LMOA

Locomotive Maintenance Officers Association

Proceedings of the 50th Annual Meeting
Chicago, September 18-22, 1988

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TECHNICAL PAPERS

JOINT MEETING OF COORDINATED ASSOCIATIONS Monday Morning, September 19, 1988

The Joint Meeting of the Coordinated Associations held at the 1988 Technical Conference of the Coordinated Mechanical Assocations convened at 9:10 o'clock in the International Ballroom of the Chicago Hilton and Towers, Chicago, Illinois, with Mr. Robert G. Buffalow, President, R.F.&O.O.A. and Supervisor Air Brakes, D&RGW R.R. Company, presiding as the Chairman.

CHAIRMAN ROBERT G. BUFFALOW: Gentlemen, would you please take your seats so we can get the proceedings started.

Good morning. My name is Bob Buffalow. I am Superintendent, Air Brakes and Grand President this year of the Railway Fuel and Operating Officers' Association.

I would like to welcome you and it is good to see such a large turnout. You know, for the past few years it has been kind of like the weather outside today, it has been a little gloomy. But as we all know now, I think we have seen a break in the clouds and have a whole lot to look forward to.

But this morning we have the four organizations who will try to present some programs to you gentlemen in the next three days that will both enlighten you, educate you and give you something to take back to your home management, so that you can tell them they have done a fine job and we would like to see more participation from our members in the organization.

As you all know, we need the membership. We are all down. And I think that is the name of the game this morning, is to try to interest management and others to get more active participation into it.

This morning's invocation will be given by Rev. Thomas J. Dove, Pastor, Old St. Mary's Catholic Church here in Chicago. Reverend.

REV. THOMAS J. DOVE: Lord, as we begin the Twenty-seventh Annual Convention of the Railway Supply Association, may we remember and pray;

Grant that my train will always run on a smooth bed with its rails true to You;

Grant that I may ride "first class" even when I find the click-clack and baggage of life monotonous.

And Lord, if I happen to be running late you'll probably find me in the caboose;

However, if I seem to be stuck on a spur, let me have enough steam to blow my horn so You won't forget me.

Lord, grant Your blessings on all who are participating in this conference. We ask this through Christ, our Lord. Amen.

CHAIRMAN BUFFALOW: Thank you, Father Dove.

It's really a pleasure for me to be here this morning. And as I sat in one of the sessions out there with you gentlemen, little did I think I would ever be standing before you. But regardless however much it is a pleasure, it is also a little scary up here. I hope you can appreciate that.

In the opening of the conference this morning I am the representative of the four organizations as I mentioned before. And these four organizations as far as I am concerned have done so much in arranging for speakers and the free technical knowledge that transpires between all of us, not only in the sessions, but in our daily grouping with each other. There's just much to be gained for everybody from each other to everybody.

And with that, I think it has kind of been the backbone that has made the transportation of this country what it is today. But there is something else other than just technical knowledge. We can't do it without the tools. And who supplies the tools? Well, our hosts today, the Railway Supply Organization. For without their tools the knowledge we have would be just useful information and be the tools be a switch liner or locomotive or a boxcar or a handcar, we have to have the tools to do the job we do.

Now before I introduce our keynote speaker this morning, Mr. Larry Parsons, I would like to introduce the gentlemen here at the head table.

Mr. Bob Hulick, President of the Air Brake Association and Vice President Equipment, Trailer Train Company.

Robert, please stand, and hold your applause, if you will please.

D.G. Goehring, President, Locomotive Maintenance Officers' Association, Manager Locomotives, Heavy Maintenance, National Railroad Passenger Corporation.

R.L. Johnson, President, Car Department Officers' Association, Assistant Vice President, Car, Chicago and North Western Transportation Company.

Mr. D.A. Peterson, President, Railway Supply Association. (Applause)

And I forgot one here, Mr. Donald M. Tutko, Chairman of the Committee of the Coordinated Association and Assistant to the President, Equipment Group, CSX Transportation. (Applause)

Now as to our keynote speaker this morning, it is a great pleasure for me to introduce my boss and I hope friend, because it sure helps to have somebody who is a friend higher up in that echelon.

Larry has been around the railroad for quite a while. I met Larry way back when he came up one time in a small mountainous area we have where I was trainmaster and he relieved me. And then the mines all went on strike and he didn't do anything for three months while I was back here in Chicago.

Larry is Vice President of Operations, Denver and Rio Grande Western Railroad Company. And as you know, he is going to become a very, very moving force in the acquisition we are making of a similar outfit that is out on the West Coast that we should acquire about the 12th of next month. The check passing is supposed to take effect then. Whether it will or not, I don't know, maybe we will lose another oil well and can't afford it.

So would you please welcome Mr. Larry Parsons. (Applause)

MR. LARRY R. PARSONS: Thanks, Robert.

Someone up here on the podium and I won't say who, suggested I stand behind the screen and make my presentation. And I hope, my representation being large and ugly that is not the reason most of you are sitting in the back of the hall.

It's nice to be here in Chicago this morning, though, because when you are sharing a sense of loss it's nice to be with those who share a sense of loss. I assume a great number of you are from Chicago this morning. Being from Denver it is easy to relate.

Mr. Buffalow's political success and the penalty attached with it did not really dawn on me until this morning. But it's really a privilege to be able to address this group this morn-

ing because this group represents in my opinion the future of this industry in terms of what we can do.

The late Jim Gastner, President of the Missouri Pacific addressed this same group in 1980. Mr. Gastner at that time spoke of the Staggers' Act and the promise of the Staggers' Act in deregulation. I remember at that point in time the Staggers' Act was a month old. Mr. Gastner concluded the promise of the Staggers' Act in deregulation had to be diversion of traffic from the other modes. Unfortunately those other modes were deregulated prior to the railroads and it has been a tough promise to try to keep.

I am not going to burden you with statistics about what deregulation has done to this industry. The Operating Officers here today know that better than I. John Riley at dinner last night told me that the Conference Committee this week in Washington is looking at the mark-up of a rework of the Staggers' Act. And generally speaking our industry has opposed that. I would guess that individually out there there might be some folks that aren't with management on that in this group, because deregulation has affected the operating departments that you represent in far different ways than any of us would have believed in 1980. I don't think there is a man or a woman associated with this industry that hasn't been surprised over the last eight years at what has happened to us.

I am not complaining about that. I think a lot of what has happened to us has been good. We have all done a lot of down-sizing. We have been a lot more creative and we are producing more for less today than any of us would have thought possible, I think, in 1980.

But if you are in the Operating Department, those ten miles drive your budgets. Those ten miles wear out the locomotives, burn the fuel, wear out the power, the wheels, the rails, et cetera.

And I will agree with one statistic. Ever since 1980 the revenue from that ten miles, which is roughly one-half of gross ten miles has been going down. In 1981 rounded off, the railroad industry received 3.2 cents per mile net ten mile. In 1987 that has fallen to 2.7 cents per net ten mile. A half a penny per net ten mile in that period.

Early statistics for the first half of 1988 indicate those numbers are still declining. So the Operating Department needs to do a lot of scratching for pennies. And the goal has to remain as it has in the last eight years to do more with less.

Other changes in our industry are not related to the Staggers' Act in my opinion. The C.M.W. recently with the help of the federal government, which I don't think they would have preferred, recently made a giant step forward in settling a crew issue. The workers were compensated before Staggers' and they certainly have been after Staggers and I am a heck of a lot more aware of mergers today than I was in 1980.

If you notice the program, Mr. Buffalow said out loud the Denver and Rio Grande Western Railroad Company and although that name may not receive top billing in the future the spirit that it represents will reemerge.

In 1980 no one was talking about paying for locomotives in terms of kilowatt-hours. I don't know of anyone on the car side that would predict that customers would be the major force in car acquisition in this country in place of the rail carriers.

A Class 1 railroad which is potentially controlled by a power leasing company entitled in 1980. They are one of the largest Class 1 railroads owned by an individual. These are changes which keep this industry

strong and keep us young or ageless depending on your point of view.

In reviewing the specific agenda for this conference, and looking for things I think will help us continue this battle, I sort of separated the categories into hi-tech and low-tech. And lo-tech I am more comfortable with than hi-tech because I understand it better. Also I think it is a hell of a lot easier to explain to a board of directors when you are trying to get them to make the investment.

The Brake Association and the Car Department start off with a joint session and there are three categories, UDEs, ABDX valves, and two-way communication. The UDE is something I think, that you gentlemen involved in that can solve or lower. It is sort of half a penny we are looking for in terms of prescheduling, less damage to customers' lading and a lot less damage to tearing up locomotives and cars. Obviously it won't be a total solution, but the ABDX valve is part of the solution.

End of train two-way communication I think is a good step forward for safety.

In the afternoon session the Brake Association gives hi-tech with microprocessor locomotive brakes. I asked Mr. Buffalow how you get a microprocessor to fibulate the blow the engineer feels comfortable with to know the brakes are set.

Magnetic train brakes, I don't understand magnetic train brakes, but it sounds like a good way to stop a train without heating the wheels and I like that.

Wednesday morning the Air Brake Association has an agenda called, "Remote Intervention Air Brake Actuation," which I initially thought was another name for UDEs. But I assume Mr. Schroeder of Collins is making the presentation, so I assume it is much more complicated than that.

The Car Department in the afternoon session has what I consider to be the most potentially rewarding topics of the conference. That's "The Accoustical Detection of Railroad Roller Bearing Defects." As long as I can remember this industry has lived with infrared detection for bearing failures and it saves this industry millions of dollars a year. However, we still spend millions of dollars a year in failed bearing derailments.

The worst, or equally bad, nine members indicate that for every ten trains we stop with a failed bearing alarm we are lucky to find one failed bearing. In terms of what that does to schedules and dispatchers is not measurable. So if this new technology can find a way to detect bearing failures, to get them out of the cars before we have to look at them with infrared to see excessive heat, those capital dollars will be easy to justify and quickly spent I would predict.

The morning session on Wednesday has a session on heat treated curved plate wheels. Mr. George Wade of AAR staff has done a great job in educating the OTEC committee. I know what that means to the industry in terms of money saved for changing wheels relative to discoloration from braking and if we can adequately convey that message to our friends in the FRA, I know John is listening and I see Mr. Joe Walsh who is on the Tuesday agenda, then again those are dollars quickly returned to this industry.

Mr. Buffalow's group, the Railway Fuel Operating Officers, I keep saying, I have to remind myself what those letters stand for, has a category which defies my ability to categorize it, the "Pictorial Railway Tour of Russia." There may be a return on investment on that presentation somewhear and I consider Ed Burkhardt a good friend and I'm sure Ed could probably refute the claim there is no return on his presentation but he'll have to show it to find out.

Tuesday afternoon, Dr. Rhine has a presentation called, "Remote Locomotive Performance Sensing and Motive Power Management Using Onboard Microprocessors." That's obviously hi-tech and I can only hope once that's in place there will be a correlated topic at some future session called, "Remote Locomotive Repairing." (Laughter)

I studied your agenda intently, the Locomotive Maintenance Officers Association. I hoped to find something called the elimination of locomotive failures enroute. I didn't find it.

Seriously, however, I think the locomotive side has made the greatest strides over these last eight years of any group here today. If you think about what wheel creep technology has done with the microprocessor on locomotives, those two things, I think, are extending the locomotive budget in some cases by a third over what we had eight years ago. But we need more of it. And there are some good variations on their agenda. Flange lubrication has hit more than one of these sessions in their group. Our studies indicate that wheel wear reduction alone would justify expenditures for lubricators in less than a year, the fuel savings in wheel wear reduction, et cetera.

Another session in this group, wheel slip control for individual axle. I am not sure who is giving it, but, thanks to the Canadian National and specifically Bill Scott, the Rio Grande has had great success in employing that approach to not only reducing fuel and locomotive requirements but improving safety.

Mr. Gill has in this locomotive group an open-ended session, the type of thing that allows transmitting of ideas and hopefully the generation of new ideas for future conferences.

Those are a few of the high points of the agendas for the next several days, the ones I thought were most important. Hopefully there are some of you there who think I am dead wrong and you have topics that are more important. And I hope you are right. And I further hope that you are able to bring those ideas to fruition because this industry needs them.

The suppliers who are exhibiting here at this conference, I think this industry owes to them a great deal of thanks for their research and development and innovation of new ideas, for their salesmen who keep knocking on our doors trying to explain the new approaches to us and helping us implement them. I see a couple of silly grins out there. I hope those are grins of accomplishments.

It is a symbiotic relationship to be sure. To the supply industry, it has been a rough eight years, to some I think even more than the railroads. But you guys, I think, are credited with the turnout at this convention today and hopefully we are going to see a bit of a renaissance for the remainder of this century.

To build market share was Mr. Gastner's hope for the rest of the century. It hasn't happened. If you look at the overview of statistics in terms of revenue share this industry has lost about five percentage points on revenue dollars in that eight-year period. That's the good news, so to speak.

The bad news is the revenue ten miles we have just about kept even. That is the half-cent I talked about earlier that reduced the rates to customers.

Deregulation I believe is here to stay and I think it's up to the railway operating officers and their suppliers to do more with less. What we have to do is supply customers with lower cost, quality, consistent services on a continuing basis so our sales and marketing organizations will continue to make rail transportation a part of the system and if we can do that, more with less, then I think we will set the stage as this decade ends with a firm foundation for railroading in the 1990s and in fact as this century ends, the foundation for railroading in North America in the twenty-first century.

You have a large part to play in firm those foundations are and over the next several days at this convention will hopefully firm those foundations up.

Mr. Buffalo. (Applause)

CHAIRMAN BUFFALOW: I don't know, what are we, hi-tech or low-tech? I never did get that one.

Now there is a gentleman to my left here I didn't introduce before. It was not oversight. But right now it gives me great pleasure to present Mr. John Riley from the FRA to make a few comments.

MR. JOHN RILEY (FRA): Just a very few, Bob, and I don't know how enlightened they are. I might add, by the way, in response to Larry's opening comment, being from Minnesota, I am having difficulty developing sympathy with the weather in Chicago. I don't know.

Larry spent a few minutes talking about the agenda for this meeting. I would like to spend about thirty seconds talking about its significance.

We no longer live in an era where the Interstate Commerce Commission is parcelling out shares, so much for rail, so much for trucks, so much to barge. Today and well into the next century we are going to have to compete for everything that we get. That's really what this conference is all about.

Don't lose sight of the fact that everything from the wage earned by the man or woman on the line to the stockholders' dividends depends on the effectiveness with which we compete.

The supply industry is the key to competition in the future. We talk a lot about the future particularly in this election year. But there is something very special about this event because we do not only talk about it but we are going to have an opportunity in about ten minutes to see it. When you go down to the first floor of this building and walk into it, you see what the future holds for this industry. It is a real pleasure Bob, to help out with that ribbon cutting.

I want to thank you and all the people holding this convention, conducting this convention for your hospitality to the FRA.

And if deregulation means nothing else, it means we are all here together. What it means is that now what we get in this industry we earn on our own terms. It is a partnership in the truest sense of the word. And I think it is symbolic when we cut that ribbon in a few minutes, you will have suppliers, you will have railroads, you will have government. The future is all about and it is fun to be here and celebrate it. Thank you very much. (Applause)

CHAIRMAN BUFFALOW: Well I am going to close this session and again, welcome you to Chicago. If you have a chance and you see a supplier out there, give him a pat on the back and say, thank you for sponsoring us and providing the things we will be able to do here for the next three days.

So with that I declare this session closed and we can now go to our own meetings. Thank you again and I hope to see you around in the next three to four days. (Applause)

(The meeting recessed at 9:40 a.m. o'clock.)

MONDAY, SEPTEMBER 14, 1987

PRESIDENT'S ADDRESS
By D. L. Ward

Distinguished Past Presidents, LMOA Officers and Committee Chairmen, LMOA Members, Ladies and Gentlemen. It is my pleasure to welcome each and everyone of you here today to the 1987 Locomotive Officers' Association's Technical Conferences. We are indeed pleased with the turnout and are looking forward to a very informative three days.

At this time, our schedule calls for me to give the President's address, and since we have quite a bit to accomplish this afternoon, I will attempt to keep it brief.

If I may, I would like to begin by reading the following headlines:

"UP Restructures Operating Ranks"
"Wisconsin Central Set For Start Up"
"Red River Valley And Western Launched"
"Rail Net Income Keeps Shrinking"

These headlines were taken from a recent railroad periodical. I selected them to begin my address to point out a fact that all of us are aware of, that we are working in an ever changing industry, and, this change is presenting each and every one of us with unprecedented challenges now, and will continue to do so in the future.

This year marks my fifteenth year in the railroad industry, and correspondingly, my fifteenth year as a member of the Locomotive Maintenance Officers' Association. No doubt, a fifteen year career is a short one compared to many of you seated here today. However, in that short fifteen years, many things have happened, and, as can be seen by the headlines I just quoted, are continuing to happen in this industry that we are all a part of. Change in the railroad industry today is the one universal constant, and this change is affecting each and every one of us, and this in turn affects your Locomotive Maintenance Officers' Association.

Let me give you an example of how this change has affected your organization. In 1972, my first year in LMOA, our total membership was 2,252 members. Last year in 1986, our total membership was 1,112 members, or in other words our total, we have had a 102.5% decrease in membership since 1972. It is not unusual that this phenomena in the LMOA has paralleled what has happened in our own railroads in the last 15 years. The number of both railroads and railroad employees has seen a tremendous decline since 1972. Remembering such names as: the Frisco, the Rock Island, the Reading, the Penn Central and the L&N, to name just a few, points vividly to these changing times in which we railroaders are living.

With change comes challenge; challenge to both us as railroad employees, and to your LMOA. Reminiscing is fun, and we all enjoy sitting around and talking about the "Good Old Days." However, we must not lose sight of those challenges that lie ahead of us. Railroad technology, and more specifically, locomotive design and maintenance technology, is changing rapidly. In fact, changing almost on a daily basis. The LMOA must remain that one single forum to disseminate the information on that new technology to each and every maintenance officer.

Your LMOA officers are committed to keeping this organization strong in these challenging times, to continuing to give you the most up-to-date information regarding high quality locomotive maintenance procedures, as well as keeping you informed on the latest technology in regard to today's motive power.

A word with which we are all familiar is "productivity." It seems to be an ever present part of our daily conversations. Increasing productivity and improving quality, we are told, is the only way that the railroad industry will survive in both the near and long-term future. As maintenance officers, we must "buy into" this concept. For it is true not only in the railroad industry but in U.S. industry as a whole.

However, the concept of increased productivity and improved quality is not new to the LMOA. Since our inception, we have, through our technical committees and technical papers, always attempted to give the maintenance officer the necessary information to increase their productivity and improve their quality. And, the information you will be hearing in the next three days is no exception. And, be assured, that the LMOA's committment to continue to give you such information will not cease.

Your LMOA is faced with many challenges, but your organization is ready to face them "head-on." In the coming years, this organization (as with every organization) will no doubt look different, however, be assured that the LMOA will not lose its commitment to you the maintenance officer. We the LMOA will continue to always strive to keep you up-to-date on the latest advances in maintenance technology and culture; information that each and every one of you can use to strive towards our goals of increased productivity and improved quality.

Again, I want to thank each of you for being here this week, and thanks to those railroads who sent you here. I know the next three days will be informative and that you will take home some new ideas which you all can use.

I want to thank those railroads and railroad clubs who have, through the years, sponsored our pre-convention presentations. The opportunity that you afford us is invaluable in our efforts to present quality technical papers.

Many thanks to the supply community and our advertisers. Without your support, we could not do the job we do.

As always, a very special thanks to Marty Hausman, Don Roberts and all of the Power Parts team for all that they have done for this organization through the years.

Thanks to all the officers of the LMOA, especially Joe and Lou Koerner, for making this year special for me.

Finally, thanks to you, the members of LMOA. Without you, we would be nothing. Thank you for your participation and I hope you will enjoy the next three days.

TUESDAY, SEPTEMBER 15, 1987

ACCEPTANCE SPEECH
By D. G. Goehring

The purpose of this Association, a non-profit organization, shall be to improve the knowledge 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.

To these I propose we add:

To learn the skills of rail transportation and contribute to innovative services that will give railroads the competitive edge over all forms of transportation.

As locomotive maintenance officers, we are no longer confined to walking circles in round houses. Our horizons are much broader; our opportunity to contribute greater; our mission is not just to make locomotives perform, but to help the railroads survive.

Many of our railroad excutive personnel have little practical railroad experience and less technical experience. The railroads "bottom-line" and the computers that determine it are in some instances the essence of their railroad knowledge. If profit is low or non-existent, it is often addressed by getting rid of the service rather than finding and implementing ways to make the service profitable again.

This is why mechanical officers, who know railroading, must be part of our industry's solution. When operating departments fail to perform and service suffers, mechanical people lose. All of our technical expertise and maintenance know-how is worthless if our locomotives disappear. The alternative to allowing our rail industry to retrench is for it to expand, hauling more cars and taking back business that was previously ours.

To this end, I propose to the LMOA the following:

1. Instill a "can-do" attitude in the minds of our mechanical personnel.
2. Eliminate waste in present operations and use what you save to take on new work opportunities even if those opportunities are not the primary mission of a work center, shop, etc. In other words, go the extra mile.
3. Sell management on the economics of fuel efficiency; self-monitoring locomotives for long-term, long distant economies and, at the same time, retain and maintain those older locomotives that are better tailored for the short and medium distance service. We have the technologies available to upgrade and improve efficiency/reliability of second and third generation locomotives.

For 1988 I propose an LMOA theme of "The **Vital Link** to Successful Railroading". I claim that locomotive maintenance people are vital to railroad operation and it is our ability to provide the means of moving freight that will keep the railroads alive. We can do this by working together, pooling our technical resources and sharing our successes.

We have to take up the challenge laid down by Mr. Bruce. We have to find ways to help reduce the 50% labor increment cost of hauling freight.

As LMOA plans for 1988, let us emphasis that LMOA provides the "Vital Link" that will inspire railroads to succeed; how we will do it will be told in next year's committee reports.

I accept the challenge of being the president of LMOA for 1988.

Chairman of the Board, Don Ward, BN, left, presenting General Desk Set to outgoing President Dave Goehring, Amtrak. Past President Darrell Walker, NS, right, in attendance at ceremony.

Bill Brown, left, BN, newly elected President of LMOA, shown accepting the gavel from outgoing President, Dave Goehring, right, Amtrak, while 3rd Vice President, Roger Vitek, C&NW observes.

Harriet Hausman, Chairman of the Board, Power Parts Company, accepted an award given by LMOA in honor, recognition and appreciation of the support to LMOA by her late husband, Marty Hausman, the founder of Power Parts Company.

MONDAY AFTERNOON SESSION SEPTEMBER 19, 1988

PRESIDENT D. G. GOEHRING'S ADDRESS

Eight years ago the World Champion Pittsburgh Pirates projected a theme of "WE ARE FAMILY" as the secret to their success. When railroad mechanical people get together at the pre-conventions and conventions we, too, are "FAMILY." We use the same tools and work on the same equipment to achieve the same goals for our respective companies. The reason we share our success and explain our failures among ourselves is because if anyone of us fails and our respective company fails, the entire industry suffers. Every railroad or part of a railroad that throws in the towel means less carloads will be generated and one more segment of America becomes less dependent on rail transportation.

The highway and air transport systems are vital to our economy and cannot be dismantled. But, there has never been a more energy efficient form of transportation devised than the steel wheel on the steel rail. Only the fixed guideway and the switching of vehicles into multiple routs detracts this system from the flexibility of the air and highway competition. But where there are railroads in place, serving communities, they are a national asset and must be preserved. While the highway and air forms ride on a sea of oil, railroads can efficiently utilize other, abundant energy sources.

Our theme this year has been "LMOA — The Vital Link To Successful Railroading." I have been trying to make it clear that mechanical people are essential to keeping this industry healthy and vital. Mechanical failures and high maintenance costs are parasites to our companies' bottom line and cannot be tolerated.

We mechanical people, you the builders and suppliers all have important parts to play in this fight. Our

Chairman of the Board, Don Ward, BN, center, accepting his bound copy of the LMOA Publication from newly elected President, Bill Brown, BN, as 1st Vice President, Paul Hoerath, Conrail, left, looks on.

competition is the highway. Railroads have to become more reliable and flexible to maintain and gain business. We need locomotives that can be parked at an industry, started and safely run by one man — just like a truck. We need locomotives that can tie onto a train and operate non-stop, except for fuel, for two thousand miles without fear of grounded traction motors when operating in snow, hot suspension bearings, brake shoes out-of-line, low lube oil, etc.

Trucks do this.

So let's get together. Let our collective mechanical knowledges and experience be the vital link to the rail industry's success. Every mile of railroad is important. Every company operating that railroad is important. The large railroad with their proud heritage, and the small railroads (with their "Go Get 'Em" and "Can Do" attitudes) have responsibilities and contributions to make.

BUILDERS — You have done a great job! Your fuel efficient locomotives have certainly contributed to our present efficiencies. Your willingness to innovate with microprocessor control and monitor the health of the mechanical/electrical systems.

SUPPLIERS — Your development of improved components, providing a competitive environment that keeps prices and costs down is a significant contribution.

CHIEF MECHANICAL OFFICERS — Your support of LMOA, by encouraging your personnel to work on committees and attend these conventions to learn and/or confirm proper maintenance techniques, bring to your companies enthusiasm and renewed dedication to solve problems.

Together we are LMOA. Together we are FAMILY. Together we will do a better job!

Past President, Darrell Walker, left, NS, presenting coveted Past President's Pin to Dave Goehring, Amtrak, while 3rd Vice President, Roger Vitek, right, C&NW, witnesses the presentation.

TUESDAY AFTERNOON SESSION SEPTEMBER 20, 1988

ACCEPTANCE SPEECH

By Bill Brown

Thank you Dave, Friends and fellow LMOA members. It's with deep pride, appreciation and humility I accept the gavel and the Presidency of the LMOA for the coming year.

Also, I wish to take this opportunity to express my thanks and deepest appreciation, for not only this honor, but to the many good friends I've made through my association with the LMOA, who, without their confidence and support I would not be here today. Thank you one and all.

It's my privilege to thank and commend our Past President, Dave Goehring, for a superb effort and a job well done during the past year. Dave has been an achiever and a tremendous asset to the LMOA. His day to day involvement and contribution to this organization will indeed be missed.

This has been a devastating year for the executive ranks of our organization. Through retirements, departmental transfers and other duties we've lost Tom Kessinger, Fran Blundon and Ken Keller. I'm sorry to see them leave and wish each of them the very best in their new endeavors.

I also want to welcome the new Technical Committee members who became active this year. Some of you I haven't had the opportunity to meet as yet. I'm sure each of you will serve with distinction. Welcome aboard!

Last, but not least, I want to thank our Associate Members for their continued and valued support. I feel a compliment is in order for the effort extended in setting the displays and I urge everyone to take the time to visit them.

Also I want to extend our warm welcome to our foreign visitors and members who are attending in this, our Exhibit Year.

Out motto or theme for this year is RAIL. R-A-I-L you've seen the buttons some of us have been wearing. Translated, RAIL is an acronym for Recognize America's Industrial Leadership.

Not to offend our good neighbors both North and South of our borders, we equally recognize and include all nations on the North American continent as partners in leadership.

We need to recognize where this industry has been, where it is today and even more importantly what's ahead in the future.

Our industry and its past leaders made significant contributions toward the development of this country. Those acts are a part of our heritage.

We recognize the major changes that have occurred in our industry such as during the conversion from steam to diesel motive power. Many of our maintenance and overhaul shops date back to that period and are still being used effectively today. This was no small achievement.

During the 1960's, we were in a locomotive horsepower race and recognize the efforts of those involved in that learning experience. Some of us doubted the wisdom of increased horsepower without total redesign, but I feel the builders who took those bold steps at that time are long overdue recognition for their efforts. Imagine the ramifications if today's main line locomotives were still rated near 2000 horsepower.

Most recently, we survived, at least for the time being, the fuel crisis of the 1970's and early 80's. We must recognize the leadership of the suppliers, builders and locomotive maintenance personnel for the fuel economy achievements accomplished during that period.

Deregulation, that word in itself has had far reaching affect on all of us. We're stronger, leaner and more aware of our position with respect to world wide competition.

These and many other events over the past 20 or so years, and our positive reaction to them, clearly demonstrates America's industrial leadership.

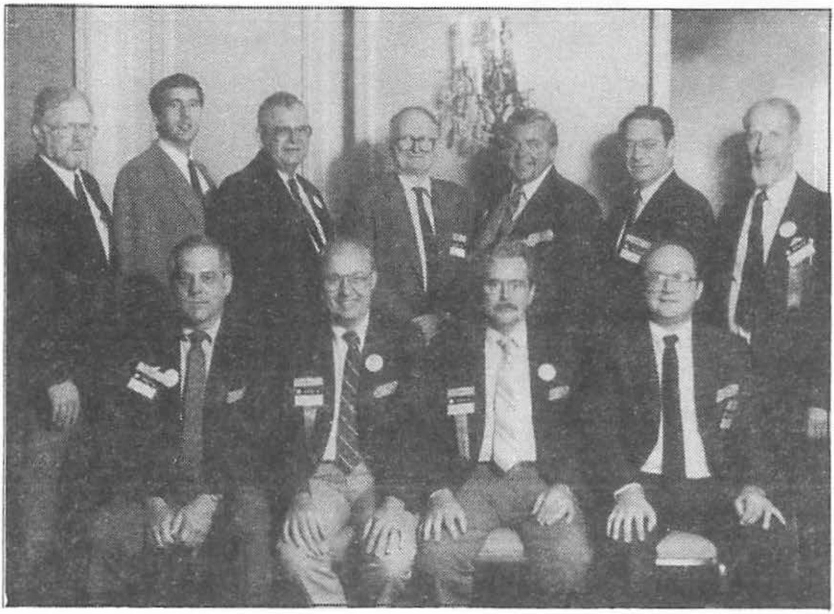
It would be very easy for us to sit back, put our feet up on the desk and reflect on past accomplishments. However, in today's global economy, one may find himself, and very quickly I may add, looking real hard for a desk or more likely another job.

Our function in the service support area of the railroad industry, the locomotive mechanical departments, do not directly generate revenues or attract new customers. Our actions or inaction does however affect the bottom line.

In reality, we are a necessary operating expense required to support corporate profit making capabilities. Herein lies the major area of our responsiblity, which is to maximize quality and minimize expense.

These responsibilities require us to provide locomotives for revenue service that exhibit maximum reliability at the least possible cost. There is a fine line balance point between reliability and cost, and it's in these two areas we must be ever watchful for an unacceptable shift.

We cannot rest. We must recognize the need to plan for the future, to solve problems before they evolve in-



LMOA officers in attendance at 1988 Annual Technical Conference in Chicago, IL. Seated, left to right: Don Ward, BN, Dave Goehring, Amt, Bill Brown, BN, Ron Pondel (Secretary-Treasurer); back row, left to right: Don Hudgens, UP, Mike Starr, SP, Allen Keller, Amt, Tom Harley, retired, Roger Vitek, C&NW, Darrell Walker, NS, Paul Hoerath, Conrail.

to crisis, to develop innovative ideas that will illustrate our industrial leadership as well as maintain our competitive edge.

Some of the developments I see in the future are increased maintenance intervals, longer service between overhauls, ongoing improvements or possible elimination of the DC traction motor, truck gearing and bearing improvements, filtering systems that eliminate contamination in all critical areas, environmental improvements, better fuel economy, advanced electronics and so on. The list is virtually endless.

I look for America's industrial leadership for development of these and many other improvements in the future.

Where, you ask, do you look for that kind of leadership? ---- The answer is easy, ---- I see a large part of it before me in this room.

Thank you.

Dave Goehring, left, receives his bound copy of the LMOA Publication from Past President, Tom Harley, as Bill Brown, newly elected LMOA President, looks on.

OUR OFFICERS

DAVID G. GOEHRING
President
Mgr. Loco. Heavy Maint.
National RR Passenger Corp.
2000 Market Street
Philadelphia, PA 19103

MEMBERSHIP THRU THE YEARS

	Advertisers	Associate	Active	Total
1939	0	27	60	87
1940	34	48	162	244
1941	38	48	210	296
1946	103	187	676	963
1947	101	284	937	1321
1948	113	295	1183	1591
1949	134	595	1789	2521
1950	123	595	2101	2822
1951	125	626	2912	3663
1952	135	510	2747	3392
1953	118	597	3288	4003
1954	118	545	2943	3606
1955	81	434	3235	3750
1956	110	419	3257	3786
1957	100	423	2678	3201
1958	82	350	2320	2752
1959	90	387	2395	2872
1960	98	393	2302	2793
1961	101	348	2201	2650
1962	118	316	2291	2725
1964	138	273	2345	2756
1965	155	289	2372	2816
1966	163	464	2368	2995
1967	180	408	2327	2915
1968	200	321	2575	3096
1969	192	335	2173	2700
1970	184	345	1929	2458
1971	140	283	1621	2044
1972	132	343	1777	2252
1973	108	345	1563	2016
1974	124	384	1735	2243
1975	103	326	1579	2008
1976	109	314	1610	2033
1977	114	317	1508	1939
1978	125	363	1367	1855
1979	120	391	1251	1762
1980	112	405	1200	1717
1981	114	445	1143	1702
1982	102	440	1261	1803
1983	92	386	1025	1503
1984	95	400	1116	1611
1985	90	386	1006	1482
1986	90	320	702	1112
1987	75	221	615	911

OUR OFFICERS

THOMAS A. KESSENGER
(1st Vice President)
Sr. Engr.-Facility Planning
CSX Transportation
Jacksonville, FL 32202

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(2nd Vice President)
Manufacturing Engineer
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Dir.-Quality Assurance Mech.
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Sacramento, CA 95814

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Passenger Corp.
Philadelphia, PA 19103

KENNETH R. KELLER
Mgr. Opns. Analysis
Burlington Northern
Naperville, IL 60566

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Sante Fe Rwy.
Topeka, KS 66616

MICHAEL M. STARR
District Mechanical Officer
Southern Pacific Transp. Co.
Oakland, CA 94007

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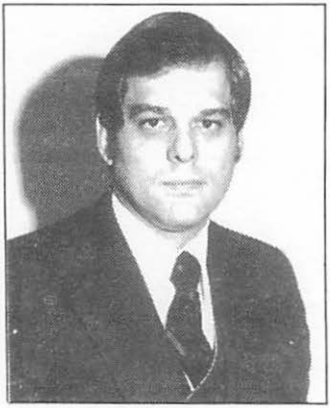

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Chief Mechanical Officer
Burlington Northern Railroad
Englewood, CO 80112

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Assistant Shop Manager
Norfolk Southern Corporation
Atlanta, GA 30303

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CSX Transportation
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— Diesel Mechanical Maintenance —
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National RR Passenger Corp.
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— New Developments —
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Union Pacific Railroad
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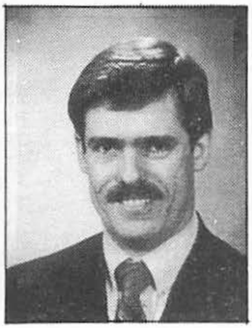

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Mgr., Loco. Planning Standards
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Union Pacific Railroad
Omaha, NE 68179

— Diesel Material Control —
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Chief of Motive Power & Car Equip.
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Chicago, IL 60604

M. L. WALL
Gen. Dir. Loco. System Shops
Union Pacific Railroad
Omaha, NE 68179

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Chief Mechanical Officer
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Overland Park, KS 66201

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Consolidated Rail Corp.
Philadelphia, PA 19103

MR. LARRY D. BELL
Vice Pres.-Mech. Svcs.
Soo Line Railroad Co.
Minneapolis, MN 65440

MR. W. M. HART
Vice Pres.-Motive Power
CSX Transportation
Jacksonville, FL 32202

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Editorial Director
Modern Railroads
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1939 & 1949—F. B. DOWNEY (Deceased) Asst. to Shop Supt., C & O Ry.
1941— J. C. MILLER (Deceased) MM, N.Y.C. & St. L R.R.
1942-1946, Inc.—J. E. GOODWIN (Deceased) Exec. Vice President, C.& N.W. Ry.
1947— S. O. RENTSCHILER (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, Retired, Asst. Vice-Pres.-Equipment, Seaboard Coast Line R.R., 206 Strongbow Court, Sun City Center, FL 33570
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. MOLLOY (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, Retired Chief Mechanical Officer, Pennsylvania R.R., 313 Hayden Street, Sayre, PA 18840
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 Mechanical 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 Mechanical Officer, National Railroad Passenger Corp., Washington, D.C. 20024
1968— G. F. BACHMAN, Retired Chief Mechanical Officer, Elgin Joliet & Eastern Ry., 612 E. Bevan Drive, Joliet, IL 60431
1969— 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. NIEMEYER (Deceased) Mechanical Superintendent, Texas & Pacific Railway
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1973— W. F. DADD, Retired Chief Mechanical Officer, Chessie System, 37 Carolina Shores Drive, Calabash, NC 28459
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1983— F. D. BRUNER, Retired Asst. Chief Mechanical Officer-R. & D., Union Pacific Railroad, 10012 Emmet, Omaha, NE 68134

1984— R. R. HOLMES, Retired Director Chemical Labs and Environment, Union Pacific Railroad, 688 J. E. George Blvd., Omaha, NE 68132

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1986— D. H. PROPP, Chief Mechanical Officer, Burlington Northern Railroad, 373 Inverness Drive South, Englewood, CO 80112

1987— D. L. WARD, Asst. General Foreman, Burlington Northern Railroad, 3253 E. Chestnut Expressway, Springfield, MO 65802

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J. J. Dwyer, Retired Engineer Environmental Control, Chessie System, Huntington, W. VA 25712 (P. O. Box 907)

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JACK L. KUHNS, Retired Manager Planning & Maintenance, CSX Transportation, 400 Deerfield, Louisville, KY

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J. F. McDONOUGH, Retired Asst. Vice-President-Mechanical, Union Pacific Railroad, 12225 Farnum St., Omaha, NE 68154

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F. E. RUSSELL, Retired Chief Mechanical Officer, Southern Pacific Co., San Francisco, CA

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Chief of Motive Power
& Car Equipment
CN Rail
Montreal, Quebec H3C 3N4

G. W. BARTLEY
Chief Mechanical Officer
CP Rail
Montreal, Quebec

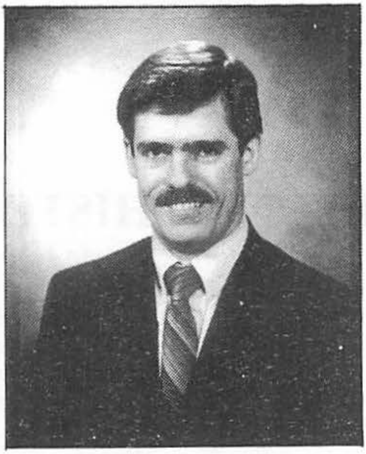
LMOA wishes to express its thanks to the Canadian Railroads for hosting and participating in the Pre-Convention Presentation of our Shop Equipment Committee in Montreal on May 18, 1988.

The attendance and interest exhibited was most gratifying.

Monday, September 19, 1988
10:00 A.M.

REPORT OF THE COMMITTEE ON SHOP EQUIPMENT

Pre-Convention Presentation: Montreal, PQ



May 18, 1988 Chateau Champlain Montreal, PQ

W. R. DOYLE, Chairman
Manager-Locomotive Planning,
Standards & Programs
Union Pacific Railroad
Omaha, NE

VICE CHAIRMAN
D. E. Tetley, Mgr.-Facilities Planning, Union Pacific RR, Omaha, NE

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J. J. Wheelihan	Supervisor-Field Engineering	EMD	LaGrange, IL
D. M. Wetmore	Manager-Production Control	CSX	Corbin, KY

1988 TOPIC:

STREAMLINED SYSTEMS FOR LOCOMOTIVE SERVICING

PERSONAL HISTORY

Weylin R. Doyle

Weylin was born in Cheboygan, Michigan. Following high school, he attended Lake Superior State College and then the University of Michigan in Ann Arbor where he earned a degree in Mechanical Engineering. He also did a year of graduate work in the field of vibration analysis.

He entered the Missouri Pacific Railroad's management training program in June of 1976. In January of 1977, he went to the Fort Worth diesel shop as Locomotive Foreman and then to Marshall, Texas as Car Foreman. He was promoted to Diesel Supervisor in 1978 at Fort Worth, then as General Foreman at the Kansas City Diesel Shop. In 1982, he served as Assistant Master Mechanic at Monroe, Louisiana, a year later returning to Kansas City as Master Mechanic. In 1985, Missouri Pacific promoted him to Assistant Mechanical Engineer in St. Louis until the merger with the Union Pacific Railroad. He moved to Omaha as Director of Advanced Equipment Engineering and is now Manager of Locomotive Planning, Standards, and Programs.

Weylin, his wife Kathy, and three children now reside in Omaha, Nebraska.

I
FUEL MANAGEMENT CONTROL SYSTEM

Since the conversion from steam to diesel locomotives after World War II, locomotive maintenance officers have been faced with an increasing need to conserve fuel while ensuring efficient handling systems and practices are used. During the first 15 years of this period, the main concern was with maintaining a large capacity delivery system which quickly moved stored fuel to the waiting locomotive. In the late 1960s with the advent of stricter environmental standards, it became necessary to contain any fuel spillage, to prevent pollution and the ensuing penalties. The higher fuel prices of the 70s forced conservation and security through both fuel handling systems and more efficient locomotives. The 80s with the reduction in manpower have dictated effective utilization of all our resources. These requirements have brought us through an evolution starting with a man with a 55 gallon barrel and a pump through automatic fuel cutoffs to a computer controlled fuel management system.

Typically, today's industry standard consists of a metered receiving and dispensing area with built in safeguards for the detection of normalized quantity, foreign liquids, and air, and a degree of security from unauthorized fuel removal. Most dispensing systems also provide for automatic fuel shutoff when the locomotive fuel tank is full, which in turn allows the operator to perform other tasks or fuel more than one unit. There are several manufacturers who provide this type of system — Houston, Buckeye, and Snyder to name a few.

It is reasonable to expect that with the popularity of the personal computer, the PC would be applied to this type of system. One such application is currently being developed on the Kansas City Southern by Snyder Equipment Co. The fuel management control system is separated into three areas of responsibility. Receipts, storage, and dispensing are brought together in one central information center. The information center processes the data received from each area, calculates, stores and prints them for billing and record keeping, while providing electronic security for receiving and dispensing.

Receiving equipment and hardware consist of a petroleum meter with pulser, temperature probe, electronic interface unit, and an optional fuel control valve or pump control security device. The system can be operated by either the person delivering the fuel or by an in-house person who checks the load in and monitors the unloading process. This depends entirely upon security needs. The operator must enter at the interface the delivering company's identification number, vehicle or tank car number, his personal identification, and invoice number. Once the information is entered, the interface unit will print "GO" on the crystal display and the unloading may begin. The company identification number or the personal number is used to activate the security portion of the system. After the fuel is unloaded the interface transmits all pertinent information to the central processor or PC for storage and record keeping. The information includes the following types of transactions: R for receipt, name of the storage tank, mode of transaction (M for manual, A for automatic, X for security), date and time of the transaction, identification of the operator, tank or vehicle, delivering company, invoice number and gallons of fuel received (calculated at 60 degrees F for net gallons).

Storage equipment and hardware for each tank consist of a tank depth gauge with electronic gauge head transmitter and temperature probe for measuring temperature of the fuel. The control processor is programmed with the tank capacity, depth and size. It uses this information to calculate and constantly monitor the fuel on hand, producing a readout or hard copy on demand.

Dispensing area equipment and hardware per outlet consist of a petroleum meter with pulser, temperature probe, electronic interface unit, fuel control valve, locomotive mounted transmitter with two antennas and nozzle antenna (the last two items allow use of the automatic mode). The dispensing area has two modes of transactions, automatic and manual. The manual mode is the same as the receiving with the exception of security which is standard in the dispensing area. The automatic mode authorizes the unit to be fueled without any manual manipulation of the interface unit. This is accomplished by electronic identification of the locomotive and railroad using a low frequency radio signal transmitted through the fuel tank adaptor and nozzle antennas to the interface unit.

In the manual mode the operator must apply the fuel nozzle, then enter his company identification number, locomotive number, and personal identification number at the interface unit to receive a "GO" and begin fueling. The company identification and locomotive number are used for accounting purposes, while the personal identification number fulfills the security requirements. In the automatic mode it is only necesssary to connect the nozzle and begin fueling; all pertinent data are transmitted via low frequency radio signal to the interface which recognizes the locomotive and ok's fueling. When fueling has been completed, the interface transmits the transaction identification D for dispensing, name of dispensing unit, mode M for manual or A for automatic, date and time, gallons dispensed, company, locomotive and operator identification (when in the manual mode) to the computer for processing and storage.

The central processor equipment and hardware consist of a personal computer and a printer. The computer monitors and stores all the information generated by the three work areas, receiving, storage, and dispensing. It also has all AAR identification initials permanently programed in the memory. This allows the computer to instantly recognize a locomotive from another railroad. The computer can, on demand, print a hard copy of any of the stored information in any combination or variation that might be needed for billing or record keeping. This includes different starting or ending times, dates, with any of the different transactions.

The fuel management control system provides the user with a useful tool that can keep up with the multiple transactions as a matter of record or for future billing purposes. This is especially useful in an environment where a railroad, such as KCS, fuels many foreign locomotives on a regular basis or in an area where a major fuel security problem exists. It would pay for itself by saving time and manpower. However, with today's relatively low fuel prices combined with the normally low number of foreign units fueled, we feel that on most railroads serious consideration must be given to the possibility that the cost will outweigh the benefits.

The emphasis of the 90s will be upon the increased utilization of one of the most volative resources, the

locomotive. At a major Eastern road, the average number of gallons dispensed per fueling is less than 25% of the locomotive tank capacity. Not only is the redundant fueling a waste of locomotive time, but it is also a waste of fuel inventory. By applying technology to fuel management systems and increasing the interval between servicing, out-of-service time for fueling can be reduced by 50%. The management systems necessary to accomplish this improvement require two key elements: 1) integrated locomotive maintenance and dispatching systems with a centralized database; and 2) real time data as to the quantity of fuel remaining on board each locomotive in the fleet.

The cost of attaining these two key elements in a stand-alone environment is prohibitive, but when coordinated into the efforts of centralized dispatching and advanced train control systems, these benefits become a very large incremental savings. The ATCS locomotive onboard computer (OBC) architecture allows for the measurement of fuel quantity. Once the data communications link is in place, the individual locomotive fuel quantities become available on demand to the central database. Dispatching decisions may now take advantage of fuel availability, fuel requirements, and operational commitments in determining whether to "turn" power or send it to the service center.

A locomotive spends about 7% of its time being fueled and serviced. A 50% improvement in this number translates into a significant increase in locomotive availability and a reduction in the resources necessary to provide the fueling services. As you can see, if there is a need and the financial backing is available, a complete fuel management system can be put in place on both the service center and the locomotive.

II
LOCOMOTIVE MOUNTED RAIL LUBRICATION FILL SYSTEMS

Since locomotive mounted rail lubrication systems have been growing in popularity, the necessity of finding an appropriate method for filling these systems must be investigated in detail. An appropriate system must address all the pertinent factors peculiar to your railroad and the type of system being installed. Some of the particulars to consider are the laws affecting the transportation and storage of the grease as well as the type of grease to be used. The volume of grease to be delivered at a particular location will affect the decision on what method of transportation to use. The decision whether to fill inside a shop or outside on the service track will be a function of the climate of the area and the grade of grease to be delivered.

Since grease is considered a hazardous waste by the Environmental Protection Agency, the system for transportation, handling, and disposal of grease must comply with all the appropriate state, federal, and local laws. Therefore the container used in the transportation of the grease is of particular importance. If, for instance, grease is shipped in non-returnable drums, care must be taken that all the residual grease in these drums is properly disposed of before the drums are discarded. However, at some locations that require a small volume of grease to be dispensed, it may be appropriate to handle 55-gallon non-returnable drums.

Because of the problems with residual grease in containers, other options to consider are either bulk storage or refillable containers. If the facility under consideration has a large enough volume requirement to

warrant building a bulk storage system, then delivery of grease by bulk tank truck or tank car may be the ideal solution., For facilities requiring an intermediate demand for grease, 500-gallon refillable bulk containers may be a viable solution. These bulk bins as they're often referred to can be transported back and forth from the grease manufacturer to the railroad without having to clean the bins or dispose of the residue. These bulk bins may also be filled from a tank truck at the facility instead of transporting them to the grease manufacturer for refilling.

Once the delivery and storage system is chosen, a method must be devised for getting the grease to the locomotive. If the locomotive shop is a major facility, then it may be economically advantageous to build a large capacity reservoir of about 10,000 gallons. With this system the grease must be further handled to get it to the locomotive. The grease could be pumped through a manifold system within the shop to dispensing locations along the service ramps. This would require a fairly large capacity pumping system and an elaborate manifold. Another possibility might be to pump the grease from the storage tank to a second portable reservoir that can be handled by forklift, hand truck, or crane to the locomotive site.

For intermediate size facilities, the bulk bin method may be more desirable. These bulk bins can be transported by either forklift or crane to the locomotive site. This will eliminate at least one stage of handling compared with the large reservoir system. In smaller facilities the 55-gallon drums can also be handled by either forklift or crane.

After the grease is delivered to the site of the locomotive it must then be pumped into the locomotive reservoir. The only exception to this is with the system utilizing a manifold with a main distribution pumping system. Under that system the grease will already be available under pressure at the site of the locomotive. In delivering the grease this final step into the locomotive reservoir, several important factors must be taken into consideration. Whether the locomotive is outdoors or in a warmed shop is the first factor to take into account. The most severe ambient temperature and the grade of grease to be delivered are important ingredients in the determination of pump size. The type of onboard rail lubrication system being filled cannot be ignored and the optimum fill time required must also be taken into consideration.

If the supply reservoir requires that the pump be physically transported from one reservoir to another by hand, then the weight of the pump may be an important consideration. If the physical size of the pump is such that it must be handled by either a forklift or crane, then the process of changing pumps from one reservoir to another becomes awkward and time consuming. The length and size of delivery hose should be factored into the decision for the pump capacity. Pump ratio on air actuated pumps should take into consideration the shop supply air pressure and the type of locomotive reservoir being filled. If the locomotive is equipped with a pressure vessel for grease delivery, then a pressure return line may have to be incorporated. If you're filling a pressure reservoir, it may be wise to size your pump to avoid over-pressurizing the reservoir in the event the pressure return line is not properly hooked up. Any failure to properly relieve the pressure on this system could cause the reservoir to rupture if a very high ratio pump were used. For this reason, the pressurized locomotive reservoir

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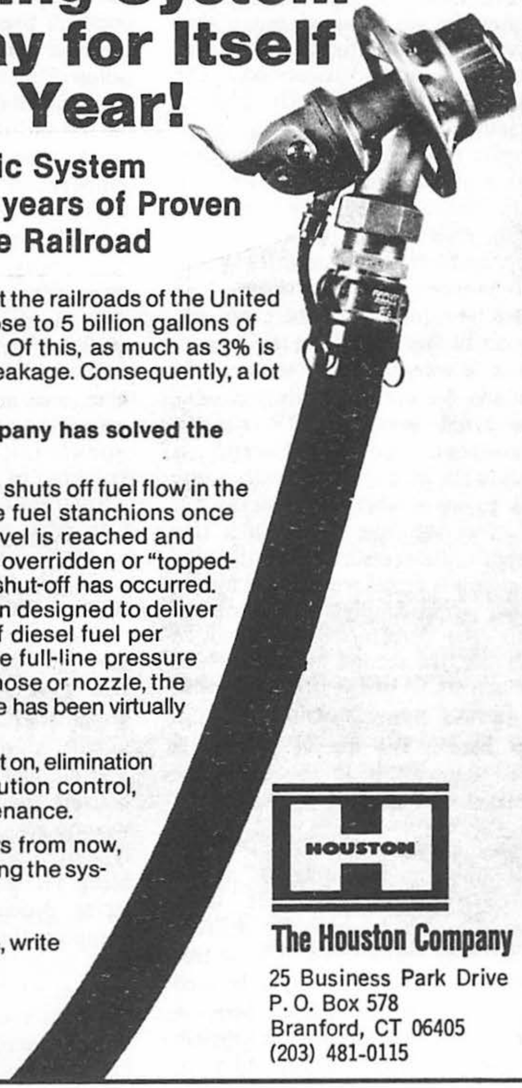

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should incorporate some type of automatic pressure relief.

One railroad plans to incorporate an automatic fill system that will simplify the filling process by automatically shutting itself off once the system is full. This system incorporates an air actuated pump that delivers the grease to the locomotive through a quick disconnect. The system works well with both a pressure reservoir or a non-pressure reservoir on the locomotive. With a pressure reservoir however, a return line must be hooked up to the supply reservoir to properly relieve the pressure in the locomotive system and prevent over-pressurizing the vessel. The quick disconnect prevents any possibility of spilling the grease.

The automatic fill system works similarly for both pressure and non-pressurized vessels. With a non-pressurized locomotive vessel, a method is incorporated within the tank to sense when the vessel is full and close the inlet valve. Once this happens, the pressure across the supply pump is equalized and the air actuated pump simply stops pumping. With the pressurized locomotive reservoir, the second pressure return line acts as an orifice which restricts the flow of grease back to the supply reservoir and effectively equalizes the pressure across the pump. This turns out to be a very clean, fast, and effective way to fill the reservoir.

Another system for filling that met with only modest success was a remote fill system that used locomotive air to drive the delivery pump. One major drawback for this system was that it was only to be used out on the service track when the locomotive was running. The system incorporated a remote fill line to be piped to the underframe of the locomotive at approximately the same height as the fuel fill port, in a position where it could easily be accessed by the service track personnel. A second locomotive air supply line was piped to the same location and served as the supply to drive the air pump. In the case of a pressure vessel on the locomotive, a third return line was also made accessible at this point. A five-to-one ratio pump was used on the supply reservoir (a 55-gallon drum in this case). This system worked well during the summer months but did not pump even a "000" grade grease when the ambient temperature dropped below 30 degrees F. For this reason it was decided that the best place to fill these reservoirs was inside a warm shop.

Since the climate and mode of operation for each railroad can vary a great deal, the system for filling lubricators must take into consideration all the parameters involved. The expected volume at each location and frequency of filling may necessitate a railroad using different systems at different locations. A well thought-out system will aid the railroads in making the filling of these lubricators easy and efficient.

III
LOCOMOTIVE TOILET SERVICING EQUIPMENT

A number of railroads are currently using retention type toilets on their locomotive fleets. The use of this type of equipment poses several problems related to servicing. This servicing process typically consists of dumping the toilet, cleaning it and then recharging it with the correct amount of water and chemicals. In most instances, the servicing operations are accomplished in the following sequence.

