LMOA

Locomotive Maintenance Officers Association

Proceedings of the 51st Annual Meeting
Chicago, September 17-20, 1989

COVER PHOTO BY JERRY PALMER, courtesy Peaker Services, Inc.

1989 Advertisers Index

LOCOMOTIVE MAINTENANCE OFFICERS ASSOCIATION

LOCOMOTIVE MAINTENANCE OFFICERS ASSOCIATION APPRECIATES THESE 1989 SUPPORTING ADVERTISERS

AEROQUIP CORP.	CONOCO	JAGGERS EQUIPMENT CO.	NEW YORK AIR BRAKE CO.	STACKPOLE CORP.
ALTOONA GEAR	C & H CHEMICALS	JBI, INCORPORATED	OGONTZ CONTROLS CO.	SUNDSTRAND DATA CONTROL, INC.
AMERICAN AIR FILTER	DUROX EQUIPMENT	LPI, INCORPORATED	POWER PARTS CO.	TAME, INC.
AMOCO	ELECTRO MOTIVE DIVISION	LUBRIZOL CORP.	PRECISION BEARING CO.	TECH. SVC. AND MRKTG., INC.
ANA LABORATORIES, INC.	FARR CO.	LYONDELL PETRO CHEMICAL	PRECISION NAT'L. PLATING SVCS.	TELEDYNE METAL FINISHERS
ANALYSTS INC.	FINE ORGANIC	JOHN W. MAHON CO.	PRIME MANUFACTURING	TEXACO, INC.
ARROWSMITH INDUSTRIES	GENERAL ELECTRIC COMPANY	M & J DIESEL LOCO. FILTER CORP.	PROCECO, INC.	TOUCHSTONE, INC.
AUTOMATIC EQUIPMENT	GEN. ELEC.—APPARATUS SVC. DIV.	MILLER FELPAX CORP.	PULSE ELECTRONICS, INC.	TRIANGLE ENGINEERED PRODUCTS
CAM INDUSTRIES	GRAHAM WHITE	A. T. MOELLER CORP.	RAILROAD FRICTION PROD. (WABCO)	UNION OIL COMPANY
CATERPILLAR, INC.	GRIFFIN WHEEL	MORAN ELECTRIC SVC., INC.	SHELL ADDITIVES	VALVOLINE OIL COMPANY
CHEVRON CHEM. (ORONITE DIVN.)	HEGENSCHEIDT CORP.	MOSEBACH MFG. CO.	SHELL OIL CO.	VMV CORP.
CHEVRON USA	HUGHES RWY. SUPPLIES CO.	MOTOR COILS, INC.	SIMMONS MACHINE TOOL CORP.	WILSON RWY. CORP.
CITATION CHEMICAL	HYDRO DYNAMICS	MOTOR OILS REFINING CO.	SNAP-ON-TOOLS CORP.	WIX CORP.
J. L. CLARK MFG.	INTERSTATE DIESEL		SNYDER EQUIPMENT COMPANY	

ADVERTISERS HONOR ROLL

ATTENTION ALL MEMBERS:

WE DO NOT ENDORSE ANYONE'S PRODUCT, BUT WE **DO APPRECIATE** OUR ADVERTISERS.

Listed above are the names of the ADVERTISERS whose ads appear in our ANNUAL PUBLICATION.

We appreciate the fine financial support these advertisers provide.

We hope to see **these and many more** advertisers' names displayed in this fashion at all of our future **Annual Meetings.**

Be sure to read their ads in the Annual Publication.

INDEX

TECHNICAL PAPERS

JOINT OPENING SESSION OF THE COORDINATED ASSOCIATION CONFERENCES
Monday, September 18, 1989

PRESIDENT BROWN: I am both honored and pleased to open the 1989 Convention of the RSA and the Coordinated Association Conferences by extending a warm welcome to all of our members, their families, guests and associates who are attending this morning. A special welcome to our friends who have travelled to Chicago from beyond our borders - Mr. Alan Constable from new Zealand and Dr. Julian Barnes from England. A warm welcome to one and all.

It is now my privilege to introduce Dr. William D. White, Retired Senior Pastor, Chicago Temple, First United Methodist Church of Chicago, who will give the invocation.

Will everyone please rise!

DR. WHITE: Let us pray. God of all creation, we gather, this date, seeking your blessings upon the meetings that lie before us. We are grateful for the beauty and the energy of this great city in which we meet and are thankful for the safe journeys of all gathered.

Grant the mercies of safe travel as we return across this continent and to New Zealand and to England.

Oh God, may we leave each other after days of new insight, satisified that we create more than machinery and schedules.

By your Grace, we are able to make it possible for goods to be delivered, and, far more importantly, lives of millions to be affected.

We pray for those who will address us. May they use the stewardship of their intellects to lift our sights to greater possibilities within our industry and new understanding of the importance of what we do.

By the time we adjourn, give us deeper appreciation of those with whom we work day by day. All this, we pray, in the name of our God, our Creator and our Saviour, Amen.

PRESIDENT BROWN: Thank you, Dr. White, for your kind and thoughtful words. At this time, I'm pleased to introduce the Committee and Presidents of each of the Associations. Mr. Donald Tutko of CSX won't be here this morning. We have Mr. Victor Mizrahi, Chief of Motive Power and Car Equipment, Canadian National Railways; Mr. Douglas Sizemore, Asst. Vice President & Chief Mechanical Officer, AT&SF Rwy. Co. The Association Presidents are Mr. Ira Jones, Mananger of Air Brakes, Union Pacific Railroad and President of the Air Brake Association. Mr. Fred Lonnes, Superintendent-Electrical Vehicle Design, Chicago Transit Authority, President of the Car Department Association; Mr. C.J. Tindol, Director of Operating Practices, Grand Trunk Western and President of the International Association of Railway Operating Officers. We also have Mr. Bill Burrows, Executive Director of the Railway Supply Association, and Mr. Ed Goedeke, who is President of the RSA.

Next on our agenda this morning is the keynote address to be given by Mr. Donald W. Henderson, Vice President-Technology, Engineering and Maintenance, Burlington Northern Railroad. Introducing Mr. Henderson has turned out to be a more difficult task than I anticipated when he first accepted our invitation to be with us this morning.

To even briefly note each of his achievements, would take a lot more time than I'm allowed for the program.

Mr. Henderson's leadership and decision-making position on a major U.S. Railroad such as Burlington Northern is, I think, a tesimony of the changes that are occurring in our industry.

Mr. Henderson began his career, not as a railroader, but in the service of our country in the United State Air Force.

In a career that spanned some twenty-six years, Mr. Henderson achieved the rank of General Officer, a most remarkable accomplishment.

During those twenty-six years, Mr. Henderson achieved degrees as Bachelor of Science, Aeronautical Engineer, University of Virginia; a Masters of Science, Astronautical Engineer, University of Michigan; a Masters of Science, Instrumentation Engineer, University of Michigan; and a Masters of Science, Systems Management, University of Southern California.

Some of the general areas of his responsibility during his career included research and development, weapons system acquisition program management, astronaut training, and space system development test launch.

Some of the specific jobs he was responsible for are as follows: Program Manager for the Navastar Global Positioning System. That's a new worldwide navigation satellite system; Program Manager for the United States Anti-Satellite Program that shot down a U.S. Satellite on a test mission; and Commander, Space and Missile Test Organization, responsible for launch of all Department of Defense satellites and the west coast space shuttle launch facility.

Burlington Northern was very fortunate to have Mr. Henderson join us in 1986. In his present position, he is responsible for research and development, technical training, track and structures and mechanical equipment, which includes locomotives and Ladies and gentlemen, **Mr. Donald Henderson.** (Applause)

MR. HENDERSON: Thank you very much. It's a pleasure for me to have the opportunity to address this group this morning.

What Bill didn't mention amongst those accomplishments, there were a few if those programs that didn't quite make it off the launch pad, like the ASAT Program, The Anti-Satellite Program, which has subsequently been cancelled. Maybe it was a little too successful in the test phase.

I think many of you know that the Department of Defense made the decision not to launch the space shuttle from the west coast, so we have a beautiful 3.2 billion dollar facility sitting out there almost ready to go in mothballs.

But be that as it may, those are some of the pros and cons of being in a research and development business. You drill a few dry holes every now and then.

I'm sure I don't need to tell a lot of people in this room that there's a lot of effort that goes into arranging a conference like this.

And I thought I'd share with you some of that effort that goes on in the preparation that Bill went through to inform me of some of the things I might expect with this group in attendance today, since it's quite a varied group.

So let me just read from a letter that I got from Bill to sort of prepare me for this group.

It say, "Dear Mr. Henderson, we're pleased that you have accepted our invitation to speak at the 1989 Technical Conference of the Coordinated Mechanical Association's and the 28th Annual Convention of the RSA.

"The following information may assist you in preparation of your remarks. Your audience will consist of members from the various Mechanical Associations and the Railway Supply Association.

"The following characteristics will help you identify various groups in the audience. Members of the LMOA will be the sharp dressers, who look very alert. (Laughter)

"People in the dark silk suits with receding hairlines will be members of the Air Brake Association or the Car Department Officers Association." (Laughter) I started to take a little bit of umberance at that myself.

"And the members of the International Association of Railway Operating Officers will appear to be staring intently at the podium, but in reality will be reading USA Today on their laps. (Laughter)

"And finally, the people asleep in the back rows will most surely be members of the Railway Supply Association." (Laughter)

And he goes on to say, "we have provided you a script approved by all the associations and suggest that you follow it closely.

"Due to our strict time constraints and your southern drawl, you may find it necessary to speed up your normal reading pace. (Laughter)

"We look forward to a interesting talk. Sincerely, Bill Brown." (Laughter)

Well, I said with that kind of preparation, I'm not sure I'm ready to talk to this group, but I'll do my best.

If I had to entitle the subject that I want to speak to primarily this morning in one word, that word would be innovation. And innovation as it applies to those of us in the railroad industry.

It's no secret, especially to the people in this group, that the heart of our business is our locomotive and freight car fleets, along with the roadway assets.

And my remarks today will center around the pivotal role that I believe innovation plays in how we step up the critical issues of maintenance, repair and utilization of two of those key elements of our franchise, our locomotives and our cars.

Now for purposes of the time I'm going to spend with you this morning, I'm going to define innovation in a reasonably narrow sense and that is as the willingness to challenge the conventional wisdom.

And history is replete with lots of examples of conventional wisdom that has been challenged very successfully.

I'm going to share two of them that I happen to like particularly well. The first was a very well known astronomer, William H. Pickering who in 1910 was commenting on the prognosis for a trans-atlantic airline industry.

And he said at that time:

"The popular mind often pictures gigantic flying machines speeding across the Atlantic, carrying innumerable passengers in a way analogous to our modern steamships. It seems safe to say that such ideas are wholly visionary. And if the machine could get across with one or two passengers, the expense would be prohibitive to any but the capitalists who could afford to use his own yacht."

And Lee DeForrest, an equally well regarded expert, in 1926 was commenting on the commercial prognosis for television.

He said: "While theoretically and technically television may be feasible, commercially and financially, I consider it an impossibility; a development of which we need waste little time dreaming."

The conventional wisdom. The theme that I'm going to concentrate today is going to be the necessity for us, especially in this industry to challenge the conventional wisdom.

And I think we're seeing, in the railroad industry, a willingness to challenge that conventional wisdom.

Typically, I think this industry has a reputation of being rather nonvisionary, relatively tied to past practices and unwilling to look at new ways of doing business.

But I see a definite change in this industry and I think it's a change that's needed and a change that's occurring much more rapidly than our critics would give us credit for.

What I'm going to do in the remaining time this morning is to share with you some specific examples of how challenging the conventional wisdom has paid off for us at Burlington Northern and try to concentrate on how I think those things could have application to our industry in general and to various other railroads and suppliers in particular.

First, I'm going to cover, since we know that the members of the LMOA are going to be alert and intent, at least initially I'm going to cover things that have to do with locomotive projects.

As many of you know, we've been working on the advanced railroad electronic system as sort of a BN version of an ATCS system for about five or six years.

As part of that particular system, we have been testing a subsystem that we call a locomotive analysis and reporting system, which essentially is designed to give us real time digital information on locomotive health and status.

Based on those test results, we've elected next year to deploy one hundred sets of that equipment on operational locomotives on the BN.

This system will monitor 33 parameters aboard the locomotive and send those data via digital data link to specified locomotive distribution maintenance and service points.

Typical parameters that it will measure include horsepower, fuel and oil quantities, fuel pressure, various other pressures, temperatures and voltages.

We'll use those data to monitor locomotive performance to assist in the assignment and management of our locomotive fleet, to improve the servicing and utilization and to assist in isolation of faults in the troubleshooting process.

A major goal of that system is to reduce the probability of en-route failures and improve our overall locomotive availability.

We spent in excess of four years working the bugs out of that system and we feel the technology is to the point where we're ready to deploy it.

We'll also, over the next couple of years, test four pre-production SD-60 locomotives with AC traction motors in a joint program with EMD and Siemens.

Now this is a part of our overall effort to address the traction motor reliability problems, especially in snow and other adverse weather conditions where moisture is bad.

I'm convinced that AC is a very promising technology with real potential for providing improved reliability, lower maintenance and better adhesion. I think this

technology is directly applicable to the heavy freight operations and the time is now to push it. That's the reason we're doing it.

Another project which shows real potential is the Caterpillar low horsepower engine that we're beginning to install on some old GP-20 hulks in a remanufacturing program.

Our initial indications, based on several months of test data, show fuel savings in the order of 15 to 20 percent.

You add that to the potential, hopefully, for reduced maintenance and overall costs compared to current engines and it looks like a very promising alternative to our existing systems.

We've just completed about a year and a half field test program of multigrade lube oils. The results show not only fuel savings, about 1 percent in notch 8 and up to 4 percent in idle, but also showed a reduction in lube oil consumption of nearly 20 percent and the potential for increased engine life, better low temperature flow and very good viscosity retention.

As a result of that test program, we've just made the decision to switch our entire fleet to multi-grade oil. We're in the process now of taking bids from vendors to implement it.

On the car side, we're working with several vendors on what I consider to be one of the more significant things that we've done in the last couple of years. That has to do with the development of some wayside acoustic field bearing detectors.

We completed a test program at Pueblo last year where we tested two manufacturer's prototypes with some known bad bearings on a consist of cars for several months.

During that test program, we had two rather spectacular events occur. We had two bearings go to catastrophic failure while they were instrumented. In both cases we were monitoring temperature.

Bearings were running 50 to 100 degrees above ambient as normal operating temperature, and in both of those catastrophic failures, the time from initial temperature rise until catastrophic failure of the bearing was less than sixty seconds, which told us that in many respects, trying to detect failing roller bearings with infra-red detectors was almost like rolling the dice. There were at least a couple of different types of failures that would not be very suitable to being detected by the heat-sensing detectors.

We also saw a couple of other bearings which on one day had a very high temperature rise, then went back to normal operating temperature and didn't show that high temperature rise again. They were known bad bearings.

As a result of that, we decided to deploy two acoustic detectors on our railroad and put them in operation. One was a little more mature than the other and we've had one system in operation since February of this year.

It's outside of Alliance and we're scanning about 125 empty coal trains per week. Why empty coal trains? We want to use this device as a tool for preventative maintenance.

One of the things I don't like about IR detectors is that even though you detect a failing bearing, a bearing that's generating heat, the best thing you can do about it is bad. The best thing you can do is stop a train and set out a car. It's costing you money and it's costing you an impact on customer service.

What we want to do with the acoustic detectors is to use them in a preventative way.

In this test site, about 16 miles east

of Alliance, we're running empty coal trains by at 45 miles an hour. When we initially put that system in operation, we found 20 to 30 FRA condemnable bearings per week.

We're now to the point where we're getting maybe 10 to 15 bad bearings per week. Since February of 1989, with that one detector, we've taken 600 bearings out of service, out of the coal fleet that runs past that detector at Alliance.

We've torn down over half of those bearings. We just haven't gotten to the rest of them yet, and at least 90 percent of them are FRA condemnable. I would categorize them as severely spoiled cups and cones primarily the types of failures we're picking up.

So based on those test results, by the end of this year we wil have five acoustic bearing detectors in operation on BN and we plan to install six more in 1990.

Another interesting car-related project grew out of some R&D efforts that we began back in 1984-85 (truck frame bracing). A cross-bracing system for freight car trucks.

We first started looking at that to determine the effects of installing those systems on wheel wear and fuel consumption, and as a third objective to look at the stability of the car truck equipment.

The stability aspect was especially important to us since we, like everybody else, had a 45 mph restriction on empty bulkhead flats because of some severe truck hunting problems.

Our tests at Pueblo, under very controlled conditions showed that the addition of the frame bracing to severely worn trucks reduced the onset speed of axle and carbody hunting above the service worn and reconditioned trucks to well over our maximum freight car speed of 60 mph. As a matter of fact, we ran some up to 80 mph.

As a result of that, we are in the process now of applying frame bracing to our first 400 bulkhead flats and lifting the speed restrictions on those cars.

We have frame bracing applied to ten coal hopper cars as a test program. If the cost of those kits comes down, I'd like to equip every freight car on Burlington Northern with it.

Significant benefits, I believe will be not only in truck stability, but also in wheel wear, rail wear and reduction in rolling resistance.

Now many of us might not think that another project I want to talk about is really a freight car project, but I'm convinced it is.

I think all of us here are pretty well familiar with our industry's abortive attempt to deploy an optical scanning car identification system or ACI system back in the 1970's.

Today's transponder, RF transponder-based, automatic vehicle identification system appears to offer a very good solution to the ACI's technical problems and at a lower cost.

We've just completed a year plus test program of two transponder-based AVI systems on the Missabe iron range in Northern Minnesota.

Our test fleet included 1600 tags from two manufacturers, on taconite cars and on locomotives. In that time period, we've made over a million reads since April of 1988 with an accuracy exceeding 99.99 percent.

This year, we'll acquire 4000-plus tags for our locomotives, our rear of train devices, our cabooses, our air-repeater cars and our fuel tender cars. We'll acquire 28 readers this year and an additional 26 readers in 1990.

Obviously, the initial goal is to improve the management and utilization of the assets that the tags were installed on, primarily our locomotive fleet and our rear of train devices.

One of the reasons why we waited this long in deciding to deploy this system was that we wanted to make sure that there was at least an interim standard established for a car identification system.

The AAR has taken action to define at least two of the three elements that are needed in that system. The frequency and protocol has been defined, the tag content, data content has been defined and the issue that's not totally resolved at this time is the tag location.

We're taking a flyer and we're going to locate where we think it's going to be. If we have to change them later, we have to change them.

By the way, we've looked at several mounting schemes and a double-faced tape appears to be a very acceptable solution and quite a cost-effective one.

I'm firmly convinced that AVI is a technology that we sorely need in the railroad industry. And the quicker we get that technology deployed across the entire railroad system, the better off we're going to be in serving our customers and meeting our competition head on.

The kind of innovative technology that we developed through R&D is essential; but it's just as essential, I think, to challenge the conventional wisdom in how we manage our mechanical resources.

For many years, the conventional wisdom when it came to locomotives was that the only way to improve the breed was through technological change in the equipment itself.

I think one of the things we found on the BN in the last couple of years is that the way we handle our locomotives is just as important to cost and service to our customers as what those locomotives are made of.

All of you are aware of some of our initiatives in power-purchase agreements and the so-called power by the hour concept, where the locomotive builders take a heavy role in the responsibility for locomotive maintenance and performance.

They've been very successful for us. This idea has caused the manufacturers to take ownership for the product after the sale. It provides an incentive for them to improve technology and build a better quality locomotive and better quality replacement parts, thereby improving the wear life and extending the overall cycles which results in reduce maintenance costs.

Based on our experience with these power purchase agreements, we've made the decision to use that maintenance concept, a joint maintenance concept between the manufacturer and our own employees, for the new locomotives that we're acquiring through traditional purchase techniques.

Secondly, to address the need for low to medium horsepower locomotives at a reasonable cost, we've entered into a competitive remanufacturing process, a process that allows us to take 25 to 30 year old hulks and turn them into modern locomotives with current technology (electronics primarily) and provide a new life expectancy of at least 20 years, with — and this is the key — a three-year warranty at about 60 percent or so of new locomotive acquisition costs.

The combination of a manufacturer's involvement in locomotive maintenance and performance, the remanufacturing process which allows us to get more locomotives in the medium horsepower range rebuilt into the fleet for a given dollar and improve quality assurance and maintenance has improved the mean days between failure for the BN locomotive fleet from an annual average of 23 days in 1985 to right around 66 days in 1989.

Let me now turn to just a few words on freight car quality, an absolutely essential element of good customer service.

Give a customer a poor quality car that he rejects and you not only risk losing his business, but you still have to provide another car.

At BN in 1981, we had a 110,000 freight cars and about 3,600 locomotives.

Last year, our average fleet size was down to less than 63,00 freight cars and about 2,530 locomotives. This is a drop of more than 42 percent in cars and 29 percent in locomotives.

I suspect that every other railroad represented here has seen similar kinds of reductions.

The bottom line is that we no longer have the capacity in this industry to keep coming back with another empty until we get one that's acceptable to the customer.

Nor can we afford the on-line failures for locomotives that cause train delays and delays to customer shipments.

We have to do it right the first time; the old traditional do it right the first time, because we just don't have the time or the equipment to do it over.

Attaining and maintaining the quality that's necessary in today's competitive environment has led us to look at locomotive and car maintenance in a totally different light.

I think, traditionally, this industry, like many other industries, has looked at and followed the old, "If it ain't broke, don't fix it" rule of thumb when it comes to equipment maintenance, especially on the freight car side.

But what does waiting for it to break mean in terms of customer service? We all know. It means a delay. It means moving a car and not getting paid for it. It means a total inability to plan or schedule work on cars and locomotives. And it means you have to have more backup equipment.

Those risks just aren't acceptable in a marketplace were low cost and high service are necessary to compete.

So last year, we began a rather aggressive preventive maintenance program, in addition to our normal maintenance program for freight cars. Our goal is to schedule freight cars into the shop every four to six years to upgrade the condition of such components as interiors, doors, and running gear, if it needs it, instead of waiting for a car to go bad order or for rejections of a given car type to go above a certain pre-defined standard.

Our new rule of thumb, if I had to characterize it, I suppose would be "Fix it before it breaks."

The last area I'd like to comment on is the area of training our people. In the past, I think BN, like most other railroads, used on-the-job training to train most of its operating employees. Firemen became engineers, brakeman, conductors, operators, dispatchers and so on and so on.

And several years ago, we recognized that if we were going to be faced with rather significant reduction in our employee count to remain competitive, it was absolutely essential that we concentrate on giving those remaining employees the best possible training that we could.

So we've seen a definite shift in our training emphasis, from an apprentice-oriented training program to a journeyman-training program. And from normal, on-the-job training to more formal training.

We've begun to use simulators extensively in training not only our locomotive engineers, but also our mechancial people, our signal people, our communications people and our engineering people.

We in the industry, just like any other industry, can't afford to be critical of our employees when they do their jobs improperly unless we've given them the tools — the tools being the knowledge to do that job right.

The competitive environment resulting from Staggers has led to very fundamental changes in the way we do a lot of things, including the way we build, own, maintain, manage and utilize our freight car and locomotive fleets, and in the way we train our employees.

Staying competitive in the transportation marketplace means not only reducing costs, but also means improving customer service.

The conventional wisdom in the railroad industry has, I think, been that customers are primarily interested in price. But that's definitely not the situation. All of our surveys indicated that customers are just as interested in service and quality.

Even more interesting is that our customers told us that condition and availability of equipment are almost as important to them as price and service.

So when you ask a shipper whether he wants quality service or low price, the answer is yes. And we can't afford to offer either quality or service and stay competitive. We've got to offer both.

Customers want quality service, and quality service begins with quality equipment in the railroad business. And we've got to give them that quality equipment to stay competitive.

If we're going to continue to meet both the price and service needs of our customers, we can't go back to the days of regulation and we can't stay static by doing business the way we've always done it.

Our only choice is to go forward and to be more innovative. Business as ususal just isn't good enough to keep us competitive.

These's a lot of interdependence in the railroad industry among the equipment suppliers, the repair organizations and the utilitzation people; all of those people need to be key players in keeping the impetus stored innovation going.

Business as usual is just not going to cut it.

In the next several days here, you're going to hear about some innovative things that are going on in various aspects of our industry.

I think the challenge to all of us here today is to take that spirit of innovation back to our own organizations and put it to work.

Not only for our own good, for our own company, our own organization's good, but for the overall good of the railroad industry in general.

I think we need to take a good, hard swipe at knocking down the traditional image that the railroad industry has of being reluctant and resistant to change. We can definitely be a part of changing that image; a change that in my opinion is long overdue.

Bill, I thank you and the people who organized this function for giving me the opportunity to speak to you. It's been a pleasure and I look forward to continued association with the group.

Thank you very much, ladies and gentlemen. (Applause)

PRESIDENT BROWN: Thank you, Don, for your very interesting and innovative remarks. And a special thank you for taking time from your busy schedule to be with us this morning.

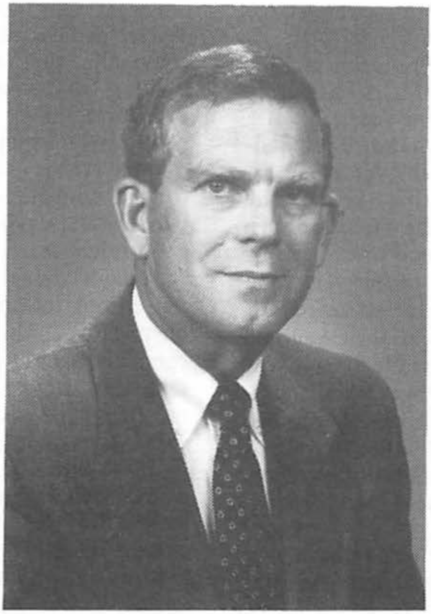
In appreciation, I'm pleased, on behalf of the LMOA and the other associations, to present you our general desk set and with it an honorary life membership in the LMOA. (Applause)

MR. HENDERSON: Thank you very much, Bill. I don't have one, it's beautiful and I'll guarantee you it will replace one of those scroungey rockets on my desk at a prominent place. (Applause)

PRESIDENT BROWN: In closing, I want to thank everyone for being here this morning and at this time, we will adjourn to our respective meeting rooms.

The Locomotive Maintenance Officers, well-dressed, intelligent group stays in this room.

Thank you very much.



DONALD W. HENDERSON
V.P.—Technology, Engineering and Maintenance
Burlington Northern Railroad
Overland Park, KS

MONDAY, SEPTEMBER 18, 1989
1:30 P.M.

BILL BROWN'S PRESIDENT'S ADDRESS

I've had a very special honor to have served as President of the LMOA for the past year, which happens to be our organization's 51st year since it was founded.

Over the past year, I have had many people to thank for the support and assistance given to me to make the duties of this office an enjoyable and memorable experience.

I want to especially thank our Secretary-Treasurer, Ron Pondel, for a super, super job.

All of our Vice Presidents and the Executives of the LMOA have given 110% throughout the year.

Our Committee chairmen responded with what I think are some excellent papers this year. The Chairmen and all the Vice Chairmen did an especially good job.

We've lost some of our very good officers this year due to retirement and other events in their railroad career. Ross Gill left the SP this year and I understand Roger Vitek is leaving the C&NW Railroad. He was one of our Vice Presidents. Marv Varns retired from the Burlington Northern. Also, Leland Salts retired from the Santa Fe.

All four of those fellows have been top notch, heavy hitters in this organization. They're going to be missed.

We want to welcome all of our guests and visitors; the LMOA Past Presidents that are here, the Chief Mechanical Offices from the various railroads and Mr. Don Henderson of the Burlington Northern, who gave us that excellent talk this morning.

Change is a message I want to leave with our organization today. The urgent need to recognize when it's needed and the ability to implement it in order to maintain the longevity of this organization.

All of us tend to resist change. It makes us uncomfortable to be removed from routine, familiar or comfortable surroundings. If offers a path down unknown trails and we often get the opportunity to have to work harder. Most of us tend to resist that.

Face it! Our industry has changed. We're deregulated! We work for companies that are controlled by holding companies who must compete in shrinking and fiercely competitive world that we know today.

Gone are the good old days of life-long, complacent jobs in a bureaucratic environment and I say good riddance.

Today's young railroaders can no longer look toward life-long employment careers where you knew, the company, would always be there to take care of you. Today, everyone has to get out and really produce if you want to find that security.

As we move into the 1990's, who would have imagined the two major locomotive builders being involved either directly or indirectly in locomotive after-market maintenance? They changed for one reason - survival.

When I began my career, who would have thought we could run the U.S. railroad system today with somewhere around two hundred thousand workers? And is the number still an over capacity?

When I started working for the former Great Northern Railroad thirty years ago, there were close to a million railroaders in the United States. That's quite a change.

Ten years ago, who would have imagined the number of short line or regional railroads in existence today? Another sign of change.

What if, in the coming decade, the major railroads consummate further mergers? What happens to LMOA if, for example, we end up with one or two large trans-continental railroads in this country?

What if our railroads end up as freight forwarding type operations with equipment and facilities leased for use as required?

Today, I don't think any scenario or changes are unreasonable to consider. I'm sure there will always be a need for a railroad transportation system, but I'm also sure it won't be as we know it today.

What will the industries, associations and, especially the LMOA, do to ensure its survival? The answer is obvious. The leaders and future leaders of our organization must do whatever is required to initiate the necessary changes to make this organization of value to the industry. The key word, again, is change.

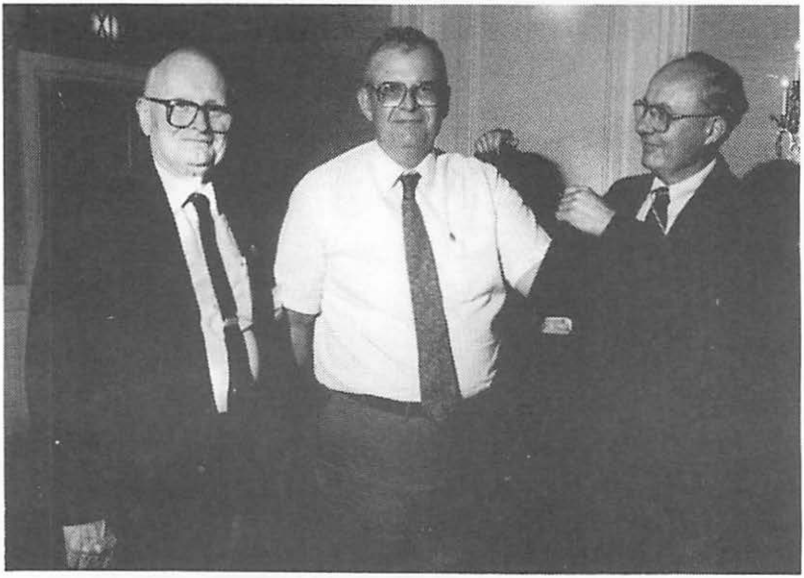
This year, I think we've broken with tradition somewhat by trying to change our presentations, to make them more interesting to hear and enjoyable to attend.

This has been, I hope, a subtle beginning of many changes that will occur in the future.

As I leave this office and the many happy memories I have of being a part of the LMOA, I feel very confident that this industry's future leaders, who will be a part of our organization, will initiate the necessary changes.

Thank You

Newly elected President, Paul F. Hoerath, Conrail, right, presenting LMOA General Desk Set to outgoing President, William A. Brown, Burlington Northern. In attendance at the ceremony is newly elected 1st V.P., Donald D. Hudgens, left, Union Pacific.



Past President, David G. Goehring, Amtrak, right, presenting LMOA blazer to newly elected 3rd V.P. and fellow Amtrak officer, K. Allen Keller. Past President, Tom Harley, Trailer Train, retired, left, in attendance at the ceremony.

TUESDAY, SEPTEMBER 19, 1989
1:30 P.M.

ACCEPTANCE SPEECH
By Paul Hoerath

Good afternoon, ladies and gentlemen. The little saying I decided to come up with for LMOA for this year, (apparently every President has to come up with something) is going to be "LMOA ON TRACK FOR THE 1990s."

I accept the gavel and responsibilities of the presidency of LMOA for the year ahead.

I started with LMOA back in the '60s when I was a member of the Shop Committee from Pennsylvania Railroad. Pennsy became Penn Central and then Conrail.

Changes have been occurring on most railroads at a fast pace, as we are all well aware. Our executives in LMOA are also changing at a fast pace and we continue to lose some very excellent talent. As some members move on to other pursuits, (mostly retirement), new members move up to take their place and LMOA just keeps right on going.

That is not to say that we do not sorely miss our departing executives. It means that those members that are still available take up the task of working to make LMOA a continuing and important organization to the railroads and LMOA members.

As subjects of committee papers are developed, hopefully with problem solutions found and presented to the membership, LMOA continues its important legacy.

The six committees can best function when the railroads of North America are each properly represented on the various committees. We urge each mechanical department to review their membership on these committees and take advantage of this excellent opportunity to bring forth problems for the Committee to develop and report on solutions.

This will allow LMOA to best fill its obligation to the railroads. It is this mutual understanding, contribution of ideas and finding of solutions by the personnel from the large number of railroads that benefit us all. This way, we learn what works, what hasn't worked, when tried, and perhaps understand even why an idea didn't work or what change is necessary to make it work.

The combined talent of these six committees can take on a lot of problems and usually not only find a solution, but find the best solution at an effective price. Many times, these solutions save the railroads untold dollars and ultimately help the bottom line. LMOA has been actively contacting the regional and short line railroads to urge these new forming railroads to become active in the organization.

Discussions are on-going for the possibility of some representation to the committees of LMOA from the various regional, shortline and commuter-passenger railroads. It is felt we can help these regional, shortline and commuter-passenger railroads and that they can help LMOA.

We're going to have a great year with LMOA and I'm looking forward to working with our executive committee during the coming year, which will culminate with the annual convention in Atlanta in September of 1990.

I will expect to see you all there.


8510
8510

Newly elected President, Paul F. Hoerath, center, Conrail, accepting the President's gavel from outgoing President, William A. Brown, Burlington Northern. 3rd V.P. Roger Vitek, Chicago & North Western, left, witnesses the ceremony.

Past President, Dale H. Propp, Burlington Northern, left, presenting the coveted Past President's Pin to fellow Burlington Northern officer, William A. Brown, while Chairman of the Board, David G. Goehring, Amtrak, looks on.

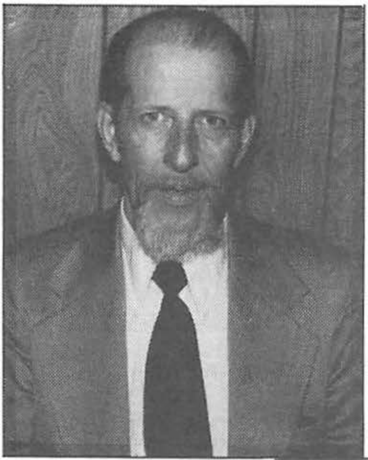
LMOA officers in attendance at the 1989 Annual Technical Conference in Chicago, IL. Seated (left to right): William A. Brown, Brulington Northern; Tom Harley, Trailer Train, retired; Dave Goehring, Amtrak; Dale Propp, Burlington Northern. Back row (left to right): Allen Keller, Amtrak; Don Hudgens, Union Pacific; Roger Vitek, Chicago & North Western; Paul Hoerath, Conrail.

