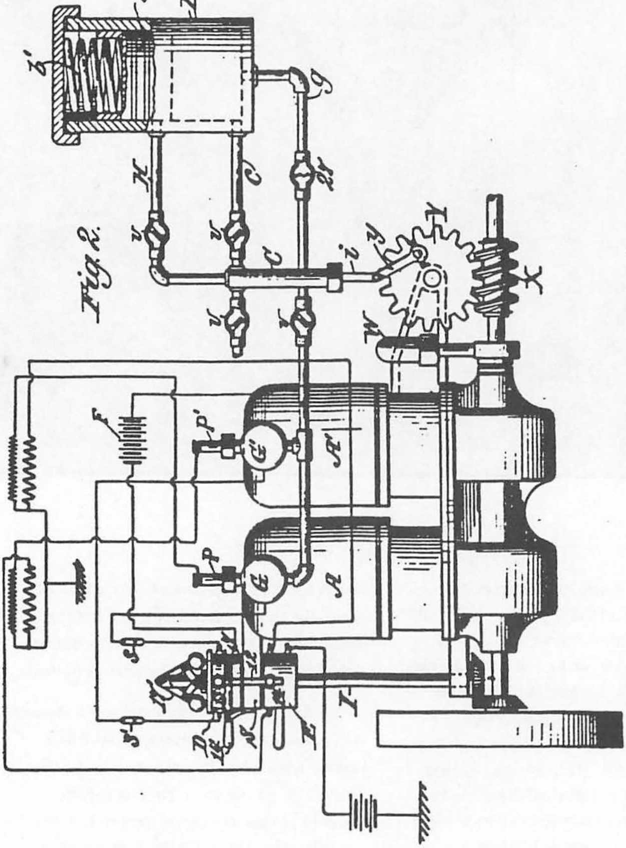
MK RAIL CORPORATION

Power Parts Company • 1860 N. Wilmot • Chicago, IL 60647 • (312) 772-4600 • Fax (312) 772-3299

T. T. GAFF.
EXPLOSION ENGINE.
APPLICATION FILED JAN. 4, 1910.

1,059,604.

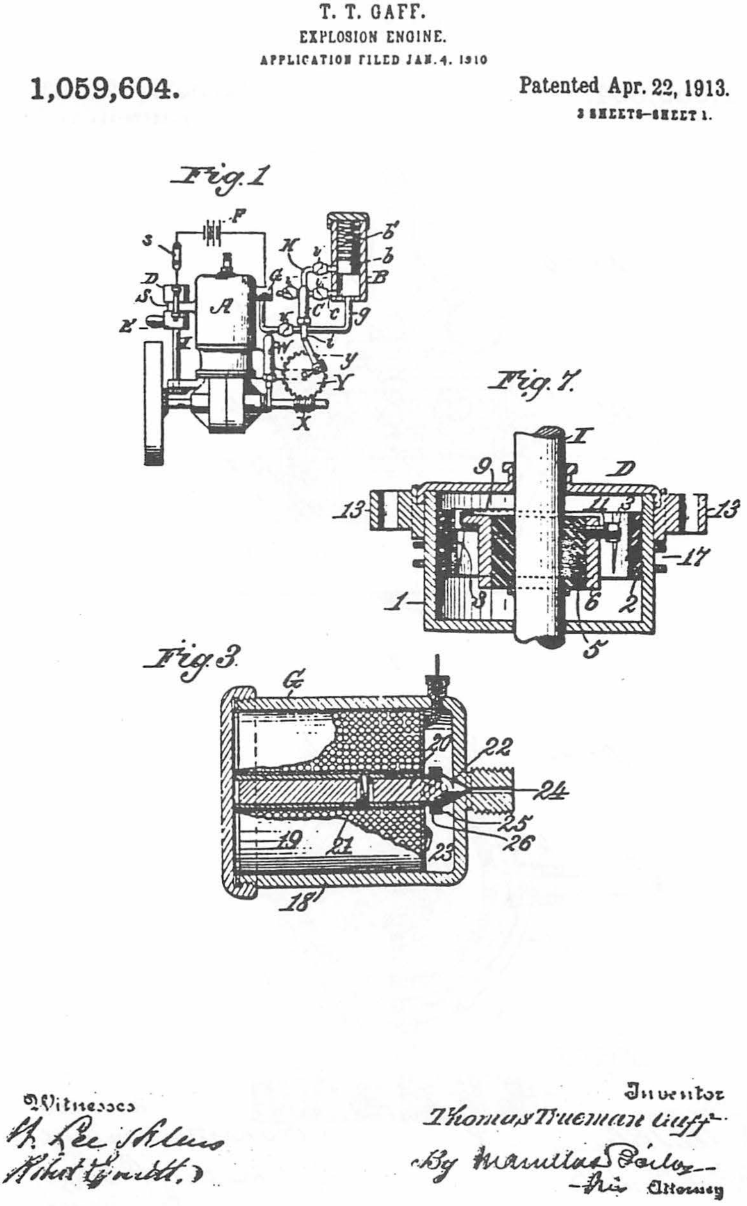
Patented Apr. 22, 1913.
3 SHEETS—SHEET 2.



Witnesses

Inventor
Thomas Trueman Gaff.
By Marcellus Bailey
his Attorney

Fig. 1



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Witnesses
H. Lee Sklew
Robert Gmdtt.

Inventor
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His Attorney

Fig. 2

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Fig. 4.

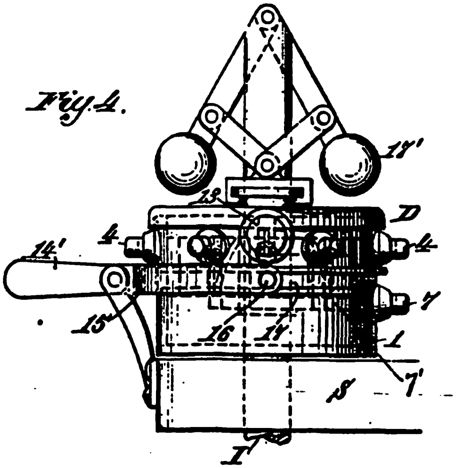


Fig. 5.

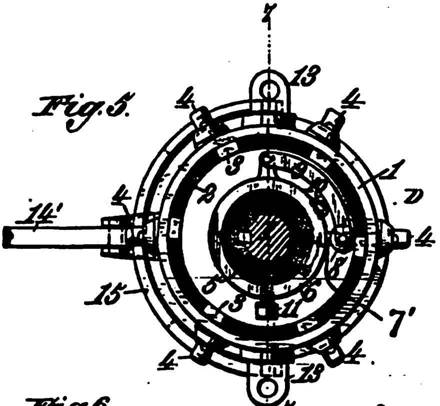
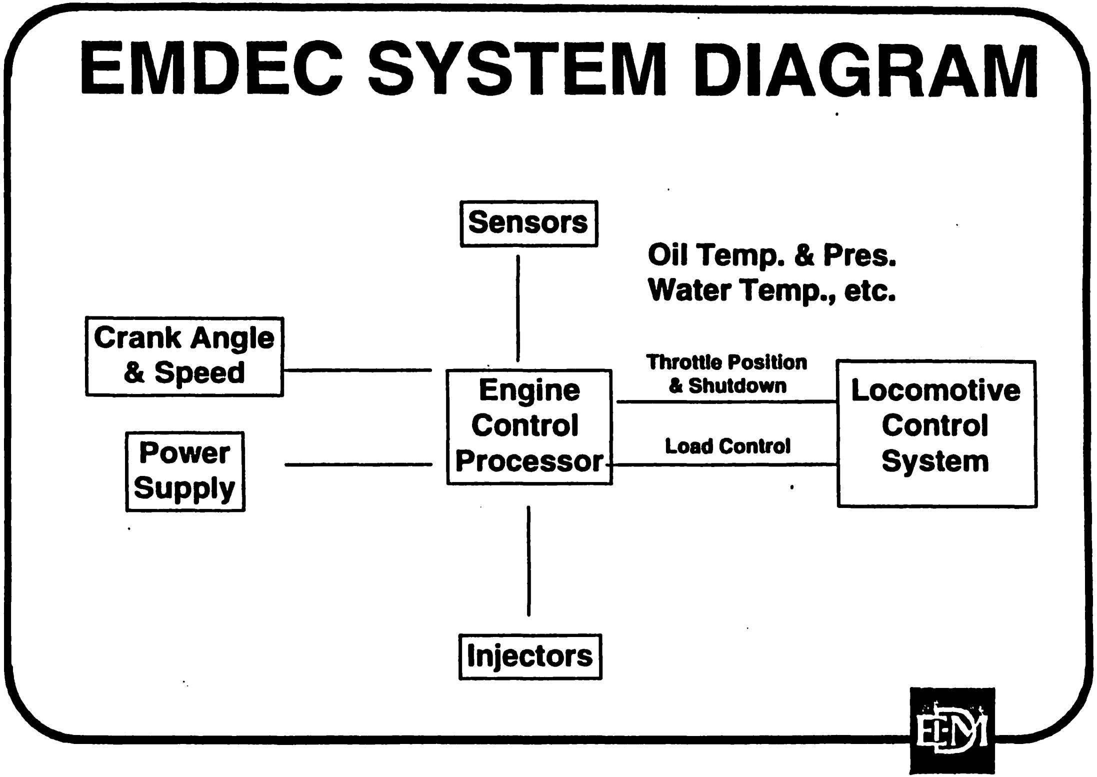


Fig. 6.

Witnesses
H. Lee Ihlen
Robert Everett

Inventor,
Thomas Trueman Gaff.
By Marcellus Bailey
his Attorney

Fig. 3



EMDEC SYSTEM DIAGRAM

Sensors

Oil Temp. & Pres.
Water Temp., etc.

Crank Angle & Speed

Power Supply

Engine Control Processor

Throttle Position & Shutdown

Load Control

Locomotive Control System

Injectors

4.93EMDEC5

ELECTRO-MOTIVE

Fig. 4

Electronic Fuel Injection

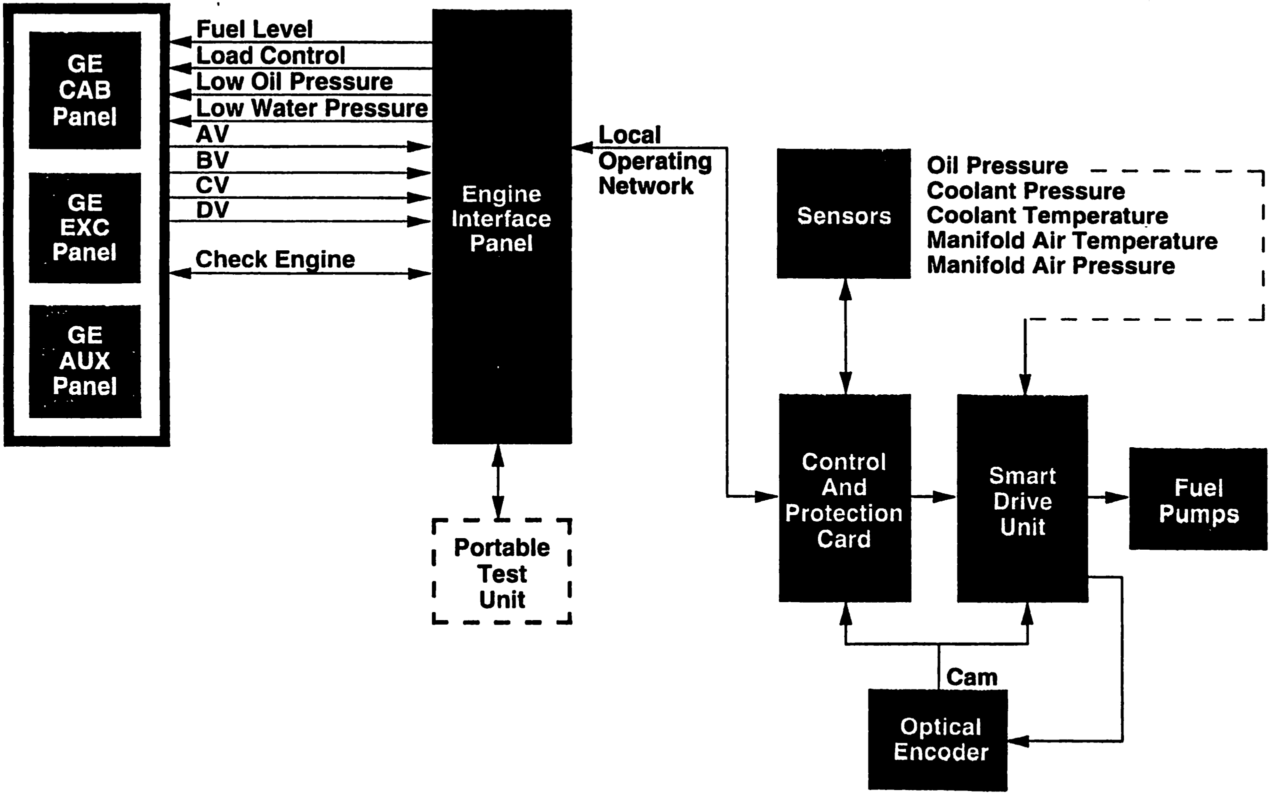


Fig. 5

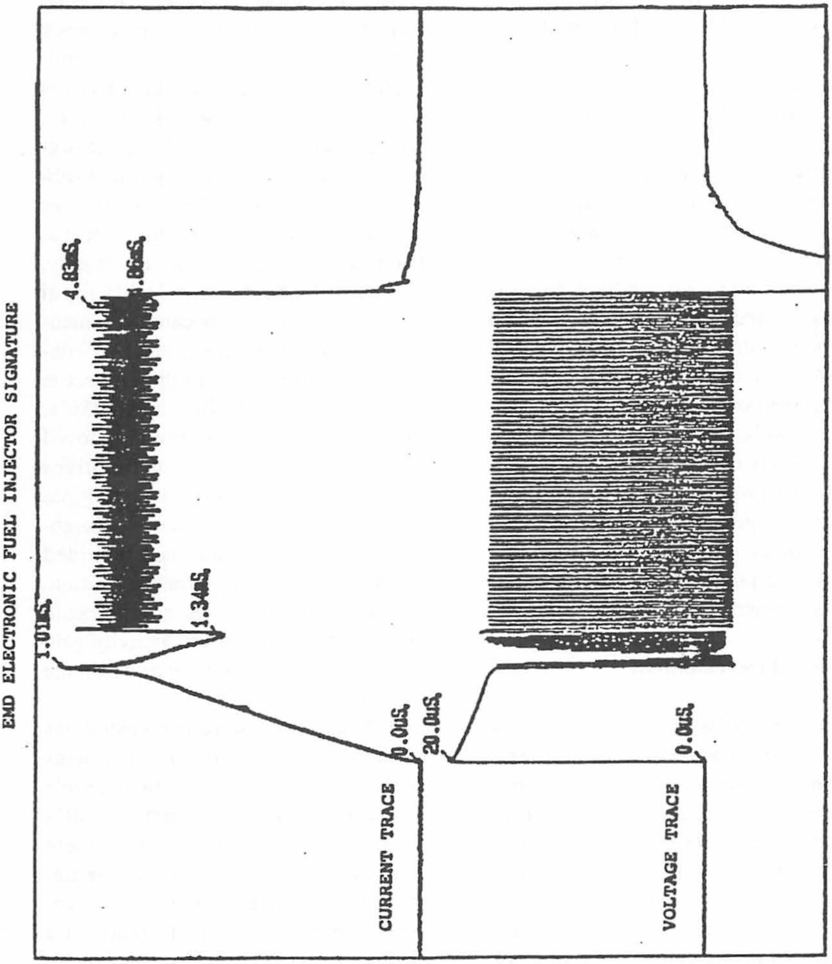

EMD ELECTRONIC FUEL INJECTOR SIGNATURE
1.01mS
4.83mS
4.86mS
1.34mS
0.0uS
20.0uS
0.0uS
CURRENT TRACE
VOLTAGE TRACE

Fig. 6

II. STATUS OF DISTRIBUTED POWER IN FREIGHT TRAINS

Prepared by: J.S. Biln - BC Rail
Presented by: Dave Jabal - BC Rail

Distributed motive power in a train has been a recent development necessitated by the need to operate longer, heavier freight trains. In addition to improved, safer train handling, benefits of distributed power include reduced equipment stresses and hence reduced maintenance costs. A number of multiple remote power concepts commenced in the 1980's, but only two demonstration projects continue to be developed. CP Rail's project involved retrofitting existing equipment for heavy haul applications, while CSX's intermodal distributed power application uses all new equipment.

Historical Development

Conceptually, trains are nothing more than an automated horse and wagon transport system operated on a guideway. For the first 150 years after the invention of the steam locomotive, each increase in capability resulted in larger or more "wagons" coupled together, and larger and more steam "horses" pulling them, over heavier guideways. During the mid 1800's, it became apparent to railroaders that heavier trains require significantly more power to start and more importantly, much more braking to stop. This limited the size of trains until the development of the draft gear and automatic air brakes allowed effective use of "slack" to serially start a train, and safely bring it to a halt. Train capacity continued to increase with larger locomotives and the development of stronger couplers and freight car structures, allowing this power to be applied to trailing tonnages.

As locomotives reached size limitations to safely operate on a given track structure and curvature, the use of multiple steam units was an obvious method of increasing train capacity. These manned units used whistle signals to synchronize operation and subsequently, the use of these locomotives in helper service became the first distributed power application. Eventually, the use of one or more additional manned locomotives became commonplace in North America, and this concept was carried over to diesel-electric units during the 1940's and 1950's. Telecommunications allowed improved coordination of remote locomotives through the voice radio, but multiple unit control of diesel-electric locomotives through the trainlines provided the potential for full synchronization. In addition, remote radio control could provide an additional productivity gain through the elimination of crews on the remote locomotives.

Although there were demonstrations of single remote radio control systems in the late 1950's, Southern Pacific's developments in the early 1960's resulted in a production system (Locotrol 105SS) that was the forerunner of systems in use today. In the mid-1960's, there was a demonstration of a dual remote system conducted by Southern Railway, but developments in distributed power beyond a single remote did not occur until the mid-1980's with the AAR's High Productivity Integral Train (HPIT) program.

Spurred by the industry's need to make significant productivity improvements, the AAR challenged railroads and suppliers to find ways of reducing train operating and maintenance costs by 50%. A number of HPIT projects and studies progressed during the late 1980's, generally revealing that although slack action is crucial for

modern freight train operations, it also has major disadvantages.

CP Rail's HPIT demonstration tests involved retrofitting existing equipment to reduce slack and operate with multiple remotes. The HPIT demonstration included up to six SD 40-2 locomotives, each coupled to a block of 10 cars with slackless couplers, and remotely controlled from the head end via a hardwired communications cable. The train operated with a segmented brake pipe, and the testing verified that the concept was viable with some component improvements.

Benefits of Distributed Power

Distributed power offers productivity improvements in allowing the safe operation of longer, heavier trains. This concept combines the improved power and braking response of short trains with the economics of operating longer trains. Distributed power results in reduced in-train forces and consequently reduced chances of pull aparts, derailments, and lading damage. Reduction or elimination of slack results in less wear on coupling components, lower buff or draft forces applied to the freight car structure, and reduced chances of head end crew injuries caused by slack run-in. Distributed power reduces the draft forces on the cars nearest the head end, resulting in lower wheel flange forces, and consequently reduced wheel/rail wear. In addition, the small/simpler couplers results in reduced tare weight of the car, allowing a corresponding increase in care capacity.

Heavy Haul Retrofit

Subsequent to CP Rail's HPIT testing, the railroad progressed with the next phase of its program that combined distributed power with increased capacity through heavier axle loading. Called the Second Generation Unit Train (SGUT), the program involved development and testing of multiple remote radio control, and axle loading at 66,500 pounds.

The remove control system is Harris' Locotrol III that allows the lead to control up to four remotes. The system is based on the single remote Locotrol II system, and includes a universal lead/remote version, allowing a locomotive to be used in either mode. The SGUT uses a segmented brake pipe of about 30 cars in each block. Freight car modifications include increased truck springs for the 286,000 pound gross weight, and self-steering or frame-braced trucks for reduced rolling resistance and reduced rail and wheel wear. Coupling between the 30 cars is a slackless link bar that is fixed on one end and swivels on the other for rotary unloading. Couplers at the ends of the 30 car block as well as on the locomotives are conventional.

CP's multiple remote testing is completed and the data are being analyzed. Areas of concern regarding financial viability include the segmented brake pipe and the slackless couples. The benefits of these features must be assessed with the drawbacks during loading or unloading. Leaving the power distributed during these processes means that the locomotives are totally captive.

In addition, the units interfere with continuous loading or unloading. Removing the units requires significant logistics before and after the loading and unloading processes. CP Rail has done extensive operational testing and analysis of the SGUT since 1991. In addition to the evaluation of the distributed power/multiple remote concepts, CP has extensively evaluated the impact of heavier axle loading on bridges, track work, and on equipment.

The remote control equipment performed effectively during the testing and CP is ordering additional sets for retrofit. At this time, this equipment is only used in a single remote application at CP.

Subsequently to CP's testing, Union Pacific Railroad is progressing a multiple remote application on bulk commodity trains in the Pacific Northwest. UP has a capacity constraint over the very mountainous and treacherous Blue Mountain region. Currently, a 100-car train is taken up the controlling grade in two pieces, despite using two helper locomotives. UP hopes to use up to three remotes to significantly reduce running time of the train.

Conclusion

Distributed motive power in a heavy haul application is technically feasible but may not be financially viable. The high cost of retrofitting and the impact on loading/unloading have not been fully resolved.

Testing and development are expected to continue at Union Pacific.

III. ADVANCES IN DISTRIBUTED POWER

Prepared by: Jim Hogan - Caterpillar
Presented by: Ben Smith - NJT

The New Developments Committee of the LMOA has twice given information in the form of updates on advances in distributed power. After nearly ten years of development, one of those concepts has completed initial testing at the AAR Transportation Test Center in Pueblo, Colorado. This paper discusses a prototype trainset and points out features which make it unique to the railroad industry.

In 1984, several railroad equipment supply companies and individuals responded to the AAR's request for a new transportation system which would compete with existing highway truck transportation to win more of the business now hauled by trucks in the 300 to 700 mile market.

The AAR asked the industry to start with a clean sheet of paper and come up with concepts to meet the challenge. Unique to the AAR request was that the system did not have to be compatible with existing railroad equipment. The idea was dubbed, "High Productivity Integral Trains" or HPIT. A number of concepts were presented by the supply industry to the AAR. Most did not get off the drawing board either due to lack of engineering soundness or financial support.

Born from the AAR charge, the only concept to make it to the prototype testing stage to date is the "Iron Highway" developed by New York Air Brake. Concept and safety testing was preliminarily completed in late 1993. The soundness and safety of the system has been demonstrated. It is now a matter of finalizing the Iron Highway and beginning production.