First the toilet is emptied. This can be done through the use of a portable disposal unit, commonly known as a "honey wagon", or it may be

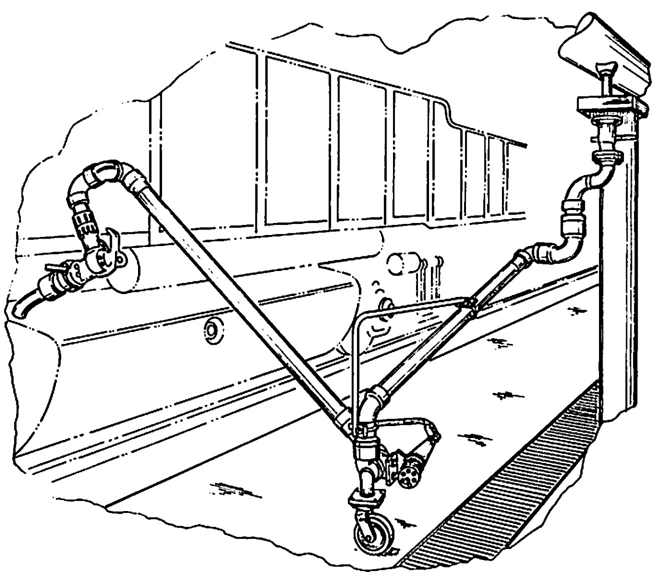
dumped directly into a sanitary sewer by connecting it to an in-ground receptacle. Next, the toilet must be cleaned. To clean the toilet, an employee must carry a bucket of fresh water, a brush and cleaning solvent into the locomotive cab. After cleaning, the toilet must then be recharged with the correct amount of water and chemicals. A second bucket containing the correct solution of chemicals and anti-freeze must also be carried by the employee into the locomotive cab.

Typically, the servicing of toilets is time consuming and constitutes a potential safety hazard. The "honey wagon" has a limited capacity of 32 gallons and will normally require dumping after servicing only three or four locomotives. It also must be transported by hand and is difficult to position during inclement weather. In-ground outlets are safer and may take less time to perform dumping operations. However, unless there are a sufficient number of in-ground outlets spaced at the correct intervals on both sides of the track at your facility, it will be necessary to re-spot locomotives. It is also necessary to spot the locomotives at the track where the outlets are available. If respotting of locomotives must be continually performed to accomplish toilet servicing, a great deal of manpower and locomotive utilization may be wasted.

In order to clean and re-charge a toilet after servicing, it is necessary to transport water, cleaning materials and chemical into the cab of the locomotive. During winter months, it is also necessary to include anti-freeze to prevent the toilet from freezing and the resultant damage. As previously described, the cleaning water and recharge solution are taken into the cab in two five gallon containers. The weight of each one of these containers is approximately 45 pounds. Lifting them onto the locomotive running board creates a risk for back injury. Carrying them while on the running board or the ground creates a potential for slipping during inclement weather. In one instance, a personal injury was sustained when a container slipped while an employee on the ground was handing it to an employee on the running board, spilling the chemical-mixed water in the eyes of the employee on the ground. It should be noted that the chemical used for servicing retention toilets contains quaternary ammonium chloride disinfectants, non-ionic wetting agents, alcohol, a blue dye and perfume. Contact with the eyes or any mucus membranes will cause severe irritation and possibly injury if not immediately rinsed. If contact with the eyes does occur, the solution must be flushed with water for at least fifteen minutes. If skin contact occurs, wash thoroughly with soap and water. If ingested, immediate medical attention should be obtained. The same precautions and procedures should be followed for the use of anti-freeze.

In order to eliminate these safety hazards and provide a more cost-effective method of servicing retention type locomotive toilets, one railroad designed and constructed a skid mounted locomotive servicing tank set. Several factors were taken into consideration during the design process.

1. **Safety:** The main objective would be to provide a safe method of servicing toilets for employees.
2. **Productivity:** In most cases, two employees are currently required to service toilets. This is a safety factor to prevent injuries caused by handling the containers. One objective of the new servicing equipment would be to allow



servicing to be completed by one employee.

3. **Capacity:** The holding tanks had to be constructed to the largest size possible based on the load capacities of the servicing vehicle to minimize dumping requirements.
4. **Accessibility:** The equipment had to be capable of easily accessing locomotives parked at existing servicing facilities. To avoid excess maneuvering of the servicing vehicle, access to the sewage tank and hose reels were provided on both sides of the equipment.

The resultant servicing tank set consists of a rectangular steel tubing skid, a 70-gallon capacity stainless steel sewage holding tank, a 70-gallon capacity stainless steel water supply tank and two water supply hose reels, The water supply tank is equipped with a fluid level gauge to enable the operator to identify how much recharge water is remaining. The entire unit is mounted on a skid which is capable of being handled by forklift. A 12 volt DC powered bronze impeller pump is used to move water from the storage tank into the locomotive. The pump is connected directly to the ignition switch of the vehicle. The pump should be turned off with the vehicle to prevent pump burn-out in case the pressure actuated shut off switch should fail. Prior to servicing, the water supply tank is filled with the correct mixture of chemicals and anti-freeze. This method allows the purchase of bulk chemicals instead of the small bottles. This amounts to a saving of about nine to 10 dollars per gallon of chemical.

In the example shown in the photographs, the tank set has been mounted on a 2000-lb. capacity utility vehicle. The unit may also be mounted on a trailer or moved with a forklift. A heavy duty trailer type quick disconnect receptacle allows the tank set to be easily connected to any vehicle's ignition system. To accomplish the servicing procedure, the operator places the vehicle adjacent to the locomotive, The dump hose is connected to the toilet dump outlet and the valve on the locomotive is opened. The sewage tank is equipped with quick disconnect fittings on both sides to allow the operator to drive the servicing vehicle up to the locomotive from either direction.

After the sewage tank has been connected, the operator climbs into the locomotive to perform the servicing operation. Depending upon the configuration of the locomotive, the fresh water outlets mounted on the hose reels may be accessed from either the running boards or the cab. The operator pulls the hose into the cab from the reel to start the servicing operation. Hose reels are provided on both sides of the vehicle, again to eliminate the need to bring the vehicle adjacent to the locomotive in a specific direction. First, the operator opens the slide valve on the toilet to purge the existing contents. He then begins to clean the toilet using the premixed recharge water. To obtain this water, the operator simply opens the ball valve on the end of the hose. A transducer will sense the drop in water pressure, automatically actuating the 12-volt pump, supplying water to the locomotive at the rate of approximately six to eight gallons per minute. Higher volumes should not be used since they will cause splashing of the recharging liquid. When the supply valve is closed, the pressure switch will sense the increase in pressure and automatically shut the pump off.

After cleaning, the operator will close the slide valve on the toilet and begin the recharging procedure. A digital in-line meter is provided on

the end of each hose to measure the exact amount of recharge water placed in the toilet. The meter also keeps an accumulative total of the number of gallons that have been used for servicing operations. The operator can stop at the recommended preset levels and eliminate any guesswork, overflow or wasted treated water. Upon completion of servicing, the operator places the hose back onto the reel and leaves the cab of the locomotive. The sewage discharge hose is then disconnected and placed back to its stored position on the cart.

In order to service the higher toilet outlets found on GE units, the sewage tank has been coated with an anti-skid surface which serves as a work platform to hook up the sewage outlet.

It has been found that this tank set will typically service seven to nine locomotives before requiring refill or dumping. Both the dumping and refilling operation are normally accomplished simultaneously since the fresh water holding tank is being depleted at the approximate rate the sewage tank is being filled. Since the unit is highly mobile, it may be transported easily to any sewage dump station. The operator uses the same hose for dumping the holding tank on the tank set that he uses for dumping the locomotive. An adapter is included on the tank set to accommodate dumping into the smaller sewage outlets. The bulk anti-freeze and toilet chemicals could be stored in the same vicinity as the sanitary sewer for convenience.

Already in use at several locations, this equipment has helped eliminate a potential safety hazard, reduced manpower requirements for locomotive servicing and decreased the cost of locomotive servicing chemicals.

IV
INNOVATIONS IN BLUE FLAG AND DERAIL PROTECTION

No thorough study of locomotive maintenance facilities would be complete without a look at blue flag and derail protection. For the shop craft employee, the color blue symbolizes a coveted protection for workmen who are assigned to inspect, test, repair or service rolling equipment.

In its most basic form, blue flag and derail protection may consist of a steel flag and portable derail appropriately positioned at the entrance of a track before work on equipment commences. At major locomotive facilities, blue flag protection may take a more sophisticated approach.

Before we examine recent developments in blue flag protection, let's briefly review the evolution of blue flag protection. Across the United States, blue flag protection was practiced by shop craft employees of all types. On June 1, 1976, "Blue Signal Protection of Workmen" was entered into the Federal Register and became the law. As a result, the Federal Railroad Administration was charged with blue flag enforcement. In fact, the FRA retains a team of inspectors within its operating practices group with responsibility for monitoring blue flag enforcement.

It should be pointed out that interpretation of the blue flag law and its application to specific situations is not a casual matter. This discussion does not attempt to interpret the blue flag law. When questions arise, you should consult the Federal Railroad Administration.

At locomotive shops, interest in blue flag and derail protection is usually the greatest at the servicing facility. This is because servicing facilities see the most movement of equipment. In addition servicing facilities are the place where operating and non-operating crafts work side by side.

At Argentine Shops in Kansas City, the Sante Fe railroad operates a major locomotive shop including the most modern servicing facilities. At the northwest corner of the massive three-track servicing facility building is a third story office where a Mechanical department supervisor is stationed. Overlooking an eight track yard for assembling locomotive consists, this supervisor has exclusive control over derails regulating movement on these tracks. All the derails are power operated from a console in the office above. Indicating lamps on the ground are interlocked with derails to provide a positive protection for employees working on, under, or between locomotives on these tracks. From above the track structure, the Mechanical department supervisor can oversee a safe working environment. Direct radio communications with shop craft employees enables the supervisor to position derails from a control board that resembles a miniature traffic control display. In addition to derail protection, shop craft employees must place their blue flags on the locomotives in positions visible from the controls.

Another installation, this one designed by railroad personnel, can be found some 600 miles to the east in Chattanooga, Tenn. Located at the J. G. Moore Locomotive Shop on the Norfolk Southern, this system also uses power operated derails supplied by a vendor of switch and signal gear. Switches providing access to each track are hand thrown. At this facility, consists of inbound locomotives are pulled on to any one of eight tracks provided with fuel, sand, lube oil and water. Locomotive consists ready for trains depart from the same servicing track they arrived on.

Ground mounted lights indicate the position of derails for engineers and hostlers moving in or out of this servicing facility. Controls for this system of derails are mounted outside the foreman's office at ground level. A key lock arrangement prohibits unauthroized movement of derails. Indicating lamps adjacent to each key lock show the position of the derail. Controls are protected from the elements by a NEMA 12 enclosure and a roof overhead. Adjacent to the control box is a track board where shop craft employees leave name tags to indicate where they are working.

A variety of derails and power equipment to operate them are available from manufacturers of switch and signal equipment. Derails themselves vary in design and size. Some of the more permanent derails require exertion to apply and remove. To deal with this potential safety problem, one Eastern railroad installed air cylinders to raise and lower the derails. This is an attractive alternative when compared with the cost of electrical switch gear for derails. Control of the compressed air operating the derail is accomplished with a modulating horn valve. Air operated derails can be remotely controlled through solenoids, but the use of air operated derails may not be practical during severe winters.

Just as the conscientious locomotive maintenance officer must be looking for ways to improve the efficiency of his shop facility, he must also be mindful of improved methods for assuring the safety of his employees who work on, under, or between rolling equipment.

V
AIR COMPRESSORS — COMPARISON AND ECONOMICS

The basic working concept of a shop or yard air compressor is to take in air at atmospheric pressure of approximately 14.7 pounds per square inch (psi) and compress it or raise its pressure to anywhere between 90 to 120 psi. Special applications such as the testing of air brake equipment may require higher pressures up to 175 psi. On the opposite end of the scale, breathing air for employee respiration may require as little as 15 to 20 psi.

The question that confronts us is, "Just what type of air compressor do we require to best serve our needs effectively and economically?" The several types of compressors available on the market today will be further discussed to help provide you with the information necessary to make your compressor selection decisions.

A. Positive Displacement Reciprocating Compressors

The reciprocating or "piston" type of air compressor has probably been around for the longest time and has evolved into a very efficient and enduring unit. Before the turn of the century, large stem driven air compressors such as the Ingersoll-Rand Class "C" compressor were capable of producing an output of around 4,000 cubic feet of compressed air per minute (cfm). Units that were installed as far back as 1914 are still operational. As electric motor technology evolved and improved, more and more compressors were equipped with large synchronized electric motors. Motors of 800 horsepower and greater were used to power 4,200 cfm compressors. These early compressors were constant displacement types.

Later developments in compressor valve controls provided us with compressors that could be fully loaded, unloaded or capable of being loaded at any percentage of their rated capacity in accordance with air

demands. This feature provided the method to obtain a saving in electrical costs whenever the fully rated capacity of the compressor was not required. In general, reciprocating-type compressors have lower or at least equivalent operating costs when compared with other types of equipment. They can operate at any range of speed from idle to full RPM and are capable of producing either low or very high compression pressures. They may also be purchased in a two-stage configuration. Two-stage compressors produce both low and high pressure air, so requirements for both can be met if necessary. They also have relatively low oil consumption and are better suited for meeting breathing air requirements. The best type of compressor for breathing air requirements is oilless, such as a diaphragm type. The use of oilless compressors for breathing air eliminates the potential danger of carbon monoxide entering the air system. The disadvantage of a reciprocating compressor lies in the fact that the initial purchase cost is about double that of an equivalent cfm rotary type of machine. In addition, the installation cost of a large reciprocating compressor is higher because they normally require a more extensive foundation for vibration control and proper cylinder alignment.

B. Sliding Vane Compressors

The sliding vane compressor incorporates on off-center mounted rotor which has lengthwise slots that contain spring loaded, non-metallic vanes. These vanes push against the walls of a chamber containing the vane and rotor assembly. As the rotor turns, the incoming air is trapped between each of the successive sets of vanes when they are in their most open or high volume position. The off-center condition causes the area between the vanes to decrease and compress the trapped air. This type of compressor works well in conditions where continuous maximum load conditions exist. It is not possible to change pressures or load conditions with this type of design, so it is not energy efficient where no load or partial load conditions exist.

C. Helical or Rotary Screw Compressors

The helical or rotary screw type of compressor uses two rotors with intermeshing lobes to accomplish the compression process. The basic elements of this compressor consist of a male, or driven, rotor and the female, or gate rotor, and the rotor chamber. About 90 percent of the drive motor power is used by the male or driven rotor.

Two methods are used to maintain the close tolerances required between the two rotors to ensure that compression takes place. One method is through the use of timing gears. This type requires no lubrication other than the rotor shaft bearings and sealing is accomplished by close tolerances. The second method is oil flooding. The rotors and chamber are flooded with oil to lubricate, seal and cool the compressed gas. This type of sealing requires the use of elaborate oil separation systems down line before the air can be discharged for use. The energy efficiency of the rotary type of compressor is generally equivalent to other models. It is capable of producing large volumes of air at moderate pressures.

Rotary compressors are not as economical as reciprocal compressors under no-load or partial load conditions. They are best used as a base source of air, especially if volumes are large. It is not uncommon to use a rotary screw compressor as the main source of air for a facility and back it up with one or more reciprocal com-

pressors. This creates the best energy savings environment since the rotary is most economical under full load and the reciprocal under no-load or partial load. The initial purchase cost is also less, as are foundation and installation costs. Typically, rotary compressors are offered as self contained packages that can be readily installed without a great deal of effort.

One thing that should be noted is the maintenance cost of the rotary screw type compressor. As previously stated, the rotary screw depends upon close internal tolerances to produce compressed air. Past experience has shown that the longevity of the air compression unit on a rotary screw is around five to seven years. This longevity is only average and depends upon the unit and the environment to which it is subjected. It should not be placed in poor, dirty environments that would introduce above normal amounts of contaminants into the air inlet. These contaminants will cause premature failure of the compression unit. Typically, depending upon the size of the compression unit, the cost for replacement can be expensive. For instance, a 650 cfm compression unit will cost about $8,000. The design of these units is such that they cannot be rebuilt in-house. Also, oil bath units have the additional maintenance expenses of oil replacement and consumption and separator maintenance and filter replacement.

D. Centrifugal Compressors

This type of compressor is somewhat similar to a steam or gas turbine, where one or more rotating sets of blades separated by one or more fixed rows of blades act upon the gas being compressed. Because of the initial cost of these units, they are not usually made in the smaller, more common sizes, but they are available up to 10,000 cfm capacities.

E. Other Types Of Air Compressors

Several other types of compressors are used but are limited in their railroad applications to furnishing shop and yard air. They are liquid piston compressors, two-impeller straight line compressors, and ejector compressors.

F. Computer Compressor Comparison Program

One computer manufacturer has designed a personal computer based program that can be used with either a Lotus 123 or a Symphony software programming package. After inputting the necessary information for comparison between the two compressors, including the type, model, initial cost, full load cfm rating and full load compressor horsepower, the computer will calculate the percent of full load capacity, the percent of full load energy required and the average horsepower used.

The computer also calculates the energy savings, depreciation, taxable income, after tax cash flow, payback period and internal rate of return. These items are calculated from inputs of motor efficiency, motor size, cfm requirements, hours used per year, electrical costs, tax rates and anticipated project life.

Southwestern Railway Club

Started in 1946, the Southwestern Railway Club this year is celebrating its 42nd Anniversary.

The organization consists of Railroad and Railroad Supply members who cooperate to discuss locomotive and freight car maintenance and other aspects of the Railroad Industry.

Railroad personnel and Railroad suppliers and builders are welcome members in the Southwestern Railway Club. Contact our Secretary-Treasurer for details on meeting dates and locations.

Application for membership should be directed to the Secretary-Treasurer.

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Springfield Region
Burlington Northern Railroad
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Monday, September 19, 1988
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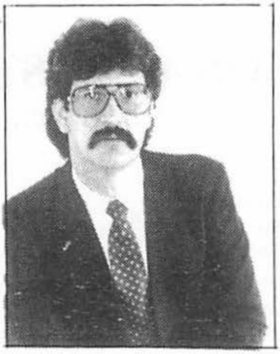
Pre-Convention Presentation: Southwestern Railway Club



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1988 TOPIC:
LOCOMOTIVE DATA ACQUISITION AND ITS RELATIONSHIP TO MAINTENANCE

PERSONAL HISTORY

A. E. (Gene) Bridges, Jr.

Gene was born in Cumberland, Maryland on December 30, 1949. He graduated from Bishop Walsh High School in 1967 and attended Allegany Community College in the Cumberland area. In March, 1968, he began his railroad career at Martinsburg, West Virginia as a Trackman with the Baltimore and Ohio Railroad.

In August of 1968, Mr. Bridges began serving an Electrician Apprenticeship at the Cumberland Locomotive Shop. Upon completion of apprenticeship worked there on various electrical positions and at Bolt & Forge Reclaimation Plant as a Maintenance Electrician. In 1977 he acquired 2nd Class Radio-telephone License with ship radar endorsement and moved to the communication department as an Electronic Maintainer at the system microwave center in Willard, Ohio. From there he was transferred to Cumberland, Maryland as Electronic Maintainer assigned to radio repair. In March of 1979 was promoted to Project Engineer in the mechanical department and relocated to Huntington, West Virginia. While there was promoted to Locomotive Maintenance Supervisor in 1981 and General Locomotive Maintenance Supervisor in 1982.

In October, 1983, relocated to Grafton, West Virginia. In 1988 Gene was appointed to the position of General Foreman of Riverside Shops in Baltimore, Maryland. He and his wife, Marita, have one daughter, Tracy, who is a full time student on scholarship at the University of Maryland.

LOCOMOTIVE DATA ACQUISITION AND ITS RELATIONSHIP TO MAINTENANCE

Introduction

This year the LMOA Electrical committee technical paper focuses on five areas in the field of locomotive data acquisition. In this text we examine the utilization of magnetic tape recorders; the use of solid state data recording systems; improvements to the GE and EMD data recording systems; and finally a locomotive analysis and reporting system that is part of the ever expanding high-tech option.

We must keep in mind that all first-rate maintenance organizations excell in the acquisition, interpretation and utilization of data. For these data provide the vital link essential for an organization to carry out and refine the maintenance function.

I
UTILIZING MAGNETIC TAPE EVENT RECORDERS FOR LOCOMOTIVE MAINTENANCE

Many North American Railroads have equipped their locomotives with a magnetic tape event recorder that records speed, time, distance, and many other "events" the locomotive has performed. This information is very helpful to the Transportation departments for enforcing operating rules, determining the cause of derailments due to faulty train-handling, and reviewing operations for good fuel economy. One use that is often overlooked is monitoring these data for locomotive performance. Many times a marginally performing locomotive will escape the notice of the engineer but could be detected by the event recorder if the results were reviewed specifically for this. Also, all the conditions that lead to a failure may not be reported on the work report. Again, review of the event recorder data would reveal these conditions and give a clue in determining the cause of a failure.

A base system records only speed, time and distance. Typically this is expanded to include traction motor current (often the #2 motor), throttle positions, trainline air brake reductions, independent brake applications, and dynamic brake applications. While this is the maximum number of events that can be recorded with the base systems, other events can be time multiplexed with these items. These items are not continuously recorded but recorded only when there has been a change in conditions. For this reason conditions such as cab signals whose condition changes only occasionally are ideal for multiplexing. Cab signals are shown as a spike of a predetermined magnitude and duration on the traction motor current trace.

The hardware of the system consists of a recorder and various transducers to measure the events. Speed and distance are measured by an axle alternator or by radar; the air brake system is monitored by an air brake manifold; traction motor current is measured by a current module; cab signals are wired to the multiplexer and other conditions are monitored by direct wiring to locomotive terminal boards. Other conditions can be monitored simply by adding the correct transducer.

The recorder uses an 8-track tape with a 48 hour capacity. The tape is an endless loop that records over itself so that the last 48 hours of data is all that is retained. At least one manufacturer is printing a ruler on the tape to measure wheel size for later use.

To retrieve the data the tape is removed from the recorder and placed in a playback machine. This machine produces a strip chart show-


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ing the values of all the events with respect to time. The strip chart can then be analyzed by a qualified individual. Wheel size is entered into the playback machine at the time of playback, making the on-board equipment independent of calibration. While the tape is being played back the information can also be digitized and downloaded into a computer. The computer can then also be used to analyze the data and issue an exception report. These exception reports are designed by the recorder manufacturer and use variables determined by the user. Three different exception reports can be generated: a train handling report, a statistical report and a mechanical report. The first two are of primary interest to the Transportion department or fuel officer.

Supervisory personnel, such as road foremen, can easily monitor engineer performance without riding the train. Undesirable conditions such as power braking, excessive speed, stalling, improper air braking, and improper dynamic braking can be determined either by analyzing the strip chart or by using the computerized train handling exception report. The statistical report can be used by a fuel officer and contains summaries of the time and miles spent in each throttle position. This is coupled with known consumption data and is used to determine gallons/mile, amp-hours/gallon and gallons/hour.

Locomotive performance can also be monitored by the Mechanical department. This falls into two basic categories: locomotive abuses and locomotive defects. Some items are presented in the computerized mechanical report, some must be recognized by reviewing the strip chart.

Locomotive abuses are defined as an engineer subjecting the locomotive to conditions it was not designed to perform, including overspeed, overcurrent, stall, and high speed application of the independent brake. Locomotive overspeed is included in the mechanical report. The computer has a 73 mph fixed limit and the user may specify up to two other speeds. The locomotive must exceed these limits for at least one minute to consider it an exception. Figure 1 shows overspeed. Traction motor overcurrent is also included in the mechanical report and has user definable limits on current and time. Stall is defined as traction motor current over 100 amps and speed equal to zero for at least 3 minutes. This is also included in the mechanical report.

Figure 2 shows a stall condition. Another abuse included in the mechanical report is application of the locomitive independent brake for at least 20 seconds above 25 mph.

Locomotive defects are not as well represented in the mechanical report. Items such as defective PC switch, defective axle generator, defective MU cable, defective current module, and excessive dynamic brake grid current are included but items such as improper loading, improper dynamic brake regulation, improper transition, wheel slip, and ground relay are not. All of these items can be defined and should be considered for inclusiuon into the mechanical report.

Improper loading: For most modern locomotives the manufacturer can specify the proper traction motor current at a given speed and throttle position. This will depend on locomotive model, performance module, and gear ratio; therefore the variables must be user specified. Figure 3 shows an SD40-2 with improper loading that was later determined to be caused by two plugged fuel filters.

Improper dynamic brake regulation: The traction motor current module measures traction motor armature current when the locomotive is in dynamic braking. This is the same as grid current and if the locomotive is equipped with grid current control dynamic brakes (FLAT) any modulation in current may indicate a dynamic brake regulation problem. If the locomotive has field current control type dynamic brakes (TAPER) the current and the speed can be used to determine if regulation is correct. Figure 4 shows an SD40-2 with improper dynamic brake regulation due to a defective DR module. In this instance this determination can be made directly from the chart.

Improper transition: This is defined as modulating traction motor current at transition speed or no change in motor current at transition speed. The exact definition is locomotive model dependent. Figure 5 shows improper transition due to a loose connection to the axle alternator on a C30-7.

Wheel Slip: Actual wheel slip will only be detected when it occurs on the wheel to which the axle alternator supplying the speed signal is attached. This appears as a spike on the speed trace and a simulations drop in traction motor current if the current to the motor is recorded. Wheel slip indication caused by other than actual wheel slip might be detected by improper loading conditions previously defined. Actual wheel slip is shown in Figure 6. No mechanical defect occurred.

Ground Relay: A sudden loss of traction motor current may be a sign of ground relay action. If the ground relay is reset current will resume. If the locomotive is reported for ground relay the strip chart will indicate the speed, throttle position and traction motor current at the time of occurrence. This is often helpful when troubleshooting the problem. A grounded traction motor caused the ground relay indicated in Figure 7.

Flashover: A sudden large increase in traction motor current for a very short duration may indicate that a flashover has occurred. As in wheel slip this will be detected only on the motor whose current is measured.

While magnetic tape event recorders are useful tools in maintaining a locomotive they present maintenance problems themselves. Most of the transducers seem to be relatively reliable but the recorder itself must be constantly monitored. Common recorder problems seem to be dirty recording heads, destroying of tapes, and driver motor failures.

Dirty heads and destroying of tapes due to dirty capstans can be solved by periodic head cleaning. One manufacturer recommends periodic cleaning with either alcohol and cotton swab or commercial 8-track type cleaning cartridges. The cleaning cartridges are the easiest to use but because of the slow speed of the tape several hours are required to adequately clean the head and capstan.

Drive motor failures can be detected by a lack of movement of the capstan and require replacement of the motor or whole assembly. Motors could be replaced on a periodic basis if the failures warrant.

Because the event recorder system is often used to determine the cause of derailment, wrecks, and grade crossing accidents periodic monitoring of the system performance is recommended. Several methods to monitor the system are available.

Ths most obvious is to review a tape produced by the recorder. Both manufacturers recommend that the tape be replaced on a six month cycle; therefore this is an ideal time to play back the tape and review the results. Shorter "test tapes" are available to be placed in the locomotive at a shop, cycle all events being recorded and immediately play back the tape. This can be done quickly since a shorter tape can be played back in less time than a 48 hour tape.

Another method to monitor performance requires the use of a "verifier" or "checker". This device plugs into the recorder and through the use of LEDs allows an operator to cycle the recorded data and verify that the signals are received by the recorder.

Finally, each component of the system has on-board LEDs that allow one to determine the signal that the device is sending to the recorder.

Many railroads have a large investment in these event recorders, but because of the expense of the playback systems and the labor to interpret the results the system is underutilized for diagnosing locomotive problems. There is, however, a potential saving due to decreased shop time and the finding of unreported defects that could lead to road failures. Additional computerization of the analysis of the results would greatly increase the usefulness of the system to the Mechanical department.

The on-board equipment also requires periodic monitoring and maintenance in order to assure it will be functioning in the case of a catastrophe.

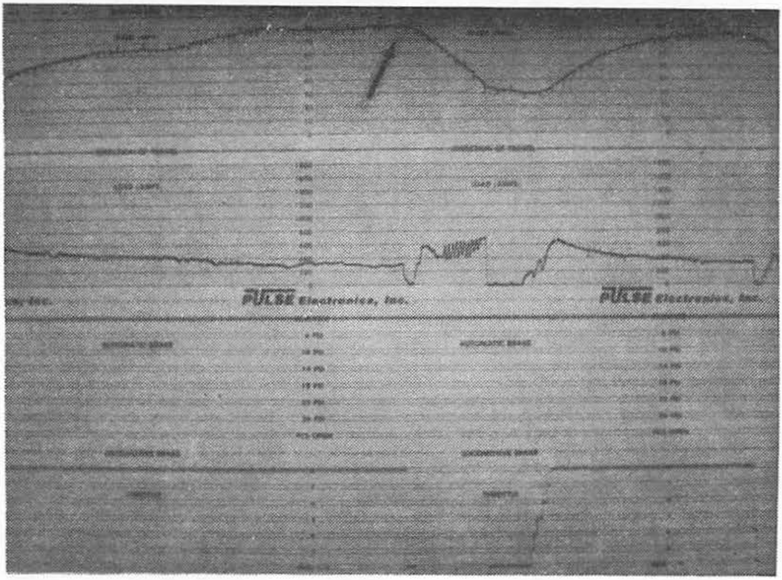


Figure 1

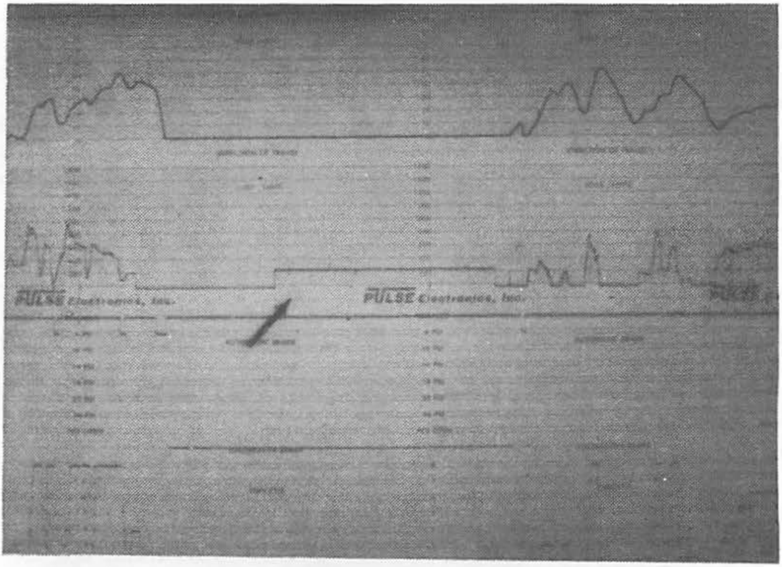


Figure 2

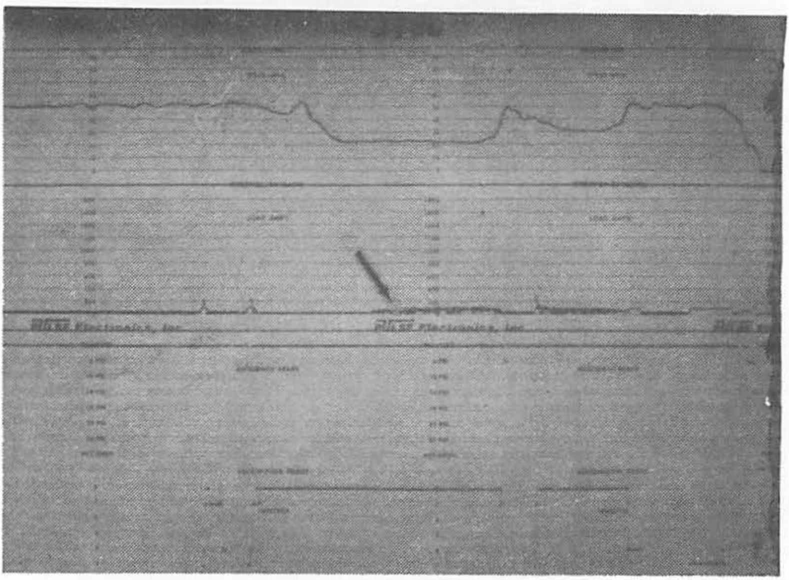


Figure 3

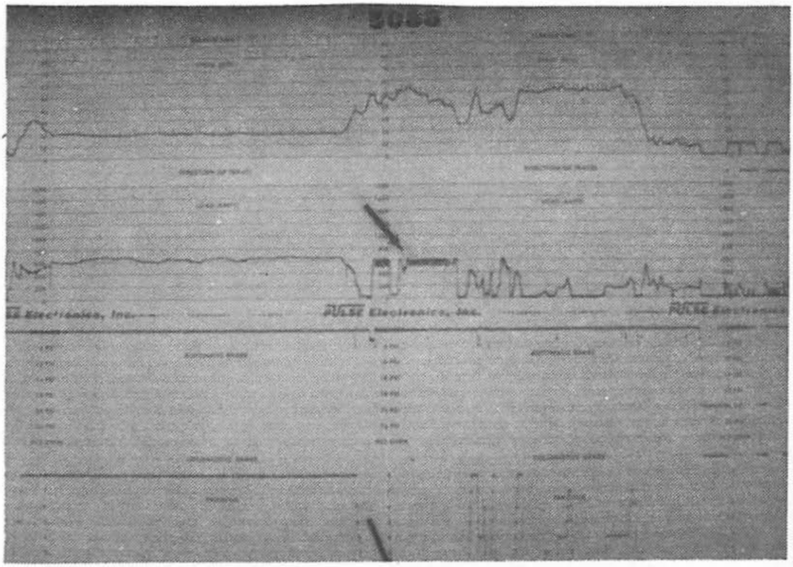


Figure 4

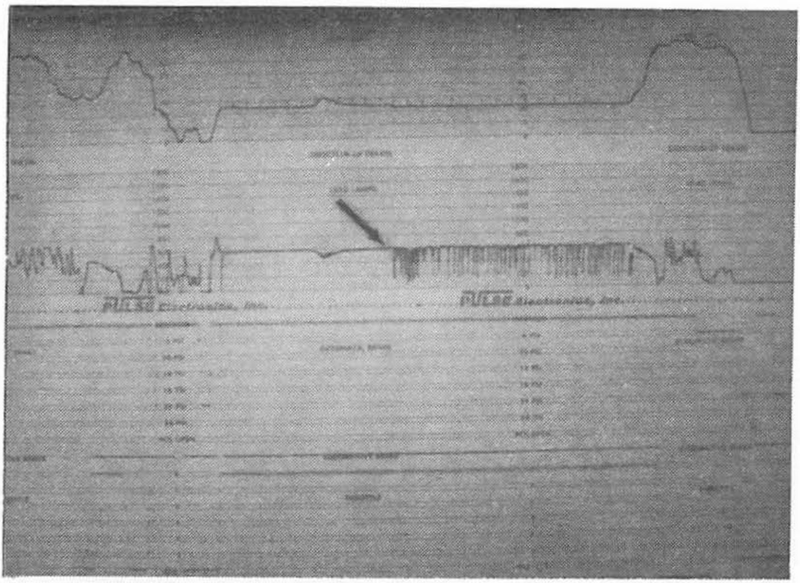


Figure 5

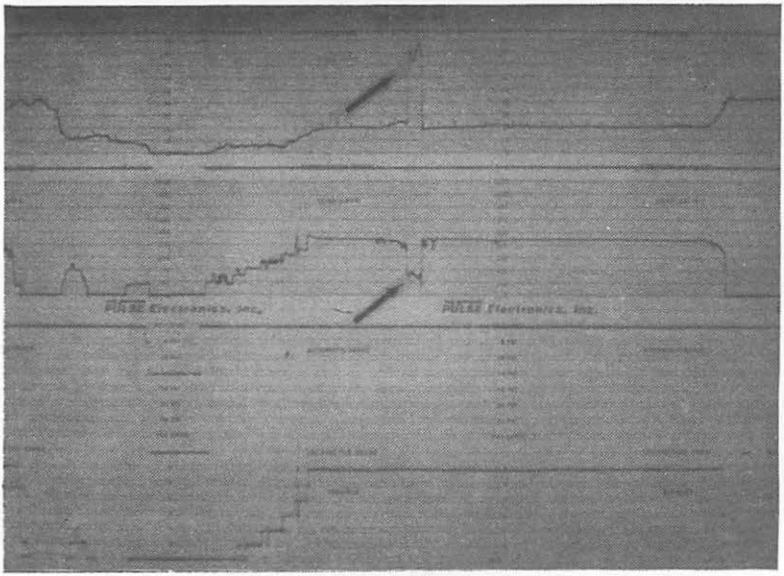


Figure 6

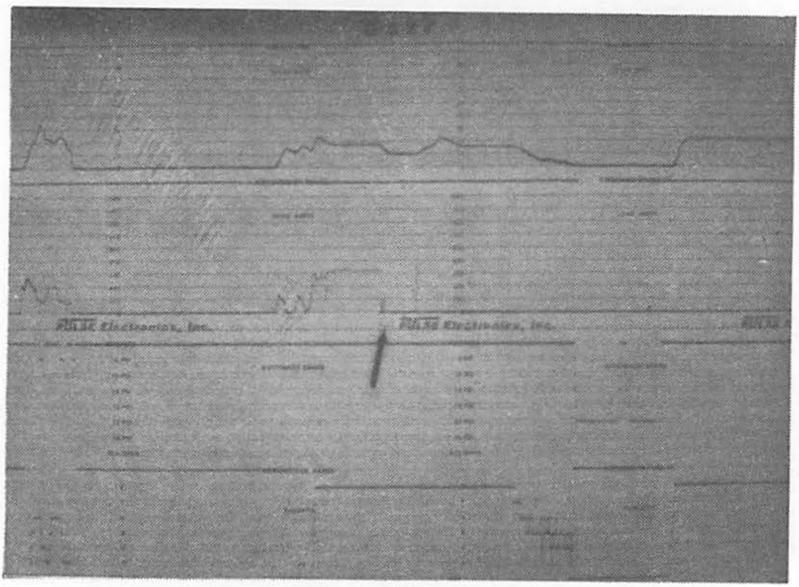


Figure 7

II
SOLID STATE LOCOMOTIVE DATA RECORDER

1. General

Technological advancements in the computer industry are starting to make their presence known to the railroad industry. Many suppliers are starting to market or develop microprocessors with solid state memories to perform the same functions as the tape recorders previously described. The solid state recorders offer many enhancements and greater flexibility over existing data tape recorders. These suppliers have acquired a great deal of knowledge from the existing data recorder systems and are putting it to use in their solid state recorders.

The solid state microprocessor based data recorder (sometimes referred to as event recorder) has no moving parts and thus minimal maintenance requirements. This is particularly appealing to the railroad industry where severe environmental conditions of the locomotive are a formidable challenge to most electrical or electro-mechanical components. Locomotives have evolved from a heavy reliance on relay based logic to a solid state based logic. This move in technology provides higher reliability and longer service life. The evolution from the tape recorders to solid state recorders is merely following the same technological path.

The microprocessor based data recorder can be programmed to fit the needs of the individual user. It can perform the functions of recording all pertinent information needed to monitor train handling by the locomotive crews and record additional information critical to the maintenance of a locomotive fleet. Thus it can fulfill the needs of both the mechanical and operating structures of the individual railroads.

The recorder can be used for failure analysis of individual components. Many times there is the question, "Did component 'A' itself fail or did component 'B' fail which caused component 'A' to fail?" This is often a time consuming and laborious question to answer. An example of this situation is a dynamic brake grid failure. Is the grid failure due to a defective grid or did the regulator circuit fail causing excessive grid current to burn up the grid. This would normally require testing and qualification of the dynamic brake regulation circuits. The data recorder could be used to answer that question by displaying the actual grid current just before the failure. One can then determine how the electrical systems were working prior to the failure and make the appropriate repairs to the locomotive.

The data recorder can be used to measure specific performance parameters. Is the locomotive producing full horsepower or do problems exist that are restricting horsepower output? This kind of information can be a tremendous diagnostic tool for maintenance facilities.

The data from the data recorder can be retrieved and subsequently transferred to a desk type computer for further analysis and evaluation. Depending on the evaluation software being utilized, it is possible to obtain graphic diagrams to interpret the analog and digital recordings in the same way as a standard paper strip chart recorder does today. As with the data tape recorders, data from the solid state data recorders have been accepted in a court of law.

2. Technical characteristics and specifications.

Some of the important technical specifications are:

A. Exclusively solid state.

B. Volatile and non-volatile memory.
C. Short or long term memory storage.
D. Modular construction for easy maintenance and repair.
E. Wide ambient temperature range (-40°C to +80°C)
F. Self diagnostic capabilities.
G. Robust construction.
H. High reliability.

The recorder is built exclusively with solid state devices and is controlled by a programmable processor which resides in a removable EPROM (erasable programmable read only memory). This provides an easy method for changing and updating the program residing within the data recorder. The data are stored in a solid state memory module built of either RAM (random access memory) chips, whose memory is lost if power is removed; or EEPROMS (electrically eraseable programmable read only memory), whose memory is retained if power is removed. The RAM chips require a battery backup to retain memory in case of power failure. The memory is stored in a separate module and is protected against impact, fire and liquids. The degree of protection differs from one supplier to another since specific standards do not exist in the industry.

The recorder operates in an endless and self erasing mode. Once memory is full, the next data stored will override the oldest data that are currently stored in the memory chip. There are basically two methods of data storage that are normally available as an option from the event recorder manufacturers.

The first method partitions the recorder memory into two sections: **short term and long term** memory.

The short term recording memory sometimes referred to as "crash recorder" operates in the following manner. All inputs are sampled approximately every 50 milliseconds and stored at one second intervals. Analog inputs are averaged while digital inputs are recorded as they are sampled. Memory capacity can vary from approximately ten minutes to one hour.

The long term memory section is done in much the same way except that the inputs are sampled and stored at longer time intervals. The main difference is that analog inputs are not averaged but are recorded as sampled. Memory capacity of up to 180 hours is available depending on the software being used.

The second recording method does not differentiate between short and long term memory storage. A full recording of all inputs is made at specific time intervals (typically four minutes) for internal reference purposes. All other data will be stored only if the input signal changes. This is accomplished through the use of a specific algorithm designed by the manufacturer.

The following data are usually recorded:

- Time: year, month, hour, minute and second.
- Speed (from an axle generator).
- Brake pipe pressure (from pressure transducer).
- Independent brake cylinder-pressure (from a pressure transducer).
- Throttle position.
- Emergency brake application.
- Spare analog inputs (eight or more), 0 to 10 volts (can be used as designated by the user).
- Spare digital inputs (up to 24 or more), 0 to 75 volts DC (to be used as designated by the user).

3. Potential uses of solid state recorders.

A concern among many railroads is the maximum utilization of the microprocessor. Many suppliers are approaching the railroads trying to sell a system to take on one facet of the locomotive. It may be an engine protection system or something as simple as fuel usage. If we are not careful, the locomotive will have several computer systems to do a variety of functions when one system is more than capable of doing the job.

With the solid state data recorder, one could utilize the full power of the microprocessor to do more than just record data. The microprocessor could be used to analyze the various inputs and take the appropriate action required to protect the equipment. Data recorders could be programmed to control the sequencing of the cooling fans through the use of thermistors in the cooling water system. The thermistors placed in the engine oil system could be used by the microprocessor to derate the engine or shut it down if the oil temperature rises to a critical level.

Input signals from the axle alternators can be used by the microprocessor for odometer or speedometer purposes. This could be used in conjunction with end of train devices or end of train markers, to allow the crew to ascertain their position relative to a predetermined point.

Present flange lubricators are equipped with control circuitry designed to sense whether the locomotive is traveling on straight track or on a curve. With this information, the control circuitry determines how much lube to apply to the rail. Curve sensors or gyros could be interfaced with the microprocessor of the solid state recorder, allowing it to take over the control functions of the flange lubricator. With the proper software and hardware, one could realize some cost savings in this area.

If it is desired, a touch pad and display unit could be interfaced with the computer to allow the crew to enter predetermined defect codes into the computer memory to be viewed by mechanical forces to make the necessary repairs. The data recorder would allow mechanical forces to compare operator reported problems with the problems actually recorded by the date recorder. Management could then evaluate the accuracy of the defect reporting by the operating crews. If there is too much discrepancy between what is reported and what is found, it might be necessary to educate the crews on how to diagnose and report locomotive defects properly.

Many control functions can be incorporated in this system, thereby increasing ROI of the equipment. With development, these systems can be used to upgrade much of the technology in most of our locomotive fleets.

4. Evaluation analysis of recorded data.

The memory of the date recorder can be down loaded to a lap top computer or to a specially designed downloader. The data can be uploaded to a file residing in a micro, mini, or main frame computer. The data can then be analyzed according to software the user has specified.

The digitized data can also be transmitted via radio communications for remote system downloading to a computer system and then processed according to user specifications.

Once the data have been transferred to a computer, the proper evaluation software will allow the user to print the recorded data in either tabular form or as a diagram illustrating speed and other analog and digital inputs against time and distance. Some evaluation software

allows the user to search for specific situations he is interested in. This could be individual or multiple digital inputs, combinations of analog and digital inputs, maximum and/or minimum values of analog inputs, or a multitude of other situations. The principal differences between available systems are particularly evident from the wide range of sophistication in their evaluation software.

5. Maintenance requirements.

The solid state data recorder requires very little maintenance. The self diagnostic feature of this system will aid in the detection of internal failures and display the appropriate alarm for proper handling. Warning alarms will also be given in case the memory backup batteries or clock batteries need replacement. The only preventive maintenance required by the system is replacement of the lithium long life batteries approximately every five years. The internal clock will also require periodic resetting like any other commercial clock.

6. Systems or circuits to be monitored.

With the solid state data recorder, railroads have the capability to monitor and evaluate a large number of locomotive mechanical and electrical systems. One can place pressure sensors, temperature sensors, current and voltage sensors, and position indicators all over the locomotive. This raises some important questions which each railroad must address. What information is needed to repair, troubleshoot, and evaluate a locomotive's performance? What information is nice to know but does not offer real cost savings or benefits to the user?

From an electrical maintenance point of view, it is felt the following is essential information needed by maintenance facilities for repair purposes.

1. Monitor main generator/alternator current and voltage.
2. Monitor traction motor armature current.
3. Position of isolation switch.
4. Position of traction motor cutouts.
5. Excitation current for main generator/alternator.
6. Water temperature.
7. Oil temperature and pressure.
8. Position of wheel slip relay.
9. Sander circuits.
10. Throttle position.
11. 24T voltage for dynamic braking.
12. Position of ground relay.

Armed with this information, the railroads will be able to determine the following:

1. Kilowatt-hour production (horsepower if they prefer) of the locomotive.
2. Whether the unit is making transition properly.
3. Whether the unit sequences through extended range braking properly.
4. The nature of traction motor cut-outs (are they due to wheel slip, ground relay or engine related problems).
5. Whether proper corrective action is taken during wheel slip conditions.
6. The percentage of time spent in each throttle notch, from which the duty cycle of the locomotive can be derived.
7. Verification of loading problems.

Many more defect conditions can be analyzed and repairs made by monitoring the systems referred to above. Software can be developed to interpret the data and output the exceptions requiring action by maintenance personnel. It is also conceivable for the microprocessor to take corrective action as specified by the user (such as automatic traction motor cut-out or reducing horsepower to prevent engine damage).

7. Conclusion.

A commonly expressed statement about microprocessors is that the only real limitation to these systems is the imagination of the user. This should be amended to include common sense and cost justification. It is a waste of time and resources to accumulate data that no one will use or benefit from. These systems have great versatility so enhancements can be added as they are developed or as need arises with minimal hardware and software changes.

The solid state date recorder is the present. There are systems available on the market today and many more will soon be available. Each railroad must look at these systems and determine if they are cost effective for it to utilize.

III
IMPROVED UTILIZATION OF GE DASH & DATA RECORDING SYSTEMS

In the GE Dash 8 Series of locomotives, on-board diagnostics and self-test feature combine to provide a powerful troubleshooting tool to simplify and expedite maintenance by pinpointing problem areas. The Dash 8 knows what it is doing, what it is not doing and what it should be doing; and it can report those data to maintenance personnel to speed up the troubleshooting process and help minimize maintenance or repair time.

Dash 8 equipment is arranged for fast locomotive turnaround and minimum downtime, with ready access to scheduled maintenance items and easy removal of major components.

Information is displayed in the operator's cab on the diagnostic information display panel, known as the DID panel. There are two levels of operation of DID available for railroad users. Level 1 is used by the locomotive operating crew. In Level 1, the locomotive computers and operating crew utilize the DID in several ways:

1. The DID panel (Fig. 8) informs the operator of the general status of the locomotive's operating condition, its computers and, in some cases, the display itself.
2. If an operating condition, called a FAULT, is detected, the computers will initiate the ALARM mode. In the alarm mode the computer uses the DID panel to alert the operator to the fault by displaying a description of the fault, which is called a fault message, and in some cases rings an alarm bell.
3. This fault is recorded in a fault "log" along with pertinent operating data for later review by maintenance personnel.
4. The fault detected may require that certain operating restrictions be imposed on the locomotive as a means of protecting the locomotive's equipment. The locomotive computers impose the necessary restrictions and informs the operator of those restrictions thru the DID panel in the form of SUMMARY messages.

4. The operator can use the DID panel to review all active faults (fault messages) and their related restrictions (summary messages). The DID panel also allows the operator to reset selected faults, and attempt to return the locomotive to normal operation.

Operation of the locomotive will not be interrupted or degraded if a mistake is made while using the DID panel in Level 1. Nor is it possible to cause any damage to the equipment.

The DID panel is user friendly and prompts the user as to the next move.

Level 2 is provided for the locomotive maintainer. The Level 2 maintainer can return the DID display to READY with no following message. Level 2 provides the maintainer with the following operating modes:

MONITOR

This feature allows the maintainer to look at approximately 40 various locomotive and environmental parameters, such as current, voltage, locomotive speed, ambient temperature, oil temperature, water temperature, engine speeds, etc., as troubleshooting aids.

HISTORY

The maintainer can review the locomotive fault log. Analysis of locomotive "history" can give the maintainer helpful information about the problems (faults) the locomotive has experienced. Along with the fault log a data pack is also written to memory. This data pack, when translated can give you 19 operating parameters (including loco speed, notch, engine RPM, etc.) of the locomotive just prior (up to 100 milliseconds) to the time the fault was logged.

This information can also be downloaded into a portable computer such as the Tandy model 1400 LT from which it can be transferred to a computer such as GE Erie's

Digital Equipment Corporation's VAX system or the railroad's computer.

CALIBRATE

This feature allows the maintainer to set wheel diameter and in conjunction with the manual self-test mode also calibrate the load meter and GE speedometer.

TEST

The maintainer can manually or automatically test the locomotive control system. In the AUTOMATIC mode, self-test is run totally by the computer. In MANUAL self test, the maintainer can step through each test, electing to do the test or skip the test. In both manual and automatic self-test, faults are written to the fault log for later review.

DASH * STAR
(Diagnostic Access Service Help * Storage Analysis and Retrieval)

Combining a number of features previously mentioned and the capabilities of the GE VAX computer in Erie, GE has developed a system called DASH*STAR. Each Dash 8 customer has its own account in DASH*STAR with its own personal password.

This system allows a railroad to take information downloaded into a Tandy computer from a locomotive and upload it, via a telephone modem, into the Erie VAX DASH*STAR system. Once entered data may be analyzed in several ways by either the customer or GE personnel.

Personnel at GE will be able to look at data from individual railroads or the entire Dash 8 fleet when investigating a problem. The individual railroads will be able to analyze their own data in several ways.

The information in the fault help area can be continually kept up to date so that GE customers have the latest trouble shooting information available with the DASH*STAR system.

When logged on to DASH*STAR a menu comes on the screen, this menu contains:

1. Fault message help.
2. Retrieve fault data.
3. Upload new data.
4. Calculate the locomotive date.
5. Exit.

FAULT MESSAGE HELP: When selecting this option you will be asked for the fault number you need help with. When entered another menu comes up allowing you to select help including "Probable Cause", "Fault Isolation", "Fault Reset", etc. There is fault message help available for 1700 faults. This information is also available in the hardcopy book. Figure 9 is an example of a DASH*STAR fault help message (445B) menu.

RETRIEVE FAULT DATA: When selecting this option you will see another menu allowing you to select data by "road number" or "date range" or "fault log last sent" or "check for duplicates" or "last fault by road number".

UPLOAD NEW DATA: New data taken from the locomotive and stored in the Tandy computer can be uploaded into the data base thru a telephone link.

CALCULATE THE LOCOMOTIVE DATE: Each fault message contains a "time" such as 7283.10 which when converted by the computer becomes October 30, 1987 -11:00 AM Eastern Standard Time. The 7283.10 number is the actual hours since January 1, 1987. This makes it very easy to calculate the time between faults simply by subtracting the two numbers. The clock is backed up by a lithium battery located in the CAB controller (CAB is one of the three main computers that control the Dash 8). The lithium battery is used only when the locomotive control system is disconnected from the locomotive battery.

GE is also exploring the possibility of adding a "data logger" feature which would capture data such as:

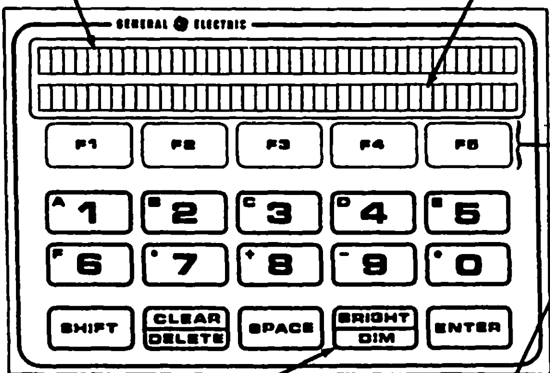
Time and date
Locomotive speed
Throttle notch
Motoring/braking indicator
Maximum motor current
Brake pipe pressure
PCS open indicator
Forward/reverse indicator
Road number
Diesel engine speed
Coolant water temperature
Engine oil temperature
Odometer
Wheel diameter

Any other signal monitored by the locomotive control system can also be selected for logging. The length of recording time available is a function of the number of parameters being monitored and the sampling rate of those parameters. Eight parameters could be recorded once every 30 seconds for a period of 48 hours before the oldest data begins to be overwritten by new data. However, if the eight parameters were recorded once every 15 seconds, the recorder has a 24 hour recording period before data overwriting begins.