OUR OFFICERS

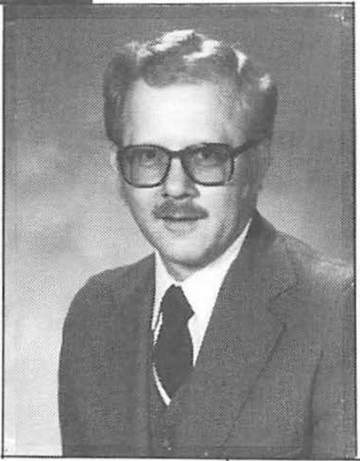
WILLIAM A. BROWN
President
Manufacturing Engineer
Burlington Northern Railroad
Northwest Burlington Avenue
West Burlington, IA 52655

	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
1988	79	226	420	725

OUR OFFICERS



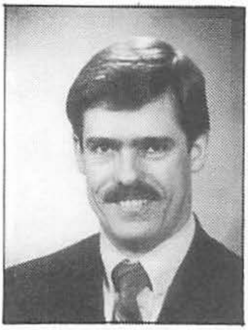
— 1st Vice President —
PAUL F. HOERATH
Sr. Mechanical Engr.-Shops
Consolidated Rail Corp.
Altoona, PA 16603



— 2nd Vice President —
DONALD D. HUDGENS
Mgr.-Research
& Development
Union Pacific Railroad
Omaha, NE 68179

— 3rd Vice President —
ROGER W. VITEK
Dir.-Quality Assurance Mech.
Chicago & Northwestern
Transp. Co.
Chicago, IL 60606

OUR REGIONAL EXECUTIVES



W. R. DOYLE
Shop Equipment
Mgr., Loco. Planning Standards and Programs
Union Pacific Railroad
Omaha, NE 68179

K. ALLEN KELLER
Mgr.-Motive Performance
National Railroad Passenger Corp.
Philadelphia, PA 19103

MICHAEL M. STARR
Plant Manager
Southern Pacific Transp. Co.
Los Angeles, CA 90039

ROSS T. GILL
Mgr.-Production Engrg. & Qual.
Southern Pacific Transp. Co.
Sacramento, CA 95814

LELAND SALTS
Ass't. Mgr. Locomotive
Atchison, Topeka & Sante Fe Rwy.
Topeka, KS 66616

MARVIN L. VARNS
Supt. Loco. Maint.
Burlington Northern Railroad
Overland Park, KS 66201

OUR OFFICERS

PAST PRESIDENTS AND CHAIRMAN OF THE BOARD

DAVID G. GOEHRING
CHAIRMAN OF THE BOARD
Mgr. Loco. Heavy Maint.
National RR Passenger Corp.
Philadelphia, PA 19103

D. H. PROPP
Chief Mechanical Officer
Burlington Northern Railroad
Englewood, CO 80112

D. M. WALKER
Ass't. Shop Mgr.
Norfolk Southern Corporation
Atlanta, GA 30315

DONALD L. WARD
Ass't. General Foreman
Burlington Northern Railroad
Springfield, MO 65083

OUR TECHNICAL COMMITTEE CHAIRMEN

— New Developments —
M. A. COLES
Mgr. Loco. Maint.-Mechanical
Union Pacific Railroad
Omaha, NE 68179

— Fuel and Lubricants —
K. A. BRINKER
Mgr. Environmental Operations
CSX Transportation
Huntington, WV 25703

— Diesel Mechanical Maintenance —
G. J. BRUNO
Facility Mgr.
National RR Passenger Corp.
Seattle, WA 98134

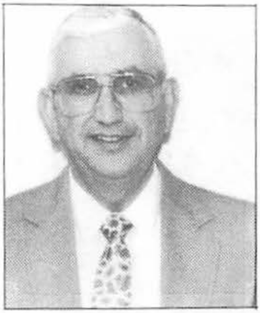
— Diesel Material Control —
C. A. MILLER
Mgr., Loco. Planning Standards
and Programs
Service Design
Union Pacific Railroad
Omaha, NE 68179

— Diesel Electrical Maintenance —
M. PASINI
Equipment Manager-MP
Via Rail Canada
Montreal, Quebec H3B 2G6

— Shop Equipment —
D. E. TETLEY
Manager Facility Planning
Union Pacific Railroad
Omaha, NE 68179

OUR OFFICERS
ADVISORY BOARD

G. W. BARTLEY
Chief Mechanical Officer
CP Rail
Montreal, Quebec, H3C 3E4



R. M. BURK
Ass't. Vice Pres. & CMO
National Railroad Passenger Corp.
Philadelphia, PA 19103

N. M. DOERR
Ass't. Vice Pres.-
Mat'l. Management
Burlington Northern RR
St. Paul, MN 55101

D. W. MAYBERRY
Vice President-Mech.
Norfolk Southern Corporation
Roanoke, VA 24042

V. H. MIZRAHI
Chief of Motive Power
& Car Equip.
CN Rail
Montreal, Quebec H3C 3N4

J. R. NUSSRALLAH
Ass't. Vice Pres. & CMO
Consolidated Rail Corp.
Philadelphia, PA 19103

OUR OFFICERS
ADVISORY BOARD

D. M. SIZEMORE
Ass't. Vice Pres. & CMO
Atchison, Topeka & Sante Fe Rwy.
Chicago, IL 60604

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

SUPPORT STAFF

T. C. SHEDD
Editorial Director
Modern Railroads
20 N. Wacker Drive
Chicago, IL 60606

— PHOTOS NOT AVAILABLE —

E. L. BAUER
Chief Mechanical Officer
Burlington Northern Railroad
Overland Park, KS 66201

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

PAST PRESIDENTS

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
1972— KY PRUCHNICKI (Deceased) General Supervisor Locomotive Maintenance, Southern Pacific Transportation Company
1973— W. F. DADD, Retired Chief Mechanical Officer, Chessie System, 37 Carolina Shores Drive, Calabash, NC 28459
1974— C. P. STENDAHL, Retired General Manager M.P.-Electrical, Burlington Northern Railroad, 1052 W. California Ave., St. Paul, MN 55117
1975— L. H. BOOTH, Retired Assistant C.M.O.-Locomotive, Chessie System, 906-13th Ave., Huntington, W.V. 25701
1976— J. D. SCHROEDER, Retired Assistant C.M.O.-Locomotive, Burlington Northern Railroad, 244 Carrie Drive, Grass Valley, CA 95942
1977— T. A. TENNYSON (Deceased) Asst. Manager Engineering-Technical, Southern Pacific Transportation Co.
1978— E. E. DENT, Retired Superintendent Motive Power, Missouri Pacific Railroad, 13500 S. Outer 40 Rd., Apt. 116 East, Chesterfield, MO 63017
1979— E. T. HARLEY, Retired Senior Vice President Equipment, Trailer Train Company, 289 Belmont Road, King of Prussia, PA 19406
1979— E. T. HARLEY, Retired Senior Vice President Equipment, Trailer Train Company, 289 Belmont Road, King of Prussia, PA 19406

PAST PRESIDENTS (Cont'd.)

1980— J. H. LONG, Retired Manager Locomotive Dept., Chessie System, 5454 Cleander Drive, Cincinnati, OH 45238

1981— R. G. CLEVENGER, Retired General Electrical Foreman, Atchison, Topeka & Sante Fe Rwy., 5802 W. 157th Terrace, Overland PK., KS 66223

1982— N. A. BUSKEY (Deceased) Asst. General Manager-Locomotive, Chessie System

1983— F. D. BRUNER, 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

1985— D. M. WALKER, Asst. Shop Manager, Norfolk Southern Corporation, 793 Windsor St., Atlanta, GA 30315

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

1988— D. G. GOEHRING, Mgr. Loco. Heavy Maintenance, National RR Passenger Corp., 2000 Market St., Philadelphia, PA 19103

HONORARY LIFE MEMBERS

KJELL AXELSON, Retired Superintendent Motive Power, Burlington Northern, 36-716 Bluebird Ave., Rancho Mirage, CA 92270

F. W. BUNCE, Retired Chief Mech. Officer, Milwaukee Road.

J. J. BUTLER, Retired Chief Mechanical Officer, Consolidated Rail Corp., 158 Woodgate Lane, Paoli, PA 19301

OWEN CLARKE, Retired Vice-President, Chesapeake & Ohio Ry., Cleveland, Ohio

B. A. CUMBEA, Retired Mgr. Locomotive Maintenance-Engineering, Chessie System, 310 Cherokee Trail, Huntington, WV 25705

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

N. C. ECKERLE, Sales Manager, Specialty Chemicals, Nalco Chemical Co., 2901 Butterfield Road, Oak Brook, IL 60521

W. T. Faricy, Retired Chairman of the Board. A.A.R.

J. G. GERMAN, Retired Vice-President-Engineering, Missouri Pacific Railroad Company, 19 Holloway Dr., Lake St. Louis, MO 63367

J. J. GREGORY, Retired Project Manager-Heavy Repair Shop, Consolidated Rail Corp., 603 Ruskin Drive, Altoona PA 16602

S. GRAHAM HAMILTON, President, Global Group, Inc., P.O. Box 2024, Winter Park, FL 32790

E. R. HAFLING, Retired Engineering Assistant, Santa Fe Rwy., 2711 James St., Topeka, KS 66614

W. J. HARRIS, Retired Vice-President, Research & Test Dept., Assn. of American Railroads, Washington, D.C.

H. W. HAYWARD, Retired Chief M.P. & R.S., CP Rail, Montreal 101, Quebec, Canada

D. W. HENDERSON, V.P.-Technology, Engineering & Maintenance, Burlington Northern RR, 9401 Indian Creek Pkwy., Overland Park, KS 66210

JOHN H. HERTOG, Retired Vice-President-Operations, Burlington Northern, Inc., St. Paul, MN 55101

JOHN W. INGRAM, Retired President and Chief Executive Officer, Chicago, Rock Island and Pacific Railroad Co.

A. W. JOHNSTON, Retired Vice-President of Operations and Maintenance, Association of American Railroads, Washington, D.C.

JOSEPH J. T. KOERNER, Secretary-Treasurer (Retired), LMOA, 3144 Brereton Ct., Huntington, WV 25705

JACK L. KUHNS, Retired Manager Planning & Maintenance, CSX Transportation, 400 Deerfield, Louisville, KY 40207

R. M. McDONALD, Retired Director of Operations, Board of Transport, Commissioners for Canada, Ottawa, Ont., Canada

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

F. K. MITCHELL, Retired Asst. Vice-President, New York Central Sys., Sleights Wildwood, Manitowish Waters, WI 54545

R. G. RAYBURN, Retired Executive Vice-President-Operations, Chessie System, Baltimore, MD

H. P. RODES, President, General Motors Institute, Flint, MI 48502

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

H. L. SCOTT, JR., Retired Sr. Vice-President and Chief Mechanical Officer, Norfolk Southern Corp., P.O. Box 3609, Norfolk, VA 23514

C. M. SMITH, Retired Manager-Mechanical Engineering-Passenger and Locomotive, Consolidated Rail Corp., 3 Princeton Road, Strafford-Wayne, PA 19087

R. D. SPENCE, Retired Executive Vice-President-Operations, Seaboard System R.R.

J. TAGGART, Retired System Mechanical Officer-Motive Power, CN Rail, 655 Richmond Road, Unit 45, Ottawa, Ontario K2A 3Y3

C. N. WIGGINS, Retired Vice-President and Asst to President, Louisville & Nashville R.R., Louisville, KY

Southwestern Railway Club

Started in 1946, the Southwestern Railway Club this year is celebrating its 43rd 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.

PERVIS MILLER
President
Dir. Loco. System Shops
Union Pacific RR
Fort Worth, TX

SHARON D. KOCH
Secretary-Treasurer
Southwestern Railway Club
P.O. Box 515
Omaha, NE 68101-0515
(402-271-3512)

Monday, September 18, 1989
10:00 A.M.

REPORT OF THE COMMITTEE ON DIESEL MECHANICAL MAINTENANCE

Pre-Convention Presentation Southwestern Rwy. Club

May 19, 1989 Oak Creek Inn Omaha, NE

G. J. BRUNO, Chairman
Facility Manager
Amtrak
Seattle, WA

VICE CHAIRMAN
C. D. Corbin, Asst. Shop Supt., Norfolk Southern Corp., Chattanooga, TN

COMMITTEE MEMBERS

J. Bandura	Senior Tech. Officer-MP	CN	Montreal, PQ
J.Drozd	Asst. Mgr.-Tech. Services	EMD	LaGrange, IL
A. C. Hillhouse	Customer Service	GE	Erie, PA
R. A. Johnson	Manager-F40 & LRC-Motive Power	Via Rail	Montreal, PQ
C. T. Kunkel	Engineer-Design	UP	Omaha, NE
E. L. Oviatt	Manager-Loco. Maintenance	DM & IR	Proctor, MN
J. M. Santamaria	Gen. Supt.-Loco. Shops	CR	Altoona, PA
B. R. Savage	Product Support	Caterpillar	Peoria, IL

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 Sante 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 Sante 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 . Gil was recently transferred to Seattle, Washington and is the Facility Manager at that location.

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

I. TRACTION MOTOR GEAR LIFE COMMITTEE FINDINGS

In 1981 the LMOA Diesel Mechanical Maintenance Committee wrote an excellent paper titled "Increased Service Life Through Improved Technology ". Part of that paper dealt with traction motor gear wear and how it affects traction motor life.

Some of the important points of that portion of the paper were that worn traction motor gearing causes:

1. Traction motor armature shaft torque to become excessive as locomotive speed increases (Fig. 1). One demonstration of this is shown on locomotive drive wheels where small discrete wheel slips are seen. (Fig. 2). This wheel shows 59 individual slip marks corresponding to the number of teeth on the adjacent drive gear.
2. An increase in armature circumferential movement (Fig. 3.) causing insulation chafing and wear (Fig. 4) leading to grounds and shorts in windings, fatigue cracks in gear cases (Fig. 5), fatigue failure at brazed stator field coil connections (Fig. 6).

The paper also goes on to state that:

1. Mixing new and excessively worn gears causes much higher traction motor stator vertical accelerations at the nose support and over the axle as compared to new gears (Figs. 7 and 8).
2. Regrinding worn gears to the correct tooth involute, by whatever approved method of reclamation, was an acceptable practice which reduced the cost over applying new gears to traction motors and gave acceptable performance.

The paper caused many of the member roads to go back and look at their policies on traction motor gearing and review their maintenance practices to see if traction motor life could be improved and to justify the purchase of a gear grinder or find an outside company to regrind gears.

The member railroads utilize GE MI-34000C and EMD MI-1518, Rev. E extensively to qualify gears for reuse.

When qualifying, the gear should first be inspected for any surface imperfections.

Light pitting or spalling on the gear teeth is a common condition and should cause no problems in reusing.

Gear teeth exhibiting heavy pitting or spalling should be scrapped.

Eraflures or scuffing which appear as vertical lines from the tip to the root of the tooth show a lack of lubrication. If this unlubricated condition continues, tooth destruction will occur.

The same holds true for gears with teeth showing cran or wear step near the root of the tooth where the mating tooth runout occurs.

If the step is greater than 1/32", it may be removed with hand grinder being careful not to undercut the tooth.

Fissures or fatigue cracks discovered visually by Magnaflux or other means indicates the start of failure, and the gear or pinion should be scrapped.

A gear with a broken tooth should be scrapped.

Gear qualification for reuse is made simple using the axle tooth contour gage with .010" feeler gage, and wear gage used to see if the gear can be reground.

After inspecting for surface imperfections, the profile gages is used to measure the deviation from the orginial tooth profile. This is known as involute error. To use the gage

(Fig. 9):

1. Place the profile gage on the gear, either pinion or axle, making sure the gage contacts the top of the tooth being measured and the adjacent tooth.
2. Place the gage against face of the tooth being checked.
3. Measure the profile deviation along this face using the .010" feeler gage, trying to probe between the gage and the tooth face.

Several teeth on the gear should be checked. If none of the teeth checked takes the .010" gage, the gear, if no surface flaws are noted, is suitable for reuse.

The accepted standard for involute error on the gear tooth is .010" for both EMD and GE, with condemning limits for gear tooth tip width at 7/32", with one member railroad using 1/8" for EMD and GE.

If any tooth shows deviation equal to or greater than .010", the member railroad usually scraps pinion gears while axle gears are checked with a wear gage and reground for reuse if they qualify.

To use the wear gage (Fig. 10):

1. Place the gage on the axle tooth being measured.
2. Press the gage firmly on top of the tooth then slide the gage until the tapered jaw contacts side of tooth.

If the gage stops in the area of the gage marked "Stock Regrind," there is sufficient stock to reprofile the gear teeth.

If the gage moves into the area marked "Tooth Scrap", there is insufficient stock remaining for regrinding and the gear should be scrapped.

Altoona Gear Company has developed a chart to be used for both EMD and GE gears which simplifies the measuring process for your mechanic. Altoona's chart allows the mechanic to measure only the tooth tip width. He can then look on the chart and see what the tooth width is ½" from the tip and the grind number to use to reprofile the gears. Most railroads when purchasing used gears buy gears ranging from No. 1 grind number for high speed service to No. 8 grind number for switcher service (Fig. 11).

Currently five companies perform most of the traction motor gear regrinding in the United States other than the O.E.M. They are:

1. Altoona Gear Co.
   Louisville, KY
2. Carl Cummings Manufacturing
   Company
   Montebello, CA
3. Motor Coil Manufacturing
   Braddock, PA
4. M & W. Company
   Sacramento, CA
5. Chrome Crankshaft
   of Illinois
   Chicago, IL

A survey was conducted of the member railroads on their traction motor maintenance policies and the life they see on their traction motors and related components.

The survey covered five railroads whose combined ownership represents approximately 36,000 EMD traction motors currently under 3200 six axle and 4200 four axle locomotives and 9700 GE traction motors currently under 1100 six axle and 780 four axle locomotives. Also included were 2437 EMD motors and 964 GE motors in inventory and rebuild que on the five railroads in the survey.

Regrinding Practices

Two member railroads regrind some of their own gears with the remaining roads extensively utilizing the gear grinders mentioned earlier to provide their regrinding needs.

In the last 12 months the five railroads purchased:

1449 new EMD axle gears.
415 new GE axle gears.
2730 new EMD pinion gears.
399 new GE pinion gears.

As can be seen by the number of new gears purchased, the railroads in the survey use reground gears extensively in their traction motor maintenance programs.

The data also indicates that the railroads who do their own regrinding experience similar gear life to those who send their gears out to be reground.

From the survey, all railroads mix new, reground or qualified axle gears with new or re-qualified pinion gears and have experienced little adverse effect on traction motor life with this practice.

Traction Motor Failures

The same survey showed that in the previous 12 months the five railroads changed out 5857 traction motors from their locomotives. The main electrical cause for removal on EMD traction motors was grounded armatures, with 686 removed. The same was true of GE traction motors, with 262 removed for grounded armatures.

The main mechanical cause for removal other than worn wheels was the same for both EMD and GE traction motors: worn or broken pinion gears. 261 EMD and 152 GE traction motors were removed for this cause. It is the committee's belief that worn or broken gear teeth are primarily due to lack of lubrication. As can be seen, 7% of the traction motors removed were for worn or broken gears.

Lubrication

One of the main causes for excessive wear on axle and pinion gears is inadequate lubrication. The member railroads were surveyed to find out their lubrication practices on applying gear grease to gear cases.

The lubricants used by the railroads are:

1. Texaco TMGL Light, Premium and 1963
2. Conoco Cog
3. Atlantic Richfield Jet Lube™
4. Centurail 516
5. Citgo RR-104S Gear Lube.

The total amount of gear lubricant used by the five railroads in the survey was 2,211,453 lbs of grease in a 12 month period or 48.4 lbs of grease per active traction motor per year.

Of the five railroads, one railroad adds 4 lbs of grease at every 23 day maintenance cycle, another adds 4 lbs at every 45 day maintenance cycle, while three railroads add grease based on the condition of the gear as viewed through the fill cap at either 23 and/or 45 days.

The railroads that add grease based on the condition of the gear use the color of the grease on the gear teeth as the criterion.

Ideal grease level allows a full tooth dip into the grease. For both EMD and GE gear case, a 1-lb bag of grease will raise the grease level approximately ¼" in the case (Fig. 12).

There is no standard or consistent method that will work under all conditions in checking gear grease levels. One method used by several railroads to check grease levels is as follows:

With the locomotive in a stationary position and proper safety precautions taken:

1. Remove bottom fill cap.
2. With a flashlight look at the color of the grease on the gear.

a. If gear grease is dark black in color this shows full lubrication and no grease is required.

b. If gear grease is brown in color, the gear teeth are seeing less than a full tooth dip in the grease. Two lbs or bags of grease will raise the grease level to the appropriate full tooth depth.

c. If gear is shiny, no lubrication is taking place. Look for any signs of overheat (blue discoloration). If discoloration is seen, change out the traction motor before gear has a chance to fail. If no discoloration is seen, four lbs of grease will raise the grease level to a full tooth dip.

3. Replace fill cap ensuring proper application.

Each railroad should look at its individual maintenance practices to determine what criteria should be used for the checking of gear grease levels and the amount of grease to add at that time.

As can be seen, gear grinding is a well accepted practice by all the member railroads. Substantial cost savings along with acceptable performance can be expected from the use of reground gears. Any of the above mentioned gear grinders can give you acceptable service in meeting your grinding needs.

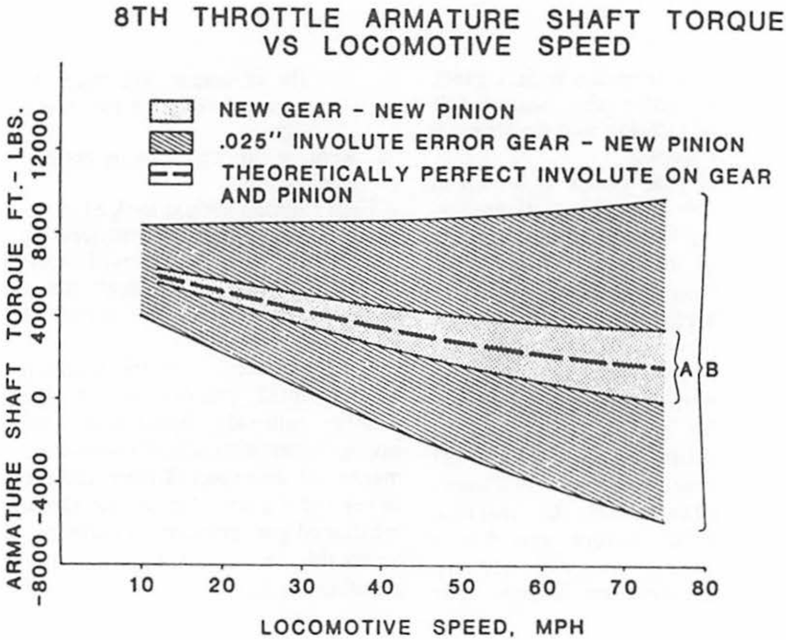

8TH THROTTLE ARMATURE SHAFT TORQUE VS LOCOMOTIVE SPEED
NEW GEAR - NEW PINION
.025" INVOLUTE ERROR GEAR - NEW PINION
THEORETICALLY PERFECT INVOLUTE ON GEAR AND PINION
A
B
ARMATURE SHAFT TORQUE FT.- LBS.
-8000 -4000 0 4000 8000 12000
10 20 30 40 50 60 70 80
LOCOMOTIVE SPEED, MPH

Fig. 1

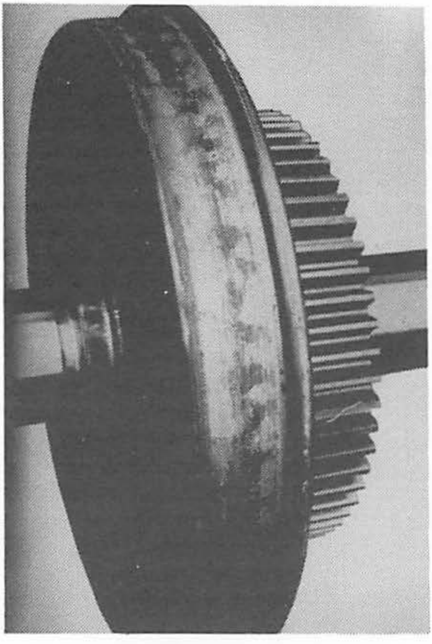


Fig. 2

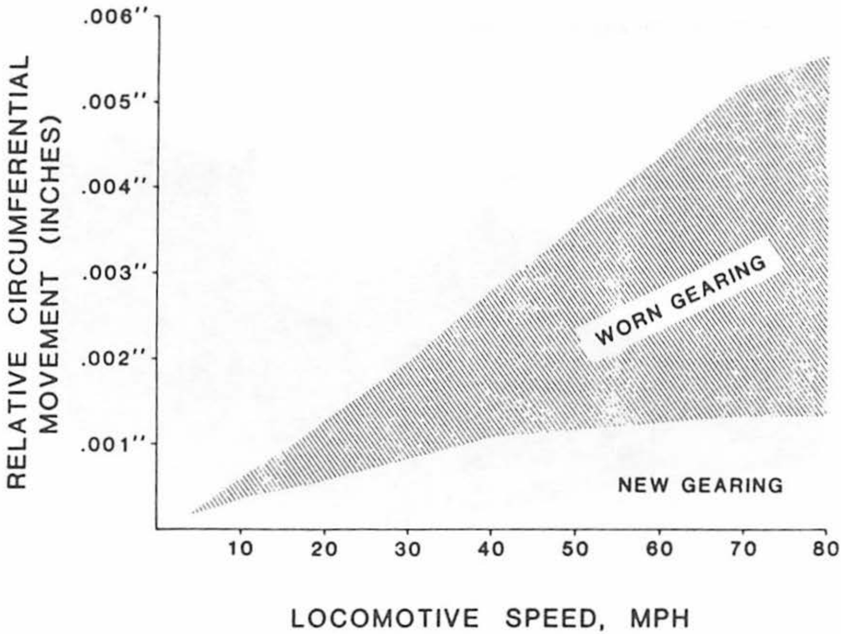

.006"
.005"
.004"
.003"
.002"
.001"
RELATIVE CIRCUMFERENTIAL MOVEMENT (INCHES)
WORN GEARING
NEW GEARING
10 20 30 40 50 60 70 80
LOCOMOTIVE SPEED, MPH

Fig. 3

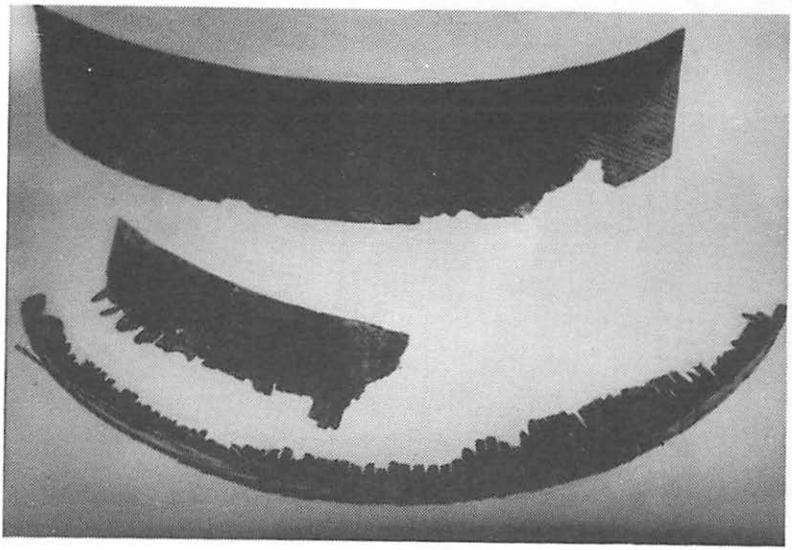


Fig. 4

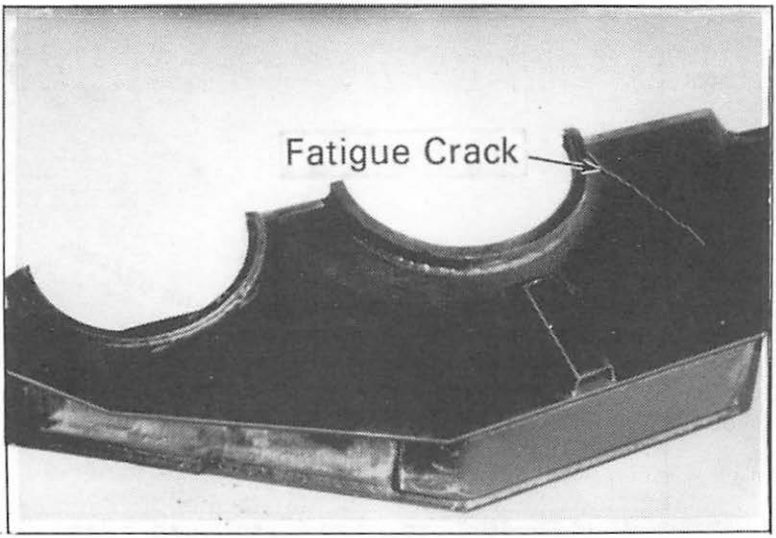


Fig. 5

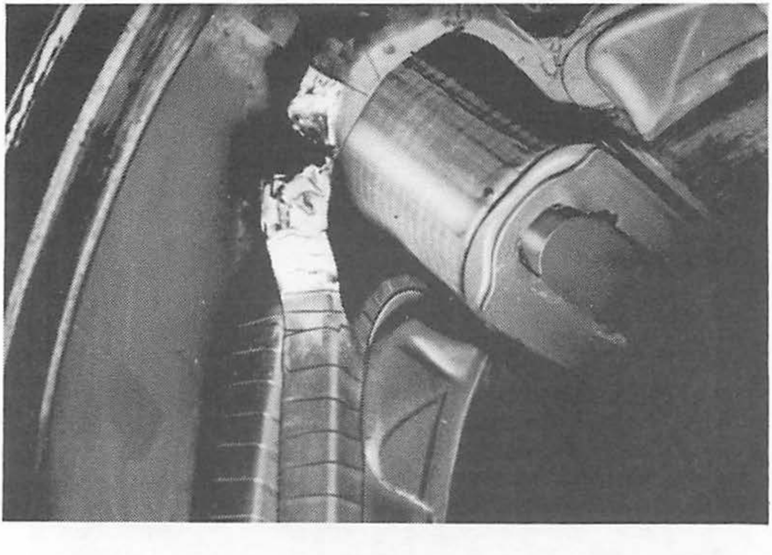


Fig. 6

TRACTION MOTOR STATOR ACCELLERATION MEASURED VERTICALLY OVER MOTOR NOSE

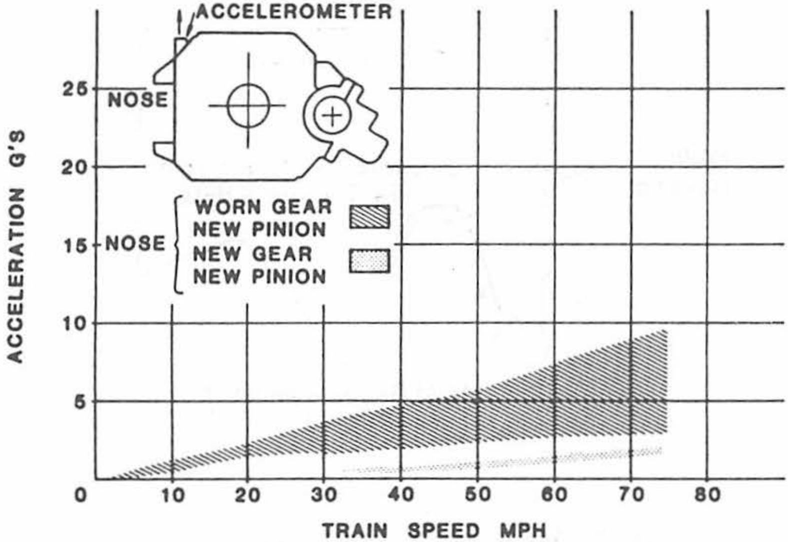


Fig. 7

TRACTION MOTOR STATOR ACCELERATION MEASURED VERTICALLY OVER AXLE

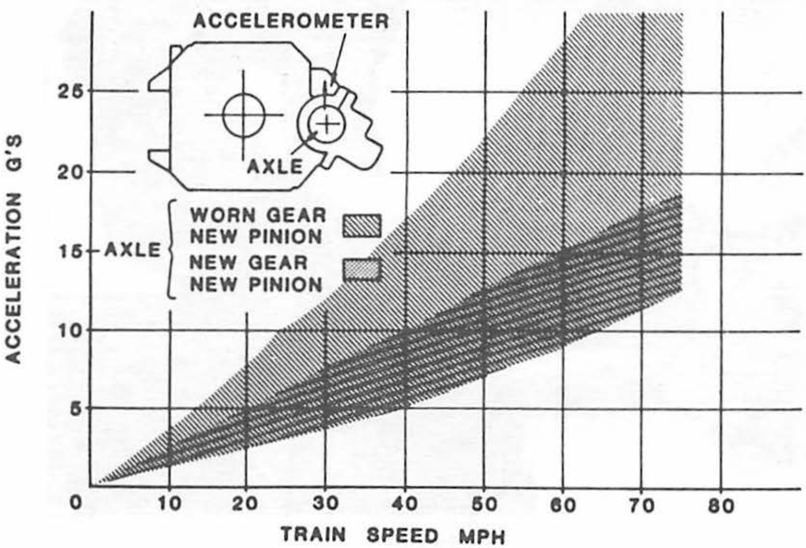


Fig. 8

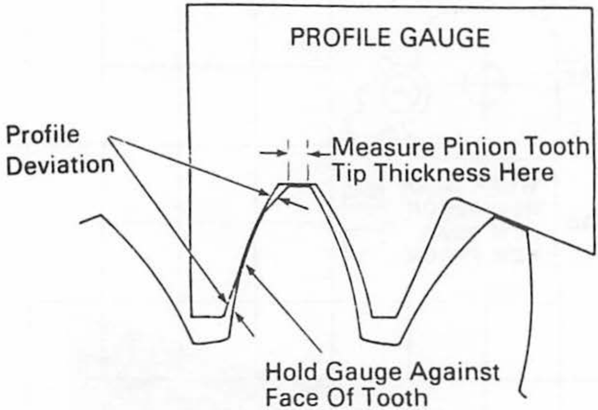


Fig. 9 – Measuring Profile Deviation And Wear Of Traction Motor Pinion

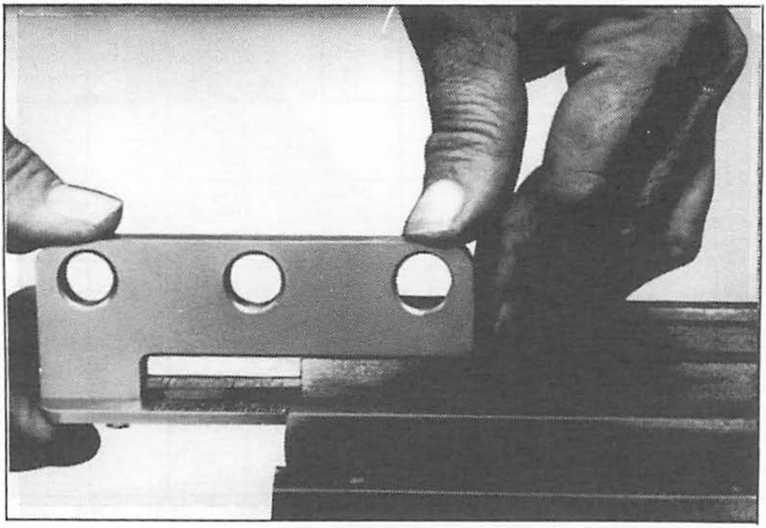


Fig. 10

Chart indicating dimensions after recycling developed by
ALTOONA GEAR COMPANY OF LOUISVILLE

57, 59, 60,61,62,63, and 65 Tooth Gears

Grind Number	NEW	1	2	3	4	5	6	7	8	9	1 0
Tip Width	.340 TO .335	.320 TO .305	.305 TO .290	.290 TO .275	.275 TO .260	.260 TO .245	.245 TO .230	.230 TO .215	.215 TO .200	.200 TO .185	.185 TO SCRAP
Range of Width At .500 in From Tip	.705 TO .695	.680 TO .665	.665 TO .650	.650 TO .635	.635 TO .620	.620 TO .605	.605 TO .590	.590 TO .575	.575 TO .560	.560 TO .545	.545 TO .530

74 Tooth Gears

Grind Number	NEW	1	2	3	4	5	6
Tip Width	.295 TO .285	.280 TO .265	.265 TO .250	.250 TO .235	.235 TO .220	.220 TO .205	.205 TO SCRAP
Range of Width At .500 in. From Tip	.625 TO .615	.605 TO .590	.589 TO .575	.574 TO .560	.559 TO .545	.544 TO .530	.529 TO .515

70T EMD, & 83T GE 25° P.A.