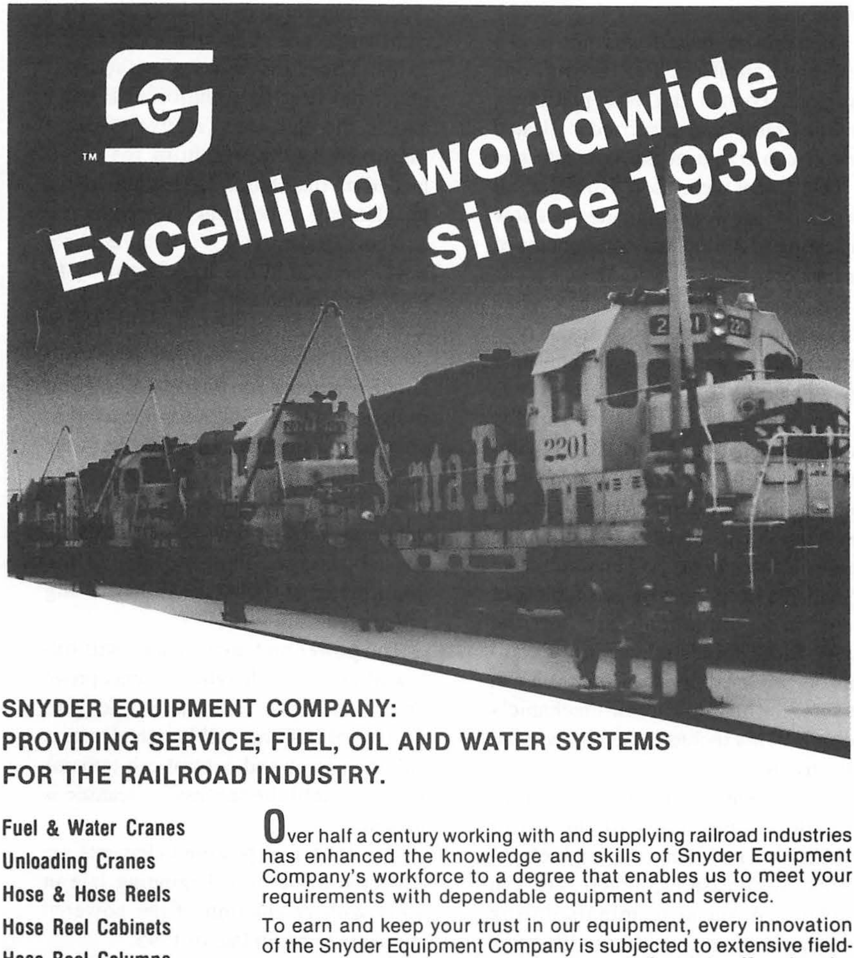
The Iron Highway is designed to haul standard highway truck trailers of any length and type at lower cost then conventional piggyback service and without the requirements of large central terminals and drayage. This is accomplished by using distributed power at each of a 120 ft. long semi-permanently coupled trainset or "element".

The Iron Highway is designed to be used with a minimum of trailer loading support equipment. The train can be loaded or unloaded without special machinery. Trailers can be loaded or unloaded at a simple level grade.

Trailers are loaded on the 28 ft. platforms with trailers mounted over the articulated joint. Loading and unloading can be done by a "split ramp' in the middle of the element. The operator uses an umbilical control to move half the element for loading or unloading. A conventional tractor or yard jockey can drive up onto the elements "circus style" and roll on or roll off trailers. Large forklifts or straddle carriers can also load/unload in major yards.

Trailers can be driven across the articulated joints without special ramps between platforms. The decks of the platforms include pull-up hitches which are arranged to be positioned at any point along the deck by the loading tractor. A shock mounted hook on the back of the tractor drops down to pull the hitch into place. The hook position can be monitored by a small TV camera mounted under the tractor. Using the camera, the operator can see the position of the hook. The camera also is helpful in backing. The tractor then positions the trailer over the hitch, locking it into position.

When the car is released, and the trailer is set, the operator uses the umbilical control to join the two halves of the element. One section rides over the other with both sections lifted into place. A lock-out pin joins the two seg-



Dir SLS
John Byrne

ments and air and electrical connections are completed automatically. A manual latch provides safety backup for the lock pin.

The train as tested was not in the final configuration. For testing, one functional control cab, four platforms, the split ramp and a second ballasted control cab frame at the opposite end of the element were used. However, all major systems were completed to allow for testing of all the key components of the concept.

The truck on the front of the control cab is not powered. Since truck type transmissions are used, you can hear the train shift like a truck.

The trainset picks up speed rapidly. Granted this is only a partial train without the weight on a fully loaded element, but it does demonstrate the rapid acceleration capability. Remember, the Iron Highway is an AC electric drive system. To keep the cost down, most of the train's components are "off the shelf". Since some highway truck components are used, most of the train can be serviced using a truck mechanic's tool box. This includes the engines and drive trains.

To improve availability and minimize downtime, most of the major components including the engine/generators, transmissions, motors, etc. can be changed out at terminals during turnaround. Components are lift-truck serviceable and can be replaced. Repairs can then be done in the shop while the train set is in service.

This Iron Highway was constructed for testing. However, the test control cab is structurally complete with two diesel engines driving AC alternators and all control equipment. The two engines are paralleled and drive truck type automatic transmissions through a right angle gear box which drives the axles. These drive axles are located under the first five platforms at each end of the element. Tractive effort is improved by the weight of the cargo loaded on the platform. This allows for the elements to be lighter in weight.

Knorr Brake, New York Air Brake's developers, sold the Iron Highway to CSX Intermodal. CSXI is now working with potential manufacturers to finish the design work and begin building full length elements for further testing and design worthiness. CSXI is expected to announce a license agreement with the successful company shortly.

Full length elements pulled by conventional motive power will likely be the next stage. This will prove the soundness of 1000 to 1200 ft long articulated train sets.

The power and control cabs will follow after the full length elements prove their worthiness. The timetable for production of both the full length elements and the power and control cab remains in the air until the successful licensee is named.

However, non-powered elements are expected to be built beginning late in 1994 with production of the powered elements to begin late in 1995.

Editors Note: After this paper was given before the LMOA convention in Chicago, it was announced MK Rail was the successful bidder to build the Iron Highway train sets for CSXI.

REPORT OF THE COMMITTEE ON SHOP EQUIPMENT

TUESDAY, SEPTEMBER 20, 1994
10:30 A.M.

Pre-Convention
Presentation
CN / CP

May 26, 1994
LeChateau Champlain
Montreal, PQ
Canada

JOHN CLONTZ, Chairman
Supt.-New Technology Implementation
Burlington Northern
Fort Worth, TX

Vice Chairman
BILL PETERMAN
Mgr-Facilities Engineering
Canadian Pacific
Montreal, PQ

COMMITTEE MEMBERS

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PERSONAL HISTORY

John J. Clontz

Superintendent New Technology Implementation, Burlington Northern Railroad

After attending the University of Maryland and serving in the U.S. Army in Europe, John began his railroad career in 1963 as a apprentice machinist with the Great Northern Railway. He worked as a machinist for the former Great Northern and the Northern Pacific railroads before becoming a supervisor in 1972.

During his tenure with Burlington Northern, John has held various supervisory and middle management positions in the Mechanical/Operating department.

He is currently responsible for implementing the mechanical department's alternative fuel program using liquid methane as the principal fuel in high horsepower locomotive engines, operating in coal service.

John is married. He and his wife Hanna have three children and two grandchildren. He enjoys golfing and fishing during leisure hours and is an avid reader.

LMOA wishes to express its thanks to the Canadian Railroads for hosting and participating in the Pre-Convention Presentation of our Shop Equipment Committee in Montreal.

The attendance and interest exhibited was most gratifiying.

I. ELECTRONIC FUEL / UNIT INJECTION TOOLING

Prepared by: John Clontz - BN
Syed Fuzail - C &NW
Bob Lynch - NS

Over the last decade, electronic engine controls and systems have become the accepted standard in locomotive manufacture, remanufacture, and upgrading of older classes of power.

Caterpillar, EMD, and General Electric have focused on the gains and benefits of electronic fuel injectors / electronic unit injectors and provided the next logical steps for integrating the proven technologies, combining unit injectors and electronic engine controls to form electronically actuated unit injectors. All of the manufacturers have built production EFI / EUI's gaining considerable experience in maintenance procedures and tooling requirements.

This paper will discuss the tooling requirements to support this relatively new technology.

A. Caterpillar

The Caterpillar EUI system consists of three major subsystems: the electronic control module (ECM), the unit injectors and the sensors.

The nucleus of the system is the ECM, which contains state-of-the-art solid state electronics with no parts to wear and no need for adjustment. The ECM serves to gather data from the sensors, interpret the input data, make decisions, and send signals to the injectors through a wiring harness to precisely regulate fuel delivery. To accomplish these tasks, the ECM must act as a data acquisition system, speed and load governor, safety control system, diagnostic display system, etc. The ECM can also be integrated into total locomotive control systems through various optional high speed data links.

The ECM is engine mounted and is completely sealed and is cooled by diesel fuel. No special tooling or procedures are required to handle the ECM and it is serviceable as a unit.

The electronic unit injectors are very similar to the traditional mechanical unit injectors they replace. The major difference is that the rack and pinion system used to control fuel delivery on the mechanical units is replaced with a solenoid operated valve on the electronic units. The electronic injectors respond to control signals from the ECM to deliver the correct amount of fuel at very high pressure at the precise time as determined by the ECM.

The electronic unit injectors are factory calibrated and fit directly into the cylinder heads. No special tooling or procedures are required to handle, install or remove the electronic unit injectors.

The locomotive engine operating environment is very severe and sensor reliability is vital to successful operation. Caterpillar electronic engine controls have evolved over many years of experience in heavy duty diesel applications, some dating back to early 1980's. The result of this long experience is that current Caterpillar sensors are very tough, durable and simple and are easily able to withstand the hostile locomotive operating conditions. Caterpillar sensors do not require any special tooling or maintenance procedures.

Most diagnostic and service tools used on Caterpillar mechanical unit injector (MUI) engines are replaced with a single tool called an electronic control analyzer (ECAP). Through a single cable connection, the ECAP communicates with the ECM to retrieve and display important status information. the ECAP is also used to select engine performance maps, adjust fuel injection timing, power settings, and other engine functions.

The ECAP stores system events and faults such as overspeeds, low oil pressures, sensor faults, open or short circuits, etc. These events can be quickly recalled on the ECAP screen for easy troubleshooting and repair. ECAP can also function as an engine monitor to display engine speed, load, pressures, temperatures, fuel flow, etc.

The only mechanical engine adjustment required for the EUI system is an adjustment for the baseline injector plunger position. Tooling for this procedure consists of a dial injector and gauge block. The same tooling is used for 3500 series and 3600 series engines.

In summary, maintenance and service tool requirements for Caterpillar EUI engines are very simple. The tooling required to adjust the electronic tool unit injector baseline position is identical to the existing tooling used to set the timing of a mechanical unit injector. In addition, as with Caterpillar MUI engines, no special tooling is required to install or remove the injectors. The only new tooling required for the EUI is an ECAP tool that allows communications with the ECM. All adjustments and diagnostic information are handled by the ECAP interface. As field experience with EUI grows, Caterpillar will continue to work with railroads to optimize the maintenance and tooling requirements for Caterpillar locomotive engines.

B. Electro-Motive

The following portion of this paper discusses the EMD/GM electronic unit injection EUI. The production 710GB engine is equipped with EUI and is being delivered to Burlington Northern Railroad with its SD 70MAC order currently being produced. With a quick glance, one will note the absence of the governor, governor drive assembly, overspeed trip mechanism, lay shaft and linkage. The tooling required to maintain this advanced electronic unit injection system is greatly reduced. The governor injection link setting jack (rack jack), rack setting indication gauge, injector timing gauge and injector pop test lever are no longer required.

The EMD EUI is comprised of three major subsystems. The first is the EMDEC (Electro-Motive diesel engine control). Two EMDEC modules are required per 16 cylinder cylinder engine. Each one controls a different side of the engine. They are the heart of the system and control all fuel injection parameters.

The second major component of the system is the electronic unit injector. It is based on the mechanical unit injector traditionally used by EMD. With the EMDEC there is no longer a need to set injector timing and fuel rack since this is now controlled by the EMDEC. A solenoid operated control valve now performs the timing and metering events of the injection process. This system is completely retro-fittable to existing engine application.

The third major subsystem is comprised of sensors that monitor the following parameters: oil temperature, oil pressure, fuel temperature, fuel pressure, air box pressure, water pump pressure, and engine RPM. These are used by the EMDEC to control the fuel injection process and protect the engine. A fault/engine protection panel is mounted at the AC cabinet near the engine start switch. It displays engine shutdown faults until reset, such as hot oil, low oil pressure, low coolant pressure, or crankcase pressure. It requires toggle of a reset switch after fault shutdown. The reset switch will also perform bulb checks on the panel. The fault code switch will allow codes to blink on the stop engine and check engine bulbs, only when engine is stopped or in idle.

The fault code switch will allow engine protection override when toggled if the engine is running and an engine protection fault occurs, other than a crankcase pressure fault. The run/stop switch will shutdown the EMDEC. When down (closed) it allows cranking of the engine without firing of the fuel injectors. The system also has the capability of using a prolink reader to access all EMDEC sensor parameters, inputs, and outputs engine RPM, throttle request input, fuel pulse width (rack), percent of engine power/load, 24 V power supply volts, oil temperature, oil pressure, coolant pressure, crankcase pressure, air box pressure, fuel pressure, and fuel temperature. It will also display injector control feedback and engine diagnostic codes both active and inactive.

The EMDEC will aid the craftsman when troubleshooting engine problems. Individual cylinders can be cut out to determine if a weak or non-firing cylinder exists. The engine computer can automatically perform this function and report suspect cylinders with the push of a button. Low horsepower and smoking problems can be isolated within minutes instead of hours. Electronic unit injection offers computer diagnostics not available on mechanical fuel injection engines. The onboard engine computer will store faults recorded during the road operation similar to the central locomotive computer on existing microprocessor controlled locomotives. This information is accessed through the use of a handheld reader. The EMDEC system has been designed for retrofitability and flexibility. The ability to install EUI's system has been designed for retrofitibility and flexibility. The ability to install EUI's in existing cylinder heads impacts retrofit economics significantly. The microprocessor controlled fuel injection system offers unprecedented flexibility. For example, if the horsepower rating of the engine is modified, there is no longer a need to remove and rebalance a governor. A simple software upgrade will accomplish a horsepower and/or engine speed modification.

The last portion of this paper addresses the General Electric EFI system configuration. The latest GE diesel engine built is equipped with electronic fuel injection. The GE EFI system went into production in late 1993, and as of September 1994 there are over 350 locomotives in operation in North America. Some of the major benefits of EFI are: fuel economy, improved emissions, reduced maintenance, improved reliability, and improved diagnostics. These benefits are attainable through electronically controlled variable engine timing and the reduction of mechanical parts. With the GE EFI system there are component changes which require special tooling. Let's review the tooling required to maintain the system.

The former camshaft split bearing has been replaced with the sleeve bearing. The sleeve bearing must be frozen and then pressed in place. The operator uses the installation tool, a hydraulic ram with special ends (T55960), to apply the bearing. This tool is also used for the removal of the bearing bushing. Alignment can be noted by the camshaft bore oil feed hole. The operator aligns the oil hole in the sleeved bearing with the oil hole in the main bearing.

The EFI engine is also equipped with larger camshaft segments, which requires eight bolts versus the four threaded dowels and locknuts. As in the past, the 7FDL engine camshafts are changed out individually in the engine. The **camshaft segment filter** (T55991) is used to assist in raising and lowering the camshaft segments into the main frame. The operator installs half the tool into the window of the main frame. The operator uses the lifter tool to remove the camshaft segment. The operator uses the lifter tool again to apply the camshaft. The upper bridge portion of the lifter tool is installed to give leverage to lift the camshaft. The lifter tool is designed to rotate the camshaft into position inside the diesel engine.

With the larger camshaft the torque values are higher. A **torque wrench** (T5440EFI) is used for assembling the camshaft segments to the camshaft journals. The operator uses the torque wrench and adapter on the EFI camshaft bolts.

The 7FDL requires the crosshead rollers to be held in place during removal and installation of the camshaft segment. The **retaining plate tool** (T57150) is installed and positioned on the crosshead guides and rollers.

The current optical encoder requires a two piece **alignment tool** (T57930). The alignment tool allows the operator to line up the optical encoder assembly. The "dog bone" drive-link on the left bank camshaft gear is aligned with the optical encoder. The alignment tool is applied to the aft end of the diesel engine. The bolts are secured after final adjustment. The alignment tool is then removed.

The optical encoder which is used for timing the firing order of the GE diesel engine must be initialized. The **initialization kit** (T56061) is used to initiate the encoder in the proper sequence. The tool is placed in series with the optical encoder communication lines. The engine is barred over at the zero degree mark. The light emitting devices on the encoder indicate proper initialization. Both lights must extinguish for proper initialization. The lights will stay off at the zero degree mark.

The fuel pump timing is different for the EFI equipped 7DFL. The push rod height adjustment is set with the use of an **adjustment gauge** (T55970). The tool is used to adjust the fuel pump push rod height. The gauge is first tested by using a master block to indicate zero. With the high pressure fuel pump removed, the gauge is secured by torquing to the power assembly jacket.

The tappet nuts are adjusted to zero the gauge. This special **torque wrench** (T56050) applies the required 200 foot pounds of torque. The EFI 7DFL tappet rod umbrella and adjustment nuts use two 1-1/8" open end wrenches. The inside threads increased from 3/4" to 5/8". The view at the lower part of the cylinder jacket shows the two fuel pump umbrella nuts and adjustment nuts.

The **tappet rod holder** (T56030) secures the rod while torquing the umbrella nut. The tappet rod holder is applied. The operator can then properly torque the fuel pump push rod without affecting the gauge setting.

The **fuel pump torque wrench** (T14974) is another tool that allows for better mounting on the high pressure fuel pump. The operator can then properly torque the mounting bolts to the proper pre-set value between 83 and 93 foot pounds.

The **fuel oil injector pump banjo wrench** (147X2313) is also used on the EFI equipped 7DFL diesel engine. This open end torque wrench allows the operator the torquing effort of 125-130 foot pounds.

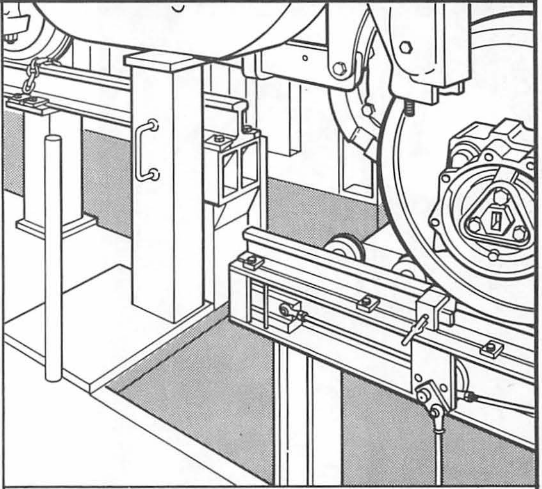
The **torque wrench for the flexible**

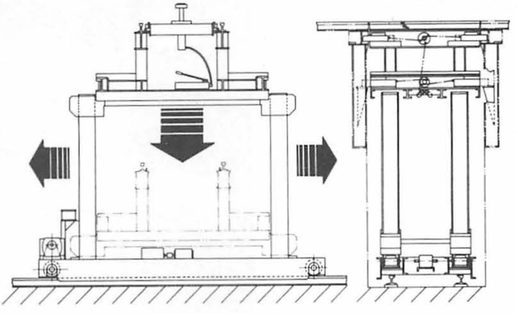
hose connections (T57140) is also open ended. The operator can properly torque these important fittings between 70 and 75 foot pounds.

The high pressure fuel pump solenoids require the only metric tool on the EFI equipped 7FDL diesel engine. The **seven millimeter nut driver** (T57160) is used to secure the Nylok nuts on the fuel pump solenoids. The tool is inserted into the housing on the left side of the high pressure fuel pump. The nuts can be applied or removed using this tool.

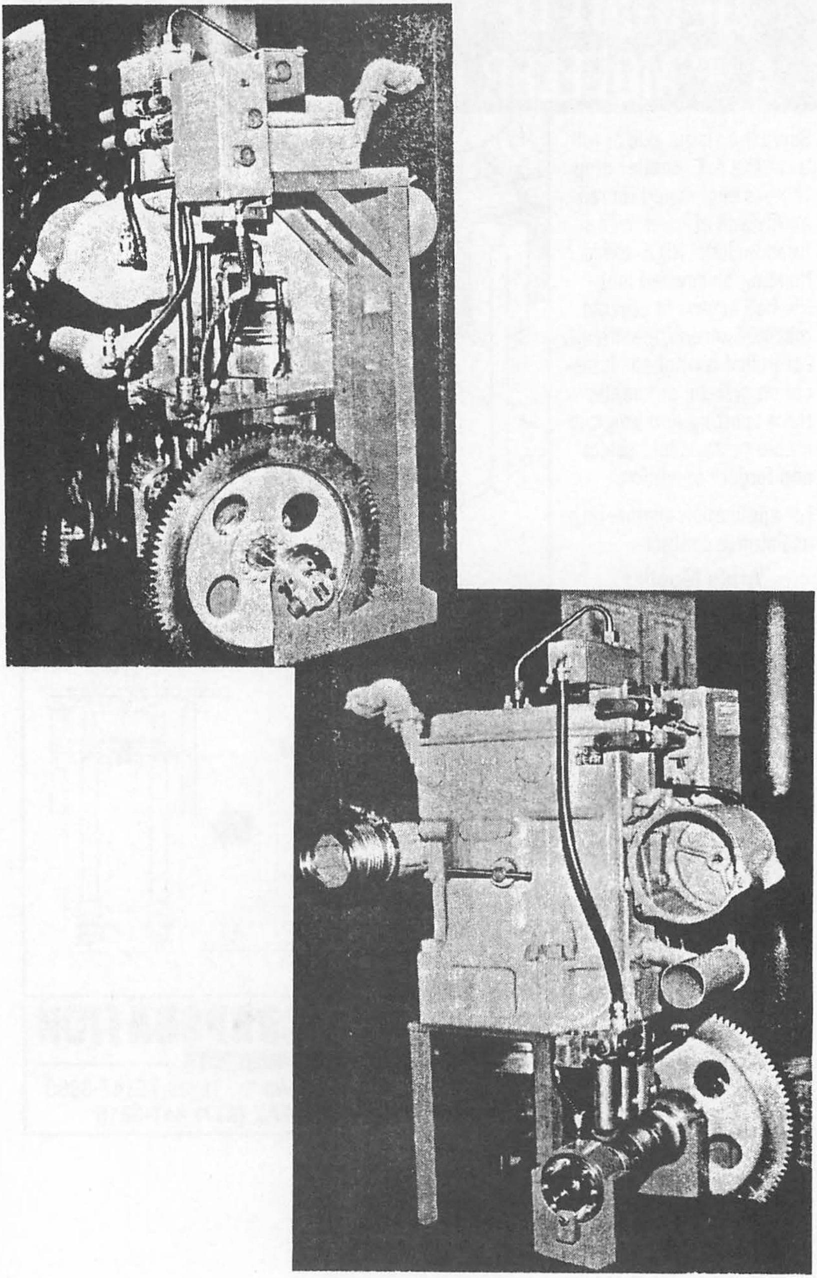
With the EFI Fuel System chart you can see the similarities with the standard 7FDL system. The major differences are in the fuel supply and return lines as opposed to a single supply line.