You can see how valuable this feature would be for trouble-shooting, performing over-the-road testing, analyzing train handling and accident investigation.

THE FIRST LINE OF THE DISPLAY WINDOW IS FOR FAULT AND SUMMARY MESSAGES

THE SECOND LINE OR "MENU LINE" OF THE DISPLAY WINDOW IS USED TO GIVE OPERATOR CHOICES FOR THE FIVE SOFT KEYS LOCATED BELOW THIS DISPLAY LINE.



BRIGHT / DIM

TO DIM THE DISPLAY, PRESS AND HOLD "BRIGHT/DIM." THE LONGER IT IS HELD, THE DIMMER THE DISPLAY WILL BECOME.

TO INCREASE BRIGHTNESS, FIRST PRESS AND RELEASE "SHIFT," THEN PRESS AND HOLD "BRIGHT/DIM" UNTIL DESIRED BRIGHTNESS IS OBTAINED.

NOTE: WHEN INCREASING THE BRIGHTNESS AND "BRIGHT/DIM" IS RELEASED, THE NEXT TIME "BRIGHT/DIM" IS PRESSED, THE DISPLAY WILL GO DIMMER UNLESS "SHIFT" IS PRESSED FIRST.

SOFT KEYS

CALLED "SOFT KEYS" BECAUSE THEIR ASSIGNED FUNCTIONS CHANGE. THE FUNCTION OF EACH SOFT KEY AT ANY SPECIFIC TIME IS STATED ABOVE THE KEY IN THE SECOND LINE OF THE DISPLAY WINDOW. THE CHOICES CHANGE DEPENDING ON LOCOMOTIVE OPERATING CONDITION, FAULTS AND OPERATOR INPUT. THE SOFT KEY CHOICES ARE EXPLAINED AT THE BEGINNING OF EACH SECTION WHERE THE SOFT KEY IS USED.

FIGURE 8

DASH 8 LOCOMOTIVE
DASH * STAR SYSTEM

FAULT ANALYSIS EXAMPLE:
FAULT 445B Aux. Alternator Fails to Build Up

1. LABEL
2. SUMMARY MESSAGE
3. RESTRICTIONS
4. RETRY INFORMATION
5. ALARM BELL
6. FAULT RESET
7. DESCRIPTION
8. PROBABLE CAUSE
9. FAULT ISOLATION
10. ALL (IN PRINT FORMAT)

FIGURE 9

IV
IMPROVED DATA ACQUISITION FROM EMD's 60 SERIES DISPLAY COMPUTER

The EMD 60 Series locomotives feature a display computer that is the culmination of EMD's engineering efforts and breakthroughs in microprocessor control technology. The display computer is a state of the art, user-friendly diagnostic and troubleshooting tool for railroad maintenance personnel. See Figure 10.

Both operating crews and maintenance personnel benefit from the display computer's ability to detect and annunciate locomotive equipment operating status and fault conditions in plain English. Operating information and fault condition messages are recorded in the computer's archive memory unit, and they enable the maintenance personnel to minimize repair time and costs after a fault. Operating information and fault condition messages are maintained when the computer's power circuits are switched off, forming an "on board" operating history of the locomotive.

The display computer is composed of a common memory unit which communicates with the locomotive's excitation and logic computers, an archive memory unit, a central processing unit, and an interactive display panel. While the excitation and logic computers control the locomotive's major operating systems, the display computer monitors and records signals from various controls, feedback, and sensing devices. See Figure 11.

During troubleshooting, the display computer's menu-driven diagnostic system analyzes fault conditions and provides maintenance personnel with detailed information to help locate the problem. These conditions are indicated on the computer's display screen. Representative status and fault message categories include:

1. Engine and related equipment (speed increase, hot engine, governor...)
2. Traction power system (excitation control, wheel creep system...)
3. Dynamic brake system (grid, blower, grid open, ground relay...)
4. Computer and control system (operating status)
5. Miscellaneous (accessories, special equipment...)

Through the use of the keyboard and display screen, maintenance personnel diagnose locomotive performance problems by observing measured and calculated data, and operator switch data.

The display computer's archive memory unit can record up to 1,509 of the most recent fault messages and data along with the date and time of occurrence. Running data are also accumulated. These data can be retrieved and downloaded to a portable computer or printer for use at another time and location. Hard copies can be made of the information for analytical purposes. See Figure 12.

How many times have we really wondered what the locomotive, or any of its systems was doing at the time of a fault? How many times have we searched for those elusive, intermittent problems that mysteriously seemed to come and go? How often have we needed additional information to assist us in effectively managing our locomotive fleets?

The display computer is placed in the diagnostic mode by pressing a concealed ON key. A main menu is displayed on two screens (one screen at a time) and contains twelve

troubleshooting functions. Maintenance personnel would be most interested in the recorded information archived under the FAULT DATA and improved RUN DATA menus.

The fault data function menu is subdivided as follows. See Figure 13.

1. **ANNUNCIATOR:** Used to display fault messages and data recorded in the archive memory unit after a preset time/date marker is entered. Supporting data consist of signals taken during the fault occurrence. These signals fall into four categories, and are displayed according to the fault recorded:

   Engine (RPM, throttle position, main generator amps, Volts...)
   Power (above signals; MPH, TM amps, volts...)
   Dynamic brake (24T, TM field amps, TM arm, volts, grid current...)
   Super Series creep control
2. **HISTORY TO DISPLAY:** All fault messages and supporting data recorded in the archive memory unit can now be recalled to the display. Signal categories are engine, power, dynamic brake, and Super Series creep control.
3. **REPEAT FAILURES:** Fault messages and supporting data in the Archive Memory unit can now be displayed by type. Fault types include: FAILED TO LOAD, IMPROPER LOADING, GROUND RELAY-POWER, GROUND RELAY-DYNAMIC BRAKE...
4. **HISTORY TO PRINTER (ARCHIVE DOWNLOAD):** All fault messages and supporting data can be downloaded to a portable computer or printer.

The improved run data function menu is composed of locomotive operating data, and is subdivided as follows. See Figure 14.

1. **RUNNING TOTALS:** Recorded data includes kilowatt-hours, horsepower-hours, miles, and hours since the locomotive entered service.
2. **DUTY CYCLE:** Running total data are recorded by throttle position, or whether the unit is operating in the dynamic brake mode.
3. **TRIP MONITOR:** A resettable accumulator that records duty cycle data during the course of a trip.
4. **KILOWATT HOURS PER MONTH:** This new feature permits the total kilowatt-hours to be recorded for the previous 12 months of operation.
5. **COPY TO PRINTER:** This new feature allows data from running totals, duty cycle, trip monitor, and kilowatt-hours per month to be downloaded to a portable computer or printer.

Information contained in the run data can be utilized to schedule routine maintenance and overhauls when they are actually needed, rather than on a fixed time and mileage interval. Maintenance schedules can now be based on actual work performed as determined by horsepower-hours or kilowatt-hours. Component life is maximized while minimizing the possibility of operating with worn components.

Additional 60 Series display computer functions that assist maintenance personnel include METER/IOL, SELF-TEST, and FAULT RESET.

1. **METER/IOL:** 150 or more feedback signals from the power, dynamic brake, and creep control categories (including main generator voltage, current, contactor and operator switch status) can be monitored

while the locomotive is operating. Through the use of user selected screens, up to nine signals each can be viewed simultaneously. These signal values can also be downloaded into a portable computer or printer for future review.

2. **SELF TEST:** Tests various locomotive systems, including cooling fans, contactors, radar, and load regulator. A separate function is provided for load testing.
3. **FAULT RESET:** For resetting latched-in faults. The computer will prevent normal locomotive operation by reducing or preventing main generator excitation after the occurrence of certain faults. A message is displayed for the operating crew, and will remain on until the fault has been corrected, and until this function has been used to reset it. These faults include:

   "ENGINE AIR FILTER DIRTY — THROTTLE 6 LIMIT",
   "DYNAMIC BRAKE GRID BLOWER OPEN"...

The ability to download recorded data stored under the fault data and run data function menus creates new dimensions in the management and operation of 60 Series locomotive fleets. Data can be uploaded into a central computer, and could be tabulated in a number of different of ways depending on the type of computer and program utilized. Commercially available software programs allow these tabulated data to be graphed as a function of time, or plotted as a histogram.

Possible uses of data downloaded from the FAULT DATA menu include:

1. **Monitor individual locomotive performance:** Fault data could be tabulated by number of fault occurrences over a specified time interval — day, week, month, year.

   Fault data could be tabulated by type of fault and frequency of occurrence over a specified time interval.

   Fault data could be tabulated by nature of problem exhibited in the supporting data.
2. **Monitor fleet performance:** Fault data could be tabulated by number and type of fault occurrences in the fleet over a specified time interval.
3. **Monitor fleet performance trends and fault trends:** The number of fault occurrences and the number of fault occurrences by type could be tabulated for specified time intervals. Comparisons can be made of the number of fault occurrences and the number of fault occurrences by type over a specified time interval in order to highlight trend changes.

Possible uses of data downloaded from the run data menu include:

1. **Improve Fleet Utilization:** Underutilized locomotives that exhibit low kilowatt hour, horsepower hour, miles and hours values could be reassigned to other routes or types of service. Overutilized locomotives could be reassigned pending required inspections, and component replacement.
2. **Monitor component life and component replacement intervals:** Performance of consumable replacement components and major components can be evaluated based on kilowatt hours, horsepower hours, miles, hours of operation, and duty cycle.
3. **Monitor Fuel Consumption:** One SD 60 customer utilizes data archived under run data, along

with its externally measured fuel quantities to compute fuel consumption per mile, and kilowatt hours of electricity generated per gallon of fuel.

4. Monitor lubricating oil and other fluid usage.
5. **General fleet operating information:** Data obtained from all SD60s could be totaled and presented in fleet operating reports.

As we have seen, the 60 Series display computer is not only a state of the art, user-friendly diagnostic tool, it can also become a highly useful tool for managing locomotives in today's highly competitive transportation industry.

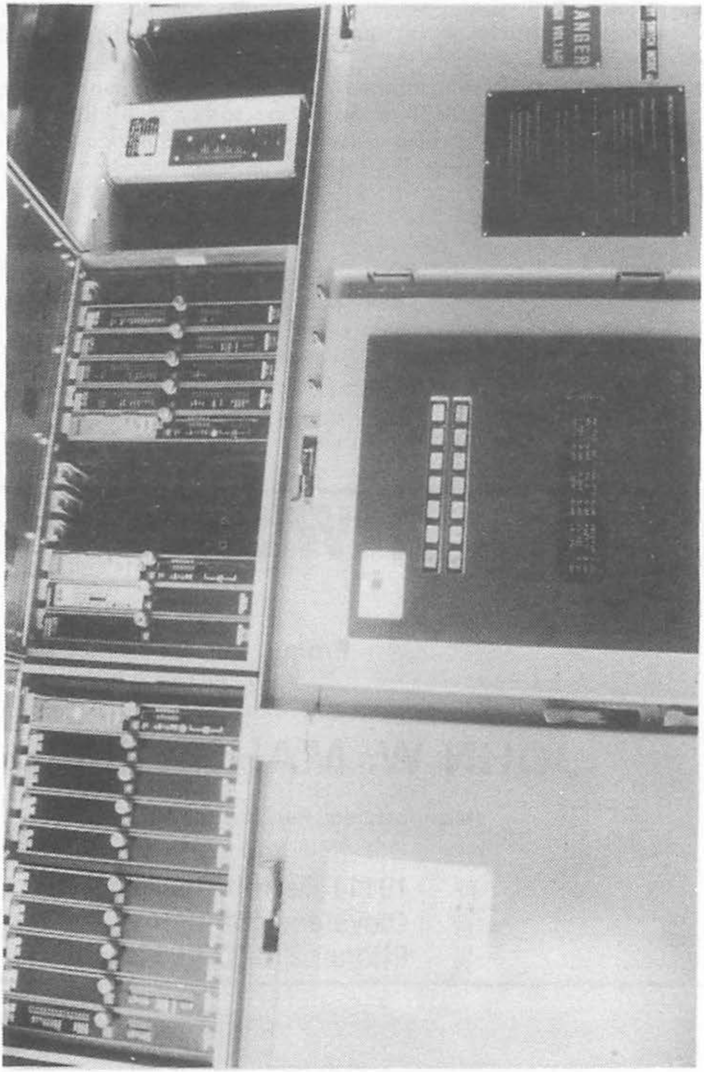
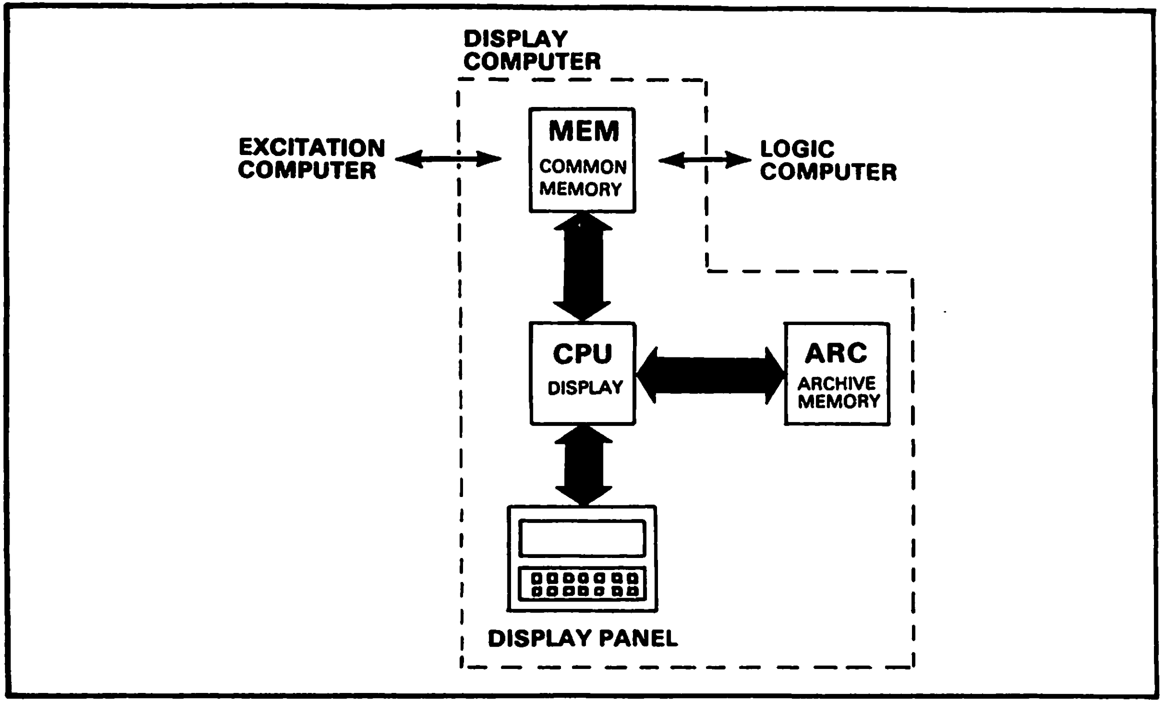


FIGURE 10



Display Computer And Related Circuits,
Block Diagram

FIGURE 11

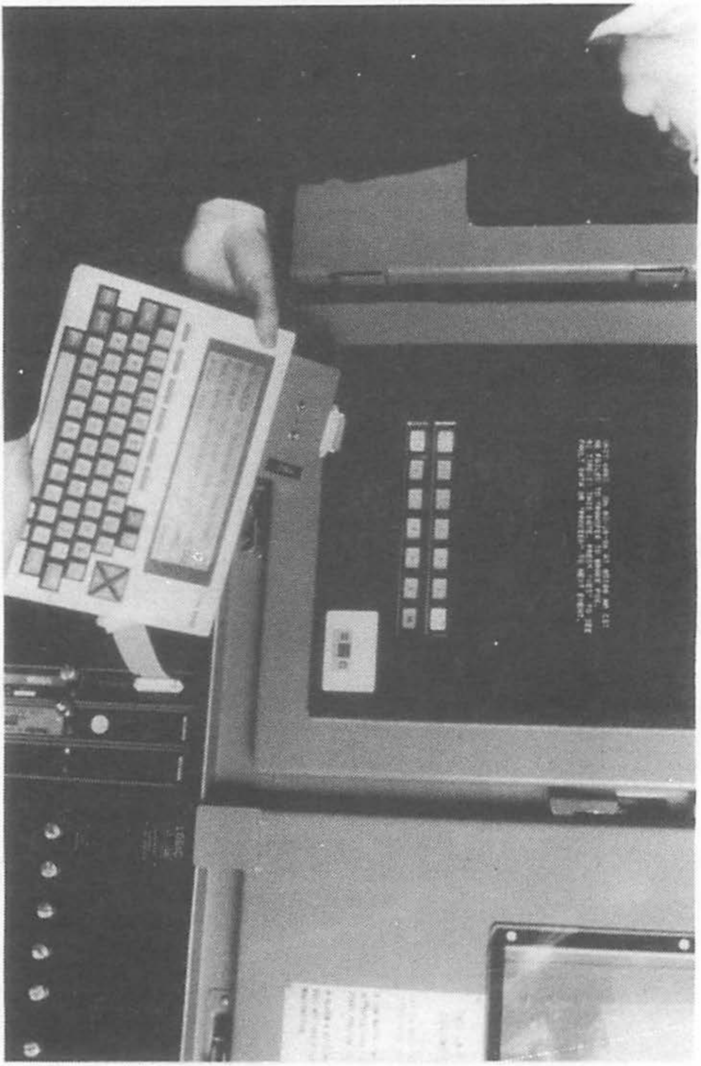


FIGURE 12

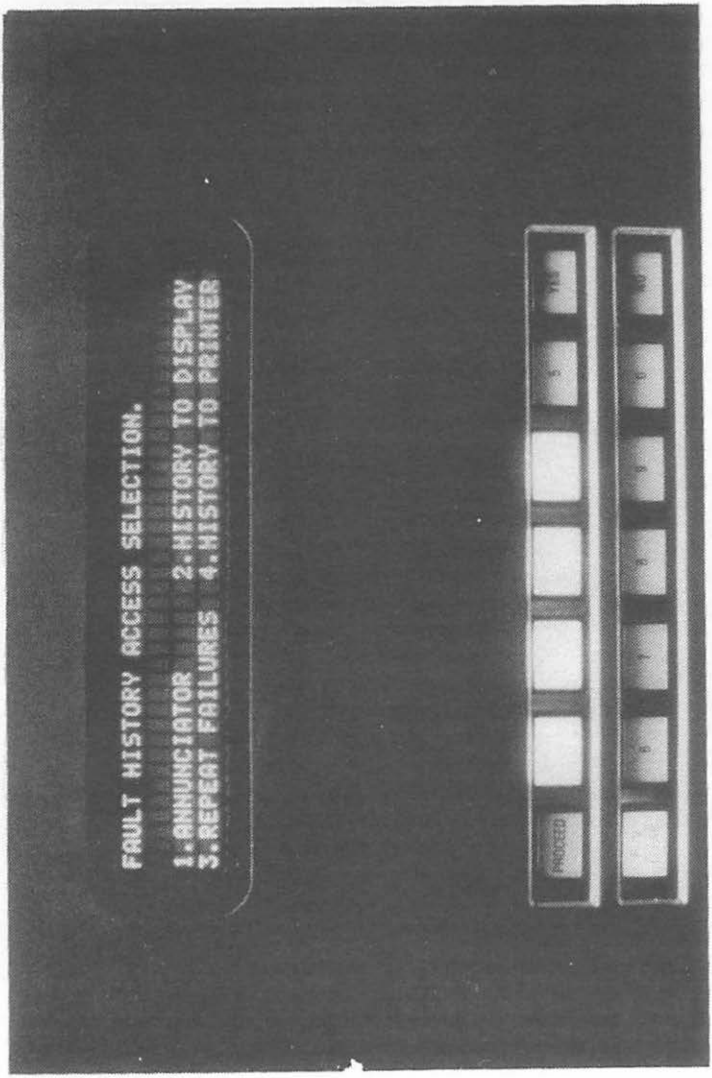

FAULT HISTORY ACCESS SELECTION.
1.ANNUNCIATOR 2.HISTORY TO DISPLAY
3.REPEAT FAILURES 4.HISTORY TO PRINTER
PROCEED

FIGURE 13

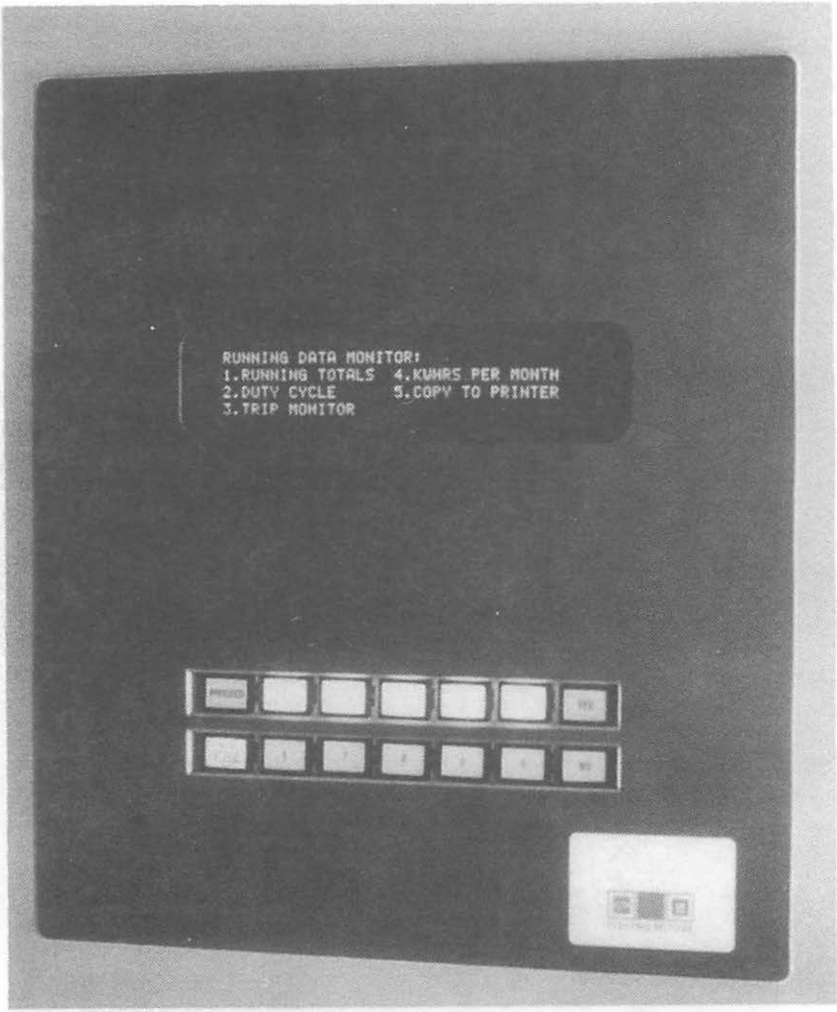

RUNNING DATA MONITOR:
1.RUNNING TOTALS
2.DUTY CYCLE
3.TRIP MONITOR
4.KWHRS PER MONTH
5.COPY TO PRINTER

FIGURE 14

V
LOCOMOTIVE HEALTH DATA AND ITS USES TO THE RAILROAD

The Locomotive Analysis and Reporting System (LARS) is a locomotive health monitor installed on nine road locomotives in the northern part of the United States. (Figure 15).

This LARS system, one subsystem of the Advanced Railroad Electronics System (ARES), provides important real time and internally stored data pertaining to the main areas of engine efficiency, fluid levels, operating temperatures and other maintenance parameters.

The LARS system reports its information through two possible data paths:

1. an RF data link (Figure 16) for over-the-road communication to an office maintenance computer, and
2. a laptop computer that can be carried on-board the locomotive.

The LARS automatically sends a message of the problem areas on the locomotive in each of fourteen categories. Other LARS information can be specifically requested by the user, either as an on-demand basis or time sequence demand.

Railroad Data Communications System

The LARS computer is directly coupled to the on-locomotive data communications system. The data communication system manages communications between systems onboard the locomotive and information flow between locomotives, and provides the radio communication link to the wayside ground stations.

Unique addressing and communication procedures, along with specific automatic error detection and correction mechanisms, ensure correct delivery and accurate communication. A network control computer in the dispatch office manages communications through a wayside distribution network that covers some 4,000 to 5,000 miles of track. Ground terminal controllers along the wayside distribution network provide for radio communications to the train as it moves throughout the railroad.

LARS System Capability

To best convey the LARS/ARES system capability, a series of computer data screens are shown which accurately reflect what the end user (maintenance personnel) can see via the data network and the office maintenance computer.

Main Menu (Figure 17)

The main menu allows the user to call up any of the data screens for view by pressing the appropriate special function key. The categories include performance, exceedance history, refueling history, locomotive location, exceedance limits, current data, and fuel efficiency.

Current Data

The current data screen (Figure 18) shows the current value of each parameter. LARS is designed to accommodate far more monitored parameters. The actual parameters to be monitored are chosen by the railroad. Generally, railroads have indicated a preference for horsepower generated, performance efficiency, fluid levels, temperatures, various pressures and other sensors that lead to improved maintenance analysis.

Performance Data

The performance data screen (Figure 19) shows information on the recent past performance of the locomotive while it was out on the road. These data include the alternator horsepower, measured drawbar force, governor position, sensor bypass voltage, engine RPM, air box pressure, and other information for each throttle position. These data are constantly being updated for most recent operation to show performance level changes. The data can be viewed upon request of the end user. The performance data are intended to be used by the maintenance personnel to troubleshoot operating problems that are not detectable in the shop without major expense.

Exceedance History

The exceedance history screen (Figure 20) is a data accumulation of the most recent occurrences of monitored faults. The currently implemented LARS monitors more than a dozen faults and records their time and date of occurrence, and associated information that can provide insight into the reason for the fault. As faults occur, LARS stores the fault and its associated parameters in non-volatile memory on the locomotive. These fault messages are also automatically transmitted via the data network to railroad-designated monitoring computers. The monitoring computers can be located throughout the railroad's facilities. The fault memory is accessible by maintenance personnel on board the locomotive as long as the equipment rack is powered.

Exceedance Limits

The exceedance limits shown in (Figure 21) for each one of the monitored faults are stored in the internal non-volatile memory of LARS. These limits have the attributes of high or low limit alert, degree of alert, and other preconditions for alert (such as being in throttle eight position before sending a report of abnormality). The exceedance limits on each LARS system in the field can be changed from the office computer for a given class of locomotives or an individual locomotive to implement changes in railroad requirements. The change can only be accomplished by sending a correct authorization code from the office maintenance terminal, through the ARES network, and is generally restricted to a few authorized individuals.

This capability to change limits from the office precludes the disruptive and expensive process of removing computers from locomotives to do minor limit adjustments.

Diagnostic History

Each time an exceedance has occurred, the system stores, in its internal memory, the time and date of the exceedance, the severity of the exceedance and a set of specific parameters associated with the exceedance that will aid in diagnostics of the problem. Figure 22 gives a representative screen using a low alternator horsepower fault as an example. The additional parameters shown are subject to railroad choice. The diagnostic history screen is intended to provide a quick method to isolate the causes for the particular problem that was reported. This diagnostic information will lead to much faster repairs by eliminating inaccurate descriptions and trial-and-error troubleshooting.

Refueling History

The LARS also has a pneumatically operated fuel gauge that reports the current fuel quantity and has the capability to determine when the locomotive is being refueled. During refueling, the LARS records the time, date and fuel quantity added for later retrieval. Currently, the last six refuelings are recorded for retrieval by the RF data link system (Figure 23).

Railroad Uses of LARS Data

LARS, as a part of an integrated command, control and communication system, is primarily designed to provide railroad officers with the information necessary to effectively manage critical assets. Consequently, the system should be configured to provide useable, easy to understand information in a timely manner to make good management decisions. Motive power allocation and maintenance efficiency can be improved with near real time data on horsepower and locomotive problems.

Horsepower

Operations personnel, given reliable information on the actual power being developed by each locomotive, can determine the best ways to manage ruling-grade power scheduling. The maintenance personnel will likewise need this information for determining the order of repair scheduling, and the cross referencing of FRA inspection schedules to minimize the percent of local fleet down time. Knowing if a locomotive has a severe problem developing power and if the local maintenance facility can handle it is important for maximizing the efficiency of current repair facilities.

Locomotive Fuel Efficiency

LARS, through use of the integral fuel gauge, can provide a current measurement of operating efficiency for each locomotive as well as the actual fuel on board (Figure 24). Maintenance and fueling personnel can use this information to make predeparture allocation and fueling decisions. LARS can automatically determine the fuel use rate and hordsepower output, using a patented real time dynamometer. (The theory of operation is explained in US Patent 4,671,106, fuel energy quantification system).

Maintenance Requirements

A major benefit of any on-board locomotive health monitoring system to a data network enables the railroad to have timely and useful access to the data. The intent must be reduced maintenance time, fewer unnecessary inspections and the resultant improvement in out of service time. The LARS fault reporting system can be instrumental in implementing an "on condition" maintenance philosophy that departs from time based maintenance wherever possible. The tie into the data network can provide advanced warning to the maintenance personnel of actual or impending problems of the locomotive before it arrives in the maintenance terminal. In many cases, creative questioning of the locomotive via the data network can help isolate the malfunction and schedule its repair before the locomotive arrives.

Conclusion

In conclusion, the LARS locomotive analysis computer system has the capability, flexibility and reporting capacity to improve the efficiency of the railroad maintenance function as well as improving the critical areas of schedule, resource and time management that are so critical for the long term viability of the railroad industry.

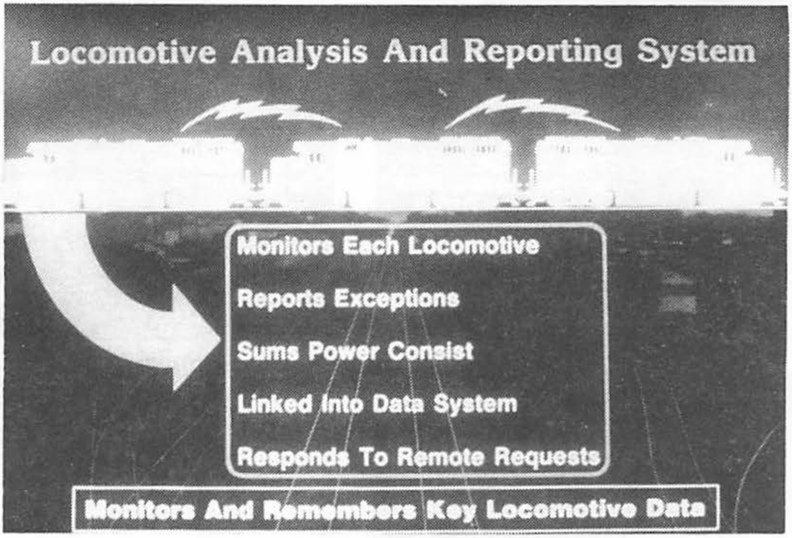


FIGURE 15

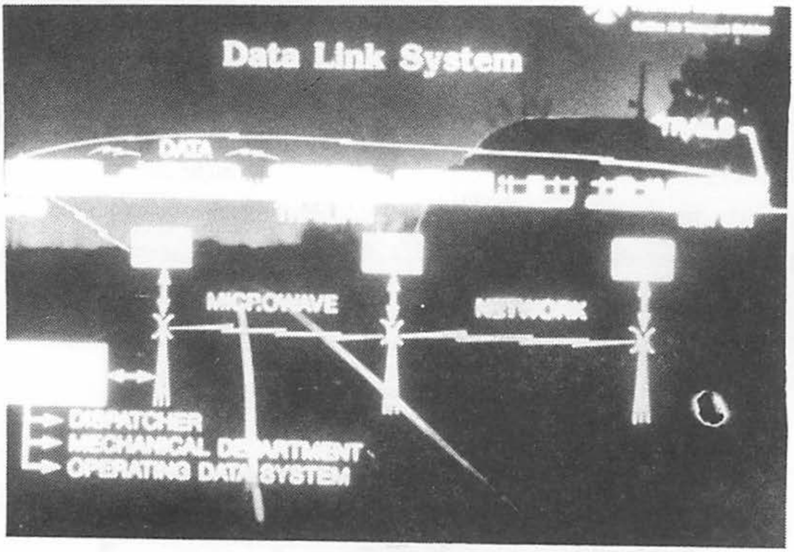


FIGURE 16

F-2	PERFORMANCE
F-3	EXCEEDANCE HISTORY
F-4	REFUEL HISTORY
F-5	GTC LOCATION
F-6	EXCEEDANCE LIMITS
F-7	CURRENT DATA
F-8	FUEL EFFICIENCY
F-9	SYSTEM CONFIGURATION
<ESC>	EXIT AGT APPLICATION

FIGURE 17

CURRENT DATA

GOV POSITION	0.80
ENGINE RPM	898
AIR BOX PRESSURE	19.32
ALTERNATOR VOLTS	1156
ALTERNATOR AMPS	1803
ALTERNATOR HP	2980
TH14 VOLTAGE	67.90
SB11 VOLTAGE	50.90
PF29 VOLTAGE	53.60
LOAD REG POSITION	97
RC12 VOLTAGE	49.90
DYN BRK VOLTAGE	53.02

FIGURE 18

PERFORMANCE

	TH 7	TH 8
ALTERNATOR HP	2582	2961
GOVERNOR POS	0.88	0.80
THROT RES TH14	59.63	67.07
SENS BYPASS SB11	44.21	50.93
LOAD REG POS	92	91
ENGINE RPM	830	893
AIR BOX PRESS	15.59	20.45
THROT POS TIME	67	218

FIGURE 19

EXCEEDANCE HISTORY

ALTERNATOR HP

17:12:32	09/10/88	INC
14:59:57	09/08/88	INC
14:50:02	09/08/88	INC
05:32:15	09/01/88	INC
17:10:30	08/15/88	INC
15:33:46	08/12/88	INC
17:40;50	08/10/88	INC
01:04:26	08/10/88	INC

FIGURE 20

EXCEEDANCE LIMITS — 6798

EXCEEDANCE	CONDITION	CAUTION OFFICE	CAUTION ONBOARD
ENG OVERSPD	TH 8	0.0%	> 0.0%
ALT HP	TH 8	85.0%	<85.0%
OIL QYT	IDLE 100% TEMP	85.0%	<85.0%
CRANK PRESS	TH8	0.0%	> 0.0%
OIL PRESS	IDLE	0.0%	< 0.0%
	TH 8	0.0%	< 0.0%
OIL FILTER	----	>25.0%	>25.0%
AIR FILTER	----	>17.0%	>17.0%
FUEL PRESS	----	>67.0%	>50.0%
WATER TEMP	LOW	0.0%	< 0.0%
	HIGH	> 9.5%	> 9.5%
FUEL QTY	----	<30.0%	<30.0%
OIL TEMP	----	>20.0%	>20.0%
A C INT PRS	----	>57.5%	>57.5%

FIGURE 21

DIAGNOSTICS 6798	17:12:32
ALTERNATOR HP	
ALTERNATOR HP	1029
GOVERNOR POSITION	1.34
THROTTLE RESPONSE VOLTAGE	34.63
SENSOR BYPASS VOLTAGE	24.89
LOAD REGULATOR POSITION	93
ENGINE RPM	576
AIR BOX PRESSURE	5.23
THROTTLE POSITION	8

FIGURE 22

REFUELING HISTORY 6798

DATE	TIME	GALLONS ADDED
12/20/87	17:00:40	1155
12/18/87	19:05:26	1677
12/16/87	00:29:26	1641
12/13/87	19:34:52	1399
12/11/87	03:20:22	1835
12/09/87	02:54:06	955

FIGURE 23

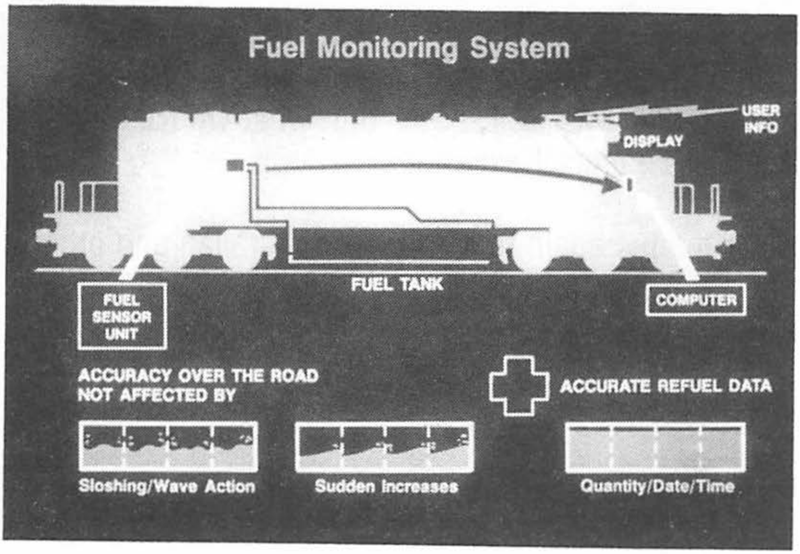


FIGURE 24

DIESEL MECHANICAL MAINTENANCE COMMITTEE

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

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

Our thanks again to Mr. J. R. Nussrallah and others responsible for and participating in this activity.

Monday, September 19, 1988
3:15 P.M.

REPORT OF THE COMMITTEE ON DIESEL MECHANICAL MAINTENANCE

Pre-Convention Presentation: Altoona, PA

May 4, 1988 Sheraton-Altoona Altoona, PA

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1988 TOPIC:

LOCOMOTIVE MECHANICAL OFFICERS DEVELOPING EXTENDED MAINTENANCE PROGRAMS — THE VITAL LINK

PERSONAL HISTORY

Gilbert J. Bruno

A California native, he was born in Los Angeles on July 21, 1945.

Gil began his railroad career in April of 1964 as a Machinist Apprentice for the Atchison,Topeka and Santa Fe Railway. He graduated from his apprenticeship in August of 1968 and was promptly drafted into the United States Army, where he served with the 2nd Infantry Division of the D.M.Z. of South Korea. After completing his military duty in 1970, Gil served on the Santa Fe in various capacities such as Journeyman Machinist, Relief Roundhouse Foreman, A.S.D.E. and Relief M.T.C. Foreman.

He left the Sante Fe in January, 1977, to work for Amtrak, after Amtrak had purchased the passenger car and locomotive facilities in Los Angeles, which were former Sante Fe Shops.

He was instrumental in establishing a Running Repair Facility for passenger locomotives there and served as Foreman, General Foreman and Assistant Manager until 1984 when Gil was promoted to Facility Manager of Amtrak's Locomotive Maintenance Shops in Chicago, Illinois which is the position he currently holds.

Gil is married and has one child. His hobbies include motorcycling and restoring classic automobiles.

I
UPDATE-ON BOARD FLANGE LUBRICATORS

Mobile automatic wheel flange lubrication systems have been in daily service on member roads for the past three years. (Figure 1) These roads have realized economic benefits of improved fuel efficiency and reduced rail and wheel wear with the lubrication of the wheel flange. (Figure 2) It has been noted in earlier papers that the reduction in rolling resistance translates to a 5 to 10% fuel saving, or a 100% plus return on initial investment costs.

The Willy Vogel STG-3 system is currently the most widely used system in this country, with almost 1,400 applications on two member roads. (Figure 3) The system features a non-pressurized lubricant storage tank, where grease is gravity fed to a positive displacement pump. (Figures 4 & 5) The pump then supplies pressurized grease to a control valve which directs the flow to the proper spray nozzles where air pressure expels the grease onto the wheel. (Figures 6 & 7) The system is controlled by a programmable electronic control unit which coordinates the spray of a metered amount of grease at a predetermined frequency of wheel revolutions. (Figure 8)

Other noteworthy features of the system incorporated by member roads are the "simulated test mode" for in-shop static testing to facilitate inspection and repair of the unit. Also, North American systems include a lubricant inhibit feature which can be programmed to stop lubricant flow during wheel slip correction, dynamic brake and slow speed (under 5 mph) operation.

Additional features resulting from three years of development experience include the application of forward and reverse grease spray nozzles to the leading and trailing axles of the same truck. (Figure 9) This simplifies application and reduces the required piping without compromising the benefits of the system.

Also one member road has been modifying lubricant storage tanks with an inspection window to allow visual measurement of lubricant level and to facilitate grease pump screen cleaning and replacement. (Figure 10) These tanks contain between 35 and 45 gallons and require service at 30 to 90 day intervals. The tanks are located in the long hood air compressor compartment or on the running board behind the fireman's window on EMD locomotives, and in the airbrake compartment under the fireman's side of the cab for GE locomotives. (Figures 11 & 12) Other major components, such as the trigger box, control box, control valves and grease pump, are usually located in proximity to the grease tank in a covered location, again to simplify installation and maintenance.

After large scale applications began, a few operating problems developed which required modifications to the standard Willy Vogel system. The first problem encountered was the inability of fittings to maintain tight connections between tubing and applicances, such as nozzles and filters. The result was grease leaking at these connections, with an occasional pull apart. This condition was caused by a poor ferrule fit, which was the result of tubing outside diameter being out of round and having uneven and high hardness spots. This problem was solved by replacing the tubing and its associated fittings with Type AT SAE 100R2 high pressure double wire braid hydraulic hose. (Figure 13)

The next deficiency encountered involved the first batches of Shell Ossagol V grease manufactured in this country which tended to separate, leaving the soap component to clog the pump strainer, blocking delivery of the lubricant. The cause, since resolved, was found to be improper blending of the grease during manufacture as complete instructions of the recipe for this grease were not furnished by Shell-Germany to Shell-USA for use at its Metairie, Louisiana plant.

Another deficiency encountered was excessive wheelslip due to migration of grease from the wheel flange area to the wheel tread. Correction of this problem was through a threefold solution. A 30 second time delay was installed in the flange lubricator drop out timing module circuit. This change was designed to turn off the lubricators at the beginning of first stage wheelslip and allow the locomotive time to "run out" of the overspray condition. Previously, lubricators were turned off at stage two wheelslip correction. Secondly, the spray angle of the nozzles was changed to reduce spray and migration onto the wheel tread. (Figure 14) Brackets were fabricated to orient the centerline of spray to 30 degrees with respect to the wheel tread plane. This alignment was found to be very important and remains a high maintenance item requiring adjustment at time of wheel truing or renewal.

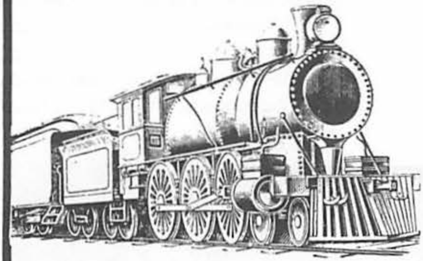
Finally, the amount of grease sprayed on the wheel flange was reduced from .15CC every 40th revolution to .05CC every 25th wheel revolution.

In addition to the above, two other changes in the system were found necessary, both related to the STG-3 solenoid control unit: (Figure 15) an in-line air filter to eliminate contaminants from fouling orifices and other air passages, and a voltage spike suppression module to prevent electrical spikes from adversely affecting the trigger box (electronic control unit) circuit board. These problems considered, the Willy Vogel system is currently the most widely used flange lube system in this country. However, at this time other systems, most of them with more sophisticated elements are gaining popularity with an increasing number of actual and scheduled applications.

The Madison Kipp system features a non-pressurized grease storage tank with a pneumatic pump that keeps grease links filled under constant pressure with the spray air actuated at the nozzles. (Figure 16) The system also incorporates a programmable microprocessor unit to control the spray of a metered amount of lubricant to the appropriate spray nozzles. (Figure 17) This system also features such options as curve sensing, function lights, speedometer interface, low speed inhibit, status lights, in-service test mode, lubricant inhibit and ruptured line monitor. Of these, the one that receives the most development attention is curve sensing with the primary benefit being to increase flange lubrication in curves where most friction losses occur. Member roads are now making additional application of the Madison Kipp system.

The Bijur flange lubricator system features either a pressurized or non-pressurized grease storage tank and constant pressure grease delivery lines (Figure 18) Spray nozzles are controlled by a solenoid at each nozzle, actuated by a programmable controller.

The TSM (Technical Service & Marketing Inc.) system utilizes a pressurized lubricant storage tank which delivers the grease to a control valve. When signaled, this valve directs the lubricant flow to the appropriate spray nozzle. The system features a programmable control unit and an air driven gyroscope for curve sensing. One member road is applying 450 of these units this year.



The Brown Boveri system utilizes a special oil, gravity fed to a distributor which in turn delivers the lubricant to the nozzles. Spray is actuated by an electronic programmable control unit.

In summary, wheel flange lubrication systems have offered member roads benefits in both reduced wheel flange and rail wear and increased fuel efficiency. (Figure 19) This can be substantiated because member roads are planning additional applications which by next year should double the amount of units currently in service.

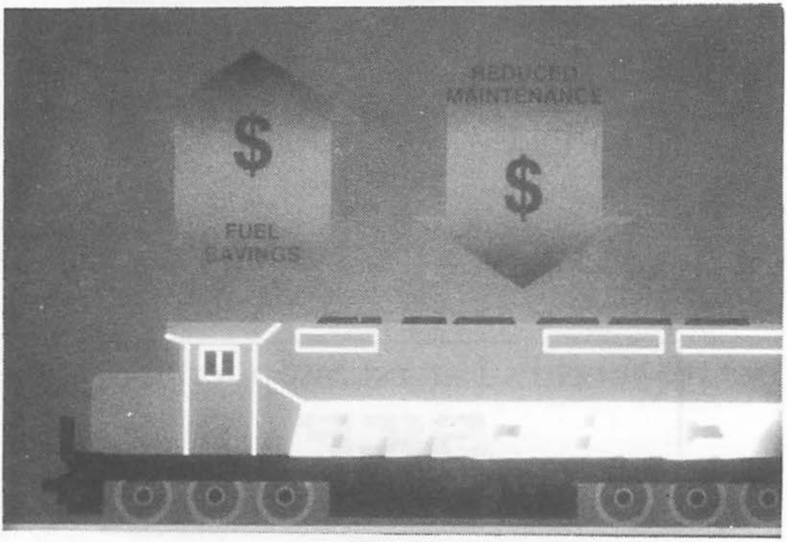


Figure 1

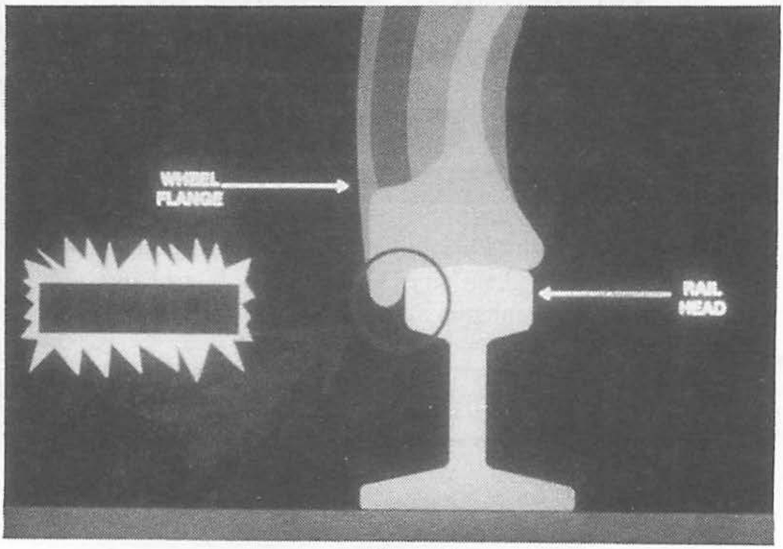


Figure 2

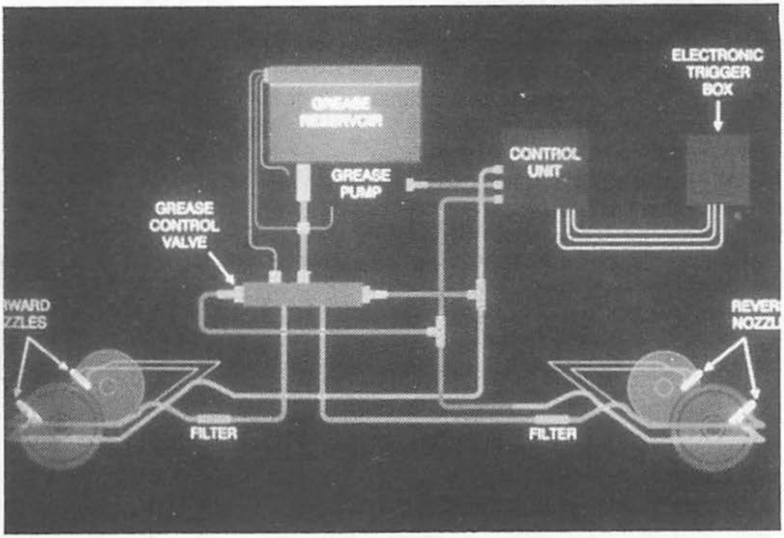


Figure 3

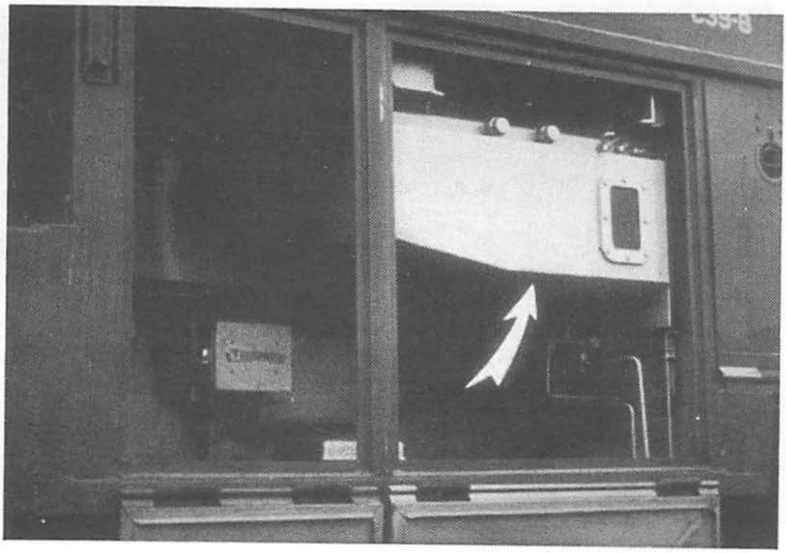
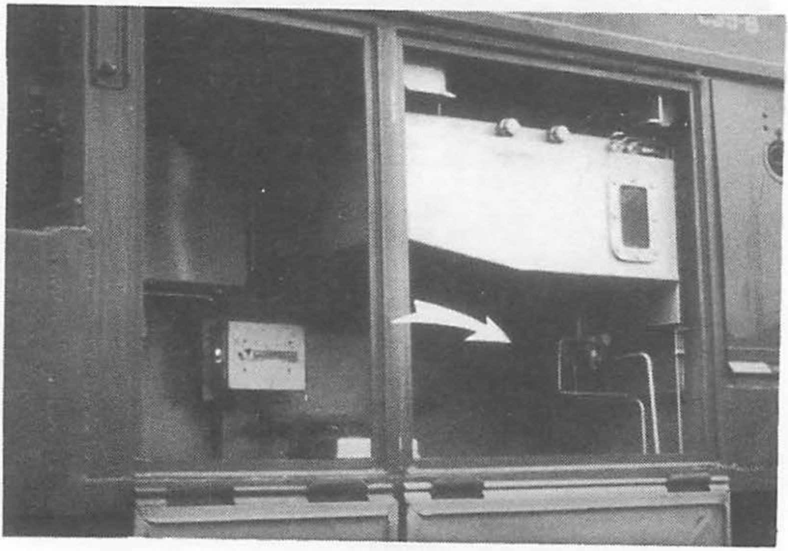


Figure 4



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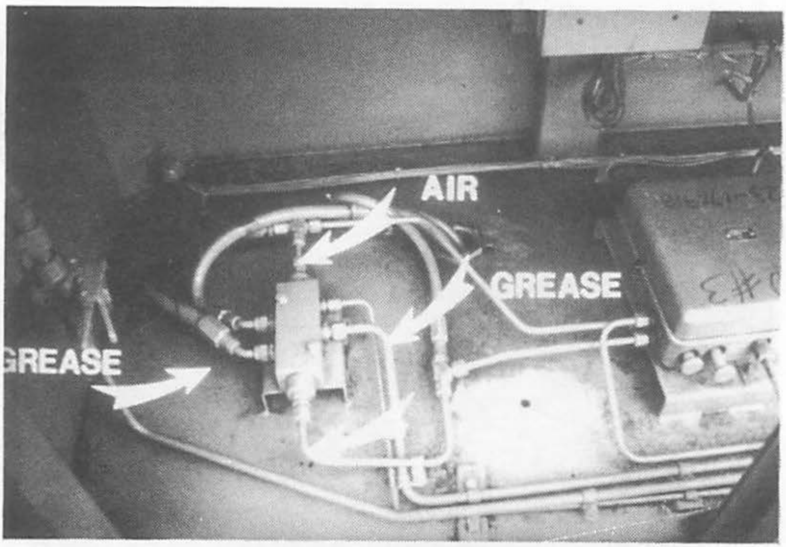

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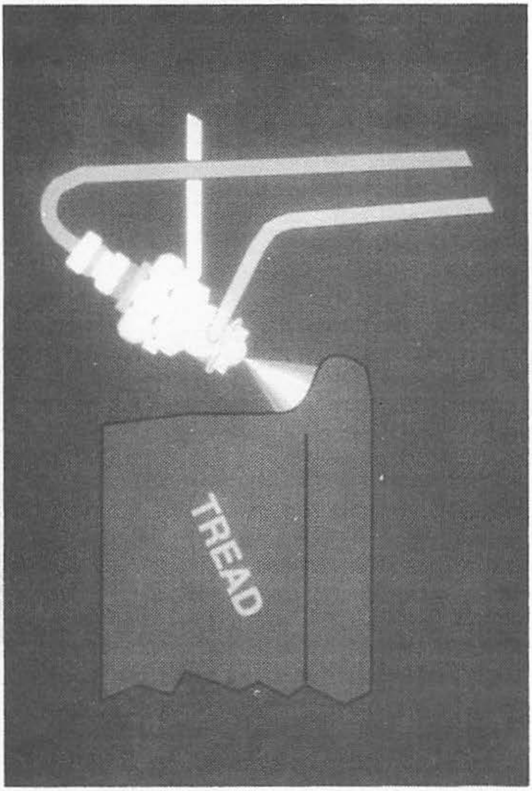