Grind Number	NEW	1	2	3	4	5	6
Tip Width	.210 TO .195	.195 TO .180	.180 TO .165	.165 TO .150	.150 TO .135	.135 TO .120	.120 TO .105
Range of Width At .500 In. From Tip	.655 TO .645	.635 TO .620	.619 TO .605	.604 TO .590	.589 TO .575	.574 TO .560	.559 TO .545

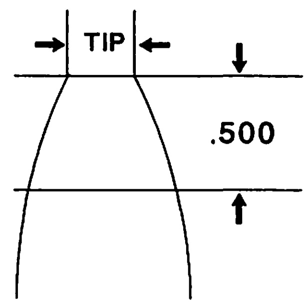


Fig. 11

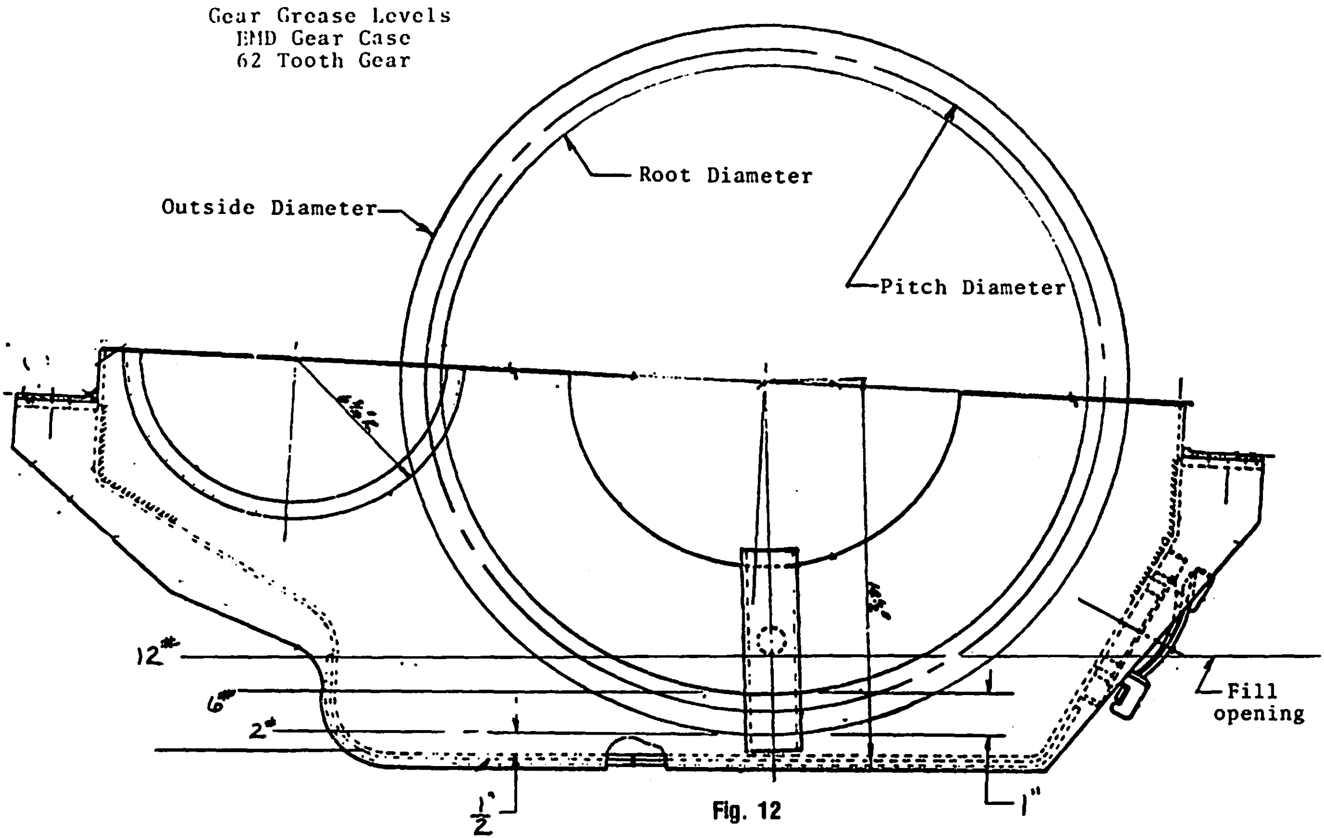

Gear Grease Levels
EMD Gear Case
62 Tooth Gear
Root Diameter
Outside Diameter
Pitch Diameter
12#
6#
2#
1/2"
1"
Fill opening

Fig. 12

II. 710 ENGINE — OPERATIONAL AND OVERHAUL UPDATE

The 710G3 diesel engine will present many new problems for member roads when the time comes to seriously consider overhauling their fleets. One member railroad participated in a mid-life overhaul study in order to evaluate the wear characteristics of these engines for the purpose of setting up its overhaul schedule. At that time some interesting component rework problems were noted and innovative solutions sought. This report will discuss the wear characteristics noted in the 710G3 engine and then discuss some of the parts reclamation options which might be considered at the time of overhaul.

Wear Characteristics

The mid-life study was done on SD-60 units with approximately 200,000 miles of service and an age of 2.5 years. Data were collected by the manufacturer and the member road in a joint teardown on two units at the member road's shops.

Liner Wear:

Liner wear measured below the ring reversal area and above the mae west ran from 4 to 7 thousandths of an inch. Since the reuse limit is 8.5 thousandths it stands to reason that these liners will probably need either plating or replacement at overhaul intervals. This wear does not seem to be a limiting factor in power assembly life at this time.

Piston and Ring Wear:

Ring face wear indicated that about 75% of life still remained in the rings. The number one ring groove ranged from .196" to .199" in width. Maximum reuse is .201" which means that some attention will probably be necessary at regular overhaul intervals.

Thrust Washers:

All of the thrust washers removed were within reuse limit and could have been reused. This has not previously been true of the 645 high horsepower engines and could be a sign of piston design differences in the 710G3. It might be wise to consider checking thrust washers for reusability in this model engine. The 2.5 year old washers measured .177" to .183" thickness and were uniform to .0015". Washers may be reused to .175" thick and .003" uniform thickness.

Cylinder Heads:

These engines had originally been equipped with non-hardened valve guides. Most of these guides were already worn past the reuse limit of .633". It is felt that this is the weak link in the 710G3 power assembly and that the only alternative is to specify hardened guides be placed in all 710 cyclinder heads. Valve and valve seats appeared to be holding up well.

Head Seat Rings:

The units analyzed did not have the anti-souping head seat rings applied. Seat ring thickness was below the reuse limit of .184" on several power assemblies. The application of anti-souping head seat rings should reduce wear in this area. The manufacturer feels that by applying anti-souping head seat rings, contaminants will be held out of the head seat ring interfaces thereby reducing frictional wear. The results of this theory are still being observed and only time will tell. This wear phenomenon has not been designed out of this new engine.

Lower Liner Inserts:

The last item of interest is the lower liner insert. As in the 645E3C and F3B engine there appears to be a lot of wear in the 710 engine inserts. The fretting observed is essentially the same and requires the renewal of inserts at overhaul time. A nickel plated insert is again recommended in this application by EMD. For those member roads who may have hydraulic devices for renewing these inserts it will require some changes to your machine. The lower liner insert is 1½ inches farther down in the block when measured from the top of the head pot. The head pot is also about 1 inch deeper from top to bottom.

The manufacturer feels that the wear of lower liner inserts may also be reduced if the engine is equipped with anti-souping head seat rings.

Reconditioning Liners

The reconditioning of the 710G3 cylinder liner depends chiefly on the philosophy of the member road. Some roads feel that chrome plating is the most economical method of extending the life of the liner. Others feel that replacing wornout liners with new increases the dependability of the engine as well as reducing possible souping with chrome plated liners. The 710G3 liner will most probably only run one overhaul cycle before exceeding the reuse limit. This means at the first complete overhaul cycle these liners must be plated or disposed of unless you intend to run oversize pistons.

One member road will be installing chrome plated liners in a 710G3 engine this year to evaluate performance. This road will install used pistons which have been phosphated. This test will be to evaluate the performance of a phosphate treated piston in a chrome liner on the 710G3 engine. If you purchase new cast iron liners for application at overhaul then a tin plated piston will be necessary to reduce scuffing during break in of the assembly.

If you reuse the 710G3 line in running repair operations you will have to modify your rework line to accept the 2'' longer liner. Honing machines will have to be reset for the longer stroke as well.

Reconditioning Pistons

Several determinations must be made in order to set up a method of handling the 710G3 piston in your rework program. Are you going to restore the tin plating? Can you turn the hardened upper ring groove to accommodate the overside rings or would you rather restore this groove to its original width? Will a phosphated piston run in your liners? These questions must be answered first before a change in your operation can be made.

Several vendors have offered a upper ring groove restoration techniques involving nickel plating for this piston. Some roads have experienced separation of this nickel plating and failure of some power assemblies. This technique still appears promising once it is perfected.

Turning out the ring groove for oversized rings is workable but may leave you with areas of soft metal exposed to the ring due to the varying depth of the hardened material in the original piston. The hard piston material will require a special cutting

SEE OUR ADS ON PAGES 249-250 — 285-286

tool and set up.

It remains to be seen whether tin plating this piston will be necessary in reworking power assemblies. Experience will tell and some roads will be gaining that experience in the coming year. One member road has overhauled one unit with used phosphated pistons and chrome plated liners and so far is experiencing good results. Tin plating, if proven necessary, will be costly and require sending pistons out on a regular basis. Running phosphated pistons would be an alternative to this procedure.

Reconditioning Heads

Any 710 cylinder heads with non-hardened valve guides should have them replaced with hardened guides. As noted earlier, this may be the weak link in your power assembly if you neglect changing these guides. Basic rework of the 710 head is the same as in 645 or 567 applications.

There are three major differences in the 710 cylinder head which restrict its use to the 710 application:

1) The head has a smaller pilot stud hole in order to reject the 645 cylinder liner.
2) The injector well is larger in order to accept the larger 710 injector.
3) The injector dowel hole is relocated and smaller in order to reject the 645 injector.

These differences may prove costly if you decide to use all new cylinder heads on a 710G3 engine. With the present testing being conducted by EMD on a tangential flow cylinder head, it becomes apparent that new heads may be a future recommendation by EMD.

One major road has decided that these heads could be reused on lower horsepower units as a cost saving measure. A request by that road to outline the steps necessary to convert the 710 head into a 645 application was answered by the manufacturer.

Steps are as follows: (Fig. 1)

Modification A: Open pilot stud hole to .818".

Modification B: Sleeve injector well bore.

Modification C: Add injector dowel hole.

You now have a 645 cylinder head at a minimal cost to the member road. One member road has already put 2 engine sets of converted heads into service.

Summary

There are many new ideas to consider when setting up your 710 engine overhaul procedures. It is not quite as easy to mesh into your present shop procedures as advancements on the 645 engine have been in the past. Keep an open mind as you progress and there may be room for standardization such as the conversion of the 710 cylinder head to a 645 head. As horsepower continues to go up there is no excuse for allowing overhaul costs to rise. Every member road must be on the lookout for ways to cut overhaul costs without sacrificing quality.

HEAD MODIFICATIONS

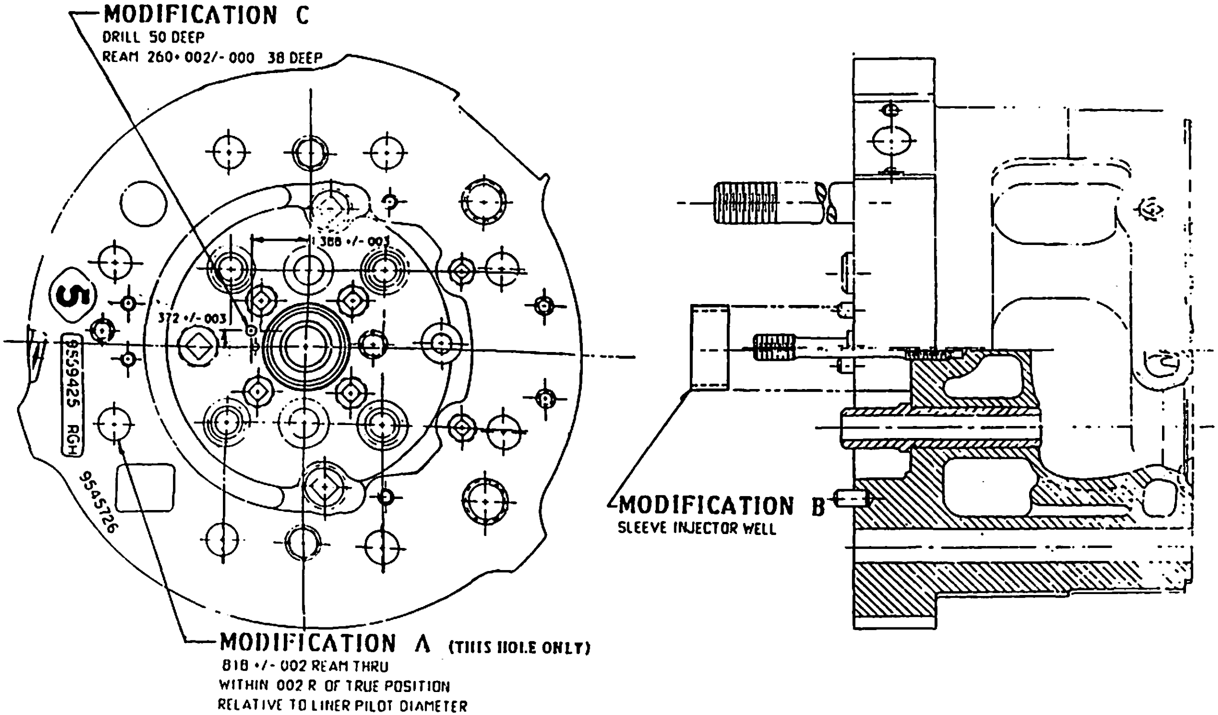


Fig. 1

III. GE POWER ASSEMBLY IMPROVEMENTS

Rework Procedures on Welded Head-to-Liner Assembly

The new welded head-to-liner assembly is the latest development in the series of innovations by GE designed to make its diesel engines the longest running and most maintenance-free engines in the industry. With the recent increases in horsepower it became evident that the head-to-liner gasketing would be the limiting item in the continued search for increased engine life, between planned maintenance intervals.

In order to successfully weld the assembly together it was necessary to change the material in the liner to melonited steel. Many years of research and testing went into the development of this assembly and the associated ring package. Testing lasted up 750,000 miles was initially performed with very little wear. The assembly is finish machined after welding to insure squareness and concentricities necessary for this critical line-up. The weld is Magnafluxed and ultrasonically inspected to insure 100% integrity of the joint. The welded assembly went into full production in January 1986 and the initial units are coming up on the first scheduled maintenance.

This is a short discussion of the proper overhaul procedures on the welded liner assembly.

As the cylinder assembly is received in Grove City, the first step is the disassembly and cleaning operation. A good visual inspection is given the parts during disassembly in order to discard any obviously unusable parts.

The valves, springs, rotators, and keepers are removed and discarded. The eight special 12 point head clamp ring bolts, clamp ring and compression release adaptor are removed, cleaned and inspected for reuse. The valve guides are removed and thrown away. The liner is carefully pressed out of the jacket and sent to the cleaning area.

The jacket is processed through the chemical bath to the roto blast machine, which uses soft steel shot. This very effectively cleans the jacket of the remaining carbon which has been softened by the chemicals, but does not damage the critical diameters and surfaces of the jacket.

The cylinder jacket is now ready for inspection. The bores are held to the following tolerances: head diameter 10.499 to 10.504 in.; upper liner bore 11.499 to 11.504; lower 11.521 to 11.528. The maximum out of round is .003 in. on the head and upper liner fit and .006 on the lower liner bore. Erosion is carefully checked in the lower liner bore with a limit of .045 in. depth in the area of the clamp ring bolt holes.

The liner assembly is first cleaned by the six-stage chemical process and then finished in the roto blast machine. After cleaning, the assembly is Magnafluxed in the area of the weld. The weld is in the center of the ½ in. wide groove machined between the head and liner.

Valve guide bores are inspected using a dial bore gage. The tolerance is .937 to .938. If the bore is found oversize, it is repaired by the dalic plating process.

The liner is now ready for honing. The bore is honed until the wear step in the ring area is removed, but a limit of 9.008 maximum diameter is held. This is to provide adequate hardened material in the bore to insure at least another four years of trouble-free running.

We are now ready to put the cleaned, remanufactured and inspected parts back together. The three "O" rings, two silicone and the large Viton, are installed in the bottom of the cylinder jacket, and the jacket is placed in the oven and heated to 300-350 degrees for a minimum of one hour. The liner is next prepared for assembly. The black EPDM gasket is installed on the shoulder of the head. The two EPDM "O" rings are placed in the grooves on the liner O.D. The "O" rings are sprayed with spray lube "A" for ease of assembly.

The heated jacket is removed from the oven, and the liner assembly is lowered into it. The press is used to push the liner past the "O" rings, and the line-up tool is used to line up the compression relief hole in the head. The square cut gasket and the proper shims are applied along with the clamp ring and bolts. The bolts are initially torqued to 65 ft lbs and are loosened and retorqued to 75 ft lbs after cooling.

The assembly's water jacket is air tested at 60 lbs for 5 minutes. The high pressure test was found to be unnecessary on the welded assemblies and has been eliminated.

The exhaust valve seats are ground to an angle of 44 degrees 30' +0' -30' and the intakes are ground to 15 degrees 30' +3' -30". These angles when compared to the angles ground on the valves, insure that both valves contact at the top of the valve face. The line contact area should be from a minimum of .005 to a maximum of .100 down from the outer edge of the valve. The valve seats are ground after the liner assembly is installed and clamped into the jacket to maintain the required .002 T.I.R. on the seat faces.

The cylinder assembly is run through the ultrasonic cleaner which cleans the liner bores of any dirt particles, which would shorten piston ring life. Next the assembly is completely washed in 200 degrees filtered water to remove any shop dirt that may have accumulated on exterior surfaces.

The valves are installed in the proper seats, the cylinder is turned over, the high temperature valve seals, valve springs, rotators and keepers are applied.

If for any reason the cylinder head or liner is determined to be unusable it should be returned to General Electric for unit exchange.

And so another high quality low cost replacement cylinder is ready to go out and provide revenue until the next scheduled maintenance period.

IV. OIL LEAKS ON EMD ENGINES

Oil leaks are not a new problem; they have been around since the conception of the diesel locomotive. Although there are many examples which could be illustrated, the following five areas have been selected:

1. Oil Leaks Between the Overspeed Trip and Accessory Drive Housing
2. Souping
3. Cylinder Head (top deck) Cover Oil Leaks
4. Copper Tubing Oil Leaks at Governor End
5. Oil Leaks at Engine Accessory Mountings and Flanges.

For each area of concern listed, the committee has suggested a possible solution and procedure.

1. Oil Leaks Between the Overspeed Trip and Accessory Drive Housing. (Fig. 1)

To cure this problem the "O" ring seals should be replaced as follows:

a. Remove the overspeed trip housing access cover (Fig. 2).
b. Bar over the engine until the counter weights are positioned at the top of the engine.
c. Remove the bolt and steel retainer strap that is inside holding the sleeve.
d. Using a suitable pry bar, insert under sleeve handle and carefully remove sleeve from housing. Remove seals and clean sleeve.
e. Install seal marked with red dot in upper groove of sleeve and unmarked seal in lower groove (Fig. 3).
f. Apply film of oil on seals and sleeve and install sleeve, bolt and retainer strap.
g. Replace the overspeed trip housing access cover.

1.1 When the diesel engine is in for major repair, a permanent fix to the same problem is EMD's pointer #3L-85 dated March 25, 1985, and titled "Internal Drain Overspeed Trip Housing" where we can do away with the oil seals altogether (Fig. 4).

a. When applying internal drain overspeed trip housings on engines with a crankcase older than June 1980, two 1" diameter drain holes must be drilled into the crankcase end plate at the locations shown. Some crankcases may also require the addition of two ½" tapped mounting holes where shown (Figs. 5 & 6).

1.2 If the older style overspeed trip and accessory drive housings are being used, the drain holes must be plugged by using an automotive type frost plug or by welding an aluminum plug in place (Fig. 7).

2. Souping

Conditions that cause souping are worn piston rings, worn cylinder liners, defective lube oil separator aspirator, or worn or defective head seat rings (Fig. 8).

A recent development to address one of these major causes is that when changing out EMD power assemblies EMD recommends replacement of existing head seat rings with an integral head seat ring. The integral seal head seat ring is an aluminum bronze ring with a Viton seal molded to the outer diameter, to prevent migration of lube oil from the top deck area into the exhaust system (Figs. 9 & 10).

3. Cylinder Head (top deck) Cover Oil Leaks

We have all seen engine blocks covered in oil. This results from top deck covers leaking (Fig. 11).

The importance of replacing top deck cover gaskets on a regular basis is emphasized. The inboard and outboard hold down clips should always be checked and replaced at the same time (Fig. 12).

3.1 Modification of Cylinder Head Cover Frames.

Developed by one member road, this will greatly reduce oil leaks by adding round corners to the square head cover frames (Fig. 13).

Figure 14 shows the middle of the frame to be modified.

Lay the cylinder cover frame upside down on a piece of sheet copper, in place for welding. Copper thickness should be enough not to be affected by the heat — ¼ to 3/8 in. should do (Fig. 15).

Using the mig welding process, start in corner and make several passes back and forth until enough metal has been laid in place to build a corner out, which will accept the round corner cover (Fig. 16).

Figure 17 shows the corner with added weld metal in place.

Use an end grinder to shape the corner. The welded surface that will be mating with the gasket on the cover may require a very light touch with a grinder to smooth out the sealing surface (Fig. 18).

Figure 19 shows the finished corner. And in figure 20 we show how the cover and casing will match after being modified.

The welding process takes approximately 40 minutes to complete the top deck cover frames for one 16 cylinder engine.

4. Copper Tubing Oil Leaks at the Governor End.

Copper tubing in use at many locations on an EMD locomotive is extremely vulnerable to breaking, due to excessive vibration during engine operation. Results based on a recent study conducted on one member road indicates that 15% of all oil related failures were caused by leaking or broken tubing. Vibration during operation has a tendency to weaken the flare of the rigid copper tubing leading to oil leaks and eventually breaking the flare.

These lines can be replaced with a flexible hose kit which consists of several hoses and a manifold system to replace copper pipes. This particular kit (Fig. 21) is available from a supplier.

Figure 22 illustrates the basic manifold system viewed from the layshaft. The manifold block is mounted on the overspeed cover and uses existing bolt holes. (No drilling is needed to apply this kit.) Also, to be seen are the engine protector supply hose and the hot oil supply and drain hoses, as well as the oil pressure gauge hose.

In figure 23, we see the system from the right bank side (the fuel return sight glass). The hose that runs along the top of the overspeed cover is the engine to block oil supply hose. Also shown is the governor oil supply hose. Both of these hoses run neatly behind the overspeed reset lever. Clearance between the block and the reset lever when tripped is sufficient to get your hand in to reset the lever. The twin swivel fitting allows connections for the governor supply hose and the oil pressure gauge hose.

The connection of the engine protector supply hose and the protector oil supply pipe are shown in fig. 24. You can also see the hot oil supply hose as it lies between the left water pump and the governor drive.

Figure 25 displays the oil gauge supply hose and the weld clamp that is used to secure it to the accessory rack.

In figure 26 is a view from the layshaft. We recommend all hose renewel during overhauls; however the block should last indefinitely.

In figure 27, the shops have

already started to convert over to the flexible hoses.

5. Oil Leaks at Engine Accessory Mountings and Flanges.

Oil leaks can now be eliminated or greatly reduced by using gaskets made of new material called Swellex. This new material is a gasketing of high density, 100 lbs per cu ft, and is capable of significant expansion when in contact with fluids. This swelling characteristic effectively fills up voids, distortions and other surface irregularities. Oil leaking at the connection (shown in Fig. 28) is normally due to the mating surfaces becoming warped or pitted by thermal cycles, disassembling, cleaning and scraping...all of which create flange surfaces that are difficult to seal with conventional gaskets. Figures 29 & 30 show how normal operations will distort flanges.

Fig. 31 shows a conventional gasket which has been soaked in 40 weight engine oil at 300 degrees F for 72 hours. You can see the oil soaked half on the right measures the same thickness as does the unsoaked half on the left. In figure 32 we see a gasket made of the new material, same oil soaking, same temperature, same time. What happens? The gauge on the left reads .125" (1/8 in. gasket material); the gauge on the right shows a thickness of .225". This is an 80% increase in gasket thickness. The side view (Fig. 33) again shows how the exposed half on the right has expanded.

Wicking is another cause of leaking flanges. The conventional gasket on the left (Fig. 34) is transferring oil. The new generation gasket on the right does not allow the oil to pass through.

There is no such thing as a "small" oil leak. One drop of oil over a long period of time will add up to a significant quantity. Tests show, for example, that typical conventional engine gaskets will leak up to 40 milliliters per hour. That is 92 gallons per year per flange! (Fig. 35) In contrast, gaskets made of the new (Swellex) material tested at .4 milliliters per hour, which is less than 1 gallon per flange per year which is 1/100 of conventional gasket leakage.

The new gasket material meets all the characteristics required of an efficient gasket. It's impervious to system fluid, won't contaminate the fluid. It fills voids and imperfections, withstands operating temperatures, is resilient and flexible, won't crush or blow out, won't corrode and is easy to remove (Fig. 36).

Here is what we are striving for...The engine of the future...with NO MORE OIL LEAKS (Fig. 37)!!

For this paper we have only concentrated on GM locomotives. Next year, we will address oil leaks on GE locomotives.

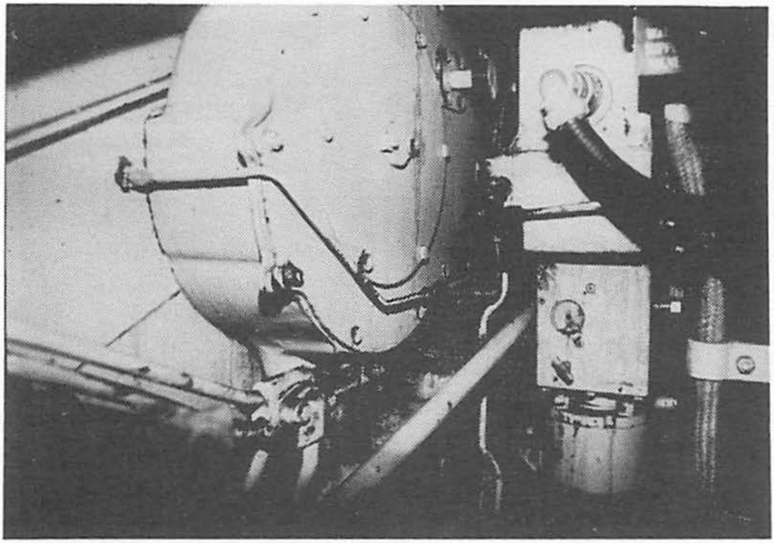


Fig. 1

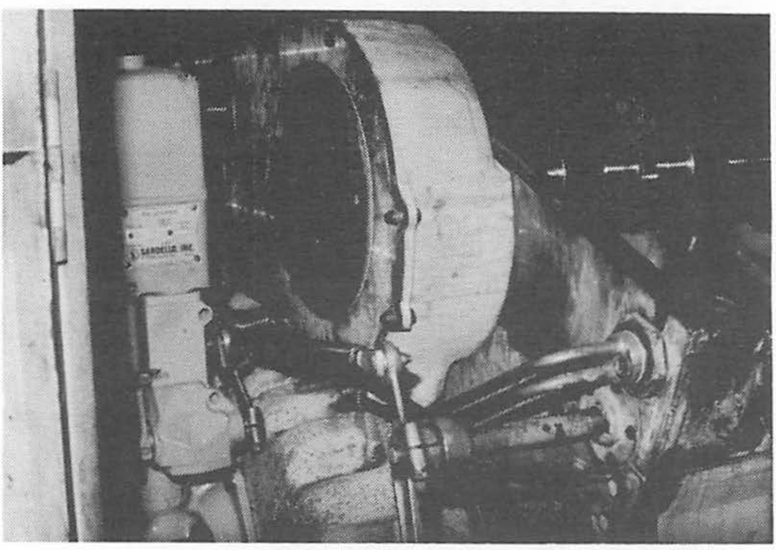


Fig. 2


YOU'RE TOUGH.
WE'RE TOUGHER.
More than 25,000 DUROX
pressure gauges ride America's rails.
Smoothly.
Railroading is a tough act for pressure gauges: vibration, pump pulsation, jarring shock. A punishing challenge to dependable performance.
That's why DUROX pressure gauges, dry and liquid-filled, are made without compromise. Our liquid-filled gauges carry an exclusive 3-year warranty, cases are solid brass, hermitically sealed, shock-proof and quickly interchangeable with existing gauges.
Others fail. DUROX gauges survive. Because, where the going is tough, the tougher keep rolling.
All sizes and pressure ranges in stock for fast delivery.
We keep you on a roll
DUROX
COMPANY
12351 Prospect Rd., P.O. Box 360288, Strongsville, Ohio 44136
216-238-5350 • 1-800-238-5360 • FAX: 216-238-5773

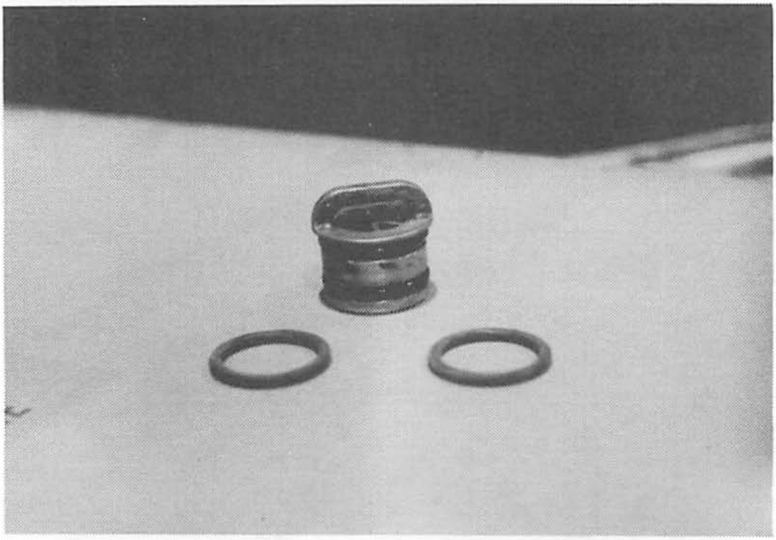


Fig. 3

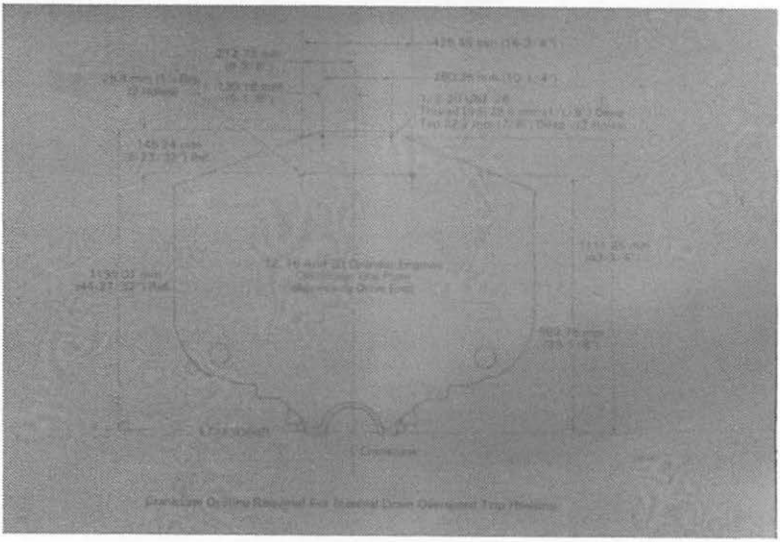


Fig. 4

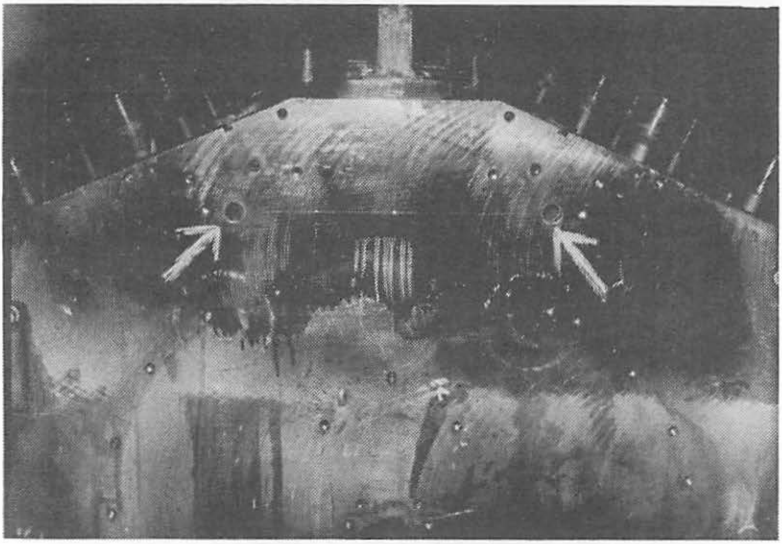


Fig. 5

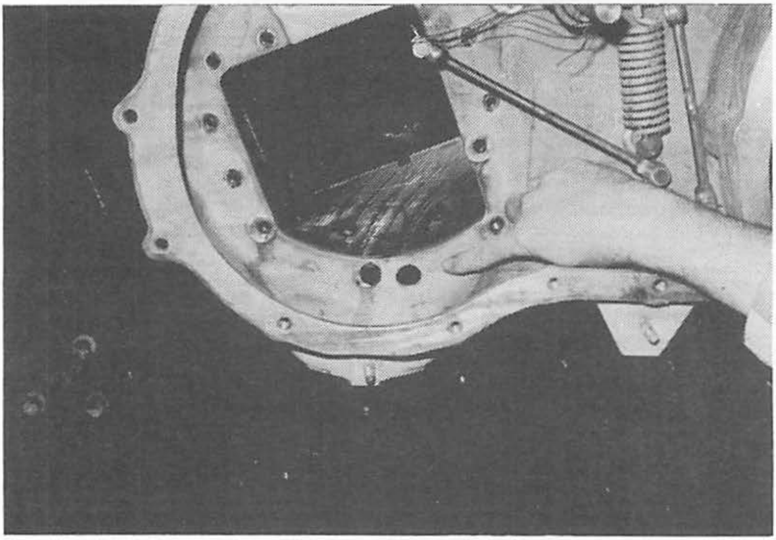


Fig. 6


WHY DUROX RUBBER
REPLACEMENT PARTS ARE
THE STANDOUT CHOICE.
Commitment to total quality is why.
We do it all: design, develop, engineer, analyze, improve, custom compound and produce.
And we do it all ourselves. Right in our own headquarters facilities dedicated to rubber – new state-of-the-art lab and production capabilities that make Durox the largest gasket and seal manufacturer in the locomotive replacement parts industry.
Our rubber products are ours. All the way.
Governor Plug Protector
DUROX
COMPANY
12351 PROSPECT ROAD, P.O. BOX 360288 • STRONGSVILLE, OHIO 44136
FAX: 216-238-5773
PRODUCTION ... COMPOUNDING ... MILLING ... MOLDING ... QUALITY PARTS.