While this is only a brief overview of the EFI tooling, more information can be found in the GE publications. The particular publications for EFI maintenance are Service Maintenance Instruction number 90015 and number 90025. Also the Service Publication number GEK 76465A can be referred to.

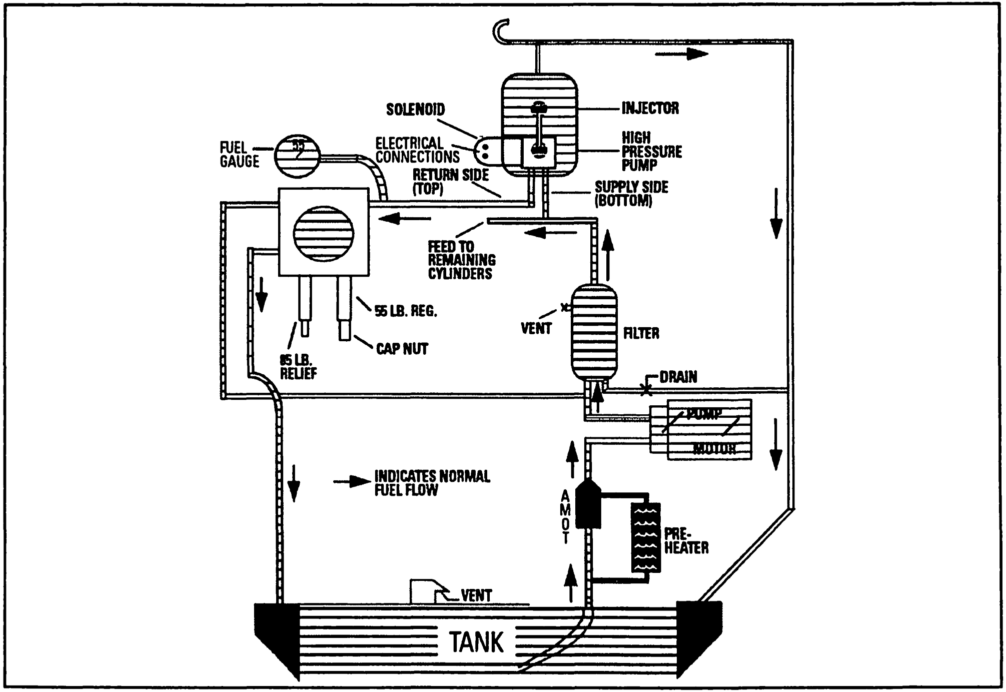




EFI CUTAWAY



GE
EFI FUEL SYSTEM



GE ELECTRONIC FUEL INJECTION TOOLS

T55960	Cam Bearing Bushing Installation/Removal Tool
T55991	Camshaft Segment Lifter
T54440EFI	Camshaft Section Bolt Torque Adapter
T57150	Fuel Roller Retaining Plate
T57930	Encoder Alignment Tool
T56061	Encoder Initialization Tool
T55970	Pushrod Height Adjustment Gauge
T56050	Tappet Nut Umbrella Nut Torque Wrench Kit
T56030	Tappet Rod Holder
T14974	Fuel Pump Bolt Torque Wrench (1/2" Straight)
147X2313	Fuel Pump Banjo Fitting Wrench
T57140	Open End Torque Adapter (Fuel Jumper)
T57160	7MM Nut Runner

II. LOCOMOTIVE ROLLER SUPPORT BEARING TOOLING

Prepared by: Mike Scaringe - Amtrak
Darlene Kisko - GE

The single biggest advance in traction motor support bearings over the last decade is the rolling element suspension bearing. There are currently two OEM's manufacturing roller support bearing wheel sets. EMD currently manufactures two BTR types of roller support bearings for both AC and DC traction motors. GE currently manufacturers its U-tube assembly for both AC and DC traction motors.

Several railroads in North America currently use roller support bearing wheel sets: Amtrak, Contrail, CSX, CN, BC Rail, Southern Pacific, Santa Fe, Burlington Northern, Chicago & Northwestern, CP Rail, Norfolk Southern and Union Pacific. Two of the locomotives currently equipped with roller support bearing wheel sets are the EMD. SD 70 Mac Locomotives and the GE AMD 103 Locomotive currently being used by Amtrak.

Before we discuss the special tools used for BTR and U-tube assembly, let's look briefly at some of the differences between the sleeve friction bearing and the rolling element suspension bearing design. The rolling element suspension bearings are encased in a bearing housing commonly referred to as a BTR (B motor tapered roller bearing) or a U-tube. The traction motor which clamps on to this assembly can be replaced without affecting the bearing assembly or adjustment. Since the bearings are enclosed in this assembly, they are protected from dirt and water even when the motor is removed. However, it is recommended that wheel sets be covered when transporting.

The difference between the roller bearing and the sleeve friction bearing is significant. The sleeve friction bearing is a simplistic design. It occupies the least volume, requires periodic inspection of oil reservoir and wick, has critical axle finish requirements, and is more susceptible to contamination. In contrast, the rolling element bearing has a higher initial material cost. It eliminates wicks which require periodic cleaning, replacement, and disposal; eliminates the need for critical axle finish; and is less susceptible to environmental contamination (i.e. water and dirt in the oil and on the wicks).

Since the introduction of rolling element suspension bearings many railroads are looking at re-tooling their wheel and axle shops in order to tear down and rebuild the U-tube and BTR housings. A list of special tooling has been prepared by both OEM's to facilitate this process. EMD's tooling required for build-up of BTR housings and wheel sets includes the following: wheel mounting and demounting press, torque wrench, grease gun, magnetic base indicator, OTC porter power and fixture, feeler gauges, oven or induction heater, freezer, pry bar, rubber mallet, mild steel drift, commutator end lifting lug, build up stand and turning device or pit, housing turnover device, bearing housing lifting device, and turning restraint. GE's tooling required for build-up of U-tube housings and wheel sets includes the following: wheel mounting and demounting press, torque wrench, grease gun, magnetic base indicator, OTC porter power and fixture, feeler gauges, oven or induction heater, freezer, rubber mallet, mild steel drift, vertical lateral set fixture, pit, axle lifter assembly, U-tube lifter assembly, and lateral checking fixture.

Now, let us go through the complete

tear-down and build-up process for both the BTR and U-tube assemblies and point out the application of the special tools that are necessary. Before transporting, it is essential that all U-tube and BTR assemblies be wrapped in plastic and covered when transporting to and from field locations and the rebuild shop. U-tubes and BTR assemblies are pre-inspected during the inbound process to determine the status of the wheel set. It is recommended by both OEM's to change the roller suspension bearings during the second wheel change-out after initial build-up, damage or worn bull gear and/or derailment. BTR and U-tube wheel sets are installed in the demounting press where wheels are removed.

BTR and U-tube assemblies are hoisted with the end of axle lifting fixture and lowered into build-up pits where the disassembly of BTR or U-tubes begins. To remove the BTR housing from the axle, install porter power with lifting fixture and attach fixture to the housing for ease of removal from the axle.

To remove the U-tube assembly from the axle, a similar procedure is followed. Attach lifting fixture to assembly and hoist U-tube from axle. After housings have been removed from the axle, the BTR and the U-tube housings are placed on a wash fixture. The fixture will then be placed in a flow-through Proceco washer to clean the housings before the build-up procedure starts. The axle with bull gear is then cleaned, inspected, and requalified. A requalified U-tube axle or new axle and bull gear are then lowered into a build-up pit where the assembly process begins. If a build-up platform is available, a requalified BTR axle or new axle and bull gear are then lowered onto the build-up platform into the turning device where they are then set in the vertical position where the assembly process begins. To start the assembly process, an oven or induction heater will be needed to heat the inner races and roller assembly to temperatures above 220 degrees F over ambient temperature, for both U-tubes and BTR's. On BTR's, fill the pinion end inner race and roller assembly with grease. Use a grease gun with a small tip to completely fill the cavities between the rollers so that the grease will extrude between the lip of the cage and the race rib at the small end of the bearing and between the rollers and the cage. On U-tubes, the grease will be added after the assembly process. The heated pinion end bearing inner race and roller assembly are placed over the upper end of the axle and seated against the gear hub. When the race has cooled, ensure it is seated firmly against the gear hub by driving it with a mild steel drift and hammer. U-tubes and BTR housings can be assembled on the floor, or the BTR housing can be placed in the turnover bearing housing fixture. The fixture allows for the installation of two bearing housings. BTR and U-Tube housing outer races will now be placed in a freezer. The temperature must be -25 degrees F to enable the outer races to be shrunk for placement in the housings. Check for seating with a 0.025 mm (0.001") feeler gauge between the thick end of the bearing race and the bottom of the bearing housing bore. The 0.001" feeler gauge should not be able to be inserted between the race the the housing.

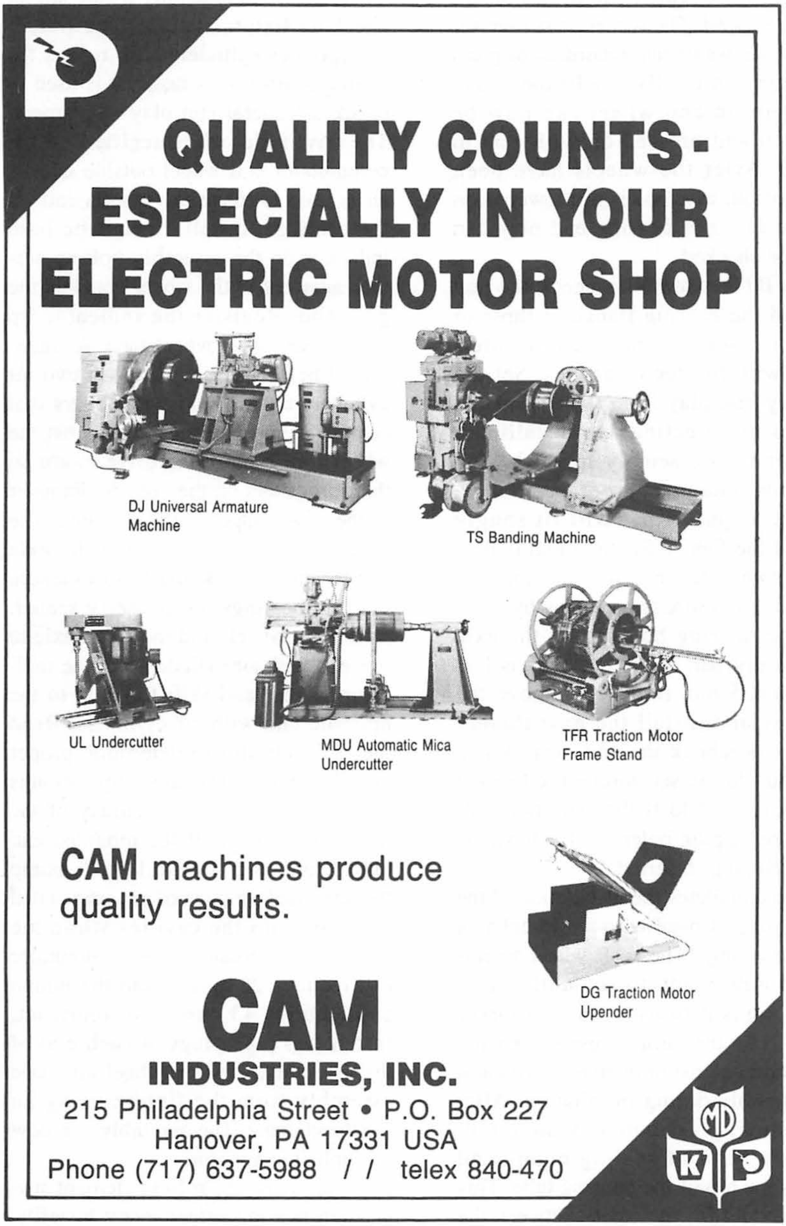
On BTR assembles fill the lower portion of the pinion end grease cavity in the bearing housing with grease in a 360-degree arc. The turnover bearing housing device can be used to rotate the BTR housing both vertical and horizontally to enable build-up of commutator end of housing, or both U-tubes and BTR housings can be rotated and assembled on the ground. Spacers are positioned on the commutator end of both BTR and U-tube housings. Commutator end outer races are placed in the freezer and are shrunk to -25 degrees F and placed in bores of both BTR housings and U-tube housings. Seat the bearing outer race flange against the spacers with a mild steel drift or a plastic coated mallet. The spacers must be tight against the outer race flange.

The housings are now ready to be hoisted and lowered over the end of the axle. On BTR housings, attach the axle housing lifting device to the commutator end of the bearing housing. Lift up the bearing housing with the pinion end down and lower over the axle until the housing rests on the pinion end bearing. Position the housing so that the drain is at the 6 o'clock position of the housing. Rotate the bearing housing to ensure there is no binding or rubbing. Torque the eight bolts to 100 ft-lbs. At this time, heat the commutator end inner race and roller assembly, place the commutator end bearing inner race and roller assembly over the axle, and seat into place against the commutator end outer race. Oscillate the bearing housing while seating the bearing.

The bearing is sufficiently seated when all rollers rotate and resistance to oscillation becomes noticeable. Place the bearing cap over the axle and engage with the commutator end bearing flange outer diameter. Position the drain hole in the bearing cap downward or in the 6 o'clock position. Secure with at least four bolts finger tight. Remove the assembly from the assembly stand and move the wheel press, and position for wheel application. Do not pick up the assembly by the bearing housing without the 3.3 mm (0.130") spacers in place. Also, leave the bolts engaged with the commutator end bearing cap to keep the cap in position preventing dislocation of the O-ring. Remove spacers at the wheel press.

On U-tube housings, assemble the U-tube lifter assembly on the commutator end of the axle and slowly lower it down until the housing rests 0.5 in. from the pinion end bearing cap, hand start the nine bolts and then torque to 76-85 ft-lbs. Rotate the U-tube to assure proper bearing roller positioning and remove U-tube lifter assembly. Heat the commutator end bearing cone assembly and install on axle, large end up, with the taper towards the center of axle. Assemble the U-tube mouting holes. Set a magnetic base dial indicator on the U-tube mouting bolt surface with the stem of the indicator set to zero against the gear face. Apply air to the vertical lateral set fixture to ensure the bearing end play is between 0 to 0.001 inches, and the bearing cone must be between 0 to 0.002 inches. Heat the commutator end collar and place it over the end of the axle and let it cool. Install the commutator end bearing cap, install the five bolts and torque to 76-85 ft-lbs. At this time, both BTR and U-tube assemblies are ready to be moved to the wheel press. BTR, U-tube, or standard axles are automatically loaded in position and raised into the wheel press. Wheels are automatically loaded and aligned on the end of the axle. Selection can now be made for the wheel press set-up on the monitor screen by touching the screen. Set the electronic probe in place and adjust the probe to measure the relative movement between the commutator end outer race and the bearing housing end play, and spike pressure for pressing on the wheels.

Pressing can now begin for commutator end wheel. On U-tube assemblies, it is very critical that wheels be pressed on the axle at 110 to 155 tons, with an additional five to 10 ton spike to assure



that the commutator end collar and the commutator end bearing cone are solidly seated. The wheel press monitor screen shows typical recording of press tonnage and the five to 10 ton spike. The pinion end wheel can now be aligned and pressed on with seal in place. After the wheels have been pressed on, assemblies are lowered on to the cart and bearing end play can now be checked.

On BTR assemblies check the gap behind the bearing flange in three or four locations around the circumference with the feeler gauges. Set the bearing end play from 0.001 to 0.005 inches by selecting and installing a thinner final assembly spacer behind the commutator end bearing flange. Select a spacer that will fit snugly behind the flange. Set up a dial indicator between the bearing housing and the gear. Measure the end play by moving the bearing housing on the axle with a pry bar. If the end play is less than 0.025 mm (0.001"), remove the spacers and install the next thinner spacer. Recheck the end play. When the end play is set, torque the bearing cap bolts to 100 ft-lbs. The two 3/8-inch grease plug holes need to have the 3/8-inch plugs inserted.

This completes the installation of the roller support bearing to the wheel axle gear assembly. The BTR wheel assembly is now ready for mounting to a roller support bearing traction motor frame. Use the turning restraint fixture to ensure against unintentional rotation of assembly during installation. After the housing assembly is mounted, apply a bead of sealing compound across the top of the housing tube. This bead should fill the cavity between the top of the housing tube and underside of the motor upper mouting rail lip. The bead should extend completely from end to end of the mounting rail.

Following the pressing of the wheels onto a U-tube assembly, move the wheel and axle assembly to the lateral checking fixture station. This fixture incorporates cylinders with rollers for resting against the wheels; it is used to check the lateral end play adjustment. The drive roller which registers on the commutator end wheel outside diameter is used to rotate the wheels and set the bearings. Install a magnetic base indicator on the assembly bolting surface adjacent to the wheel opposite the gear end. Register the indicator lip against the inside wheel face. As mentioned before, this fixture has two air cylinders at each end with rollers that can be actuated to register against the wheel rim, Engage the drive motor so that it registers on the outside diameter of the wheel opposite the gear end. The wheels are then rotated and the axle can be shifted back and forth to assure that the bearings are properly seated. Rotate the wheels and move the axle to one end with air cylinders; set the indicator to zero and shift the axle to the opposite end with air cylinders. Read the dial indicator to determine proper lateral end play. The above operation is repeated to verify the accuracy of the indicator readings. If the mounted end play setting is 0.002" to 0.007", pump the specified amount of recommended lubricant into the cavities while the axle is being rotated. The commutator end requires 26 ounces and the pinion end requires 43 ounces of lubricant. Install two pipe plugs at each end of the assembly. Lift the wheel and axle assembly from the fixture using an overhead crane. The assembly can now be applied in a motor.

In summary, the rolling element suspension bearing offers many benefits, including: easy motor removal from the axle, reduced maintenance, increased axle support bearing life, electrically same, an oil-filled gear case, and a combo assembly which is interchangeable with the friction sleeve bearing design. In addition, the special tooling that is required for the build-up of BTR and U-tube housings and wheelsets are: wheel demounting and mouting press, OTC porter power and fixture, build-up platform or pit, commutator end lifting lug, grease gun, mild steel drift, rubber mallet, pry bar, turnover device and housing lifting bracket, torque wrench, magnetic base indicator, feeler gauges, oven or induction heater, freezer, turning restraint, vertical/lateral set fixture, axle lifter assembly, U-tube lifter assembly, and lateral checking fixture.

III. FALL PROTECTION AND MANLIFTS

Presented by: Joe Muench –
CSX Transportation

The nature of locomotive and car repair today is such that employees must work from elevations to make necessary repairs or inspections. These activities may occur in a repair shop, a service center or on a repair track. As elevated tasks are an integral part of the job, there exists the potential for injuries due to falls from elevation. How then do we protect our employees from falls?

The intent of fall protection is to limit or prevent injuries associated with elevated falls. It may be defined as measures taken to control or reduce the risk of injuries while accessing work or performing tasks at heights. History shows that those employees who are regularly exposed to fall hazards incur a serious or fatal injury every two to three years.

Evidence indicates that there is a low awareness of the potential severity of injuries or of the existence of fall control measures. The low frequency of elevated falls has contributed to complacency. Warnings which clearly depict fall hazards are effective and provide the first line of awareness to those exposed to fall potentials. Experts project that 20% to 50% of falls could be prevented, just by raising awareness levels. Signs, posters, hard hat stickers and informational pamphlets are some of the available means to communicate fall hazards.

Elevated falls produce more severe injuries than slips and trips at the same level with injuries generally proportional to elevation and free fall distance. We, as maintenance officers, must take measures to minimize fall potential for employees. Fall hazards should be analyzed and steps taken to accommodate elevated work and limit the possibility of injury. The various types of fall protection products must be known and those most suitable for the work place deployed.

Fall protection methods include the use of scaffolds, platforms, baskets or nets to minimize the fall distance to the surface as well as the use of personal fall protection equipment attached to suitable anchorage. An effective fall protection system should provide continuous and complete protection without interfering with required task mobility, including moving to and from the task site. Therefore, climb and tie off - untie and move types of protection overlook the fact that moving often represents a major portion of the workers activities.

One large Western railroad has equipped some of its locomotive servicing centers with fall protection systems that utilize horizontal lifelines running above and parallel to locomotives being serviced. This system employs retractable vertical lifelines, shock absorbers and full body harnesses to protect workers from falls from the tops of locomotives. As the worker climbs, the cable retracts. In case of a slip, the sudden downward movement locks the cable, arresting the fall after only a few inches. Shock absorbers allow dissipation of energy by extending the deceleration distance. This is an example of a passive system, one that comes into service should a fall take place.

A well conceived protection plan begin with identification of all fall hazards in the work place. Falls often occur from scaffolds, ladders, roofs or catwalks when workers are removing, installing, repairing, cleaning, loading or unloading equipment or when climbing up to or down from an elevated location. Falling risks are often

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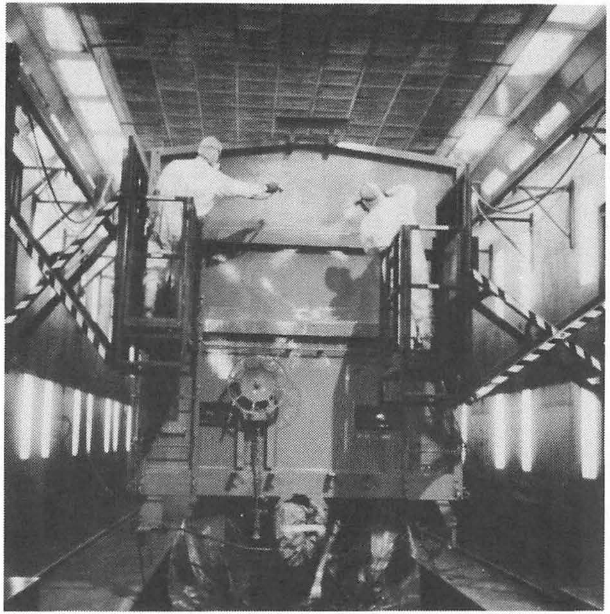

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increased when work is conducted from a ladder. Elevating personnel platforms can, in some cases, allow work to be completed while reducing exposure associated with certain accidents. As the result of work site analysis, several North American railroads have utilized manlifts or mechanically adjustable work platforms to enhance their car and locomotive maintenance operations. Effective where tasks are inconvenient and repetitious, these apparatuses can be used to adapt the job to fit the worker. They have been found to reduce hazards while increasing efficiency in the work place.