Figure 7

Figure 8

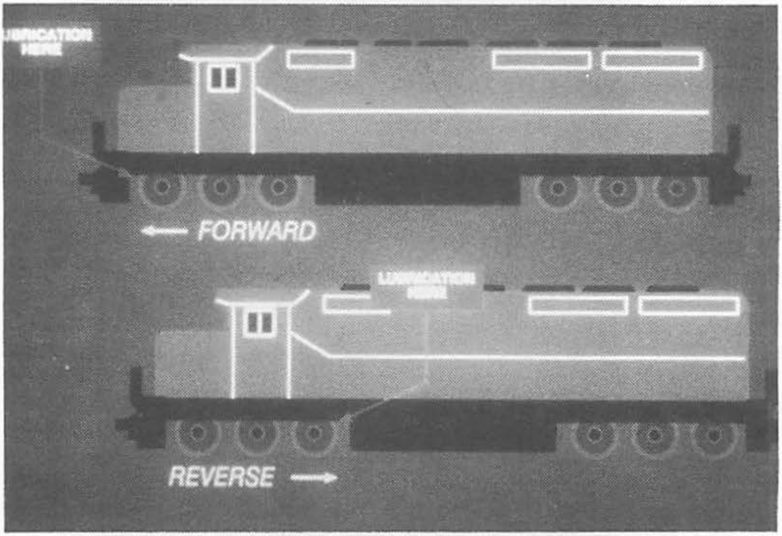

Figure 9

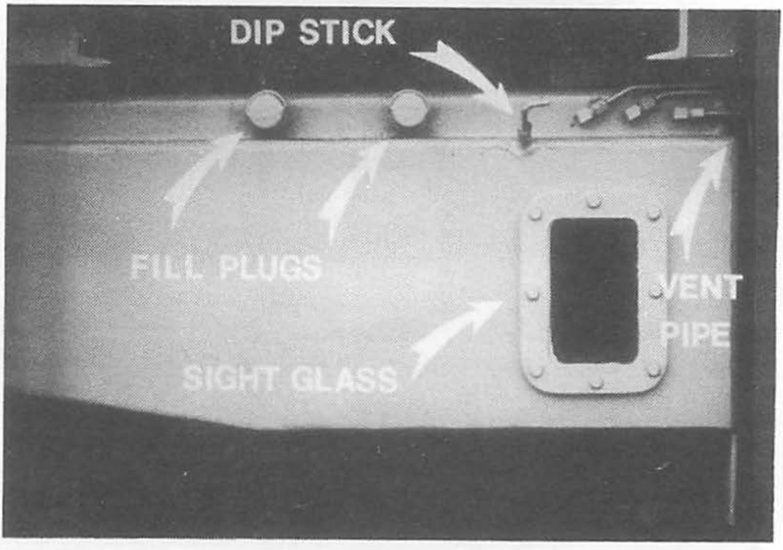

Figure 10

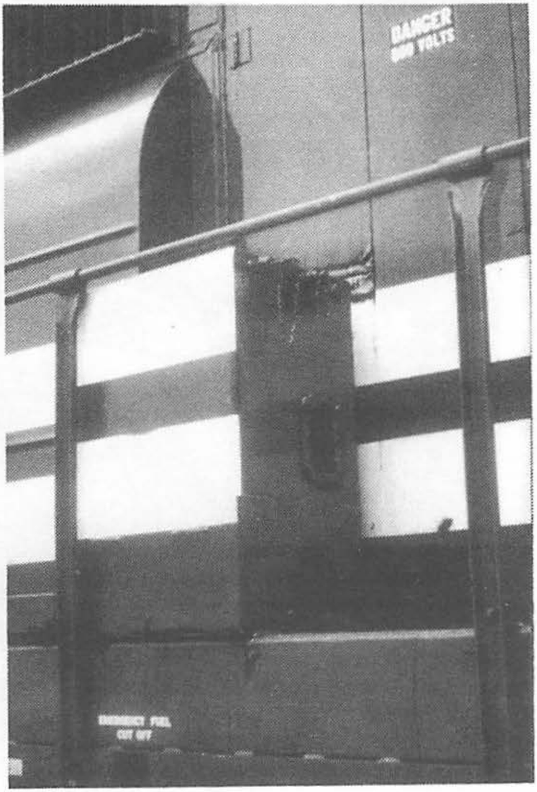

Figure 11

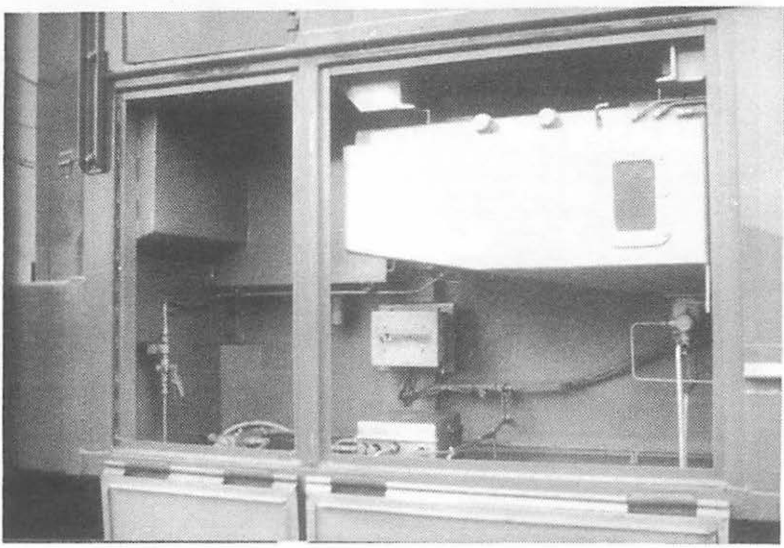

Figure 12

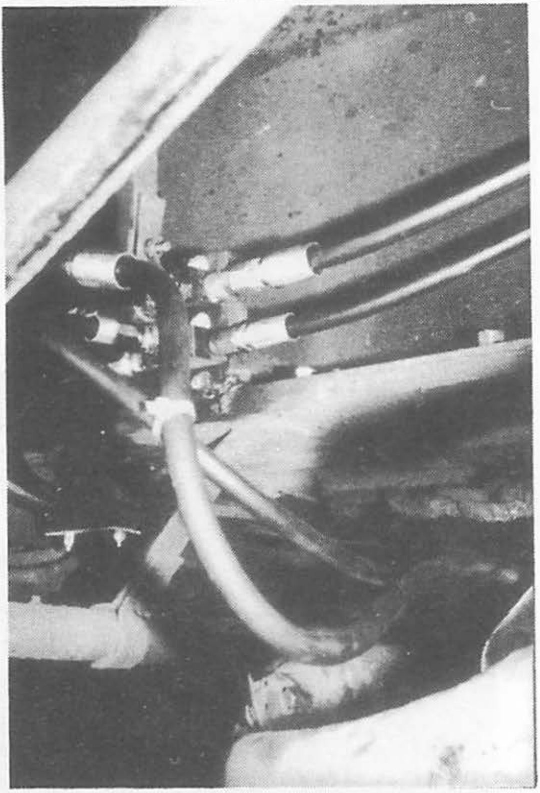

Figure 13

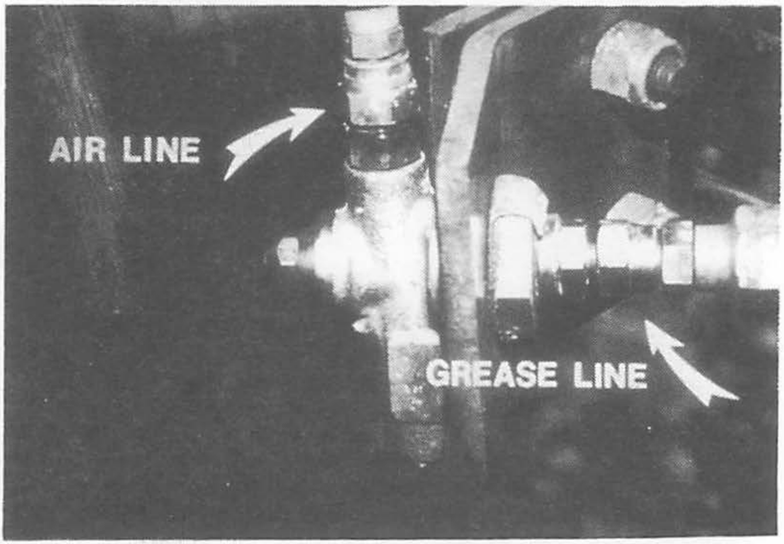

Figure 14

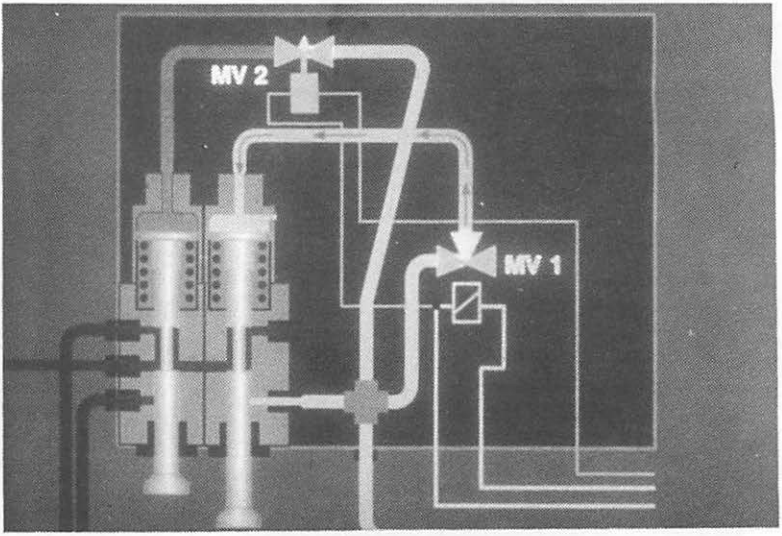

Figure 15

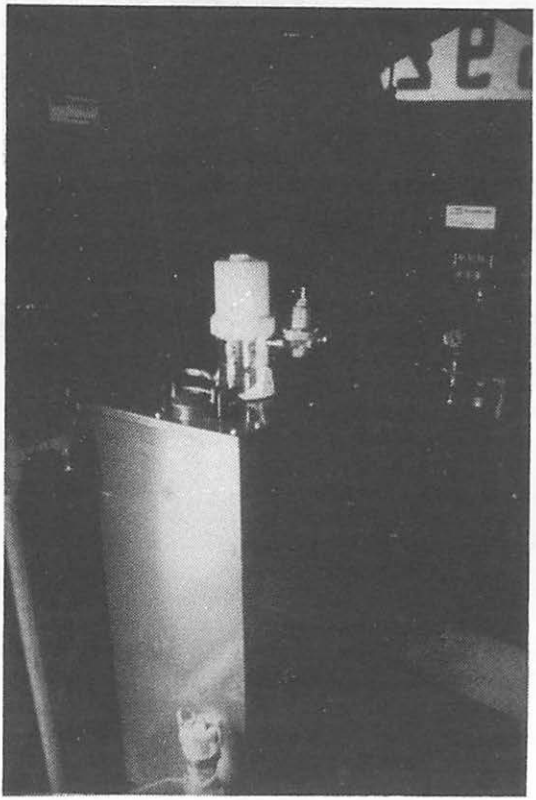

Figure 16

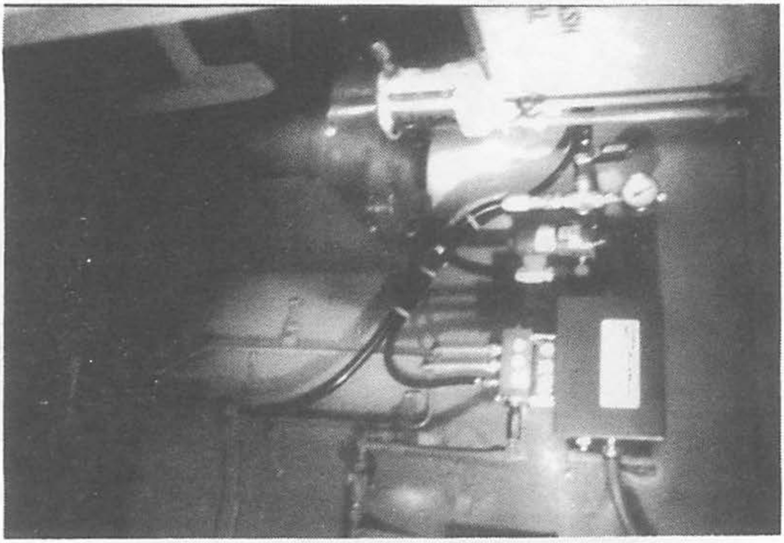

Figure 17

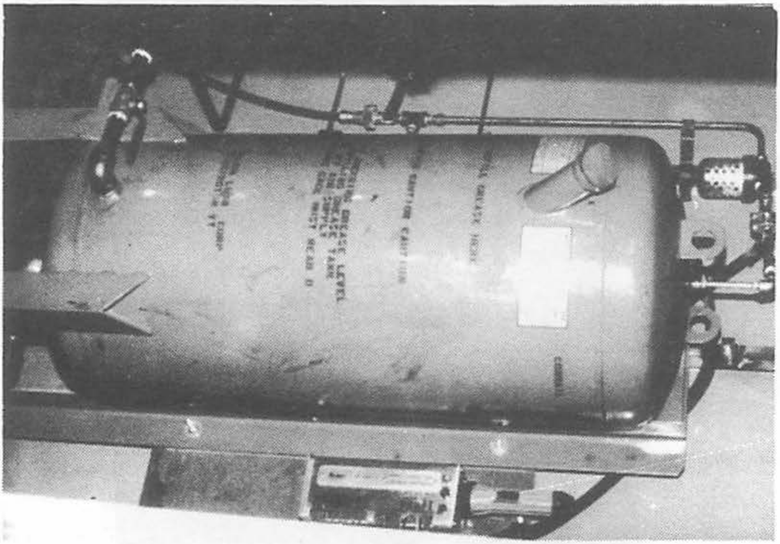

Figure 18

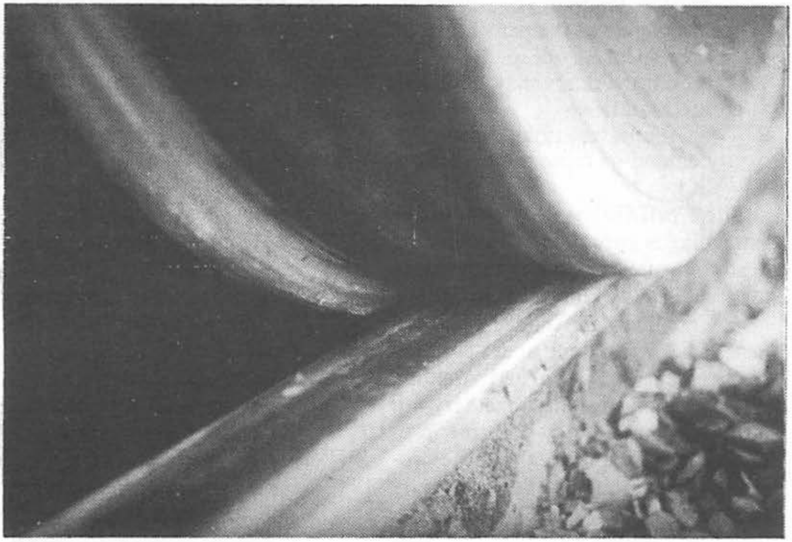

Figure 19

II
REBUILDING OF GE'S EB LINER

Head to liner seal integrity has always been difficult to maintain, with fire on one side, water on the other. Changing factors have aggravated the problem:

- — better fuel efficiency has demanded higher peak firings;
- — greater locomotive utilization has increased the percentage of time spent at full load;
- — rebuilt cylinders may have less life than new;
- — at the same time, users are demanding more power, longer life.

The reliability of cylinder assemblies is improved by welding the head to the liner, virtually eliminating top seal leaks (Figures 1 & 2) The head and liner are mated by a full penetration weld done under exacting requirements. Specialized welding techniques and tooling together with ultra-rigorous quality control procedures are used throughout the process of joining the head and liner. By this method the zones affected by heat and residual stress are kept to a minimum, the head to liner concentricity is maintained and the liner bore distortion is held to a minimum. The welding of the head to liner eliminates the spiral wound top seal and the silicone backup seal.

The GE engine development laboratory started testing in 1970, followed by field experience commencing in 1976 and full production in May 1986. At present GE has produced over 10,000 EB cylinders.

Although field experience indicates that wear on the steel liner of a welded assembly may be less than on a standard iron liner, it must be inspected, qualified and reworked at overhaul time.

The following are instructions for rework of EB cylinder liner/head assemblies with hardened bores, with liner/head removed from the jacket. (Figure 3)

1. WEAR LIMITS
   a. Liner bore must be free of scoring, scratching or scuffing.
   b. Maximum bore diameter must not exceed 9.012" diameter.
   c. The wear step (measured on the radius) is not to exceed .006".
   d. The out-of-roundness is not to exceed .006". **Note:** To establish the wear and out of roundness of cylinder bores. Determine maximum and minimum bore diameters in at least three planes of the bore — in upper piston ring travel reversal area, middle of bore and outside piston ring travel area.
   e. Stain marks occasionally found in the bore of hardened liners need not be removed.
2. REWORK PROCEDURE
   a. Liner bores must be cleaned up by honing, removing only sufficient material to clean up wear step and uneven wear, to maximum bore size of 9.008" diameter because of depth of the meloniting. To assure maximum service life and minimum liner material removal, a small wear step, less than .002", may still remain at the upper ring reversal area. This step will not be completely around the bore, and is considered acceptable. (Figure 4)
   b. Liner bore sizes exceeding 9.012" diameter should be returned to the manufacturer to be reworked. The head/liner cannot be melonized as a unit because of the high heat which would affect the hardness of the valve seat. As an optional method, worn bores may be repaired by rechromeplating per GE specification,

without separation of the liner from the cylinder head.

3. Coat the outside diameter at indicated locations with molybdenum disulfide 147X1613 solution of 1 part DAG 210 and 5 parts isopropyl alcohol or coat the outside diameter with a suitable molybdenum disulfide spray, polish coated areas. Keep coating off cylinders head shoulder gasket surface, cylinder head top face and liner "O" ring grooves.

4. Identify by stenciling 1/2" high letters with white paint the following note:

For assemblies with hardened bores: "use chrome plated ring only"

For assemblies with chrome plated bores: "chrome bore-do not use chrome rings"

All stenciling is to be on same surface as permanent marking.

5. All water contact surfaces must be free of rust and scale.

6. Refer to GE publication MI-93105-006 for the valve guide and valve seat criteria and rework. (Figure 5)

Figure 1

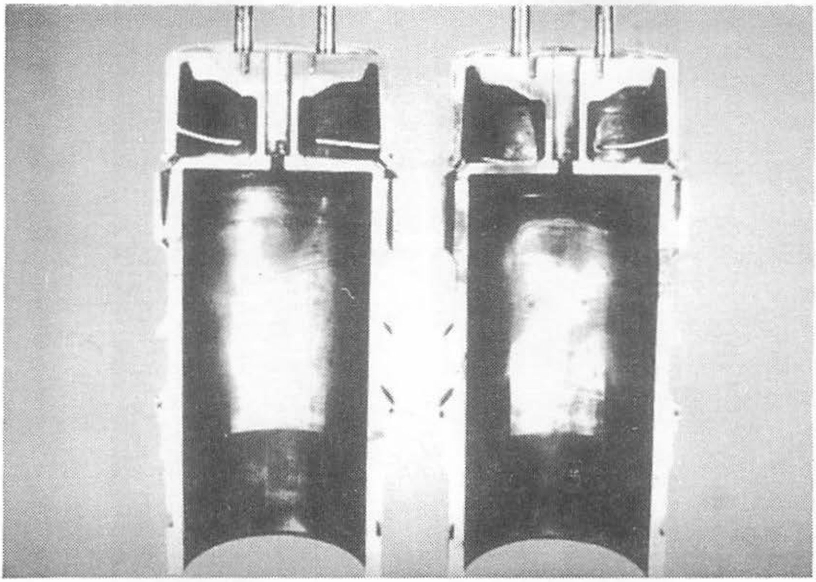

Figure 2

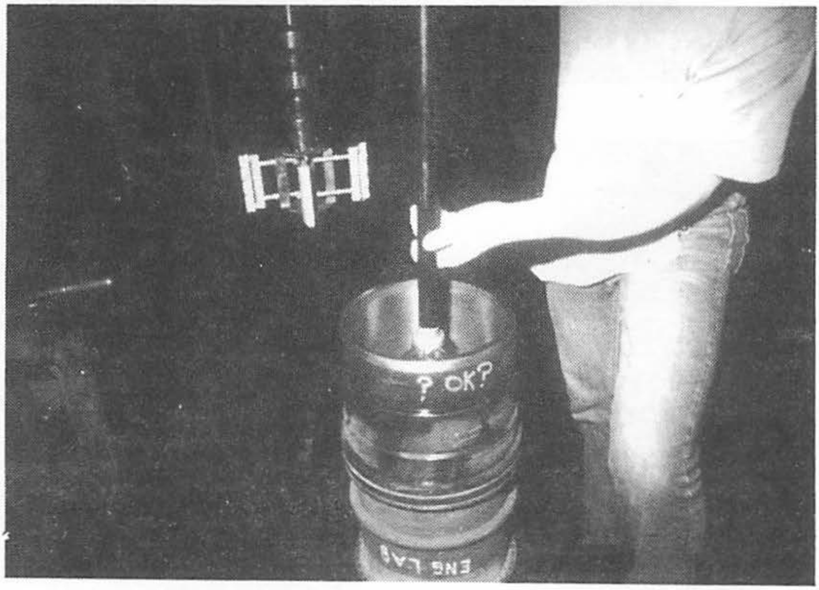

Figure 3

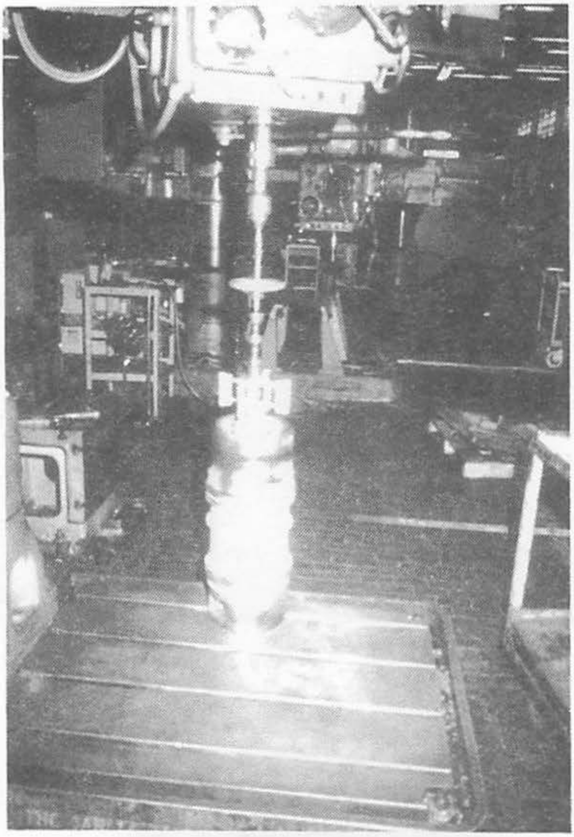

Figure 4

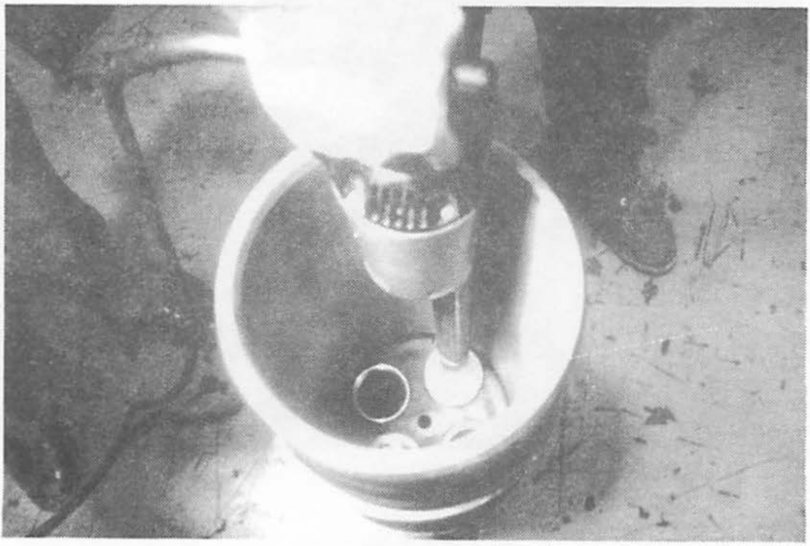

Figure 5

III
LOW IDLE — FUEL SAVINGS VS MAINTENANCE COSTS

Ever since the energy crisis, the railroad industry has been looking for ways to reduce fuel costs. One of the first retrofit options offered by the locomotive builders was "low idle". Low idle, as offered, provides fuel savings through reduced idle speeds.

The feature enables the locomotive to reduce engine speed approximately 100 RPM from the normal idle speed when the locomotive is in layover status, reverser centered, and throttle closed. One member road estimated a savings of 2,800 gallons of fuel per unit, per year. Actual savings will depend on the duty cycle and maintenance costs associated with each unit. It should be noted that all new locomotives delivered by the manufacturers are equipped with low idle as basic equipment.

In order to extend the cost savings of low idle to the remainder of the locomotive fleet, in June of 1977 instructions were written and retrofit kits were made for application to specific line haul locomotives. Locomotives equipped with both 10 KW auxiliary generators and electric cab heat could not be retrofitted because the lower idle speed affected battery charging. The cost of retrofit became increasingly higher as various problems were encountered. Engine governors could not be reliably reset in place, necessitating their removal from the engines and speed resets on a test stand. Another modification had to be applied to reduce 50% of the electric cab heat when in the low idle mode.

Railroads operating in subfreezing environments found that their engines were running cold, causing them to smoke excessively and form sludge deposits. These adverse results nullified the advantages of the low idle feature which ultimately led to increased maintenance costs in terms of unscheduled oil and filter changes.

In addition, fuel preheater efficiency was affected by the lower engine water temperature, so another modification was necessary. A water bath temperature switch had to be applied which would nullify low idle when inlet engine cooling water temperatures fell below 125° F. It must be noted that all of the previously described modifications were one time costs; however, they by far exceeded the original retrofit cost estimate. Therefore, the payback time, in terms of reduced operating costs, was extended significantly.

After application of low idle, additional maintenance items have been identified. For example although it was originally thought that this feature would reduce engine souping, daily field service has found this not to be the case. Locomotives, especially ones equipped with silencers that have been in low idle for extended periods of time, are known to soup more profusely than before. It must be noted that low idle is just one of many factors contributing to engine souping. Also, air compressors labor harder when locomotives are coupled to trains and brake pipe pressure has to be maintained.

In summary, the most ideal method of fuel conservation when danger of freeze damage is not present is to shut the engine down. However, in many cases this is not always practical. Furthermore, low idle is practically nullified when locomotives are operated in subfreezing temperatures. Individual railroads should analyze the overall duty cycle and added maintenance costs of their locomotives before considering retrofit of the low idle system.

IV
THE EXTENDED MAINTENANCE TRUCK

As locomotive maintenance departments on all railroads strive to extend maintenance cycles, it becomes apparent that, although attention above the running board has been reduced to quarterly chore, attention at the running gear level remains at a 30 to 45 day interval. Truck components sustain perhaps the most harsh conditions present in the locomotive operating environment. Great temperature changes, heavy shock loadings, plus wet and dirty conditions make the locomotive truck a prime candidate for improvement in order to extend the length of its maintenance cycle.

A major railroad performing truck maintenance (primarily lubrication) on a 45 day schedule to a fleet of 2,000 locomotives can incure the following costs each year:

Gear Lube		
10,000 cases x 4 lbs/cs x $.37/lb x 8 insp/yr	=	$118,400/yr
Labor		
1/2 hr x 2,000 units x 8 insp/yr x $63.44*/hr	=	507,520/yr
Bearing Oil		
10,000 axles x 1.55 gals/axle/yr x $1.03/gal	=	15,965/yr
Out of Service Cost		
1/2 hr x 2,000 units x 8 insp/yr x $26.97/hr	=	215,760/yr
* (1988 AAR labor rate)	**TOTAL:**	**$857,645/yr**

Elimination of the need for this 45 day maintenance attention could produce a considerable saving in manpower and material. The improvements necessary to achieve this goal are available and are now being tested on a few member roads. Three key components necessary for the extended maintenance truck will be discussed in this paper. These components complement each other and work together to reduce required maintenance. They are the tapered roller journal bearing, the roller bearing motor suspension unit (MSU) and the oil lubricated gear case.

1. Tapered Roller Journal Bearing

The first component to be discussed is the tapered roller journal bearing. Of course, the great advantage here is that no field lubrication is necessary between wheel changes. In addition, there is the elimination of bearing lateral adjustment with thrust blocks and shims. Most roads now operate a part of their fleet with the tapered roller journal bearing and have first hand knowledge of its advantages. An advantage not as commonly known is the reduced lateral loadings on the axles of a tapered roller journal bearing truck with controlled axle clearances. Tests conducted jointly in 1984 by one locomotive manufacturer and one member road indicated a 30 to 40% reduction in net lateral loads using tapered roller journal bearings with lateral elastic cushioning, controlled axle lateral at end positions and increased axle lateral at the middle positions (see Figures 1 & 2) (Ref. 1). In order to realize a 40% reduction in cost on a new truck application over cylindrical roller bearings, the tapered bearing is the practical journal bearing for the extended maintenance truck.

2. Roller Suspension Bearing

The second component to be con-

sidered in the truck is the motor support bearing. (Figure 3) In order to extend the maintenance cycle here we need a sealed bearing which will operate throughout the interval between wheel changeouts. These are presently available in both a cylindrical and tapered roller suspension bearing. (Figures 4 & 5) These sealed units are grease lubricated and have no need for field lubrication. At wheel changeout, removal and inspection of the bearing may be the only maintenance necessary (Figure 6) (Ref. 2). Advantages of the roller suspension bearing are as follows:

a. Field lubrication is eliminated.
b. Radial clearances are reduced, resulting in:
    1. Reduced gear teeth wear due to proper meshing and better alignment.
    2. Reduced gear case sealing problems.
    3. Reduced motor vibrations.
c. The roller suspension bearing and wheel/axle assembly need not be matched to any particular motor but can be bolted up to any roller suspension type motor. (Figure 7) This eliminates the need to keep suspension bearing assemblies matched by serial number. (Figure 8)
d. The need for precise finishing of the axle at support bearing surfaces is eliminated.

Figure 9 shows an exaggerated view of the misalignment possible with conventional split-sleeve suspension bearings. These friction support bearings allow .015" to .018" radial clearance. The roller suspension bearing is adjusted to .001" to .005" radial clearance greatly reducing the allowable free play between the motor and the axle. This difference also becomes important in gear case sealing.

3. Oil Lubricated Gear Case

Third component to be disucssed is the oil lubricated gear case. A gear case which will hold lubricant for at least a 92 day period will need the latest in sealing advancements and must be tight to retain as much lubricant as possible. In order to have a tightly sealed case we need a lubricant which can be easily measured for level thus eliminating the need for over filling and overflowing the gear case. The oil filled gear case provides the answer to this problem. A major saving introduced by the oil filled gear case is the very fact that by measuring lubricant level, waste is eliminated. An oil filled gear case can be either steel or fiberglass. However until railroads' fleets are equipped with roller bearing support, the steel case will continue to present a problem. On General Motors traction motors in particular, the support arm location on the pinion and suspension bearing cap tends to distort over a period of time. This is a gradual deformation of the arm brought about by the weight of the heavy case bearing on these support arms in the unsprung location. Complete and continued total sealing can only be assured when the sealing areas, particularly where the pinion enters the gear case, are maintained geometrically in an as new condition. Gradual distortions promote increasing lubricant leakage. It is here that the light non-metalic case comes into play.

An additional point to consider is the distortion to both the metal case and its supporting members when striking ice, raised crossing planks or other between-track debris. The steel case frequently does not pierce but the ultimate result is either a distorted gear case and/or a distorted traction motor support member. Experience has shown that in most instances both these actions occur. This of

course destroys the sealing capabilities of the gear case and loss of lubricant results. The fiberglass gear case, on the other hand, should the impact be of sufficient force, will puncture but not distort.

The latest in gear case sealing is shown in Figure 10. These parts combine well with the reduced radial clearances of the roller motor suspension bearing to create a more lubricant-tight gear case.

Besides being suitable for level measurement within the gear case, oil lubrication of pinion and bull gears is preferred. This is especially true in cold weather when channelling of heavy grease can occur creating dry starts and greater rolling resistance. One member road reports a decrease in gear wear through the use of oil lubrication, which it tested in 300 wheel sets. Data gathered from this test indicate that a 60% saving in annual gear case lubricant usage can be attained by the use of a tightly sealed gear case and a measurable lubricant (Ref. 3).

4. Testing

In order to get an idea of what has been done in the areas discussed so far, let us take a look at what is being or has been tested in railroad service.

The tapered roller bearing motor suspension unit is widespread in its applications overseas. Many countries have standardized on this application over the past 20 years. (See Figure 11) (Ref. 2)

In North America the Canadian roads have led the way in extensive testing of roller bearing motor suspension units. Harsh winter conditions make the sealed roller design more attractive for these roads. Listed below are the recent roller bearing MSU production applications:

Motor Builder	Railroad	Service Dates	Loco Model	Motor Model	No. Motors	Tapered or Cylindrical
GE	Amtrak	1974-1987	E60C	GE780	150	T
GE	Black Mesa	1974-1987	E60C	GE780	36	T
Hitachi	CP	1986-1987	SD40-2	HS24247	15	T
Hitachi	CN	1986-1987	GP40-2	HS24247	25	T
EMD	CN	1985-1987	SD50F	D87BRS	354	C
EMD	CN	1987	SD50F	D87BRS	6	T
EMD	CN	1987	SD60F	D87BRS	24	C

Amtrak reports the failure of roughly two bearings per year due to excessive lateral when adjustment shims are dislodged. Some seal wear has also been observed resulting in lubricant loss. Canadian National as well as Canadian Pacific removed the Hitachi motor applied MSU's due to dirt and moisture migration at the inboard bearing to axle labyrinth seal. Hitachi, along with the tapered roller bearing manufacturer, modified these MSU's and they will be returned to service in 1988. The cylindrical roller bearing MSU has had better success. It is suggested that this is due to the straight tube protection around the center axle area preventing dirt and other elements from reaching the inboard seals. The tapered roller

bearing manufacturer has adopted this design and applied it to the six motors shown above for use on CN SD 50 locomotive.

Oil lubricated gear cases are in the testing stage on several member roads. Perhaps the most extensive testing has been done on the CN. This road has tested 300 gear cases on oil. It reports a 60% saving in lubricant expense due to a well sealed gear case and measurable lubricant. Gear wear has also been reduced due to the elimination of dry gear starting in cold weather. CN has standardized on the fiberglass gear case for all EMD locomotives. Tight lubricant sealing can be achieved with either a steel or fiberglass case, providing the most recent seals, as in Figure 4, are used.

The components necessary for a true extended maintenance truck are all available and operating either together or separately in many applications. The savings available in manpower and material through elimination of truck servicing between periodic inspections is considerable. CN, as well as both major locomotive manufacturers, are moving toward the roller bearing motor suspension unit and tapered roller journal bearings as standard production equipment on future locomotive designs. It is doubtful that these savings would justify a retrofit program on units presently in operation due to the extensive motor frame changes necessary. The realistic course of action for roads desiring to make use of this technology would be to phase these changes in on newly purchased equipment. The committee feels we are now at a crossroad and all roads should take a serious look at the options presented here when specifying truck equipment on future purchases of new locomotives.

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2. **Springer, T. E.,** "Tapered Roller Bearing Equipped Traction Motor Suspension Unit Development In North America," ASME Paper No. 87-WA/RT-13, December 1987.

3. **Canadian National,** "Gear Case, Bull Gear and Pinion Gear Longevity in the 80's," presented September 1987 at LMOA Annual Convention in Chicago, Illinois.

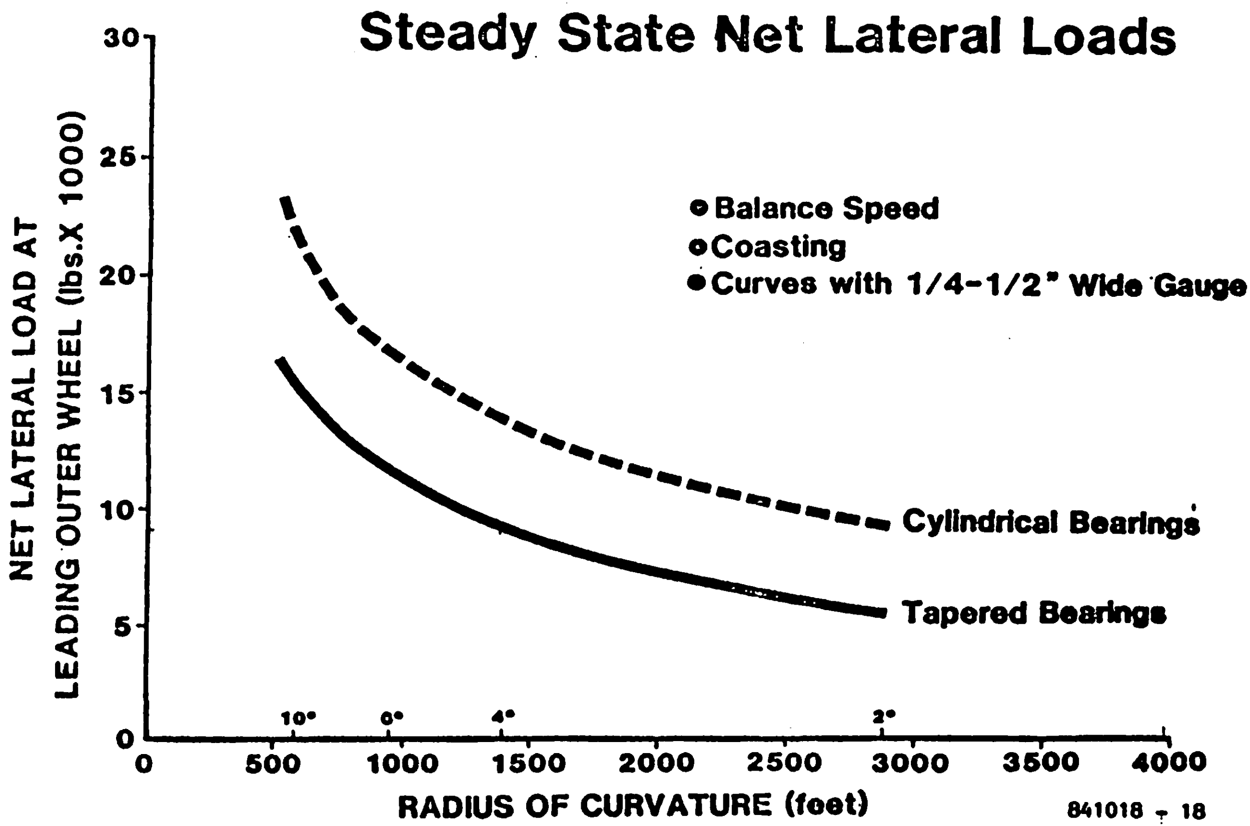

Steady State Net Lateral Loads
NET LATERAL LOAD AT
LEADING OUTER WHEEL (lbs.X 1000)
30
25
20
15
10
5
0
Balance Speed
Coasting
Curves with 1/4-1/2" Wide Gauge
Cylindrical Bearings
Tapered Bearings
10°
6°
4°
2°
0
500
1000
1500
2000
2500
3000
3500
4000
RADIUS OF CURVATURE (feet)
841018 - 18

Figure 1

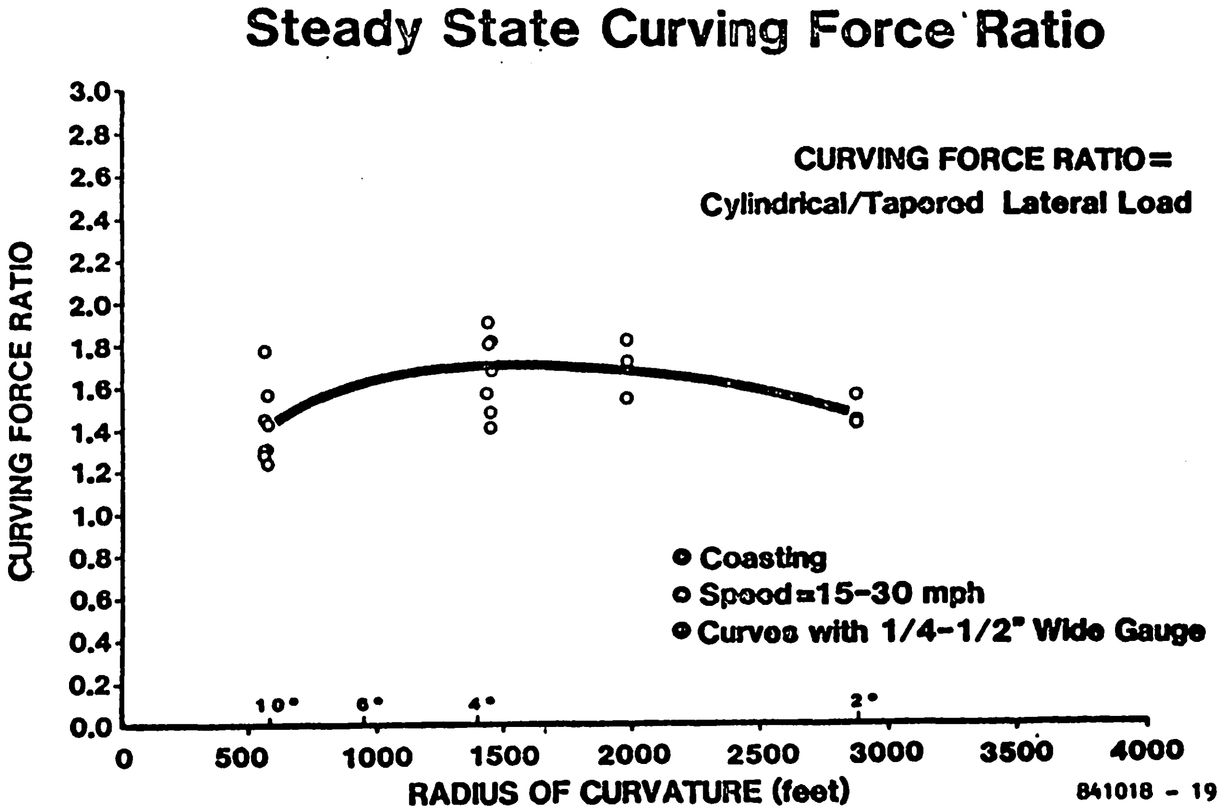

Steady State Curving Force Ratio
CURVING FORCE RATIO=
Cylindrical/Taporod Lateral Load
CURVING FORCE RATIO
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Coasting
Spood=15-30 mph
Curvos with 1/4-1/2" Wide Gauge
10°
6°
4°
2°
0
500
1000
1500
2000
2500
3000
3500
4000
RADIUS OF CURVATURE (feet)
841018 - 19

Figure 2

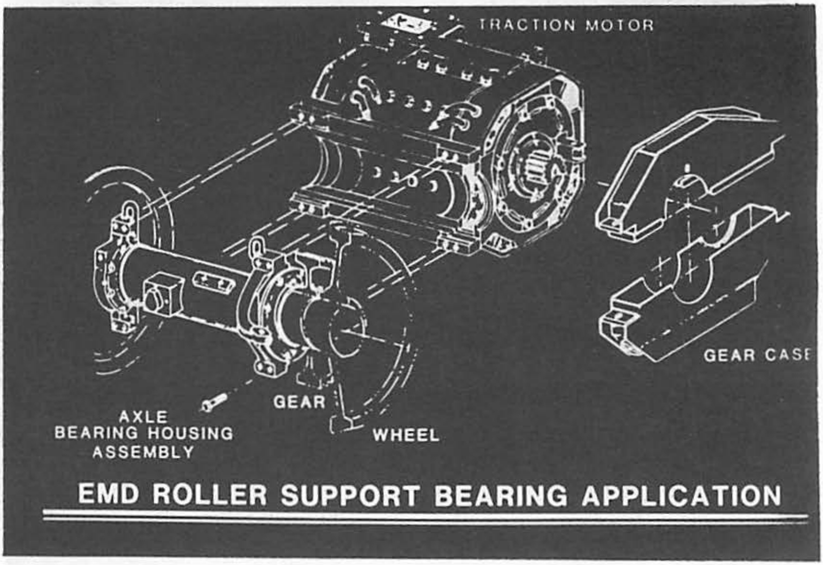


Figure 3

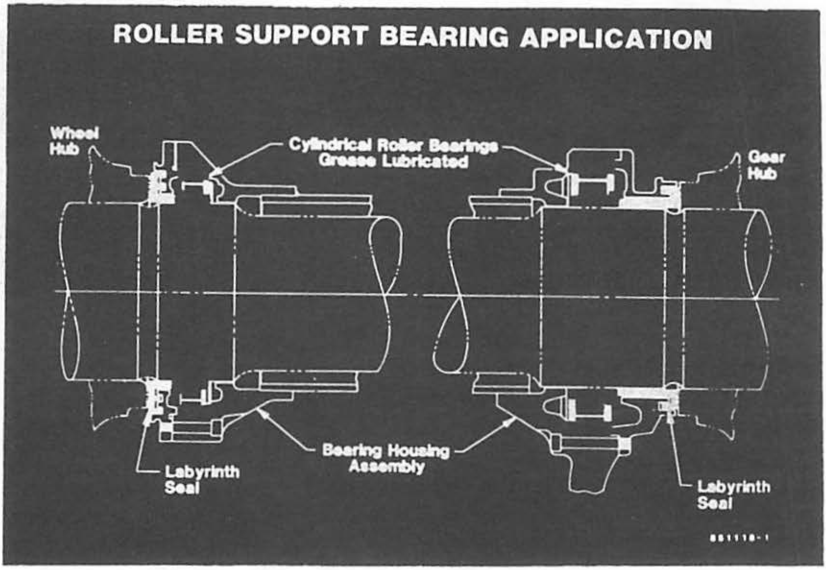


Figure 4

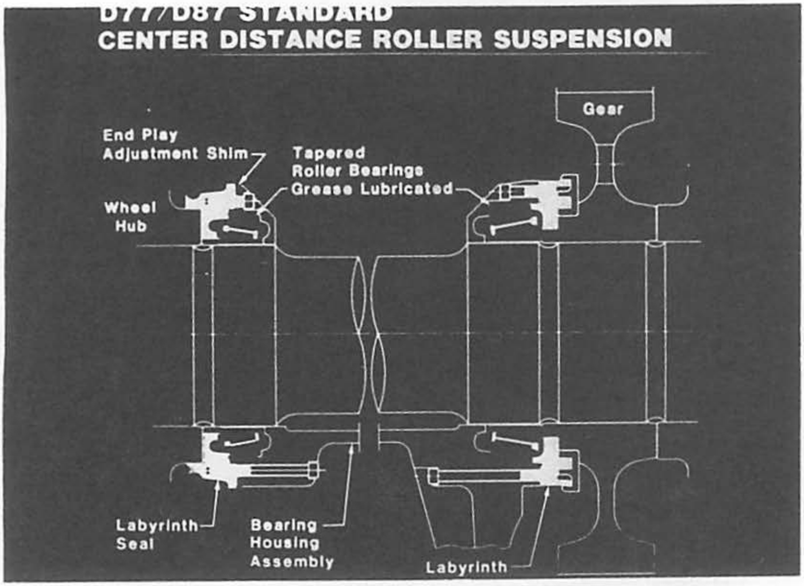


Figure 5

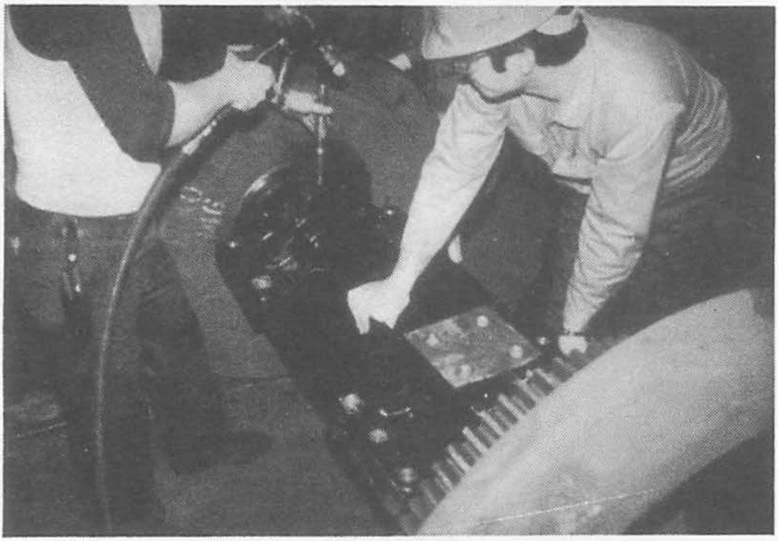


Figure 6

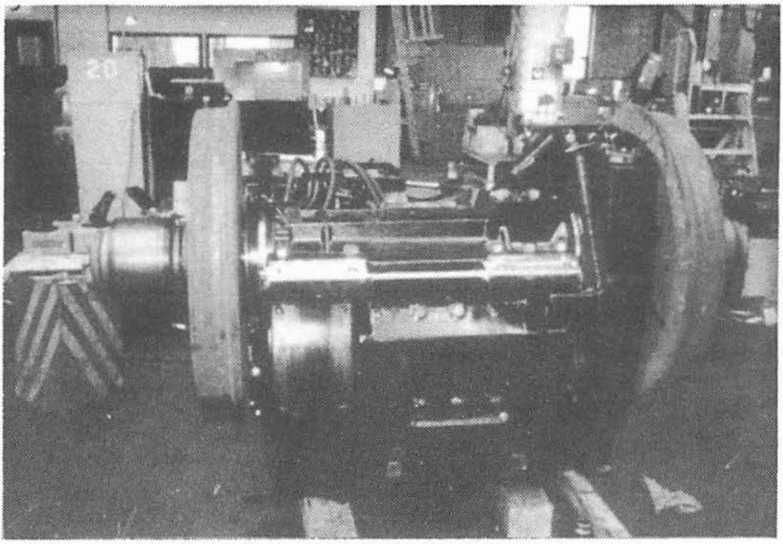


Figure 7

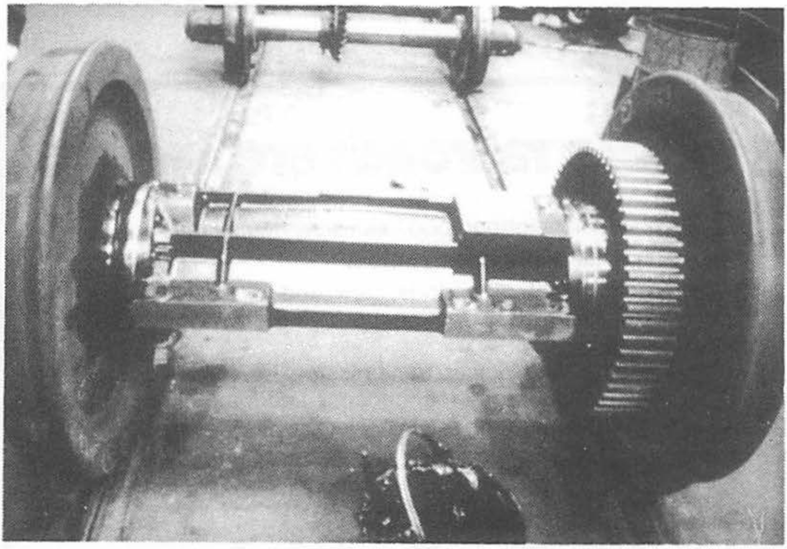
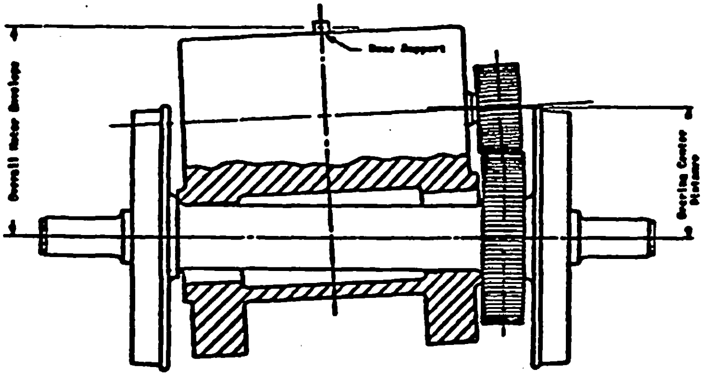


Figure 8



- Radial clearance induced misalignment of motor armature shaft and axle.