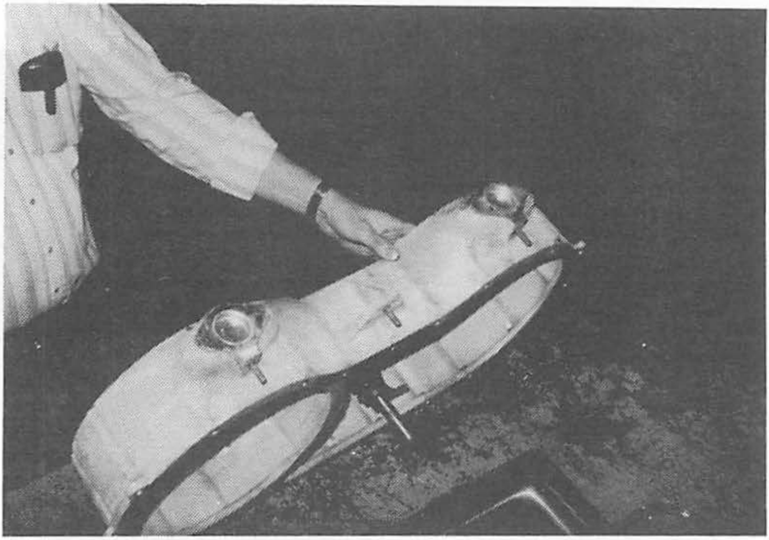


Fig. 7

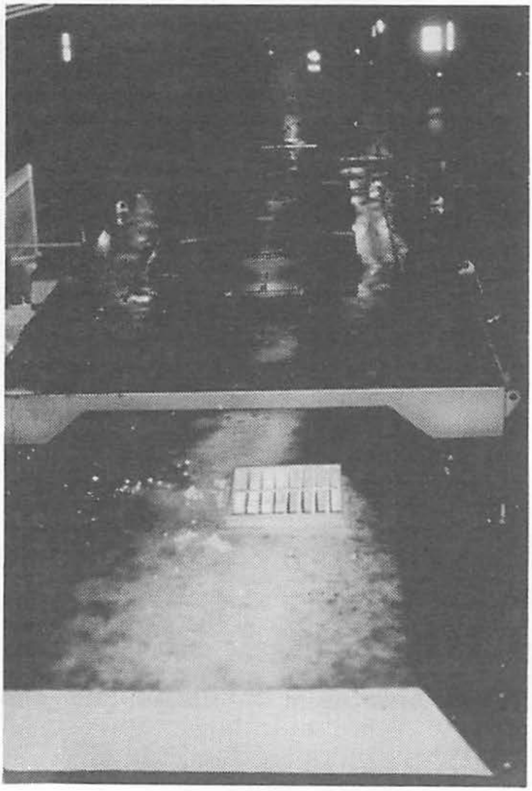


Fig. 8

Fig. 9

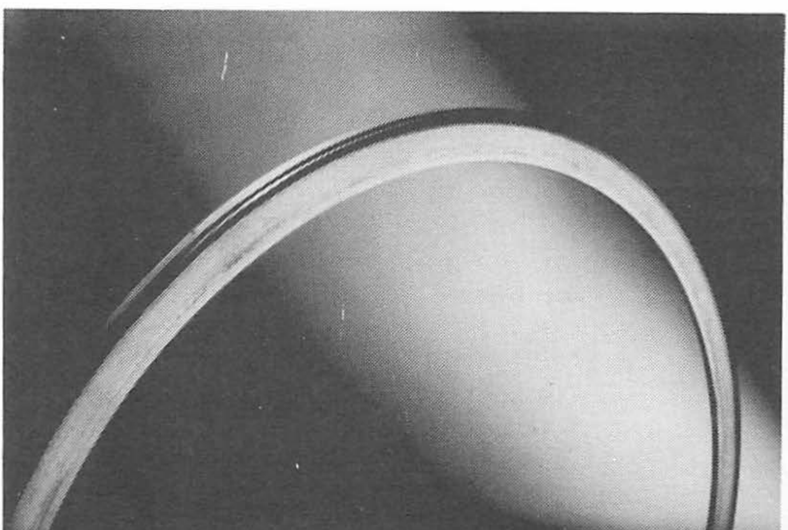


Fig. 10

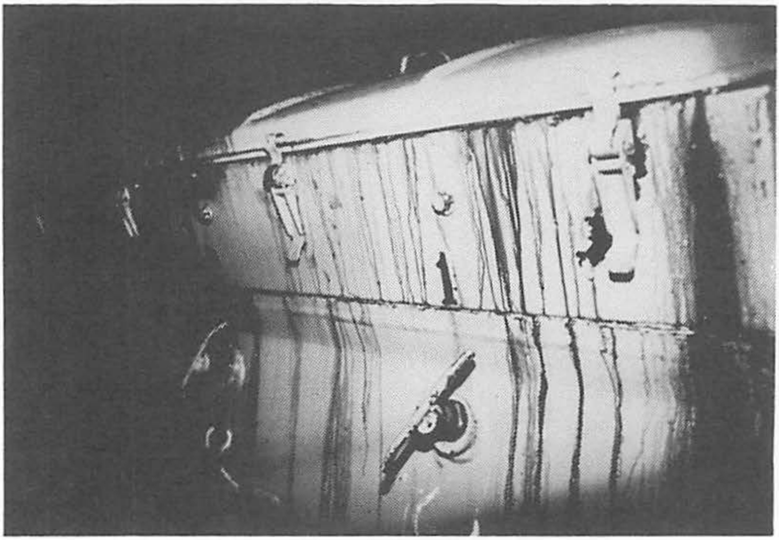


Fig. 11

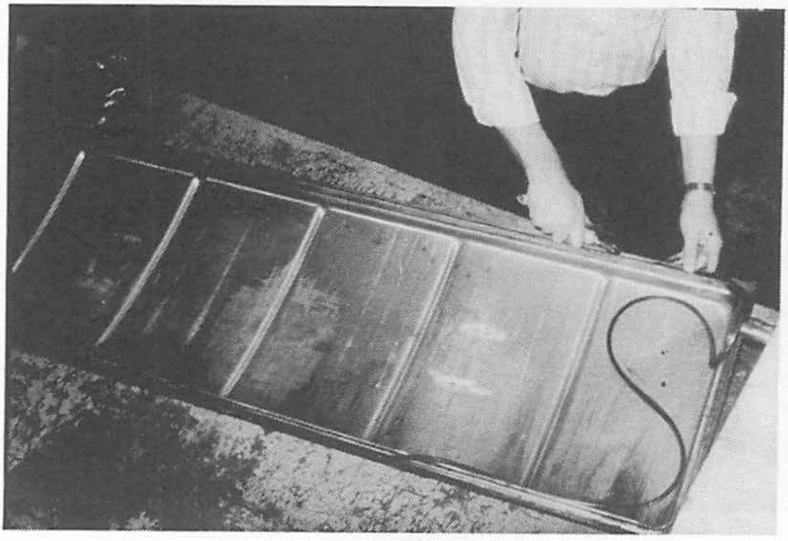


Fig. 12


CLARK
The #1 Name In Diesel Engine Protection.
For more than 40 years we've been the pioneers and innovators in locomotive filtration products. Our full-flow, long-life cartridges for OEM and specialized applications have set the quality and service standard for American railroads and around the world.
We offer the only long-life filter for turbo protection with spin-on convenience and reliability.
This same dedication to serving your needs is now available in our new fiberglass bags. More glass per square inch and higher loft mean a less restricted air flow with greater dirtholding capacity. All this adds up to reduced operating costs for you.
One-stop convenience and outstanding service, call today.
Together we are #1.
CLARK FILTER
a member of the CLARCOR filtration products group
3649 Hempland Road • Lancaster, PA 17601 • (717) 285-5941