Ladders, scaffolds and fixed level platforms are frequently employed in positioning employees to access parts of railroad rolling stock for maintenance and repair. Although these devices are widely used, continuous improvement demands that work stations, tooling, equipment and techniques be evaluated with a focus on increased efficiency, capacity and safety.

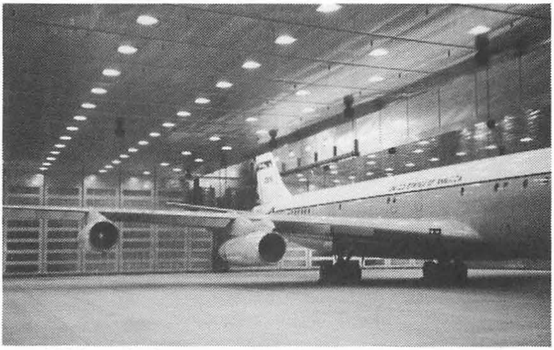
Observations made during a work site and analysis may include repetitive flexing motions of the hands, arms, back and legs. Histories of injuries that can be attributable to straining, twisting, bending, reaching or even staying in one position too long may be found. Age of employees may also be a consideration. Inefficiencies and unsafe conditions may be observed in repositioning ladders, erecting scaffolds and marshalling tools.

Manlifts or elevating work platforms such as bucket trucks, "cherry pickers" or scissor lifts, which are often used in facility maintenance, have more recently been identified as alternatives to ladders, scaffolds or fixed position platforms in the maintenance and repair of locomotives and rail cars. Manlifts fill the need for work stations that accommodate a full range of human movement. Manlifts can accommodate most all workers, not just the "average" or "typical" worker. Incorporating manlifts into work stations can allow employees to adopt several different healthful and safe postures, avoid overreaching and allow efficient job completion. Mechanized work platforms can be precisely positioned and repositioned to improve ergonomics and job performance, then may go conveniently moved out of the way when not needed.

Three axis movement is featured on some manlifts. Three axis movement allows for movement up and down, side to side and in and out. Others may allow movement in one plane only. They can be configured to carry tools in addition to the electric and air services needed for task completion and thus reduce handling. Scissor lifts are often equipped with casters or steering control which is used to reposition or relocate the work platform. Other features may include:

- Smooth operating drives
- Equipment that allows operation in hazardous environments
- Protection for workers from moving parts
- Powerful hydraulic systems capable of lifting and holding entire work crews and tools
- Convenience of platform mounted controls
- Wide ranges of elevated heights.

Several railroads and suppliers have found paint booth operations improved by deploying manlifts. Employees are effectively positioned to apply paint to car or locomotive surfaces. Paint and air hoses can be festooned or tractor fed to the manlift so that the employee does not become fatigued or encumbered by dragging or manhandling hoses. Wash racks have been improved in like manner. Locomotive repair and overhaul can be assisted by manlifts in



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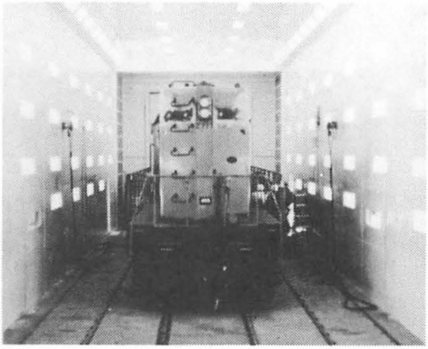


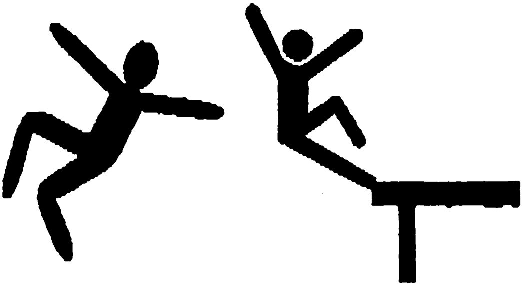
JBI's booths are especially well suited to the rail industry.

the removal and replacement of engine manifolds, power assemblies, blowers, turbochargers, grids, radiators and other locomotive features. Wreck repair areas may be more easily accessed.

Reduced detention time is often realized when manlifts are employed in the maintenance of railroad rolling stock. Work station designs such as these provide employees better access to work for increased efficiency and cost effectiveness.

It is a key function of management to provide employees the means to safety, ergonomically and efficiently complete their tasks. No one has served their employer very well by falling from equipment or being injured. We must therefore look to innovations in equipment and work methods, such as those presented herein, to address safety and productivity issues in our servicing and repair facilities.

⚠ DANGER



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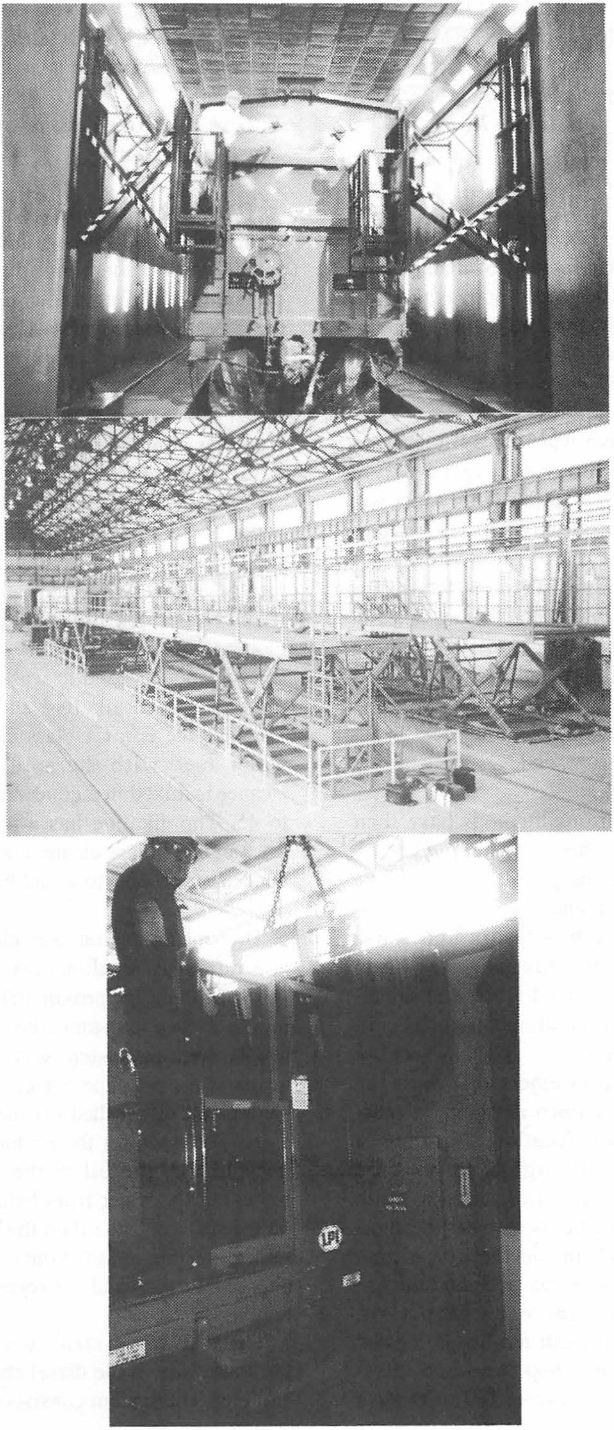


IV. LOCOMOTIVE WASHING SYSTEMS

Presented by: Bill Peterman - CP Rail
Assisted by: Jack Hunt - IC

A. Introduction

Washing of locomotives is becoming more important as part of maintenance operations. Clean locomotives meet the requirements such as safety, appearance (marketing), inspection and regulations. They are also easier to work on.

Locomotive washing systems vary from the hand washing to drive-through brush washing. This paper will mainly address two types of locomotive washing that are becoming the choice of major railroads today: the high pressure wash and the brush wash.

The types of locomotive washing fall into the following categories:

- hand or manual
- chemical / detergent
- high pressure, and
- brush.

All the various methods have their place, but the high pressure and brush wash are gaining popularity due to the increased demand for clean locomotives. The high pressure and brush washes have the advantages of faster throughput, reduced labor and drastically reduced requirements for chemicals and detergents.

Another requirement that must not be overlooked when designing a locomotive wash is location. The flow of locomotives through a diesel shop facility must be considered. The wash facility should be located on the most traveled track in the facility so that every locomotive has an opportunity to be washed during each shop visit. Many times a wash facility is located out of the main shop flow, and therefore many locomotives fail to receive regular washing.

Now we will describe the operation of a high pressure and a brush wash.

B. High Pressure Locomotive Washing System

This washing facility consists of a three-hoop enclosed washing system including two soap hoops and a high pressure rinse. The following operation describes a wash system that was built in conjunction with an existing facility and uses cleaning products that were found to be successful for one railway. (Another, completely new installation with no space and track restrictions might result in different spacing for the hoops and the use of different chemical products.) This particular facility is located in a very northerly climate and is only operated during the summer months from May to October.

The products used to wash the locomotives are an alkaline and an acid. The alkaline is a C1 class cleaner and when used with the acid C2 class cleaner is mixed in a concentration of 1 to 45. The alkaline has a ph of 12.2. The acid, C2 class cleaner, is used in a concentration of 1 to 8 and has a ph of 3.0.

The rinsing station uses clean water at a rate of 272 gallons per minute at 405 psi. It takes approximately 10 minutes to wash a four-unit consist.

The washing system was built over an existing pit. The pit captures the sludge and oil washed off the locomotives. The drain for the pit has a goose neck to trap the oil in the pit while removing the water from below the oil on the surface. The oil on the surface is removed using an oil skimmer and discharged to the used oil recovery system.

The washing system is located on the south side of the diesel shop on the east end. The system consists of a alka-

line foam hoop, and acid spray hoop and a spinner rising system. The movement of the units is from east to west. Operation of the system is as follows:

1. The alkaline foam station:

- The foaming hoop is located approximately 13 ft from the northeast corner of the building, on track 7. (On a new installation the space could be 16 ft.)
- The solution tank, pump and foamer are located inside the shop along the outside wall adjacent to the alkaline hoop.
- The solution is supplied direct from the shop washing solution piped throughout the shop.

2. The acid spray station:

- The spray hoop is located approximately 83 ft from the northeast corner of the building, or 70 ft from the alkaline hoop. (On a new installation the distance between hoop can be 36 ft.)
- The solution tank and pump are located inside the shop along the outside wall adjacent to the acid hoop.
- The solution is mixed in the solution tank from water and acid. The acid is stored outside in a minibulk.

The increased distance is due to the need for increased dwell times for the acid.

3. The spinner rinse system:

- The rinse hoop is located approximately 118 ft from the northeast corner of the building, or 35 ft from the acid hoop. (On a new installation recommended space is at least 50 ft between hoops.)
- Each of the 16 spinners requires 17 gpm. or a total flow of 272 gallons at 400 psi.
- Two 50 hp supply pumps are located in the basement of the drop table area approximately 300 ft away.
- A 1,800 gal. storage tank is located at the pumps and used as a surge tank.
- A 3 in. fresh water feed line supplies water to the surge tank.
- A level gauge in the surge tank will open/close a valve in the fresh water feed line to maintain the required water level.
- 300 ft of 4-in. water feed line connects the two 50-hp rinse pumps with the rinse hoop. The line passes through the service tunnel and comes up along the wall connecting to the rinse hoop.

4. Enclosure:

- A structure 20 ft wide by 140 ft long covers the locomotive washing system.
- The metal frame is made from galvanized steel tubing.
- The metal frame is covered by a grey four-season fabrene canvas by Dupont, laminated both sides. This Fabrene canvas also protects the wall of the diesel shop.
- Several mesh skylights have been placed in the roof for smoke evacuation.
- Four clear plastic windows are placed along the side of the enclosure for viewing the operation of washing locomotives.
- 120-gauge clear plastic strip doors have been installed at each end of the structure for water containment.

5. Oil skimmer:

- A rope type oil skimmer is located just before the acid hoop.
- The oil skimmer will operate continuously, removing oil floating on the surface of the water. The oil removed is piped directly to the dirty lube oil collection system.

6. Operation:

- Locomotives approach the washing system from the east end, and stop before entering the wash system.
- There is a cord hanging down from the start switch. Hostler pulls this cord thereby activating the wash system.
- When activated, yellow lights will flash at both the east and west ends of the wash system, warning employees that the washing will commence.

- The hostler then slowly moves the locomotive(s) into the wash bay through the plastic door.
- On approaching the first hoop (alkaline) the front of the locomotive pushes aside a yellow rod which trips a switch which turns on the alkaline system.
- The alkaline solution is put through a foaming station and then sent to the hoop.
- As the foam begins to spray, the locomotive moves forward slowly through the hoop, covering the locomotive with foam.
- The locomotive continues down the track and at the acid hoop activates another yellow rod connected to a switch which turns on the acid system.
- The locomotive proceeds through the acid hoop and is sprayed with the acid solution.
- Continuing down the track, the locomotive reaches the rinse hoop. Again, the locomotive pushes a yellow rod, activating a switch which turns on the rinse hoop.
- At each of the hoops, there are two yellow rods and switches. There is one on each side of the hoop; this ensures that the hoop will stay on until the locomotive has passed the hoop.
- At the rinse station, there is one additional yellow rod and switch. This switch controls the shutting down of the system. After the last locomotive has passed, the switch closes a timer which after 30 seconds shuts the system down.
- The yellow warning lights go out and a locomotive may pass through the locomotive washing system without being washed.
- To wash a locomotive, the system must be reactivated from the east end.

Some new facilities have an additional low pressure rinse after the high pressure rinse. In designing a new facility it would be recommended to install a system of blowers to remove excess water from the locomotive after the low pressure rinse.

For a new self contained facility the building itself should be at least 135 feet long and have the first soap hoop 16 feet from the entrance. Space between the soap hoops should be at least 50 feet. Distance from the last soap hoop to the high pressure rinse should be 30 feet. Distance from the high pressure rinse to the low pressure rinse should be 25 feet. Distance from the last rinse to the blow-off fans should be 30 feet.

C. Locomotive Brush Washing Facility

The following is a description of a locomotive washing facility using brushes to clean the exterior of a locomotive.

The facility utilizes a pre-wet spinner arch, a detergent foam arch, 16 brushes, a pre-rinse spinner arch, a final rinse arch and an air blow-down for stripping water. Additional stations were provided alongside the outbound drip pan for spot washing engineroom interiors, one station per locomotive in a four-locomotive consist. Additionally, an interior wash bay has been provided which utilizes pneumatic personnel lifts to bring high pressure wash wands to all interior surfaces of the locomotive.

The brush wash facility has a "wash", "no-wash" status light at the facility entrance. Controls are provided at ground level to control this condition. For run thru, "no wash" is selected. When in wash, the first thru beam sensor senses presence of a locomotive, which initiates the wash process. Sensors, a total of five, are used to initiate the various wash components.

The brush system is configured to cover all surfaces, where possible, of the various locomotives that are sent through. The brushes form the basic shape of a locomotive facade.

Four brushes are used to clean the trucks, fuel tanks and edge of the running board. For over the handrail and deck cleaning, three sets of brushes are used. Each set of brushes is configured to clean a particular portion of these areas up to the top of the handrail. From the handrail up, the cleaning is done by roof, eave and body brushes. The body brush also cleans the nose.

An air blow-down strips rinse water from the units as they exit the facility.

The main goal in the installation of an automatic brush type washer is to increase efficiency and appearance. The efficiency is realized because:

#1 - There is a labor saving.

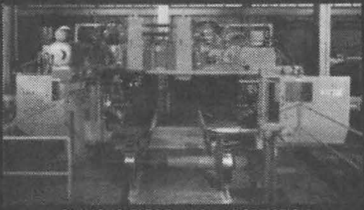
#2 - The brushing action lowers the level of detergent consumption. This in turn lowers the cost of waste water treatment.

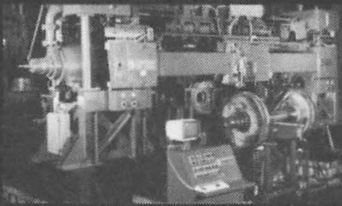
#3 - Oil and grease-free locomotives are safer and easier to maintain.

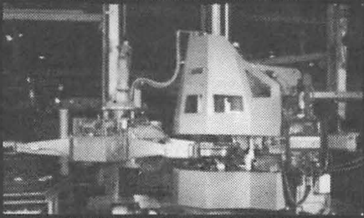
Experience, the best teacher, has led to many discoveries.

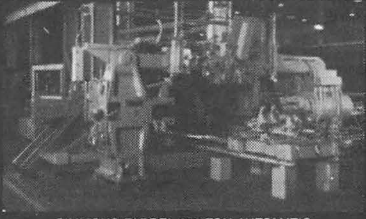
Because of the vulnerability of the brush system to a moving locomotive, every effort was made in the design to keep brush structures from coming in contact with the locomotive. Within reason, this was accomplished by using large diameter brushes with the ability to reach deep and climb to safety.

The detergent presently being used is a highly caustic alkaline which is a good grease cutter, but has little effect on the built-up red oxides on the surfaces. Presently experiments are being performed using an organic acid which does an excellent job of chemically removing these oxides.









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R. Lindenmuth	Manager of Testing	Chgo. & North Western	Chicago, IL
M. Logan	Staff Engr.	Chevron Oronite	Richmond, VA
D. McAndrew	Fuels & Lub. Spec.	General Electric Co.	Erie, PA
T. Nowak	Sr. CTS Rep.	Ethyl Petroleum	Richmond, VA
S. Pearson	Product Engineer	Mobil Oil Corp.	Fairfax, VA
D. Pridemore	Mgr. Tech. Prod.	Valvoline	Lexington, KY
J. Reber	Product Engineer	Conoco Incorporated	Houston, TX
G. Schafer	Senior Technologist	Texaco, Incorporated	Beacon, NY
M. Schlauch	Sr. Research Engr.	AAR	Washington, DC
E. Shamah	Sr. Engr. Assoc.	Chevron Research	Richmond, CA
R. Skurla	Mgr-Purchasing Log.	Burlington Northern	Ft. Worth, TX
C. Tincher	Product Manager	Lyondell Petro. Co.	Houston, TX
M. Wierucki	Engineer of Test	CP Rail System	Winnipeg, MB

PERSONAL HISTORY

Ron Lodowski

Mr. Lodowski was born in Buffalo, New York on March 4, 1950. After his elementary and high school education he scholared at Canisius University in Buffalo and received a Bachelor of Science degree in chemistry in 1972.

He began his railroad career with the Penn Central as a Freight Carman in 1975. In March 1977 he transferred to the Locomotive Department and was promoted to General Foreman in Buffalo. In July 1984 he was transferred to Selkirk, New York and was promoted to Manager-Environmental Operations. In August of 1989 he was given the additional duty of Supervisor-Oil Control Labs.

Ron's hobbies are travel, photography, and he enjoys viewing spectator sports such as hockey and football.

He has been married for 25 years and his wife's name is Susan. They have two children, Michael, 24 and Nicole, age 8.

I. TBN - A REVIEW OF CURRENTLY ACCEPTED METHODS

Presented by: L.H. Haley, Jr.
Norfolk Southern

Introduction

One of the functions of a crankcase lubricating oil is to neutralize acids that are formed during the combustion process and from oxidation of the oil. When an oil's ability to control the acid level is lost, the acids build up and contribute to engine deposits and attack engine components. To insure that the ability to neutralize acids is not exceeded, oil should be monitored on a routine basis and changed before the danger level is reached. A locomotive lube oil analysis program should include test procedures that provide accurate and meaningful results, indicate the suitability of the oil for continued use, identify mechanical problems in the engine, and are easy for the routine production laboratory to use. A typical oil analysis program includes oxidation and fuel dilution as measured by viscosity, insolubles content, spectrographic determination of wear metals, and alkalinity retention as measured by Total Base Number (TBN) or pH.

With the switch from single grade to multigrade oils, the relative importance of each test has changed with the changing nature of the oil. When the industry used single-grade oils, the primary condemning factor, excluding water leaks, was viscosity increase due to oil oxidation. The switch to multigrade oils with their HVI base stocks has greatly reduced oil condemnations due to high viscosity or oxidation, and the oil remains in the engine longer. Due to the extended service time of the oil, elevated insoluable content and loss of alkalinity have become the primary reasons for oil drains due to degradation.

Total Base Number

Total base number or TBN is defined as the amount of acid required to neutralize the basic constituents in one gram of oil. The results are expressed in units of milligrams of potassium hydroxide. The basic components in an oil are necessary for the control of engine deposits and corrosive wear. If the base or alkalinity level drops too low, acids produced from the combustion of the fuel along with oil oxidation products can lead to excessive deposits and acid attack of the internal engine components. Figure 1 shows the results of laboratory induced acid attack on a section of a main bearing. These results were obtained by heating used oil to 300°F in the presence of main bearing material, and with air being bubbled into the oil. As can be seen, the level of lead in the oil increases sharply once the oil is sufficiently degraded. The total base number serves as an indicator of the ability of an oil to prevent corrosive wear - once the TBN drops to a sufficiently low value, the oil can no longer neutralize the acids and corrosion proceeds rapidly.

Historically, TBN has been measured using two ASTM procedures - D664 and D2896. Normally new oils are tested using D2896 while D664 is applied to used oils. D664 is a manual procedure that is labor intensive and as a result many labs have modified it in an effort to have an automated procedure. Through all of the modifications, the precision of the procedure was lost. In addition, the reproductivity between labs was not good and as a result, ASTM, several years ago, discontinued the TBN part of D664 and adopted a new procedure, D4739. However, since

a significant amount of historical data exists and OEM condemning limits are based on D664, the rail industry has not embraced the new procedure and continues to utilize D664 or some modification of it for used oils and D2896 for new oil.

As shown in Table 1, each procedure uses a different solvent system and titrant. It is not surprising that since each procedure uses a different system, the results obtained differ according to the procedure used. To quantify these differences Figure 2 shows actual TBN data (using D664) for one oil obtained from five locomotives along with a non-linear curve fit that describes the data fairly well. Figure 3 shows the curves on the same oil for the three ASTM methods and as mentioned earlier, the results obtained depend on the method used; D2896 produces the highest results and D664 the lowest for a given sample. The data points have been removed for clarity but the scatter around each curve is similar to that seen in Figure 2. Figure 4 shows TBN decay curves for the standard procedures plus one for a modified version that is currently used by one railroad. Data for this fourth curve were derived from a procedure that is based on D664. The modification is that instead of titrating with acid as in D664, a fixed volume of acid added to the sample, allowed to stand 15 minutes and back-titrated with alcoholic potassium hydroxide (KOH). Although this method was based on D664, the results obtained are significantly higher than for D664.