Figure 9

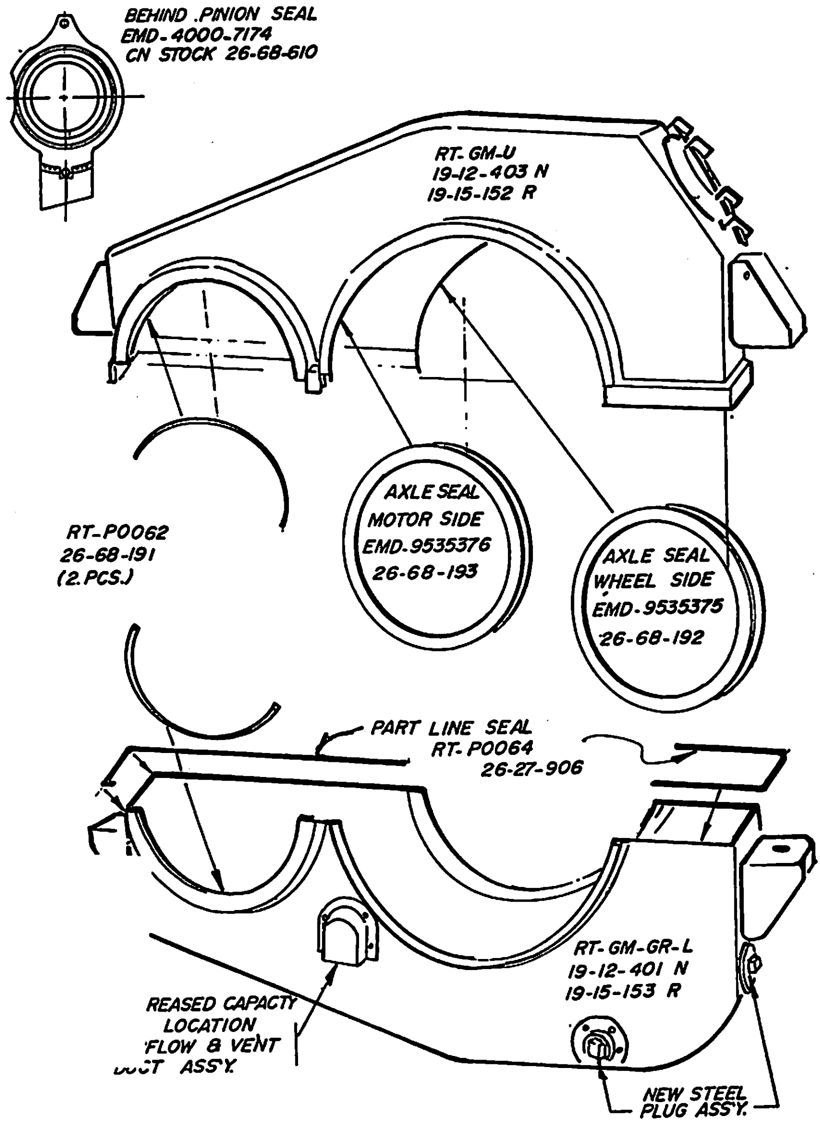

BEHIND PINION SEAL
EMD-4000-7174
CN STOCK 26-68-610
RT-GM-U
19-12-403 N
19-15-152 R
RT-P0062
26-68-191
(2.PCS.)
AXLE SEAL
MOTOR SIDE
EMD-9535376
26-68-193
AXLE SEAL
WHEEL SIDE
EMD-9535375
26-68-192
PART LINE SEAL
RT-P0064
26-27-906
RT-GM-GR-L
19-12-401 N
19-15-153 R
REASED CAPACITY
LOCATION
FLOW & VENT
ASS'Y.
NEW STEEL
PLUG ASS'Y.

Figure 10

Overseas tapered roller bearing MSU applications.

User	Locomotive Type	Tube Type	Quantity
British Rail	Diesel	Solid & U Tube	1800
	Electric	Solid & U Tube	800
	EMU	Solid & U Tube	5000
South African Railways	Electric	U Tube	6700
	EMU	Split & Fabricated	3500
DBB	Electric	Solid	6
	EMU	Solid	8
Taiwan	Electric	U Tube	90
	EMU	U Tube	60
SNCB	EMU	Solid Welded	1100
Netherlands	EMU	Split	600
Danish Railway	EMU	U Tube	30
Estoril Railway	EMU	Solid Welded	150
Indian Railways	Electric	U Tube	200
QGR	EMU	U Tube	100
	Electric	U Tube	460
Pakistan Railway	Electric	U Tube	360
New Zealand Railway	EMU	U Tube	200
Brazilian Railway	EMU	U Tube	200
Austrian Railway	EMU	Fabricated	300
London Transport (London Underground)	Subway Car	(200) U Tube	6300.
Hong Kong	Subway Car	U Tube (Aluminum)	1560
Turkey State Railway	Electric	U Tube	270
Zimbabwe	Electric	U Tube	120
Morocco	Electric	U Tube	60
New South	EMU	U Tube	40

Figure 11

V
PERMASPRAY II

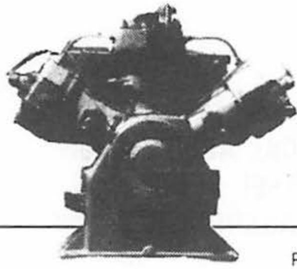
With the cost of chromium plating increasing substantially due to increases in energy costs and chromium chemicals, plus the major factor of stringent environmental controls, Precision National Plating Services, Inc. continued its research to develop a process that would give excellent liner wear and a dramatic reduction in lube oil consumption, with no adverse effect on ring life regardless of the type of ring used, plus a significant reduction in cost to the user, without utilization of chrome. The Permaspray II process is the end result of that research.

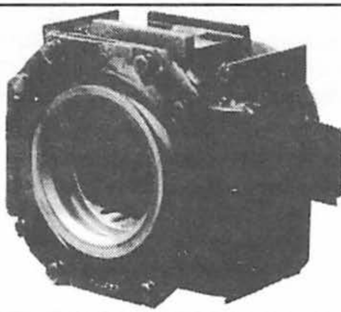
This new patented process has many advantages in that the liner has now been restored to the original OEM tolerances without the utilization of chromium. When overhauls are made, this liner can be recycled with a light honing operation and then be re-installed for additional service. The same unique porosity pattern will still be present. When additional overhauling is necessary, the cylinder can be returned for rebuilding with the process or can be plated with a thickness of chrome according to the customer's specifications.

The sprayed material has a hardness of approximately Rockwell C42 to C45. The running surface is smooth, and due to the metallurgical structure of the spray, it is also extremely tough and durable. There is a sound metallurgical bond between the sprayed surface and cast iron which is achieved by properly preparing the surface prior to the spray coating. This coating also enables the reconditioned liner to compete with the laser-hardened liner, as it has the advantage of being able to run with chrome-plated rings, cast iron rings or the pre-stressed stainless steel rings.

The process was introduced to the industry as a running surface in 1983; in late 1984 and early 1985 extensive field testing was started. The first two test units were in EMD 16 cylinder turbo-charged E-3 engines and were put into operation in March 1985. These units were put into continuous service and were monitored frequently. After 28 months of continuous service, power packs were pulled to make an evaluation of performance. Cylinder wear showed less than .001" with no significant ring wear. Test engines at that time had in excess of 400,000 operating miles. The units also operated with extremely dry air boxes. These units were put back into operation and are presently running.

Today there are over 3,000 Permaspray II liners operating in the field, all performing with excellent results. The basic process is accomplished utilizing stringent controls; after the cylinder has been cleaned and water-tested, the liner is measured dimensionally and visually and then a boring operation is performed to re-establish concentricity. The liner then goes through subsequent proprietary operations prior to the spray operation. The spray operation is then applied with controlled temperature and uniformity of the deposit. Next, the liner returns to the boring operations where it is bored to a predetermined size again, insuring that the bore is now concentric with the OD fits. The liner is then honed to the final size and finish and prepared for final shipment.





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 of Chicago at 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 (312-258-9660), 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

Tuesday, September 20, 1988
2:00 P.M.

REPORT OF THE COMMITTEE ON DIESEL MATERIAL CONTROL

Pre-Convention Presentation: Chicago, IL

April 18, 1988
Union League Club
Chicago, IL

C. A. MILLER, Chairman
Manager-Locomotive Planning,
Standards & Programs-Service Design
Union Pacific Railroad
Omaha, NE

VICE CHAIRMAN
L. J. Cala, Manager Material Control, Conrail, Altoona, PA

COMMITTEE MEMBERS

T. R. Gerbracht	Property Engineer	GE	Erie, PA
T. D. Murphy	Director-Supplier Qual. Assur.	C&NW	Chicago, IL
H. H. Pennell	Director-Material	BN	Naperville, IL
R. K. Perkins	Director of Inventory Cont.	Amt	Philadelphia, PA
D. G. Schonauer	Parts Material Manager	EMD	Hodgkins, IL

1988 TOPIC:
COMMUNICATIONS — THE VITAL LINK IN MATERIALS ACQUISITION

PERSONAL HISTORY

Charles A. Miller

Charles A. Miller was born in Omaha, Nebraska 50 years ago. There he attended High School and, while in college, hired on with the Union Pacific Railroad as a Mail Handler. After working as a Freight Handler and Car Checker, he transferred to the Accounting Department.

After 10 years he left the railroad, only to return 13 years later in the Mechanical Department as a Material Planner at the Omaha Shop. He was promoted to Shop Scheduler, Production Control Supervisor, and Manager- Production Control. At the present time he is Manager-Locomotive Planning, Standards, and Programs.

Charlie and Marilyn Miller have seven children and four grandchildren.

He and Marilyn are active in their church, scouting, and home and school associations. To get away from the kids, Charlie plays golf and enjoys working with his flower garden.

His 15 years working with material planning, scheduling and expediting for the Mechanical Department and subsequent relations with the Purchasing and Materials Department, make him well qualified to chair the LMOA 'Diesel Material Control Committee'.

PS. Our committee is the only one made up of mechanical, purchasing, materials, and suppliers. Our goal is to bring to you new technology and innovations used by the railroad industry, and, outside our industry, to alleviate material procurement problems.

Anyone wishing to assist us in this task is welcome to join our committee.

(This is a paid political announcement)

I
COMMUNICATION — THE VITAL LINK IN MATERIALS ACQUISITION

Most of us become interested or involved with material when we run out! Especially when power is tight, and units are held for components. After we are reminded of our incompetence, we tend to pass it on to the Materials department, to our friends in Purchasing, or to the vendors. After we point fingers at everyone but ourselves, we spend labor dollars cannibalizing parts from other units. Then we expedite the missing components while supporting our competitors (trucking services, or air freight) all of which add needless costs to our overworked budgets.

What's not working? Why do we run out of material? What is wrong with the Materials department? With Purchasing? With the suppliers?

How many times have we heard or made these statements?

This paper is an attempt by this committee and our resources to discuss one reason for material stockouts, and provide some suggestions on what can be done to alleviate them.

We believe that the problem is in communication!

To understand the problem, you first have to understand the importance of the customer/supplier relationship, and what it takes to make it work. All of us are suppliers of something whether it be a product, a service or information. We are also customers to others who furnish us with data, services or supplies. As a supplier we demand to know all the specific requirements of the customer so we can deliver exactly what he asked for. As customers, if we tell the supplier specifically what we want, we expect to get it.

If the communication of requirements is aborted in any way, someone will not get what he wants when he wants it.

This seemingly simple lack of communication is the basis for the majority of problems that we experience awaiting parts. The entire material acquisition process is no more than a series of these customer/supplier relationships whose overall success depends on establishing clearly defined requirements. Let's look at the process a little more closely.

To illustrate the material acquisition process, we will use the chain. Each link of the chain represents a critical step in the overall process.

Let's begin with the first link, the user. The user is the person actually consuming or using the material. In our case, it's the Mechanical department, which is also responsible for determining product specification. In other words, what we need (what to buy). The user is also the one to answer, "How many will be needed?", "which shop will do the work?", and "when will I start and finish the project?".

The materials link is the traditional railroad "store" function. In most cases Materials is separate from Purchasing, and is responsible for inventory control, warehousing, and physical distribution. It determines if additional materials need be ordered or moved from one warehouse to another. If an order is to be placed, it establishes the order quantity and where to warehouse the items.

Purchasing normally selects vendors, negotiates price and terms in the vendor quality evaluations, and is responsible for the bidding process. Purchasing is normally the only direct contact with the vendor. It answers the question, "whom do we buy from?".

The final link is the supplier. He is expected to conform to the

customer's requirements. The material is expected to conform to the user's specifications, delivered on time to the appropriate location, in the right quantity, for the negotiated price.

These are the links of the material acquisition chain.

With proper inputs by all concerned, the overall process is simple, but questions still arise. The users ask Purchasing, "why do you keep buying the lowest priced bearings especially from that vendor? He is not even approved!" You might hear the materials people tell the mechanical people, "why didn't you tell us you were starting the modification tomorrow!" Purchasing has been known to say, "the specs were so general, and the vendor said his component was just as good as the other guy's, and besides it was cheaper." The vendor complains, "you haven't bought three fuel pumps in eight years, now you want 100 by next week?"

The complaints and accusations persist. Each link thinks the other's requirements on him are not important, or he's too busy to bother! We still have stockouts and units held, and we still expedite and we still catch hell!

Here is a suggested solution. You know the elements of the chain of communications, you know the requirements you developed as a customer for your supplier, and you know what requirements are set for you when you are the supplier. In order to make the chain strong, in addition to establishing and understanding requirements clearly you must:

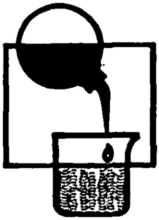
1. Establish two-way communication link with your suppliers and agree to what is beneficial to both the customer and the supplier.
2. Establish a measurement and feedback process for quality assurance.

At least one railroad has implemented this process. It began by integrating the materials and purchasing functions into one solid link. The result of this is that the primary concerns of each of the former links become one set of concerns of requirements understood and beneficial to both.

This railroad has established an active three-way communications path with the user and the supplier, thus letting each other know of changes or problems affecting their operations. It has implemented a feed-back process, and you will hear more about the feed-back process in the next paper.

The quality assurance group of this railroad has developed what it feels is the ideal communications model, illustrated by three overlapping circles or links. The three circles represent the customer or the "user", the "supplier" and the "purchasing group". Mutual concerns, or shared responsibilities, are represented by the area where the "supplier" and "user" circles overlap. All three participants are mutually concerned with maintaining and raising quality, which means meeting the requirements. The area where all circles join represents their universal concerns.

If we are aware of each other's responsibilities and we respect and understand each other's requirements, and if open communications and feedback are a part of our materials acquisition processes, then we can operate more efficiently and become the lowest net cost, most profitable segment of the transportation industry.



II
COMMUNICATIONS: QUALITY CONTROL THROUGH FEEDBACK

So far this paper has reviewed the key role communications plays in providing material. Now it's time to consider the role of feedback, that critical communication of performance of the material at the time of its end use, back "upstream" in the supply cycle.

Let's review what is today a common definition of "quality". Briefly stated, quality is conformance to requirements. Obviously, some attempt must be made to monitor material at the time of this end-use application in order that its performance can be determined. In the real world, this monitoring occurs every time a worker applies the material. The worker is generally knowledgeable about the material and its fitness for end-use. When material is found to be defective or inadequate, the worker is usually the first to become aware of it. A problem sometimes exists in communicating this information back from the worker level to the level in the organization where corrective or preventive action can be taken. There are often many layers of the organization through which this information must pass through before it reaches the person who can make decisions affecting which supplier the material is obtained from.

One railroad solved this problem by creating a new, direct channel of communication between the worker in the field and the Materials department. What follows is a case study, describing the origins, development, implementation and use of this communication channel and its larger role in supporting a supplier quality assurance program.

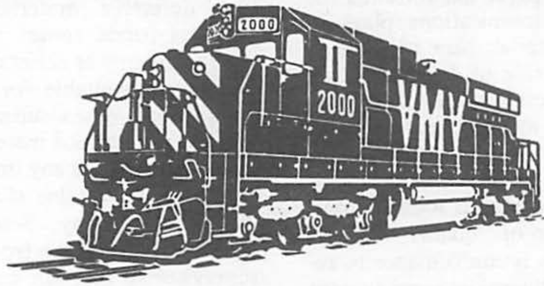
A. Origin of the "Defective Material Field Report"

In the spring of 1986, one of the operating divisions of the railroad uncovered a chronic problem in getting defective material changed. Workers found some material supplied to them was either defective, or somehow unsuitable for its end-use application. When supervisors were notified of the poor material, it took a long time to see any improvement.

The causes of this situation were diverse and many. Sometimes the communication chain from worker to supervisor to division staff to headquarters staff to Purchasing department simply broke down. Sometimes there was a legitimate difference of opinion as to what the quality of the material should really be. Sometimes there was apathy on the part of the staff department ot the worker's complaint. Sometimes the specific nature of the defect was not clearly communicated or documented. Sometimes the specifications for the material supplied did not match the actual end-use requirements. These and many other causes combined to foster a perception on the part of the worker that "no one cares, so why should I". This occurred at a time when the railroad had undertaken an extensive quality improvement program across all segments of the railroad, which had the goal of changing this type of attitude.

B. Development of the Report

To solve this problem, the operating division formed a team of workers and supervisors and asked this team to find a better way of resolving problems with inadequate or defective material. This team developed the "Defective Material Field Report", DMFR, and im-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plemented it at the division level. Subsequently, senior operating management became aware of the benefits of the DMFR and broadened its use to include the entire railroad. In its first year of existence, the form was used essentially only on the operating division that had created it. This was largely due to poor implementation effort across the balance of the railroad. To correct this, senior management mandated a system-wide implementation effort.

C. Implementation

The use of the form was made mandatory whenever material was found to be "inadequate for its intended use", and made into a formal Operating department policy. A training effort was undertaken to familiarize the various work units of the Operating department with the new form and policy.

The training effort included presentations at each of the diesel shops, down to the shop floor level. The presentations included the origins of the DMFR, the philosophy of quality that was the driving force behind it, the completion of the form and its routing through the company to the Supplier Quality Assurance group.

D. Completion of the Defective Material Field Report Form

Figure 1 is the currently used format for the DMFR. Figure 2 shows how the report is handled. The DMFR is completed in three steps. First, the employee (any employee) who comes across defective material initiates the report. The employee identifies himself, the nature of the problem, the specific material that is defective and any suggestions he or she has regarding a new standard or supplier.

Next, the form is given to the employee's supervisor, who adds his or her comments to the form. This is particularly valuable for two reasons. First, it directly involves the supervisor in the process and makes him aware that one of his employees feels there is a problem. Second, it gives the supervisor the opportunity to add comments to those of the employee.

Finally, the form is passed to the local storekeeper who reviews the description, adds a code number if it is missing, and acknowledges to the employee that the form has been forwarded to the Supplier Quality Assurance group.

The preponderance of the information is supplied by the initial employee reporting the problem. This is particularly useful for two reasons. First, the person most directly affected by the defective material is the person supplying the information. Second, the employee initiating the form has a sense of participation in the feedback process, and as will be seen below, becomes the focus of the further handling of the report.

The reporting employee then passes the DMFR off to his/her supervisor for review and comment. The supervisor often can add additional information and/or clarification of the reported problem. This also ensures that the worker's supervisor is made aware of problems with material being used by his work unit. Often it is the supervisor who is contacted for additional information or follow-up, rather than the employee, simply because the supervisor is more accessible to the Supplier Quality Assurance group.

The local storekeeper receives the form next, and he reviews it for completeness, adds code numbers if appropriate, and verifies the supplier. The storekeeper has the critical responsibility of acknowledging to the reporting employee that the form has been received and is to be researched.

Sampling indicates that completing the form takes no longer than 5-7 minutes, total, unless additional documenatation is prepared by the employee.

E. Responding To The Defective Material Field Report

Once the Supplier Quality Assurance group receives the report, it is reviewed for completeness and clarity of the problem statement. Generally, the originating employee must be contacted to clarify the specific nature of the defect.

It should be noted that "defective", as applied to the DMFR, has a broad definition. Usually when we say something is defective, we mean it is broken or improperly made. In other words, there is a clear failure in workmanship or materials used to make the item. In the context of the DMFR, however, "defective" means any material that is any way unsuitable for its intended end-use. Included in this broader definition are such factors as the durability of the item; the ease with which the worker can use the item; the manner in which it is packaged and handled en route to the user, the timeliness of deliveries, and any changes in the basic specifications of the material that would represent an opportunity to improve the safety, durability or quality of the item.

The railroad classifies all reports of defective material into one of four basic types: **Warranty, Specifications, Technical** and **Other.**

Warranty defects are those we traditionally think of when we speak of "defective". A warranty defect is defined as a failure in materials or workmanship for which the responsibility lies solely with the supplier.

Specification defects are those which relate to the specifications of the material, which are seen to be somehow deficient in the eyes of the reporting employee. An example will help to illustrate. If, say, a coffee cup is supplied to the employee and it is cracked, that is a "warranty" defect. If, on the other hand the employee reports that he is supplied with a coffee cup of 6-ounce capacity and he really needs a 10-ounce capacity, then the deficiency is one contained within the specifications. A specification defect is in some part (perhaps totally) the responsibility of the railroad, and is not simply a matter of poor supplier performance. In the example, the 6-ounce cup supplied may be in complete conformance to the specifications, yet it still is inadequate in the eyes of the employee.

Also included in this category are any problems in the communication of specifications to the supplier. In a fairly significant number of instances the specifications given to the supplier have been unclear, contradictory, incomplete or otherwise inadequate.

Technical defects are those for which a remedy is not immediately apparent and that may require a change in design, materials, manufacturing process or other substantial technical change. Generally, the solution takes time and research to find and can be characterized as attempting to "build a better mousetrap."

The final defect classification is **Other,** and includes packaging and delivery problems, and other quasi-defective problems like improper or incomplete worker training, sizing problems or incorrect use of the DMFR.

Once the reported problem has been identified completely, it is corrected in one of several ways. Any warranty problems are handled directly with the supplier, who arranges for no-charge warranty replacement. As required, quality controls may be instituted by the supplier to prevent a recurrence of the problem. Depending on the severity and/or the scale of the problem, a product recall may be initiated to limit the effects of the defect on the railroad. Any specification problems are referred to the appropriate staff departments for review. If the staff department concurs in the requested specification change, the new specification becomes the railroad standard. Technical problems are also referred to the appropriate staff department for review. As they deem it necesssary, additional study and design changes are made to the product.

In all cases, the reporting employee is kept advised of the handling of his/her report, as are the supervisors and other concerned or affected employees. Once a clear plan to remedy the defect is made, the DMFR is "closed out", but routine follow-up is made to ensure the defect is finally corrected.

F. Case Study

Some years ago the railroad began using a remanufactured locomotive part. A process was used to repair what had formerly been thought to be an unrepairable part, at considerable savings compared to the cost of new parts. For some years these remanufactured parts were used, and then field maintenance officers noticed an accelerated change-out record with the remanufactured parts.

At the time these manufactured parts came into use, it was believed they were more cost effective than new parts because of their substantially lower purchase price. Over time, however, some of the supervisors came to believe that the overall cost of remanufactured heads was substantially greater than new, due to the shorter in-service life and subsequent increase in locomotive down time and change-out costs. The question of actual life-cycle costs of remanufactured parts was left more or less unanswered for several years.

The supervisor of the railroad shop that installed these parts gathered extensive data comparing new versus remanufactured parts and submitted it in support of DMFR. This was a novel and bold use of the DMFR, for the problem was defined as "vendor product has short life" and "poor quality workmanship". Instead of using the DMFR to report purely defective material, it was now used to heighten management awareness of an opportunity to improve the economic performance of a type of material.

The entire question of these remanufactured parts and their economic merit compared to new parts was given over to a special committee for a comprehensive review. The supervisor who submitted the DMFR participated in the review and supplied the necessary background data on new versus remanufactured performance. The data revealed that new parts had a service life of three times as long as the remanufactured parts. A detailed performance and economic evaluation was submitted to Staff Motive Power, with a recommendation that change-out policy require the use of new parts only. The net saving to the railroad of adopting the new policy exceeded $240,000 annually.

The creation and use of such a field report cannot by itself guarantee continued improvement in operating practice. However, such a report can become a useful channel of communication when other channels become blocked, and when coupled with a commitment to seriously investigate such reports by Motive Power and Materials, can overcome the inertia and apathy that sometimes creeps into the normal chain of communications.

Stock Code 41-06710
Rev. 7/87

SYSTEM DEFECTIVE MATERIAL FIELD REPORT

IN TURN:	NAME (Please print)	TITLE	LOCATION	PHONE	DATE
Reported By					
Supervisor					
Storekeeper					

Director-Supplier Quality Assurance — Chicago

_______ MATERIAL FAILURE

- _______ Caused by misapplication
- _______ Caused by unsatisfactory mat'l.
- _______ Other Cause _______________
- _______ Cause Unknown

_______ MATERIAL PROBLEM

- _______ Problem with used material
- _______ Problem with new material
- _______ Misapplication of material
- _______ Other

PRESENT LOCATION OF DEFECTIVE MATERIAL: _______________

NOTE: PLEASE HOLD ON TO DEFECTIVE MATERIAL UNTIL ADVISED WHAT TO DO WITH IT.

STOCK CODE _______________ DESCRIPTION _______________

MANUFACTURER/VENDOR _______________

PROBLEM _______________

____

____

IS THIS NEW OR REPEAT PROBLEM? _______________

SUPERVISOR COMMENTS: _______________

____

____

_______ WOULD LIKE NEW STANDARD ESTABLISHED. SUGGESTION _______________

____

_______ PREFER OTHER MANUFACTURER. WHO _______________

WHY _______________

_______ DIFFICULTY OBTAINING SUFFICIENT QUANTITIES. EXPLAIN _______________

____

ONCE THIS FORM HAS BEEN INITIATED BY THE EMPLOYEE, IT MUST BE PROCESSED THROUGH TO THE DIRECTOR-SUPPLIER QUALITY ASSURANCE.

FIGURE 1

INSTRUCTIONS FOR COMPLETING
THE DEFECTIVE MATERIAL FIELD REPORT (DMFR)

1. This form should be completed whenever material supplied by the Materials Department or local Store, a CNW Production Shop or outside supplier is found to be defective or inadequate for its intended use.

2. The employee initially completing the form must complete the "Reported by" line, and as much of the form as possible.

3. The employee reporting the defective material will forward the completed form to his Supervisor, who will determine if the material can or should be used or replaced. IN NO CASE SHOULD THE DEFECTIVE MATERIAL BE DISPOSED OF WITHOUT PRIOR WRITTEN APPROVAL OF THE DIRECTOR-SUPPLIER QUALITY ASSURANCE. ANY DEFECTIVE MATERIAL NOT USED IS TO BE TAGGED AND HELD BY THE SUPERVISOR, PENDING DISPOSITION.

4. The Supervisor MUST forward the DMFR to his local Storekeeper, who will acknowledge receipt to the author within 7 days of receipt. The Storekeeper will add any missing information before forwarding the form to the Director-Supplier Quality Assurance.

5. The Director-Supplier Quality Assurance will review the DMFR with the appropriate Purchasing Agent and, as required, Staff Department. Upon receipt, and every 30 days thereafter if required, the reporting employee, Supervisor and Storekeeper will be advised of the current status of the DMFR.

FLOW OF DEFECTIVE MATERIAL FIELD REPORT

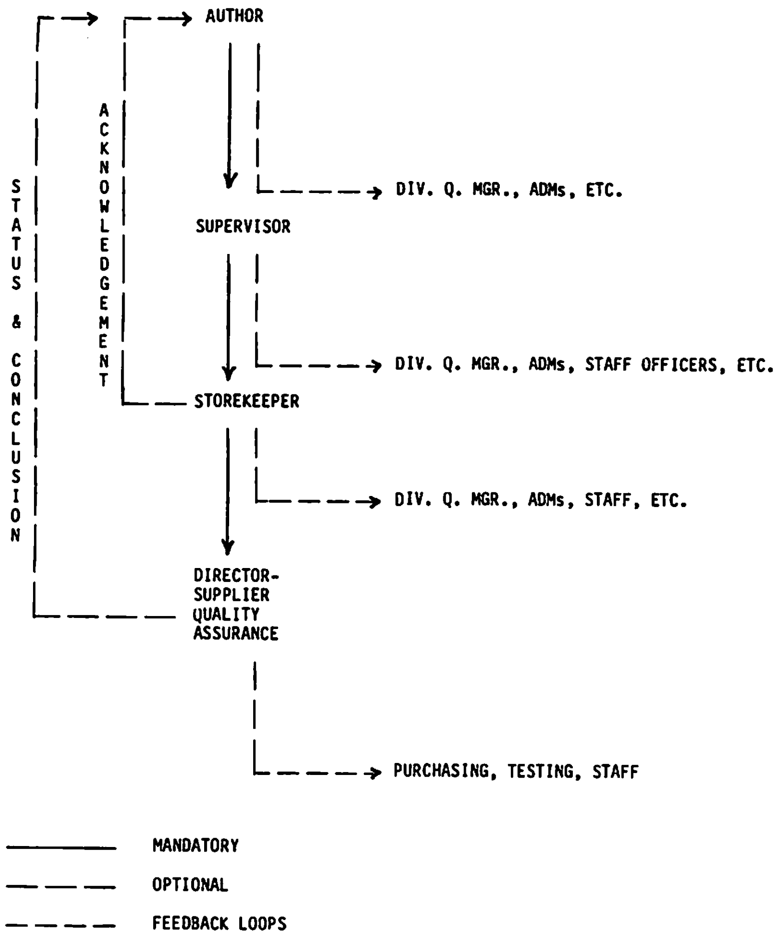

FIGURE 2

III
PAPERLESS REQUISITIONS

During the past two or three years this committee has made a number of presentations about bar codes and electronic data exchange. The committee felt more could be accomplished by using the latest technology. This presentation will deal with what is currently being done by at least one or more railroads in this country.

A. The "Old" Way of Requisitioning Material

With the current system most locomotive facilities requisition material as follows:

1. The requisition is hand written by the foreman or typed by clerical personnel. The majority of the time this requisition contains only a part number and a very brief description. It may also require further discussion with the using department to determine what is actually needed, in the event descriptions are not legible.
2. The requisition is then either picked up by the Material department employee during a delivery run or is hand carried to the Material department.
3. The requisition then must go through numerous other individuals to check for proper accounting codes, stock codes and inventory status. This check could further include checking the part number against the computer for correct description, substitute materials, and checking catalog references to determine what is actually required.
4. The location of the material must be determined. This can be as simple as checking a locator list or as involved as making an inquiry into the system with a CRT. The correct part number and/or stock code number must be known to perform this function, to determine the precise location within the storehouse.
5. The material must be retrieved and delivered to the designated area in the shop and ultimately charged to the proper account by keying all the data into the mainframe computer by a trained key punch operator. At best this is a very time consuming and labor intensive procedure.

B. Brief Overview of the Paperless System

We will briefly describe the events which take place in a paperless requisition environment. The electronic requisition is most effective in an operation where material of a repetitive nature is used, such as in repairs or replacement of injectors, power assemblies, water pumps, or traction motors.

The following equipment must be secured prior to establishing this type of system:

- Personal computer "PC".
- Bar codes and a hand held data entry device with a bar coding reader wand attachment or a laser gun attachment.
- Telephone, line and modem.
- A quality printer (to print bar coded pick tickets).
- Bar coded bin labels or catalog.

After the equipment has been connected pertinent information, such as description, stock code number, part number and stocking location, are then downloaded from the main frame computer to a local PC thus creating a data base for the PC.

Next a special eprom chip is placed in the hand held device. This chip contains a program which prompts the user for all necessary requisition information. This can be entered manually by using the key pad or scanned by using the high resolution wand.

After the equipment is in place, it is necessary that bar coded bin labels be applied to the shelving or pallet racks where the material is stored in close proximity to where the material is used.

A material management person, in the area with a hand held data entry device, scans the bar code and enters the quantity remaining on the shelf. To speed inventorying of the stored materials in the shops a fixed quantity tag, with a quantity of a day or a week or whatever the area can handle, is also affixed to the material allowing the individual to inventory more quickly. After all the items in that particular area are inventoried, the employee dials the telephone number connected to the PC and secures the hand held device to the phone for transmission directly to the PC. Then — faster than a speeding bullet — the information is transmitted. Transmission of an inventory of 50 to 100 items takes no more than a few seconds.

With a couple of key strokes this information, which was transmitted from the hand held device to the PC is formatted and sent to the printer to produce a pick ticket. This pick ticket shows the bar coded information and prints the proper information such as quantity required, determined by the difference between the fixed quantity and the actual on hand amount, stock code number, part number, three line noun description, accounting information, material location and delivery point. The material is then delivered to the point of use and put in the appropriate area.

The perpetual store inventory is then reduced by use of the pick ticket as the bar code on the pick ticket is then scanned and entered into the main frame with no further keypunching required. If the reorder point in the perpetual file is reached, then it would automatically generate a computer purchase order which would be electronically forwarded to the supplier.

C. Benefits Of The Paperless Method

With the "new" way of paperless requisitioning of material, many of the steps previously mentioned can be eliminated.

1. The foreman's writing of the requisitions can be eliminated which will allow him to supervise the people he is responsible for to be assured that locomotives or components are being repaired to the proper specifications. The requisition would also be free of grease, smudges, etc. and the typing of the requisition by the clerical individual is completely eliminated.
2. The delivery of the requisitions to the Material division can be eliminated. We have all seen many cases where requisitions are lost for a period of time; and you would almost swear they were sent via the U.S. Mail.
3. It should also reduce the chances of incorrect parts being ordered or delivered due to transposed or incorrectly copied numbers.
4. It reduces the number of people involved in handling of the requisitions or pick tickets.
5. The checking of stock code numbers and accounting codes will be eliminated because this information will


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reside in the PC.

6. No additional inquiries will be required to locate the material as this information will also reside in the PC and be printed on the pick ticket.
7. Retrieving and delivering of the material will certainly remain; however, the retrieval will be simplified because the requisition is in good condition and legible in all cases. Retrieval is simplified by grouping materials by location so that an individual makes as few moves as possible.
8. Another benefit will be a detailed material distribution report which lists the quantity, description and value on a daily, weekly or monthly basis.This is a valuable tool which can be used in monitoring cost associated with various repairs.
9. Any of this work can be conducted on the second or third shift without interrupting work and eliminating congestion in the work area.
10. The last benefit, which is one of the most important, is the accuracy in using the bar coding in place of key strokes which eliminates virtually all errors.

D. Closing Comments

In conclusion, while we are on the right track with all the technology which is available, it is essential that railroad suppliers get involved and begin bar coding of packing slips and labels so that we can acknowledge receipt of inbound shipments.

We would like to challenge all of the members of the LMOA to cooperate in finding ways to be more productive in order to improve the railroad industry; because, even if we are on the right track, we will get run over if we just sit there.

IV
A PRACTICAL APPLICATION OF BARCODING IN THE RAILROAD INDUSTRY

Last year this committee brought to your attention the need for the railroad industry to consider and expand the use of barcode technology beyond inventory control, and into locomotive history data collection. Other data documenting currently being accomplished by our force should seriously be analyzed for possible barcoding.

The committee believes barcode technology is needed to provide the date entry capabilities required to get full benefits from computer-based locomotive and car maintenance systems. Through the years we have implemented systems to provide information necessary for managers to make decisions on maintenance policies and operations. In many cases business pressures have hindered us from committing the proper support necessary to receive full benefits of these systems.

In some cases, responsibility for data collection and entry has been placed on the first line supervisors. This, of course, compromises the supervisor's efforts toward his primary duty, which is managing his people. The results are impaired data integrity and loss of confidence in the information generated from the systems. Further, it has caused systems to be designed to collect a lower level of detail than is actually needed to run a business.

The committee believes the use of barcode data input will allow supervisors and mechanics to perform data entry as a byproduct of their work, rather than an additional clerical task.

In addition to innovations by the member railroads, we asked the LMOA convention to work together and establish workable standards for barcoding in our industry. For example:

1. Which code should be our standard?
2. Which components should be barcoded?
3. What data should be coded?
   A) Serial numbers?
   B) Vendor info, who, date built, part number?
   C) Other?
4. What type and size of markings? Should they be man-readable?
5. Where to apply data to components?

We're pleased to report that in the past year, the AAR committee has adopted the 3 of 9 code as a standard. Prior to this, the railroad industry group of the NAPM did establish the 3 of 9 code as a standard for packaging and label marking.

Many suppliers have begun to investigate use of barcodes for their internal requirements in addition to possible customer uses. Finally, several railroads report they began to use the barcode in other areas, or are well into the planning process for use.

For example, a Southern railroad is already using a hand-held radio frequency terminal to collect car-billing data. Although the hand-held unit is not a barcode reading device only, a scanner or reader can be easily plugged into this smart portable device, and when data to be collect are barcoded, they can be read and transmitted instantly to a base station computer for processing.

The same railroad is planning to use this new communication process to capture labor data in its locomotive and car shops.

In addition an Eastern railroad has proposed using barcodes to record data, and monitor production in its large backshop operation.

In the Midwest, a major carrier reports the planning and design of a complete pacakge of data collection utilizing barcodes. The savings will come partially from clerical reduction, but the major portion of the savings is expected to come from productivity gains by putting the supervisors back to their primary duty of managing the force. In addition to this, management reports will be more accurate and the data base can be expanded to include more pertinent information for management decision making.

Here is an outline of this energetic plan for barcode use:

Timekeeping — The railroad will replace its current timecard system with barcoded employee badges which will be read when each task is started and finished. It will also capture what equipment is worked on and what materials are ordered and used.

Materials requisitioning — A barcoded catalog will be scanned and orders fed directly into the materials system. Current practice is to write and key in requisition data. The locomotive number will be associated with the material issues to produce maintenance costs by units.

Locomotive maintenance — The locomotive work reports will be barcoded for maintenance data collection, such as what repairs, what components, which positions, and reasons for failure. Selected components will have barcoded serial numbers to assist in warranty monitoring and life cycle studies.

Other uses of barcode technology to be implemented by this road are component rebuild data collection, locomotive status reporting, and end of train device control. In the shop, power and special tools will be barcoded for better controls and maintenance planning.

In conclusion, we regret to tell you that most railroads and suppliers are waiting for someone else to begin the standardization process. This organization, the LMOA, must support the lead of the rail industry group and strongly suggest that other railroads move toward the use of this barcode standard.

Management is demanding more information from fewer people. There is a way to give managers what they need to keep us in business. To collect data faster, easier, with more accuracy and with no additional people — barcoding is the answer!

D. W. MAYBERRY
Vice President-Mechanical
Norfolk Southern Corporation
Roanoke, VA

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

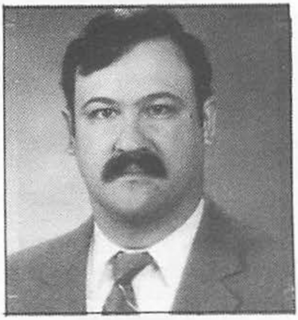
Our New Developments Committee was well received in what we trust was a mutually beneficial experience.

Our thanks to Mr. Mayberry and others responsible for and participating in the program.

Tuesday, September 20, 1988
3:15 P.M.

REPORT OF THE COMMITTEEON NEW DEVELOPMENTS

Pre-Convention Presentation: Roanoke, VA



May 4, 1988
Hotel Roanoke
Roanoke, VA

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1988 TOPIC:
THE LINK TO RELIABILITY AND PRODUCTIVITY

PERSONAL HISTORY

M. A. Coles

Mark was born in Rocky Mount, North Carolina. Most of his early years were spent in the northeast where his family settled in Rhode Island. Following high school, he attended Franklin Institute in Boston, Mass. where he studied Automotive Technology. He then attended the University of Rhode Island where he earned a Bachelor's Degree in Mechanical Engineering.

He started his railroad career when he entered the Missouri Pacific's Management Training Program in June of 1976. Later that year he was assigned to the position of Assistant-To-The Mechanical Superintendent at North Little Rock Arkansas. In 1977 he was assigned as a Locomotive Foreman at the Fort Worth, Texas Diesel Shop, and then returned to North Little Rock in 1978 where he was promoted to the position of District Diesel Supervisor. In 1979, he was promoted to the position of Road Foreman of Engines and was stationed at Falls City, Nebraska. At the end of 1980, he was transfered to Railroad Headquarters at St. Louis, Missouri, where he was assigned as Facility Planning Engineer, and worked on the design of the Downing B. Jenks Locomotive Heavy Repair Facility at North Little Rock. In 1985, he was promoted to the position of Supervisor of Locomotive Equipment, which he held until the consolidation of the Missouri Pacific and Union Pacific Mechanical Departments in 1986, where he was assigned the position of Engineer — Mechanical Equipment in Omaha, Nebraska. Following the reorganization of the Operating Department in 1987, he was promoted to his present position of Manager Locomotive Maintenance — Mechanical, Union Pacific Railroad, Omaha.

Mark, his wife Susan, and three daughters now reside in Omaha, Nebraska.

I.
WHEEL SLIP CONTROL FOR INDIVIDUAL AXLES

Diesel-electric locomotives built for main-line railroad operation have made extensive use of series-connected, direct-current motors for traction. The ability of such a motor to deliver usable tractive effort over a wide speed range, while demanding only moderate variations of voltage and current from the power source, is a significant reason for its continuing widespread use. However, this same characteristic will permit the traction motor to reach destructive speeds when its wheels slip on the rails, because the available friction between wheel and rail often drops faster than tractive effort with increasing slip speed. Consequently, virtually all such locomotives employ some means to prevent a runaway wheel slip condition.

Conventional Wheel Slip Control

The process of locomotive wheel slip control, as it pertains to diesel locomotives built prior to the last decade, resolves itself rather neatly into two parts: detection and correction. Ideally, the former should be able to identify one or more axles that have exceeded track speed by a specified amount, indicating that corrective action is needed. Historically, however, track speed has eluded direct measurement, so the locomotive builders have settled for detecting a given speed difference between the fastest and slowest axles. This has been done both directly by measurement of axle speeds, and by inference through comparison of traction motor currents. Implicit is the assumption that the slowest wheels are rotating at track speed, which is not always the case in fact.

Recognizing the shortcomings of this method of detection, all modern control systems have been supplemented with means to detect the wheel acceleration that results from a sudden loss of adhesion under high tractive effort, thereby affording some protection against a simultaneous slip of all wheels. In practice, however, an axle can accelerate too slowly for detection in this manner and still reach an excessive speed, so the need remains for a level detection system such as described above.

The foregoing detection methods all share one particular feature in common: a detected wheel slip is potentially a runaway wheel slip. If adhesion is not restored immediately, such as by application of sand, the tractive effort delivered by the slipping wheels must be reduced at once to a level that can be supported by existing adhesion. This requires a reduction of power input to the corresponding traction motor. There is no way to predetermine the exact amount of power reduction needed; only by observing that the wheel speed is returning to normal can it be determined that power has been reduced sufficiently. In practice, by the time this fact is known, the power will have fallen well below the level needed for recovery.

Because conventional diesel locomotives have no provision to independently control the power applied to each traction motor, any reduction to correct a wheel slip must be made at the power plane, affecting all traction motors alike. One might argue that a wheel slip detected at one axle will eventually show up at the others for the same reason, justifying its prevention in advance. However, it rarely happens that poor rail conditions affect all wheels of a locomotive equally and simultaneously; experience has shown that the leading wheels will slip more frequently and, by so doing, will present better rail conditions to the remaining wheels.

Effect Of Slip Speed On Adhesion

In 1976, EMD completed an exensive research program wherein the specific behavior of wheel-rail adhesion was examined under various conditions of speed, track curvature, axle loading, and rail contamination. The results were later published in the ASME Journal of Engineering for Industry (*), and established beyond doubt that substantial improvement in available adhesion can be gained by permitting locomotive wheels to creep, or slip steadily at a speed which can be as much as 15 percent greater than track speed.

Figure 1 shows a few representative friction-creep curves as presented in the ASME publication, which portray average performance on tangent track over the speed range of 10 to 20 miles per hour. Two common features of these curves are the need for several percent of wheel creep to realize the maximum available adhesion, and the higher creep speed needed as the peak adhesion is reduced by worsened rail conditions. It should be emphasized that these curves are only typical under the conditions stated, and do not in any way represent the worst adhesion likely to be encountered in normal operation.

Effect Of Slip Speed On Tractive Effort

In January, 1982, the author supervised a test whereby two EMD D77 traction motors were operated with coupled shafts, one as a motor and the other as a generator, at various levels of field and armature currents. From the measurements taken during this test, algorithms were developed to permit the calculation of D77 motor parameters with reasonable accuracy under a variety of operating conditions, including those with different armature and field currents. For this reason, all subsequent graphs and quantitative references to traction motor characteristics will apply specifically to the D77 model. Also stipulated will be 40-inch wheels, 62:15 gear ratio, and average motor temperature of 75 degrees Celsius.

It is instructive at this point to observe the slip speed versus tractive effort of a D77 motor and its dependence upon circuit arrangement. In Figure 2, the upper curve represents a single traction motor being driven at constant horsepower. The speed and tractive effort are almost inversely proportional, as one would expect with constant power and reasonable efficiency.

The other two curves in Figure 2 depict the behavior during wheel slip of one motor in a four-motor circuit, showing both series-parallel and full parallel connections, with the other three motors operating at a constant track speed of 10 miles per hour. It has been assumed in each case that constant horsepower is being applied to the entire circuit. The greater reduction of tractive effort with increasing slip speed comes from the stabilizing effect of the three non-slipping axles. With the full parallel connection, the current diverted from a slipping axle can be absorbed by the other motors with only a slight rise in terminal voltage, so stability is much better.

Unfortunately, a wheel slip is not always confined to one axle. Figure 3 illustrates the effect of multiple slips on the full parallel motor arrangement just described. For simplicity, it is assumed that the speed selected at the lower edge of the graph applies to all slipping axles, which will each deliver a reduced tractive effort as indicated by the appropriate curve. Obviously, the reduction becomes less pronounced as more axles participate in the wheel slip, but this is only the beginning. There are now more motors drawing less than normal current, and fewer motors still running at track speed to absorb the current diverted thereby. The stabilizing ability of the latter motors becomes a moot issue when their current reaches an unrealistic value, as reflected in the much shorter curves for 2- and 3-axle slip conditions.

It is apparent, therefore, that one should not rely on the non-slipping axles for stability without some means to limit the motor currents to a safe value.

Recent Improvements In Wheel Slip Control

One system that seeks to maximize adhesion by permitting substantial wheel creep is the Vapor "Positive Traction Control" system, in which acceleration is used as the primary detection parameter with 1.7 miles per hour per second being the amount at which a wheel slip condition is declared. The designers of this system have assumed that any wheels accelerating faster than the above rate have slipped to the point of declining wheel-to-rail friction, and require intervention by the control system. For reasons already stated, a differential level detection scheme is retained as a backup system.

As a consequence of their recent findings concerning the friction-creep relationship, EMD developed the "Super Series" wheel slip control system, whereby track speed is continuously measured by radar and current is monitored individually in each traction motor. From this information, a signal is derived which represents the voltage that should appear across the motor terminals. With all motors connected in parallel and the main supply voltage regulated to the calculated value, any axle that exceeds track speed will cause its associated traction motor to unload along a constant-voltage curve without diverting current to the other motors. While this curve is not markedly different from the lower curve of Figure 3, one should remember that the original curve was valid only with the wheel slip confined to a single axle. The Super Series arrangement, on the other hand, is not adversely affected by the number of axles involved, and is thus somewhat protected against a simultaneous runaway slip of all axles.

Other, more exotic methods of wheel slip control have also been tried. In Europe, for example, circuit arrangements have been used in which the traction motor fields are powered separately from the armatures, thus permitting individual control of the motors to some extent. While somewhat expensive due to the extra equipment needed, such a method affords phenomenal speed stability as long as one or more axles remain at track speed, as the tractive effort of a slipping axle can be made to completely vanish with only a moderate degree of wheel slip.

Combining The Most Desirable Control Features

From the foregoing discussion of various wheel slip control systems already in use, several desirable features stand out which, if they could be combined inexpensively on a locomotive, would result in a system with substantially better performance:

1. Tractive effort, and therefore traction motor armature current, should drop rapidly with a slight increase in wheel speed due to slip, preferably intersecting the prevailing friction-creep characteristic at or near its peak, to enhance self-recovery of the slipping wheels as rail conditions improve.
2. Tractive effort should vanish completely at some greater but moderate level of wheel slip speed, thus making a runaway slip impossible. It would then be unnecessary to make a general power reduction and penalize the performance of all remaining wheels just to recover the ones that slipped.
3. Current should be limited individually in the traction motor armatures to a safe value, to protect against a simultaneous wheel slip at two or more axles.

The second feature listed above would require that a motor's field current never drop below a moderate value due to wheel slip, even when its armature current is at or near zero. Short of the costly method of energizing the motor field windings from a separate controllable power source, it is necessary that any motor subjected to wheel slip be able to "borrow" a portion of the field current from the other motors. This suggests the use of a circuit as shown in Figure 4, in which the traction motor fields and armatures are separately connected in parallel. With a loss of armature current in one motor due to wheel slip, that remaining in the other motors will be shared equally among all the field windings.

However, this arrangement is not without problems, as the wheel speed is too stable for its own good. For example, if a four-axle locomotive equipped with this circuit is proceeding at ten miles per hour and one wheel pair slips, the tractive effort from that motor will plunge abruptly to zero before the slip speed reaches 10½ miles per hour. Referring again to the friction-creep curves in Figure 1, it can be seen that tractive effort drops too rapidly to take advantage of available adhesion with poor rail conditions, Further, if a few percent variation in speed has such a precipitous effect on tractive effort, so will be the effect of minor variations in wheel diameter, or in other parameters resulting from normal manufacturing tolerance within the motors.

At 20 miles per hour the situation is worse yet, as tractive effort and armature current can drop to zero with no increase in wheel speed at all, making it impossible to achieve any balance of tractive effort among the motors. The explanation for this behavior lies in the manner by which armature reaction can sometimes offset the normal IR drop in the armature windings, which is beyond the scope of this discussion.

Norfolk Southern Wheel Slip Control System

Instead of connecting the field-armature nodes together as described above, they can be connected to each other through a suitable resistance network as shown in Figure 5. A resistance of .01 ohm per leg has been used for illustration, since this value is commonly available in dual-resistor assemblies with a 500-ampere rating. Note that with this arrangement, current is shared among the traction motor fields, but not equally as was the case in Figure 4.

As discussed earlier, current in the non-slipping motors should be limited to a safe value. This was accomplished at Norfolk Southern by monitoring the armature current in each traction motor, and using the highest of these to provide feed-back control to the excitation system.

Figure 6 shows the performance of a slipping axle in the arrangement just described, assuming a track speed of 10 miles per hour as in previous examples. Several curves were included to show the effect of various amounts of armature current in the non-slipping motors, ranging from substantial overload to well below rated load. Included for comparison is a representative wheel slip curve for current-limited operation with the field tie connection omitted. To lend perspective to the figure, a typical friction-creep curve for oily rails was extracted from Figure 1 and included here, scaled to 65,000 pounds axle load.

Of paramount interest is the overall performance improvement under wheel slip conditions. If one axle slips to 13 miles per hour, where the curves intersect, its tractive effort falls to about 1250 pounds which can be sustained with only two percent adhesion. By way of comparison, the same axle in a conventional four-motor parallel circuit (without field tie), even with the other motors current-limited, will deliver several times as much tractive effort at the same slip speed. Additionally, the field tie circuit imposes a practical limit on the speed of a slipping axle, even at zero tractive effort, which represents the worst adhesion possible.

The above is a somewhat oversimplified version of the real-world situation, As already pointed out, all wheels must slip to a slight degree, or creep, in order to deliver a substantial tractive effort. Therefore, what has been referred to as "track speed" is technically the speed of the slowest axle, which is presumably close to actual track speed and sets the pace for the remaining axles.

Figure 7 shows the result of an equal and simultaneous slip of three axles, all other conditions remaining unchanged. With at least marginal adhesion, the effect of the two extra slipping axles is insignificant. At extremely low adhesion levels, slip speed is moderately higher than in the single-axle case, but is much less than that encountered with the conventional circuit.

It should be noted that, in both the situations just given, the reduction of tractive effort with slip speed is more abrupt with the higher pre-slip current levels, where it is more useful in controlling the wheel slip. This is to be expected, as the higher current levels will drive the traction motor fields well into saturation. Under this condition a substantial fraction of a motor's field current can be diverted through the field tie network with only a minor reduction of field strength.

Effect Of Changing Parameters

As mentioned earlier, the value of .01 ohm per leg of the field tie network was selected initially due to availability of the hardware. Figure 8 shows the results of a single-axle slip when using lower resistance values, with all but the 1200-ampere current limit curves omitted to eliminate clutter. Control of slip speed improves as the resistance is lowered, but at the expense of larger possible variations of tractive effort due to differing motor characteristics or wheel sizes. As discussed in connection with Figure 4, the curve representing zero resistance is so steep that much of the available adhesion is forfeited.

It was pointed out in comparing Figures 6 and 7 that higher slip speeds are possible when more than one axle participates. This effect becomes reduced and eventually reverses itself with lower values of tie resistance, as can be observed by comparing Figure 8 with Figure 9, in which two axles are slipping simultaneously. The .0025-ohm curve in this case is almost identical with its counterpart in Figure 8. However, one must not assume that the similarity would extend to conditions of lower current levels or other track speeds.

The zero-resistance curve of Figure 9 has assumed a preposterous shape, missing the friction-creep curve entirely. This is just one more example of why a solid connection will not work as a field tie.

All discussion to this point has assumed a track speed of 10 miles per hour, for ease of illustration, but the analysis would be incomplete without checking performance at other track speeds as well. Figure 10 permits a comparison of salient performance features at three speeds, covering the range requiring perhaps the most attention to wheel slip control. At each speed, curves are included for operation with up to three slipping axles, with and without the .01-ohm field tie. The sample friction-creep characteristic used earlier has been included at 10 and 20 miles per hour, which are its limits of applicability.

It can be seen that the speed of an axle slipping with very low adhesion, while limited by the field tie network, becomes proportionately higher as the track speed is increased. Another effect, not apparent in Figure 10, is the fact that lower values of motor current will prevail at the higher track speeds, which of itself contributes to higher slip speeds as was shown earlier in Figures 6 and 7. Consequently, as the track speed continues to increase, a point will eventually be reached above which the field tie network alone cannot prevent an individual axle from reaching a destructive speed. Added to this fact is the chance that all four axles can slip at once, whereupon the field tie is rendered ineffective. Therefore, any locomotive not confined to low-speed operation should incorporate some additional means of overspeed protection.

Nothing has been said thus far about the use of a field tie with six axles, although the principles already discussed would be applied to a circuit of six parallel motors with excellent results. The problem is that most locomotives, built before the high-adhesion systems became available, have a main power source that can deliver rated current to only three or four parallel motors. One solution to this dilemma is to apply the field tie network individually to two groups of three motors each, which is the grouping normally used for series-parallel operation at low to moderate track speeds, and to connect the intermediate points between motors through suitable cabling. A shortcoming of this arrangement is the fact that only two axles per group can slip before the field tie is rendered ineffective.

Conclusion

The most desirable characteristics of a wheel slip control system using the field tie network can be summarized as follows:

1. Loss of tractive due to poor rail conditions is minimized.
2. The system employs a simple concept, and requires no critical adjustments for proper functioning.
3. A minor rearrangement of the existing power circuit will permit the system to be retrofitted to many older locomotives built since the late 1960's.
4. Components are generally no more expensive than those required for conventional wheel slip control.

It should be understood that the use of a field tie network, of itself, does not make a high-adhesion locomotive. The latter would require, in addition, a power source and traction motors that can handle the higher current needed on a continuous basis.