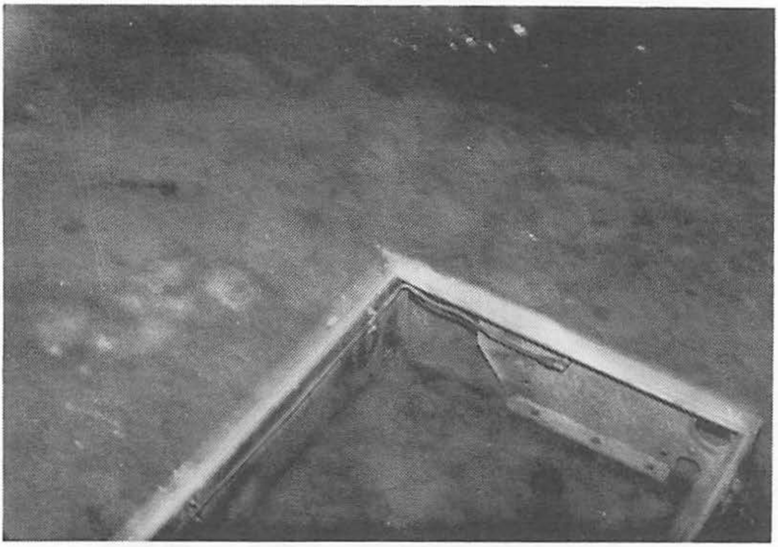


Fig. 13

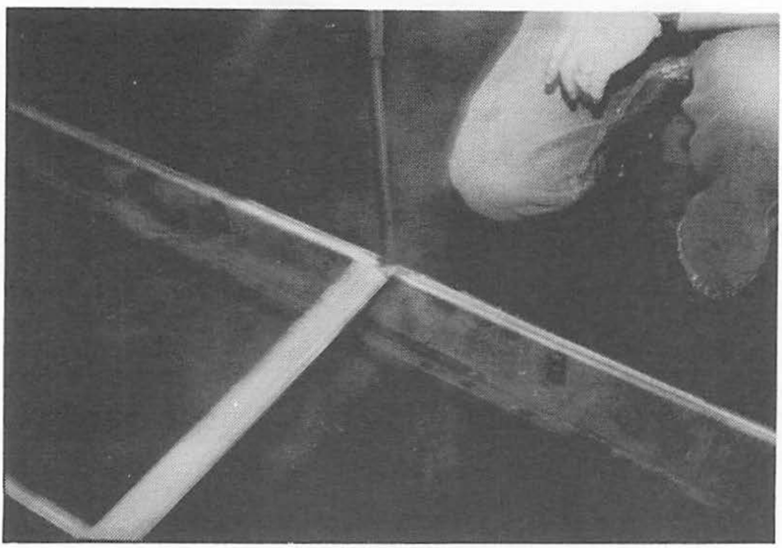


Fig. 14

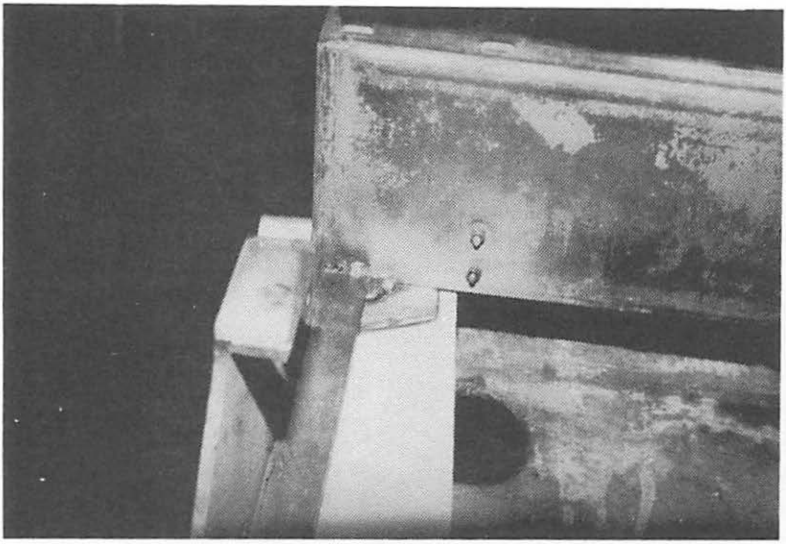


Fig. 15

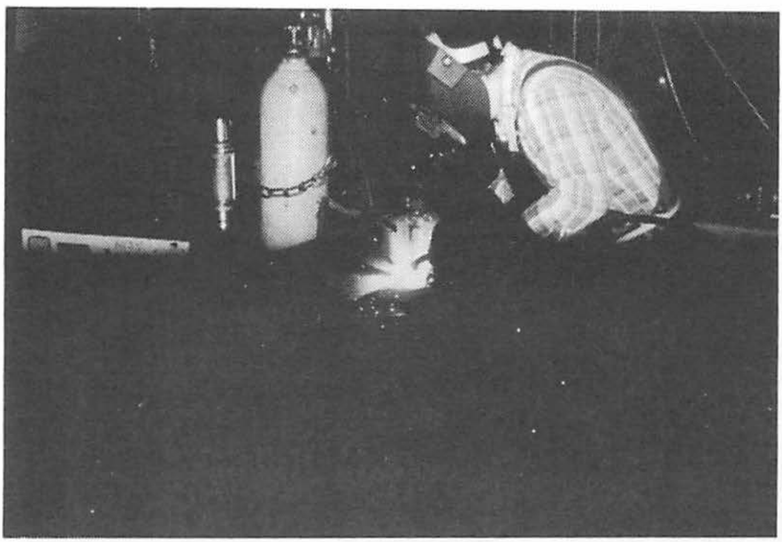


Fig. 16

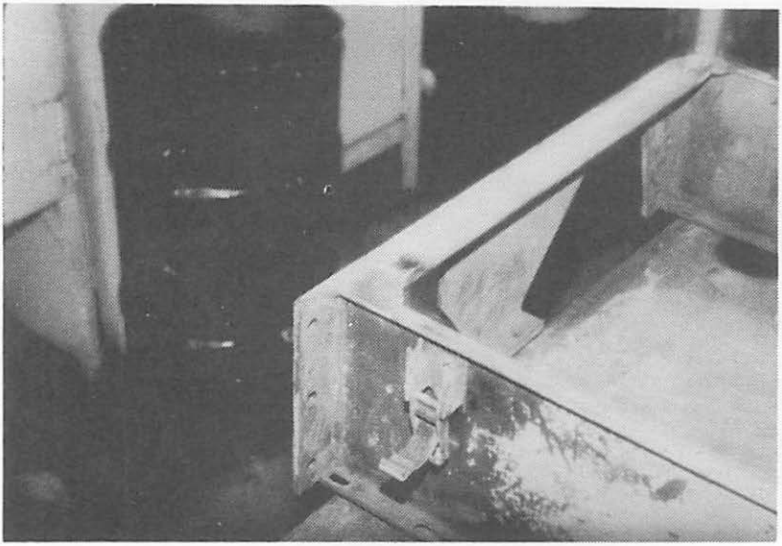


Fig. 17

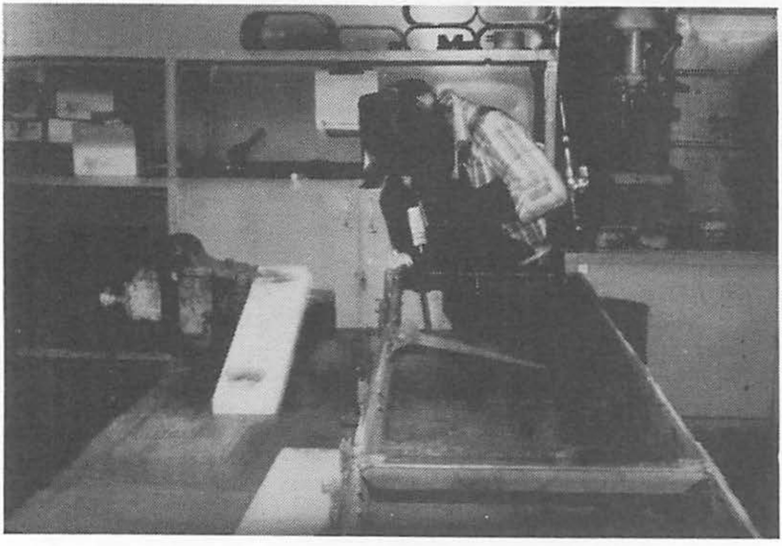


Fig. 18

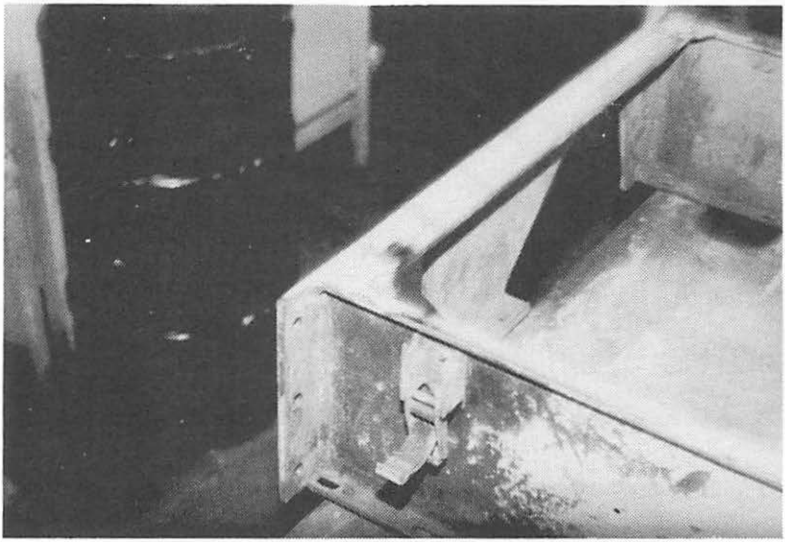


Fig. 19

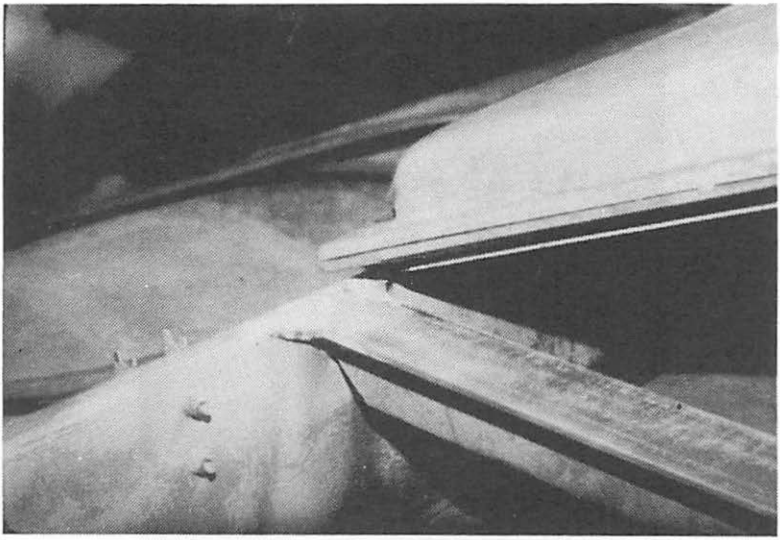


Fig. 20

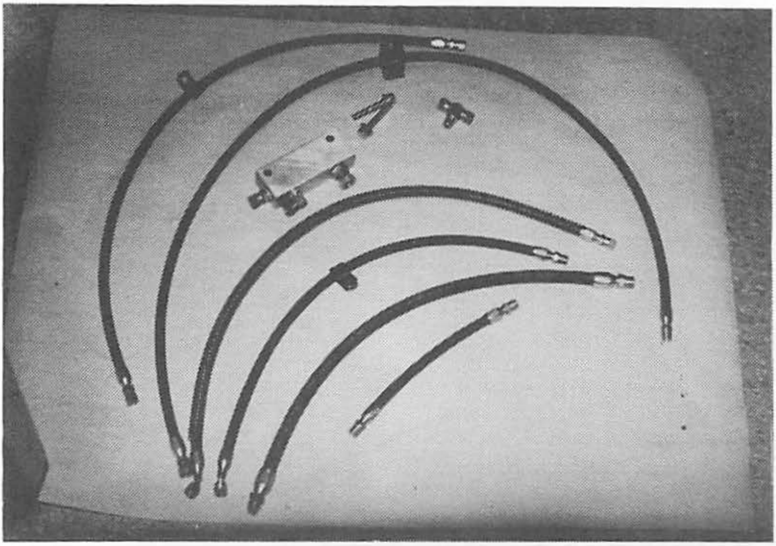


Fig. 21

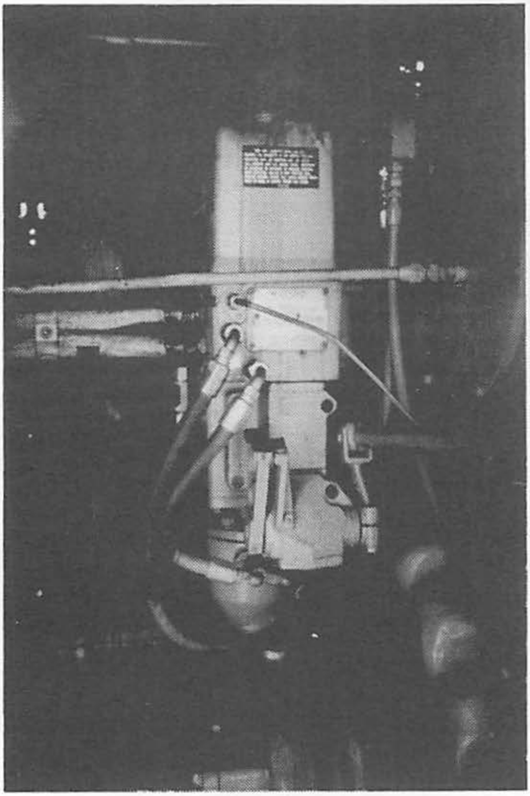


Fig. 22

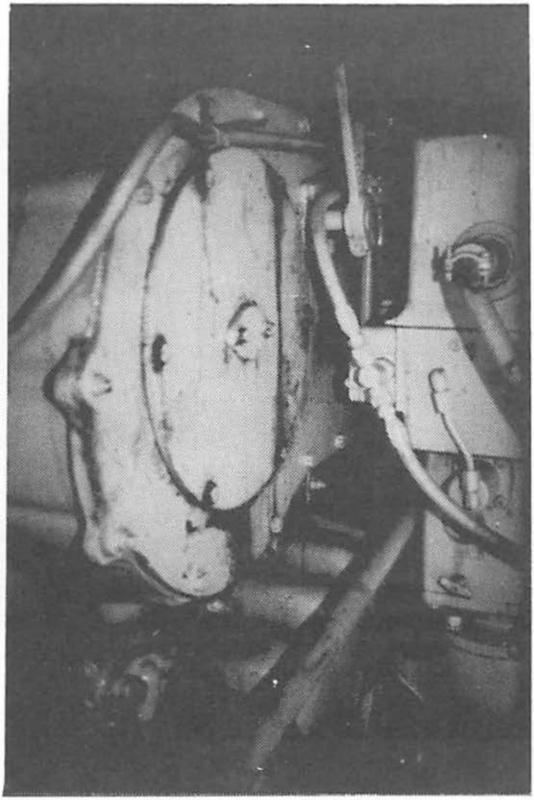


Fig. 23

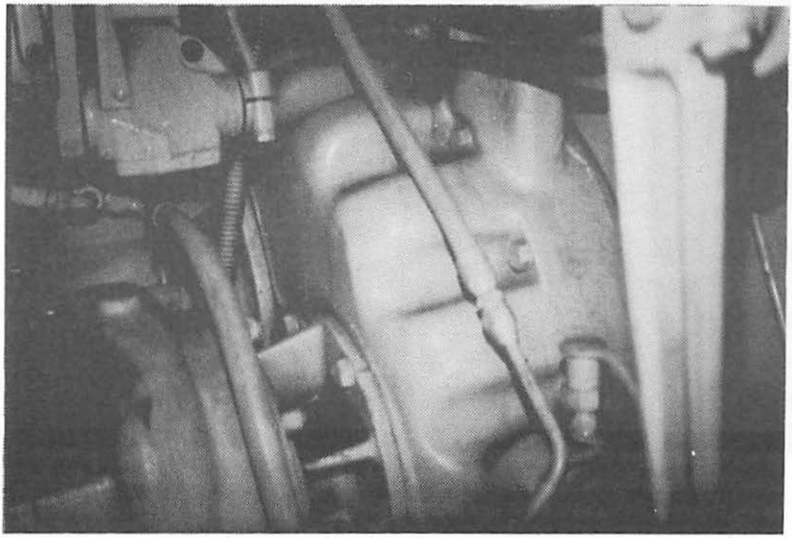


Fig. 24

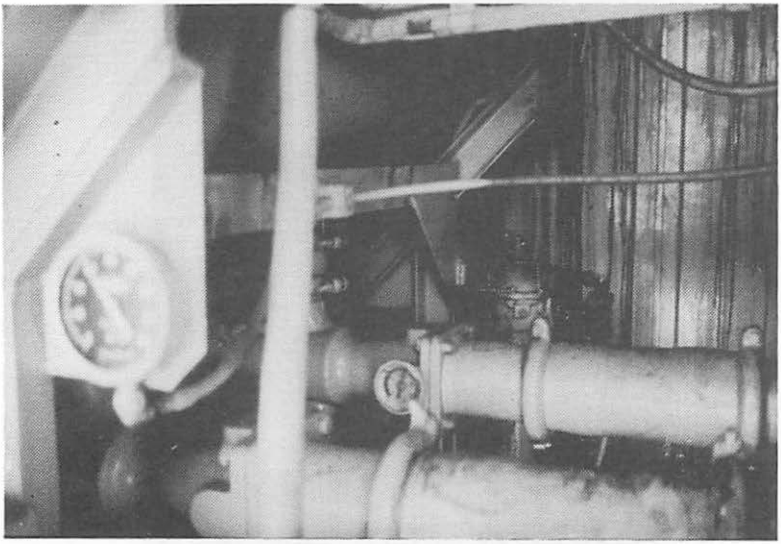


Fig. 25

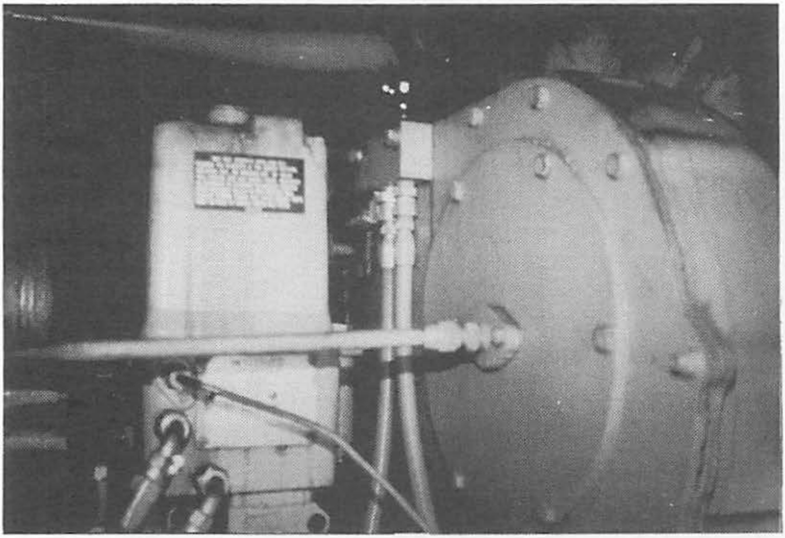


Fig. 26

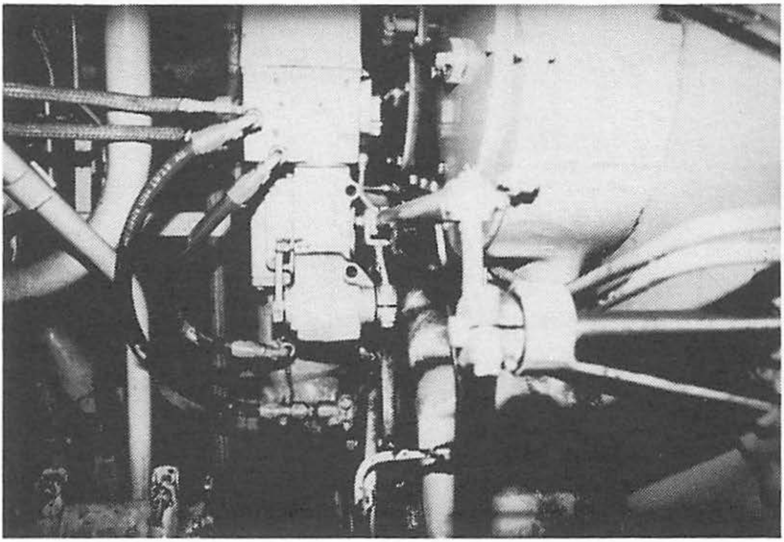


Fig. 27

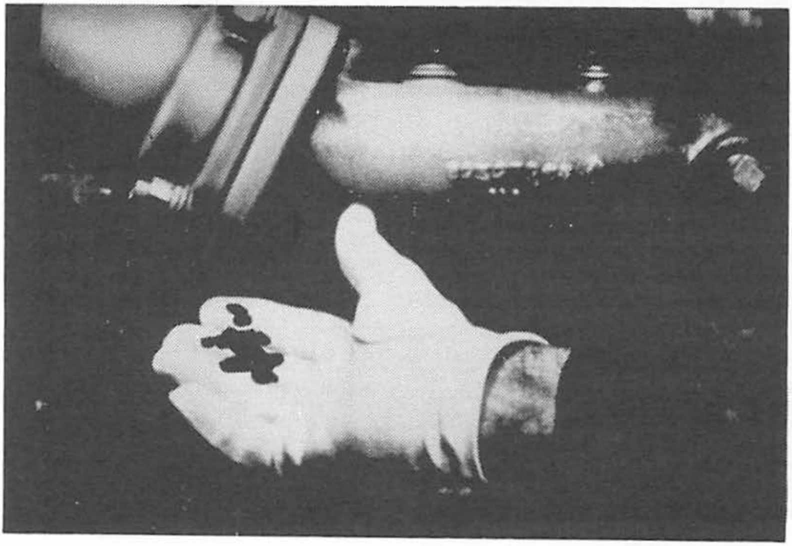


Fig. 28

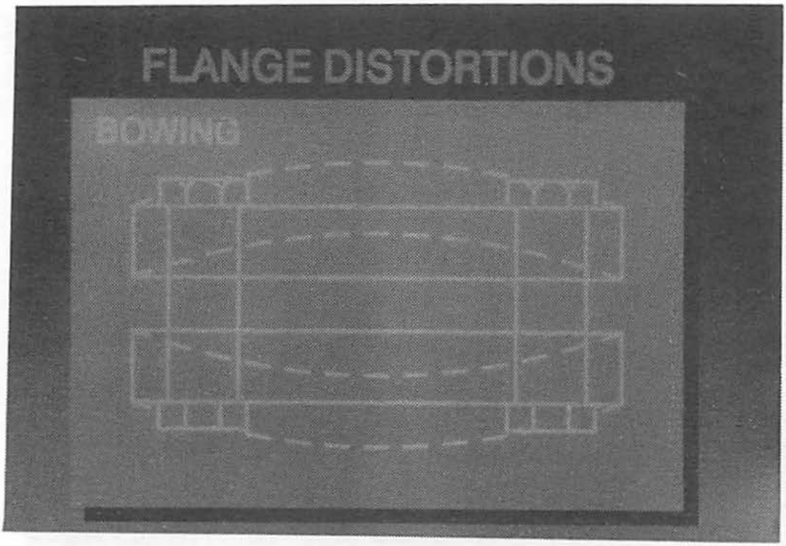

FLANGE DISTORTIONS
BOWING

Fig. 29

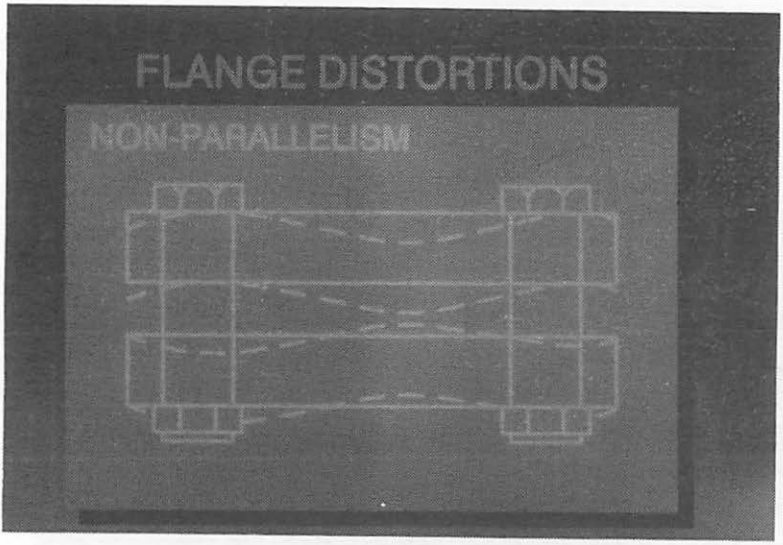

FLANGE DISTORTIONS
NON-PARALLELISM

Fig. 30

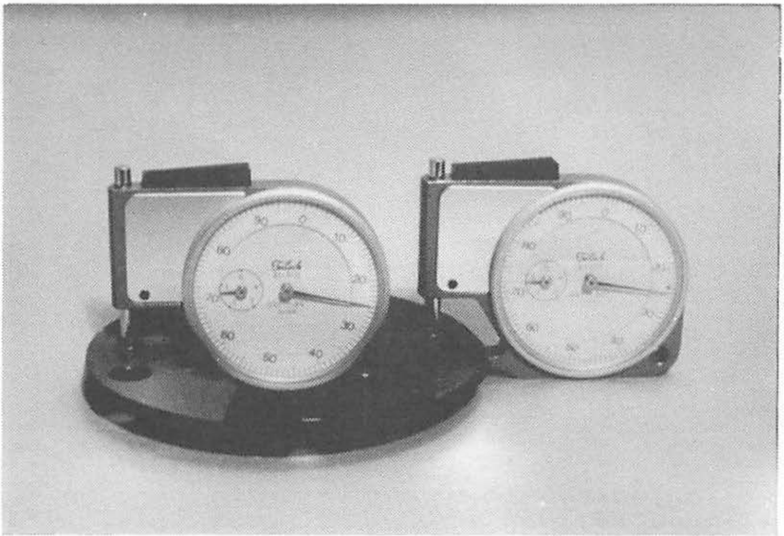


Fig. 31

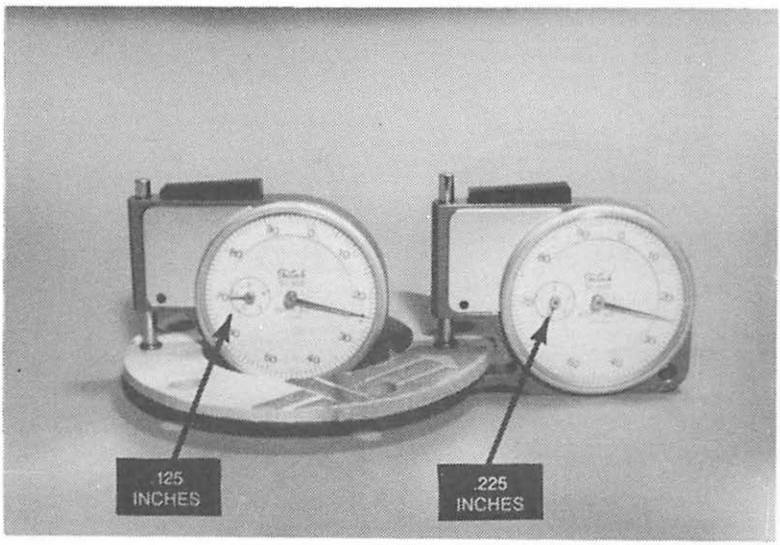


Fig. 32

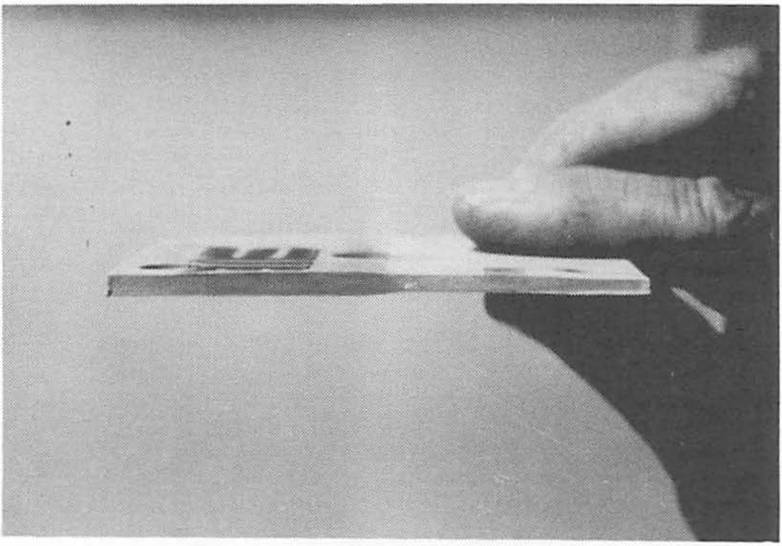


Fig. 33

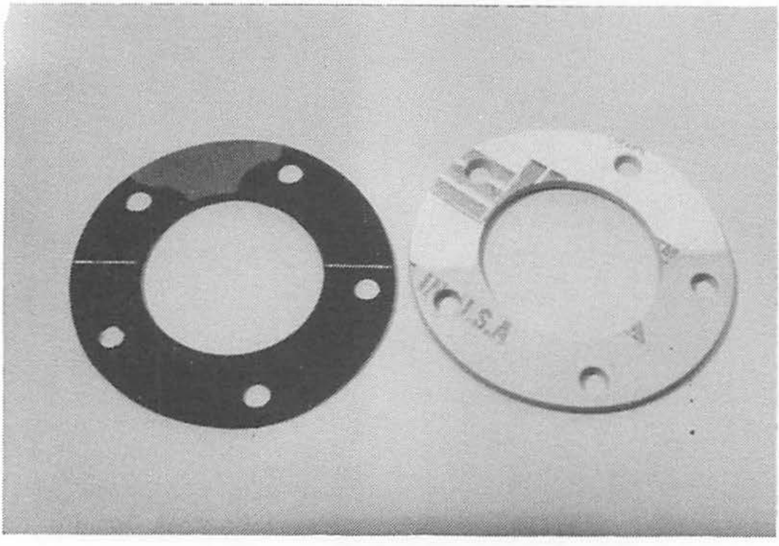
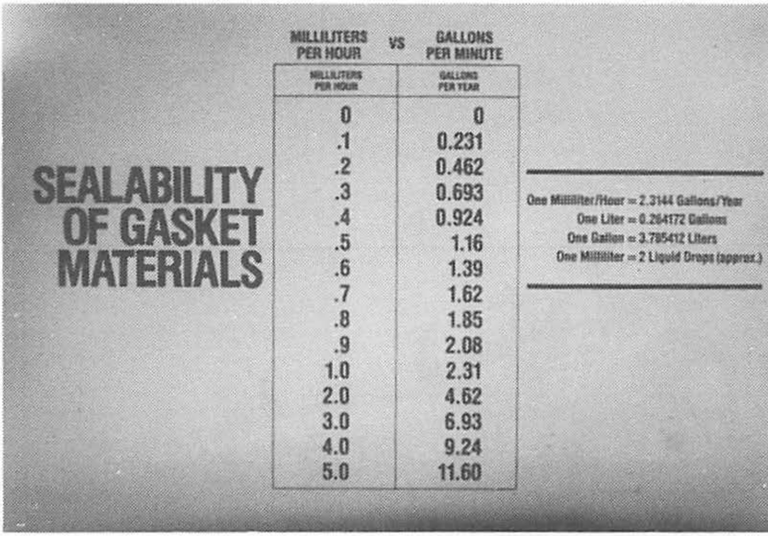


Fig. 34


SEALABILITY OF GASKET MATERIALS
MILLILITERS PER HOUR VS GALLONS PER MINUTE

MILLILITERS PER HOUR	GALLONS PER YEAR
0	0
.1	0.231
.2	0.462
.3	0.693
.4	0.924
.5	1.16
.6	1.39
.7	1.62
.8	1.85
.9	2.08
1.0	2.31
2.0	4.62
3.0	6.93
4.0	9.24
5.0	11.60

One Milliliter/Hour = 2.3144 Gallons/Year
One Liter = 0.264172 Gallons
One Gallon = 3.785412 Liters
One Milliliter = 2 Liquid Drops (approx.)

Fig. 35

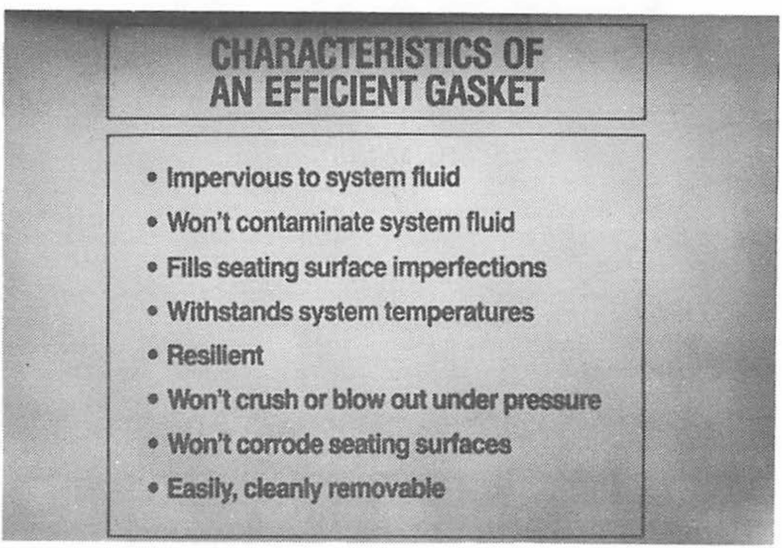

CHARACTERISTICS OF AN EFFICIENT GASKET
• Impervious to system fluid
• Won't contaminate system fluid
• Fills seating surface imperfections
• Withstands system temperatures
• Resilient
• Won't crush or blow out under pressure
• Won't corrode seating surfaces
• Easily, cleanly removable

Fig. 36

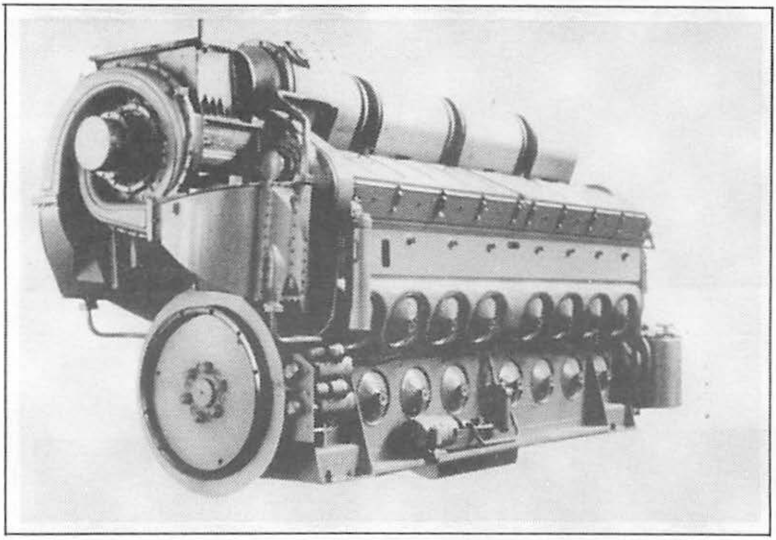


Fig. 37

V.
SECONDARY AIR FILTRATION -- BARRIER VS. IMPINGEMENT

Presented by
American Air Filter Company

The air filter is by far one of the most universally used products in both the commercial and industrial sector today. American Air Filter designs and manufactures literally hundreds of models, shapes, and sizes, for a wide variety of applications, and cleaning efficiencies, ranging up to 99.9995% on pointone micron size particles.

Air filtration products from AAF can be found in such commonplace locations as commerical office buildings, manufacturing facilities, hospitals and labs, and in some not-so-ordinary settings such as nuclear submaries...and even on the moon!

For the past thirty years, American Air Filter has been a major supplier of air filtration products for the nation's railroad industry, providing clean engine intake air for diesel electric locomotives coast to coast.

The primary purpose of filtering the intake air to diesel engines is to extend the service life of the engine between overhauls, at a minimum cost. Over the years, the railroad industry has used many different filter types for cleaning intake air. These have included metallic viscous impingement unit filters, centrifugal or flat blade inertial filters, oil bath air cleaners, barrier or surface loading paper filters, and viscous impingement glass fiber filters.

With each type having been used extensively, the performance characteristics of the filters have improved dramatically, as has the technology involving other locomotive components.

We are going to review the evolution of engine intake air filters. But before doing so, it would be helpful to examine the test procedures used to evaluate the different types of air filters, from which comparisons can be made, relative to filter life and engine wear.

Attempts at adopting a uniform test procedure date back to the 1933 American Society of Heating and Ventilating Engineers, or ASHVE. Because progress in this area was slow to come over the years, the Air Filter Institute, or AFI, which was formed by major filter manufacturers in 1952, appointed a committee to review all test procedures, and to establish a uniform, standard test code.

Among the developments of the AFI code were the establishment of a standard sampling and weight procedure; standardized testing equipment; the selection of a uniform test dust, and the rate of dust feed, or dust concentration.

The dust selected is commonly known as Arizona road dust fine, which is commercially available. To this was added a percentage of carbon black and cotton linters, since the test procedure was mainly concerned with ventilation type filters.

The concentration specified was .625 grams per 100 cu ft, which is the concentration specified by the railroad test procedure, developed in the 1950s. It was based on the AFI code, but was modified to feed Arizona road dust fine, without any additions.

A short time later, General Electric and EMD adopted this procedure, and procured test ducts so they could run similar filter evaluation tests in their own laboratories.

Eventually, the AFI merged into the American Society of Heating, Refrigeration, and Air Conditioning Engineers, known as ASHRAE. The test procedure, including the equipment and type of dust, remained constant thereafter.

Prior to the development by AFI of a standard test procedure, the Society of Automotive Engineers, or SAE, had approved a test procedure in 1941, which also adopted Arizona road dust fine, but without the carbon black or cotton linters specified by ASHRAE.

The only major difference between the SAE and the modified ASHRAE railroad procedures is the dust feed concentration, and the fact that the SAE procedure was specifically designed for surface loading-type engine filters.

Surface loading filters designed for locomotive applications can have up to 54 times the surface area for the same amount of air flow as a viscous impingement bag filter.

This permits the use of the much higher SAE dust feed concentration of 28 grams per 1000 cu ft, which is 45 times the concentration fed to a viscous impingement filter. In other words, the concentration per square foot of surface area fed to a surface loading filter is less than that fed to a depth loading filter at the lower feed rate.

IN 1977, after reviewing all of the testing history and extensive visits to EMD, GE and the major filter manufacturers, the AAR adopted a procedure which utilized the ASHRAE equipment, and Arizona road dust fine as the dust most representative of that encountered in railroad service. This then established the uniform test method for locomotive engine intake air filtration, which is recognized by General Electric, EMD and the AAR.

Now that we have briefly reviewed the history of test procedures, let's take a look at the evolution of locomotive engine intake air filtration.

Since the introduction of the high horsepower diesel electric locomotive, a number of engine intake air filtration systems have been developed. These have included inertial engine air filters, panel oil bath filters, cycoil oil bath viscous impingement filters, pleated paper surface loading filters, and the viscous impingement bag filter.

The introduction of the GP-30 and GP-35 locomotive models in the early 1960s ushered in the age of the high horsepower locomotive. Inertial intake air filters were first utilized on the GP-30 locomotive in the form of tube type inertials, while the GP-35 utilized flat blade type inertials.

It soon became apparent, however, that engine wear caused by air borne dirt was resulting in the need to overhaul the GP-30 and GP-35 units prematurely.

Experience with inertial engine intake air filters led to the development of the cycoil oil bath filter. The cycoil increased the efficiency of the intake air filter from 85% with the inertial filter to 93%. Unfortunately, the cycoil required a great deal of maintenance due to vibration, which led to the development and introduction of pleated paper. Even though pleated paper provided higher efficiency of 98%, it is well known that cycoil and pleated paper equipped units showed no difference in engine wear from air borne dirt.

The pleated paper filter which has been treated to resist soot and fire, contains very small pores and although sometimes labeled as barrier type filter, it separates dust by utilizing inertial forces and pore size. This enables the capture of particles down to the one micron range, typically smaller than the pores of the paper, resulting in high efficiencies.

Although pleated paper was extensively used, many railroads felt there was a need for a filtration product that would be easier to install, would mesh with the routine locomotive maintenance cycle, and would protect engines at a lower cost.

These demands led to the next step in the evolution of engine intake filters: the development of the AMER-kleen fiberglass bag filter by American Air Filter in 1970.

In 1972, the AAF AMER-kleen cartridge was approved by both locomotive builders, and by 1974 it was being specified on more than half of all locomotive orders.

The AMER-kleen from AAF features high cleaning efficiency, ease of installation, attractive pressure drop characteristics, overall dependability, and outstanding engine protection.

In order to fit in with railroad maintenance schedules, the AMER-kleen life cycle was designed to be at least 92 days with a generous failsafe allowance, in the event of a missed changeout. This also allows the changing of a filter to be done without having to resort to manometer readings which have been known to be misread.

The AMER-kleen cartridges are manufactured at one of AAF's newest plants in Fayetteville, Arkansas, where we also produce our own fiber glass to exacting standards. The process begins with glass pellets placed in hoppers and taken to the individual furnaces. As melted glass is pulled out through the orifice plate, a mercury switch trips, setting off a vibrator, which delivers more glass to the furnace.

The melted glass is collected on rotating drums to form blankets. The drum speed, the traversing action back and forth beneath the furnace, the total spin time, and the dye application are controlled by process computers.

Following the spinning operation, the blankets are taken to a cold storage room. Here a large number of blankets of a similar type are collected so that longer runs of a given product can be made. Next, the blankets are staged at the entrance to the oven, and are then pulled or expanded. The oven "sets" the thickness and cures the thermosetting resins. As the media "exits", it is cut to the proper width and length.

All of the finished product testing is done at the exit of the oven. This includes the pad weight of a sample, adhesive weight, pad compression, nail board tests on both sides of the media, and air resistance tests.

After the media exits the spray booth where the viscosine adhesive is applied, it is stacked, and a layer of scrim is added to each side. It is then fed through the sewing machine where flutes are sewn in. Next, the scrim is cut, separated into individual pad units, folded in half and placed on a rack for later transfer to the department which actually performs the sewing operation.

The first part of the sewing operation involves trimming off the cut ends after they have been folded, followed by side stitching. The bag filters are then transferred to a second operation where red chino is sewn on. The chino acts as the holding agent for the iron ring that ultimately holds and seals the finished filter in the filter housing.

The next operation involves the physical sewing of the chino around the iron ring. The final step in the process is inverting, inspection, and boxing for shipment.

The AMER-kleen cartridge, which provides 97% cleaning efficiency, is truly failsafe in design. The dirt collects in the air entering media, and when this becomes clogged, it collapses on a fresh layer of media which serves as the failsafe barrier. After exhaustive lab and field tests, this filter was approved by both EMD and GE for use on their locomotives.

Another advantage of the AMER-kleen is its resistance to damage. While a pleated paper filter could be torn or punctured from handling, it would be extremely difficult to damage a fiber glass element in this manner.

Ease of installation is another AMER-kleen feature. Installation is a relatively easy procedure, with the sealing area visible to the installer. Fig. 1 compares the annual cost of using AAF AMER-kleen cartridges versus paper elements. The cost of the paper elements rises dramatically if they are replaced more than once a year, which is often the case. The AMER-kleen operating cost is made all the more attractive, thanks to significanly lower pressure drop, which results in lower fuel consumption.

In summary, the combination of field testing and lab tests over the years has shown conclusively what is required of an engine intake filter. Since there are several air filters which meet these requirements, the decision to use one over another must be based on which filter is the easiest to maintain, has an adequate safety factor, is failsafe, and is the most economical. The AMER-kleen cartridge from American Air Filter satisfies these criteria more thoroughly than any other comparable product offering. In 1989, 98 percent of all the locomotives scheduled for delivery to North American railroads will be equipped with AMER-kleen bag filters and housings.

At American Air Filter, the research and testing that resulted in the AMER-kleen is an ongoing process. We are constantly exploring ideas that will ultimately produce new generations of air quality control products to meet tomorrow's needs, and beyond.

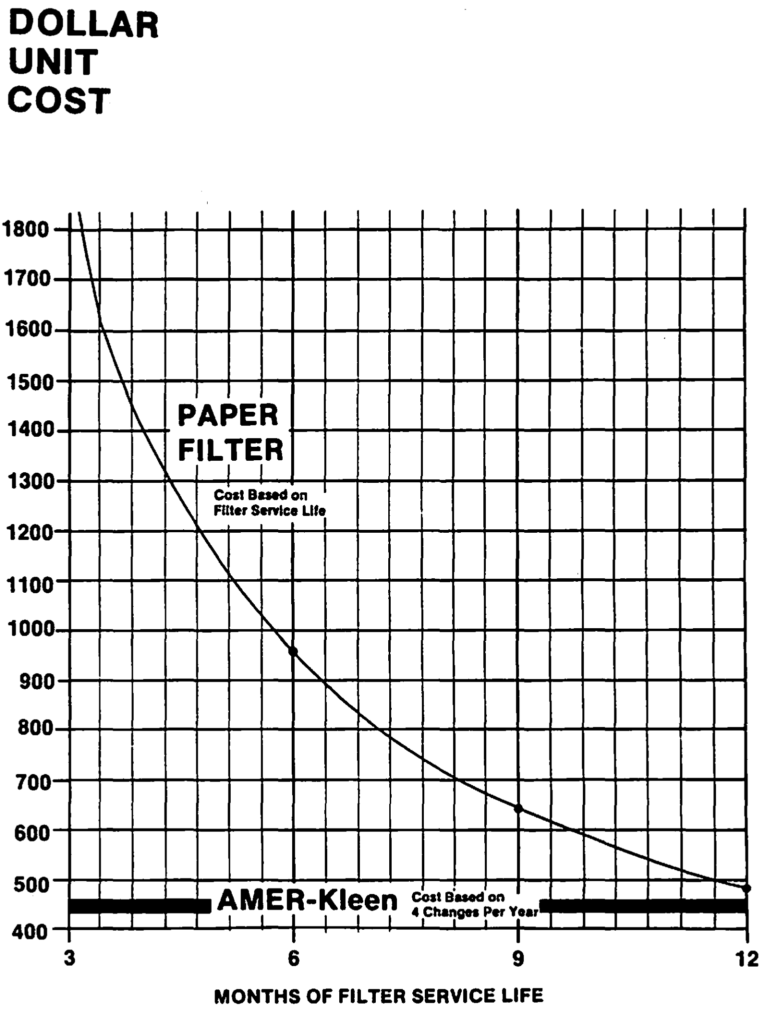

DOLLAR
UNIT
COST
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
PAPER
FILTER
Cost Based on
Filter Service Life
AMER-Kleen
Cost Based on
4 Changes Per Year
3
6
9
12
MONTHS OF FILTER SERVICE LIFE

Fig. 1

VI. SECONDARY AIR FILTRATION BARRIER VS. IMPINGEMENT

Presented by Farr Company

In the railroad industry today, locomotives are running at higher horsepowers than ever before while engines and turbochargers are handling larger volumes of air at higher air flow rates. This combination makes air filter performance a critical concern.

We will look at the two types of disposable locomotive engine air filters used by railroads today; how they work and how well they perform based on laboratory tests and actual field data.

There are two different types of air filters; fiberglass bags and paper filters. Bag filters are made of relatively coarse glass fibers spun into a thick mat on a large drum. Drum speed and feed rate are computer controlled. The mat is removed from the drum and fed through a stretching machine. Final displacement of fibers is not determined until the mat comes through the stretcher. The glass itself has limited filtering capability because the individual fibers aren't dense enough. Then the media is impregnated with an oil adhesive to trap contaminants. This is called impingement principle of filtration.

With an impingement-type filter, mass and velocity cause large particles to follow a path different from the air stream, and impinge upon the filter bag. The oil adhesive used to cause impingement is applied by spraying.

Fiberglass filters are typically found in air handling systems for buildings as well as locomotives. Paper filters are used primarily for internal combustion engines.

Unlike bags, paper filters are "barrier" type filters. Barrier filters work by straining particles from the airflow. Straining is effective because the space between the filter fibers is smaller than the size of the particles being filtered.

In fact, paper filters are made of microscopically fine paper fibers and resins formed into a dense matrix. This density prevents even microfine particles from passing through the system, and creates greater air flow resistance, so the paper is pleated to provide extended surface area. This provides improved dirt holding capacity and long filter life.

Computers control and monitor the manufacturing process, to ensure consistent displacement of fibers and porosity of the finished product. The media is corrugated to add stiffness and enhance air flow. Flame retardant and soot treatment are later applied and permanently oven cured into the filter.

Railroads base their use of air filters on several key points: including changeout, cost, service, life, and the efficiency of engine protection. Let's start with a look at changeout, storage, and the cost of bag filters. Because four bags can replace 12 paper filters, changeout can be faster. There are also fewer parts to store, handle and install. Bag filters usually require less space in the air filter compartment. Bag filters average about $30.00 each or $120.00 per changeout ($480.00 annually), and changeout labor takes about 15 minutes per changeout (one hour per year).

Bag filter manufacturers recommend a 92 day changeout of bags, a practice virtually all railroads follow. John Sefakis, technical manager, Farr Company, states "after monitoring many locomotives using bag filters, we've found the 92-day service interval appropriate for most locomotives. However, bags may not always operate safely within that service interval on new, high horsepower locomotives such as the SD-60's and C40-8's. Increased air requirements on these units place additional stress on bags, and allow more dirt to penetrate (Fig. 1)."

EMD stresses the importance of 92 day service, because of adhesive evaporation and migration. Reliance on changing when the pressure switch trips can cause rapid engine component wear. For example, migrating adhesive can cause the disintegration of turbo rubber boots which connect the turbo to the bag housing, and, if adhesive and dirt migrate into the aftercoolers, the fins can become plugged and air flow restricted. Malfunctioning aftercoolers may result in less efficient combustion, and can raise air box and exhaust temperatures which may cause an overheat, overspeed condition of the turbocharger.

Another problem is oil buildup. Balancing machine tests at Globe Turbocharger Specialists have shown that oil build up can actually cause a harmful, out balance condition. Globe's sophisticated machinery balances rotors to extremely tight tolerances, and just a slight amount of oil throws an assembly out of balance.

Now let us take a look at data concerning changeout and cost of paper barrier filters. Unlike fiberglass bag filters, paper barrier filters do not require a 92 day changeout interval. Instead, paper filters are designed to last one year between changes.

Paper filters average about $40.00 each. Multiplied by 12 filters, the annual total is the same as for bags (about $480.00). Paper filter changeouts require only 30 minutes (half the time required to change bag filters over the course of a year). One changeout per year instead of four reduces downtime and labor costs, because filter maintenance needs to be performed only at regularly scheduled intervals.

Although some railroads still question the long service life of paper filters, as early as 1975 EMD stated that paper type filters could be expected to provide a minimum of 12 months service life under most railroad operating conditions. In our monitoring of paper equipped units, we've found that most filters last a year. In very severe environments, such as tunnel operations, more frequent changeouts may be required, and in situations where locomotives are run backwards, oil mist pumping out of the exhaust stack may get sucked back into the air intake system, which causes filters to plug prematurely (but these are the exceptions, not the rule).

Along with changeout and filter cost, the other key considerations for selecting air filters involve efficiency of engine protection. There are two methods used to measure efficiency: an HVAC industry test and a more accelerated SAE test used to rate all types of engine filters.

The Association of American Railroads (AAR) is working to develop test standardization with the assistance of the Southwest Research Institute. Using either test method, bag filters typically have an efficiency range of 86 to 96 percent. Bags depend on air velocity to function so they are most efficient at full speed. AAR figures show that the average locomotive operates at full throttle less than 20% of the time, and bag efficiency can drop to 86 percent at idle, allowing greater dirt penetration to occur.

Fiberglass bag filters typically start out at a pressure drop of approximately 2 inches, with increases of about one inch during 92 days of service. As pressure drop increases, bags can pass contaminant. In severe cases, channeling of bags may occur, causing both air and dirt to leak through fibers that have separated under stress and have not retained an adequate amount of adhesive oil to trap dirt. This condition may be indicated by an actual decrease in pressure drop.

The lower efficiency of bags can also allow damaging amounts of contaminant to build up on the turbo. After dismantling hundreds of turbos, experts at Globe Turbocharger have found a build up of adhesive, dirt, soot and other elements around the compressor impeller cover area of units equipped with bag filters. Paul Chartrand of Globe states that "this can possibly create an out of balance condition, and it can result in premature bearing failure. Whenever we've found this build up, labyrinth seals have also been plugged. Plugged seals can cause oil to escape up the exhaust stack or into the engine. This condition is not normally present when paper filters have been used".

Paper filters have an efficiency range of 97 to 99 percent - a range higher than bag filters' top rating of 96 percent, and, with paper filters, efficiency is maintained at all engine speeds. Paper filters also gain efficiency with time, as dirt particles entrapped on the surface make the media even more dense. In other words, paper filters gradually plug over time. Paper filters usually start at a 1 to 2" pressure drop and increase 3 to 4 inches over one year, and when pressure drop increases, so does efficiency.

After weighing a large number of used filters, we determined that the average paper filter collects one pound of dirt during its service life, while a typical bag filter collects half a pound during service. In other words, paper filters are capturing more dirt per year, preventing that dirt from entering the turbo, aftercoolers and engine.

Diesel engine wear tests document the importance of high efficiency air filtration. In an SAE test measuring the effects of several operating variables on ring wear, the efficiency of engine air filtration was listed as the number one factor impacting engine wear.

Recently, a midwestern railroad performed a controlled test to analyze how well bag and paper filters protect costly engine and turbo components. Three GP-50 locomotives with newly rebuilt turbos were used in the test - two equipped with bag filters from different manufacturers and the third locomotive equipped with paper filters. After one year and 140,000 miles of service, all three units were torn down with dramatic results. The two units with bag filters faced potentially early turbo failure. Compressor end seals were completely plugged and turbine and seals partially plugged (Fig. 2). Compressor impeller cover and bearing support showed a heavy build up of carbon dirt and oil (Fig. 3). In contrast, the paper equipped locomotive was in excellent condition. Seals were almost completely clean and the impeller cover and compressor bearing support showed only a light amount of build up (Fig. 4). This turbo was reassembled and returned to service as is. Because of these findings, the railroad that performed these tests is now specifying paper filters on all new units.

This discussion has taken a look at

both paper and fiberglass bag air filters. With filter performance a vital concern, examining the facts about both types of filters is essential so that you can select the air filter system that will most enhance engine turbo protection longevity.

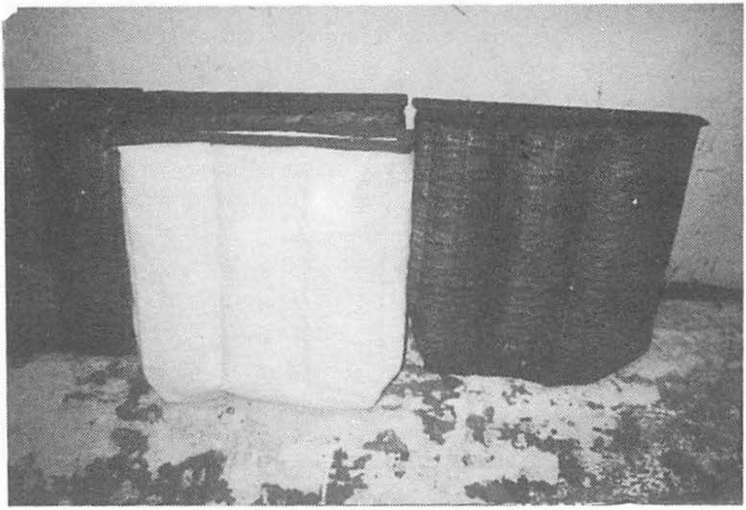


Fig. 1

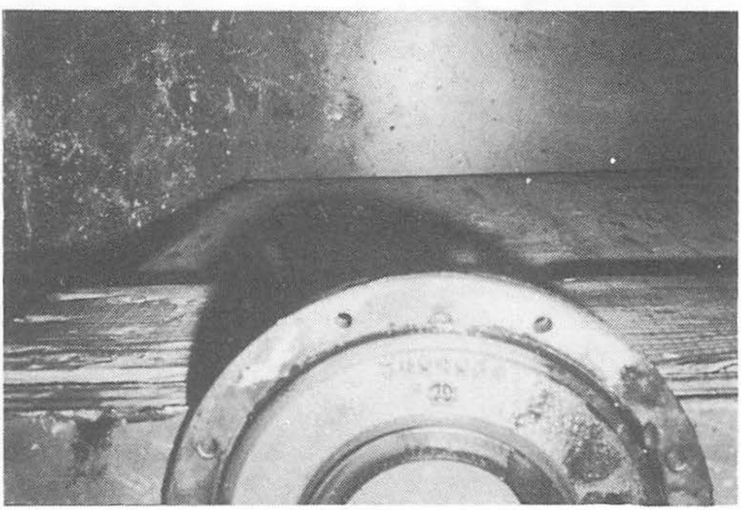


Fig. 2

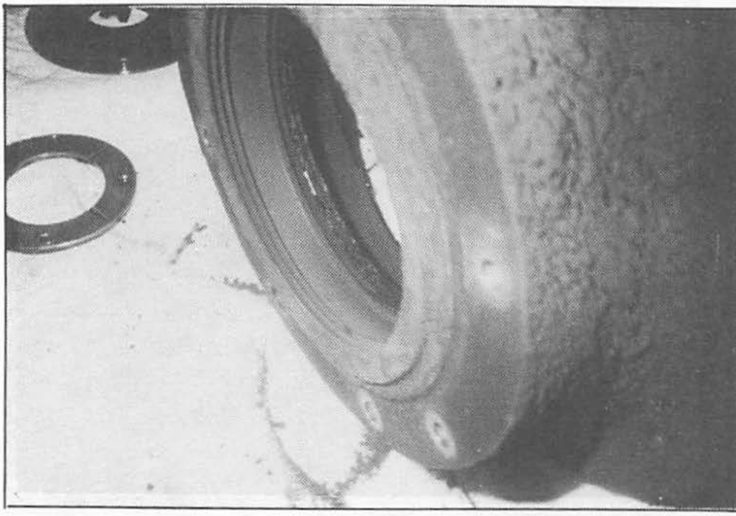


Fig. 3

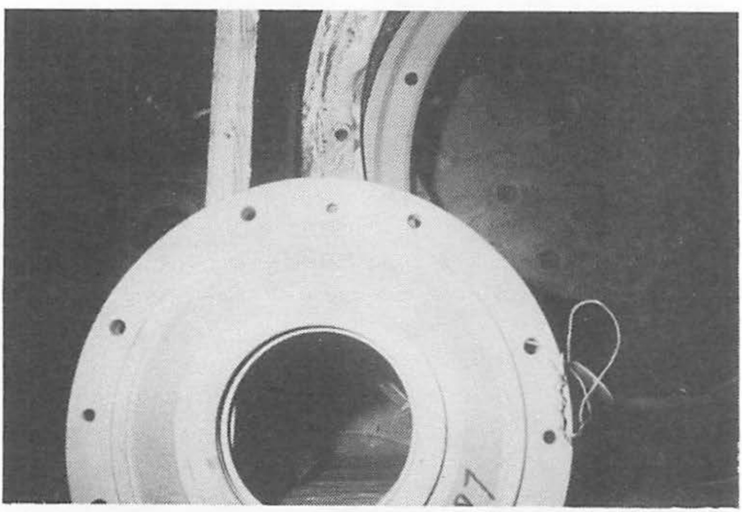


Fig. 4

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 Shop Equipment 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.

Monday, September 18, 1989
1:45 P.M.