Each year, a rail industry round-robin analysis program is undertaken. The results from this program demonstrate the extreme variability of the TBN procedure used and the results obtained (Table 2). In 1993, 15 labs reported TBN results for one sample that ranged from 8.05 to 3.1 using six separate procedures. These results substantiate that each separate or modified procedure measures different basic components and unless the actual method used is reported, the results have little meaning. With numerous methods available for TBN measurement, it falls to the individual lab to correlate the procedure used to the OEM condemning limits. This also demonstrates the need for an acceptable industry standard method for the measurement of TBN or more importantly the onset of corrosive wear. Even though the various methods yield different results, the main disadvantage to all of these procedures is that they are time consuming and not practical for a production lab.

pH

Due to the time required and the difficulty of running TBN analysis, most rail labs have adopted pH measurement as a surrogate for TBN. Although pH is a procedure for aqueous systems and its meaning in a non-aqueous system is not clear, it enjoys widespread use. The reason for the widespread use is that a pH measurement can be made in relative short time (less than 5 minutes) as opposed to the long time (up to one hour per sample) associated with TBN measurements. However, the correlation between pH and TBN is not exceptional and the chance of a pH measurement giving a high reading when the TBN is too low to protect the engine is real (Figure 5). To further support the inability of pH to accurately predict TBN, Table 3 shows correlation coefficients of pH with four TBN methods. The correlation coefficients are in the 0.7 range which shows a general relationship; however, good correlations are normally in the 0.95 to 0.99 range.

The Future

Other methods for measuring TB or an oil's ability to prevent corrosive wear are being investigated. A subcommittee of this group has been formed and is charged with looking at alternative methods for predicting the onset of corrosive wear. Various methods such as a kit TBN method, a cyclic voltammetric procedure, and a pressure change technique, in addition to more conventional processes are being investigated. The goal is to find an accurate, meaningful procedure that can indicate the end of the useful life of an oil and is suitable for use in a production laboratory. This will be accomplished through a four part program of which this review is Part 1. Part 2 will establish the ability of various procedures to predict corrosive wear. Part 3 will look at developing new procedures if nothing unfolds in Part 2. Finally in Part 4 a correlation between laboratory and field work will be established.

Conclusion

The methods currently used to measure TBN are numerous and produce highly variable results. The difficulty of all the TBN methods is that they are time consuming and require each lab to correlate its results with the OEM's limits. Because of these difficulties, TBN is not routinely used and most labs rely on pH measurement. Although pH does not correlate very well with TBN this committee believes that there is value in having a test that can give an indication of an oil's ability to prevent corrosive wear.

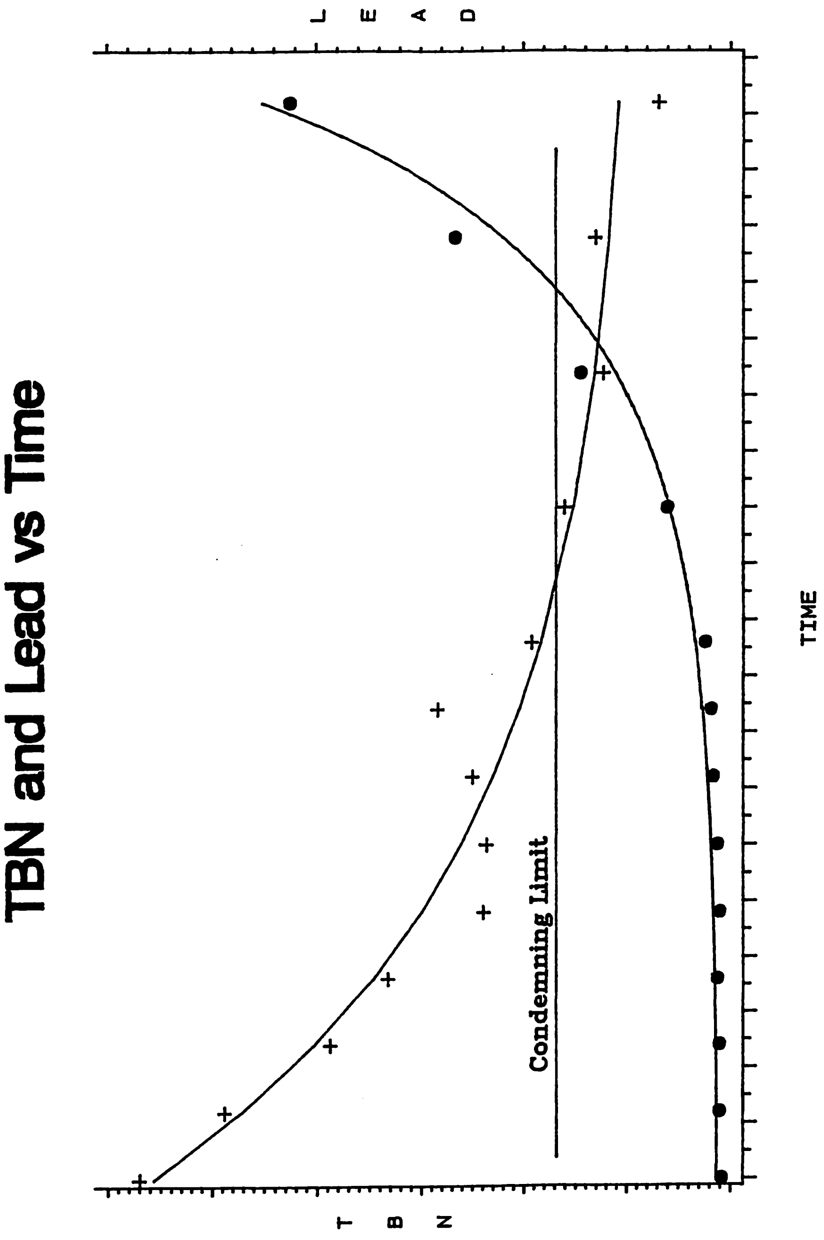


Figure 1


SAP3113A
SAP3113A

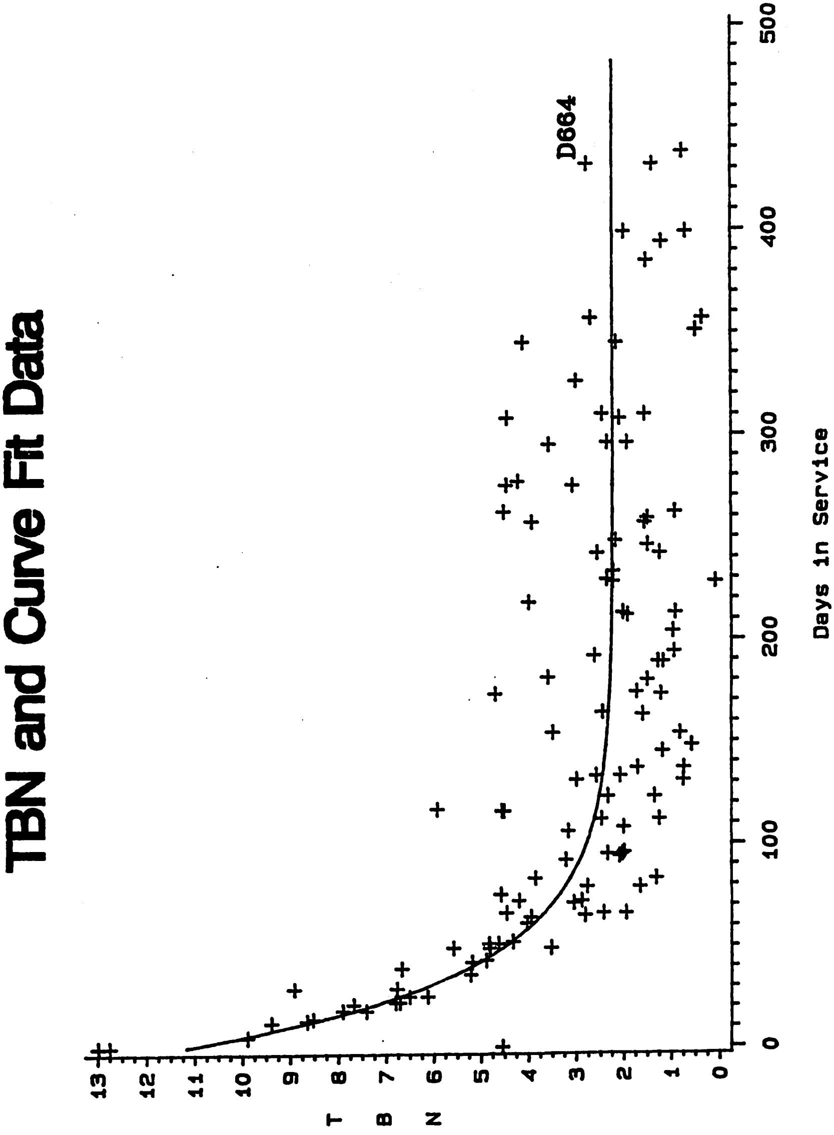

TBN and Curve Fit Data
D664
T B N
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
Days in Service

Figure 2

TBN Curve Fit Data For ASTM Methods

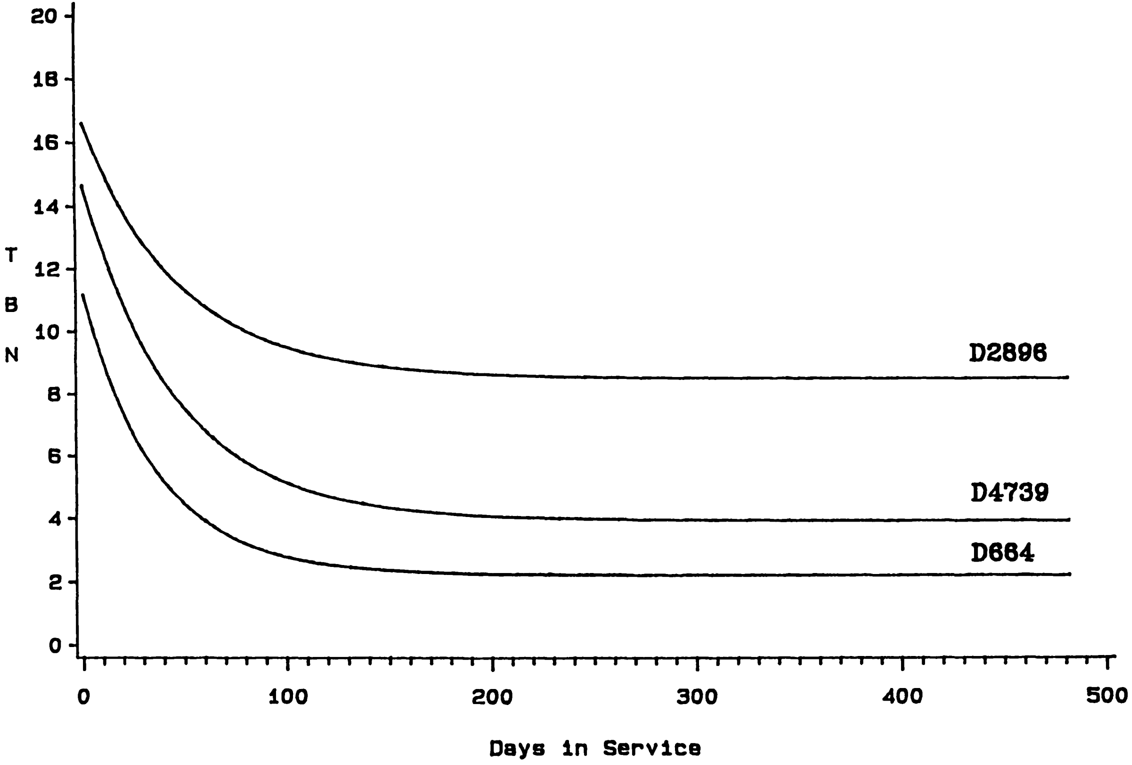
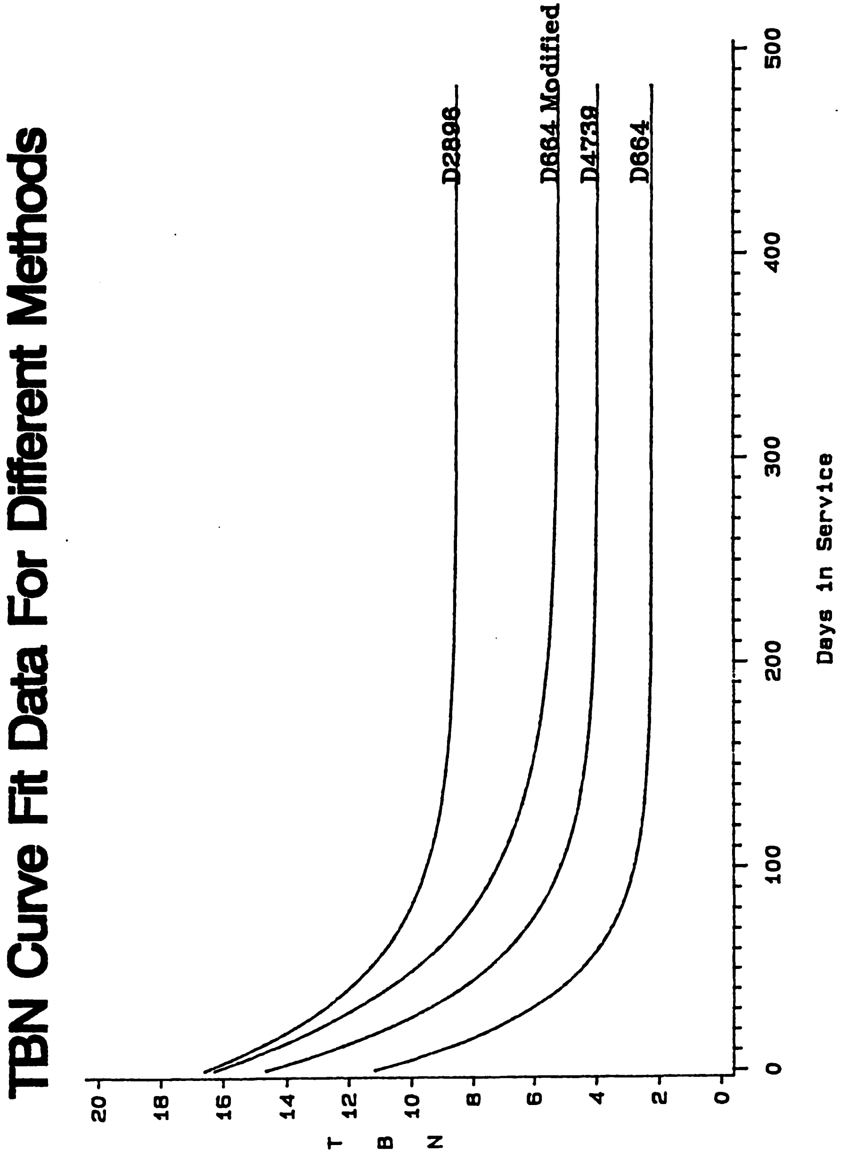


Figure 3



TBN Curve Fit Data For Different Methods

Figure 4

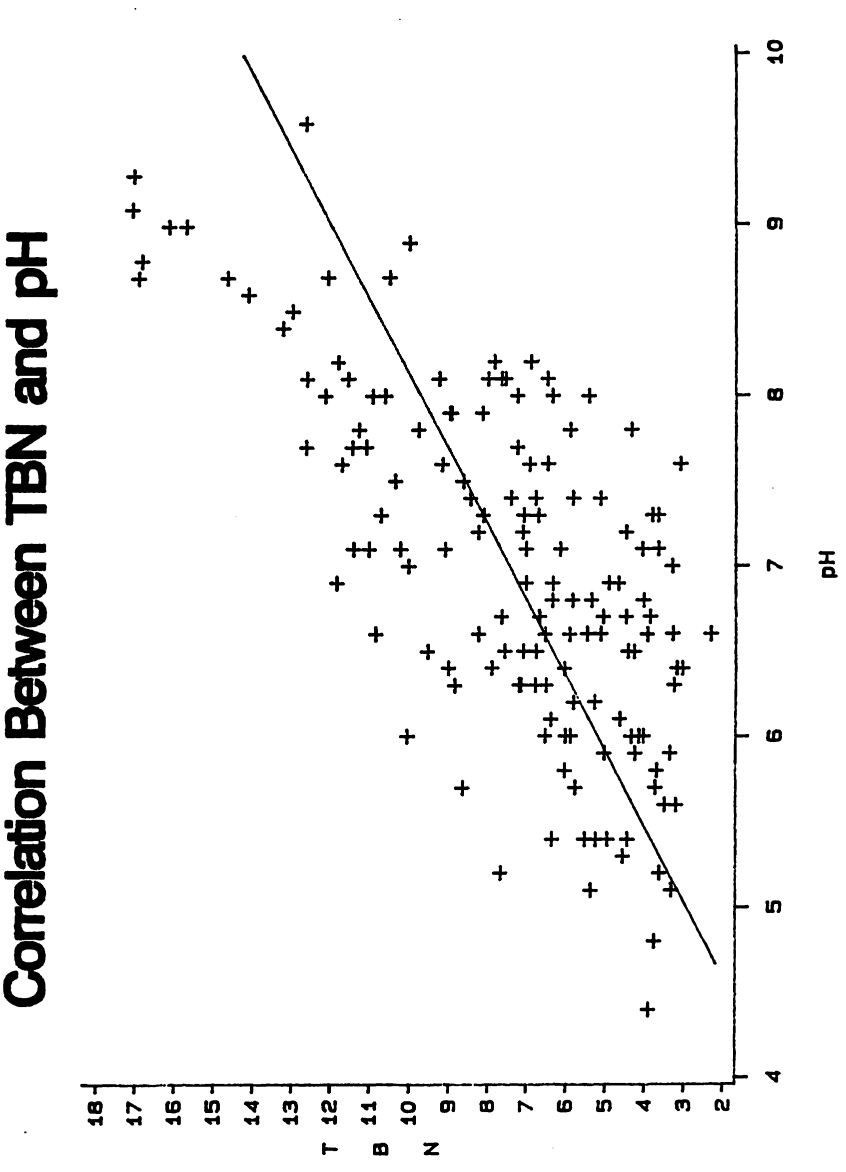

Correlation Between TBN and pH
T B N
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
4
5
6
7
8
9
10
pH

Figure 5

TABLE 1

TBN SOLVENT SYSTEMS

TBN Method	Solvent	Titrant
D664	Toluene / IPA / Water	Alcoholic HC1
D2896	Chlorobenzene / Acetic Acid	Perchloric Acid Acetic Acid
D4739	Toluene / IPA / Water / Chloroform	Alcoholic HC1

TABLE 2

ROUND-ROBIN RESULTS FOR pH & TBN

pH	TBN	TBN METHOD
7.6	5.8	TEST KIT
7.7	3.1	INFRARED
7.7	3.5	INFRARED
7.8	3.1	INFRARED
7.8	8.05	D664 MODIFIED
7.4	5.5	D664
7.3	4.1	D664
7.9	5.13	D664
7.7	6.6	D664
7.2	5.7	D664
8.4	6.46	D4739