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** C. F. Logston, Jr. and G. S. Itami, "Locomotive Friction-Creep Studies," ASME paper No. 80-RT-1, 1980.*

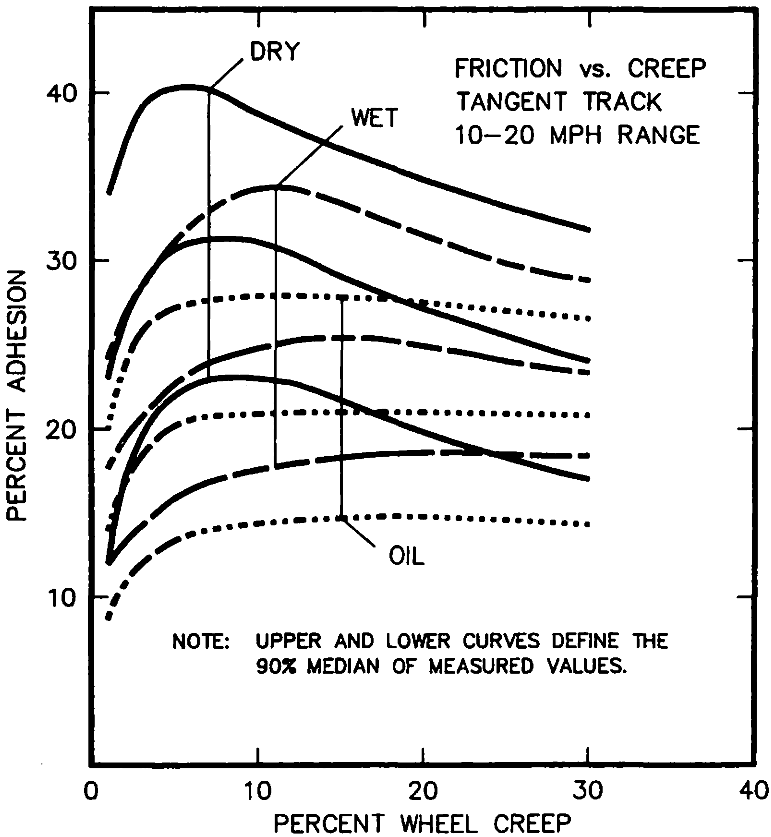


Figure 1. Typical Friction–Creep Characteristics

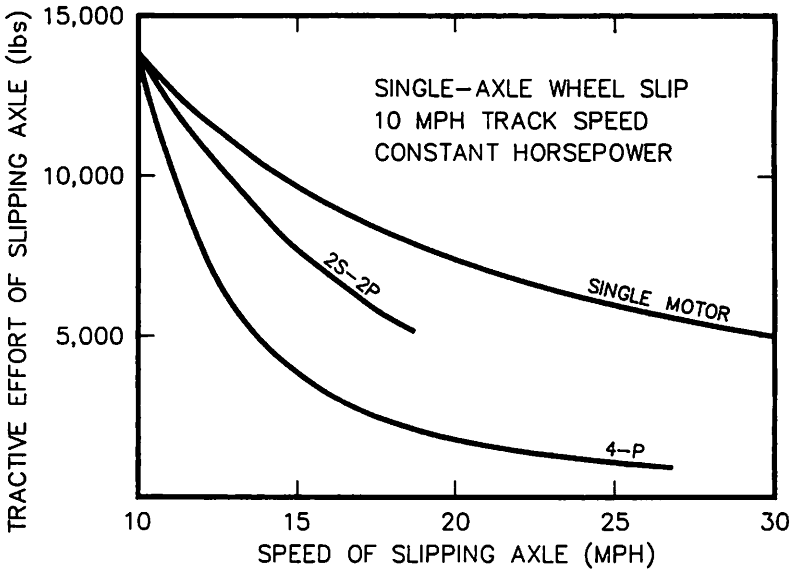


Figure 2. Slip Speed vs. Tractive Effort as Affected by Circuit Arrangement

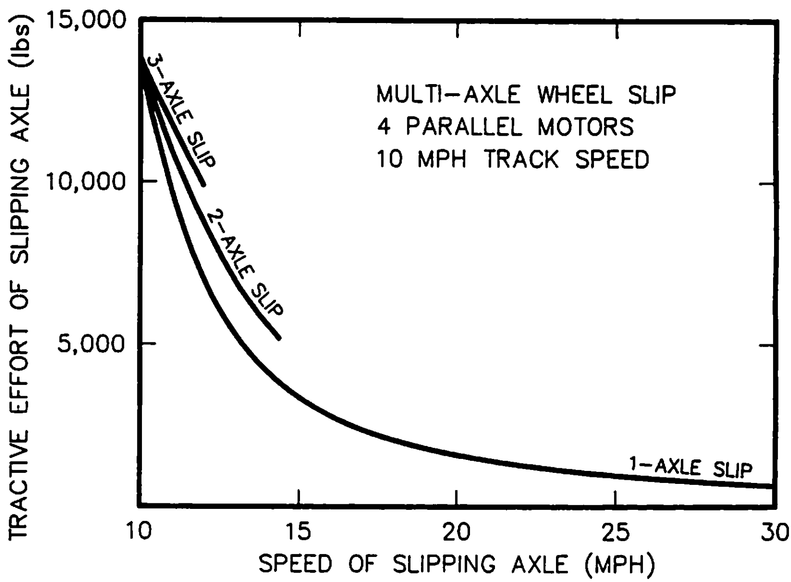


Figure 3. Slip Speed vs. Tractive Effort with Multiple Slipping Axles

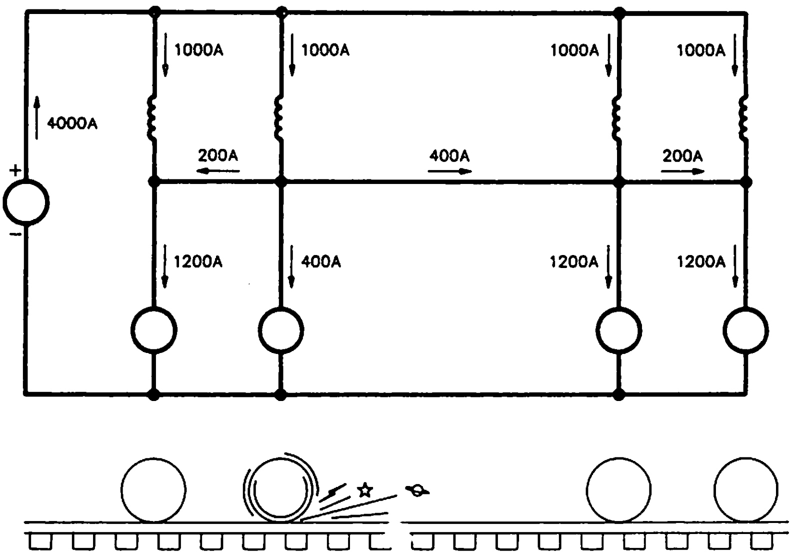


Figure 4. Current Distribution in Parallel Motor Circuit with Solid Field Tie

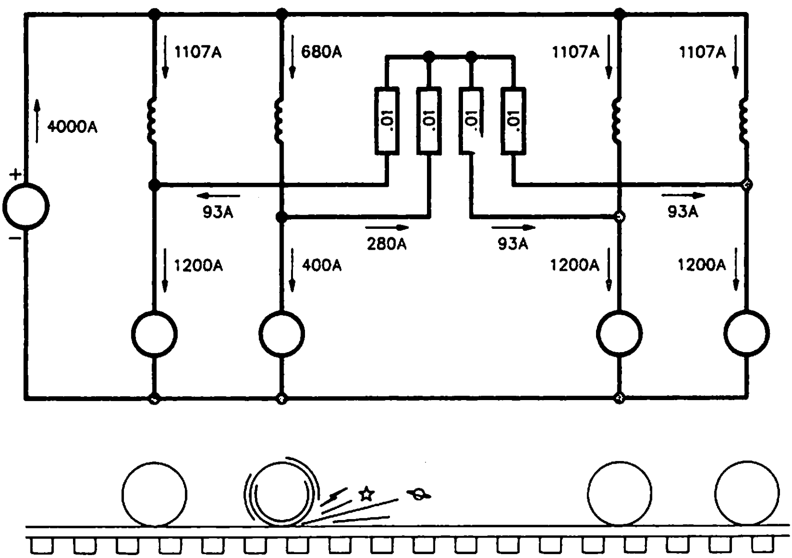


Figure 5. Modified Current Distribution with a Resistance Network Field Tie

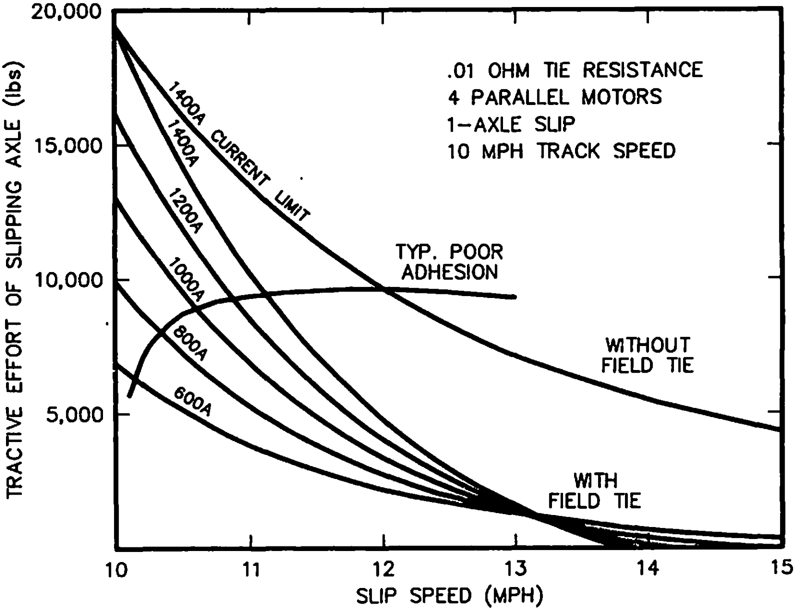


Figure 6. Single-Axle Wheel Slip Performance as Improved by Field Tie Network

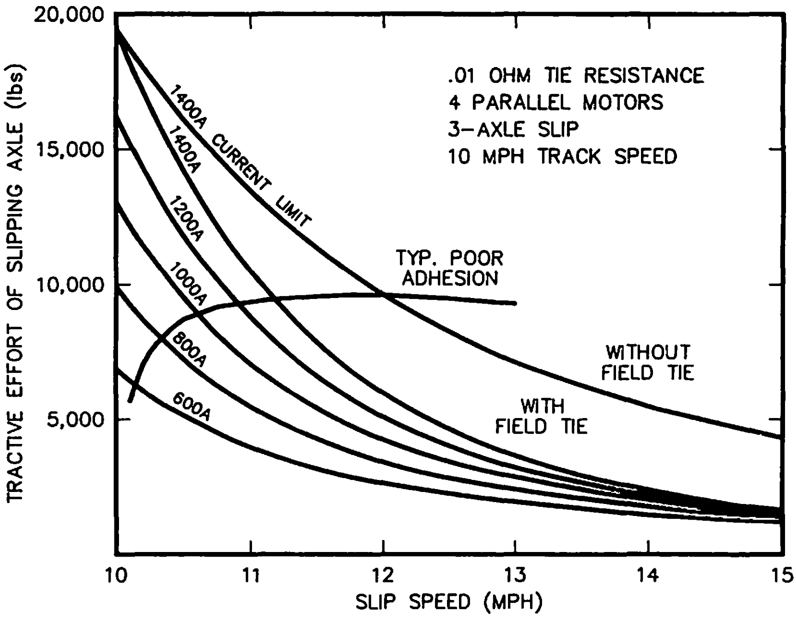


Figure 7. Three-Axle Wheel Slip Performance as Improved by Field Tie Network

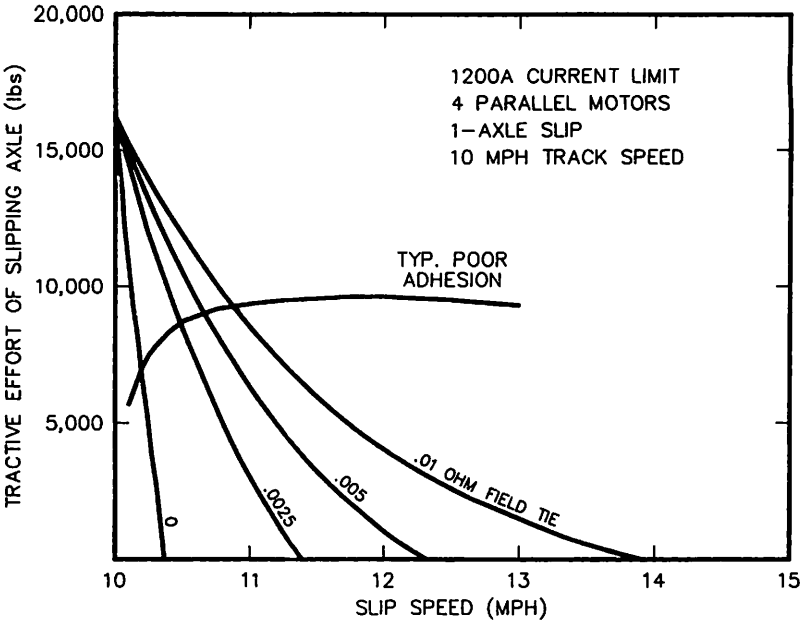


Figure 8. Performance Variations Resulting from Modified Resistance Values

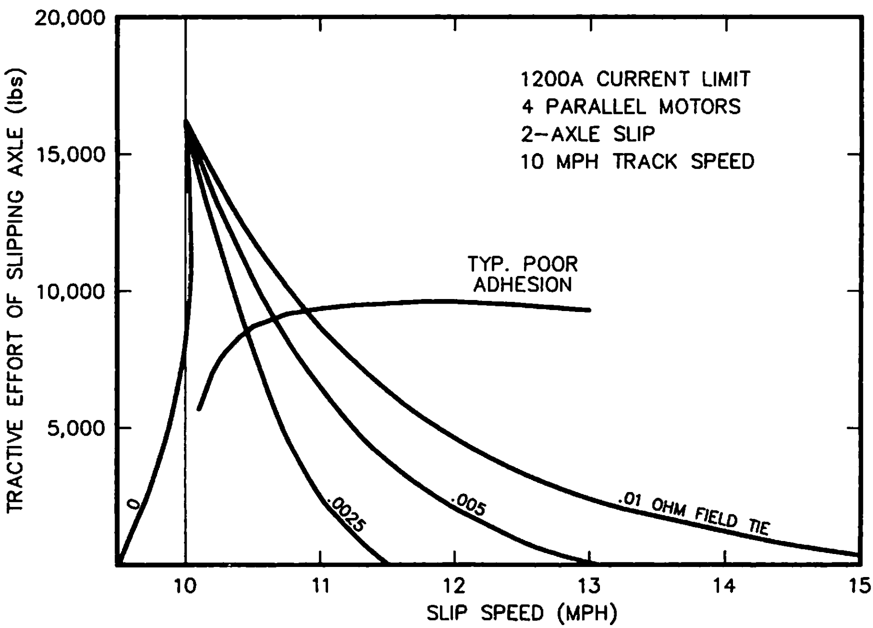


Figure 9. Two-Axle Wheel Slip Performance with Several Resistance Values

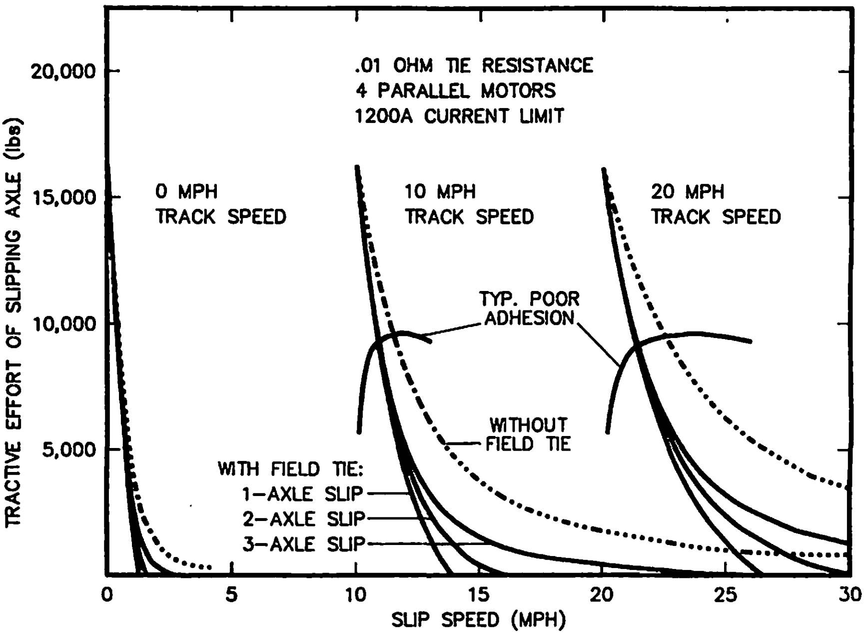


Figure 10. Effect of Track Speed on Wheel Slip Performance

II. THE AMTRAK F69PH LOCOMOTIVE

A. Introduction

As technology changes and advances are made, it becomes apparent that these advancements can and should be utilized in the railroad industry. With Amtrak's experience with solid state inverters and a prototype locomotive with AC drive, the potential of this technology became quite obvious; a passenger locomotive could be built to surpass the present DC locomotive in reliability, maintainability, and lower operational cost and can be implemented with today's proven technologies.

It is with this philosophy that Amtrak has placed an order with Electro-Motive Division (EMD) for two diesel-electric locomotives with AC traction designated as the F69PH. It is not the intent of this presentation to elaborate on the advantages of AC traction versus DC traction, but rather the benefits of a complete locomotive system that is integral to the needs of Amtrak. By utilizing the induction motor, solid state inverters, and microprocessor controls, increased performance with more reliability and economic advantages in most other locomotive subsystems will be obtained. These subsystems are what make the whole AC traction package so intriguing and advantageous.

B. Engine Speed Schedule

One area that has always been synonymous with Amtrak's F40 locomotive is its ability to produce a 480 volt 60 Hz 3 phase head-end power (HEP) trainline buss for the purpose of temperature control and lighting of passenger cars. However the F40's production of HEP, using today's standards, is mechanically inefficient. This inefficiency is demonstrated in terms of fuel consumption (see Figure 11). The 645E3B engine has the horsepower capacity of generating 2,100 KW total for traction and HEP. The average HEP load for the Broadway Limited is approximately 200 KW, or 10 percent of the engine capability. To obtain 10 percent more of the engine's power, 27 percent more fuel has to be expended. This conclusion is not based on theoretical calculations, but rather on actual records of the amount of fuel added to the locomotive tanks. The reason for this is quite easy to explain. The engine producing HEP and traction has to constantly maintain 893 RPM in order to rotate the head-end power alternator through a 1 to 2 gear box to provide a constant 60 Hz frequency on the HEP trainline. It is this higher RPM of the engine that causes such a discrepancy of power output versus fuel consumption.

With the AC traction package, HEP will be supplied by the main traction alternator, instead of a separate mechanically driven machine, thereby eliminating the mechanical gear box and HEP alternator. On the F69PH, the frequency of the HEP will no longer be based on engine speed. Maintaining the 60 Hz frequency will be the task of the HEP inverter.

It does not take too much of imagination to appreciate that if engine RPM is lowered, fuel efficiency will increase, and the mechanical stress on the engine will also be lowered by some factor. This problem of engine speeds has been addressed by some transit agencies by the addition of another engine/alternator set to the locomotive to supply HEP. This approach is a sign of frustration with the engine speed issue.

The F69 will be capable of providing the full 800 KW HEP rating at throttle notch 5 (643 RPM) or higher. This is a 25 percent reduction in engine speed when compared to the F40. However, Amtrak trains have significantly lower power requirements. If the steady state condition power demand is 200 KW or less, the engine speed can be as low as throttle notch 3 (493 RPM) depending on the demand for traction power.

The engine speed issue is one of great concern to Amtrak. Many major mechanical problems seem to be unique to Amtrak and have been attributed to the higher engine RPM. On completion of the F69, extensive testing will be performed in order to obtain the lowest possible engine RPM for HEP.

Other areas that will be improved as a result of lower engine speeds will be noise pollution, lube oil consumption and exhaust emissions in station areas.

Lube oil consumption will be drastically reduced. Using the Broadway Limited as an example, approximately 20 to 40 gallons of oil are added daily to the locomotive that is producing HEP, while the second unit in the consist, producing traction power only, requires no additional lube oil. The elimination of high RPM and lightly loaded engine operation and this "pumping" out of lube oil should greatly enhance the physical appearance of Amtrak's equipment, helping to make a more marketable product.

C. Cab Configuration

The most outstanding physical feature of the F69PH is its redesigned cab area. This new cab profile accomplishes two objectives: improved aerodynamics and greater marketing appeal. The interior design enables the operating personnel to perform their various duties with greater efficiency. The cab features a console style control station along with an additional console to assist the crew.

The brake equipment will utilize the 30 CW brake valve and module. Suppression will be made at a 17 pound brake pipe reduction for speed control operation.

The cab will also be equipped with air conditioning, electric heaters, additional sound deadening material, pedestal design seats and electrically heated windows. Flush mounted into the control and upper consoles will be cab signal aspects, air gauges, solid state speedometer, load meter, alertor and radio control system display.

The digital display screen will be mounted directly above and in front of the engineman. All in all, this cab will feature all the sophisticated enhancements which provide both comfort and performance.

D. Control System

The F69 will be controlled by four microcomputers. Three will be assigned the task of inverter control, one for each inverter. The remaining processor will be in control of all other locomotive functions including excitation control, logic, display and diagnostics.

The microprocessor on the CPU is from one of the newer generations of microcomputers. Some of the advantages of this chip are size, speed, lower power consumption and capacity for computing.

CPU, I/O, ROM, RAM and buffers will be physically applied into the locomotives on removable modules or cards from a common printed circuit card rack. At present, the application to the I/O cards of LEDS to signify analog inputs and outputs has not been finalized.

The microprocessors have been programmed for a self diagnostic test. An indicator will display a fault condition if any discrepancies are found in memory, accumulator, pro-

gram counter, I/O, clock and registers.

At Amtrak, one of the most perplexing problems is the diagnosing of en route failures. This is due mainly to the limited information that is obtained by maintenance personnel concerning the specifics of the failure. With the diagnostics furnished by the microprocessor, and its ability to record events, the microprocessor memory display screen will be one the most useful tools in returning the locomotive back into revenue service with the confidence that the malfunction will not reoccur.

Road failures should also be minimized due to the fact that the operating personnel will finally have a device that can guide them out of their difficulties, primarily data confirming the operating conditions of the HEP system.

Needless to say, interface relays and power switch gear will still be an important part of the electrical system. EMD will incorporate a system used on its Sixty Series. If the I/O logic output is used to pick up a relay, a confirming feedback to the microprocessor will be required. If the confirmation is not received, the sequence will stop. The data display screen will indicate which device or relay stopped the sequence. This feature should considerably reduce fault finding time.

With the use of the microprocessor, horsepower produced by the engine using self load will be indicated on the display. This process verifying horsepower on DASH-2 locomotives, which include F40s, was always viewed as a test where great care was needed; otherwise, electrical flash over of the test instrumentation could easily occur. The display feature of the microprocessor control system will help maintain the mechanical integrity of the 710G3 engine and its subsystems.

E. Inverters

The technological development that had the greatest impact on three phase traction development was the advent of solid state inverters. As advancements were made in semiconductor technology, these results were incorporated in the design of traction control systems.

An example of this occurred in diesel electric locomotives when DC traction generators were replaced by AC alternators. The concept was made possible only by the advancements in high voltage and current diodes. The diode allowed a major design change which eliminated a very labor intense problem of brushes and commutator maintenance on the main traction generator. The AC alternator is the accepted standard in today's locomotive. The next semiconductor that has had a major impact in the design of this traction system is the silicon controlled rectifier (SCR). This device has changed all approaches in the design of traction control, power supplies, battery charging, three-phase inverters and module control cards.

The diode and SCR have been the two major semiconductors that have made today's standard locomotives possible. As with any accepted standard, technology has a way of changing that standard. A new semiconductor called a gate turn off thyristor (GTO) will be introduced in the inverters of the F69. The major advantage of the GTO is its ability to turn off electrical current on command, unlike the SCR which has to rely on natural biasing or force back biasing or zero crossings of a wave form to be turned off or to a state of not conducting.

The GTO inverter will have the task of converting the DC source from the main alternator to three-phase AC for the traction motors and HEP. The GTO that will be used will be approximately 76 mm in diameter with electrical capabilities of 4,500 volts at 3,000 amps.

Inverters are not new to Amtrak. They are used on AEM7s to supply HEP and to power all rotating devices aboard the locomotive. As with most electrical devices, packaging, connectors, dirt, loose connections and cooling are the most labor intense areas on the inverter; not the semi-conductors or the control modules.

All of the labor intense areas have been addressed with the Siemens design GTO inverter modules. These modules are hermetically sealed. All electrical connections to the components within the module are cast into the epoxy resin end plate which is bolted to the aluminum tank. Replacements of devices in the module will be done in a controlled environment external of the locomotive, in order to assure a quality repair. The module's heat sinks will be cooled by freon, which is self contained in the module package. There will be no external piping or condensers with which to contend. The components in the modules are submerged in the freon bath which will cause the freon to boil and vaporize as the devices heat up. Unfiltered air will be blown across the modules in order to remove the heat, thereby causing the freon gas to condense back into a liquid and repeat the cycle.

Another new approach will be that the inverters will be utilized to regenerate dynamic brake current back into the HEP trainline buss rather than dissipate all of the braking energy as waste heat.

With the flexibility of the inverters, if a malfunction occurs in the HEP inverter a traction inverter can be activated to take over the HEP inverter assignment. The remaining traction inverter will still have the capability to move the train consist.

F. Design Criteria And Components

The F69 will use the F40's specifications in the following areas:

1) Traction effort
2) Braking effort
3) Head end power
4) Suspension and drive
5) Carbody, buff load capacity
6) Fuel capacity

7) Sand capacity
8) Multiple unit compatibility
9) Maximum noise emissions
10) Maximum dimensions
11) Nominal weight
12) Minimal radius of curvature.

Due to the nominal weight requirement, a 12 cylinder 710G3 will be used to compensate for the additional weight of the AC traction and HEP inverter equipment. The 12-710G3 does produce the equivalent horsepower as the 16-645E3B engine that is used on the F40. The maximum speed will be raised to 110 mph and full horsepower minimum speed will be lowered from 30 to 20 mph due to AC traction controls.

The main alternator AR10-D18 will be replaced with a lighter and more compact AR7, which will provide up to 1700 volts to the DC link.

The trucks will be modified F40 style, with low profile elliptic secondary suspension. Traction motors will be a ITB2626 axle hung on tapered roller support bearing with a link motor nose support. The traction motors will be equipped with one pinion, and it will mesh with the bull gear in an oil lubricated gear box. The wheels will be 40 inches in diameter, with GG axle journal bearings. The brake system will utilize a SAB unitized package brake.

G. Conclusion

The F69, from its conception, was not intended to be a high production model locomotive. It was viewed as a stepping stone to what will be a new generation passenger locomotive. Having the versatility to accommodate the needs of Amtrak and other passenger agencies, the design will be well founded and not a conceptual theory.

As this locomotive goes through its growing pains, each system will be enhanced mainly due to the flexibilities of the microcomputer. From this base it is surmised that the next generation will be able to handle both high speed rail operations or normal intercity passenger service, and perform in the environments associated with both.

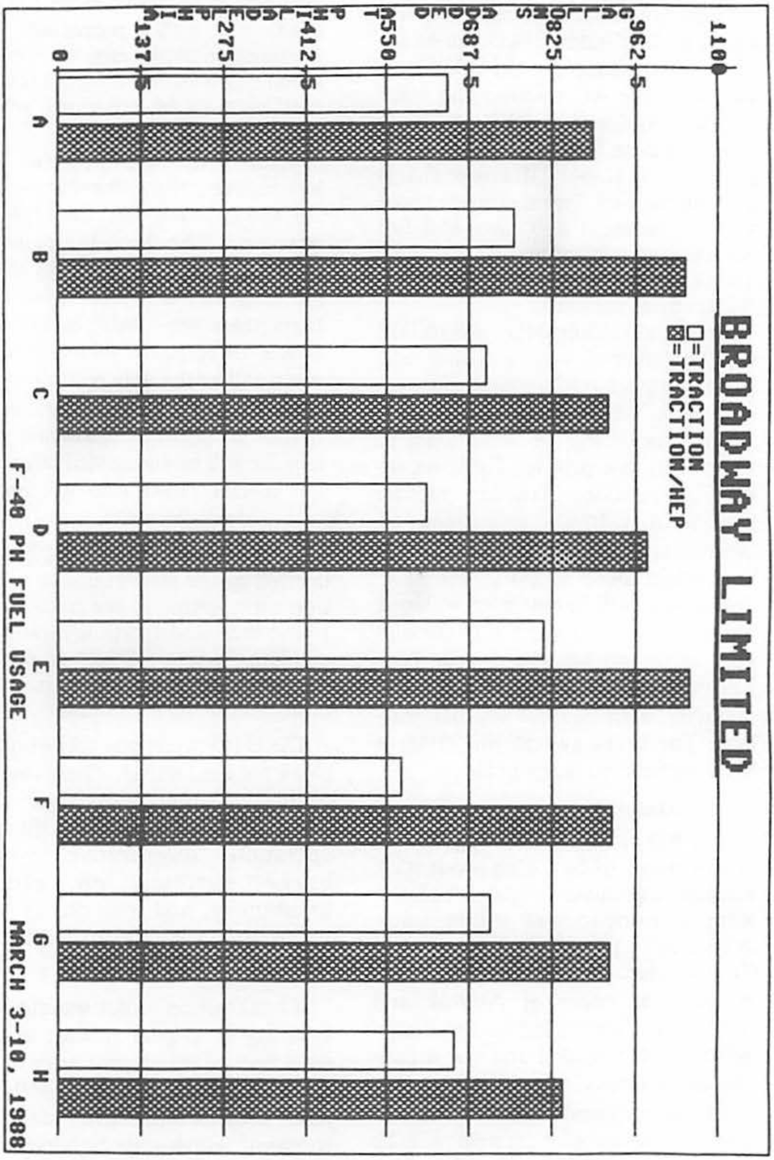
This new generation locomotive will have a lower center of gravity, a reduction or elimination of all accessory power drives from the diesel engine and with a potentially higher horsepower diesel engine, while still remaining within the weight restraints that have to be complied with for passenger service.

With these high-powered diesel locomotives, there should be no need for special train sets for high speed operation. The flexibility of utilizing passenger equipment on any designated train is where economic advantages transpire. With higher horsepower three-phase locomotives, the track will be the only restraint for 125 mph service. The need for specialty shops to perform standard maintenance will be eliminated, along with the special prices that are incurred with a small fleet size.

Some areas that have not been addressed on the F69PH due to production time restraints are truck design, frame mounted traction motors and auxiliary inverters supplying power to commercially available induction motors and battery charging.

The GTO inverter is a key building block for the F69PH. These inverters could be interfaced into other locomotive needs such as third rail operation, regenerative dynamic brake systems on electric locomotives, and multiple unit cars, which would be a significant power saver.

If less traction motor maintenance, lowering of engine speeds, and the reduction of switch gear were the only improvments from the F69PH project, they would still make the endeavor worthwhile because of the improved reliability and financial savings. However, the F69PH addresses many other areas of concern to Amtrak. Much expectation has been generated for the F69PH.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MARCH 3-10, 1988

Figure 11

III
NEW COMPONENTS RETROFITTABLE TO OLDER LOCOMOTIVES

Railroads must improve the availability and economic performance of all parts of their locomotive fleets, including the older locomotives. Benefits can be achieved in this area through modest investments in new components which were developed in conjunction with recent products but which can be retrofitted to older locomotives.

A. Retrofittable G.E. Components

COMPONENT	APPLICABLE TO
1. Lateral shock absorbers	Floating Bolster "B" trucks
2. Air compressor drive	Dash-7 locomotive, (1981+)
3. Welded cylinder head/liner	FDL engine
4. 3-ring piston	FDL engine
5. Overspeed system	FDL engine
6. Grooveless bearings	FDL engine (with new-style rods)
7. Low sac fuel injectors	FDL engine
8. Turbocharger oil seals	FDL engine (except Elliot turbo.)
9. Fuel pump inlet fittings	FDL engine
10. Fuel injection pump	FDL engine

1. Lateral Shock Absorbers For Floating Bolster "B" Trucks

The ride quality of two-axle floating-bolster trucks has been improved since 1985 by the introduction of Koni hydraulic shock absorbers, replacing lateral friction snubbers. These shock absorbers substantially reduce the locomotive's response to lateral track inputs at speeds above 40 miles per hour. This modification is best done at truck overhaul, due to torch cutting and welding required for installation.

2. Air Compressor Drive

Dash-7 locomotives can be equipped with a new air compressor drive featuring a gear-tooth coupling on the engine end and rubber compression inserts at the compressor end. The gear coupling allows for thermal growth of the crankshaft and simplifies axial alignment during installation.

Cavity lubrication and sealing is *improved* through simplified construction and minimization of mechanical joints. Annual lubrication with 4 ounces of a specific oil is required.

This coupling is original equipment on Dash-7 units built after January, 1981. Older Dash-7 units can be retrofitted; a special coupling is available for engines with roller thrust bearings.

The mechanical drive between the air compressor and radiator fan drive can also be upgraded, using a new drive shaft with rubber cushioning.

3. Welded Cylinder Head-And-Liner

Integrity of the cylinder head-to-liner seal has always been a problem in diesel engine design. Engines with firing pressure and cooling water on opposite sides of the fire face always have the potential for water leaks. Other designs minimize the flow of water through this area but at a cost of increased complexity. Installation of head-to-liner seals requires holding close tolerances.

The new welded head-and-liner, applicable to any GE FDL engine, totally eliminates the upper liner seal by joining the head and liner with a full-penetration weld. This results in minimization of liner stresses and bore distortion. Welded head-and-liner assemblies have been in service for several years, with typical liners experiencing less than 0.004" wear, very slight wear steps, and no reported water leaks.

The welded head-and-liner assembly can also be honed at overhaul to remove any wear step; valve seats can also be reground. If desired, the liner can be chrome plated and reground with the integral head in place. If a welded head must be removed for repairs or the liner has condemning wear, the two parts can be cut apart.

4. Three-ring Piston

The FDL engine has had a three-ring piston design since 1983. This piston design features a cut back top land; advantages are reduced oil consumption, longer life and greater reliability.

This piston's key design feature is the smaller diameter of the top land on the crown, allowing high combustion pressure to more-quickly energize the top compression ring. This helps seal the ring to both the liner and the groove for reduced oil loss. With the old four-ring piston design, hard carbon would accummulate in the top ring land, leading to increased oil consumption.

The three-ring piston reduces oil usage by over 40 percent, which means less make-up oil but more frequent oil changes (three to four per year).

5. New Overspeed System

A new engine overspeed system has been available for FDL engines since 1984, providing for quicker starting, improved engine protection and greater reliability.

The new overspeed design makes fuel available to the engine as soon as the governor requires during start-up, as opposed to the 30-second or more delay with the old design. A layshaft lever is also included on both sides of the engine to provide for extra fuel when starting a cold engine.

Engine protection is improved through use of a redesigned overspeed link trip which can cut off fuel delivery at all positions of the layshaft levers. Hence, the layshaft levers cannot override the overspeed protection.

The new overspeed link has no critical machined surfaces or tight tolerances, both of which previously lead to binding and heavy maintenance. The hydraulic actuator is completely sealed.

The new overspeed governor has a service life of three or more years as opposed to the one year life of the old design.

6. Grooveless Bearings

The FDL engine has used grooveless bearings since the early 1980's, resulting in improved bearing life because of increased oil film thickness; this allows for higher bearing loads and lessened sensitivity to dirt in the oil. Connecting rod bearings can now be expected to run at least 500,000 miles even in severe service conditions, typically for the life of the power assemblies.

The grooveless design can be used on both main and connecting rod bearings; newer-style rods must be used, however. Grooveless piston pin bearings are also available for retrofit to engines without cast iron pistons.

7. Low Sac Fuel Injectors

A low sac injector has been available for FDL engines since 1983, resulting in a fuel saving of more than 1½ percent as compared to older injectors.

The low sac injector design reduces the volume of fuel between the injector needle and nozzle holes by 96 percent, and also includes a staggered nozzle hole pattern for improved combustion. Smoke reduction with the new injector can be expected to be as much as 30 percent in notches 3 and 4.

The new injector is a complete replacement for the older design; internal parts are not interchangeable.

8. Turbocharger Oil Seals

The latest oil sealing design for turbochargers on FDL engines has eliminated all external oil piping plus the compressed air supply from the locomotive's air compressor. An internal drilled air passage provides for compressed air to flow from the turbocharger's compressor section to the turbine end seal.

This modification can be retrofitted to all turbochargers for FDL engines except the old Elliot turbochargers.

9. Fuel Pump Inlet Fittings

A new fuel pump inlet fitting can be installed on the FDL engine to reduce failures due to engine vibration and overtorquing during installation. This new "banjo" is machined from steel bar stock and features brazed connections to eliminate leakage.

10. New Fuel Injection Pump

A new 18 millimeter double-helix fuel injection pump is available for FDL engines resulting in improved combustion and fuel efficiency. The new pump features a shortened injection plunger time as compared to the older 17 millimeter injection pump design. Typical fuel savings are 0.5 to 1 percent.

The machining of the second timing helix in the new pump plunger also permits automatic variation of the injection timing in lower throttle notches; injection can be retarded at lower engine speeds, and matching of injection timing with engine speed results in optimum combustion in all notches.

B. Retrofittable E.M.D. Components

COMPONENT	APPLICABLE TO
1. HUB liner	645 engine
2. Tin-plated piston	645 engine
3. Prestressed st. steel rings	645 engine (cast iron liners)
4. Diamond-5 head	567C-thru - 645 engine
5. Head seat ring (Viton seal)	567C-thru - 645 engine
6. Plate crab	645 engine
7. Lower liner insert/seal	567C-thru - 645 engine
8. Improved power assembly	645 engine
9. Turbocharger screen	567 & 645 Turbocharged engine
10. Transposed TM arm. coil	D57-thru-D77 motor
11. DE 7000 TM brush	Any EMD traction motor
12. Pedestal liner	Any EMD truck
13. Pinion seal	D77 & D87 motors
14. Ground pinion gear	15 & 17 tooth pinions (40 & 50 series units)

1. HUB Liner

Over the years, the standard cast iron cylinder liner has performed very satisfactorily. However, as engine output and lubricating oil temperature increased, the liner became more sensitive to scuffing. Using gas laser technology, EMD developed a process to harden the cylinder bore while maintaining the dimensional and joint integrity of the composite design cylinder liner. The hardened upper bore (HUB) liner has further enhanced long term scuff resistance and reduced upper bore wear by 30% over previous design liners.

Laser hardening processes only the base metal. The reduced wear characteristics significantly extend the normal service life of the liner and the hardness depth provides for additional service life after reconditioning. The HUB Liner is compatible with all type piston rings; however, use with longer life chrome faced rings further extends power assembly life.

The HUB liner is standard on the current production 710 engine and is retrofittable to all 645 model engines.

2. Longer Life Piston

The evolutionary development of more fuel efficient, high output diesel engines resulted in higher combustion temperatures and pressures. Piston top ring groove wear is recognized as the primary cause for power assembly removal in high output engines.

To improve the wear characteristics, an EMD patented resistance hardening process was developed that provides a substantial hardness depth in the top ring groove integral to the piston. The resultant long term wear reduction significantly extends piston service life over other surface hardening or plating processes. The hardened surface is compatible with chrome-sided and unplated piston rings. At overhaul, a higher percentage of hardened ring groove (HRG) pistons will be reusable with standard width ring sets.

Higher output engines also exert increased side thrust forces, increasing the potential for liner bore scuffing during engine break-in. To overcome this condition, EMD has incorporated tin-plating on the piston skirt. The lubricating properties of tin perform well under high temperatures and dynamic forces and improve the compatibility of piston and liner materials.

The hardened ring groove and tin-plated "fire inge" piston is standard on the current production 710 engine and is retrofittable to all 645 engines. Older engines using the straight piston pin may reuse pins and carriers or upgrade to the rocking piston pin for greater durability and standardization.

3. Prestressed Stainless Steel Piston Ring

The prestressed stainless steel ring has superior mechanical properties, high heat stability, excellent fatigue strength, and improved corrosion resistance, which improve its performance and durability. Prestressing all but eliminates ring breakage and increase ring life. The stainless steel ring with chrome-plated face and sides can operate with increased side clearance, thus extending the life between overhauls up to 40% when compared to ductile iron rings. The specially designed ring shape and profile reduces ring tip scuffing and port clipping without sacrificing the integrity of the seal.

While use of this ring design is most important for durability in high output engines, it can be used in all 645 engines with cast iron liners for extended life performance.

4. "Diamond 5" Cylinder Head

Since the cylinder head is one of the most thermally-responsive components in the diesel engine, it is critical that its development keep pace with other components aimed at providing higher output and reduced fuel consumption. The features of the current design "Diamond 5" head provide the performance necessary to meet thermal and structural durability requirements.

The thin, controlled thickness fire deck with spined protrusions on the water side provides improved heat transfer characteristics which reduce the potential for thermal cracking. A liberal injector seat radius also aids in reducing fire face thermal gradients.

The Diamond 5 head is retrofittable to all 567C and newer engines. (For lower horsepower applications not requiring the high performance characteristics of the Diamond 5 head, the Diamond 4 cylinder has been re-introduced, for 567C through 645E engines only.)

5. Integral Seal Head Seat Ring

High output engines have exhibited accelerated head seat ring and crankcase head retainer wear. This condition contributes to lube oil carryover, known as "souping".

To overcome the high wear rate, EMD has developed a patented aluminum bronze head seat ring with an integrally bonded Viton seal. Field test results confirm significant wear rate and "souping" reductions, which will extend service life and yield less crankcase rework at overhaul. Where similar improvement is desirable on older units, this patented design is directly interchangeable with the previous design on all 567C and newer engines.

6. Plate Crab Retention System

A very important design feature introduced on the 645F engine is the power assembly retention system, or crab bolt system as it is commonly referred to.

This system utilizes a simple, thin plate crab to replace two individual hold-down crabs, in combination with two necked down heat-treated crab bolts, providing the increased force necessary to retain the power assembly at the elevated firing pressure of high output engines. The greater stretch provided by the necked down crab bolts make the system less sensitive to loss of torque due to wear; as a result, the service requirement of retorquing the crab nuts annually has been extended. Previous engine models had required annual retorquing of crab nuts to maintain system stretch and eliminate potential loosening and fatigue of the bolts.

While this feature is standard on current production engines, the advantage of extended retorquing intervals can be achieved on any 645 turbocharged engine by retrofitting this plate crab system. On older engines straight crab bolts, these bolts must be replaced with the newer necked down bolts.

7. Lower Liner Insert & Power Liner Seal

Another high wear area recognized on high output engines is the lower liner insert, where high temperature has contributed to premature aging of the lower liner seal.

Introduced on the 645F engine, a nickel-plated lower liner insert replaced the previous phosphated insert. Reduced wear was achieved and as a result, a high percentage of inserts need not be replaced at overhaul, reducing crankcase rework. The lower liner seal material was also upgraded to Viton, which is highly resistant to compression set, resulting in extended seal life. Where desirable, these design improvements can also be directly applied to 567C or newer engines without modification.

8. Improved Power Assembly

As noted from the previous comments, significant progress has been achieved in power assembly component design. Not only do these improvements contribute to reliable performance in high output engines, but they can also further enhance extended performance in older units. By combining the achievements of each design improvement into a single power assembly, the synergies of systems design gives you a truly high performance power assembly for EMD engines.

Based on field performance data monitored over the past four to five years, an improved life power assembly will include these components:

- HUB Liner
- Hardened ring grove fire ring piston
- Tin-plated piston skirt
- Prestressed stainless steel top ring
- Diamond 5 cylinder head
- Integral seal head seat ring
- Plate crab retention system
- Nickel plated lower liner insert with Viton seal.

9. Reduced Gradient Turbocharger Screen

Turbocharged EMD engines have historically been equipped with a turbocharger screen, designed to protect the turbine from foreign material damage. Because of the higher exhaust gas temperatures of the 645F engine, thermal fatigue problems were encountered with the traditional grid type screen. Subsequently, a modified contour screen which minimizes the temperature gradients during transient load conditions was developed, providing an annular ring of increased mass, which serves as a heat sink to reduce thermal stress and maintain a more uniform temperature across the screen. A radius at the entrance and exit of each hole further serves to reduce stress concentrations and improve flow characteristics.

This patented design screen is standard on current production engines and can be applied without any modification to any 645 turbocharged engine. It can also be applied to 567 engines, but will require replacing the rear exhaust manifold.

10. Transposed Traction Motor Armature Coil

EMD's current production D87 traction motor provides high performance and improved thermal characteristics. The continuous current rating of the D87 motor has been increased more than 11% and occurs at a lower operating temperature when compared to the previous generation D77 motor.

A key feature of this motor contributing to the performance improvement is the armature, built with transposed conductor coils, which reduce eddy currents, improving efficiency and generating less heat for lower operating temperatures. With a locomotive operating in power, armature temperatures are reduced as much as 27 degrees F. In dynamic brake mode, temperature reductions may be up to 45 degrees F. This allows the motor to transmit more horsepower and significantly increases insulation life.

These same operating advantages can be utilized to enhance the performance of older motors as well. The transposed armature coil is applicable to armatures back to the D57 generation. Both rebuilt armatures and rebuild kits are available.

11. Traction Motor Brushes

The DE7000 brush was introduced in an attempt to meet the need for a brush that lasts for one full year on all locomotives models under all operating conditions. DE7000 was developed by EMD and its supplier; to assure superior performance on EMD equipment, DE7000 has been tested, qualified, and approved on EMD traction motors devoted only to carbon brush testing.

Through brush test results accumulated to date, DE7000 exhibits, on average, a 36% advantage over its predecessor grade DE7. When comparing brushes in terms of miles of brush life per dollar spent, DE7000 provides the best value at almost 36,000 miles per dollar on average.

Brush life of one year is achievable through the use of DE7000 at lower ranges of locomotive mileages. Work continues between EMD and its brush supplier to develop a brush that consistently provides a one-year life in all locomotive applications.

12. Pedestal Liner

Applicable to any EMD truck.

13. Pinion Seal

For EMD D77 and D87 motors.

14. Ground Pinion Gears

In March of this year new 15 and 17 ground tooth traction pinion gears were released and are now available.

The basic pinion design has not changed; this is a processing change rather than a design change. This process change now provides the following improved gear characteristics:

Reduced profile tolerance
Reduced crown tolerance
Reduced tooth taper tolerance
Improved surface finish.

The reduced tolerance characteristics provide more uniform loading and lubrication coverage, which should improve durability and extend useful product life for these pinion gears. Test stand data indicate comparable performance to previous gears.

Maintenance is the same as with existing pinions. These new pinions are completely interchangeable with any of the same tooth size pinions that they would replace. They are identical to existing pinions regarding safety and there is no change in weights.

IV
LOCOMOTIVE APPLICATIONS OF CATERPILLAR ENGINES

In the last four years, growing numbers of North American railroads are considering Caterpillar as a source of engines to repower locomotives. Outside North America, Caterpillar has been a supplier of locomotive engines for many years. Some of the goals of repower are extending locomotive service life while saving fuel, reducing maintenance costs, and others. Caterpillar continues to work with railroads and locomotive rebuilders repowering older four-axle road switcher locomotives downgraded to switching and transfer duties. This application normally requires lower speeds and thus lower engine power. On the other hand, less fuel-efficient, larger, six-axle locomotives placed in storage during the economic downturn are being recalled to service and repowered with more fuel-efficient engines using microprocessor-based controls.

This discussion presents some locomotive engine repowering considerations and railroad reactions to Caterpillar power. We will discuss installations of the most popular engines, the 3500 and 3600 families.

Figure #12 shows the 3500s, rated from 800 to 2075 bhp input for traction, including ratings of 850 and 1200 bhp at 900 rpm. These ratings are used primarily in switcher, transfer, and "peddler freight" operations, although heavy-duty linehaul ratings are available.

The first repowers were the Caterpillar 3512 V12 engines. However, repowers have been completed using the V8 and V16 engines. Most 3500 engines are mounted on a common base with the traction alternator and one or two auxiliary drives. This unitized package allows for rapid removal of the entire engine/generator package at overhaul intervals.

Locomotive frame modifications are held to a minimum to reduce repower costs. No main frame structural changes are made other than repositioning engine mounts. Two inch nominal plate steel engine mounts (one on each side) with support gussets are welded to the frame. One or two one-inch Grade 8 bolts on each side hold the engine in position. The third engine mount is supported by a cross-member welded to the frame under the generator. This three-point mounting system allows the locomotive frame to twist on rough rail without affecting generator to engine alignment. Crash blocks on both ends of the engine generator base are included for safety.

For auxiliary power, an AC synchronous alternator provides power for traction motor blowers, radiator cooling fans, and the air compressor if mechanical drives are not used. The 74-volt DC generator system can be reused and driven by a separate engine auxiliary drive or can be incorporated into the same frame as the AC auxiliary alternator.

To reduce parasitic loads, air compressors can be driven electrically. When air is not needed, the motor and compressor are shut down. The air compressor can be driven directly off the engine crankshaft, through belts for higher speed engines, or direct driven by an induction motor. All these systems are matched to the speed range of the air compressor.

Engine-mounted, paper-type cannister air cleaners drawing combustion air from outside the car body are normally used; however, baggie-type filters are being adapted.

Since 3500 family engines normally reject less heat to the radiators than the engines they replace, some radiator sections and cooling fans can be eliminated.

High idle times are common on switcher/transfer locomotives. Therefore, when not in use, the locomotive can be shut down, saving fuel and extending engine service life. Rain caps are recommended to keep water out of the engine exhaust system.

Ease of engine service is a primary repower consideration. All 3500 engine components can be serviced through the side doors. The compact 3500 packages will allow even the 3516, rated up to 2075 bhp input for traction, to fit easily inside the long hoods even in EMD SW model car bodies.

Caterpillar 3500 engines are in locomotive service including repowers of 70 ton class Baldwins, EMD SW-900, SW-1200, GP-9, GP-20, and GP-35s. In addition to switcher and branchline applications, steel mills hauling hot metal cars and utilities unloading unit coal trains are common 3500 applications.

The first 3500 repowers in North America were 3512 Engines repowering EMD GP-9 locomotives. The first Class I railroad to own these locomotives downgraded them to switcher and transfer duties. The locomotives are frequently used away

from the terminals on branch lines or industrial complexes. The locomotives are antifreeze equipped and shut down year-round when not in service. The results have been improved fuel consumption and improved response because the engine package is matched to the locomotive's duties.

With more than five years' service on the oldest unit, no major engine problems have occurred. However, some water pump seal leaks caused by antifreeze incompatibility have caused Caterpillar to modify the seal and monitor the types of antifreeze used. The electronic governor has been updated due to vibration and software modifications. However, governor update continues related primarily to locomotive monitor functions and wheel slip protection.

Figure #13 shown the ratings of the larger, newer 3600 engine family, designed for linehaul locomotive service. These 900 to 1000 rpm engines are rated from 2100 to 6000 hp. The most popular engines are the 3000 hp (in-line 8) 3608 and the 4500 hp (V12) 3612. Radiators, air compressor, main traction alternator, and auxiliary equipment are reused. The 3600 physical size allows it to generally fit within the envelop of the engine being replaced.

In order to reduce repower costs and maintain the locomotive's strength, no major modifications are made to the locomotive's frame. Old engine mounts are removed and replaced. A steel plate and gusseting is welded to the frame as needed. The mounting location of the main traction alternator in EMD locomotives can be maintained in its original position, eliminating sheet metal and generator lead rework.

After the engine is installed, it is aligned to the traction alternator and auxiliary drives. Couplings to mount the alternator and air compressor drive shaft are provided with the engine package. The auxiliary drive is located above and centered over the traction alternator on both the in-line and vee engines. The auxiliary generator and blower fan assembly are reused; however, in some installations, this equipment may have to be relocated directly above the traction alternator which requires some duct work.

On MLW and General Electric installations, the generator is cantilevered and supported by the 3600 Engine. This is done to reuse the successful GE design avoiding generator mounting rework and allowing the use of major components without modification. By eliminating main traction alternator or generator modifications to fit the engine, these components can be exchanged without rework.

Both paper and baggie-types air filters have been used; however, most of the repowers to date have been paper type. The 3600 vee engines use two air cleaners (one on each side); the in-lines normally use one.

The 3600 engines are generally shorter than the original engine being replaced. Air compressors can be moved closer to the engine to reduce drive shaft length. This allows for some component position changes which contribute to locomotive weight distribution.

Radiators are reused or upgraded at time of repower. Several water expansion tank systems are used. Caterpillar has supplied water tanks mounted on Caterpillar equipment racks replacing the original rack. On other installations, the original equipment rack and water tank are reused; however, other components, although still installed, are not needed.

The 3600s have natural sound attenuation provided by the exhaust

gas-driven turbochargers. Small 30" by 15" mufflers have been installed on most vee engine configurations. They do offer some additional sound attenuation but are used primarily as water traps when the locomotive is shut down. Both oblong and rectangular designs have been sued.

In order to reduce cold start wear due to lack of lubricant to bearings, a 74-volt DC prelube pump circulates oil and pressurizes the main bearings, rod bearings, and turbochargers before starting. The system locks out engine start until minimum safe oil pressure is assured. This eliminates dry bearing engine starts which can greatly reduce engine and bearing life.

Engine control panels are mounted on the engine equipment racks. Panels match the options specified by the user. Complete panels include engine tachometer, coolant temperature, oil pressure, hour meter, and air start manifold pressure if air starting is used. Controls include emergency stop, engine prelube/fuel prime, engine start/stop, glow plugs (if required), and engine prelube pressure light.

Microprocessor engine controls (reviewed by the New Developments committee in 1987) are also being installed during repowers and rebuilds to improve both engine and locomotive performance. The Caterpillar PEEC system (Programmable Electronic Engine Control) used on both 3500 and 3600 engines can be mounted anywhere on the locomotive. Locations include engine/generator mounting, radiator fan control panel, and main electrical cabinet.

Like the older 3500s, the 3600s are also being accepted by railroads. The first 3612 repowers were SD 45, SD 40-2, and SD 45-2 locomotives. The oldest repower (an SD-45) has been in service since early 1986. The newest, an MLW 636, was placed in service early summer this year.

Caterpillar has modified engines and installations as its experience level with 3600s has increased. Improvements have been made in engine mounting including the addition of vibration isolation pads to reduce noise and vibration transmitted from the engine to the locomotive frame.

Cylinder liner cooling improvements greatly improved the 3600's lubricating oil sensitivity, so many railroad grade oils can now be used. In many cases, the railroad's fleet oils are acceptable.

Other improvements have been made to auxiliary drives used primarily on EMD locomotives to accept auxiliary generator and blower fan loads. Bellows-type exhaust manifolds have been installed, reducing exhaust leaks inside the long hood.