REPORT OF THE COMMITTEE ON SHOP EQUIPMENT

Pre-Convention Presentation: Roanoke, VA

May 3, 1989
Hotel Roanoke
Roanoke, VA

D. E. TETLEY, Chairman
Manager-Facilities Planning
Union Pacific Railroad
Omaha, NE

VICE CHAIRMAN
D. M. Wetmore, Manager-Production Control, CSX Transp., Corbin, KY

COMMITTEE MEMBERS

J. J. Clontz	Asst. Supt.-Regional Loco. Opns.	BN	Overland Park, KS
S. Fuzail	Mgr.-Industrial Engineering	C&NW	Chicago, IL
D. D. Graab	General Foreman	NS	Roanoke, VA
J. D. Hunt	Mechanical Foreman	IC	Homewood, IL
D. Kisko	Field Test and Marketing Adm.	GE	Erie, PA
C. Pope	Industrial Engineer	Amt	Wilmington, DE
B. G. Sullivan	Engineering Assistant	ATSF	Topeka, KS
J. J. Wheelihan	Supervisor-Field Engineering	EMD	LaGrange, IL

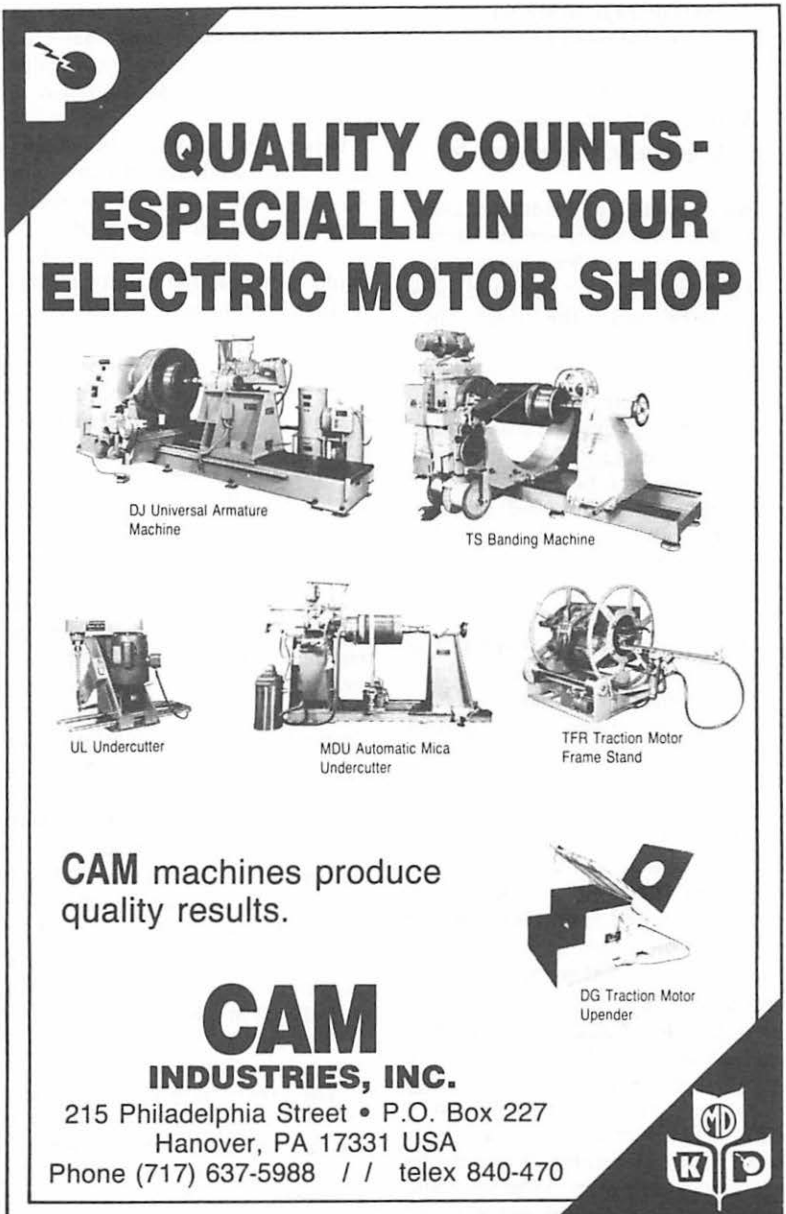
PERSONAL HISTORY

Donald E. Tetley

I was born in Omaha, Nebraska on November 2, 1945. I attended Field Club Grade School and South High where I graduated in 1963. After graduation, I immediately began working for Union Pacific as a carman apprentice. Later in 1963, I joined the Marine Corps where I served for four years and saw one year of action in Vietnam during 66-67. Upon my return from the service, I again resumed my position at the Union Pacific. I completed my apprenticeship and performed work as a carman and relief foreman during 67-71. During this same period, I attended evening classes at the University of Omaha.

During 1971, I was appointed to the Mechanical Department Staff as an Industrial Engineer. In 1972, I was transferred to the new car construction shop at Portland, Oregon where I served as the Senior Industrial Engineer for this facility. I remained in Portland for 10 years. During this time, I again attended evening classes at the University of Portland. I was transferred back to Omaha in 1983, where I now hold my current position of Manager, Facilities Planning.

I have been married for four years to my wife, Pat and have two stepchildren, Chris and Eric, living at home. I also have five children, Rhonda, Tammy, Pam. Jamie and Jay from a previous marriage.


QUALITY COUNTS-
ESPECIALLY IN YOUR
ELECTRIC MOTOR SHOP
DJ Universal Armature Machine
TS Banding Machine
UL Undercutter
MDU Automatic Mica Undercutter
TFR Traction Motor Frame Stand
CAM machines produce quality results.
DG Traction Motor Upender
CAM
INDUSTRIES, INC.
215 Philadelphia Street • P.O. Box 227
Hanover, PA 17331 USA
Phone (717) 637-5988 / / telex 840-470

SHOP EQUIPMENT COMMITTEE

I. Automated Guidance Vehicles

By Dave Butler, Caterpillar, Inc.

This discussion of automated guided vehicles will cover several topics. The first is how AGVs have been used effectively in the past and how they may be used in the future. Then we will discuss some of the inherent limitations in some of the guidance technologies that exist and finally discuss new guidance technologies. We will explain how the new technology works; how it expands the applications of AGVs and briefly a little bit about where it makes economic sense to apply AGVs.

A. History

AGVs go back over 30 years. The original AGV was a towing vehicle and the concept was that you could eliminate the driver on long haul distances by having an automated vehicle follow a wire. We'd load the trailers, we'd push a button and off the AGV went...a thousand, 1500, 2000 feet over to another warehouse, stop, then wait to be unloaded. When it was unloaded, somebody would push a button and it would come back. This saved manpower...was very simple, and worked very well.

As that technology expanded and evolved into the 1960s and 70s we found that the guidance technology allowed us to do more things. First, it allowed us to set up flexible assembly lines. These assembly line vehicles eliminated drag lines in the floor and replaced them with multiple paths for an assembly line, so that if one assembly station or an object got tied up we would bypass it and still get throughput through the assembly line. That way, items in assembly that were waiting on parts or might have been misassembled didn't have to go completely through the assembly process and then be disassembled and fixed.

Other uses that began to evolve included wire guidance on man-aboard vehicles in very narrow aisles. Since we could control the vehicle to plus or minus a quarter of an inch, we could control it much more accurately than the human operator. This allowed us to get high rise racking closer together and still have vehicles that could go in and out of racks, between aisles and have human operators.

The next generation of AGVs began when the computer began to get less expensive and smaller chips. With the advent of these computers, the AGV became one of the devices we used to connect between islands of automation. It could deliver and remove material from ASRS or deliver materials within flexible machining cells. The example in figure 1 is a flexible machining cell. The vehicle is unloading a machine pallet having a fixture with a part mounted on it. It's taking it from a robotic area to a machining cell where the part is machined, then brings it back. The robot turns it over, the AGV takes it back and has the other side machined. Finally, it's delivered, removed from the fixture and placed in a waiting bin for a fork lift operator to take away. All without any human intervention.

The other thing that happened is that as these vehicles got smarter and we had better and better communication we got closer and closer to just in time inventory, or what we might call just in time manufacturing. In other words, we could use AGVs in a work in process cell and we could depend on the proper part being in the proper place at the proper time, becasue we had all that control and all that scheduling centralized under computer control. And with more control, we got reduced inventory and better parts flow through complex machining operations.

B. Limitations

Even though AGVs were becoming more and more useful, they had limitations. In the early 80s, Georgia Tech did a study of what it thought the AGV of the future would need to do to meet the future needs of American manufacturing. Figure 2 discusses the three primary areas Georgia Tech identified; flexibility, integration, and control. Control means the ability to know where things are and to schedule more effectively. In other words, get the load that we want to the right place at the right time. We need that kind of control to get to just in time inventory.

Integration means that you not only have to have computers talking to computers, but also material has to move between pieces of automation and to do it automatically. AGVs can provide that kind of link. And flexibility...has several meanings. First is the flexibility to evolve with the facility or process. At Caterpillar we don't have a single building that doesn't change something once a month. Machine tools and processes move as we continue to try to come more efficient. AGV systems have to flex to accommodate those changes.

They have to live within the existing factory — integrate into whatever processes are there rather than requiring the pouring of concrete or building new buildings. The Georgia Tech researchers saw the need to go outdoors, between buildings. They also saw the need for what they called "soft automation," because existing systems depended heavily on hardware at every decision point, every crossing aisle, every docking point. When changes to the system needed to be made, hardware had to be moved...very difficult, time consuming, and expensive. If we could handle more of these decision points in software, reducing wire in the floor and programmable controllers at pickup and drop off points, changes would become easier and less costly.

After identifying these needs, they looked at what was and wasn't available; those needs they felt were met very well at that time, and the needs that were not yet met.

Some of the most compelling shortfalls where the problems with installing wire and following wire within the floor. Too many floors did not tolerate wire. Figure 3, for example, shows floors with wood block. You can't put the wire in the block because the block shifts and cuts the wire. You can't put it below the block because the signal can't get to the sensors on the vehicle; and concrete to replace wood block is very expensive. Steel embedded in the floors such as shown in Figure 4 at a Cat plant, or even steel plate floors like the one at Ford preclude wire altogether. Another shortfall was operating in existing facilities with existing constraints such as multiple pickup and dropoff points, complex turns, and narrow aisles.

C. Self guided vehicles

About the same time as Georgia Tech published its paper, we at Caterpillar recognized that we had many of those problems. We were asked if we would look at coming up with a better way to move vehicles automatically. The result is what we call a self guided vehicle.

While this happens to be the first commercial autonomous guided vehicle, it is just the first of an entire generation of autonomous vehicles that can operate without fixed path guidance. We know that many other people are working on concepts and expect to see this kind of technology becoming dominant within five years.

D. How they work

When you have a wire in the floor or other type of fixed path to follow, all the guidance system has to do is just follow the path. This makes guidance relatively easy. Once you remove that fixed path, you have a more complex problem. The way we have chosen to solve it, and the way other people with successful concepts appear to be solving it, is to apply multiple guidance systems. If you have some redundancy then the systems can cross check each other, and that constant cross checking will give you the accuracy and the confidence that the vehicle needs to operate.

One of the systems is simple dead-reckoning, in which the vehicle calculates the number of rotations of the wheels and the angle the steer wheel has to turn to negotiate corners. The second system uses a laser Figure 5 that is rotating on top of the vehicle and reading fixed sign posts which are simple bar-coded targets. It updates the dead-reckoning system. It measures angles to the targets it sees and triangulates its exact position. Then, the two systems communicate back and forth and cross check each other. That way if we are temporarily blocked from seeing a target, no problem, the dead-reckoning system will continue to navigate the vehicle. If we strike something on the floor and the steer wheel is knocked off center or the vehicle veers because it hit a pothole or some object, the triangulation system will say, "hey, you're off course, get back on course" and it corrects itself.

A coordinate system is set up so that paths and stopping points are identified by x-y coordinates. That allows the traffic controller to send instructions with "go to this coordinate then to that coordinate and stop at this coordinate". Communication is simple. We can also change destinations and aisles simply because all we have to do is identify the two end points of an aisle or the docking point coordinates and the software takes care of everything else.

It appears that this is going to be the technology of the future. What it does for us is that it expands the places where we can apply AGVs. We are not limited to those applications that are never going to change...or at least are not going to change in the next three or four years. The new SGVs can go into applications where the tasks change or pickup and destination points change. They can stack in racks, they can control inventory (because of centralized processing). Figure 6 shows an application where the SGV system actually tracks work in process piece part inventory from the time it enters the system until the completed part comes out. It's tracked at all different stages so that when the operator needs a part on his terminal and the system finds the piece for him. He doesn't have to holler at "Joe" to go and find him some widgets on the floor. The system knows where the part he needs is and it goes and finds it, gets it, and keeps track of it, reducing the amount of inventory required to support this process.

We can travel on all types of floors, even outside, and because the path is no longer very expensive to put into the floor, SGVs can handle longer routes. They can handle more complex routes, more complex docking points - where maneuvering is difficult. SGVs can change easily and evolve with you rather than forcing your process to work around them. Essentially, this kind of technology will let you automate almost any repetitive task that fork lifts are currently doing.

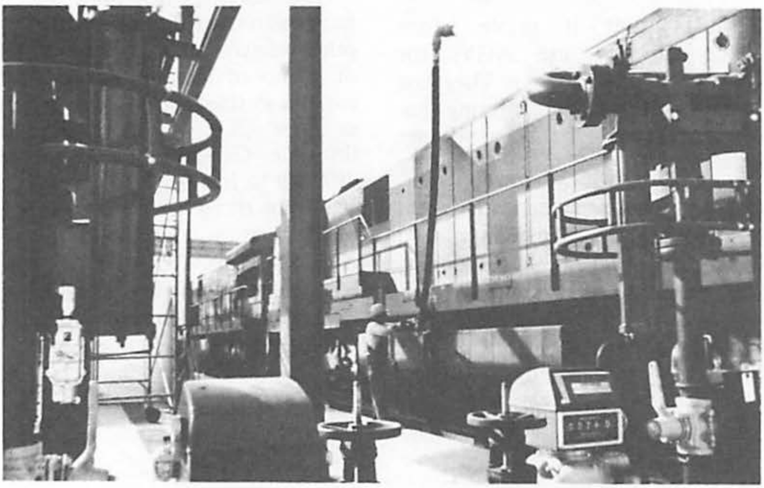
E. Economics of AGVs/SGVs

Where does it make sense economically to use AGVs (or SGVs)? They aren't cheap. They cost money, both in the engineering that goes into the system and the vehicles themselves. First, if you are dealing with replacing people; that is, you will reduce employment levels by installing a system, then generally speaking, you must have multiple shift operations. If you are able to achieve inventory reduction so that the system will have significant impact on just in time inventory you have have different (and better) economies. The general rule of thumb, however, is that multiple shift operation is necessary.

Second, the task has to be repetitive and definable. It doesn't have to go from point A to point B always, it may go point A to B or A to C or from A to F or whatever. But, it must be the kind of task that can be clearly defined and takes place with reasonable frequency.

And lastly, the task must require a fairly high utilization of the AGV. In other words, you must need that task or group of tasks performed often enough so that you can use one, two or more vehicles 80 to 90 percent of the time. Otherwise, it will be very difficult to justify.

Within those kinds of parameters the return on investment generally meets what is acceptable for most companies, with say a before-tax ROI of 20 to 25 percent or a two-year payback period.



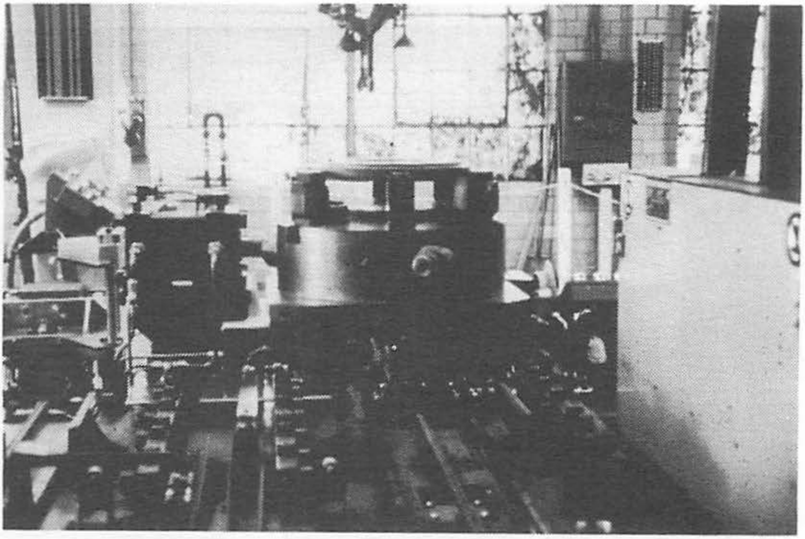


Fig. 1

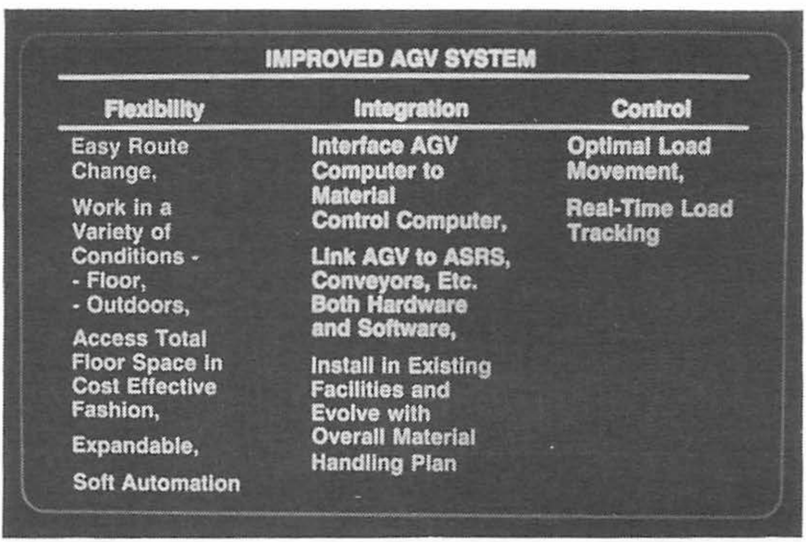

IMPROVED AGV SYSTEM
Flexibility
Integration
Control
Easy Route Change,
Work in a Variety of Conditions - - Floor, - Outdoors,
Access Total Floor Space in Cost Effective Fashion,
Expandable,
Soft Automation
Interface AGV Computer to Material Control Computer,
Link AGV to ASRS, Conveyors, Etc. Both Hardware and Software,
Install in Existing Facilities and Evolve with Overall Material Handling Plan
Optimal Load Movement,
Real-Time Load Tracking

Fig. 2

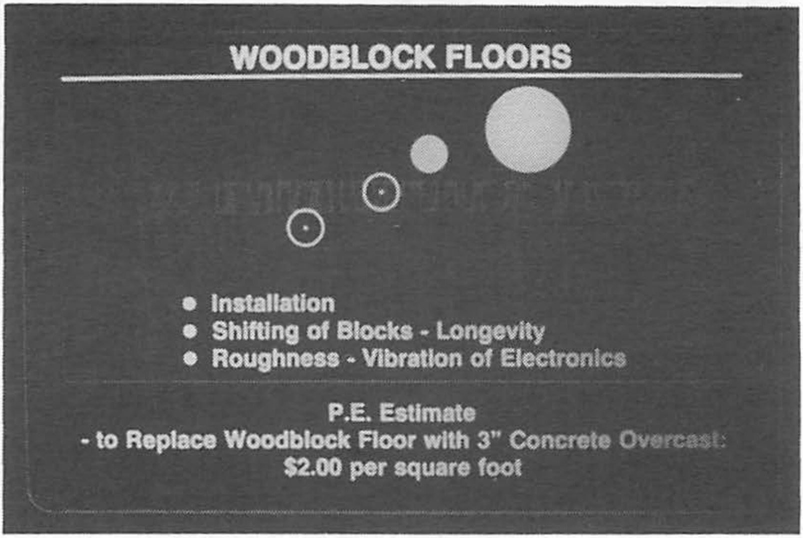

WOODBLOCK FLOORS
• Installation
• Shifting of Blocks - Longevity
• Roughness - Vibration of Electronics
P.E. Estimate
- to Replace Woodblock Floor with 3" Concrete Overcast:
$2.00 per square foot

Fig. 3

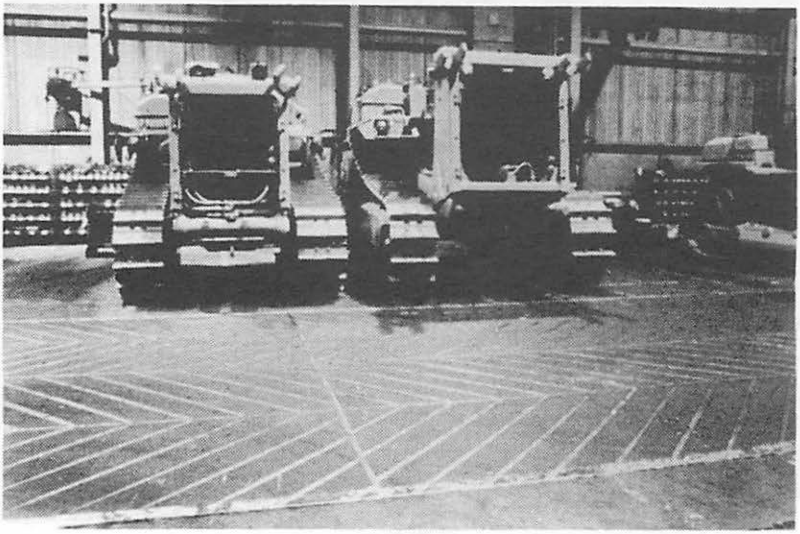


Fig. 4

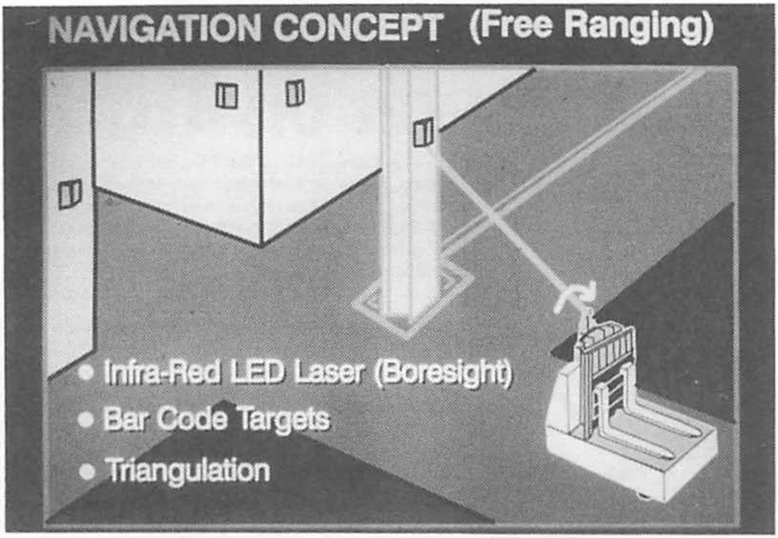

NAVIGATION CONCEPT (Free Ranging)
• Infra-Red LED Laser (Boresight)
• Bar Code Targets
• Triangulation

Fig. 5

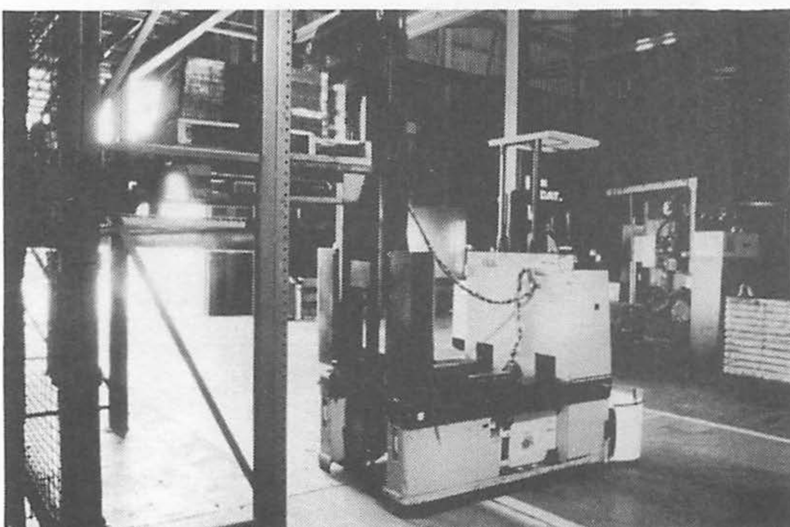


Fig. 6

II. A NEW SHOP MACHINE FOR STRAIGHTENING LOCOMOTIVE PILOT PLATES

At the south end of the Shenandoah Valley, Norfolk Southern operates one of two major facilities for routine maintenance and unscheduled repairs of its locomotive fleet. Since 1919 a running repair shop has existed at this place called Shaffers Crossing in Roanoke, Virginia. In 1980 planning began to replace the old roundhouse with a new shop. Construction of the new shop between 1982 and 1984 included installation of a shop machine for straightening locomotive pilot plates.

The idea of a locomotive pilot plate straightener had its origins in the earlier design of a car end straightener. Beginning in the 1970s, four car end straighteners were installed at Decatur, IL, Brewster, Ohio, Portsmouth, Ohio and Roanoke, VA. The primary purpose of the car end straightener was to deal with the bulging ends from shifted loads of box cars. The car end straightener provided a movable hydraulic ram to push the car end back in as the freight car was held stationary. The car is held stationary when it is coupled to the machine which is anchored to a concrete foundation.

Straightening locomotive pilots is a task locomotive maintenance officers will face for as long as there are grade crossings. At the Shaffers Crossing roundhouse, boilermakers and their supervisors had developed a technique for pulling locomotive pilots in the '60s. The procedure involved chaining the bent pilot to the rail and using the power of the locomotive to pull the pilot plate back to its original position. The problem with this techinque was knowing when to stop. Seasoned supervisors at the controls applied some independent brake before notching out on the throttle, but much was left to chance. On more than one occasion, a bent pilot was inadvertently pulled out beyond the normal plane to about the degree it had previously been bent in. This lead to cutting the pilot off, straightening it on a press, and welding it back in place.

With the advent of the new locomotive shop, it seemed like the time for a better way to straighten locomotive pilot plates. Management at Shaffers Crossing knew about the car end straighteners and believed a locomotive pilot plate straightener was feasible. After some discussion, authority for capital expenditure in the amount of $62,000 was granted for 1983. Justification was reduced man-hours for repairing damaged pilots. Soon after, design responsibility for the project was assigned to Shop and Equipment Engineer R.A. Thompson of the Mechanical department staff in Roanoke.

The primary design consideration in adapting the car end straightener concept to locomotive pilots was the nature of the damage locomotives incur in most collisions. Most locomotive pilots are bent in towards the truck whereas box car ends have usually been bulged out. As a result, a direct adaptation of the car end straightener to locomotive pilot work would be difficult. Such a design would require a method for securing the base of a portable hydraulic cylinder at various locations on the new machine while somehow attaching the other end of the cylinder to the damaged pilot. Pulling a pilot plate back to its normal position with a hydraulic cylinder that could be readily repositioned appeared difficult, if not impossible.

This problem was addressed by

redesigning the car end straightener for locomotive pilots. The coupler of the new machine is moveable. A large hydraulic cylinder mounted in the middle of the machine positions the coupler to move the entire locomotive. During the pilot plate straightening operation, the large cylinder moves the locomotive as the pilot is pulled or pushed back to its normal position.

The pilot is pulled when the pilot is bent in towards the trucks. The bent pilot plate is chained to the stationary machine. The hydraulic cylinder positions the coupler of the machine to engage the damaged locomotive. To straighten the pilot, the large cylinder pushes the locomotive away from the machine, pulling the bent pilot back to position as the locomotive moves.

In those cases where the pilot is bent out away from the trucks, the machine pushes it back to its normal position. The pilot will be bent out away from the trucks when a locomotive has derailed and the trailing pilot drags the ground. It may occur in grade crossing accidents when a highway vehicle is thrown back against the locomotive consist after initial impact.

For this type of damage, an accessory ram was designed to make the pilot plate straightener useful. The ram works like portable blocking. The ram is suspended from a one-ton air hoist on an I-beam trolley. It can be placed anywhere along the face of the pilot plate straightener. The ram is adjustable in length.

When a pilot plate has been pulled out, the operator first positions the machine's coupler to engage the locomotive. Then, the portable ram is placed between the face of the pilot plate straightener and that portion of the pilot that is damaged. To straighten the pilot, the hydraulic cylinder pulls the locomotive closer to the machine while the stationary ram pushes the bent pilot back to position.

Structurally, the pilot plate straightener is constructed of ten-inch wide flange I-beams and weighs about 27,000 pounds. The base of the machine is approximately ten feet square. I-beams forming the base are secured to a concrete foundation consisting of twenty-five cubic yards of concrete. Rising from the base, a triangular structure backs the two-inch steel plate across the face of the pilot plate straightener. The two-inch steel plate and its reinforcing provide a rigid surface for pushing bent pilots back towards the locomotive with the auxiliary ram. Slots in this two-inch face plate permit shackles with an 80,000 lb rating to move up and down on a 1½ in. threaded rod which serves as an elevating screw.

The accessory ram described earlier is also a weldment constructed from ten-inch steel pipe. This ten-inch steel pipe has been reinforced with gussets down the sides. A threaded shaft through the center of the ram makes its length adjustable. The shaft is machined with American standard buttress thread, giving the ram extreme strength in compression. The head of the ram is machined with concentric circles to form a non-skid surface when placed against a locomotive pilot.

At the center of the two-inch steel plate on the face of the straightener is an opening almost four feet square to accommodate the movable coupler. The large hydraulic cylinder is connected to this coupler by a specially made coupler shank. This steel coupler shank is approximately four feet long and eight inches square. One end of the shank is threaded for connection to the hydraulic cylinder. The opposite end is welded to a

freight car coupler. Prior to welding, the cast steel shank of this E60CHT coupler was sawed off behind the coupler head; then, the machined coupler shank was welded to the head.

The coupler shank and coupler are guided through 16 inches of travel by ways inside a machined casting. The 12-in. cylinder, coupler shank and ways are mounted on top of a massive cylinder mounting bracket in the center of the machine. The cylinder mounting bracket is a casting poured at the Roanoke Shops foundry. The casting is machined for mounting of the cylinder and ways.

Operation of the cylinder and associated hydraulic equipment is performed by the operator from a pendant control. The pendant control is on a cord of sufficient length so that the operator can move around the machine as necessary. The large cylinder was incorporated in the design of the straightener not because of the forces required for straighteneing pilots, but for control and safety reasons. The volume of a cylinder with a 12-in. bore aids the operator in harnessing this powerful machine when he straightens a pilot. The cylinder size permits the hydraulic system to operate at lower pressures, minimizing the chance of injury if a hose or fitting were to fail under pressure. The additional cost of the large cylinder was more than offset by the savings from a less expensive hydraulic pump and pipe fittings. Fluid power for the cylinder is supplied by a 20-hp, 30-gal. hydraulic unit with a 13.4 gal. per min. pump. All these components are mounted on the I-beam base of the machine.

Prior to pulling a locomotive pilot, the shackles on the damaged side of the locomotive are positioned to the correct height with the elevating screw. Then one end of a heavy chain is attached to the shackle and the other end to the pilot plate. Attachment to the pilot plate is usually accomplished with an eyebolt. A hole is burned in the pilot plate and the eyebolt is attached with a combination of washers and nuts. When the chain is pulled tight between the shackle and eyebolt little force is applied to the elevating screw. Mounting of the shackles is such that all forces from the shackles are applied to the backside of the two-inch steel plate. This section of the machine's face is rigidly supported by two ten-inch I-beams at 24-in. spacing. Sixteen gussets in the corner between the steel plate and I-beams further reinforce the pulling surface adjacent to each slot.

Most pilot plates are heated before straightening. HPG gas on portable wagons is preferred over acetylene for more rapid heating. A Lincoln electric welder on casters is plugged into a receptacle mounted on the straightener for use in wreck repairs. Quick disconnects around the base of the pilot plate straightener provide a source of compressed air for impacts, chisels and other tools. Adjacent to the machine, water is available from standpipes. Outlets for 120 volt AC power are on each side of the machine. Lights mounted on the structure supplement outside lighting at the facility. Hinged guards on either side of the machine protect operators if a chain should break. Vertical rails protect the machine from shop vehicles like fork lifts.

The pilot plate straightener is considered a success by the people who use it. It is estimated 80 percent of the locomotives arriving at Shaffers Crossing with pilot plate damage are repaired using the pilot plate straightener. Most pilot plate damage is outside the center sill I-beams. Rarely does the pilot plate sustain

structual damage between the sills. In severe cases the steel plate may break or tear along the ends of these sills.

In a worst case situation, if the pilot plate straightener fails to effectively straighten a damaged pilot, it must be cut off. When this happens, it is usually desirable to cut the bent portion of the pilot off. When this does occur, the loss of time is minimal. Experience with the pilot plate straightener teaches the operators what the best course of action will probably be.

When the pilot is bent inward, the steps usually bend the adjacent step support plate. Boilermaker operators have had some success in pulling back the step support plate by welding it to the edge of the pilot plate with pieces of angle iron. In most cases, where the step support plate has been significantly damaged it is replaced with a new one.

The pilot plate straightener has been relatively maintenance free. The only maintenance problem has been with the 1½ in. elevating screws that raise and lower the big shackles. Here the problem has been difficulty in turning the screws with the ten-inch hand crank. Maintenance of bearings and frequent lubrication have been helpful in this area.

Shaffers Crossing personnel have seen fit to make a few minor changes to the machine from its original design. Steps were added to access the elevating screws for the shackles. Floor plate between I-beams in the base provides a safe walking surface to the steps. An additional I-beam was mounted horizontally across the top of the machine. Provisions for a movable eyebolt on this I-beam permit pulling out minor carbody damage on the locomotive hood.

On the majority of locomotives which are involved in collisions, the damage is confined to those areas below the sill or walkways. Fabrication equipment like brakes and shears is of limited help in making repairs in these areas. However, the locomotive pilot plate straightener described here is a valuable tool for minor wreck damage at a running repair shop. Pilot plates can be straightened to the satisfaction of even the most discriminating locomotive maintenance officer with two tangible benefits. The benefits are reduced man-hours for shopcraft labor and reduced locomotive out of service time. In the final analysis, the primary mission of any locomotive facility is to provide reliable motive power on a timely basis. The pilot plate straightener promotes this goal in its special application to wreck and collision damaged locomotives.

III.
AN AUTOMATED LOCOMOTIVE WHEEL SHOP

by Thomas H. Smith, President
Simmons Machine Tool Corporation

Introduction

This section of the report describes a new diesel locomotive wheel set production facility especially developed for and recently installed at the Burlington Northern's Havelock, NE shop.

This shop is unique in that it is the first such facility to utilize a high degree of automation in a railroad diesel wheel set repair facility. This includes state-of-the-art machine tools as well as interprocess material handling systems. Heretofore, such techinques have been only in high production freight car wheel shops.

The object of this discussion is to examine technology and techniques that are new or unique to the industry. The focus will be on equipment associated with the wheel mounting as opposed to tread turning.

The shop is designed to mount new wheels on new and used locomotive axles at a high production rate with a minimum of manpower. To achieve this objective, automatic material handling systems working in conjunction with computer controlled machine tools are employed throughout.

The shop is divided into several areas or work cells. We will examine four of these cells:

1. Demount cell
2. Axle machining cell
3. Wheel machining cell
4. Wheel set mounting cell

1. Wheel demount cell

The demount cell includes facilites for wheel set washing, wheel set disassembly, scrap wheel dispatch to gondola cars, dispatch of gears to the gear processing area, and dispatch of axles to the appropriate level of a multi-tiered axle storage system.

Bad order wheel sets entering the facility are washed and routed to the demount press.

The demount press (Fig. 1) is based on an earlier generation high production freight car wheel set demount press. In freight car service this press is capable of stripping up to 180 wheel sets per eight hour shift.