TABLE 3

PEARSON CORRELATION COEFFICIENTS

	pH
D664	0.69
D2896	0.74
D4739	0.71
D664 (MODIFIED)	0.66

Comparisons of Kinematic Viscosities

Single-Grade SAE 40 and Multigrade SAE 20W40 Fresh Oils

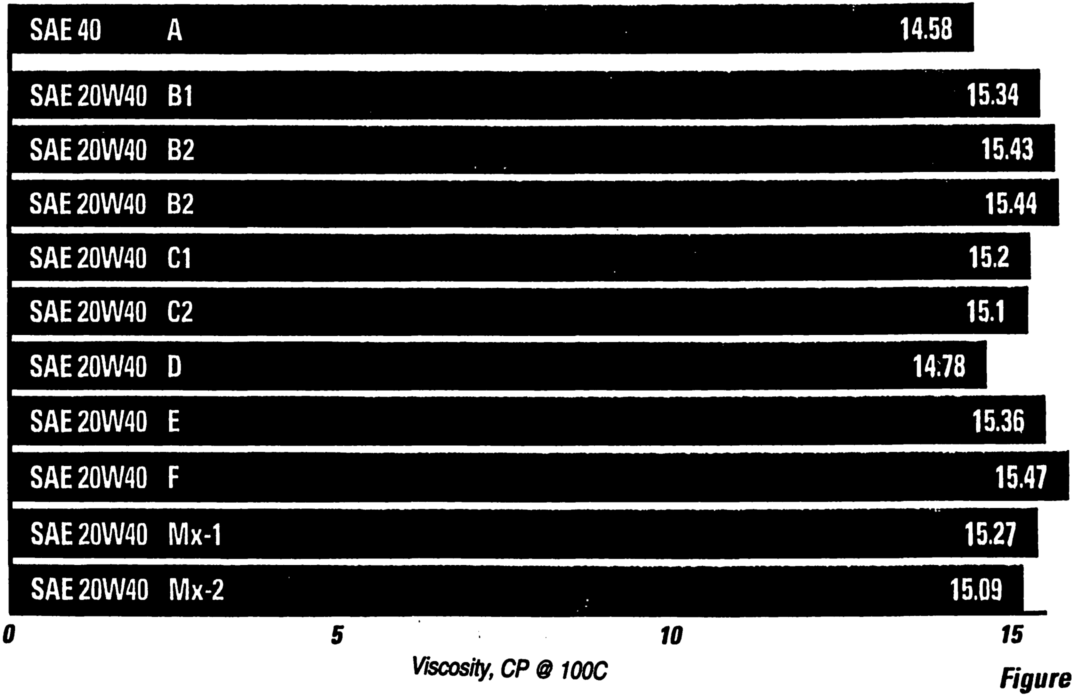


Figure 1

Comparison of High Shear Rate Viscosities

Single-Grade SAE 40 and Multigrade
SAE 20W40 Fresh Oils

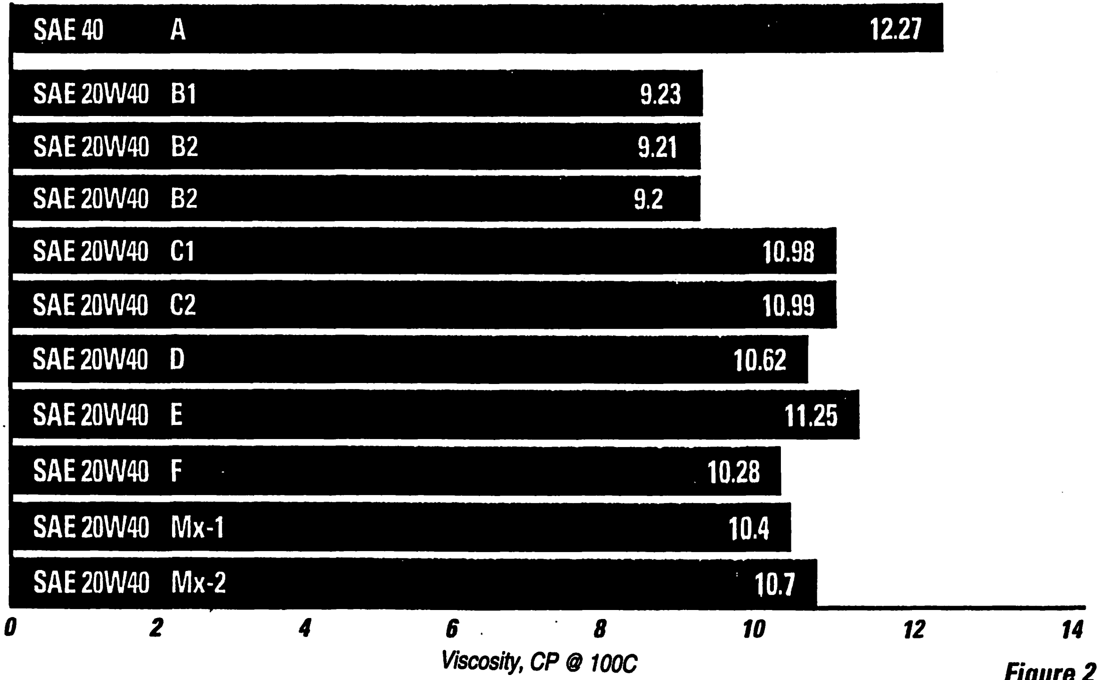


Figure 2

Comparison of High Shear Rate Viscosities

Single-Grade SAE 40 and Multigrade SAE 20W40 Fresh Oils

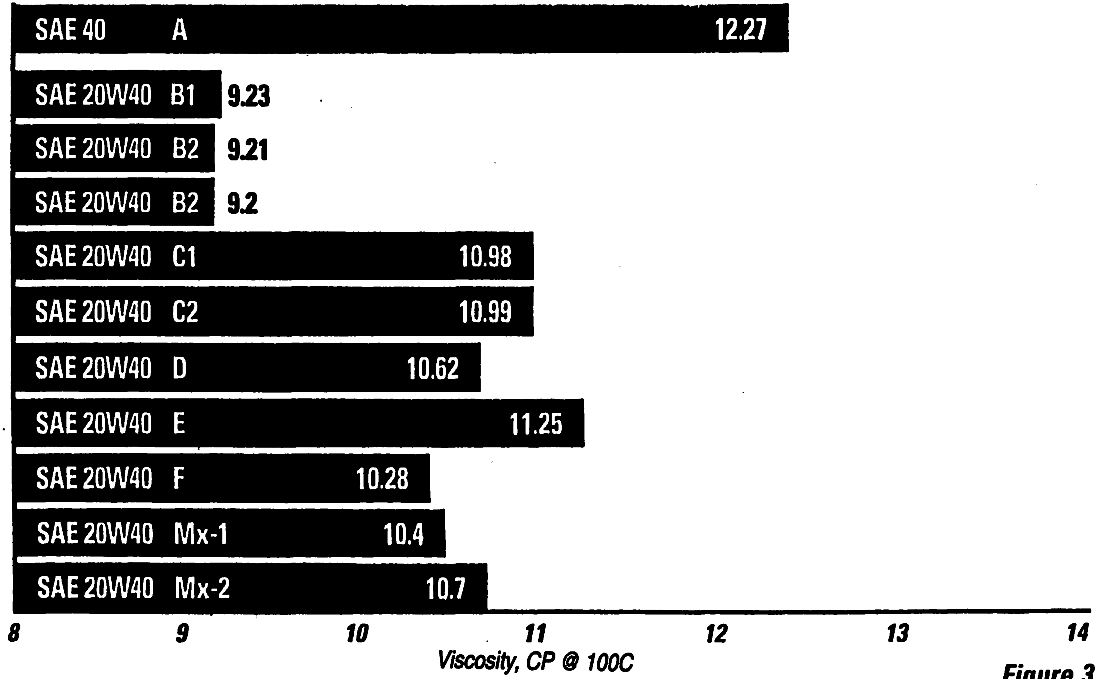


Figure 3

Combined Effects of TVL and PVL

Single-Grade SAE 40 and Multigrade SAE 20W40 Degraded Fresh Oils

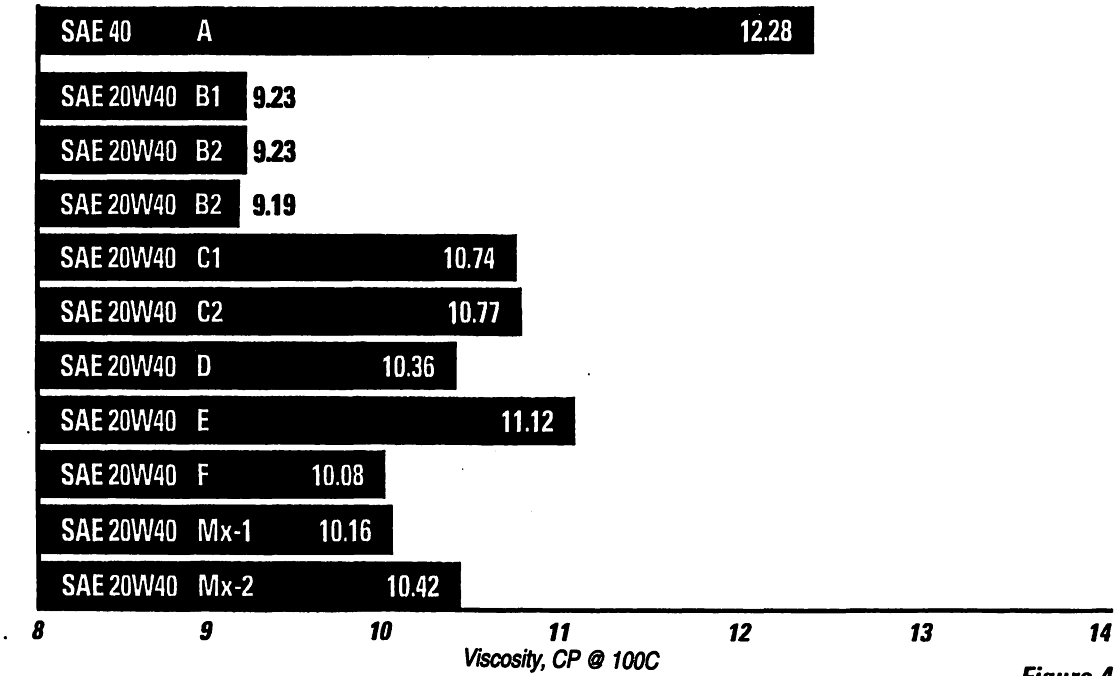


Figure 4

Viscosity Loss

Permanent and Temporary

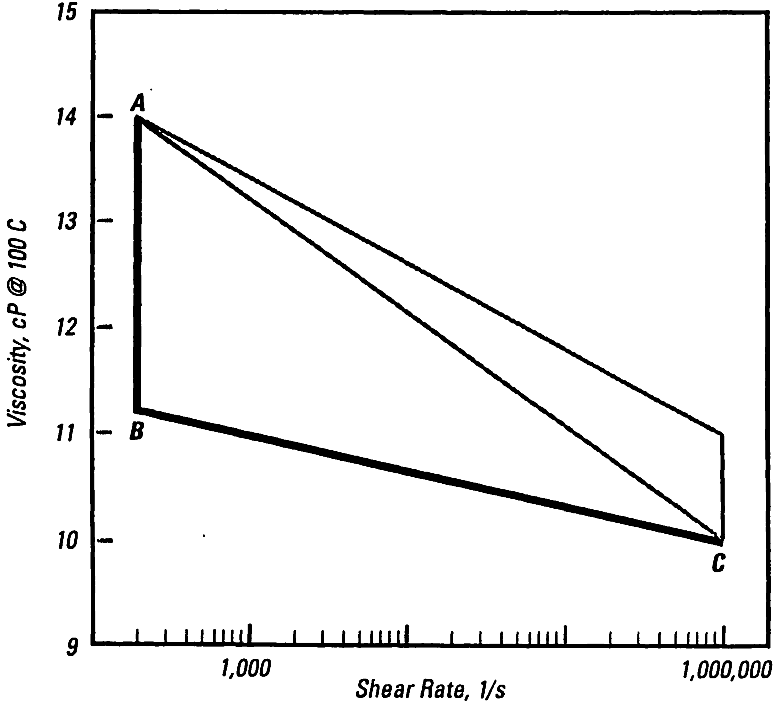


Figure 5

Viscosity Loss

Engine Oil A – Erie

(Newtonian)

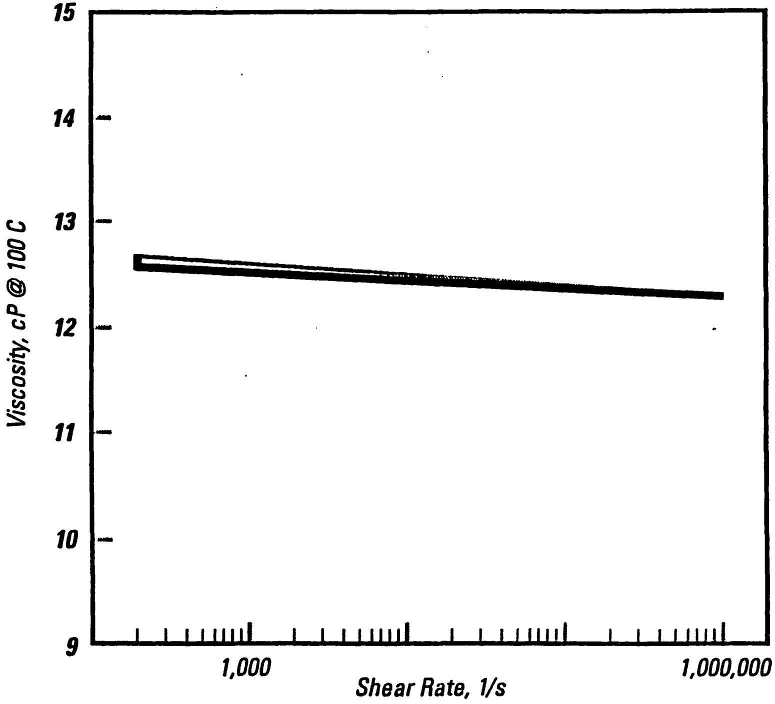
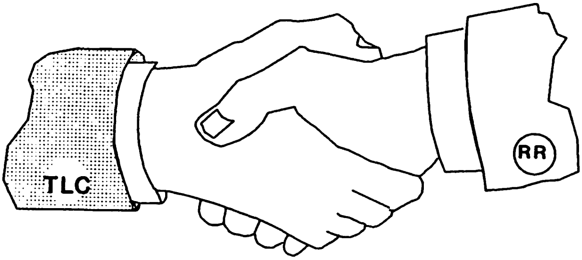
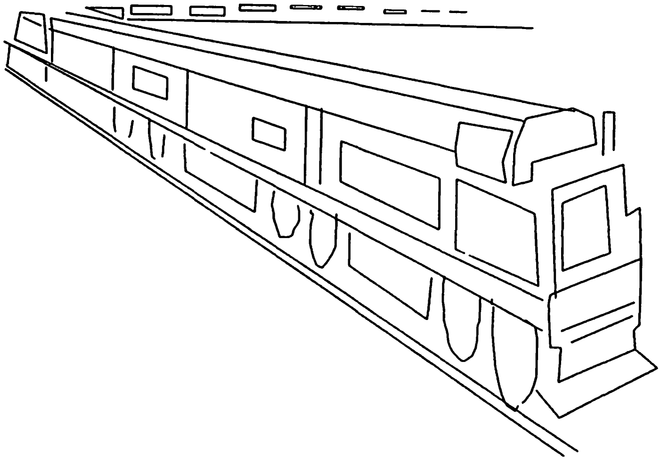


Figure 6


TLC
RR



Viscosity Loss

Engine Oil B

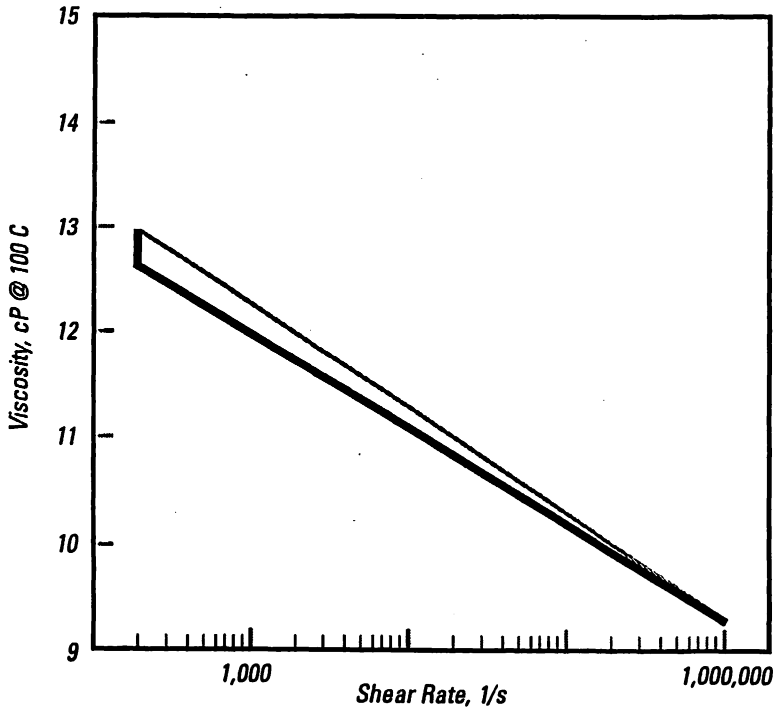


Figure 7

Viscosity Loss

Engine Oil F

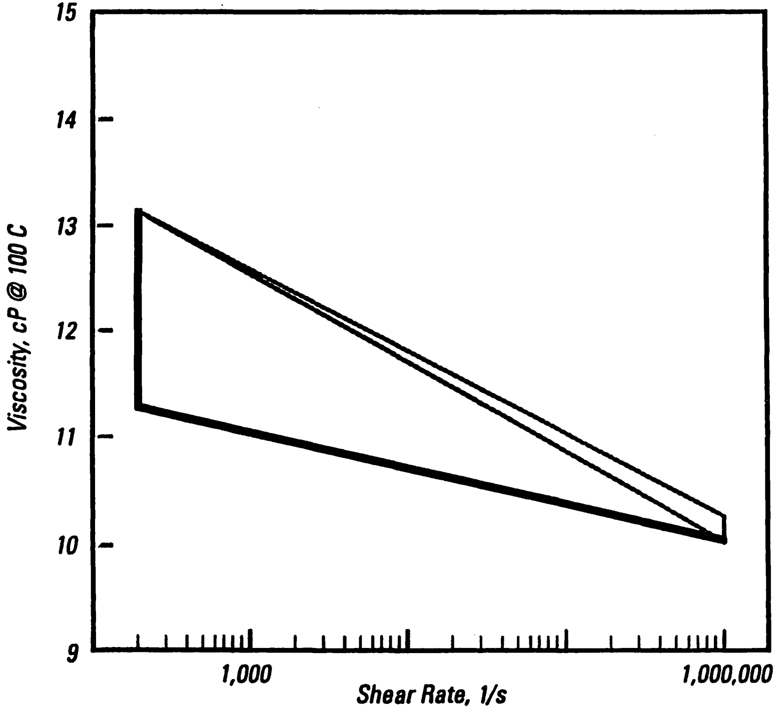


Figure 8

Viscosity Loss

Engine Oil C

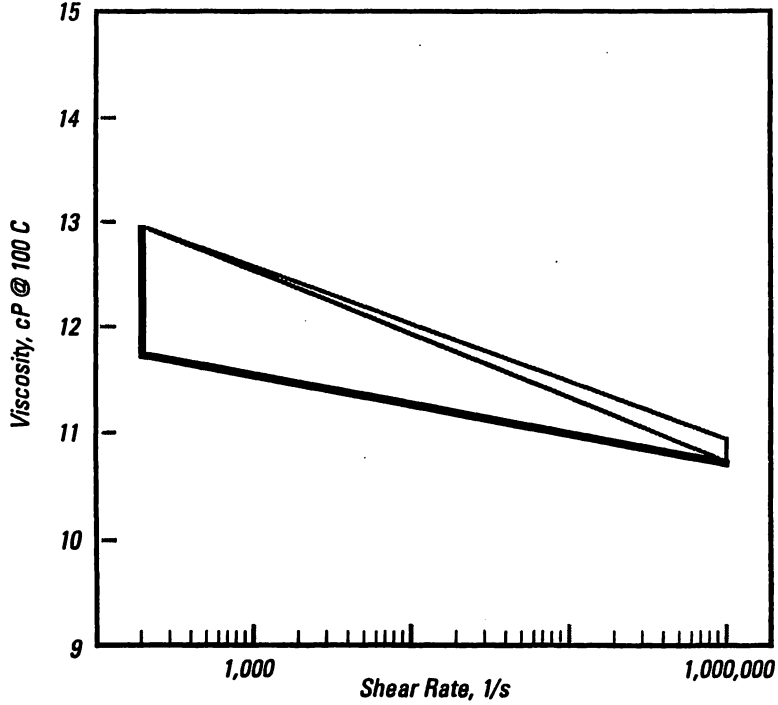


Figure 9

II. GENERAL ELECTRIC MULTIGRADE LUBRICATING OIL TESTING AND SPECIFICATION

Presented by: Dennis McAndrew
General Electric Co.

General Electric Company has recently redefined "new engine oil specifications" and "used oil condemning limits" for the 7FDL engine. This was required to ensure long component life because of the many new application requirements and types of lubrication oils currently available. Optimizing fuel efficiency and lubricating oil consumption benefits were also key objectives for the specifications. These specifications are based on information collected during an extensive study of field laboratory data of railroad oils for different applications ranging from light to severe duty.

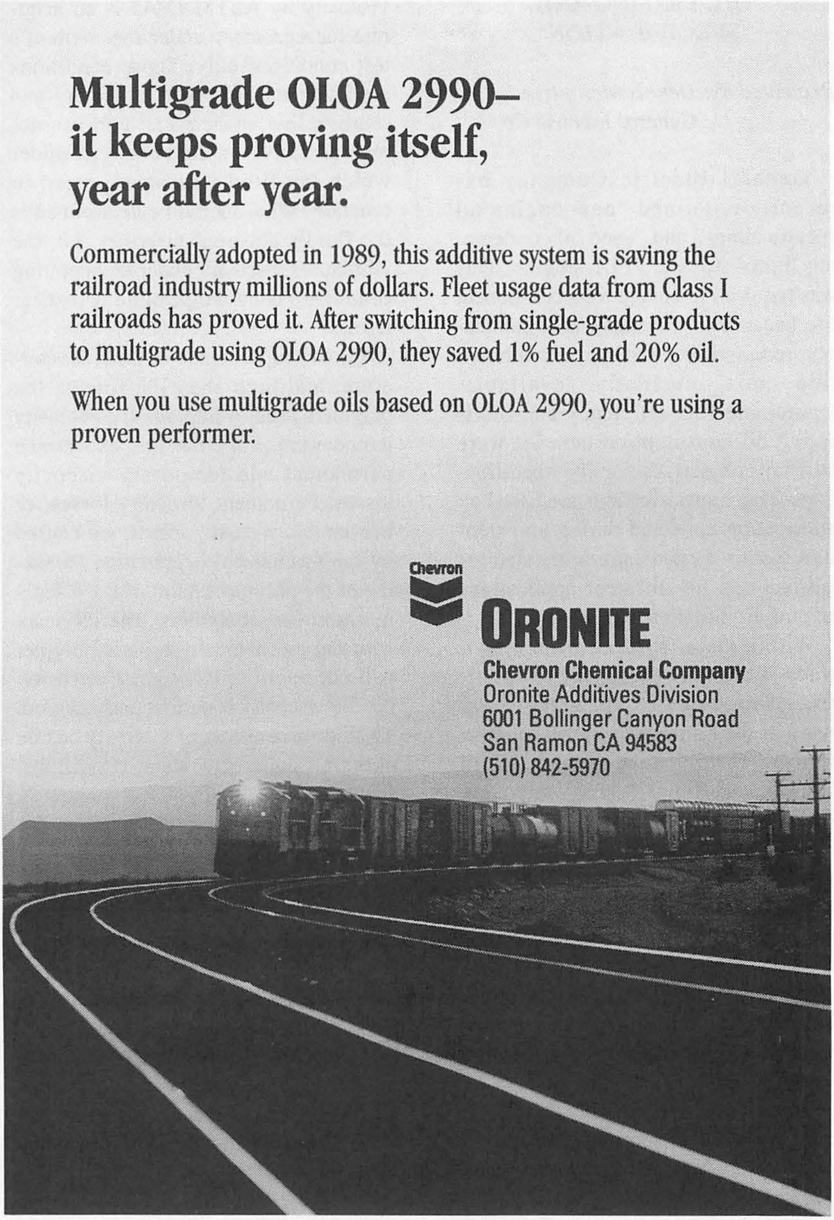
With a major shifting from monograde lubricants (SAE 40) to multigrade lubricants (SAE 20W-40) by many of the railroads, controls must be established to ensure adequate fluid film thickness, and engine protection. Typically monograde lubricant kinematic viscosities are currently measured by using a glass capillary kinematic viscometer (ASTM D445) at 40°C and 100°C. Results are reported in centistokes (cSt), with 1 cSt = $10^{-6} m^2$ /s. This is an accepted whose viscosities do not change with shear rate (where shear stress is proportional to the rate of shear).

Multigrade lubricants contain oil soluble polymers to improve the lubricants' viscosity temperature properties. The viscosity of these fluids can also be determined by using a capillary viscometer. However, these multigrade fluids are non-Newtonian fluids, i.e. fluids whose viscosities do not change with shear rate and stress (viscosity falls with increasing shear rate). The determination of a multigrade lubricant viscosity by ASTM D445 is an accurate measurement under the method's test conditions only. Those conditions are under the influence of gravity and relative low shear rates, and are not representative of the condition under which the fluid will be expected to function. What should be determined is the fluid's apparent viscosity, i.e. the lubricant's viscosity under its operating condition (same temperature and shear rates).

Under the influence of time, temperature, and high shearing forces, the polymers used to improve the viscosity temperature properties can experience permanent and temporary viscosity losses. Permanent viscosity losses, or irreversible viscosity losses, are caused by the mechanical degradation (breaking of the polymer chain) of the viscosity improver's polymers. The lubricant with the mechanically broken polymer will not return to its original viscosity, i.e. the viscosity is permanently altered. This permanent loss of viscosity can be observed under low shear conditions, such as ASTM D445.

Temporary viscosity losses can be caused by an alignment/orientation of the polymers under high shear conditions. References indicates that temporary viscosity losses can range between 5 and 30%. This condition of temporary loss of viscosity cannot be determined under low shear test conditions, such as ASTM D445. Only with instrumentation simulating engine operating conditions (high shear rates and stress) can temporary viscosity loss be measured. If a lubricant was selected that was susceptible to a high percent of temporary viscosity loss, under certain operating conditions it will contribute to wear and potential failures.