These improvements, along with others, have been made to all 3600 locomotive engines in service and are now included in new engine production.

The goal of sizing locomotive engines is to match the application (either upgraded or downgraded). It allows older, less-efficient locomotives to be updated to remain useful and improve their value in the fleet.

3500 LOCOMOTIVE RATINGS
(HP @ RPM)

MODEL	CONFIGURATION	HEAVY-DUTY LINE-HAUL	LIGHT-DUTY SWITCHING
			2075 @ 1800
3516	V-16	1600 @ 1800	1975 @ 1800
		1450 @ 1500	1775 @ 1500
		1350 @ 1300	1605 @ 1300
		--	1200 @ 900
3512	V-12	1200 @ 1800	1480 @ 1800
		1090 @ 1500	1300 @ 1300
		1000 @ 1300	1050 @ 1300
		--	850 @ 900
3508	V-8	800 @ 1800	975 @ 1800
		725 @ 1500	875 @ 1500
		675 @ 1300	800 @ 1300

JMH-1

Figure 12

3600 LOCOMOTIVE RATINGS
(HP @ RPM)

MODEL	CONFIGURATION	HEAVY-DUTY LINE-HAUL
3606	I-6	2100 @ 900
		2250 @ 1000
3608	I-8	2800 @ 900
		3000 @ 1000
3612	V-12	4200 @ 900
		4500 @ 1000
3616	V-16	5600 @ 900
		6000 @ 1000

JMH2

Figure 13

Wednesday, September 21, 1988

9:00 A.M.

REPORT OF THE COMMITTEE ON FUEL AND LUBRICANTS

Pre-Convention Presentation:
Southern and Southwestern Railway Association

May 21, 1988
Holiday Inn (Gateway)
Huntington, WV

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Manager-Environmental Opns.
CSX Transportation
Huntington, WV

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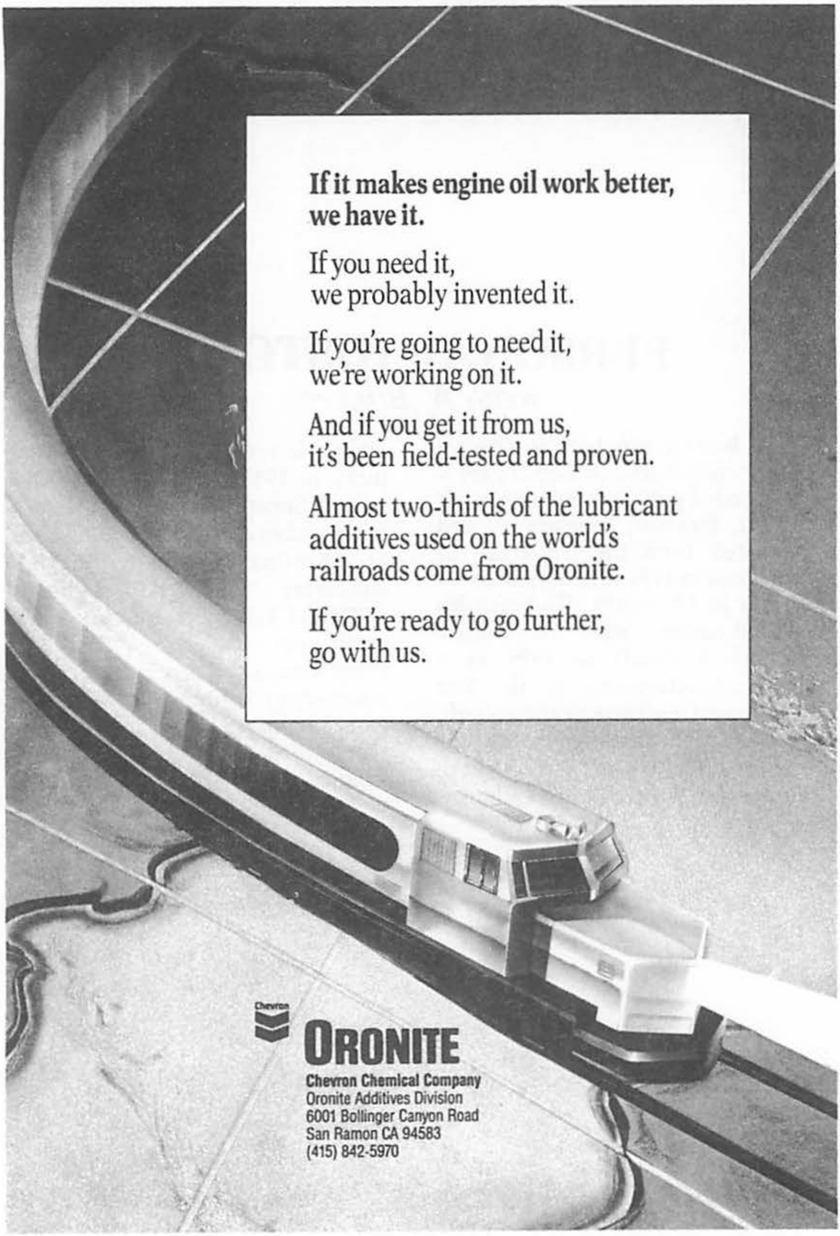
1988 TOPIC:

LUBRICATION '88 — THE VITAL LINK TO SUCCESSFUL RAILROADING

PERSONAL HISTORY

Keith A. Brinker

Mr. Brinker was born in Greensburg, Pennsylvania on July 20, 1957. He attended public schools in Norvelt and Mt. Pleasant, Pennsylvania and graduated from the University of Pittsburgh in 1979 with a Bachelor of Science in Chemistry. He began his railroad career with the Chessie Systems Railroads in 1979 as a Chemist-Spectrograher in the Test Department assigned to the Russell, Kentucky laborabory. In 1981, he was promoted to Test and Environvironmental Specialist in Cincinnati, Ohio. He returned to Russell, Kentucky in 1983 as Test and Environmental Supervisor. In 1985, he was promoted to Assistant Chief Chemist at Huntington, West Virginia laboratory. With the formation of CSX Rail Transport in 1986, he was transferred to Waycross, Georgia as Chief Chemist. Then in 1987, Keith returned to Huntington, West Virginia as Manager, Environmental Operations. He and his wife, Charlene, enjoy professional sports, dancing, plays and travel.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If you're going to need it, we're working on it.
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I.
USED OIL ANALYSIS AND CONDEMNING LIMITS

This section of our report will describe the benefits of lubricating oil analysis to govern diesel engine maintenance and to reduce locomotive engine downtime.

A. Why Test Engine Oil?

Railroads are subjecting locomotive engine lubricating oils to greater stress through longer, heavier trains and increased maintenance intervals. In addition, locomotive engine conditions become more severe as locomotives become more fuel efficient. These changes in the railroad industry are causing greater stress to the lubricating oil. As the severity of locomotive service increases, analysis of the lubricating oil becomes more important. To efficiently lubricate the locomotive engine, it is necessary to have the oil in satisfactory condition.

In addition to reflecting the condition of the lubricating oil, oil testing provides useful information on the mechanical condition of the locomotive engine. By learning how to interpret the analytical data, maintenance shops can repair mechanical problems before they escalate and cause serious damage.

Another reason to analyze the engine oil is to insure that the correct oil was used in the locomotive. For example, analysis of the engine oil can determine if a highway diesel engine oil containing zinc has been added to the locomotive.

B. What Reduces Engine Oil Life?

Degradation

Oxidation increases the viscosity of the oil. Increased oil viscosity results in "viscous drag" in the engine, which reduces power, increases operating temperature, and consumes more fuel. If the oil becomes so thick that it will not flow to the moving parts, they become starved for oil and catastrophic engine failure can occur.

In addition, oxidation can cause oil to form insoluble material which can deposit in the engine. Oxidation of the lubricant also creates acids which corrode metals and cause wear. These acids can also be the starting material for deposits.

Nitration or nitro-oxidation is the result of oxygen and nitrogen reacting in the combustion chamber to form nitrogen oxides (NOx). These gases react with unburned fuel oil and the lubricant base oil to form acids and insoluble products.

There are limitations to the work additives can do. Dispersants function by suspending deposit-forming compounds until they can be removed from the engine when the oil is drained and the filters changed. Once the dispersant has reached its load carrying capacity, any additional sludge, soot or resin can cause the dispersant to be pulled out of solution, dumping the previously suspended load and causing a rapid build up of deposits in the engine.

As the lube oil ages in the locomotive, alkaline overbased additives are depleted. Alkaline additives are used up as they neutralize acids and nitro-acids formed during the combustion of fuel and the oxidation of the lube oil. When the alkaline reserve falls below the minimum safe level, ring and cylinder wear can occur. Therefore, pH and/or total base number (TBN) condemning limits are set at a level where corrosive wear is minimized.

Contaminants

Many fuel by-products are formed in the combustion chamber of the engine. Some of these combustion

by-products escape past the rings by way of blowby into the crankcase oil. The most frequent fuel combustion by-products are:

- Water
- Sulfur compounds
- Soot
- Partially oxidized fuel.

Fuel combustion by-products can increase oil viscosity, form deposits, and corrode engine parts.

Water can get into the lube oil through a variety of mechanical problems, such as leaking head gaskets, cracked heads or liners, etc.

Excessive water in a lubricating oil can cause several problems:

- It causes rust and corrosion, which may produce high wear and bearing failures.
- It can disrupt the oil film on heavily loaded bearings and cylinder liners.
- It can form sludge by combining with contaminates; sludge can plug oil lines and filters.
- It can combine with blowby to form corrosive acids.

To cite an example, one railroad had 22 locomotives develop sludge deposits in the top deck area, cylinder air intake ports and filters. Inspection of these locomotives showed water leaks to be the only common problem. Elimination of the water leaks corrected the problem.

Another oil contamination problem is fuel dilution. Fuel can get into the oil in a variety of ways depending upon the operating condition of the engine. Common causes are dribbling injectors, leaks in the fuel fittings and seals, etc. Fuel dilution is a problem because it reduces the lube oil viscosity resulting in reduced oil film thickness. Reduced oil film thickness can cause increased wear rates. In extreme cases, inadequate lubrication can result in scuffing of engine parts or even bearing failures.

Sulfur oxides are formed when fuel sulfur is burned in the combustion chamber. Sulfur oxides in the blowby gases can form acids which react with overbased additives in the engine oil. As the alkalinity of the oil is depleted, corrosive wear is accelerated in the locomotive engine.

$$S + O_2 \longrightarrow SO_X$$

(Sulfur oxides)

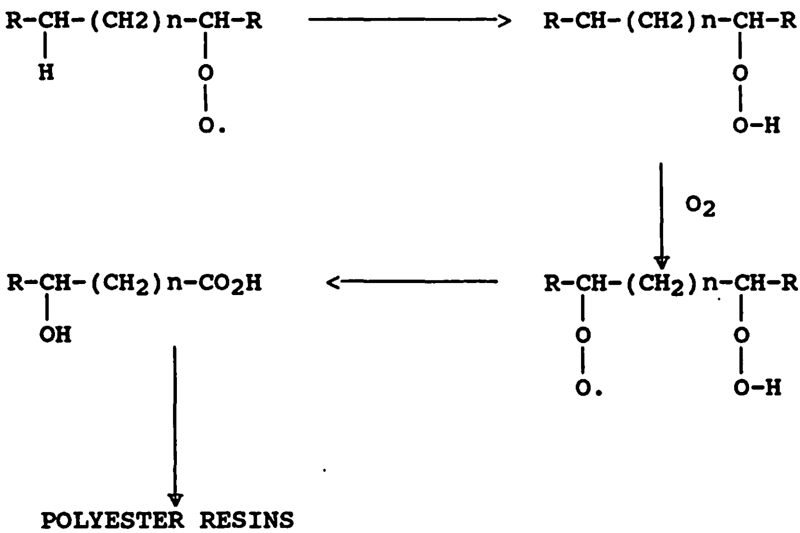
$$SO_X + H_2O \longrightarrow H_2SO_4$$

(Sulfuric acid)

Soot is formed during the combustion of fuel. When soot finds its way into the lubricating oil via blowby gases, it causes the oil viscosity to increase. If soot loading is allowed to increase to where the dispersant system is unable to handle the amount of soot in the oil, the oil "dumps" and deposits form in the engine. This problem can be minimized by not allowing the pentane insolubles to go past the condemning limits.

Partial oxidation of fuel results in the formation of hydroxy-acids. Hydroxy-acids react to form polyester resins, which act as binders for soot in the formation of deposits in the piston ring belt area. In addition this resinous material can form deposits on the hot surfaces of the engine, such as the top deck or the cylinder covers.

HYDROXY - ACID FORMATION



Solid contaminates found in the lube oil that can cause engine wear include:

- Dirt and airborne dust particulates
- Engine wear metals
- Rust
- Carbonaceous materials.

The hardest particles, such as dirt, rust, and carbonaceous materials, can cause abrasive wear to critical engine components if they are not removed from the lubricating oil. They can continue to cause wear if they are too small to be removed by the oil filter. Therefore, airborne contaminants can be a problem if air filter maintenance is inadequate.

C. Engine Builder Condemning Limits

The locomotive builders have established recommended condemning limits for viscosity, pentane insolubles, total base number (TBN) and pH. When condemning limits are exceeded, changing the lube oil is recommended. If mechanical problems such as fuel leaks are indicated, check the engine to locate and correct the problem. The published condemning limits from the Electro Motive Division of General Motors (EMD) are listed in Table 1, and the published limits from General Electric are listed in Table 2.

Metal analysis is used to monitor engine component wear and outside contamination, such as dirt and dust, for preventive maintenance. Mechanical problems can be stopped before they occur or escalate to cause serious damage to the locomotive engine. High limits have been established above which the locomotive should be shut down, the lube oil be drained, and the mechanical problem located and repaired. Intermediate limits have been developed by EMD, where the progress of the wear metals in the lubricating oil should be monitored. EMD recommended warning limits for the interpretation of lube oil analysis are listed in Table 1. GE has not issued recommended warning limits for metal analysis in its locomotive engines. It recommends the railroad follow the trend of the metal analysis and upon any sudden increase in wear metal levels, the

locomotive engine should be inspected to locate and repair the indicated mechanical problem.

D. Railroad Lubricating Oil Condemning Limits

Railroads have established analytical condemning limits for their used lube oil based on a combination of the OEM (original equipment manufacturer) recommended warning limits and limits derived from their own operating experience. The limits listed in Table 3 for viscosity, pentane insolubles, TBN, and pH are the values at which corrective action must be taken, which includes shutting down the locomotive and draining the oil. If a mechanical problem such as a fuel leak is indicated, the appropriate repairs are made.

Wear metal analysis is used to monitor engine component wear, as well as contamination from outside sources such as dirt and dust. Many railroads use General Electric's recommended procedure for the interpretation of oil analysis by using a sudden rise the wear metal values as a warning to inspect the engine components rather than a single value as a condemning limit. In addition, many railroads have used EMD's condemning limits and intermediate warning limits as an indication for fuel leaks, water leaks, and mechanical problems to be checked and corrected before they can escalate. These warning limits are usually determined from operating experience by using a value at which the problem, such as a water leak, can be located by maintenance personnel.

The critical part of a lubricating oil analysis probram is taking oil samples. Oil samples should be taken from the locomotive engine at least once a month. Some railroads take oil samples whenever the locomotive goes to the fuel pad.

Proper Sampling Procedures

To get a useful lube oil analysis, a representative sample must be taken from the locomitive engine. The following guidlnes for taking lube oil samples are recommended:

- — Take sample prior to adding make-up oil.
- — If possible, take sample while engine is running.
- — Use a new container (clean and dry) for the sample to prevent contamination of the oil.
- — Purge the sample system before a new sample is taken.
- — Fill the sample bottle completely.
- — Label the sample container.
- — Immediately send to the labortory for analysis.

Another important step in a lubricating oil analysis program is to analyze the new lube oil delivered to the railroad. This will insure that the correct oil has been delivered, that the oil meets the railroad's product specifications, and that the new lube oil is not contaminated.

E. Summary

Railroads are actively cutting costs to make their operations more competitive. Increased pressure is being put on mechanical departments to keep locomotives in service. Used oil analysis can help keep locomotives in service by uncovering problems before they cause serious damage to the engine that require major shop time.

The condemning limits listed here can serve only as guidelines. Locomotives operating in a specific environment may require higher or lower condemning limits.

Even though appropriate condemning limits have been established, factors that affect the condition of the lubricating oil interact, making intrepretation of the analytical results a matter of judgment. The more that is known about the service history of the locomotive, the better the decision that can be made about the engine's condition.

Although there are problems with obtaining timely, accurate lube oil samples, lube oil analysis can save the railroad money through less locomotive downtime, lower repair costs and longer engine life.

Used oil analysis is vital to an effective railroad preventive maintenance program. The Fuel and Lubricants Committee recommends that the railroads maintain an active lube oil analysis program for the protection of their equipment.

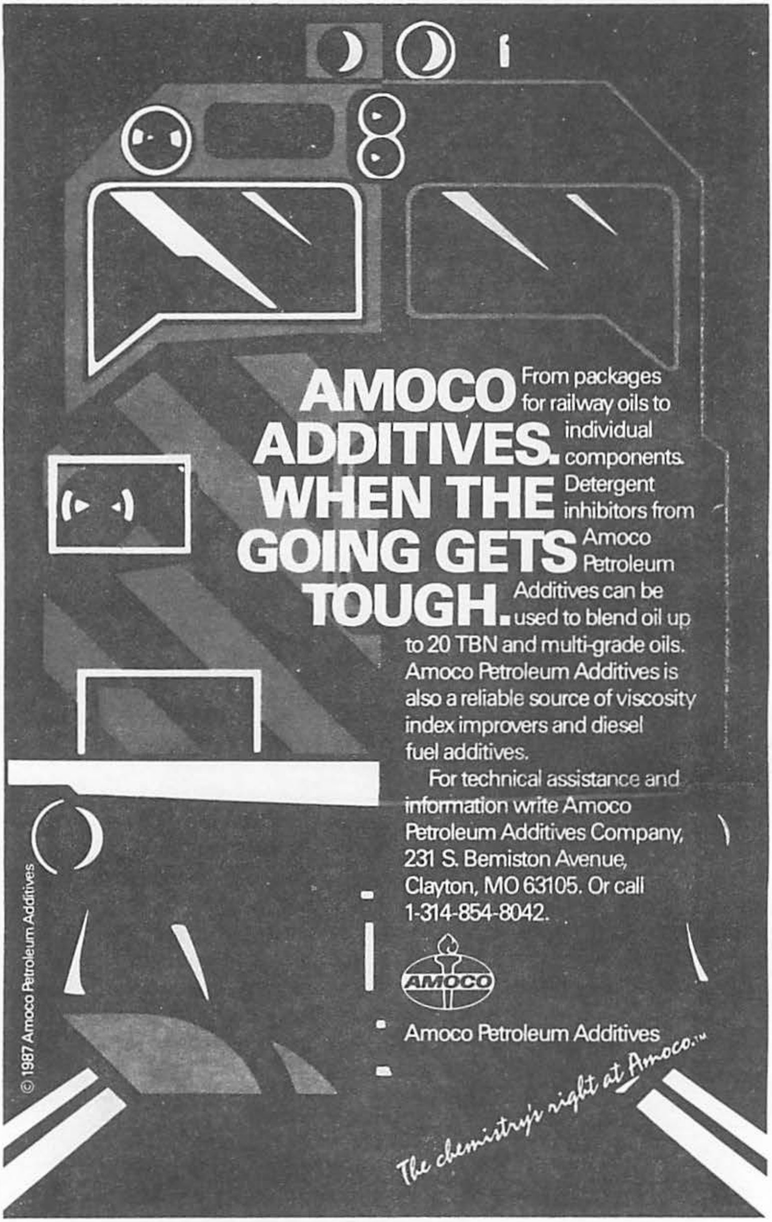

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TABLE 1
INTERPRETATION OF LUBE OIL SAMPLES ANALYSIS

LUBE OIL ANALYSIS	BASIS FOR ANALYSIS	NORMAL No Action Required	BORDERLINE Take Extra Oil Samples	HIGH Correct Condition	RECOMMENDED ACTION ☐ Shut Down Engine, Drain Lube Oil Change Filters ☐ Change Filters Only.
Fuel Leak	Viscosity & Flash Point Check for dilution if flash point less than 400° F or oil viscosity drops 15% or more at 100°F.	0 to 2%	2 to 5%	Above 5%	Borderline — Find a fix fuel leak. High — check main bearings per maintenance manual.
Water Leak	Free Water	None		Any	Resample with dry container. Find and fix leak. Check main bearings per maintenance manual.
	Chromate Inhibitor	0 to 20 ppm	20 to 40 ppm	Above 40 ppm	Find and fix water leak. Check lube oil filter tank pressure.
	Boron Inhibitor	0 to 5 ppm	5 to 10 ppm	Above 10 ppm	
Air Filtration	Silicon	0 to 5 ppm	5 to 10 ppm	Above 10 ppm	Improved air filter maintenance required. Anti-foam agent present in new oil.
Excessive Oxidation	TBN (D-664) TBN (D-2896) Viscosity Rose pH Pentane Insolubles			Min TBN (D-664) 0.5 Max. Vis. Rise In SUS @ 100°F. 30% Min. pH 5.0 Max. Pent. Insol. 2%	Change Oil. If short oil life persists, check lube oil quality, fuel sulfur content, oil cooler efficiency, engine temperature controls, power output (governor and rack settings), engine condition (worn rings, cracked pistons, poor combustion), oil filtration, or oil pump suction leak.

TABLE 1 *(Cont'd.)*

Contaminated fuel (cracking catalyst)	Aluminum, Silicone and/or Magnesium		Above 5 ppm		Check fuel cleanliness. Notify fuel supplier. If engine smokes, check injector calibration and tip erosion. Check of piston rings are excessively worn.
Oil Contamination	Zinc	0 to 10 ppm	Above 10 ppm becomes more dangerous with increasing values.		Check if oil is contacting galvanized or zinc painted surfaces. Check if make up oil in stock is within specifications. Notify lube oil supplier. Check for silver bearing failures.
	Silver	0 to 1 ppm	1 to 2 ppm	Above 2 ppm	Check if oil contains zinc or is corrosive to silver. Check for broken piston cooling tubes, inefficient oil cooler, or improper temperature control. Feel loaded areas of piston pins for signs of distress. Measure piston to head clearance with lead readings. Oil draining is not mandatory. Check strainers and bottom of oil pan for debris. Consider turbo bearing condition.
Abnormal Wear Or Corrosion (Rapid increases within normal range should be considered borderline condition).	Chromium (Not applicable if chromate coolant inhibitor is used)	0 to 10 ppm	10 to 20 ppm		Check for rapid wear of rings & liners
	Copper	0 to 75 ppm	75 to 150 ppm	Above 150 ppm	Measure piston to head clearance with lead readings to locate owrn piston thrust washers. Check connecting rod bearing blade thrust faces for distress.
			High iron and copper increase oxidation rates.		

TABLE 1 *(Cont'd.)*

Abnormal Wear Or Corrosion (Rapid increases within normal range should be considered borderline condition). *(Cont'd.)*	Iron	0 to 75 ppm	75 to 125 ppm	Above 125 ppm	Check for rapid wear of rings & liners.
	Lead	0 to 50 ppm	50 to 75 ppm	Above 75 ppm	Most likely lead flash is disolving off bearings. Premature lead removal, before bearings are broken in, can lead to bearing distress. Inspect and replace upper con rod bearings in service less than 6 months if lead flash has been removed from the unloaded area of the fishback bearing surface on turbocharghed engines. If con rod bearings require replacement, wrist pin bearings should also be checked and replaced if lead flash has been removed.
In Combination	Copper Iron Lead		Two out of three elements in borderline or high range.		Check for debris under crankshaft gear indicative of gear train bushing distress. Check idler gear bearing clearances. Check main and con rod bearings per maintenance manual. Oil draining is not mandatory.
In Combination	Tin	0 to 20 ppm	20 to 40 ppm	Above 40 ppm	1. When in combination with iron or chrome rise, check for piston distress. 2. When in combination with lead or copper rise, check for bearing distress.

‡ Due to carbon buildup on both the fire face of the cylinder head and the crown of the piston during service life, lead wire readings should not be used as a basis for power assembly changeout. Lead wire readings may continue to be used to indicate wear trends. Significant clearance increases should be investigated as possible component failures.

TABLE 2

CONDEMNING LIMITS OF ENGINE LUBRICATING OIL

Property	Recommended Method	Limit For Generation 3 Use With Class A Fuel Only	Limit For Generation 4
Viscosity Max. at 100 C at 210 F Min. at 100 C at 210 F	ASTM D445	 19.7 cSt 100 SSU 12.5 cSt 70 SSU	 19.5 cSt 100 SSU 12.5 cSt 70 SSU
Total Base Number (min.) (Units are mg KOH per gr.)	ASTM D664	0.5	0.5 2.0 For Class C Fuel
Water Contamination (max.)	ASTM D95	0.2%	0.2%
Pentane Insolubles (max.)	ASTM D893	3.0%	5.0%

TABLE 3

RAILROAD USED OIL CONDEMNING LIMITS
GENERATION IV LUBRICATION OILS

	A		B		C		D		E		F		G	
Test	EMD	GE	EMD	GE	EMD	GE	EMD	GE	EMD	GE	EMD	GE	EMD	GE
FUEL LEAK														
Fuel Oil % Max	5	5	5	5	-	-	5	5	5	5	-	-	-	-
Vis. Dec. 100°F SUS min.	700	700	-	-	750	750	650	650	-	-	615	615	-	-
Vis. Dec. 210°F SUS min.	-	-	-	-	71	71	-	-	67.5	67.5	-	-	67.9	67.9
WATER LEAK														
Free Water %	Any	Any	Any	Any	Any	Any	0.2	0.2	Any	Any	Any	Any	0.2	0.2
Boron Inhib. ppm	200	200	250	250	24*	24*	-	-	100	100	50-65	50	20	10
AIR FILTERS														
Silicon ppm (max.)	25	25	10	10	10	10	10	15	13	13	15-20	15	20	20
EXCESSIVE OIL OXIDATION														
pH (min.)	4	4	4.99	4.99	5	5	5	5	4	4	5	5	4.5	4.5
TBN (D664)	-	-	-	-	0.5	0.5	-	-	-	0.5	-	-	-	-
Viscosity														
SUS 100°F Max.	1300	1300	1300	1300	1330	1330	1250	1250	-	-	1350	1350	-	-
SUS 210°F Max.	-	-	-	-	95	95	-	-	*96.3	96.3	-	-	95	95
Pentane Insol. % (max.)	3	5	5	5	4	4	3	4	3	5	-	5	3	5
WEAR METALS ppm (max.)														
Lead	150	35	High[1]	High	100*	30*	150	20	High	High	80-110	80	75	40
Copper	150	35	High	High	100*	100*	120	40	50	50	60-80	60	80	40
Iron	120	50	High	High	50*	50*	120	75	High	High	80-110	80	100	100
Aluminum	20	10	4	4	10	10	25	25	-	-	20-25	20	20	20
Silver	6	-	1	-	2	-	2	-	13	-	4-6	-	12	-
Chromium	80	80	High	High	-	-	-	-	-	-	-	-	-	-
CONTAMINATION														
Zinc	25	-	10	-	25	-	20	50	10	-	15	15	40	-

*Plus 15% greater than average of last four analysis

[1]High = Above normal range (a sudden jump)

II. REVIEW OF AAR PROCEDURE RP-503 "LOCOMOTIVE DIESEL FUEL ADDITIVE EVALUATION PROCEDURE"

A. Introduction

In the late 1970's the Association of American Railroads (AAR) was requested by member roads to develop a fuel additive test procedure in which the results would provide the information necessary to determine if the product's use would:

1. Damage the diesel engine;
2. Improve engine performance;
3. Increase fuel efficiency.

The resulting AAR Recommended Practice (RP-503) was introduced to the industry in 1981. In view of the recent emergence of new short line railroads and the reorganization and down-sizing of many major railroads, the LMOA Fuel and Lubricants committee feels it would be beneficial to re-introduce this evaluation procedure to the industry. This should be helpful to staff personnel who have been given the responsibility of selecting petroleum products without the benefit of previous experience in this area.

Estimated cost of the complete basic test is approximately $110,000. If the test engine must be operated for an extended period of time to observe the benefits of the treated fuel, the total cost will increase in proportion to the additional fuel and labor costs.

B. Procedure Scope

This procedure is intended to:

* evaluate the effectiveness of diesel fuel additives in medium speed diesel engines;
* provide a common set of testing methods and evaluation techniques;
* serve as one indicator. Subsequent actual operating condition testing is recommended.

C. Evaluation Procedure

The evaluation procedure consists of four phases (Figure 1). The tests are organized to first determine that the additive will cause no harmful effects, and second to verify the claimed beneficial effects.

Phase I — Fuel properties. American National Standard Institute/American Society For Testing and Materials (ANSI/ASTM) D 975 tests for base fuel and treated fuel samples. These tests are mandatory.

Phase II — Caterpillar 1-G2. ASTM standard test procedure 509A except that the additive-treated fuel is the test object, not the engine lubricant. This test is mandatory.

Phase III — EMD 2-567C engine. Preliminary full-size laboratory engine test with baseline and additive-treated fuels.

Phase IV — EMD 645 E3 and/or G.E. 7 FDL engines. Final full-size laboratory engine test with baseline and additive-treated fuels. This test may be done in addition to, or in lieu of, the Phase III test.

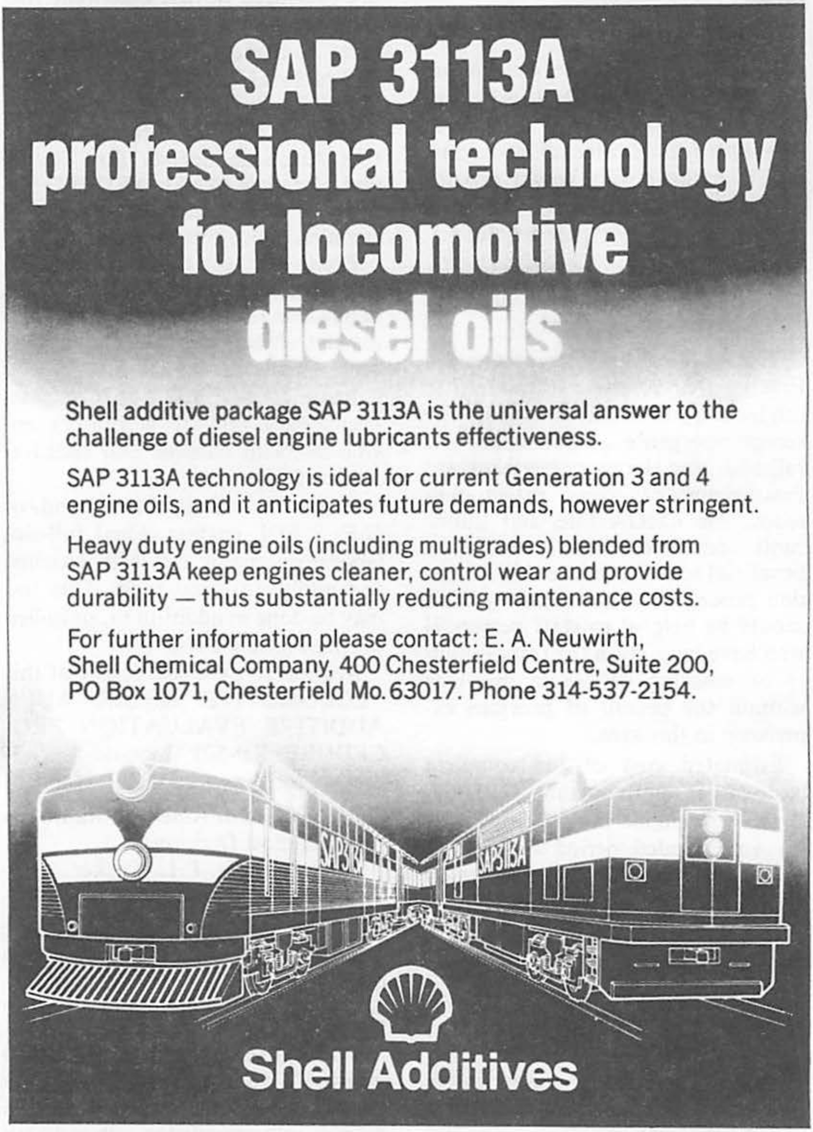
Request to purchase copies of this "LOCOMOTIVE DIESEL FUEL ADDITIVE EVALUATION PROCEDURE RP-503" should be addressed to:

Association of American Railroads
Mechanical Division
Attention: Ms. P.L. Tucker
50 F Street, N.W.
Washington, D. C. 20001

Prices are available from this address.

D. Summary

The potential fuel additive vendor's presentation of his product's test data, reported in this format, will provide the railroad with a comprehensive report which can be interpreted in a straight-forward manner, and will allow a cost effective decision to be made with confidence.


SAP 3113A
professional technology
for locomotive
diesel oils
Shell additive package SAP 3113A is the universal answer to the challenge of diesel engine lubricants effectiveness.
SAP 3113A technology is ideal for current Generation 3 and 4 engine oils, and it anticipates future demands, however stringent.
Heavy duty engine oils (including multigrades) blended from SAP 3113A keep engines cleaner, control wear and provide durability — thus substantially reducing maintenance costs.
For further information please contact: E. A. Neuwirth, Shell Chemical Company, 400 Chesterfield Centre, Suite 200, PO Box 1071, Chesterfield Mo. 63017. Phone 314-537-2154.
SAP3113A
SAP3113A
Shell Additives

III.
UPDATE ON IMPROVED OILS MULTIGRADE OILS

A. Introduction

Multigrade engine oils for use in passenger cars were introduced into the marketplace in the mid-1950's. Multigrade high speed diesel engine oils were introduced in the early 1970's. Over the years multigrade oils have been very successful in both these markets, currently accounting for approximately 60% of the oil volume in these combined markets. Some of the benefits of multigrade oils have been improved fuel economy, control of oil viscosity increase, reduced oil consumption, longer engine life and improved cold starting and lubrication during warm-up.

Recognizing the potential benefits of multigrade oils, it is appropriate that this technology be considered for application to railroad engine oils. In Canada, multigrade locomotive engine oils have undergone years of successful field evaluation, beginning in 1981, and have been marketed commercially. (1) (2)* Nonetheless, since the experience with multigrade locomotive engine oils is limited, there are concerns which also must be addressed; most significant among these are engine wear, oil viscosity loss, and engine cleanliness.

The 1987 Fuel and Lubricants Committee reported included discussion of the requirements and performance of a new generation oil. (3) Some of these performance requirements may be met through the use of multigrade oils; other requirements may be met through the use of newly developed and yet to be developed additive systems. Future experience may demonstrate that the best next generation oil is the combination of a multigrade oil with a premium performance additive system.

B. Properties and Performance of Multigrade Oils and Newly Developed Oils

A single grade SAE 40 locomotive engine oil is composed of the base oil and the additive system. A multigrade oil, such as SAE 20W-40, is composed of the base oil, the additive system, and a viscosity index improver. Viscosity index (VI) is a numerical expression of how the viscosity of the oil changes with temperature. A locomotive engine oil containing medium VI (MVI) base oils may have a VI of about 75, an oil containing high VI (HVI) base oils may have a VI of about 100. Figure 2 illustrates the change in viscosity with temperature for SAE 40, SAE 20W and SAE 20W-40 oils. Base oils manufactured by conventional processes do not have a VI of much over 100. An SAE 20W-40 multigrade oil would have a VI of approximately 125. This VI required to obtain the SAE 20W-40 viscosity characteristics would typically be obtained through the use of a VI improver. VI improvers are oil additives that reduce the amount of change of viscosity of the oil with temperature. There are usually high molecular weight polymers that effect the VI by contributing more to the viscosity of the oil at high temperature than they do at low temperature. The overall performance of a single grade oil is dependent on the combined performance of the additive system and the base oil; a multigrade oil is dependent on the performance of the additive system, the base oil and the VI improver.

** Numbers in parenthesis designate reference at the end of section.*

The viscosity of a single grade oil is primarily determined by the viscosity of the base oil. (The additive system does have a minor influence on viscosity.) The viscosity of a multigrade oil is determined by the base oil and the contribution to viscosity of the VI improver. The magnitude of the contribution of the VI improver to viscosity can be affected by the environment in the engine. In the engine, this contribution to oil viscosity may be reduced by permanent viscosity loss or by temporary viscosity loss.

Since the VI improver is a large, high molecular weight polymer, it can be subject to mechanical or oxidative shearing which results in the reduction of the size of the polymer and therefore reduces its contribution to viscosity. The result of this phenomenon is a permanent viscosity loss of the oil.

The viscosity of single grade oils, oils not containing a VI improver, is affected by the oil's temperature. The viscosity of a multigrade oil containing a VI improver is affected by the oil's temperature and by the shear rate to which the oil is subjected. Shear rate is a function of clearance and relative velocity between moving surfaces. Engine piston rings and bearings are examples of areas where oil is subjected to high shear rate. In areas of high shear rate, the VI improver polymers are temporarily distorted and aligned with the direction of shear. This reduces their effective size and reduces their contribution to oil viscosity. The oil, when no longer subjected to the high shear rate, returns to its previous viscosity; therefore the viscosity loss is temporary. Figure 3 shows how the viscosity of an SAE 20W-40 multigrade oil is affected not only by temperatures but also by shear rate. Note the reduction in viscosity at high shear rates.

The characteristics of temporary viscosity loss and permanent viscosity loss would appear to be significant disadvantages of multigrade oils. In fact, with the proper selection of VI improver and base oil, temporary viscosity loss and permenent viscosity loss can provide very significant performance benefits not available in single grade oils.

Late model, high output, four-cycle locomotive engines with piston rings designed for low oil consumption can experience short oil change intervals because of viscosity increase. This viscosity increase is due to the combined effects of oil oxidation, insolubles thickening and oil volatility losses. As discussed in this Committee's report in 1987, the selection of a premium performance additive system and the proper base oil can affect this viscosity increase. The additive system can have a greater effect on controlling viscosity increase due to oxidation. Unfortunately, viscosity increases due to insolubles are not controlled by the additive system. Viscosity increase is more severe in late model low oil consumption locomotives as there is less make-up oil added to reduce the viscosity increase by dilution with new oil and replenish the additive system.

Permanent viscosity loss in service with a multigrade oil containing a VI improver can provide some compensation for the mechanisms of viscosity increase. Of course, this can be achieved only through careful selection of the VI improver. A VI improver with inadequate permenent shear stability would cause excessive loss of oil viscosity.

Figure 4 demonstrates the ability of an SAE 20W-40 oil to control viscosity increase compared to an SAE 40 oil. These evaluations were conducted in a stationary 16 cylinder, 4-cycle locomotive engine. The same 13 TBN (total base number) commercial additive system was used in both

oils. The SAE 40 oil experienced a steady, linear viscosity increase through the test length of 700 hours. The SAE 20W-40 oil had no change in viscosity through the test length of over 1400 hours. Other than viscosity, all parameters of used oil condition, eg, stabilized TBN level, coagulated pentane insolubles, wear metals, were similar and satisfactory. Table 4 compares the change in used oil viscosity in laboratory diesel engine testing of four 13 TBN oils.

Two of the SAE 40 oils contained commercial additive systems and a third contained an improved additive system. The SAE 20W-40 experimental oil contained the improved additive system in HVI base oil. In 150 hour tests the SAE 40 commercial oils experienced significant viscosity increase of 93% and 116%. The SAE 40 oil containing the improved additive system experienced 41% viscosity increase. In contrast, in a slightly extended 180 hour test the SAE 20W-40 experienced essentially no change in viscosity with a 2% reduction. Piston cleanliness and ring wear were also evaluated in those tests. The SAE 20W-40 and the SAE 40 oils were similar and quite acceptable in performance.

Table 5 lists a summary of the areas frictional losses within an engine. (4) Any reduction in the magnitude of these losses will result in an energy saving and reduced engine fule consumption. The two larger areas of frictional loss are piston and rings and bearings. These areas have hydrodynamic oil film lubriction in a high temperature, high shear rate environment. As was seen in Figure 3, it is in these areas that VI improved multigrade oils experience a reduction in viscosity due to temporary viscosity loss. This reduction in oil viscosity results in lower frictional losses and lower energy losses. In turn, this results in reduced engine fuel consumption with multigrade oils compared to single grade oils.

Table 6 shows the significant reduction of locomotive engine fuel consumption achieved with an SAE 20W-40 oil compared to an SAE 40 oil. (5) The fuel savings in percent of fuel consumed are largest over a switcher or a light duty cycle where frictional loses consume a greater proportion of fuel used. At the higher load conditions the percentage value of fuel savings is less but because of the higher fuel consumption rate the number of gallons of fuel saved may be greater.

Table 7 shows another evaluation of fuel saving benefit of an SAE 20W-40 oil compared to a commercial SAE 40 oil over a medium duty cycle. (6) Again, in both 2-cycle and 4-cycle engines the SAE 20W-40 multigrade oil provides reduced engine fuel consumption compared to an SAE 40 oil. Overall, the above experience indicates a one percent minimum fuel saving can be anticipated through the use of an SAE 20W-40 locomotive engine oil compared to an SAE 40.

Since one of the mechanisms of reduced fuel consumption with VI improved, polymer containing multigrade oils is temporary viscosity loss, can this reduced viscosity in the high shear rate areas of an engine such as pistons, rings, and bearings cause increased wear rates? After years of commercial experience this certainly has not been the case with the use of multigrade passenger car engine oils and high speed heavy duty diesel engine oils. In fact, experience has been that in many applications the use of today's multigrade engine oils results in reduced engine wear rates and longer engine life.

Tables 8 and 9 review some additional experience with engine bearing lubrication using multigrade engine oils. (7) Table 8 compares the L-38 rod bearing weight loss with SAE 20W-40 and SAE 15W-40 multigrade oils, compared to SAE 40 single grade oils. All oils contained the same additive system. The L-38 tet is a part of the API CD and other oil classifications. The multigrade oils provided significantly reduced bearing weight loss in this test. Table 9 compares the miltigrade and single grade oil performance in the EMD 2-567 silver bearing lubricity test. In these tests, the same additive system was used at the 10 TBN and 13 TBN additive treat level. As can be seen, the multigrade and single grade oils were equivalent in performance.

In passenger car and high speed diesel applications, the use of multigrade oils has been shown to result in lower engine oil consumption. Although the mechanism for this reduced oil consumption is not fully understood, it is felt to be related to the viscosity of the oil at the shear rates and temperatures that exist in the liner, piston, piston ring environment and perhaps better control and drain back of excess oil from this area. Table 10 shows a 27% reduction in oil consumption with SAE 20W-40 oil compared to an SAE 40 oil over an extended period of operation in a 20 cylinder two-cycle engine. The same additive was used in both oils.

In another oil consumption evaluation, two 16 cylinder, two-cycle locomotives were operated in the same train in normal railroad service. (8) Following a testing matrix, each oil was tested in each locomotive, and differences other than the oil effect were accounted for. Oil consumption was determined by oil sump level monitoring and metal tracer techniques.

Table 11 shows that the reduction in locomotive oil consumption with the SAE 20W-40 oil compared to the SAE 40 oil ranged from 32% over a switcher duty cycle to 13% over a heavy duty cycle.

In addition to the VI improver effects on multigrade engine oil performance discussed previously, a VI improver can have a very significant effect on engine cleanliness and especially piston deposits and ring sticking. A VI improver which oxidizes and breaks down in the high temperature regions of an engine and contributes to lacquer and carbon binding deposits will have a detrimental effect on enging cleanliness and engine life. Experience with diesel engine oils has shown this to be influenced by the VI improver chemistry and the amount of neat polymer required to meet the desired SAE viscosity grades. VI improvers which require a higher concentration of neat polymer are more likely to contribute to engine deposits than more efficient VI improvers which require lesser amounts be blended in the oil. Nonetheless, with the proper selection of the VI improver and additive system, multigrade oils can be equal in engine cleanliness to single grade oils.

The Caterpillar 1-G2 test is a laboratory engine test used to measure an oil's effect on piston deposits. The 1-G2 test is included in the API CD and other oil performance categories and, as was reviewed in this Committee's paper last year, is a part of a locomotive engine manufacturer's oil approval requirements. Table 12 compares the Caterpillar 1-G2 piston cleanliness performance of multigrade and single grade oils containing the same additive system at the 13TBN treatment level. (7) The piston cleanliness as measured by top ring groove fill and weighted total demerits. Both the multigrade and the single grade oils were equivalent and both were very acceptable. The API CD requirements are 80% max top ring groove fill and 300 max weighted total demerits.

C. Judgment of Used Oil Condition with Miltigrade Oils

The engine oil viscosity classification is defined by SAE J300. In that classification the viscosity of SAE 20, 30, 40 or 50 oils is defined at 100°C. The viscosity of SAE 0W, 5W. 10W, 15W, 20W, or 25W oils is defined at low temperatures ranging from -35° to -5°C. As was seen in Figure 2 the viscosity of an SAE 40 and an SAE 20W-40 would be similar at 100°C. But because of the much higher VI of the SAE 20W-40 oil, their viscosities at 40°C (and 100°F) would be very different. Therefore, if an SAE 20W-40 oil was used in service where there was a chance of mixing in the crankcase of an SAE 40 oil, perhaps by make-up oil, or during a changeover from a single grade to a multigrade oil, used oil viscosity judgments would have to be based on measurements at 100°C or 210°F. The addition of the SAE 40 oil would make it appear that the used oil had experienced thickening if measured at 40°C or 100°F. If, because of the type of service, there was no chance of mixing with a single grade oil, used oil viscosity could be measured at either temperature.

In many types of service the primary indicator of used oil condition is viscosity. As we have seen earlier, the use of a properly selected multigrade oil can result in significantly better control of viscosity increase compared to a single grade oil. This may shift the limiting factor of oil life to another performance area such as TBN or perhaps oil insolubles. In some operations, this may require a shift in used oil analysis procedures and emphasis. Also, the performance benefits of multigrade oils, especially longer oil life through control of viscosity increase, may require premium performance or next generation additive systems to take full advantage of these benefits.

D. In Summary

High quality, premium performance multigrade locomotive engine oils can be produced through the careful selection of VI improver, additive system and base oil. There are areas of significant potential performance benefits with multigrade oils which include reduced fuel consumption, improved control of used oil viscosity increase, reduced engine wear, and reduced engine oil consumption. These performance benefits of multigrade oils can have significant economic impact on the cost of locomotive operation. The immediate benefits are savings on fuel and engine oil consumption and longer oil life without compromise to engine durability.

References:

(1) Hewson, W. D. **"Durability and Fuel Efficiency Performance of Multigrade Railway Diesel Engine Lubricants"**, ASLE Preprint No. 87-AM-38-2, May 1987.

(2) **Hamilton, G. D. S. and Mullins, D. O. "Reduced Locomotive Fuel Consumption with a Multigrade Engine Oil in Field Service"**, Lubrication Engineering, Vol. 43, No. 4, pp 252-263, April 1987.

(3) Locomotive Maintenance Officers Association. **1987 Fuel and Lubricants Committee Report, September 14, 1987.**

(4) McGeehan, J. A. **"A Literature Review of the Effects of Piston and Ring Friction and Lubricating Oil Viscosity on Fuel Economy"**, SAE Paper 780673, June 1987.

(5) Logan, M. R. and Shamah, E. **"Multigrade Railroad Lubricants — Fuel Savings and Field Performance in 2-Stroke and 4-Stroke Engines"**, Presented at National Railroad Lubrication Council, ASLE, Toronto, May 14, 1986.

(6) Kelly, T. M. and Cannon, M. J. **"New Technology for High Performance Railroad Oils"**, Presented at National Railroad Lubrication Council, ASLE, Toronto, May 14, 1986.
(7) Cannon, M. J. and Kelly, T.M. **"Composition and Rheology of High performance Multi-Grade Railroad Lubricants"**, Presented at National Railroad Lubrication Council, STLE, Anaheim, May 13, 1987.
(8) Logan, M. R., Staley, R. M., and Hamilton, G. D. S. **"Multigrade Engine Oil Consumption Benefits — Results of Field Test in Railroad Service"**, Presented at National Railroad Lubrication Council, STLE, Cleveland, May 11, 1988.

TABLE 4

OIL VISCOSITY INCREASE IN LABORATORY ENGINE

CLR Diesel Engine -
2400 rpm, 290°F Oil Temperature

Oil Tested	Test Length, hr	Oil Viscosity Increase, % at 40°C
Commercial Oil A SAE 40/MVI/13 TBN	150	93
Commercial Oil B SAE 40/MVI/13 TBN	150	116
Improved Oil SAE 40/MVI/13 TBN	150	41
Improved Oil SAE 20W-40/HVI/13 TBN	180	-2

TABLE 5

SOURCE OF FRICTIONAL LOSSES

Source	% of Total	Lubrication Mode	Condition of Lubrication
Piston and Rings	65	Predominantly Hydrodynamic	High Temperature, High Shear Rate
Main- and Big-End Bearings	15	Hydrodynamic	High Temperature, High Shear Rate
Pumps	10	Hydrodynamic	High Temperature, Low Shear Rate
Valve Train	10	Mechanical	High Temperature, High Shear Rate

TABLE 6

FUEL SAVINGS

SAE 20W-40 Over SAE 40
Locomotive Load Box Testing

Engine Type	Duty Cycle Switcher	Light	Medium	Heavy
Two-Cycle, 16 Cyl.	3.3%	1.4%	1.1%	0.9%
Four-Cycle, 16 Cyl.				
Test A	5.5%	1.7%	1.1%	0.5%
Test B	6.4%	2.1%	1.3%	0.8%

TABLE 7

FUEL SAVINGS

SAE 20W-40 Over SAE 40

Test Type	Fuel Savings-Medium Duty Cycle
Two-Cycle, 2 Cylinder Lab Dynamometer Test	3.4%
Two-Cycle, 16 Cylinder Locomotive Load Box	0.9%
Four-Cycle, 16 Cylinder Lab Dynamometer Test	1.2%

TABLE 8

L-38 BEARING WEIGHT LOSS

13 TBN Oils - Same Additive System

SAE Grade	Number of Tests	Bearing Weight Loss, mg
40	3	30.8
15W-40) 20W-40)	4	16.6

TABLE 9

EMD 2-567 PERFORMANCE

Same Additive System

Oil TBN	SAE Grade	Number of Tests	Average Demerits Left	Average Demerits Right
10	40	6	21.5	23.1
	15W-40) 20W-40)	5	21.5	22.6
13	40	5	19.6	21.0
	15W-40) 20W-40)	6	20.6	18.9

TABLE 10

REDUCED OIL CONSUMPTION

SAE 20W-40 Over SAE 40
Same Additive System

Two-Cycle 20 Cylinder Diesel-Electric Marine Installation

12 Months SAE 40 Followed by 6 Months SAE 20W-40

	gal Oil/100 hr
SAE 40	46.2
SAE 20W-40	33.8

Oil Consumption Reduced 27% with SAE 20W-40 Oil

TABLE 11

ESTIMATED REDUCTION IN OIL CONSUMPTION

SAE 20W-40 Over SAE 40
Two-Cycle 16 Cylinder Locomotives In Train Service

Duty Cycle			
Switcher	Light	Medium	Heavy
32%	19%	15%	13%

TABLE 12

CAT 1-G2 PISTON CLEANLINESS

13 TBN Oils - Same Additive System

SAE Grade	Number of Tests	Top Ring Groove Fill, %v	Weighted Total Demerits
40	6	23	124
15W-40) 20W-40)	6	30	135

FIGURE 2

Effect of Temperature on Engine Oil Viscosity

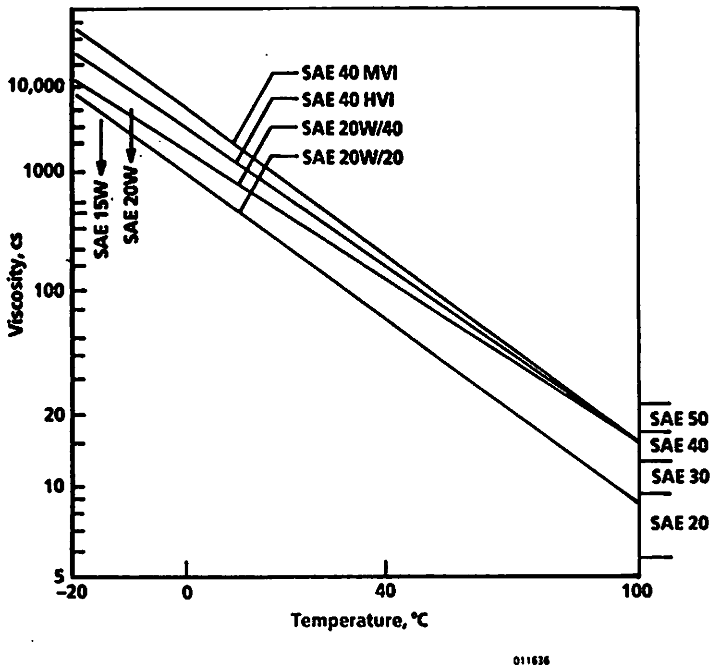


FIGURE 3

Effect of Temperature and Shear Rate on the Viscosity of an SAE 20W/40 VI Improved Oil

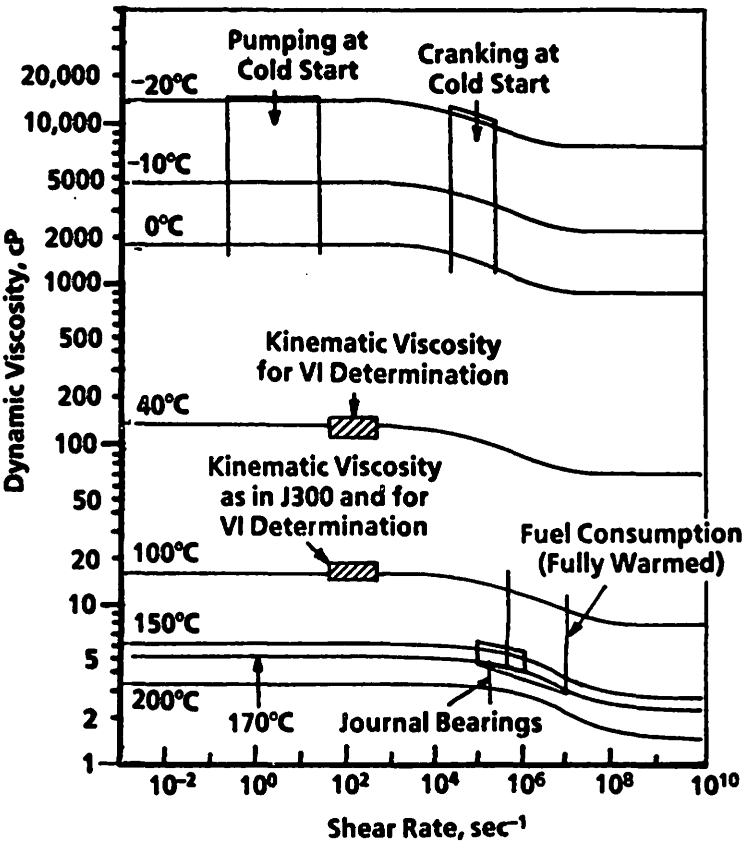


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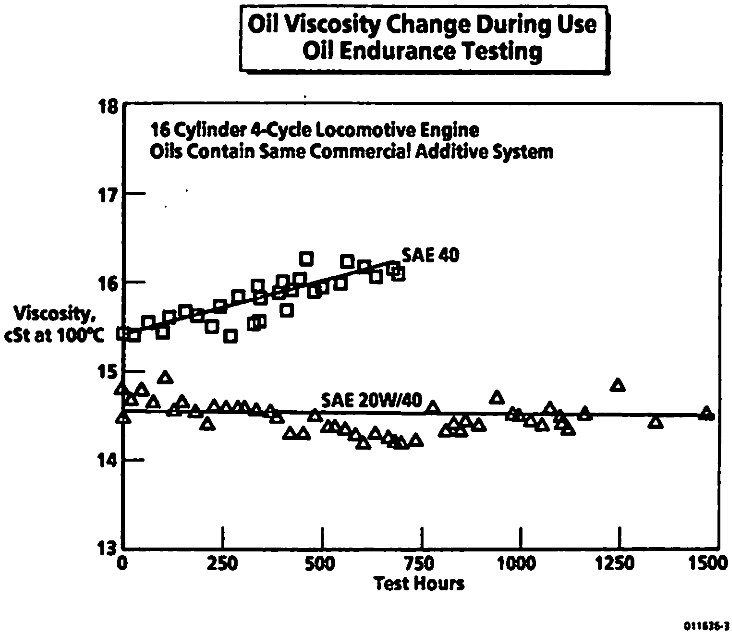
FIGURE 4


Oil Viscosity Change During Use
Oil Endurance Testing
16 Cylinder 4-Cycle Locomotive Engine
Oils Contain Same Commercial Additive System
SAE 40
SAE 20W/40
Viscosity, cSt at 100°C
18
17
16
15
14
13
0
250
500
750
1000
1250
1500
Test Hours
011636-3

IV
WHEEL FLANGE LUBRICATION UPDATE — THE LUBRICANTS BEING USED

A. Introduction

In earlier years, most recently in 1986, this Committee reported on the subject of lubricants then in use and some of the problems associated with locomotive flange lubricators. That same paper also described some of the laboratory tests and equipment that can be used to evaluate these greases. Since 1986, a number of railroads have tested equipment from various manufacturers and several major railroads railroads have applied lubricators to over 1,700 locomotives with plans to equip that many additional locomotives. There is much ongoing testing involving various lubricants aimed at finding the lubricant that best suits the particular railroad's operating conditions and application equipment, and produces the desired results. Ongoing tests combined with the railroad's operating experience to date have uncovered certain system deficiencies. These tests are directed to improving the system's overall performance.