Special provisions had to be incorporated for fully automatic diesel wheel set stripping. Specifically, tooling had to be provided to rim strip the gear side wheel and then hub strip the gear. The gear side elevator had to be modified to allow removal of both the wheel and the gear.

A two step cycle was developed which provides for stripping and removing the wheels from the press first, then stripping the gear. The demount cell operator classifies each wheel set as to component routing. He may elect to remove wheels only or wheels and gear. He may specify whether wheels are to be scrapped or saved, and may specify axle dispatch routing at the axle storage system. Normally the wheels are removed and automatically routed to a scrap wheel car. Provision is made for even loading of 40, 50 or 60 foot gondola cars.

Normal practice is to also remove all gears. Gears are automatically dispatched from the press to a gear storage area for inspection and processing. Axles are stored in the designated level of a multi-level storage rack to await processing. The cycle time of the demount cell for complete stripping of diesel wheels and gear is approximately five minutes.

2. Axle machining cell

The principal task of the axle machining cell is to qualify, repair and return used axles to service. However, the cell is also capable of producing new finished axles from semi-finished forgings and is also capable of down-size conversion of axles.

Used axles are cleaned by hand and the motor journals are inspected for nicks, gouges and upsets. Cleaned axles are delivered automatically to the CNC axle lathe for dimensional inspection and machining (Fig. 2). The lathe must be extremely flexible, as each axle may require different machining operations. In this installation its primary job is dimensional inspection operations and roller burnishing of the traction motor support journals. However, the machine is equipped for complete turning operations not only for wheel seats and motor journals on used axles, but also for finish machining of new diesel axles.

The machine is equipped with an eight-station automatic tool turret to accommodate all necessary tooling for completely automatic operations. It is also fitted with a special self-contained opposed roller burnishing attachment mounted on a rear tool slide. This arrangement allows rapid fully automatic burnishing operations with opposed rollers without subjecting the precision cross feed ball screws to repeated burnishing forces.

The probe system built in to one station of the tool turret is used to make both diameter and length measurments on all working surfaces of the axle. No pre-sorting or batching of axles is required. Axles of different types and with different machining requirements may be brought to the machine at random. Selection of the axle type is made instantaneously from the CRT and keyboard. The operator is presented a menu of functions the machine is capable of performing and he selects the desired operations in the order in which he wishes to perform them.

The operations common to all used axles are probing for diameter, taper and runout on the bearing journals, dust guards, wheel seats, gear seat and motor journals; and the roller burnishing of the motor journals. The operator may also elect to have the wheel seats, motor journals and/or the body of the axle turned.

Axles leave the cell via an **axle wheel seat measuring station** (Fig. 3). Here the axle wheel seat is measured and the diameter information automatically transferred to the wheel borers for boring wheels to fit. Since wheel seats are not normally turned, the axles are measured, rotated and measured again on at least two diameters and these readings compared to ensure that a measurement has not been made on a score mark.

3. Wheel boring cell

Wheels are stored in stacks of four on wheel storage conveyors. Adequate inside storage is provided to ensure that in winter wheels have come up to shop temperature before boring.

A wheel stack is delivered to a pickup station between the two wheel machining centers. A **robotic manipulator** associated with each wheel borer takes a wheel off the stack and loads each wheel borer (Fig. 4).

The wheel borers may be programmed to bore only, or to bore, turn and face dust guard and water guard hubs. If water guard hubs are to be machined, the manipulators automatically remove the wheels, invert them and reload them in the wheel machining centers for water guard machining. The finished wheels are unloaded by the manipulators, the flanges oriented properly, and released in a vertical position for delivery to the mounting press.

The wheel machining centers are also based upon earlier generation machines. New developments on these machines are associated with the requirement for unattended operation. To accommodate this an improved chip guard was developed to better contain the chips. The boring ram was equipped with a **tool monitoring system** that will interrupt the machine in the event of tool breakage. Improved monitoring techniques were developed to ensure proper unchucking of the wheel when placed in the chuck. One station of the side head tool turret also carries a probe. In addition to dimensional probing for machining operations, the machines probe each wheel as it is loaded to ensure that it is resting flat in the chuck. Again, for unattended operation, this ensures that a chip is not lodged under the wheel.

4. Wheel mounting cell

Perhaps the most unique part of this facility is the mounting cell, which is based on a standard 300 Ton wheel press (Fig. 5). The principal use of the mounting cell is to automatically mount wheels and gears on diesel axles; however, like the wheel borers, the cell is also designed for fully automatic high production mounting of 100-ton freight car wheel sets.

To accomplish these goals a special **axle transfer cart** and a unique **component positioning gage** system were developed (Fig. 6). For mounting diesel sets, the component positioning gage system locates the axle center relative to the outboard bearing journal fillets and positions the gear properly to the axle center. The free side wheel is then positioned hub-to-hub with the gear and the gear side wheel back-to-back with the free wheel.

When mounting car wheel sets, the axle center is located with respect to the ends of the axle and the first wheel mounted to center. The second wheel is then positioned back-to-back with the first wheel.

Wheels are delivered to the cell in the vertical position by the manipulators. Axles are delivered from the wheel seat measuring station via overhead monorail. These material handling systems operate fully automatically.

The diesel set mounting cyle begins by advancing the next axle toward the press. The wheel seats are lubricated as the axle rolls towards the mounting press. The axle is centralized and lowered into the axle transfer cart. The axle is clamped in the transfer cart in vertical alignment with the centerline of the press. The cart then moves the axle through the press to a station on the outbound side of the press where the operator may conveniently place the gear on the axle using the overhead crane.

When he has positioned the gear onto the axle wheel seat, he presses a button to continue the automatic mounting cycle. The cart then positions the axle/gear assembly into the press. The automatic gaging system is lowered to the axle. The gear press then proceeds to mount the gear to the proper position on the axle. Controls on the press console select either GE or EMD gear spacing. When the gear is mounted, the gage retracts and the cart moves back to the wheel premount position.

During the gear mounting operations, the wheels have been lubricated and moved into the premount press.

When the cart returns with the gear mounted on the axle, the wheels are started onto the axle with enough force stick them there prior to mounting. When the wheels are premounted, the cart returns the assembly to the mounting press.

The proper tooling is selected and the component positioning gage again brought into position. First the free side is mounted to the proper hub-to-hub dimension with the gear. Finally, the gear side is mounted to the proper back-to-back dimension with the free side wheel.

Mounting charts of all components are recorded on an electronic press recording gage. This gage prints all AAR required data including the maximum tonnage and the wheel/gear serial number right on the chart.

The completed wheel set is unloaded from the transfer cart and lowered to the outbound track for dispatch to the shop shipping track.

Summary

The experience gained with the development of this facility adds to the knowledge base of our industry. The type of technology that was developed at great effort to automatically process freight car wheel sets has now been extended to the processing of diesel wheel sets. Those involved with facilities engineering know first hand the multitude of details that have to be worked out to make such a complex system operate successfully.

Not all of the technology used in this facility is first-of-a-kind. The **wheel machining centers with robot manipulator loaders**, for example, are the third generation of such machines built, along with the **automatic axle wheel seat measuring system.**

What is unique is extending the technology to **unattended operation** — no operator is required at either wheel borer.

The **CNC axle lathe** is also a standard product; however, the special probing and the unique rear slide **"caliper burnisher"** system as well as the **"pick and choose" machining operations menus** have been developed specifically to accommodate the operations unique to diesel axles.

First-of-a-kind technology is present in the **demount press** — the **fully automatic stripping diesel wheels and drive gears** is a new development. Also, the **automatic mounting of diesel wheel sets** and especially the concept of combining in the same press the cabability to fully automatically mount freight car wheel sets is a new and important advancement in technology.

Though not as obvious, the most demanding task of all was the planning, design and engineering of the overall system concept. The development of new hardware and software was necessary to integrate the automated work cells into a complete production line and ensure the reliable transfer of materials as well as data between the work cells.

The result will now enable Burlington Northern to produce consistent top quality wheel sets at the lowest unit cost in its diesel wheel set shop in much the same manner as in its automated freight car wheel set shop.

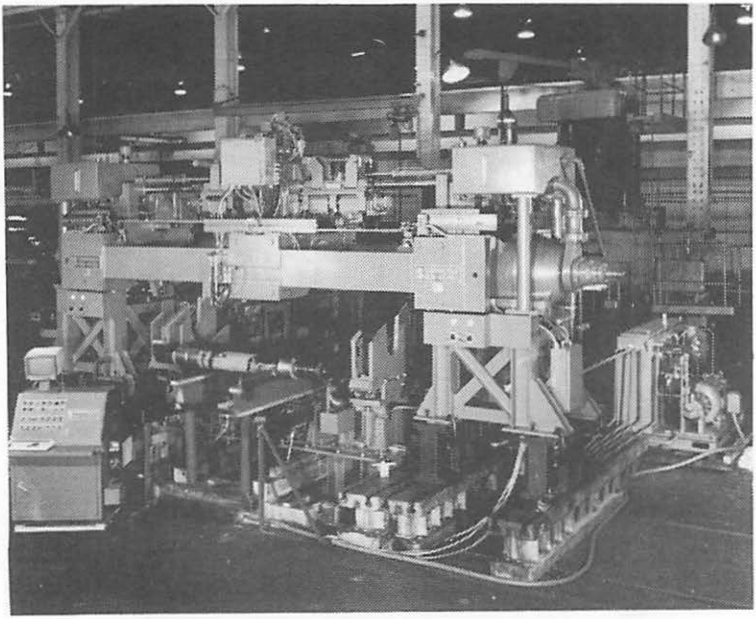


Fig. 1

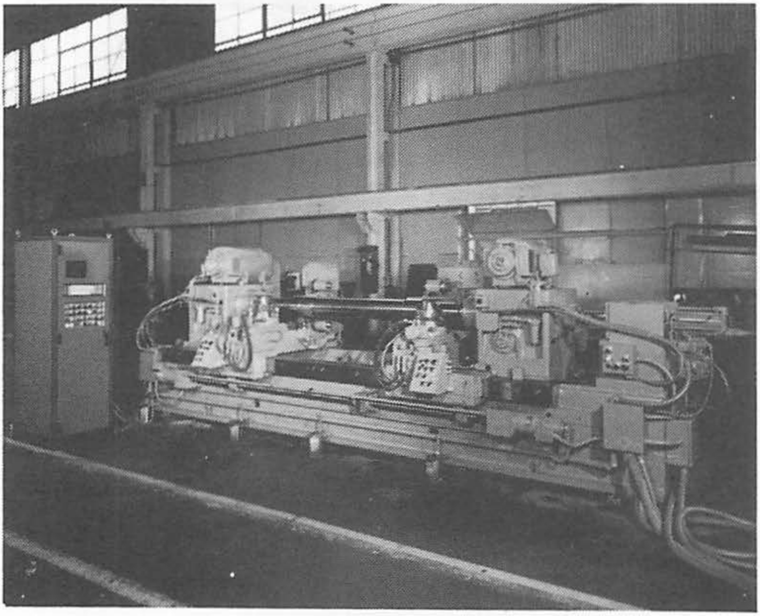


Fig. 2

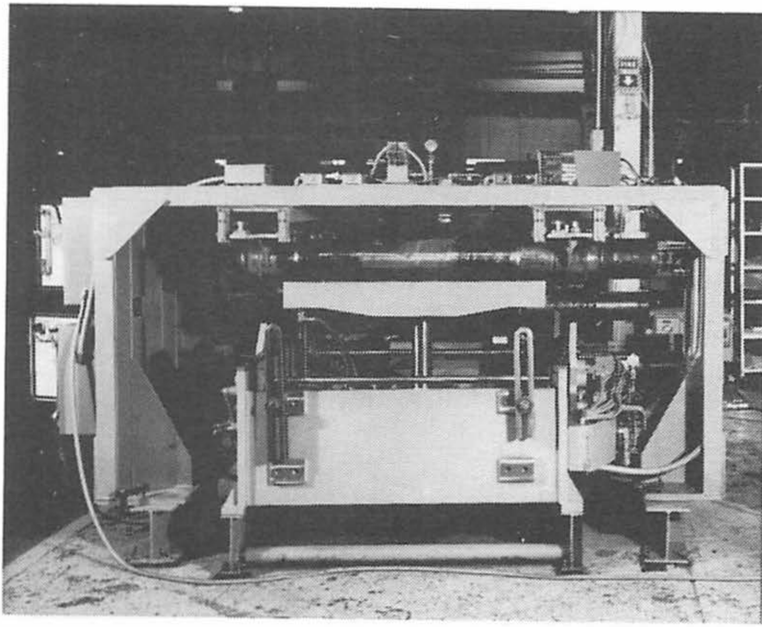


Fig. 3

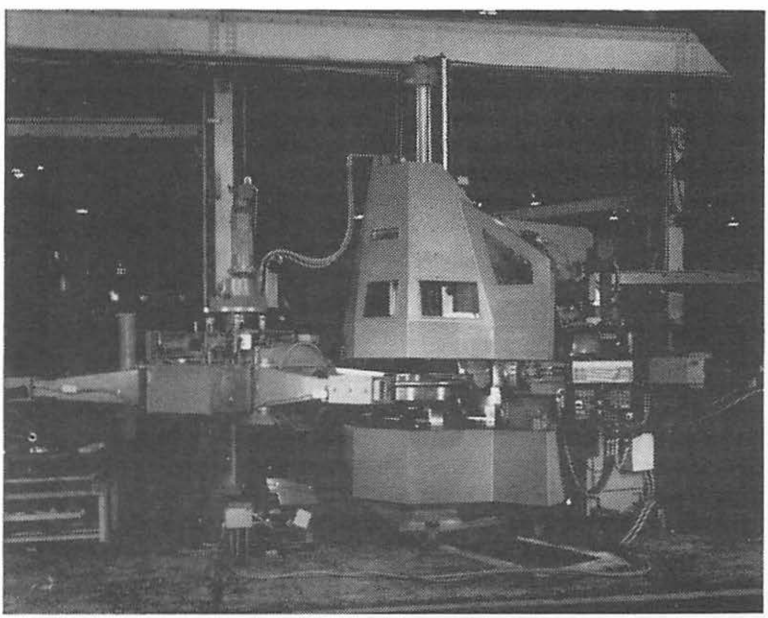


Fig. 4

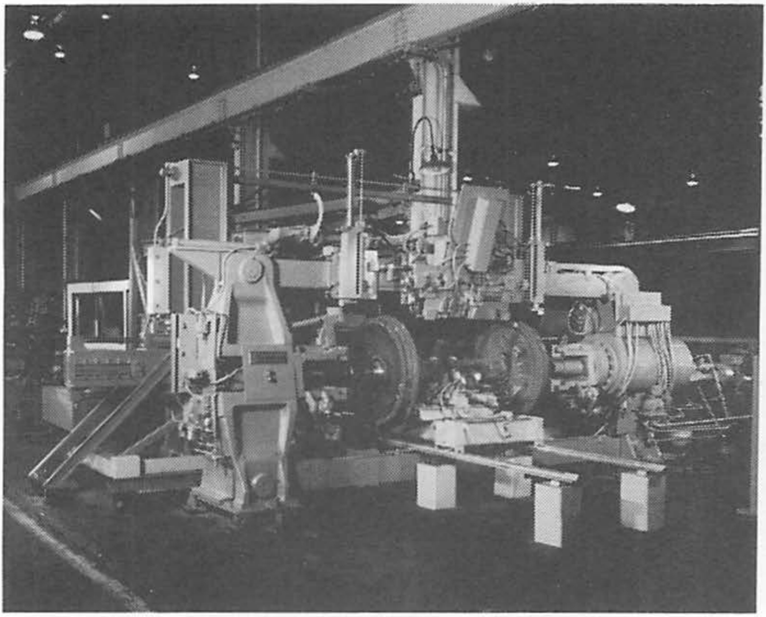


Fig. 5

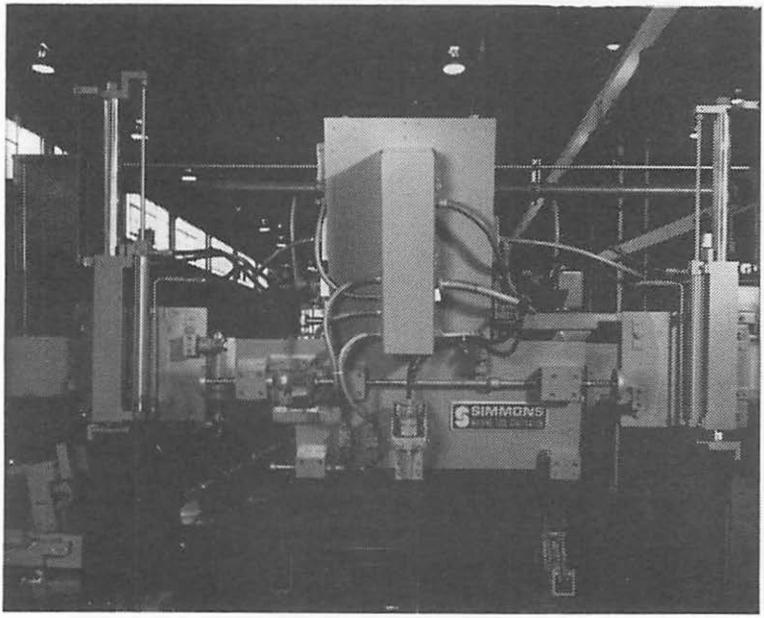


Fig. 6

IV. NEW BULK RAIL LUBRICATION STORAGE AND FILL SYSTEM

Locomotive mounted rail lubrication systems are continuing to grow in popularity and are now being used by a number of railroads. In conjunction with their expanding applications, it is becoming necessary to investigate appropriate, cost effective methods of storing lubrication media and supplying them to locomotives. In cases where the number of locomotives to be serviced with rail lubrication is comparatively high, bulk systems should be considered as a viable method of storage and delivery.

One western railroad decided to apply on-board flange lubrication systems in 1986 after a positive series of over-the-road tests was concluded using revenue coal trains. A maintenance shop located in western Nebraska was soon required to perform grease refilling operations to more than 500 locomotives, making this location a prime candidate for a bulk grease storage and distribution system.

Early on, the refilling of grease in locomotive reservoirs was accomplished at the time of the 92-day scheduled maintenance by transporting the product with a fork lift from the Material department to the waiting locomotive.

Mechanics then opened each five gallon container and diligently tried to funnel its contents into the locomotive lubrication holding tank. This operation soon proved to be cumbersome and wasteful, and represented a potential safety hazard because of the container's weight and the possibility of spills.

Other railroads and manufacturers utilize another method consisting of pumping the lubricant directly from 55-gallon drums into the locomotive holding tank. Pumps with flexible supply lines and quick disconnect ends, are availble for this application. This procedure requires the use of a fork lift, crane, or hand cart to move the 400 pound grease drum. While this method of distribution is more effective and lessens the likelihood of excessive waste or spillage, the container must be moved from the material storage area to the work place. The possiblity for personal injury still exists because of the drum's weight and the chance for spillage. The operation is also labor intensive, and requires the disposal and handling of empty drums which are considered to be hazardous waste. This type of operation should only be considered in those locations which have a smaller volume of locomotives requiring rail lubricator servicing.

Locomotive maintenance officers at this location recognized the immediate need for a system to store and dispense rail lubricant to a large number of locomotives at various work stations throughout the repair facility. A bulk storage and distribution system seemed to be the ultimate solution and a capital expenditure for $61,000 was approved for its installation. The project was justified through a reduction in man hours, bulk versus small container price savings, safety improvements, and the elimination of wasted products as well as the handling and storage of empty containers.

Bulk grease is delivered by means of a specially insulated tractor-trailer unit which supplies 34,000 pounds of temperature controlled triple 0 (000) grease. This amount of grease is normally ordered on a quarterly basis. An internal air piston slide mechanism controls the unloading of each of the three grease compart-

ments. After the flexible unloading hoses are connected to the housing tee, the proper control valves are opened. Unloading of the product is accomplished by pressurizing the individual cylinders with vehicle-supplied air to activate the piston slide mechanism in each cylinder. The entire trailer can be unloaded in about 45 minutes.

This system uses a 10 ft diameter by 12 ft high 10,000 gallon capacity bulk storage tank located in the lower level of the shop. Two Graco 20:1 ratio pumps are used to deliver the grease throughout the shop area. Each pump has a rated capacity of 3.75 gallons per minute and run on shop air pressure which has been regulated to 30 pounds per square inch. Time delay relays which operate solenoid valves control the pumps. When a pressure transducer downstream of the pumps senses a pressure drop below 350 psi, a solenoid valve opens to operate the first pump. After one minute of pumping and if the demand for grease has not been satisfied in the manifold system, the second pump is activated. Maximum time for continuous pump operation is two minutes, after which the system shuts down. This control feature protects against broken pipes and other mishaps.

This air pressure provides 800 pounds of grease pressure through the 1800 feet of schedule 80, two-inch pipe throughout both the multi level and single level light and heavy repair shops. The size of the supply pipe is reduced to one inch at the dispensing reels. It is possible to compensate for other lengths of distribution systems simply by changing the air pressure to provide more or less flow volumes from the Graco pumps.

Eighteen hose reels mounted in convenient locations in the shop area allow access to the locomotive grease storage tanks. The convenient center ramp location of the dispensing stations permits filling the lubricant tanks of adjacent locomotives from one reel. The reels have 60 feet of ¾ inch high pressure hose and nozzle attachment.

The bulk storage and fill system located at this repair facility has provided an efficient, safe method of storing and distributing rail lubrication grease. It has minimized waste and disposal; more importanly, it has provided a new way to increase productivity while at the same time reducing costs. This system and its components should be considered by locomotive maintenance officers for locations that require a considerable volume of grease to be dispensed to higher numbers of locomotives.

Since the climate and mode of operation for each railroad and each individual location can vary a great deal, the system for filling on board lubrication systems must take into consideration all the parameters involved. The expected volumes and frequency of filling at each location may necessitate using different systems at different locations. A well thought out filling system will help the railroad make this task cost effective and safe.

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 (708-258-9660), and we will be happy to provide you with complimentary tickets for one of our meetings. We'll look forward to seeing you at the next meeting where you will find a friendly informal atmosphere in which to learn more about the railroad industry and its people.

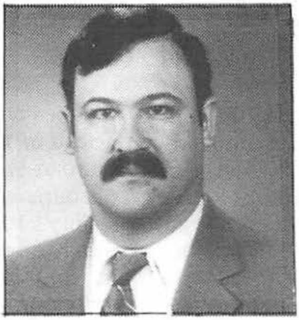
The Board of Directors
The Chicago Railroad
Mechanical Association

Monday, September 19, 1989

3:00 P.M.

REPORT OF THE COMMITTEE ON NEW DEVELOPMENTS

Pre-Convention Presentation: Chicago RR Mech. Assn.



April 10, 1989
Union League Club
Chicago, IL

M. A. COLES, Chairman
Manager-Locomotive Maintenance-Mech.
Union Pacific Railroad
Omaha, NE

VICE CHAIRMAN
Mike Iden, Director-Motive Power Engineering
C& NW Chicago, IL

COMMITTEE MEMBERS

T. E. Brunner	Gen. Mechanical Supt.-Loco.	AMT	Philadelphia, PA
J. Hogan	National Accts. Mgr.-Loco.	Caterpillar	Peoria, IL
R. Mackowiak	Supt.-Locomotives	Alaska	Anchorage, Alaska
R. Runyon	Engineer-Locomotive Design	NS	Roanoke, VA
N. Sandberg	Product Planner	GE	Erie, PA
B. S. Simonovic	Senior Project Engineer	EMD	LaGrange, IL
Ben Smith	Mgr.-Maint. Procedures & Equip Engrg.	NJT	Kearny, NJ
Blair Smith	Director of Planning & Analysis	CSX	Jacksonville, FL
F. W. Wilson	Shop Manager	CR	Plainfield, IN

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. NEW DEVELOPMENTS IN LOCOMOTIVE CAB AND CONTROL DESIGN

After World War II ended, most U.S. railroads converted from steam to diesel power. General Motors (EMD), Alco and Baldwin were some of the main locomotive builders at that time. Very little crew comfort was designed into the locomotive cab. For example, many switcher locomotives were designed without a toilet, some cabs had only a chair for the engineer and a box for the fireman to sit on and a block of ice was the water cooler.

The controllers in the cabs were the drum and sliding contact finger type and most locomotives were equipped with the 24RL brake stand.

The EMD F7 (freight) and E7 (passenger) locomotives were designed for straight ahead vision and were usually trailed by "B" units with no cabs. There was hardly enough room in the cab for a third person to ride.

The next decade (1950s) brought about another change in cab design with the introduction of the general purpose and road-switcher type locomotive. General Motors (GP7 and GP9), Alco and Baldwin were the primary road switcher builders at that time, toilets, water coolers, cam/microswitch type controllers, 26L air brakes, three cab seats, three channel radios, short and narrow hoods on cab ends, all emerged as the basic cab design.

The next two decades (1960s and 1970s) brought about more cab changes due to new state and federal environmental laws. General Electric also emerged as a locomotive builder.

Some of the cab changes are listed as follows:

1. Safety glazing and window frames
2. Noise reduction
3. Electric heating (previously hot engine water)
4. Refrigerators
5. Holding type toilets.

The 1980s have brought further cab design changes because of caboose removal from most trains and the microprocessor chip/electronics boom.

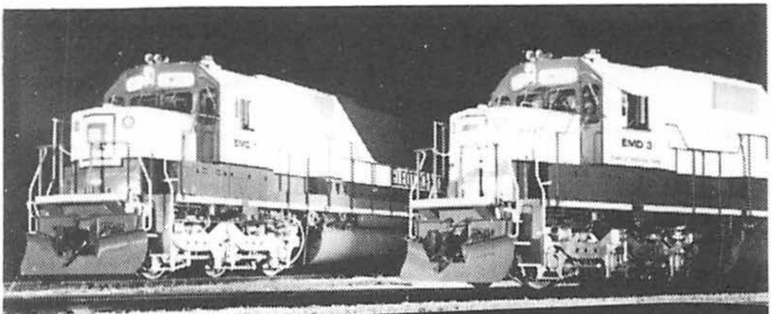
Three-man cabs suddenly had to change to five man cabs, detection devices for "end of train" signals were applied to the cabs, electronic speed recorders were added, on board microcomputers for various functions (from control to data aquisition) were also added.

Deregulation of the railroad industry and various agreements with the train crews have again created a need for more cab changes. Unit coal and freight trains are now running longer distances between crew change points. High speed core railroad systems and central train dispatching are being implemented and automatic train control systems are being tested.

The Canadian Railways and several U.S. railroads have seen that there is an immediate need for more changes for the safety and comfort of our crews as well as a need for more room for equipment.

The General Motors Locomotive Group (GMLG) in conjunction with the Canadian National and Canadian Pacific Railways, have designed a console type "comfort cab" which is now operating on Canadian locomotives.

General Motors has also designed a console cab that was applied to 131 SD60M locomotives for the Union Pacific railroad. The group used a full size cab mockup to allow designers to review the space relationships and also provided railroad people the opportunity to insure that the design met their operating re-



quirements.

The exterior of the new cab is characterized by a wide short hood which replaces the narrow short hoods that have been standard on EMD locomotives since the early 1950s. The cab interior is characterized by a desk type operator's console that replaces the AAR control stand. Cab entry and exit can be made through the door in the short hood front partition or through the door in the cab rear partition behind the engineer.

The safety and comfort of the crew were the main design considerations for the new cab. Following is a list of improvements:

1. Improved collision resistance.
   a. The short hood walls are constructed using 3/8" thick high strength steel to provide puncture resistance in the event of a collision.
   b. The collision posts have been increased to resist a one million pound load at a height of 30 inches above the underframe deck level.
2. Improved cab vision.
   a. The front portion of the cab has three windows that are electrically heated for defrosting.
   b. The height of the subbase structure has been increased to 32 inches, thus improving visibility over the short hood nose.
   c. Two additional fixed windows in each of the cab side walls will provide additional side visibility.
3. Improved noise reduction.
   a. Vinyl covered acoustical floor mat along with additional insulation in the roof and cab walls will reduce sound levels at full throttle operation to approximately 82 db.
4. Improved short hood interior.
   a. The diesel cranking batteries and hand brake were moved to the rear of the locomotive to give more room inside the short hood.
   b. The roof is over 6 feet high and provides comfortable entry into the cab.
   c. The interior is divided into 3 partitioned areas:

      A front vestibile provides room for storage of equipment and also acts as a barrier to prevent cold air drafts from entering the cab. The exterior door is also designed for sealing in the event of a collision.

      A separate toilet compartment with molded corners and all extraneous mechanical and electrical equipment removed, thus allowing easy maintenance of the compartment. The compartment walls are also lined with a plastic material which inhibits rust and cleans easily. The compartment is heated and vented by make-up air from the cab. Floor drains are also installed in the toilet compartment to allow the entire area to be hosed down.

      An alcove for mounting of cab signal equipment and for storage of the crew's luggage is the 3rd compartment. The sand box has also been split and moved to each front side.
5. Improved cab interior.
   a. A desk type control console is installed at the right front for the operator. A separate desk is provided on the left side of the cab.

The operator's console has a front panel and side panel that includes the speedometer, ammeter and various airbrake gauges. The side panel provides for future application of ATCS equipment. The desk top has the throttle (power), dynamic brake and train braking control. The horn is operated by push buttons on each side of the cab. In addition, a foot pedal can be activated to blow the horn in a controlled sequence for crossings. The bell is activated by push buttons or rings automatically when the foot pedal is activated.

b. A full width upper console is provided above the front windows for mounting equipment such as the auxiliary speed recorder, radio and end of train monitoring device. Both sides of the cab will have separate hand microphones and speakers.

c. A central forced air heating system is also provided. Outside air is filtered before it enters the central heating system. Duct work is incorporated in the cab walls to provide uniform temperature distribution in the cab. A thermostat in the cab controls the system. A central air conditioning system is also available for future applications.

d. Thermal pane side windows are also installed for additional insulation.

e. Separate overhead spotlights are available to help the crew read instructions. A fluorescent light is also installed in the ceiling for additional light.

f. Four pedestal mounted cab seats with arm rests and an additional jump seat mounted on the rear cab wall (five total) are also included.

g. A cab subbase is also provided for air brake equipment mounting.

General Electric is presently designing and building a "crew-comfort" cab for its Canadian National CM40-8 locomotives and the DASH 8-40CM locomotives due for delivery to the Union Pacific in late 1989.

GE designed a "crew-comfort" cab for its demonstrator GE 809. A mockup was built and the design evolved with the help of various representatives of several railroads and their many suggestions. During mid 1988, the GE 809 cab was ready for public inspection. By October 1988, GE 809 was ready to go on tour.

During the next 3 months 809 traveled the Union Pacific system. On each leg of the journey first-hand and written comments were received from operating crews, supervisors, and maintenance personnel (well over 300 survey sheets). Response was very positive and the information and input from the 809 tour is being incorporated into the new CN and UP locomotives orders.

In other cab developments, New York Air Brake Co., in conjunction with CSX Transportation Inc., has designed and installed a computer controlled locomotive brake and propulsion system (CCL) with controls housed in a desk top operator's control stand.

The master control stand has three handles for the operator to operate. They are described as follows:

1. The automatic brake handle located on the left, in a vertical position, provides the analog signal to the micro computer which controls all of the automatic brake functions. Only one air brake pipe is attached to the handle, that being the brake pipe which is used in an emergency application and circumvents the computer controls. Pulling the lever towards the engineer results in a brake release command.
2. The independent brake lever is located in the center and has a knob type handle. The handle also incorporates a "bail off" switch. The handle also provides an analog signal output to the computer proportional to the handle extreme positions. Loss of an analog signal output (minimum) signals a brake release.
3. The throttle handle is to the operator's extreme right and has a "tee" type handle like the automatic brake. It combines the function of power and dynamic brake in a single lever control. The lever has a distinct "Y" pattern for transition between dynamic braking and power commands. The lever incorporates an analog output proportional to the handle position and sends this signal to the computer which controls the 27 trainline control wires for power and dynamic braking.

All three handles are aligned in the throttle idle, automatic brake release position and independent brake release position. Pushing the levers away produces brake commands. The positions of the levers are so aligned and arranged as to provide at a glance, the status for the command for power or braking. All levers are independent of each other with no mechanical interlocks between them.

The microcomputer located behind the operator in the electrical cabinet controls all power and brake functions as received from the operator through the master control stand. The computer will then modulate propulsion control via the locomotive's 27 wire trainline and apply the brakes via the new brake control valve and pneumatic train lines.

Proven technology and software are utilized by the computer which is based on the experience NYAB has acquired from installations on passenger cars for NICTD, WMATA, LRC, and GCRTA.

The computer features a modular design which allows special features to be added or removed (card frame with printed circuit cards), 68000 single chip microprocessor for the CPU, 4 ROM chips for capacity up to 256K bytes of ROM, 64K bytes of RAM memory and 16K bytes of NOVRAM (non-volatile RAM) which retains information when power is removed and can be used to store up fault information for maintenance personnel. Also included are the following:

1. A digital input board which can handle four frequency inputs and up to 16 discrete digital inputs. LED lamps indicate state of the inputs.
2. A digital output board which can drive 16 independent relays. LED lamps also indicate status.
3. An analog board made up of eight inputs (-10 to +10 VDC), three outputs (0 to 10 VDC) plus one output from 0 to 100 VDC. Four digital outputs are also available for direction control of braking magnet valves.

4. A communications board for control and reading of the touch screen display and eight digital inputs and outputs.
5. A relay board that provides 10 solid state relays with fusing and transient suppression provided on all the outputs. The relays are used to control the 27 wire trainline and brake control solenoids.

An interface control valve is mounted under the cab floor on the operator's side provides all the functions for the control of brakes, both pneumatically and electrical signaling, and for the auxiliary controls.

All air pipes interface with this device via a pipe bracket. The unitized valve also simplifies maintenance. The control valve consists of three portions:

1. Pipe bracket with all pipes interfaced.
2. Brake control portion providing all braking functions, electrical interfaces from the microcomputer for the operation of the brake system.
3. Auxiliary portion providing sanding, horn, bell, etc., functions and operating independently of the brake portion.

The last major component of the new system is the touch screen display which is located to the left of the operator and accessable to the touch. The display communicates directly with the microcomputer for all functions.

The terminal is a touch/display, graphics design seen on an 8½ in. square screen. The screen is divided into four distinct zones as follows:

1. A touch sensitive (lower) zone that controls 18 switch functions, either momentary or latching according to the software control. The selected function shades in. Forward and reverse, power reduction, automatic speed control, etc., are some of the selections.
2. A digital indicator zone provides 18 "shade-in-block" indicator light functions and becomes active on key-in.
3. The message zone is for the information provided the operator by the microcomputer such as operational instructions, fault occurrences, or as information only. The messages appear as promoted by the computer. Short time ratings derived from the amp load are displayed in this zone. ATCS messages could also be communicated through this device.
4. The variable indicator (top) zone provides the indications previously shown by gauges, flow meters, dynamic brakes, load meters, speed, etc. Unit loading, air flow, and acceleration are shown in bar graph design. The zone become active on key-in.

In conclusion the CCL locomotive control seems to be a good way to create more room in a crowded cab by the reduction of gauges, electronic speed devices, meters, alarms, etc., that clutter the control stand and walls on conventional locomotives.

The filtered HVAC systems should be included in all future locomotive cab designs not only to improve the comfort of the crew but should also be directly diverted to the computer and electronic control cabinets and devices, thus insuring more reliable and dependable operation.