These viscosity losses necessitate a measurement of true (absolute) viscosi-



ty for multigrade lubricants rather than the kinematic viscosity (which is a comparative very low shear measurement involving the effect of the lubricant's density as well). To adequately represent the needs of engine bearings, very high shear rate measurements of viscosity are required when dealing with multigrade engine lubricants. However, only within the last few years has the equipment, the techniques, and the correlation with the bearing performance been developed, published, and accepted by the technical experts. As a consequence, General Electric will use very high shear rate viscometry as one of the methods of qualifying multigrade engine lubricants.

General Electric began an evaluation of multigrade lubricants viscosities that are currently being used by the railroads. The viscosities of the multigrade oils were determined after the materials were permanently sheared, then measured under high shear conditions. Materials were sheared by using a diesel injector nozzle, ASTM D3945 Shear Stability of Polymer-Containing Fluids Using a Diesel Injector Nozzle, Procedure B, Fuel Injector Shear Stability Test (FISST). The high shear condition was accomplished by using a tapered bearing simulator, ASTM D4683 Measuring Viscosity at High Temperature and High Shear Rate by Tapered Bearing Simulator (TBS). The standard TBS test temperature is 150°C. General Electric's TBS test temperatures were adjusted to 100°C (approximate engine temperatures).

The resultant measurements of absolute viscosity (dynamic viscosity) takes into account both permanent and temporary loss of viscosity. Because the multigrade lubricants are non-Newtonian, these extra steps are necessary to evaluate the lubricant's suitability for use in a diesel engine.

The results from the evaluations of one monograde (SAE 40) and ten multigrade (SAE 20W-40) unused engine oils from four railroads and GE are illustrated in Figure 1 through Figure 9. In Figure 1 the kinematic viscosities of all the unused lubricants are shown. It can be seen that all of the lubricants meet the requirements of an SAE 40 grade engine oil, i.e. the viscosities are all above 12.5 cSt (lower limit) but below 16.3 cSt (upper limit) for an SAE 40 grade.

The same unused lubricants in Figure 1 were analyzed under high shear conditions at 100°C (approximate engine temperature). Results are shown in Figure 2. Figure 3 is the same data with an adjustment to the Y axis to emphasize differences. This data shows that there are marked differences among the SAE 20W40 lubricants. It also shows that the SAE 40 engine oil is more viscous than any of the multigrade engine oils, under those test conditions. Once the high shearing force is removed, the lubricant's viscosity is restored. This is a temporary loss of viscosity and is not reflected in a kinematic viscosity measurement.

The change in the multigrade lubricant's viscosities, when tested under high shear conditions (ASTM D4683), is a result of the viscosity index improves being aligned/oriented (the fluid is non-Newtonian). The differences between the multigrade lubricants can be from several factors, such as: the length of the polymer, branching of the polymer, concentration of the polymer, stability of the polymer, and type of polymer.

In addition to the temporary viscosity loss measurements, the materials were permanently sheared in the FISST test. After the materials were permanently sheared, the specimens were retested by ASTM D4683. The FISST permanently degrades those molecules susceptible to high physical forces. The combined results are shown in Figure 4. This is the total loss of viscosity due to temporary and permanent loss.

The effect of the viscosity loss can be graphically illustrated as in Figure 5. Point A is the low shear viscosity measured by ASTM D445. By subjecting the same specimen to a high shear force (ASTMD3945) Point B can be obtained which represents the permanent loss of viscosity, again measured with ASTM D445. By further stressing the specimen under test conditions such as ASTM D4683 the temporary viscosity loss can be observed and measured. This viscosity is indicated at Point C. It should be noted that Point C is the combined loss of viscosity, i.e. permanent and temporary viscosity loss. It is this overall viscosity loss that must be understood and controlled to provide adequate fluid film thickness.

The general multigrade lubricant represented in Figure 5 can be contrasted with Figure 6, which is of a SAE 40 grade lubricant. The SAE 40 viscosity remains relatively constant, and does not change with a high shear rate and force. This fluid is a Newtonian fluid and there is very little permanent and.or temporary loss of viscosity under the test conditions. Figure 7 through Figure 9 are multigrade railroad oils. These fluids are not only non-Newtonian, but each has its own characteristic response to the test conditions.

Differences in the railroads' lubricants response is due to the viscosity index improvers. Figure 7 is a multigrade lubricant that shows little permanent viscosity loss, but a high degree of temporary viscosity loss. Figure 8 is a product that has more permanent viscosity loss than Figure 7 but less temporary loss. The test material in Figure 9 is between the two. These figures show that there are different responses of the lubricants packages to temporary and permanent forces, which affect the viscosities. A Summary Table lists the absolute viscosity and the percent changes of the test materials.

SUMMARY TABLE

Engine Oil	SAE Grade	Kin.Vis. @ 100 C cSt	Dynamic Viscosity at 100 C, cP				Percent Viscosity Loss
			Low Shear Rate		High Shear Rate		
			Fresh	Degraded	Fresh	Degraded	
A	40	14.58	12.58	12.52	12.27	12.28	2.38
B1	20W40	15.34	12.95	12.62	9.23	9.23	28.73
B2	20W40	15.43	13.07	12.72	9.21	9.23	29.38
B3	20W40	15.44	13.06	12.68	9.20	9.19	29.63
C1	20W40	15.20	12.98	11.72	10.98	10.74	17.26
C2	20W40	15.10	12.94	11.63	10.99	10.77	16.77
D	20W40	14.78	12.56	11.31	10.62	10.36	17.52
E	20W40	15.36	12.38	11.94	11.23	11.12	10.18
F	20W40	15.47	13.17	11.25	10.28	10.08	23.46
MIX-1	20W40	15.27	13.07	11.15	10.40	10.16	22.26
MIX-2	20W40	15.09	12.81	11.48	10.70	10.42	18.66

The percent viscosity loss was calculated from the low shear fresh viscosity to the high shear degraded viscosity value (cP).

As a result of this investigation it became clear that minimum absolute (dynamic) viscosities must be established.

GE's minimum limit for the kinematic viscosity of SAE 40 used oils has been defined as 12.5 cSt at 100°C. This kinematic viscosity of 12.5 cSt converts into a dynamic viscosity of 10.5 cP at 100°C. By adding a margin of safety, should fuel dilution occur, the SAE 20W40 minimum dynamic viscosity was established at 10.8 cP at 100°C.

The new viscosity requirement is intended to continue to offer fuel efficiency benefits while at the same time improving lubricant benefits to the lubricants which did not meet this minimum viscosity requirement. Without test data on reblended lubricants, approvals were withdrawn April 1, 1994. For those materials that did not meet the minimum of 10.8 cP and were reblended, a mechanism was established to evaluate that blend and grant approvals when appropriate.

Lubricants will only be considered reblends when the ratios of these base stocks and additives have been adjusted to meet the new requirements. If a new component is added to the blend, the product will no be considered as a reblend. This would be a new blended product which must be fully evaluated before approval through the normal process.

This absolute viscosity specification applies to multigrade engine lubricants only. It will not be necessary to go through this process with previously approved straight weight engine lubricants.

THE ECONOMIC IMPACT OF LOW-SULFUR DIESEL REQUIREMENTS

Harold L. York
Exxon Company, U.S.A.

Introduction and Background

- Clean Air Act reduces highway diesel fuel sulfur content to 0.05% by weight
  - + Previously 0.20% - 0.30% by weight
  - + Other countries soon to implement
    - Mexico - 1994
    - Europe - 1996
    - Japan - 1997

- About 55% of middle distillates demand can continue to consume high-sulfur diesel
  - + Residential heating
  - + Non-highway transportation
    - Railroads
    - Farmers

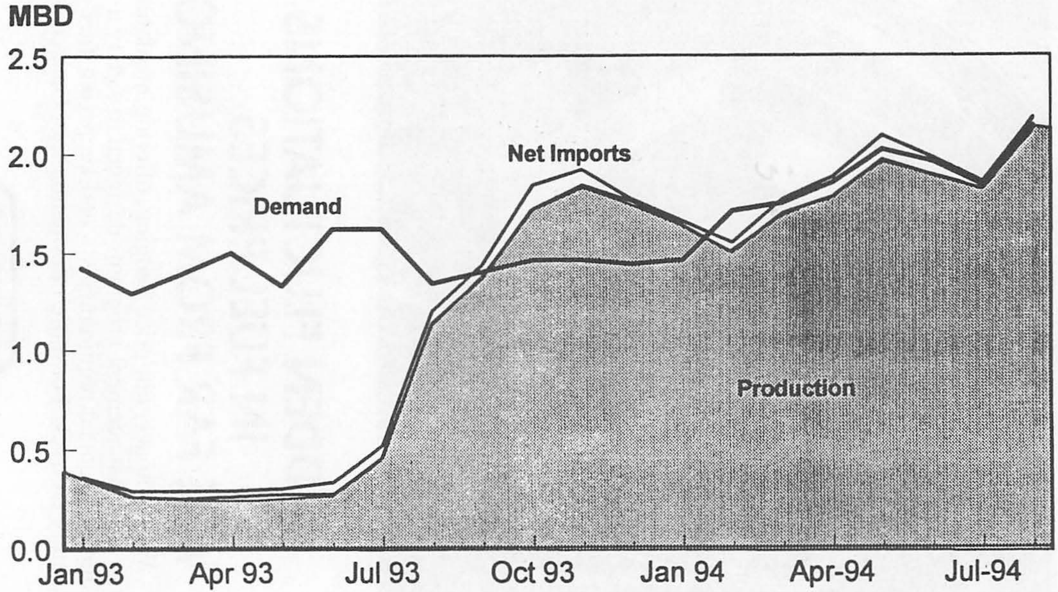
- Diesel demand for over last 10 years
  - + Highway use has grown 3.5% per year
  - + Non-highway use has contracted 2% per year

Cost Differences for Reducing Sulfur Among Refinery Size Groups

Refinery Size (kBD)	Operating Expense (CAG)	Capital Service (CAG)	Total Cost (CAG)
30 to 100	1.0	3.2	4.2
100 to 200	0.9	1.9	2.8
Over 200	0.7	1.1	1.8
Total U.S.	0.9	2.2	3.1

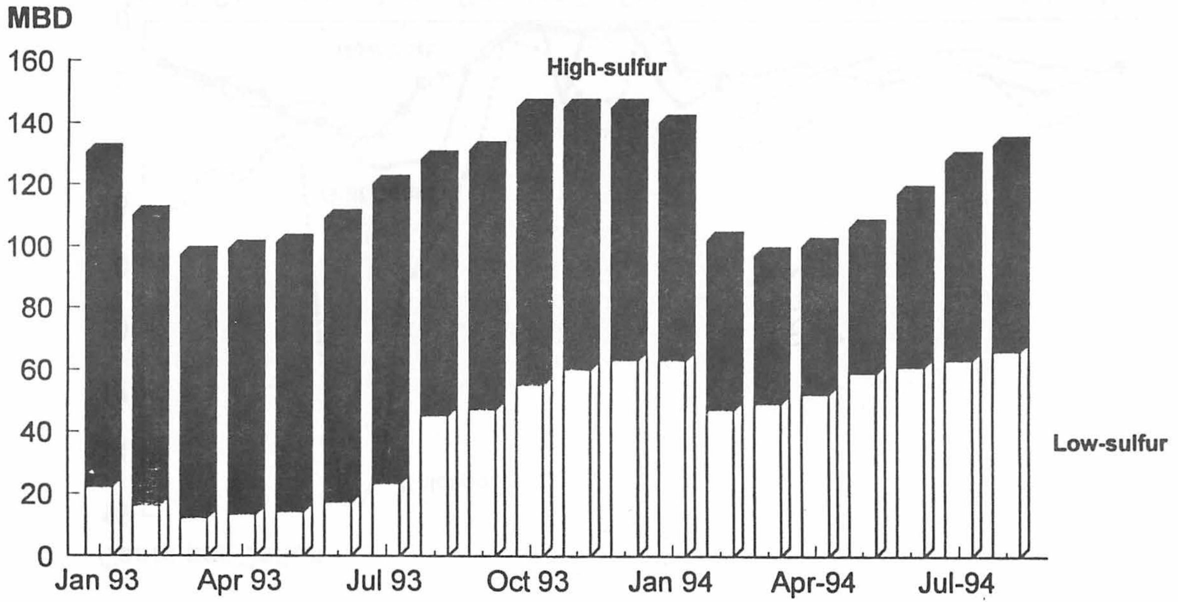
SOURCE: National Petroleum Refiners Association

Low-Sulfur Diesel Fuel Supply and Demand



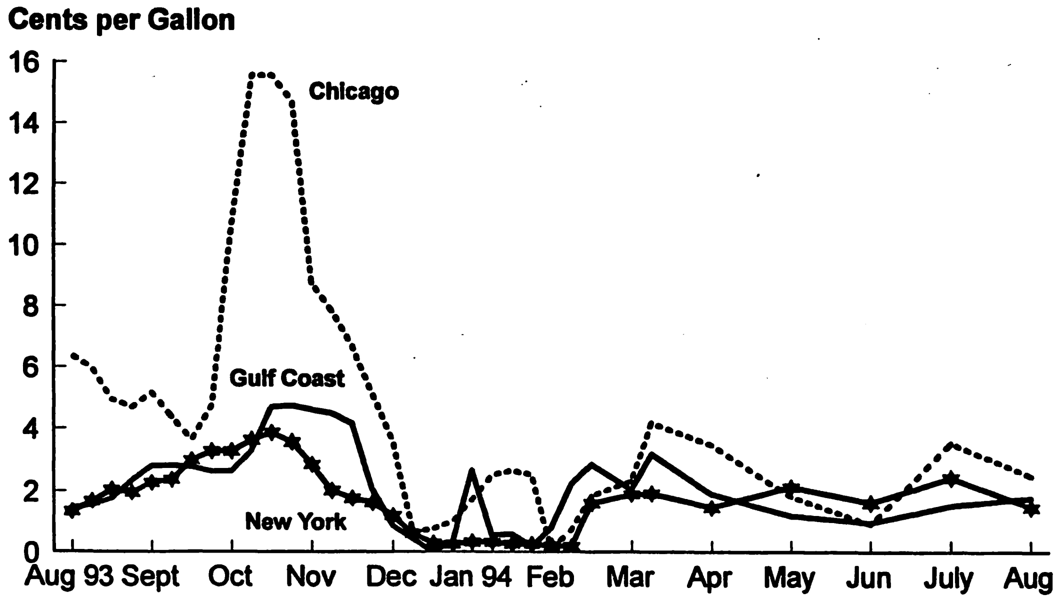
SOURCE: U.S. Department of Energy

Middle Distillate Inventories by Sulfur Content



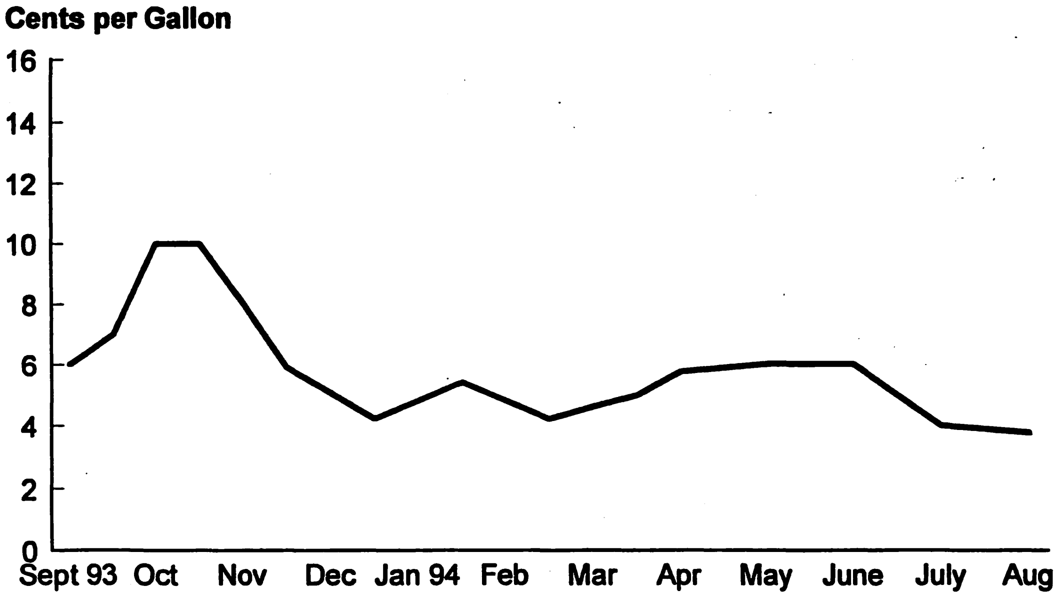
SOURCE: U.S. Department of Energy

Low-Sulfur Diesel Price Premium



SOURCE: J. P. Morgan

CARB Diesel Price Premium to Low-Sulfur



SOURCE: J. P. Morgan

Conclusion

- Supply will remain ample for the foreseeable future
- Annual cost to U.S. consumers: $600M to $1,500M
- Refiners' choices reflect regional regulations and demand
  - + Large refiners have high degree of desulfurization capacity already in place
  - + Independents add capacity ahead of regulation deadline
  - + Capacity exceeds anticipated demand over next few years
- Demand for LSD indirectly reflects industrial activity
  - + Moderate economic growth suggests LSD demand increases 3% - 4% annually
  - + Incremental impact of NAFTA concentrated in Southwest
  - + HSD demand growth more modest
- Little impetus for energy issues in federal government
- Highway engine problems in California are probably overstated

DIESEL MECHANICAL MAINTENANCE COMMITTEE THIRTEEN YEAR INDEX

1993

1. EMD's Three-Axle Radial Steering Truck
2. The Natural Gas Locomotive at BN RR
3. Locomotive Waste Oil Retention
4. Fragmented Maintenance

1992

1. Mechanical Quality Progress Developing on Major Railroads.
2. Coal Fuelled Diesel Locomotive Development.
3. 18:1 Upgrade for the 645E Engine
4. Automatic Stop and Start Control System
5. Acquiring Locomotives for Regionals and Shortlines.

1991

1. Recommended Practices for upgrading 567 to 645 Design.
2. Conversion of SD40 Locomotives to SD 40-2 on CSX.
3. Update: Diesel Engine Emission Controls.
4. Stationary and Dynamic Test Procedure for Locomotive Fuel Efficiency measurement.
5. Personnel training on New Technology.

1990

1. Caterpillar Power in Remanufactured Locomotives.
2. The EMD 710G3A Engine
3. Improving Performance of Traction Motor Friction Suspension Bearings.
4. Fluid Leaks on GE 7FDL Engine.
5. Rebuild of the EMD F3B Fuel Injector.

1989

1. Wheel Axle Gear Wear/Impact on Traction Motor Life.
2. 710 Engine - Operational and Overhaul Update.
3. GE Power Assembly Improvements on Welded Head-to-Liner
4. Assembly Rework Procedures.
5. EMD Engine Oil Leaks.
   Secondary Air Filtration - Barrier vs. Impingement.

1988

1. Low-idle Operating Costs vs. Fuel Savings.
2. Rebuilding GE's EB Liner.
3. The Extended Maintenance Truck
4. Flange Lubricator Update.
5. Permaspray II - Cylinder Liner.

1987

1. EMD Water Pump Rebuilding.
2. On Board Flange Lubricators.
3. Gear Case, Bull Gear and Pinion Gear Longevity in the 1980's - Gear Cases - Canadian National Experience.
4. Maintenance of Locomotive Fueling Systems for a Spill Free Operation.

1986

1. Rebuild of Valve Bridge Assemblies.
2. Update of New Locomotive Service Problems, EMD and GE Effecting Quality Performance.
3. Chromium Plating and Its Uses.
4. Development of a New Diesel Engine for Heavy-Duty Locomotive Service.

1985

1. Procedures for Storing Serviceable Locomotives for Quality Performance.
2. New Locomotive Service Problems, EMD and GE.
3. 92 Day Service Requirments: EMD, GE and Bombardier.

1984

1. Mechanical Aspects of New Locomotive Designs.
2. Maintenance of Locomotive Components.

1983

1. Leaks: Cooling Water, Lube Oil, Fuel Oil and Air.
2. Torquing Recommendations.
3. Update on Fuel Efficient Locomotives.
4. Radiator Screens
5. Alternate Starter Systems

1982

1. Fuel Conservation - Effects on Maintenance.
2. Fuel Conservation - What It Costs.
3. Diesel Fuel Receipt and Disbursement.
4 Turbochargers.

1981

1. Running Gear.
2. Filtration.
3. FRA Rules.
4. Follow-up on Previous Topics.

SHOP EQUIPMENT COMMITTEE
THIRTEEN YEAR INDEX

1993

1. Dynamic Balancing for GE Dash 8 Model Locomotives
2. Air Compressor Automated Station
3. Ergonomics in the Work Place
4. Hydraulic Traction Motor Shimming Table

1992

1. Automated Test and Production Equipment
2. Safety Corrective Action Team
3. Automated Locomotive Wheel Shop
4. Cleaning and Surface Preparation with Sodium Bicarbonate Based Abrasive Blasting
5. Trainline Continuity Tester
6. BN - Railroad Power Assembly Shop of the 1990's.

1991

1. Economic Separation of Emulsified Oil from Waste Water Using Ultra Filtration Membranes.
2. EMD Cylinder Head Valve Seat Machining.
3. Automated Barring Over Machine for EMD Diesel Engines.
4. New Equipment for Testing EMD Engine Protectors.
5. Compressed Air for Railroad Facilities Issues and Solutions to Achieve Clean, Dry, Oil Free Air.

1990

1. EMD Valve Bridge Machine
2. GE Traction Motor Roller Suspension Bearing Replacement Equipment and Procedure.
3. Locomotive Component Replacement Forklift Attachment.
4. Locomotive Sanding, Fueling and Drop Tables.
5. Hazardous Waste Disposal.

1989

1. Automated Locomotive Wheel Shop.
2. Laser Guided Material Handling Vehicles.
3. Bulk Rail Lubrication Storage & Fill System.
4. Pilot Plate Straightening Equipment.

1988

1. Fuel Management Control Systems.
2. Locomotive Mounted Rail Lubrication Fill Systems.
3. Comparison of Shop Air Compressors.
4. Locomotive Toilet Servicing Equipment.
5. Innovations in Blue Flag and Derail Protection.

1987

1. Modern Servicing Facility for Improved Reliability and Availability.
2. New Developments in GE Tools.
3. Implementation of a Quality Process.
4. A Quality Traction Motor Shop.
5. Wheel Truing Machine Technology.

1986

1. Robotics Update 1986 - Now What?
2. CNC Machine Tools.
3. A New GE Power Assembly Area.
4. Locomotive Wash System - 1986.

1985

1. Computer-Assisted Preventative Maintenance.
2. New Tools for Material Handling and Overview of Balancing Technology.
3. Effect of Governmental Regulations on Locomotive Finishing.