B. Deficiencies Noted

Some problems found by operating railroads that are leading to system improvements are as follows:

1. Ineffectiveness of certain lubricants in building up and staying on the gauge face of the rail.
2. Maintenance problems caused by the lubricant not being applied to the flange-rail interface but being thrown off and building up on truck frames, brake rigging, underframe, and sand hoses. This problem has been reported as having resulted in at least two fires caused by accumulated grease, both resulting in minor damage.
3. Application problems with the lubricant and the particular lubricator being used to apply it, such as nozzle plugging or grease hardening in the reservoir.
4. Pumpability problems with the lubricant under extreme temperature conditions.
5. Compatibility problems between grease used in trackside lubricators and those used in on board lubricators.
6. Excessive wear on lubricator components from the use of some solids containing greases.

C. Summary of Physical Properties

The lubricants being used in everyday service and being tested by member railroads have a wide range of properties. The ranges of these properties are shown below in Table 13.

D. Reports and Observations

Some reported findings of member roads concerning lubricant use are as follows:

One member road reported a 12 percent fuel saving over dry track alone when using a calcium based grease with 11 percent graphite in wayside track lubricators. When additional lubrication was added in the form of the same grease applied from a vehicle mounted application an additional five percent fuel saving was noted on top of the 12 percent already realized. When an unidentified oil was applied from a vehicle mounted flange lubricator, no additional fuel saving was observed over that obtained with lubricators alone. Actually, the level of fuel saving observed dropped to 11 percent in this case, but the precision of the test was not good enough to have confidence in distinctions as small as one percent. The road concluded that the flange oil did not give any additional lubrication benefits over that already gained from trackside lubricators.

One member road is performing extensive laboratory and road tests of a lithium based grease with 10 percent graphite and a 500°F minimum flash point. These tests are being undertaken first to prove the compatibility of the test grease with the lubricators used by this railroad, and second to determine that there are no long term wear problems associated with this grease. This grease has been engineered to overcome some of the system deficiencies mentioned earlier and at the same time provide the persistence to lubricate the entire length of a normal freight train. The initial results of the lab tests with this lubricant have shown that there was an undesirable amount of wear occurring in the internal parts of the nozzles of this system. The member road and manufacturers of this system are currently redesigning the parts of the nozzle that were adversely affected and are planning the start of over the road tests shortly.

Two member roads have been testing a clay based grease with graphite and molybdenum disulfide for several months. Initial reports from one road indicate that some problems were encountered with bleeding, which is a term that they have used to indicate a decomposition of the grease, particularly in the presence of water, after application to the rail. They also report that there appear to be compatibility problems with the lubricant currently being used in wayside lubricators. The grease was also causing some filter plugging on the same railroad when used with one particular style lubricator system.

They are currently working with the supplier on a reformulated mixture that will have the composition changed by changing the specification of graphite to a smaller mean size and using it in the colloidal form instead of plate form. A restart of the test is planned for August of this year.

Another member railroad is testing a naphthenic based oil with 30 percent graphite while another road is testing a calcium based grease with 10 percent graphite added.

E. Summary

On board lubrication is undergoing a continued refinement of equipment designs and lubricant specifications in the desire to find the best system. The system will hopefully require the least maintenance by the Mechanical Department and will produce efficient lubrication.

Railroads which mix power in pooled consists should consider that there may be consists with locomotives using different greases not all of which are compatible. This problem does not seem to be of any concern at the present, but should be considered as new greases and/or oils are developed.

TABLE 13

Type of Lubricant:	Oils and Grease
Grease Soap Type:	Calcium, Lithium and Clay based
Grease NLGI Grades:	000, 0 and 1
Additives to Greases	Graphite and Molybdenum Disulfide
Range of Graphite Additive:	0 to 34 percent
Base Oil Viscosity of Grease (SUS at 100°F):	263 - 2600
Flash Points of Grease: (degrees F):	240 - 500 minimum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V
SURVEY OF DISPOSABLE PRACTICES FOR LOCOMOTIVE ENGINE LUBE OIL AND LUBE OIL FILTERS

United States and Canadian railroads were surveyed to determine what practices are currently utilized for handling and disposal of used locomotive engine lube oil and lube oil filters. Some related considerations are also discussed. Results of the survey are obviously limited to those railroads which responded, i.e., the results reported are not all-inclusive.

A. Lube Oil:

As recommended in the 1985 LMOA paper "Disposal of Lube Oil Drainings", recycling has become the preferred method of handling used oil. As shown in Table 14, four Class 1 railroads and six other railroads sell their used locomotive lubricating oil to a re-refiner or an energy recovery company but do not buy any re-refined oil. Two Class 1 railroads sell their used lubricating oil to a re-refiner and also buy some oil from that re-refiner. Six Class 1 railroads report having much or all of their oil re-refined and returned to the railroad, although a major re-refiner reports that oil is not segregated in this manner. Each of these roads reports having its oil handled separately from other oils by the re-refiner. One major railroad processes 90 percent of its oil on-site to remove contaminants before reusing it. Two major railroads process 10 percent or less of their oil on-site for reuse. Two major railroads burn 10 to 20 percent of their used oil. One Class 1 railroad uses approximately 5 percent of its used oil to oil switches.

B. Filters:

Lube oil filters are handled as shown in Table 15. Almost all railroads surveyed simply drain their filters before disposing of them in a "dumpster" and having them hauled to an appropriate sanitary or hazardous waste landfill. Some analytical testing of the filters may be required to determine what type of landfill is appropriate. The appropriate type of landfill may vary with state regulations. One major railroad compacts all of its filters to eliminate as much oil as possible before disposing of the carcasses in a dumpster. Another major railroad crushes approximately 50 percent of its filters in compactors costing approximately $10,000 each. This eliminates potential objections to landfilling free oil accumulated from filters in dumpsters. This railroad determined that approximately ¾ gallon of oil is removed from each filter by the compactor. This oil is then handled as drain oil. The filter carcasses are disposed of in a dumpster. Three major railroads compact from 5 to 20 percent of their filters.

Another major railroad burns approximately 50 percent of its filters in environmentally approved incinerators and disposes of the rest in a dumpster.

Peter Conlon of AAR will address environmental regulations affecting railroad practices in the next section. A brief discussion of those regulations which could have a direct impact on disposal and handling of used lube oil and filters follows.

EPA's Resource Conservation and Recovery Act (RCRA) is best known for regulating hazardous waste. Several railroads have analyzed representative samples of their used oil and found that it is not a hazardous waste by the analytical characteristics enforced by EPA. Consideration is being given to listing used oil as a hazardous waste, which would make it hazardous regardless of its analytical characteristics. Comments filed when this was proposed suggested that listing used oil as a hazardous waste would discourage recycling and have an overall negative impact on recycling. EPA currently appears to be leaning toward regulating used oil separately and not as a hazardous waste.

Some states have more restrictive regulations than the U.S. EPA. Each railroad should familiarize itself with state and local regulatory requirements. The following information is based on responses to the survey. California regulates used oil filters as a hazardous waste, therefore filters must be incinerated in an approved furnace or disposed of in a hazardous waste landfill. Some states including California, New Jersey, Massachusetts and Connecticut, regulate used petroleum products as hazardous wastes and all shipments must be manifested and handled according to state RCRA-type regulations. In some other states, including New York and Pennsylvania, most sanitary landfills are so restrictive that they will not accept used locomotive lube oil filters so that in practice the used filters are disposed of in hazardous waste landfills.

The disposal of liquids is now banned at hazardous waste landfills. If used filters must be disposed of in a hazardous waste landfill, they may need to be compacted to pass EPA's mandated liquid-free test.

Regulations are not the sole consideration. It is true that most states do not currently carefully regulate the disposal of used locomotive lubricating oil and oil filters. According to current regulations and case law, however, the company disposing of a material retains responsibility for that waste after it is disposed of, i.e. cradle to grave responsibility, unless it is recycled and reused. Therefore, this Committee recommends that each railroad gather or develop information on the relevant characteristics of used oil filters to assure that their current disposal methods are proper.

Furthermore, it is recommended that consideration be given to compacting filters to remove as much oil as possible before disposing of the carcasses appropriately. This will reduce the amount of oil which may go to sanitary landfills and it will reduce the potential for environmental problems in the future. By reducing potential environmental problems now, railroads will reduce the probability of governments adopting regulations that will increase the cost of lube oil filter disposal. Sometimes, the best defense is a good offense.

TABLE 14

Lube Oil Disposal Practices

Number of RRs	Oil Sold*	Rerefined and Returned to RR**	Buy from Rerefiner	Process to Clean, Re-Use	Burned
Class 1:					
4	100%	0%	No	0%	0%
2	100%	0%	Yes	0%	0%
1	97%	0%	No	3%	0%
1	80%	0%	No	0%	20%
1	60%	40%	No	0%	0%
1	30%	60%	No	10%	0%
1	0%	0%	No	90%	10%
1	20%	80%	--	0%	0%
1***	0%	95%	No	0%	0%
2	0%	100%	--	0%	0%
Other RRs:					
6	100%	0%	No	0%	0%

* Sold to rerefiner or energy reclamation company in most or all cases.
** A major rerefiner of used lube oil reports that oil from different customers is not segregated for rerefining.
*** 5% of used lube oil is used to oil switches.

TABLE 15

Lube Oil Filter Disposal Practices

Number of RRs	Placed in Dumpster	Compacted and Placed in Dumpster	Incinerated
Class 1:			
7	100%	0%	0%
1	95%	5%	0%
1	90%	10%	0%
1*	79%	20%	0%
1	50%	50%	0%
1	50%	0%	50%
1	0%	100%	0%
Other RRs:			
7	100%	0%	0%

* 1% disposed of as hazardous waste.

VI
OVERVIEW OF ENVIRONMENTAL REQUIREMENTS FOR THE USE OF PETROLEUM PRODUCTS IN THE RAILROAD INDUSTRY

The following material was prepared by Peter C. L. Conlon, Manager Environmental and Hazardous Material Research, Association of American Railroads, for presentation at the 1988 LMOA Annual Meeting.

A. Introduction

The importance of safe handling of petroleum products cannot be overstated. Avoidance of environmental pollution is vital to cost-effective operations. Many government rules apply to handling these materials, and they change frequently. This paper will briefly discuss only the federal requirements; state and local rules can differ and may be more restrictive. For a complete understanding of the requirements affecting a particular facility, you should contact your company's environmental officer. The following is a discussion of each major environmental law and the primary regulations that cover railroad use of petroleum products and wastes.

B. Water Pollution

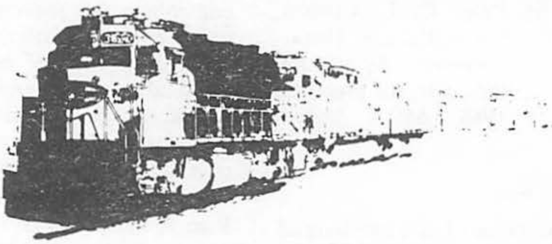
The Clean Water Act generally prohibits discharges of oil of any kind into the navigable waters or adjoining shorelines. The phrase "navigable waters" includes any streams, wetlands, etc., that feed into navigable lakes, rivers, and oceans, and has been interpreted so broadly that a discharge in almost any area where the discharge is likely to reach water is prohibited. Any spills of oil in contravention of the prohibition in the Clean Water Act must be reported to the National Response Center (1-800-424-8802). The presence of an oil sheen on water is the basic indication of a spill.

Oil spills are to be cleaned up pursuant to the National Oil and Hazardous Substances Pollution Contingency Plan. The Plan addresses controlling the source of discharge, use of physical barriers and booms to deter the spread of oil, and use of physical and chemical recovery techniques. The Plan establishes an organization for responses to spills of oil and hazardous substances. An on-scene coordinator designated by the Plan is the principal federal government representative at spill sites.

SPCC Plan

EPA developed the Spill Prevention Controll and Countermeasure Plan (SPCC) to ensure proper operation of facilities involved in the storage, distribution, and use of oil. Railroads have adopted the SPCC plan for fuel storage and distribution facilities. Its intent is to prevent accidental discharge of oil and hazardous substances. The SPCC plan should contain information about a site including flow system plans, locations of valves, piping and pumps. Maintenance practices to ensure spill-free operation should be included. Spill notification procedures should be specified for contacting in-house personnel, government officials, and cleanup contractors.

According to the regulations, provisions and methods for a practical and immediate effort must be available to contain spilled oil and safeguard life and property. The plan must also outline methods to remove and dispose of the spilled oil. A list of material and equipment needed to respond to a spill is desirable, and this material should be stockpiled and maintained. The SPCC Plan



should be available to employees and EPA or Coast Guard inspectors at all times. It would be wise to review the plan occasionally to ensure familiarity with the procedures.

Locomotive Fueling

The fueling area has the greatest potential to contribute to spillage. Around the clock fuel dispensing operations, pumping rates of 200 gpm, pumps, pipes, hoses, and couplings all contribute to spillage. One road reported sources of spillage (in 1982) as follows:

Failures of automatic shutoff	57%
Overriding automatic shutoff to top off tank	24%
Worn/defective coupling and gaskets	9%
Locomotive pull-away before disconnect	1%
Other Causes	9%

Two programs were recommended to resolve these problems. The first was a coordinated effort between mechanical and maintenance personnel to maintain fueling locations, locomotive equipment, and other fueling equipment. The second was an educational program focusing on fuel oil inventory control, responsibilities of fuel handling, and benefits of spill prevention.

Even with the best of plans and equipment, fuel spills will occur. Railroads have equipped permanent fueling areas with spill collection systems. These include track pans made of steel, concrete, fiberglass or synthetic materials. Once contained and collected, spilled fuel is piped to a treatment facility to separate oil from water. Separation of oil from water by gravity is the most common method of treatment for simple fueling facilities.

Product Recovery

Recovered fuel can be recycled of by several means. Spilled fuel recovered from a wastewater treatment plant may be of good enough quality to be reused in locomotives, following filtration to remover water and sediment. Recovered fuel can also be used as boiler fuel for heating buildings. Contractors can be retained to remove recovered fuel oil from a treatment plant periodically.

Wastewater Treatment

Wastewater generated at railroad facilities is subject to EPA regulation if it is discharged to surface waters or to a publically owned treatment works (POTW). Discharges to surface water must be permitted under the National Pollutant Discharge Elimination System (NPDES). Pretreatment requirements often apply to discharges to POTWs.

Intermediate or heavy maintenance facilities produce wastewater from numerous operations. These include fuel and lubricant handling, surface runoff, sanding, cooling water, boiler blow down, heat treating, groundwater, locomotive washing, paint shop, light and heavy maintenance, sludge dewatering, and parts cleaning. When combined, these sources of wastewater contain dissolved and emulsified oils, other dissolved and suspended contaminants, and cleaners and caustic agents.

Treatment of these wastes basically involves removal of oil, cleaners, and other contaminants from water. Some facilities at locomotive shops also neutralize caustic wastes in the wastewater treatment process. The preferred industry method for treating such wastewater is air flotation. Solids are removed first by gravity separation followed by de-emulsification by air flotation, then followed .by biological treatment when necessary for discharge to surface waters or to reduce local sewer surcharges. Additional treatment may be provided by filtration, carbon absorption, chlorination, and/or pH control when required for specific wastes or discharge conditions.

EPA is currently examining the railroad industry to see if further wastewater regulations are needed. The main concern is with toxic organic compounds and heavy metals. Through industry sponsored research, we hope to demonstrate that the decline in the use of chlorinated organic solvents coupled with hazardous waste reduction programs obviates the need for further regulation. A final determination is expected in late 1988 or 1989. If regulations are to be developed, they would be completed by 1992 or so.

Stormwater runoff is also subject to EPA regulation if it comes in contact with wastes, raw materials, or pollutant contaminated soils from areas used for industrial or commercial activities. An NPDES permit must be obtained for such discharges. The Water Quality Act of 1988 requires EPA to establish new stormwater runoff rules that will greatly expand the number of facilities affected.

C. Solid and Hazardous Wastes

EPA rules require that wastes be identified as either hazardous or non-hazardous. Ordinary garbage, trash and sanitary wastes are not hazardous wastes. These wastes may be placed in sanitary landfills. Wastes listed by EPA as hazardous, or that possess health threats and characteristics of toxicity, ignitability, corrosivity, or reactivity must be managed in compliance with hazardous waste regulations.

The Resource Conservation and Recovery Act (RCRA) established a cradle-to-grave system for handling hazardous wastes. A manifest system is used to track wastes transported from the sites where they were generated to ensure that waste shipments are disposed of properly. An extensive system of regulations exists for treatment, storage, and disposal facilities.

Facilities that produce hazardous waste in quantities between 100 and 1000 kilograms per month are referred to as small quantity generators and are exempt from much of the regulations. Wastes may be accumulated on-site for up to 180 days without an EPA permit. (It's important to note that some states regulate ALL hazardous waste regardless of amount generated). Waste shipped off-site must be accompanied by a Uniform Hazardous Waste Manifest.

Facilities that generate over 1000 Kg. of hazardous wastes a month must comply with the full set of regulations. This includes notification of hazardous waste generation activities, labelling and placarding, on-site storage requirements (limited to 90 days without a permit), waste manifest for transportation off-site, and record-keeping and reporting. Other rules apply to waste transporters, and treatment, storage, and disposal facilities.

Fuel and Lubricating Oil

Oil by itself is not a hazardous waste. If contaminated with a hazardous waste, it is subject to regulation. Used lubricating oil that exceeds specified limits for arsenic, cadmium, chromium, lead, flash point, or total halogens is also regulated when recycled. Locomotive engine lubricating oil is ordinarily very low in metallic contaminants. It should be collected and stored apart from other wastes to avoid contamination by fuel or other materials.

Used lube oil may be burned in industrial boilers provided it does not exceed certain contaminant limits set by EPA. One road has reported that fuel oil blended with 15 percent lube oil produces a satisfactory heating fuel requiring no modifications to burners or nozzles. A simple water and sludge removal system is needed to clean the oil for blending.

Lube oil is a highly refined product that does not lose its lubricating properties after ordinary service. British Rail has developed a method to recycle its oil by removing the metallic and liquid contaminants. Several North American railroads are using or studying this system, reputed to recover 90 percent of the used oil and reduce new oil requirements by up to 20 percent.

Other Wastes

Other waste materials generated during locomotive maintenance operations may be subject to hazardous waste regulations. Unless recycled, lead-acid batteries used on locomotives are hazardous if disposed of. Lube oil filters, used greases, and sludges may also be hazardous if the metals contents exceed allowable levels of the toxicity test criteria.

Underground Storage Tanks

Pursuant to RCRA, EPA also regulates underground storage tanks in which oil or hazardous waste is stored. Owners of underground storage tanks must notify the state agency designated by the governor in state in which they are located. Construction requirements for new tanks apply. These rules require that all new tanks and piping be structurally sound, product compatible, and corrosion resistant in corrosive soils. The objective is to prevent groundwater contamination caused by leakage. Tank owners were to have notified the appropriate state agencies of the location, age, size, type, and uses of all tanks by May 8, 1986. Rules requiring corrosion protection leak detection and spill or overfill prevention systems for existing tanks were scheduled to be in place in 1988.

D. Comprehensive Environmental Response Compensation, and Liability Act (Superfund)

CERCLA has several elements. It establishes a strict liability scheme for releases of hazardous substances, a reporting scheme for releases of hazardous substances, a plan (the National Contingency Plan) for responding to releases of hazardous substances, and a fund for cleaning up hazardous substances when private parties do not. CERCLA hazardous substances include Clean Water Act hazardous substances and toxic substances, RCRA hazardous wastes, Clean Air Act hazardous pollutants, Toxic Substance Control Act hazardous chemicals, and any other substances that EPA chooses to designate as hazardous.

Petroleum is not a hazardous substance. However, if petroleum is mixed with or contaminated with a hazardous substance, then the resultant mixture may be considered a hazardous substance.

Some railroad facilities have been found listed by EPA as hazardous waste sites because they are contaminated with various materials that pose an environmental risk. Chlorinated organic solvents, formerly widely used for parts cleaning, have been found in groundwater below some facilities. Chromates, once used as rust inhibitors in locomotive cooling water systems, have also been found. Those areas must be thoroughly investigated and cleaned up, usually at great expense.

AAR Research

Fuel and lubricants are common contaminants in soil and can affect groundwater quality. AAR is currently conducting research into the fate of spilled diesel fuel in soil. Our objective is to identify low-cost cleanup methods that can be easily implemented. Barring that, removal and incineration of oil-contaminated soil is often the only method allowed.

E. OSHA Hazard Communication (Worker Right-to-Know)

OSHA's Hazard Communication Standard, currently applicable to manufacturers, now applies to railroads and virtually all other businesses. (At the time of this writing, a court has temporarily prevented the rule from going into effect). This rule basically says that employers must develop a program to communicate information on hazardous chemicals to employees. In terms of locomotives, this means fuel, lubricants, batteries, coolants, paints and cleaners.

Railroads must implement a hazard communication program, label containers in which there are hazardous chemicals, provide employees with access to material safety data sheets, and train workers on the handling of the chemicals.

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PERSONAL HISTORY

Ross T. Gill

Ross was born in Albuquerque, New Mexico on July 24, 1939. Following high school he attended Colorado State University before receiving a federal appointment to White Sands Missile Range as a coop student mathematician in 1959. In 1965, he received his BS degree in Mechanical Engineering at New Mexico State University. Ross joined the Southern Pacific in 1961 holding several positions in the Maintenance of Way Department at El Paso, Texas. He was promoted to Assistant Engineer in San Bernadino, California for the construction of the Southern Pacific's Colton Cutoff in 1966. In 1967, he joined the Mechanical Department as Equipment Engineer headquartered in San Francisco. Major projects included the Vert-a-Pac and Stac-Pac automotive rail cars. In 1970 through an exchange agreement, he joined the U.S. Department of Transportations, Office of High Speed Ground Transportation (now the Office Research and Development in Washington, D.C.). After two years in Washington, he was promoted to General Engineer at the Transportation Test Center in Pueblo, Colorado. At Pueblo, he was responsible for construction planning and test operations at the facility. Major projects included the Linear Induction Motor Research Vehicle Test Track, Rail Dynamics Laboratory, Tank Car Torch Facility, Transit Car Test Track and the Facility for Accelerated Service Testing (FAST), a joint AAR and DOT funded program. In 1977, he returned to Southern Pacific in San Francisco to become manager of Research and Development in 1978. In 1980, he joined the Sacramento Locomotive Works where he presently serves ad Manager of Production, Engineering and Quality.

He resides in Fair Oaks, California with his wife, Donna, and four children, Michael, Sandy, Randy and Karen. His major hobbies are classic automobiles and playing golf.

Wednesday Morning Session
September 21, 1988

QUESTION:

What are some of the most effective ways of reducing/preventing diesel fumes from becoming a problem in the locomotive cabs?

Has anyone developed a system of detection/measuring the degree?

Keith Brinker—CSX Transportation

I'll start off with the second question. There are devices that can be used to monitor various diesel emissions; nitric oxides, sulphur dioxide, hydrocarbons, etc. You can utilize a personal sampling pump with detector tubes or a sample collection system. All samples collected can then be analyzed by a laboratory. The detector tubes can give you a quick and simple indication of the presence or concentration of one of the mentioned contaminants. As far as what is being done to prevent emission fumes in the locomotive cabs, I am going to refer that portion of the question to one of the locomotive builders for comment.

Jack Malovich—General Electric

We're constantly looking at the engine in terms of the load rate and the horsepower rate that we apply to look at it from an engine standpoint. More recently, we have done some development work, but have not executed into production yet an exhaust stack blower. It is effective for doing that. There is a tradeoff of that between the cost of it and the benefit derived but we'll continue to look at things like that in the future and plow our way through it as best we see it along with the railroads.

Peter C. L. Conlon—AAR

It is a timely question. We don't know what the answer is to control but it is indeed a problem. In 1987, Harvard Public Health School issued a research paper on the effects of railroad workers exposed to diesel exhaust both in locomotive cabs and in the shops. The paper concluded that the people exposed to diesel exhaust for a ten-year period had a 41% chance of lung cancer. On that basis, the AAR plans to study locomotive cab environments to determine the concentrations of exhaust in the cab, and we plan to start this in 1989. In August 1988, the National Institute of Occupational Safety and Health (NIOSH) published Current Intelligence Bulletin No. 50 which states that diesel exhaust is a potential occupational carcinogen. They don't say that particulate matter in the air is the culprit, although many researchers suspect it is. NIOSH, in fact, recommended that not only the particulate be sampled, but the gaseous elements of the exhaust also be measured. Our research program will first quantify the atmospheric conditions in the cab followed by risk analysis, and, if needed, methods for reducing exposure. We hope that the results of that study will be of use to the builders and the railroads.

Henry Marta—EMD

EMD is working with some of the customers for the development of cabs with improved comfort and environment; and what we need to do is work very closely with the customer in defining their requirements and

determining to what extent improvement in ventillation needs to be done; what are the requirements that we have to meet, and I'm sure that the filter manufacturers in the US will work with us to develop what is required. One of the cabs that we are providing in 1988 to one customer has a certain amount of ventillation, but I think there is a lot of work that has to be done in this area to define the problem fully and develop what is considered to be entirely satisfactory to the customer.

Mark Coles—Union Pacific

The problem of diesel exhaust in the locomotive cab really didn't get to be a problem until we started using the head end devices in the electronic cabooses. When the locomotive cab, in general, seats only two to three people. You have a four-man crew, or when there are dead-heading crews, you end up with people riding the trailing units. This is where the biggest part of the problem arises. One of the things that can be done, and we have done it on the UP, is retrofitting locomotives with additional seats in the cab of the leading units, also allowing us, in some cases, to reduce a train to a single unit. By moving the people into the lead unit and getting them away from the trailing units, you can eliminate the perceived problem. The other thing is the fact that the locomotive cab, in the past, has not been designed to allow shutting the windows to keep the smoke out and still maintain adequate ventilation. You run with the windows open and again that makes the problem worse. Like the man from EMD was saying, we, on the UP, are doing a lot with locomotive cabs. In the future, virtually all of the locomotives we purchase will have the large, four-man cabs with central heating, air conditioning and filtering systems as another way to protect the people in the cab.

Ross Gill —SP

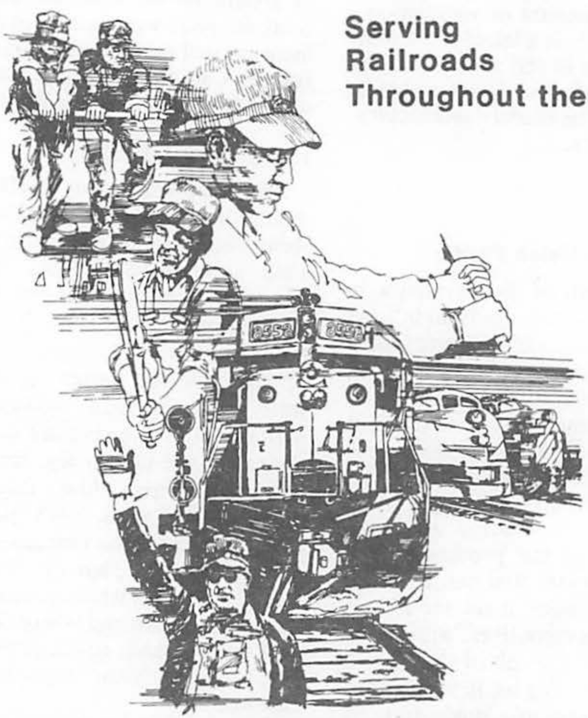
While we're on the subjects of cabs, I did get one question in regard to apparently the wide cab design. I think the issue was; is this going to be incorporated as a universal cab in the future? Can we have some comment on the future of the wide cab design?

Henry Marta—EMD

As I indicated earlier, EMD is providing the console cab with the wide, short hood to one U.S. customer in 1988 and whether it will become universal or not will depend quite a bit on you, the customer. We're certainly very much in favor of ending up with one cab design for the majority of the railroads; however, this matter will evolve. We are designing the same type of cab also for a four axle locomotive. Our interest is definitely to work with you, the customer, to try to eventually end up with one design. That will depend to a great extent on what the customer's requirements are and where does that lead us to, which to the greatest extent is to satisfy the majority of the customers.

Weylin Doyle—Union Pacific

I'd like to add a little bit to that. We're also implementing the ATCS program, and I think with the electronics that are now coming into play with locomotives, we're going to see more development toward a totally new cab concept that will more readily accommodate this new equipment; however, we will also need to get more feedback from our customers who are the crews out there working in these cabs. I think once we get some of these new cabs out and running and see how the crews accept



them, as well as how easily they can be maintained in our shops, we'll have a better idea. I think, definitely, it's going to be the trend to go to a new style cab, but the verdict on the particular design is still out.

Bill Crisp—GE

We're also working on some alternate cab designs. At this point, we have no plans to standardize. We will be driven by the railroad industry, but, unless, you, the industry, has a standard cab, we will continue to produce the cabs that are demanded by our customers. We do believe there is a trend towards new cabs. We're not sure whether the current design is the one that will eventually evolve; what may evolve might be several designs that are needed by different customers for different types of purposes, and we intend to meet the demands that you, our customers, require.

QUESTION:

Our railroad is beginning to convert from oil to grease cartridge type journal bearings under EMD locomotives. EMD recommends a bearing adapter with a resilient pad for lateral control. Timken's adapter does not have this pad. What experiences are railroads having with the respective adapters when they convert to the cartridge bearing on EMD road power?

Gil Bruno—Amtrak

With the application of the Timken GG bearing, it is possible to adapt the Hyatt box and realize some cost savings in terms of retrofit. There are several vendors who can supply these modified Hyatt boxes to accept your Timken or other brands of roller bearings; however, EMD has come out with a design of their own which has a resilient pad to control your lateral and to help reduce crew complaints of rough riding or poor ride quality. Perhaps, there is a representative from EMD who probably can further explain the logic in designing the journal box with the elastic pads. Our fleet of roller bearing locomotives have had these applied and, to date, they've been relatively maintenance free. Our crews are very sensitive to ride quality, and we try to be as responsive as we can to their needs and concerns; however, from a cost standpoint, a significant savings can be realized by adapting all your Hyatt journal boxes to Timken if that's what you want to do.

Henry Marta—EMD

As many of you know, Electro Motive designed an application of the GG tapered grease lubricated bearing to the EMD locomotive, with the resilient pad. The objective of the resilient pad was, as Mr. Bruno indicated, the assurance of improved ride comfort in the cab. Also, in addition, there is a significant reduction in lateral acceleration loads between the wheel and rail as a result of this resilient pad. It really reduces the dynamic loads by something between 20-30%. It's very, very significant. In addition to that, of course, the grease lubricated bearing provides much longer interval between the maintenance attention that you have to give this bearing. The applications have been, as many of you know, very successful.

Question:

Regarding Bar Coding: To be of use in streamlining the receiving process, the bar code must identify, not only the part number, but the purchase order number and line item. This requires that a unique label be applied to each part at time of shipment. Is the railroad industry willing

to pay this cost? How do they evaluate the value?

Charles Miller—Union Pacific

In regards to standardization of marking, the railroad branch of NAPM has designed a label including the purchase order number, the items number, the supplier, and that type of information which makes the receiving much easier and conducive to use for other bar code applications. There are probably four railroads I know of that are now utilizing bar coding in the receiving process. The standardization of which bar code to use is not quite that definite. One major locomotive builder is using the code 128; another is using the code 39. Our committee has suggested to the AAR group and to the LMOA group, that we standardize with the code 39 so that all of our receiving message transfers, or any type of bar coding data will be standard and usable for whatever applications we want after that. As far as the cost goes, if I have to buy two bar code readers to read code 128 and code 39, I probably wouldn't do it. If the suppliers have to print a code in three or four different makeups, they're probably not going to do it, either. I think the standardization has to come before any cost effectiveness can be realized by anyone.

As for the cost benefit of using bar codes beyond inventory control, the value centers around more accurate locomotive maintenance records, better and less time consuming labor records, data records and freeing up the Supervisors to do their management duties instead of performing bookkeeping chores.

Ross Gill

This is a serious problem to all of us if we don't standardize. If everybody is going to do something different, it's really going to mess up things. Does anybody from the industry out there have any comments on this subject? (the standardization for bar coding of materials).

Question:

Are there any advantages of applying the wheel slip system presented by the New Developments Committee to the new microprocessor locomotives.

Mark Coles—Union Pacific

As Bob Runyon stated in his paper, this was a system, primarily developed for retrofit to older locomotives. It was not intended for use with the super series or centry-type wheel slip controls.

Question:

Can the GE 5" bull gear be modified to 4½" for new locomotives?

Jack Malovich—General Electric

The current standard production is a 5" wide pinion with a 4½" wide gear. We did that for two reasons; one to cut down the stress on the gear and second to reduce the amount of oil splash on the side walls of the gear case. If you have a 5" wide gear out there now, it is not necessary to change it. I don't know how you'd do it to begin with off hand. We went to it strictly as a product improvement. It's about all I can say at this point.

Ross Gill—Southern Pacific

What you're saying is that you can go either way. Is that correct?

Jack Malovich

Yes! It is a product improvement with what we have in current production. There is nothing wrong with the present 5" wide pinion with the 5" wide gear.


Compressor Problems?
Call Triangle!

Ross Gill

It will go into the AG motor case?

Jack Malovich

Yes, it will.

Question:

Specifically addressed to the Caterpillar engine people?

Your paper implies a large quantity of repowering has taken place in the high horsepower road locomotive sized engine. Exactly how many 3600 series engines have been installed and are operating in U.S. locomotives?

Jim Hogan—Caterpillar

There were two engine families we talked about. With regard to the 3600 engine, the large one, we're still controlling the distribution of them because we still consider all of them, to date, to be on test. There are four major North American railroads that are testing the 3600's. The smaller 3500 series engines are available so there are no restrictions on those.

Ross Gill

Do you have a quantity that are in use for the 3500's?

Jim Hogan

In the United States, there are better than 50.

Question:

With regard to the presentation on new locomotive components retrofittable to the older engine. Do customers get the new armature coils in D-77 traction motors when they are unit exchanged with EMD?

L. A. Richter—EMD

Let's address the larger question of what happens when the customer sends in a D77 motor for rebuild. Currently, we supply both D-77 armature coils and D87 armature coils. When a D77 armature comes in for rewind, it can be rewound with either D77 or D87 coils.

Ross Gill—SP

Are they new? Does the customer get a new armature coil on a unit exchange motor?

L. A. Richter

If the armature is stripped and rewound, it receives new armature coils. There are several options that the customer has under the overall umbrella of the UTEX operation that do different things. If the customer specifies a strip and rewind, that's what he gets including new coils. They are either D-77 or D87 coils again depending on what is specified.

Ross Gill

If the coils qualify, then nothing is done!

L. A. Richter

If the customer specifies a "repair and return" armature, the coils are tested. If they qualify, then the armature is not stripped but cleaned thoroughly and vacuum-pressure impregnated with varnish. In this case, he gets the re-processed armature. If in the process of qualifying the coils, some are found defective, those armatures are stripped and rewound also.

Question:

In relationship to the presentation on rail lubricators. Long term or near term, do we anticipate a universal specification for grease in the lubricators?

K. Allen Keller—Amtrak

In all the research I did on this paper the past year, it leads me to see that there is no way we're going to have one specification for grease, right now. People seem to be going in six different directions, at the moment. Everybody is trying to find out what's going to be the best for their particular operation. In the next year, there is at least one railroad that is planning on testing various kinds but that testing is going to be limited to one lubricator system, and whether they come up with a final answer saying "this is the best grease", and whether that finding is going to translate over into other manufacturer's systems, I don't know. Maybe some of the lubricator systems manufacturers' people might want to say something about that. At the moment, I don't see us heading toward one specification.

Ross Gill—SP

It appears that there is no one specification, at least at this point.

Question:

Relative to Mr. Murphy's paper.

It is not quite clear when you have material from the quality side of the fence where you have a quality control person who has rejected an item and how that flow must go back through the system. Everything was flowing to the user, but how do you deal with the flow back from the user when the part is unacceptable and may get scrapped, or if it's a warranty item the assurance that it gets handled properly. It wasn't quite clear if there was a mechanism to make that happen from the user feedback standpoint because of the cost factor that may be involved (user's budget).

Charles Miller—Union Pacific

The gist of Terry Murphy's (C&NW) paper and what is in practice on his particular railroad is a feedback form. A user-originated feedback form that tells the engineering group of the mechanical, purchasing people, the materials distribution people and everybody right up the chain of command what kinds of problems are seen by the user (the floor man). The report is generated and fed through a very definite process that they have installed, beginning with the supervisor. He adds whatever he knows about the component. It goes on to the engineering group to review a need for a new specification, perhaps, if the component doesn't meet the requirements. It then goes on to the materials and purchasing people who do what they have to do either alleviate the problem with the supplier or force the specification people to come up with the proper specification. The most important part of this whole process is that the originating mechanic, or whoever originates this particular problem report is notified what is happening. He is recognized for his observations, to promote the continuation of this type of a feedback process. They had four categories of component quality problems; one would be obviously the warranty, which was marked accordingly and handled in a particular direction. The other three were as follows: it doesn't meet specifications; it didn't fit the application; and I can't remember the fourth one.

Ross Gill—SP

Thank you, Charlie. I think we've all had the experience of taking the material, turning it all in and you assume that it has been handled. Three years later, you're expecting to continue with that particular item and the part you rejected three years ago shows up, and the guy is using it again. It's the same material you put away! I think you clarified that fairly well.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National® DE-7000 is so tough, it even out-performs our standard DE-7. Available for all types of traction motors, DE-7000 delivers outstanding commutation, extends service life and reduces electrical maintenance to previously unattained levels.
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a name you can depend on.

Question:
Can RP-530 be used to evaluate aftermarket mechanical devices that claim to reduce fuel consumption or improve engine performance?

Keith Brinker—CSX

The RP-503 procedure was initially intended to be used to screen chemical fuel additives for reduced fuel consumption and improved engine performance. This procedure would lend itself very well to evaluate a mechanical fuel savings device and the recommended final report would provide all the information necessary for a complete economic analysis of this device. Yes, you can expand its format to other products.

Question:
What affect will multi-grade oil have on engine cleanliness and deposits?

Doug Carlson—Shell

A properly formulated, properly compounded multi-grade oil will not suffer any cleanliness or deposit shortcomings compared to an equivalent single-grade oil. An important phrase is a PROPERLY CONSTRUCTED MULTI-GRADE. The selection of a VI improver would be an important aspect, a VI improver not designed for or not up to the requirements of a heavy-duty diesel engine has the potential to decompose in the high temperature areas of the engine such as the piston ring area and generate lacquer deposits and carbon binding deposits. So the answer to the question is that there must be proper formulation of the oil. A properly compounded multi-grade oil certainly will be equivalent to a single grade and this is addressed to a degree in our published paper. I have extra copies of the paper in case someone would like to look at it.

Ross Gill—Southern Pacific

Do I understand you correctly in saying that the multi-grade oil or a single-grade oil in terms of cleanliness and deposits is more dependent on the formulation of the oil than it is on the grade of the oil?

Doug Carlson

The difference in viscosities comparing the single grade to the multi-grade does not have a significant affect on cleanliness. What does enter into it is the multi-grade, unlike the single grade oil, contains an additional additive. It contains a VI improver and the VI improver must be up to the environment, and if it is not, it has the potential to reduce the cleanliness of the engine using the multi-grade oil.

Eli Shamah—Chevron Research

We are running field tests with multi-grade oils. Inspections to date show directionally cleaner engines compared with control units using single grade oils. However, I don't know if the difference is statistically significant. In general, our field experiences show multi-grade oils to be equivalent, in engine cleanliness and deposit control, to the respective single grade reference oil.

Curt Dieterich—Southern Pacific

With all the information we have available and certainly all the benefits that are shown with the multi-grade oils and the higher TBN's that the

new generation oils have, I'd like some input from both builders as to where they stand on approving these types of oils.

Tom Savage—EMD

I'm responsible for the approval of new engine oils. EMD has published procedures for approval of lube oils, and we are entertaining and approving requests for field test on these oils. These new oils generally have 17 TBN ratings and are considered generation IV or advanced generation IV oils.

Ross Gill

Are the oil companies coming to you and you run the tests?

Tom Savage—EMD

EMD'S procedure, and what normally happens, is that the additive company sends us data on the lab bench tests for the lube oils that are under consideration. We review the data and ask them questions if need be and issue a full-scale field test approval on the oil, and then the oil would go into a one to two year field test conducted by the additive company. The length and type of test is determined by EMD considering the type of oil, how new it is, what we know about the additives, and what the base stocks are. In general, that's the way the procedure goes. The tests to initially qualify an oil are lab tests done by the additive companies, the data is provided to EMD, we review the information to determine what sort of field tests are required, if any, and upon satisfactory completion of testing, the oil is fully recognized by EMD.

Ross Gill

In this process of getting recognized or approved by EMD, are there multi-grade oils now recognized or approved by EMD?

Tom Savage—EMD

Yes.

Dennis Bachelder—General Electric

At the moment, we have one multigrade oil approved for use outside of the country; in South Africa. We are currently involved in field testing multi-grades on a major North American railroad with the locomotives in heavy-duty service. The field test follows LMOA guidelines in addition to preliminary type screening tests done by General Electric. Based on the results of the field test, GE approves an oil for use in GE manufactured locomotives.

Ross Gill

Is this just a single manufacturer or is there a group that you are working with?

Dennis Bachelder

We actually have quite a group of manufacturers. There are two different oil additive manufacturers field testing at the moment. By June, we should have final reports written and the results analyzed. By the end of the year, we should have an idea as to what the situation is although the results may not be fully analyzed.

Jim McClain—Arrowsmith

With the different viscosities encountered with the multi-grade oil, will there be consideration given to the affect on hydro-dynamic bearings in the turbo?

Dave Scott—EMD

Not to put too fine a point on it, but we run the field test and our turbo-charger doesn't have a problem. In those activities where the locomotive is equipped as it was designed, there has not been a problem and that's why Tom Savage specifically answered the question about the field test process to verify that sort of thing.

Dennis Bachelder—GE

In the field test which was run using the oil we have approved, the turbo-charger bearing was part of the final inspection, and there were no indications of a problem with the turbo-charger bearing.

Jack Hillard—Texaco

I cannot comment specifically on the turbo-charger, but I would like to comment on the hydro-dynamic bearing lubrication of multi-grade oils, in general. We have done a lot of testing, both ourselves and with the ASTM Committee working on this, and multi-grades do not give drastically different hydro-dynamic bearing film thickness in a controlled test. In other words, the oil film thickness with a multi-grade (10W40, 15W40) is only nominally lower in our testing than a straight 40 grade and in fact, even though the VI improver may shear in use, the actual bearing film thicknesses with the sheared VI improver are the same as when the oil is new.

Bob Helene—Caterpillar

I've got corporate fluids in the 3600 engine and 3500 engine. Both have run in locomotive service with multi-grade oils at various times, and we have found no deteriorating affect as compared to the straight weights.

Question:

Directed to Jim Hogan of Caterpillar

You showed a slide of the 3600 engines that alluded to "lube oil senstivity" and remarked that current oil systems could be used in the "CAT" repowered locomotives. What, if any, approvals are required for lube oils in the 3500 and 3600 engines? Are warranties in effect?

Carl McClung—Caterpillar

Let me start by responding to the 3500 engine portion of that question. The 3500 engine doesn't really require anything other than a typical railroad class oil. It is relatively insensitive. It has its own onboard filters. The 3600 engine, initially, as we started into the early application, had some deposit sensitivity. Since then, we have added the upper liner cooling with the drilled liner flange which has desensitized it. That may have been what the questioner was alluding to. We do have procedures to qualify oils and have investigated the capability of various oils. I'm not sure I answered the question because I'm not sure I fully understand it.

Jim Hogan—Caterpillar

I wrote the paper. What he's referring to is the original 3600's put into service. We had to control the grades of oil being used. It's like anything that is a new product. We learned as we progressed. We have done a lot to change the engine. One of the complaints the railroads had on the 3600 engine is that we had a limited number of oils which were qualified. The modifications that Carl referred to have now allowed us to use much broader grades. Before any 3600 engine is put into application, we still want to make sure that the railroad grades of oils being used are within the parameters the engine can use. This cooling system that we put inside the piston helped a bunch.

Ross Gill

As I understand what you're saying, the 3600 engines do have, perhaps, a tighter, more defined specification on oil than the general overall oils that we buy?

Jim Hogan

They certainly started out that way. The engine was more sensitive. The modifications were intended to desensitize the deposits on the piston. That has been accomplished.

Ross Gill

Thank you very much. Before I get to the last question, does anybody want to ask some questions that haven't been handled.

Henry Alford—Hatch & Kirk (a company from the marine industrial sector)

Although EMD has done a fine job of marketing the laser hardened liner (the HUB liner), in our marketplace we have found that the liners have met with mixed reviews. I was wondering if I could get some feedback from you people on your experiences with that liner.

Gil Bruno—Amrtak

In our fleet, we use the HUB liners extensively and, by virtue of the duty cycle that Amtrak locomotives experience, they've worked out pretty well. We've also used chrome liners, of course, from various manufacturers. By and large, the HUB liner has performed very well in the type of service that the passenger locomotives see. Perhaps John Drozd would like to comment on other duty cycles in terms of the performance of the HUB liner.

John Drozd—EMD

Our experience with the HUB liner on 710 and 645 engines has been very good. It all depends, especially in the marine industry, on the type of fuel burned which could affect power assembly performance, but as far as the HUB liner, we're happy. It's been very successful.

Ross Gill

Anybody else care to comment on their experience with the HUB liner.

Dave Scott—EMD

One quick comment. We currently provide a chrome liner for marine applications where the anticipated fuel sulphur content will exceed something on the order of seven-tenths to one percent sulphur. Certainly, North American railroad applications don't meet that kind of guideline. In the application where the power assembly useful life is limited by the wear limitations of the friction surfaces of the piston ring, primarily, and in chrome liners, there is a ductile iron ring that we provide that has, by far, a greater mass of material to be removed before it reaches condemning limits, and in the high sulphur fuel application, that is the preferred power assembly. We certainly don't see the corrosive wear affect in normal fuel sulphur applications and, universally, our experience has been that the HUB liner and the stainless steel top ring is by far the longest wear life power assembly for North American railroad applications.

Ross Gill

Dave, is there a recommended cutoff on sulphur in the fuel as far as when you use chrome versus iron?

Dave Scott

I think our cutoff is seven-tenths percent. The crossing point of the wear life curves is at seven-tenths percent sulphur. Nominally, for conversation purposes, one percent sulphur seems to be a place you would probably opt for chrome liners and ductile iron top rings with heavy side plate of chrome on the side of the ring to maximize wear life.

Ross Gill

What do you project in extended life over what we had in terms of the iron liner that we're all so use to in the 645's. What is the iron liner life versus the HUB liner life? How much better is the HUB?

Dave Scott

In life to replacement of the power assembly, the power assembly taken as a whole (which includes the new pistons, rings and HUB liners) versus what would have been typical for an engine delivered with soft liners, something between 50%-100% longer wear life seems to be demonstrable in back to back testing where we are very careful about controlling the variables and are able to normalize other things like duty factors and things we tested. In even numbered and odd numbered power assemblies in a given engine and in locomotives within a small delivery on a customer's property, that appears to be very repeatable and demonstrable kind of wear advantage for that power assembly. The wear life of the power assembly, of course, is not significantly a thing that you inspect for and look at the liner and decide it's worn out. It's a factor of piston ring wear and, of course, the HUB liner appears to be more compatible, over the long term, with the chrome faced ring and the other wear advantage design changes we've made in the power assembly over time. The short answer is 50% more to twice as long.

Ross Gill

Any more questions about the upper hardened bore liner?

Question:

The keynote speaker on Monday mentioned that there weren't any papers in LMOA on eliminating road failures. Does anyone in LMOA have any idea how much a road failure costs the railroads in terms of net present value?

Marvin Varns—BN

We estimate that a road failure on our railroad costs us $1,300.00 every time we have a failure.

Ross Gill—SP

Thank you. I'll put that down.

Gil Bruno—Amrtak

On Amtrak, a road failure is significantly higher when you factor in the inconvenience to the passenger and carrier.

Ross Gill

Bill Brown was just making the comment that if you own one locomotive and it is out of service, you're out of business. I had one last question in the box that was really kind of interesting. What happened to Casey Jones? The only answer I have for you is that he is in the Napa Valley Wine country running old Alco's. I want to thank all the committee chairmen for participating and all who asked questions and gave us their attention, and we hope to see you next year and that the problems will be fewer. Thank you very much.

DIESEL MATERIAL CONTROL COMMITTEE SEVEN-YEAR INDEX

1987
Materials — The Link Between Productivity and Quality

1. Supplier Selection from Component Failure Analysis
2. Vendor Performance or Service Level
3. Bar Codes
4. Bar Coding — Railroads
5. Material Handling Innovations by the Airline Industry

1986
Electronics: New Methods For Handling Material — With Proper Quality and Sources

1. The In-House Electronic Requisition System.
2. Electronic Data Interchange
3. RAILINC and Electronic Purchasing
4. Quality Evaluation of Material
5. Sourcing Decisions

1985
Controlling the Material Investment — A Requirement For Deregulation

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
Material Control In A Changing Environment

1. Bar Coding of Material
2. Forecasting 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
Material Systems — Action Through New Ideas

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
Maintaining Product Quality Through Improved Material Handling

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
Diesel Material Control: Innovations In Material Handling and Control

1. Disposal of Unserviceable Component Parts: What is the Most Profitable Method?
2. Innovations in Stores Material Handling, Via Computer Technology
3. Locomotives Held for Material: An Update for the 80's
4. The Best Approach to Procuring Material; New, UTEX, Repair and Return or Shop Repair

DIESEL ELECTRICAL MAINTENANCE COMMITTEE SEVEN YEAR INDEX

1987

Maximizing Fuel Efficiency Through Quality Electrical Maintenance Program

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

1986

Cleaning, Handling and Storage of Electrical Equipment

1. Solid State Components
2. Rotating Equipment

Qualification of Locomotive Power Plants Through Self Load

GE Load Test
EMD SD40-2 Load Test

1985

Innovations, Maintenance and Troubleshooting Locomotive Electrical Systems

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

1984

Electrical Technology To Improve Performance

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

New Solutions To Locomotive Electrical Problems

1. Ground Relay Trouble Shooting
2. Traction Motors
3. Locomotive Storage (Electrical)
4. Water Cooling and Refrigerating Methods for Locomotive Cab Application

1982

Quality Maintenance — Assuring Thorough Repairs

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

1981

Innovation: Past and Present Traction Motors

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

DIESEL MECHANICAL MAINTENANCE COMMITTEE SEVEN-YEAR INDEX

FUEL AND LUBRICANTS COMMITTEE SEVEN-YEAR INDEX

1987
Improved Products Through Technology

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
Fuel and Lubricants — Effect on the Bottom Line

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
Managing Maintenance For Quality Performance

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

1984
Improving the Bottom Line: With Technology

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

1983
Changes in Fuels and Lubricants

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

1982
Quality Maintenance Thru Fuel and Lubricants

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
Problems, Solutions and New Techniques In Fuel and Lubrication

1. Effects of Using Alternate Fuels on Existing Diesel Engines
2. Update on Cold Weather Procedures for Fuels
3. New Techniques in Lube Oil Analyses
4. Traction Motor Gear Lubrication
5. Multi-Viscosity Oils as an Energy Conservation Technique

NEW DEVELOPMENTS COMMITTEE FIVE-YEAR INDEX

SHOP EQUIPMENT COMMITTEE
SEVEN-YEAR INDEX