1984

1. Shop Tools.
    A. New Tools.
    B. Shop-Made Tools.
2. Traction Motor Shop Equipment Up-Date.
3. Hazardous Waste Handling and Disposal.

1983

1. Locomotive Maintenance Using a Production Line Process.
2. Shop Tools to Increase Productivity and Improve Quality.
3. Dynamic On-Line Performance of Locomotives Without On-Board Tele-Metering.
4. Management in Action.
5. New GE Training Center.
6. Welding Qualifications.

1982

1. Tools.
2. Rebuild line for EMD turbochargers.
3. Air brake equipment line.
4. Industrial robots.
5. Automated machines.
6. Safety related items and equipment.

1981

1. Training Aids.
2. Testing Devices Inspired by New FRA Laws.
3. Tools and Training for Productivity.
4. Changes to Shop Facilities Required by Newly Adopted EPA & OSHA Regulations.
5. Tour Through Conrail Altoona Shop.
6. Supply/Service Facilities.
7. GE Assembly Shop.

DIESEL ELECTRICAL MAINTENANCE COMMITTEE THIRTEEN YEAR INDEX

1993

1. Automatic Engine Shutdown and Restart System
2. Layover Systems/Standby Power Systems
3. CN North America - Electronic Temperature Control
4. Speed Sensing Devices
5. Adhesion Alternative
6. Modern Tooling Update

1992

1. Nickel-Cadmium Batteries as an Alternative
2. Overview of Locomotive Microprocessor Based Controls
3. Locomotive Air Conditioning
4. Testing Traction Alternator Fields on EMD Loocmotives
5. Flange Lubricators

1991

1. Locomotive Rebuilding - Something Old - Something New.
2. Standardization of Electrical Equipment.
3. Locomotive Batteries
   a. Storage Handling Procedures.
   b. Recommended Maintenance Procedures.
   c. Recommended Repair Procedures.
4. Amtrak's AC Traction Locomotives.
5. Modern Tooling for Electricians

1990

1. Modern Tooling of Electrical Troubleshooting.
2. Maintaining Solid State Event Recorders.
3. Why Can't We Have One Central Computer?
4. EPA and Regulation Driven Cleaning.

1989

1. Modern Tooling for the Troubleshooting Electrician: a) test meters available (single function); b) test meters available (multiple functional); c) analysis and diagnostic tools.
2. Sound Electrical Repairs and Practices for: a) traction motors; b) grids and fans; c) wire and cable solderless termination.
3. Guildelines for Preparing Electricians for the 1990s.

1988

1. Utilizing Magnetic Tape Event Recorders for Locomotive Maintenance.
2. Solid State Locomotive Data Recorder.
3. Improved Utilization of GE DASH 8 Data Recording Systems.
4. Locomotive Health Data and Its Uses To The Railroad.
5. Improved Data Acquisition From EMD's 60 Series Display Computer.

1987

1. Proper Maintenance of Electrical Fuel Savings Options.
2. Preliminary Report on AAR Traction Motor Study.

1986

1. Cleaning, Handling & Storage of Electrical Equipment
   A. Solid State Components.
   B. Rotating Equipment
2. Qualification of Locomotive Power plants through self load.

1985

1. Locomotive Microprocessor Technology in Retrospect.
2. Dynamic Brake Protective Devices and Troubleshooting EMD-2 and GE-7 Locomotives.
3. Indicators and Recorders for Locomotive Retrofit Application - Fuel, Speed, Power and Selected Events.

1984

1. On-Board Diagnostics.
2. GE's CATS (Computer Aided Troubleshooting System).
3. Fuel Conservation Through Electrical Modifications.
4. Performance of Locomotives After Storage.

1983

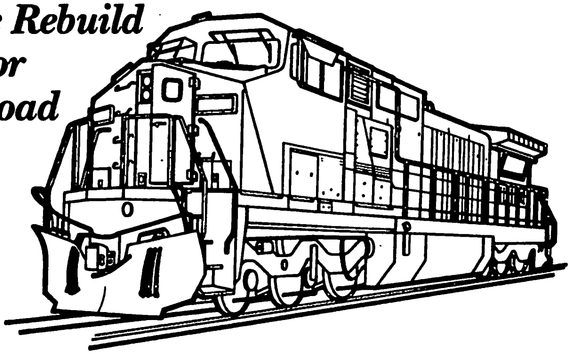
1. Ground Relay Trouble Shooting.
2. Specification for remanufactured D87 Traction Motor Frames (Using D-77 Armature Coils)
3. Locomotive Storage (Electrical).
4. Water Cooling and Refrigerating Methods for Locomotive Cab Application.

1982

1. Tests on Traction Motors.
2. Transition Trouble-Shooting.
3. Onboard Diagnostic Systems.
4. Starting Systems.

1981

1. Evaluation of Improved Test Methods.
2. Teflon Bands.
3. New Generation Locomotives.
4. Electrical Troubleshooting.
5. Batteries and Charging Systems.
6. Troubleshooting EMD AC Auxiliary Generator System.
7. Selection of Locomotives for Major Locomotive Overhauls.



NEW DEVELOPMENTS COMMITTEE ELEVEN YEAR INDEX

1993

1. New Technology to Solve Old Problems
2. Developments in Off-Shore Technology
3. Updates on AC Traction Developments

1992

1. Talking to the "Smart' Locomotive
2. Cab Noise Abatement
3. Electronic Management of Locomotive Drawings
4. Update on High Productivity Integral trains
5. AC Traction - A New Development

1991

1. Locomotive Cab Integration and Accessory Management
2. Improvements in Locomotive Adhesion Performance.
3. The Role of Duty cycles in Locomotive Fuel Consumption.
4. What's New in Gadgets and Black Boxes: What do our Locomotives Really Need?
5. Failure Analysis

1990

1. Motor Driven Air Compressors for Diesel-Electric Locomotives
2. Locomotive Cab (HVAC) Heating, Ventilation and Air Conditioning Systems.
3. Effect of Technology on Standardization of Cab Control Equipment.
4. Locomotive Durability, Reliability and Availability - Understanding Your Abilities.

1989

1. A Rational Approach to Testing Locomotive Components.
2. New Developments in Locomotive Cab Design.

1988

1. Amtrak F69 PH AC Passenger Locomotives
2. New Component Developments Retrofittable to Older Model Locomotives
3. Locomotive Applications of Catepillar Engines.
4. Wheelslip Control for Individual Axles.

1987

1. Electronic Fuel Injection Systems.
2. Update on Electronic Governors.
3. Recent Advances in Steerable Locomotive Trucks - the E.M.D. 4 Axle, 4 Motor HT-BB Articulated Truck.
4. Converting an F40 Locomotive to A.C. Traction.

1986

1. Future Train Control Systems.
2. Bringing Future Train Control Systems Back to Earth.
3. Low Maintenance Locomotive Batteries.
4. Electronic Engine Control Systems.

1985

1. The Sprague Clutch for E.M.D. Turbocharged Engines.
2. A.C. Traction Locomotives Update.
3. Natural Gas Locomotive Update.
4. Ceramic Coated Engine Components.
5. Locomotive Cab Developments.

1984

1. G.E. Dash 8 Locomotives.
2. E.M.D. 50A Series Locomotives.
3. Natural Gas Locomotives.
4. Appraisal of the A.C. Traction Locomotive.

1983

1. Microprocessors for Locomotive Control and Self Diagnosis.
2. Locomotive Fuel Tank Gauges.
3. Locomotive Aerodynamics
4. Bombardier HR 616 Locomotive.
5. Missouri Pacific - Phase III Locomotive Heavy Repair Facility, N. Little Rock, Arkansas.

FUEL, LUBRICANTS AND ENVIRONMENTAL COMMITTEE
THIRTEEN YEAR INDEX

1993

1. Used Oil Analysis of Multigrade Oils and Condemning Limits.
2. Insoluble Determination with the Advent of Multigrade Diesel Engine Oils
3. Bioremediation.

1992

1. Environmental Issues Relating to Multigrade Railway Issues.
2. Readily Biodegradable and Low Toxicity Railroad Track Lubricants
3. Support Bearing Oils.
4. Recycling and Re-refining Locomotive Oils.

1991

1. Infrared Spectroscopy as an Analytical Tool.
2. Diesel Exhaust: Health Effects Research and Regulations.
3. Traction Motor Gear Case Seals and Lube Containment (Oil Lubricant)
4. Partnership in Development.

1990

1. The Responsibility of Railroads and Facility Managers in the Handling and Disposal of Hazardous Materials.
2. Update on Diesel Fuel Regulations.
3. Diesel Exhaust and Worker Exposure.
4. Field Experiences with Multigrade Railroad Locomotive Oils.
5. Conrail Wheel/Rail Lubrication Update.

1989

1. Field Test Data Follow-Up and Description of "Generation 5" Locomotive Crankcase Oil.
2. Diesel Emissions: Regulations and Fuel Quality.
3. Petroleum Storage Tank Regulations - Guest Speaker - George Kitchen, International Lube & Fuel Consultants.

1988

1. Used Oil Analysis and Condemning Limits.
2. Review of A.A.R. Procedure RP - 503, "Locomotive Diesel Fuel Additive Evaluation Procedure."
3. Update on Improved Oils - Multigrade.
4. Wheel Flange Lubrication Update - Lubricants Being Used.
5. Survey of Disposable Practices for Locomotive Engine Lube Oil and Lube Oil Filters.
6. Speaker on Overview of Environmental Requirements for The Use of Petroleum Products in The Railroad Industry - Peter Conlon - AAR.

1987

1. Common Fuel Additives and their Effectiveness.
2. History of LMOA Lubricating Oil Classification System.
3. Performance Requirements Needed by the Railroads for a New Generation Lube Oil.
4. How do we Provide the Performance Needed for a New Generation Oil.

1986

1. Extended Performance Lubricants Through Better Chemistry.
2. Fuels and Lubricants Handling Hygiene.
3. Fuels Availability and Price Outlook.
4. Selection of Lubricants for Wheel Flange and Rail Lubricators.

1985

1. Disposal of Lube Oil Drainings.
2. Non-ASTM No. 2 - D Fuel.
3. Oxidation Analysis.
4. Wheel Flange and Rail Lubrication.

1984

1. Locomotive Filters
2. Traction Motor Gear Lube Field Test.

FUEL, LUBRICANTS AND ENVIRONMENTAL COMMITTEE THIRTEEN YEAR INDEX

1983

1. Field Test Update of Mulitgrade Oils.
2. Update of Alternate Fuel Testing.
3. A Review of Locomotive Fuels.

1982

1. Energy Conserving Lube Oils.
2. Alternative Fuels Update.
3. Availability of Medium and High Viscosity Index Railroad Oils.
4. Journal Box Oil and Aniline Point.
5. Traction Motor Gear Lubricant Update.
6. Traction Motor Gear Case Seals.

1981

1. Effects of Using Alternate Fuels on Existing Diesel Engines.
2. Update on Cold Weather Procedures for Fuels.
3. New Techniques in Lube Oil Analysis.
4. Traction Motor Gear Lubrication.
5. Multi-Viscosity Oils as an Energy Conservation Technique.

DIESEL MATERIAL CONTROL COMMITTEE THIRTEEN YEAR INDEX

1993

1. Technology Transfer
2. Electronic Cataloging from a Material Perspective
3. Computerized Reordering from the Mechanical Employee's Point of View
4. Electronic Catalogues: OEM/Supplier Point of View

1992

1. Warranty Overview and Issues
2. Recycling - 1992
3. Bar Coding
4. Material Packaging

1991

1. The World of Recycling.
2. Problems with Solutions.
3. Problems with Opportunities.

1990

1. Waste Minimization.
2. Hazardous Materials End Cost
3. The Role of the Suppliers.

1989

1. Packaging and Containerization for Today's Railroad.
2. Innovations in Material Distribution Resulting from Shop Consolidations.
3. Outsourcing! Does Anyone Really Understand the Difference Between UTEX and Repair and Return and the Affect on the Budget?
4. "Stuff" Happens! - A Skit About the Necessity of Feedback from Suppliers - Suppliers to the end User.

1988

1. Communication - The Vital Link in Materials Acquisition.
2. Quality Assurance Through Communications and Feedback.
3. Paperless Requisitions.
4. A Practical Application of Bar Coding in the Railroad Industry.

1987

1. Suppliers Selection for Component Failure Analysis.
2. Vendor Perforance or Service Level.
3. Bar Codes.
4. Bar Coding - Railroads
5. Material Handling Innovations by the Airline Industry.

1986

1. The In-House Electronic Requisiton System.
2. Electronic Data Interchange.
3. RAILING and Electronic Purchasing.
4. Quality Evaluation of Material Sourcing Decisions.

1985

1. Evaluating Locomotive Maintenance Projects.
2. Reconditioning Material: In-House vs. Vendor.
3. Identification and Disposition of Surplus Material.
4. Cost of Carrying Surplus.
5. Evolution and Future Directions of Material Handling Equipment in Railroad Use.

1984

1. Bar Coding of Material.
2. Forcasting Material Requirements.
3. a. Fuel Security - Are You Getting What You Pay For?
   b. Fuel Oil Is Expensive.
4. Pros and Cons of Material Purchasing Contracts (Single Source - Just In Time Inventory).

1983

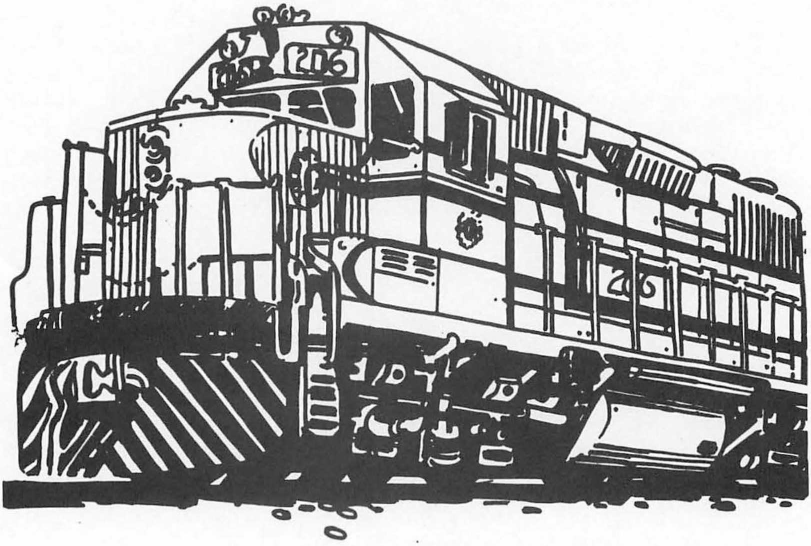
1. Improved Locomotive Productivity Through Computerized Data.
2. Inbound Material Inspection.
3. Minimize Maintenance Cost Through Material Management Systems.
4. New Ideas In Material Storage Containers.

1982

1. Use of kits in locomotive maintenance.
2. Cost effective methods of shipping material from vendors.
3. Union Pacific's Component Inventory Maintenance System (CIMS).
4. Advantages of using shipping containers.

1981

1. Disposal of Unserviceable Component Parts: What is the Most Profitable Method?
2. Innovations in Stores Material Handling, Via Computer Technology.
3. Locomotive Held for Material: an Update for the 80's.
4. The Best Approach to Procuring Material; New, UTEX, Repair and Return or Shop Repair.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CONSTITUTION AND BY-LAWS LOCOMOTIVE MAINTENANCE OFFICERS ASSOCIATION

Article I - Title:

The name of this Association shall be the Locomotive Maintenance Officers Association (LMOA).

Article II - Purpose of the Association

The purpose of the Association, a non-profit organization, shall be to improve the interests of its members through education, to supply locomotive maintenance information to their employers, to exchange knowledge and information with members of the Association, to make constructive recommendations on locomotive maintenance procedures through the technical committee reports for the benefit of the railroad industry.

Article III - Membership

Section I - Active Railroad Membership shall be composed of persons employed by a railroad company and interested in locomotive maintenance. Membership is subject to approval by the Board of Directors.

Section 2 - Associate Membership shall be comprised of persons employed by a manufacturer of equipment or devices used in connection with the maintenance and repair of motive power, subject to approval of the Board of Directors.

Associate members shall have equal rights with active members in discussing all questions properly brought before the association at the Annual Meeting, but shall not have privilege of voting or holding elective office.

Section 3 - Honorary Membership: Honorary Membership may be issued at the discretion of the President, subject to the approval of the Board of Directors. Honorary Members may not vote or hold elective office; all Honorary Membership shall expire at the end of the current membership year.

Section 4 - Life membership shall be conferred on all Past Presidents. Honorary life memberships shall be conferred on others for meritorious service to the Association, subject to approval by the General Executive Committee.

Section 5 - Dues and Fees: Membership dues for individual active and associate membership shall be set by the Board of Directors and shall be payable on or before September 30th of each year. The membership year will begin on October 1 and end September 30. Life and honorary life members will not be required to pay dues. Members whose dues are not paid on or before the opening date of the annual convention shall not be permitted to attend the annual meeting, shall not be eligible to vote and/or shall not be entitled to receive a copy of the published Pre-Convention Report or the Annual Proceedings of the annual meeting. Failure to comply will result in loss of membership at the end of the current year. A registration fee will be set by the Board of Directors for those attending the annual meeting. Life, life honorary, and honorary members will be entitled to receive a copy of the Pre-Convention Report and Annual Proceedings.

Article IV - Officers

Section 1 - Elective Officers of the Association shall be President, First Vice President, Second Vice President and Third Vice President. There will be one Regional Executive for each technical committee. Each officer will hold office for one year or until successors are elected. In the event an officer leaves active railroad service, he may continue to serve until the end of his term.

Section 2 - Board of Directors: There shall be a Board of Directors composed of the President, Vice Presidents, and all Past Presidents in active official railroad service. In the event a member of the Board of Directors becomes inactive, he may continue to serve until the end of his term of office.

Section 3 - General Executive Committee: There shall be a General Executive Committee, composed of the Board of Directors, the Regional Executives, and the Technical Committee Chairpersons.

Section 4 - Secretary-Treasurer: There shall be a Secretary-Treasurer, appointed by, and holding office at the pleasure of the Board of Directors, who will contract for his or her services with appropriate compensation.

Section 5 - Advisory Board - There shall be an Advisory Board composed of at least nine members, who are Senior Mechanical Officers, Assistant Vice Presidents or Vice Presidents. They will be invited by the Board of Directors and serve as ex-officio members of the General Executive Committee without vote.

Article V - Officer, Nomination and Election of

Section 1 - Elective officers shall be chosen from the active membership. The nominating committee, composed of the Board of Directors, shall submit the slate of candidates for each elective office at the annual convention.

Section 2 - Election of officers shall be determined by a voice vote, or if challenged, it shall require show of hands.

Section 3 - Vacant offices. Vacancies in any elective office may be filled by presidential appointment, subject to approval of the Board of Directors.

Article VI - Officers - Duties of

Section 1 - The President shall exercise general direction and approve expenditures of all affairs of the Association.

Section 2 - The First Vice President, shall in the absence of the President, assume the duties of the President. he shall countersign all expenditures of the Association and be responsible for preparing and submitting the program for the Annual Meeting.

The Second Vice President shall be responsible for selecting advertising. He will coordinate with the Secretary-Treasurer and contact advertisers required to underwrite the cost of the **Annual Proceedings.**

The Third Vice President will be responsible for maintaining a strong membership in the Association. He will ensure that membership applications are properly prepared and distributed, monitoring membership levels and reporting same at appropriate time to the General Executive Committee.

Section 3 - The Secretary-Treasurer shall:

A. Keep all the records of the Association.

B. Be responsible for the finances and accounting thereof under the direction of the Board of Directors.

C. Perform the duties of the Secretary of the Board of Directors, Nominating Committee, and General Executive Committee, without vote.

D. Furnish surety bond in amount of $5000 on behalf of his/her assistants directly handling Association funds. Association will bear the expense of such bond.

Section 4 - The Board of Directors shall be responsible for the following duties:

A. Assist and advise the President in long-range Association planning.
B. Contract for the services and compensation of a Secretary-Treasurer.
C. Serve as the Nominating Committee.
D. Serve as the Auditing and Finance Committee.
E. Determine the number and name of the Technical Committees.
F. Exercise general supervision over all Association activites.
G. Handle all matters of Association business not specifically herein assigned.
H. The Vice President shall perform such other duties as are assigned them by the President.
I. Those present at any meeting called on not less than thirty days advance written notice, shall constitute a quorum.

Section 5 - There will be one Regional Executive officer assigned to each technical committee. Their duties wil consist of:

A. Participate in the General Executive Committee meetings.
B. Monitor material to be presented by the technical committees to ensure reports are accurate and pertinent to the goals of the Association.
C. Represent LMOA in their respective regions.
D. Promote Association activities, especially those held within their assigned region and monitor membership activities on those railroads so assigned.
E. Promote and solicit support for LMOA by helping to obtain advertisers.

Section 6 - Duties of General Executive Committee:

A. Monitoring technical papers for material considered unworthy or inaccurate for publication.
B. Approve topics for the **Annual Proceedings** and Annual Meeting program.
C. Approve the schedule for the Annual program.
D. Administer all Association activities not specifically assigned to the Board of Directors.

Section 7 - The Advisory Board shall act in a consulting capacity. Past Presidents still in official active railroad service shall automatically become members of the Advisory Board.

Section 8 - The Board of Directors are entrusted with all public relation decisions within LMOA and coordinated associations with confidentiality.

Article VII - Technical Committees

The technical committees will consist of:

Section 1 - A chairperson, appointed by the President and approved by the Board of Directors.

Section 2 - A vice chairperson, selected by the chairperson and approved by the President.

Section 3 - Committee members will be made up of:

A. Representatives of operating railroads and regional transit authorities submitted by their Senior Mechanical and Materials Officers and approved by the President of LMOA.
B. Representatives of locomotive builders designing and manufacturing locomotives in North America.
C. The Fuel and Lube Committee will include members from major oil companies or their subsidiaries as

approved by the General Executive Committee.

D. At the discretion of the General Executive Committee, non-railroad personnel may be allowed to participate in committee activities, subject to annual review.

E. All individuals who are on technical committees must be LMOA members in good standing. (See dues and fees, Article 3, Section 5).

Subjects for technical papers will be selected and approved by the General Executive Committee.

Article VIII - Proceedings

The Locomotive Maintenance Officers Association encourages the free interchange of ideas and discussion by all attendees for mutual benefits to the railroad industry. It is understood that the expression of opinion, or statements by attendees in the meeting, and the recording of papers containing the same, shall not be construed as representations or statements ratified by the Association.

Article IX - Rules of Order

The proceedings and business transactions of this Association shall be governed by Roberts Rules of Order, except as otherwise herein provided.

Article X - Amendments

The Constitution may be amended by a two-thirds vote of the active members present at the Annual Meeting.

Article XI - The Constitution and By-Laws have been amended at the Annual Convention on September 19, 1988.