II. A RATIONAL APPROACH TO TESTING LOCOMOTIVE COMPONENTS

A. What to test

Railroads, like most industries today, are hard pressed to get the best return on their investment in locomotives and component parts. Numerous suppliers are developing new products that will out-perform an original product, increase reliability, or increase cost effectiveness. Since the railroads have more to gain from a better mouse trap than do the locomotive manufacturers, they are the prime target of many new developments.

When an item or product that is not an original manufactured part is being considered for use on locomotives, testing is a viable procedure to determine if the product will perform satisfactorily. However, there are many factors to consider prior to testing. Usually the product will fall into two categories, either an alternate source or a new development. An alternate source means a product that is a replacement for the original manufactured product, which meets original specification but is less expensive, or exceeds the original specifications and is usually more expensive but out performs the original product. A new development product is one that is completely different from the original, or is one that provides some service or action totally different from anything original. Both categories have many factors that need to be considered, some common, others unique.

The locomotive manufacturers have spent an enormous amount of time and money in research and development on all the component parts that make up a new locomotive. The original manufacturer's specifications should be the beginning baseline for testing an aftermarket test component. If the product is equivalent in performance to the original but less expensive, the economy must be due to using a different grade of materials, a different manufacturing process, or a marketing short cut, the latter being most beneficial (essentially you are getting the same product for less money). The first two can be benefical provided the product completes its life cycle as intended. To prove this, testing may be required, always bearing in mind that the product may fail in service. One must always consider the consequences of total or catastrophic failure of a critical product being tested, and whether or not the testing is worth the risk involved. In any case, projected benefits must exceed the risk.

How long do tests have to run? This is an extremely difficult question to answer. Replacement products that claim to be superior to originals in service life usually need to be tested over extended periods, to confirm that they perform as advertised. It is, however, difficult to test long-life components, particularly when other related components limit the application time. Also, if long term tests are not run to completion, the risk of future failure is increased when large numbers of the components are applied.

Products which are to be serviced at periodic intervals must have life cycles designed to meet the desired interval or extend through the following interval. If it fails between intervals, there is little point in testing it. When testing a product, particularly of high risk, one should consider liability of the manufacturer; it is a good idea to have written agreements as to who bears the cost of the testing, or more important who will

bear the cost if the test fails. Most manufacturers will only warrant their products, not extra costs incurred because their product failed (associated damages). In these high risk areas all factors should be considered prior to any agreement to test a product. Consider also materials produced in other countries; United States laws and regulations are difficult if not impossible to enforce in other countries.

Other questions which need to be answered are: Is the vendor qualified, capable, and reliable? Can he meet deadlines? Is he financially stable, and will he be available at the conclusion of any testing? To answer some of these, a vendor site inspection would be appropriate. Another important consideration: Is the product that is going to be tested the same as the product to be used later?

In order for the test product to be viable, usually more than one locomotive would be equipped for the test. A cross section of the fleet should be used considering such factors as type of service, environmental conditions, etc. Keeping track of a test product can become a real problem. If the sample size diminishes below the amount originially planned, if the samples cannot be accurately tracked, or if test results cannot be verified, there is no justification for performing a test. A test without valid results is no better than no test at all.

When considering a new development test, particularly of a product that has not been previously tried, there are many more variables that have to be considered. Besides the already mentioned items, such things as environmental and regulatory effects must be considered. The most difficult thing to evaluate on a new development is the overall monetary value. Usually a manufacturer or vendor will focus on only one or two areas of cost effectiveness. Economic evaluation can get very involved but is important for determining future value, hidden costs, and whether or not an item needs to be tested or even considered for testing. Our job is to try to evaluate the intangible and other tangibles which might have been overlooked or ignored by the vendors.

B. How to test

Once a product has been approved for testing, the most important task of "how to test" begins. The test plan development process and follow-through is the most crucial part of the test, for failure to prepare a well thought out and well designed test plan may lead to a costly mistake. Verification of a vendor's claims of product performance, cost and reliability through testing is essential to determining the true value of the product. It is also important to obtain a vendor's full involvement before, during, and after the test, in order to fully understand the product's impact on the test and the test's impact upon the product.

Before a test is started, it is essential to review the vendor's claims, historical field test data, and his inhouse testing methods and results. After this review has been accomplished, an opinion or hypothesis can be formed as to the likelihood of a meaningful and successful test.

Once we are satisfied that the product has reasonable expectations of success, then an arrangement can be reached with the vendor as to the following points for the test:

1. Who bears the cost of the test product?
2. Who bears the cost of the product's application for the test?
3. What are the risks associated with the test and how can the

risks be minimized? What is the worst case scenario failure and how can it be avoided?

4. If the product fails, who bears the total costs of the failure?
5. What should be the size of the test sample?
6. Who, in your organization, is best qualified to track the tests and how much vendor participation is required?
7. What will end the test; time, failure, or other?
8. Is it possible to achieve meaningful test results with an accelerated test method?
9. What is required for the application of the test product, and in what way can the vendor provide support (such as special tools or training)?

Some of the often overlooked aspects of a test plan include the following:

1. What caliber of people are required to follow the test? Meaningful observation can be as important as measured data. For this reason people who follow the tests, or make the measurements, should be the type that can be relied upon to make and record non-measurable observations, as well as measurable ones.
2. Does the product in question require that the locomotive system, or a portion of the system to which it is to be applied, be brought into OEM specifications? Will the test product be as effective on "as is" equipment, and if so, within what constraints? We can find ourselves trapped into approving a product that has tested well on newer equipment, only to find that older equipment has to be rebuilt and reworked to facilitate the use of the new product. Such oversights can place undue burdens on the railroad in modification costs or useless inventory that could have been avoided.
3. The language or accepted guidelines of the test can also cause problems. Basic nomenclature can vary between railroads and vendors. Therefore basic ground rules as to what is and is not acceptable, how measurements are made, how observations are recorded and definitions of terms, are necessary to insure harmony during the test.

And finally,

4. It must be remembered that the size of the test population will directly affect the validity of the results. Statistically speaking, the smaller the test sample, the higher the degree of freedom, and thus the greater the probability of an erroneous conclusion.

C. How to evaluate a test

After a test has been completed, results must be analyzed and the success of the test must be determined. Test evaluation can be the hardest part of the test procedure because some items may not be able to be evaluated as "pass" or "fail".

Earlier, we discussed the importance of the supplier completing his own analysis and development work to estimate the component reliability. Statistical analysis of a test is used by many railroads and their suppliers, typically "mean time between failure" (MTBF).

Simply, MTBF is an estimate of the probability a test item will perform for an expected period of time. This predicted reliability controls the test length and helps determine the sample size. For example, let's say a manufacturer predicts that his new component has a one-year life and the available sample test is 10 units. A prediction of the life cycle of the items tested must be established. The odds are some failures will occur before the one-year test is over, while others will continue to perform well beyond the one year. The railroad and the manufacturer should agree to a confidence level to verify the test.

If a railroad accepts an 80% probability, then at least eight of the ten items tested will last a minimum of one year. Now both the railroad and the supplier have a pass/fail target. This is most beneficial in order to verify the success of the test.

Some test items can be removed and inspected to see if they passed the test. Lab tests can also verify that the item passed or failed by doing dimensional checks for wear. Chemical or metallurgical tests can also reveal information not visible. Questions which need to be asked as a result of test evaluation are: Is the tested item still serviceable? Is the item within predicted wear limits? Is it within predicted life? What were the reactions of maintenance personnel taking care of the item? What are reactions of train or engine crews (if applicable)?

After an acceptable mean-time between failures and the minimum confidence levels have been met, the original cost justification must be reviewed and analyzed. If the confidence level is met or exceeded and the MTBF is equal to or lower than predicted, then the test item's cost analysis can be completed.

A "cost per hour" method is an easy way to give a "thumbnail" sketch of the test item's performance. Life can be judged based on hours of operations (or days, miles, whatever is most appropriate). For example, if the tested item has a higher initial cost but under test shows an overall longer life and/or a low MTBF, then the tested item may offer better service and value to the railroad. If the standard item currently in use costs $100 and lasts for an average of one year, then the cost would be $8.33 per month (100 ÷ 12 = 8.33). However, if the item tested costs $110 but showed an average life of 15 months, then its cost per month would be $7.33 (110 ÷ 15 = 7.33), clearly a cost saving advantage.

Some tested items may be more difficult to judge, particularly those items which affect the performance and life of other components. Items such as lubricants, for example, may have an initial cost advantage, but if the lubricant does not protect the component, the adverse wear could reduce component life. The cost of more frequent component overhaul or replacement may well offset the cost advantage of the lower-priced lubricant. Once again supplier confidence and accelerated lab testing may be required. The cost per hour method is still valid. However, it should include the cost and life estimates of other components.

Closing the loop is nothing more than "follow through". Did the performance of the tested item meet or exceed expectations? If not, why not? Did the cost of the tested item and the resulting economics show an advantage? Was the mean-time between failure acceptable?

In both product and vendor evaluations, follow through with the vendor must be stressed.

Remember, the supplier of the tested item has as much and even more interest than you have in the outcome of your test. If the item fails, discuss the shortcomings with your supplier. If you have documentation or lab test data, be sure to share that information. If you simply reject an item and/or a supplier because of a failed test, you and the supplier lose because important data needed for product improvement may be denied.

PRESENTATION ON THE CURRENT AND FUTURE STATUS OF SHORTLINE AND EMERGING REGIONAL RAILROADS

W.O. Albritton, Mech. Supt.
Paducah & Louisville Rwy. Inc.
Paducah, Ky. 42001

I would like to take a moment to express the appreciation of the regional and shortline railroads for the opportunity to be a part of this committee and a participant of the LMOA.

Regional and shortline railroads have become an important link in the nation's railroad system. This was not an easy accomplishment. Today, regional and shortline railroads operate in forty-three (43) states, with ten-thousand (10,000) miles of track. Some of the shortlines have failed, some are struggling, and some are doing well. Many of the problems faced by the shortlines are similar to ones facing the larger railroads; many are not.

Following are five (5) topics facing regional and shortline railroads, which I would like to briefly discuss:

1. Limited Capital
2. Skilled Employees
3. Quality Supervisors
4. Material Shortages
5. Maintaining Locomotives with Limited Facilities

1. Limited Capital:

Cash flow and credit are two (2) major obstacles faced in beginning a regional or shortline railroad. Some suppliers, especially oil companies and manufacturers of railroad components, are reluctant to extend credit to railroads, when they first begin operation. Many require a very detailed and complex credit application for consideration which would require a financial expert to complete. Others require cash upon delivery. These requirements have a great impact on being able to establish cash flow for operation of your railroad. As we all know, you must move the freight before you can collect the revenue.

The importance of establishing a realistic business plan with an adequate operating budget is essential to the startup of a shortline railroad.

If locomotives are not obtained with the purchase or lease of the regional or shortline railroad, many are forced to buy older, obsolete units due to limited funds. This creates operating problems because of the inability to find the necessary materials and tools required to maintain the locomotives to meet customers demands for moving their products.

Many regional and shortlines are not able to establish an adequate capital expenditure budget. Without an adequate budget, the ability to make long range plans such as improvements of locomotive fleets, purchasing of tools and equipment, and other necessities is limited. Maintenance is forced to fighting fires versus performing the preventative maintenance that has the best payback in terms of dollars spent.

2. Skilled Employees:

Skilled employees are a major factor for the success of a shortline railroad. Because of the continued decline in the nation's railroad employment, skilled employees are becoming difficult to locate. The insecurity of working for a new railroad, plus the fact that a shortline's hourly rate of pay is less than that of Class I railroads, are a couple of reasons why skilled employees are difficult to find and some are not willing to relocate for employment with start-up railroads.

The major railroads have established apprentice programs to fill their employment requirements for the future; thus, the number of unemployed experienced employees

available to work on regional and shortlines in the future will continue to decline.

The Paducah and Louisville Railway, Inc., (of which I am associated) is fortunate because the IC left behind dedicated and skilled railroad personnel.

3. Quality Supervisors:

If you were starting a regional railroad today, where would you turn to find quality supervisors if you were not associated with a Class I railroad? This is one of the problems regionals and shortlines experience in putting together a good management team for operation of the railroad.

Class I railroads have the luxury of being able to promote within their own organization for filling management positions. Regionals and shortlines do not have this capability in the beginning and must search for employees with managerial experience whom they can train or look elsewhere in the railroad industry. Again, trained experienced Class I supervisors are reluctant to transfer to a start-up railroad due to lower pay scales and the uncertain future of start-up railroads.

4. Material Shortages:

Most regional and shortline railroads operate the older type locomotives manufactured by EMD, General Electric, and Alco. As we are all aware, parts for the older locomotives are sometimes very difficult to locate. In most cases, used material is all that is affordable.

The establishment of a parts clearance house for surplus and obsolete locomotive materials would be a great asset for regional and shortline railroads. Class I railroads could play a vital part in seeing that this becomes a reality by contributing their resources in putting this together. There is one company who has expressed interest in assisting us to establish this parts clearance house. We hope that in the near future a committee will be put together to review the feasibility of promoting this program.

5. Maintaining Locomotives with Limited Facilities:

An article in a recent railroad magazine states that the FRA inspectors have not been visiting the shortlines and regionals to insure they are complying with FRA regulations. Evidently, no one has informed the FRA that the Paducah and Louisville Railway is a regional rail carrier, because we have FRA inspectors visit us quite regularly!

Some shortlines and regionals do not have adequate facilities for properly maintaining their locomotive fleets. A good example of this is a southeastern regional railroad who maintained a fleet of fifty (50) plus locomotives without any type of building facilities. Their operation continued in this manner until they were able to construct a suitable maintenance facility.

I am confident there are other regional and shortlines who experience this same obstacle in maintaining their locomotive fleets. The fact that the FRA has worked with us shows their concern for the problems with which we are faced as small rail carriers in properly maintaining our fleets without adequate and modern facilities.

It is important for shortline and regional carriers to establish credibility with their customers, as well as other connecting carriers. This can be accomplished through dependable service of which properly maintained locomotives play a vital part. To achieve this, we must continue to improve our maintenance facilities and the performance of our locomotive fleets.

V. H. MIZRAHI
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 Fuel and Lubricants Committee in Montreal on May 11, 1989

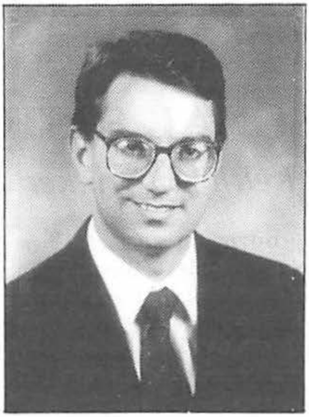
The attendance and interest exhibited was most gratifying.

Tuesday, September 19, 1989

10:30 A.M.

REPORT OF THE COMMITTEE ON FUEL AND LUBRICANTS

Pre-Convention Presentation: CN/CP



May 11, 1989
LaChateau Champlain
Montreal, PQ

K. A. BRINKER, Chairman
Manager-Environmental Operations
CSX Transportation
Huntington, WV

VICE CHAIRMAN
Glen A. Peters, Manager-Locomotive and Environmental Testing, ATSF, Topeka, KS

COMMITTEE MEMBERS

S. C. Archambault	Senior Product Engineer	CONOCO	Houston, TX
D. Bachelder	Evaluation Engineer	GE	Erie, PA
D. C. Carlson	Staff Engineer	Shell	Houston, TX
G. Hamilton	Senior Research Engineer	Petro Canada	Sheridan Park, ON
T. J. Hansel	Product Manager	Chevron USA	San Francisco, CA
W. J. Harris, III	Mgr.-Chemical & Environment	NS	Alexandria, VA
J. F. Hillard	Consultant	Texaco	Beacon, NY
J. T. Jackson	Mgr.-Advance Train Development	AMT	Wilmington, DE
R. J. Kamenick	Product Manager	Mobil Oil	Fairfax, VA
R. R. Lodowski	Mgr.-Environmental Operations	Conrail	Selkirk, NY
J. C. McCarty	Technical Engineer	EMD	LaGrange, IL
W. H. Melgren	Manager-Springfield Lab	TSD	Springfield, MO
W. Runkle	Supvr.-Auto & Commercial Lubricants	Ashland Oil	Ashland, KY
P. A. Shackelford	Manager of Tests	P&L	Paducah, KY
R. D. Schmisseur	Asst. Manager Testing	C&NW	Chicago, IL
J. Thompson	Senior Research Engineer	AMOCO	Naperville, IL
C. W. Tincher	Product Manager	Lyondell	Houston, TX
J. W. Turner	Technical Advisor	Exxon	Houston, TX

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 degree in Chemistry.

Keith began his railroad career with the Chessie System Railroads in 1979 as a Chemist-Spectrographer in the Test Department assigned to Russell, Kentucky laboratory. In 1981, he was promoted to Test and Environmental Specialist in Cincinnati, Ohio. He returned to Russell, Kentucky in 1983 as Test and Environmental Supervisor. In 1985, Keith was promoted to Assistant Chief Chemist at the 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.

On June 10, 1989, Keith and his wife, Charlene, became the proud parents of their first child. Charlene gave birth to a 6 lb. 7 oz. baby boy, named Justin Michael. Already Justin has brought Keith and Charlene many memories to cherish.

Keith and Charlene enjoy professional sports, dancing, plays and travel.

I
GENERATION 5 LOCOMOTIVE CRANKCASE OIL DESCRIPTION AND FIELD TEST DATA FOLLOW-UP

A. Field Test Data Follow-Up

Changes in the railroad industry have placed tougher demands on locomotive engine oils. As a result current Generation 4 lubricants do not fully meet the needs of all of the railroads' operational equipment. This is due to the fact that:

a) The locomotives have a high utilization rate;
b) The locomotives are pulling longer and heavier trains, and;
c) The engine maintenance intervals have been extended.

In addition, there are a greater number of the new fuel efficient diesel locomotives which have a lower oil consumption rate and higher operating temperatures. These factors place a higher level of stress on the locomotive diesel engine oils. For example, lower oil consumption means less fresh oil and therefore smaller amounts of the additive being added to the crankcase. This accelerates the additive depletion rate, the total base number loss, and the used oil viscosity increase. Figure 1 illustrates how lower oil consumption rates can lead to higher used oil viscosity increases for a group of modern 3600-hp engines. This figure was taken from the 1986 paper presented by the LMOA Committee on Fuel and Lubricants, entitled "Extended Performance Lubricants Through Better Chemistry."

Low oil consumption rates also accelerate the total base number depletion as is graphically demonstrated in Figure 2. It should be noted that in 1976 when Generation 4 lubricants were first introduced, the driest of the locomotives had a lubricant consumption rate of about 0.6% of the fuel consumption. Today, some of the locomotives have an oil consumption rate that is lower than 0.3% of the fuel consumption, which means there is less oil make up to help maintain a 2 total base number (TBN) minimum when measured by the ASTM D2896 procedure.

Figure 3 shows how the engine oil temperature can affect the viscosity increase or the oil oxidation rate. About half of the 23 locomotives included in this study had an elevated coolant temperature of 193°F (89.5°C), whereas the coolant temperature on the remaining locomotives was the standard temperature of 175°F (79.5°C). The lower coolant temperature allowed the locomotives to operate without an oil drain. In contrast, the locomotives with the higher temperature accelerated the used oil viscosity increase and caused the viscosity to exceed the viscosity limit in 120+ days. This was due to the fact that the oil oxidation severity about doubles for each 18°F (10°C) increase in the crankcase oil temperature. As the oil oxidation rate increases, there is also an increase in (a) the formation of organic acids, (b) engine wear and (c) the used oil viscosity increase rate.

Because of the lower oil consumption and higher operating temperatures of the new fuel efficient diesel locomotives, the additive suppliers and oil companies are developing a new class of lubricants. These engine oils are being recognized by one OEM as "Generation 4 long life". Improved additive technology is required to meet the long life definition. For example, the additive package must provide:

- Improved oxidation inhibition to keep used oil viscosity within capable limits;
- Good TBN retention to

neutralize combustion acids and to control corrosive wear;

- Higher levels of dispersants to suspend insolubles and to reduce oil thickening; and
- Proper balance of detergents, antiwear agents and metal deactivators to minimize deposits and wear.

Several improved technologies have already been successfully demonstrated in new low oil consuming diesel locomotives. These field tests were conducted in both EMD and GE locomotives and were operated in compliance with the LMOA field test procedures for a period of one year minimum. In spite of the fact that the oil changes were made at 180 days or longer, the deposits, wear, TBN retention and viscosities were all maintained within the specified limits. This new additive technology has been proven to be effective in both naphthenic and paraffinic base stocks, as will be shown in the following five field tests.

The first evaluation is labelled as test A and is described in Table 1. This evaluation was conducted in three 3600-hp GE B36-7 engines for a period of 13.5 months and 139,400 test miles. Even though the engines had a low rate of oil consumption (average of 0.22 as a percent of fuel) the crankcase oil containing additive "X" allowed oil drains in excess of 180 days without exceeding the condemning limits for used oil viscosity, oil oxidation and total base number. However, as shown in Figure 4 and Figure 5, the used oil viscosity increase and oxidation of the used oil were greatly influenced by the oil consumption of the engine. The two engines with an oil consumption rate of 0.18 (as a % of fuel consumed) reached the used oil condemning limit after 206 service days. However, the engine with an oil consumption rate of 0.30 as a percent of fuel, never reached these condemning limits before the oil was changed in the engine. The TBN depletion rate was also affected by the oil consumption rate of the diesel locomotives as is shown in Figure 6. This graph shows that the TBN of the used oil approached the condemning limit of 0.5 for the low oil consuming engines, but was maintained at about 2.5 minimum for the higher oil consuming engine. At the conclusion of the field test all three engines were torn down and rated for deposits. The average ratings are compared against the Generation 4 reference oil in Table 2. This comparsion shows that the new additive technology was able to control the deposits even at the extended oil drain of 206 days.

The second field test, labeled as test B, was conducted in the Eastern part of the United States in 9 GE C36-7 and 9 GE C39-8 engines. Details on this evaluation are summarized in Table 3 and show that the test oil was blended with MVI base stocks and additive "Y". In this evaluation, used oil samples were taken periodically and examined in the laboratory for viscosity at 100°F (37.8°C). When the used oil viscosity reached the condemning limit of 270 cSt, the crankcase oil was changed in the respective diesel engines. As shown graphically in Figures 7 and 8, the new lubricant technology allowed oil drains of 190 up to about 200 service days.

Field test C is described in Table 4. This evaluation included 8 EMD SD-50 locomotives that were operated by an Eastern US railroad in heavy duty main line freight service. The test oil was blended with additive "Y" in MVI base stocks. The results of this one year evaluation are summarized in Figures 9, 10, and 11. These 3 graphs plot the used oil viscosity, total base number and wear metals against engine oil service days. Because of the higher oil consumption rate of these engines (about

0.6 as a % of fuel consumed), none of the inspections approached the condemning limits even though the oil was never changed throughout the one year testing period. It will also be noted that raising the oil outlet temperature had little effect on the overall performance of the oil.

Another field test, D, was conducted on a Southeastern US railroad using 5 GE C39-8 and 14 GE U23-B engines. As shown in Table 5, the engines were operated in heavy duty main line freight service using an engine oil blended with additive "Y" and MVI base stocks. The purpose of this study was to determine the oil change interval based on an established condemning limit for the viscosity increase and/or total base number. As shown in Figures 12 and 13, the 5 GE C39-8 engines operated for almost one year without an oil change. The engines will continue to be operated without an oil change until the used oil viscosity increases by 30% or the TBN drops to 1. The 14 GE U23-B engines were operated for 350 days before changing the oil. At this point, the used oil viscosity had increased to 270 cSt which was the predetermined condemning limit as shown in Figure 14.

Field test E was conducted in the Southwestern portion of the United States using one GE B36-7 and two GE B39-8 engines. As shown in Table 6, these engines were operated in heavy duty, mainline freight service and were lubricated with a new additive technology "C" blended in high VI base stocks. The field test was conducted for 15 months and 130,000 test miles. The oil consumption average 0.69 as a percent of the fuel consumption which enabled the oil change interval to be extended to 222 days. As shown in Table 7, the only used oil inspection that exceeds the condemning limit at this extended oil change period was pH. All other inspections were well within the allowed maximum limit.

Based on the results of the five tests just described, it can be concluded that:

(a) improved technology has been successfully demonstrated in both EMD and GE diesel locomotives;
(b) the new formulations allow oil drains of 180 days or more when lubricating new, low oil consuming engines that are operated for approximately 10,000 miles per month;
(c) deposits, wear, viscosity increase, and TBN of the used oil are maintained in spite of the extended oil drains.

B. Definition of Generation 5 Oils

These conclusions allow the LMOA Committee on Fuel and Lubricants to define Generation 5 diesel locomotive engine oils as detailed in the following paragraphs.

Diesel locomotive engine oils will be recognized as Generation 5 quality if:

- They allow oil drains of 180 days minimum (6 months) for new, low oil consuming engines averaging 10,000 miles per month or consuming fuel at a rate of 20,000 gallons per month. Sulfur content of the diesel fuel must be 0.3 to 0.5%;
- They pass all critical OEM oxidation, corrosion and friction tests;
- The additive technology has been field tested and accepted by EMD and GE:

(a) field test must be conducted in accordance with LMOA procedures utilizing late model locomotives (three EMD/three GE minimum). The engines must be operated for 100,000 miles minimum in a service having a severity level accep-

table to the OEMs;

(b) the technology must demonstrate good deposits and wear control in these tests at extended drains without exceeding the following used oil guidelines:

— 1.0 TBN minimum (ASTM D664-84)

— 30% maximum viscosity increase at 100°C (ASTM D445)

— 5% maximum pentane insolubles (ASTM D893 Method B);

(c) the technology must meet the OEM requirements when evaluated in the following engine tests:

— 25 Hour EMD 2-567

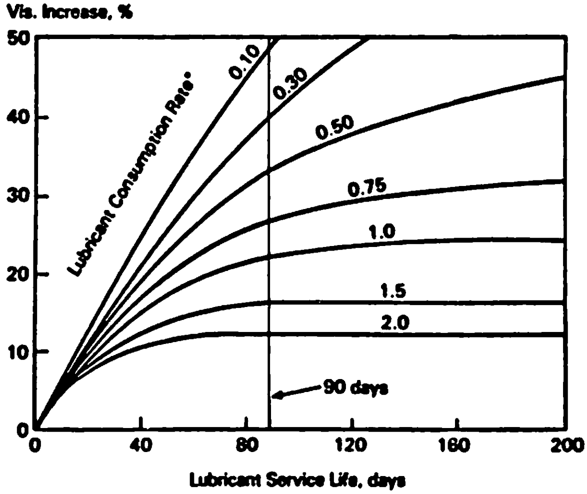
— 480 Hour Caterpillar 1-G2

— 750 Hour GE 7FDL

FIGURE 1

THE LUBRICANT CONSUMPTION RATE AFFECTS VISCOSITY INCREASE

Severe Mainline Railroad Service, Generation 4 Lubricant
(Calculated from Field Service)

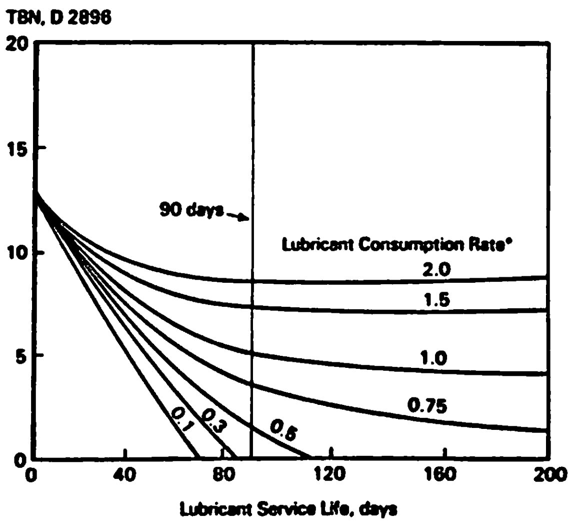


*% of Fuel

FIGURE 2

LUBRICANT CONSUMPTION RATE AFFECTS BASE LOSS

Severe Mainline Railroad Service, Generation 4 Lubricant
(Calculated from Field Service)



*% of Fuel Consumption

Oil Viscosity vs Time

FIGURE 3

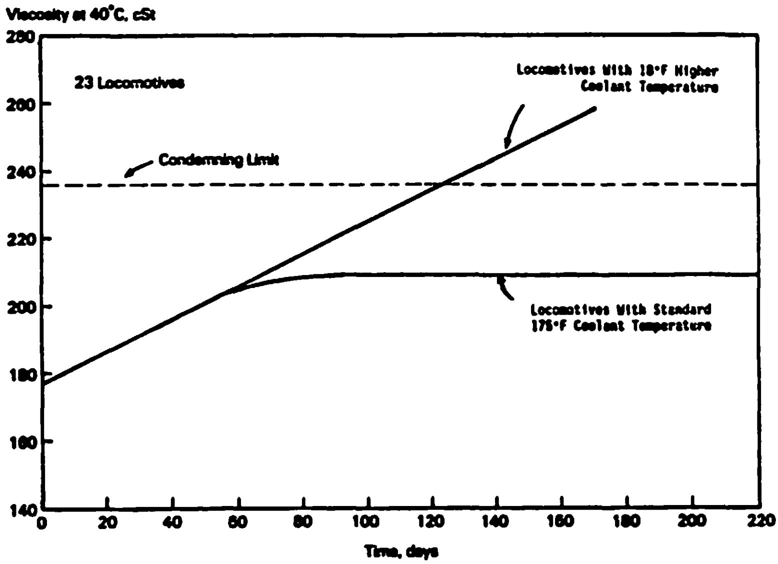


TABLE 1

FIELD TEST "A"

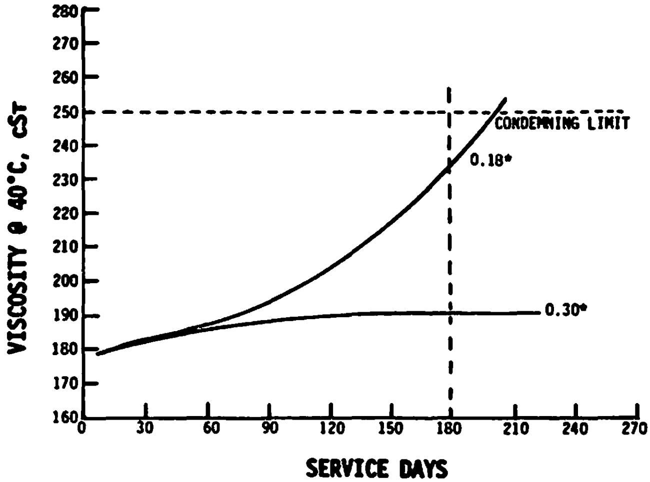
NEW ADDITIVE TECHNOLOGY "X"

SITE:	EASTERN U.S. / APPALACHIAN MOUNTAINS
LOCOMOTIVES:	THREE 3600 HP, GE B36-7
SERVICE:	HEAVY DUTY MAIN LINE FREIGHT
TEST OIL:	MVI BASE STOCKS, 13 TBN, ADDITIVE "X"
AVG. OIL CHANGE:	206+ DAYS
AVG. FILTER CHANGE:	90 DAYS
AVG. TEST MILES:	139,400
AVG. TEST MONTHS:	13.5
AVG. OIL CONSUMPTION:	1.77 GALS/DAY OR 0.22 AS % OF FUEL

Figure 4

FIELD TEST "A"

Used Oil Viscosity Increase Vs. Service Days

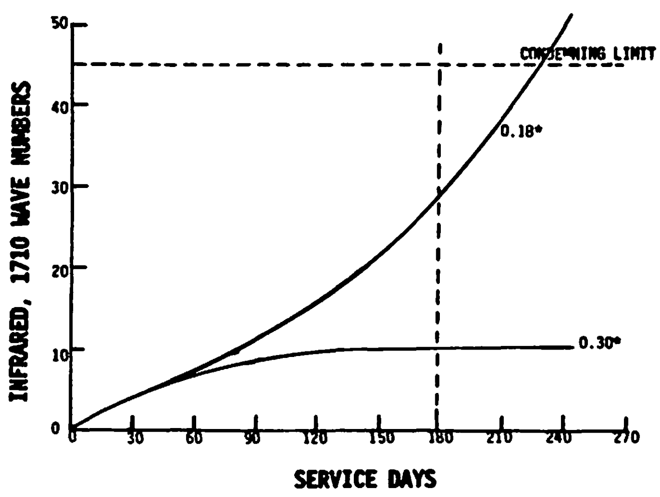


* Oil Consumption As % Of Fuel

Figure 5

FIELD TEST "A"

Used Oil Oxidation Vs. Service Life



* Oil Consumption As % Of Fuel

FIGURE 6

FIELD TEST "A"

TOTAL BASE NUMBER (TBN) VS. SERVICE LIFE

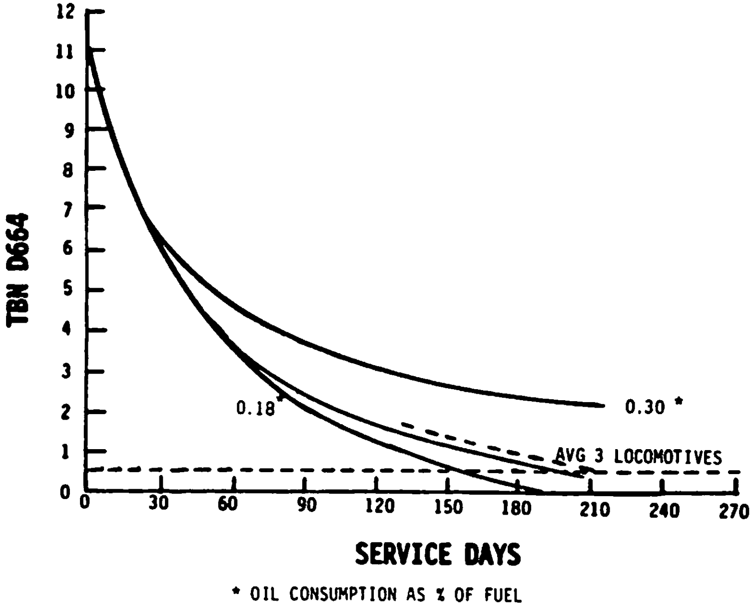


TABLE 2

FIELD TEST "A"

NEW ADDITIVE TECHNOLOGY "X"

AVG. DEMERIT RATINGS	NEW GENERATION OIL	GENERATION 4 OIL
RING GROOVES	115	118
LANDS	39	41
TOTAL RINGBELT	154	159
UNDERCROWN	14.6	18.2
TOTAL DEMERITS	168	177
AVG. OIL LIFE, DAYS	206+	135

TABLE 3

FIELD TEST "B"

NEW ADDITIVE TECHNOLOGY "Y"

SITE:	EASTERN U.S.
LOCOMOTIVES:	9 GE C36-7 9 GE C39-8
SERVICE:	COAL
TEST OIL:	MVI BASE OIL, 17 TBN, ADDITIVE "Y"
OIL CHANGE:	AT CONDEMNING LIMIT
AVG. FILTER CHANGE:	85 DAYS
TEST DURATION:	CONTINUING

FIGURE 7

FIELD TEST "B"

USED OIL VISCOSITY INCREASE VS. SERVICE DAYS

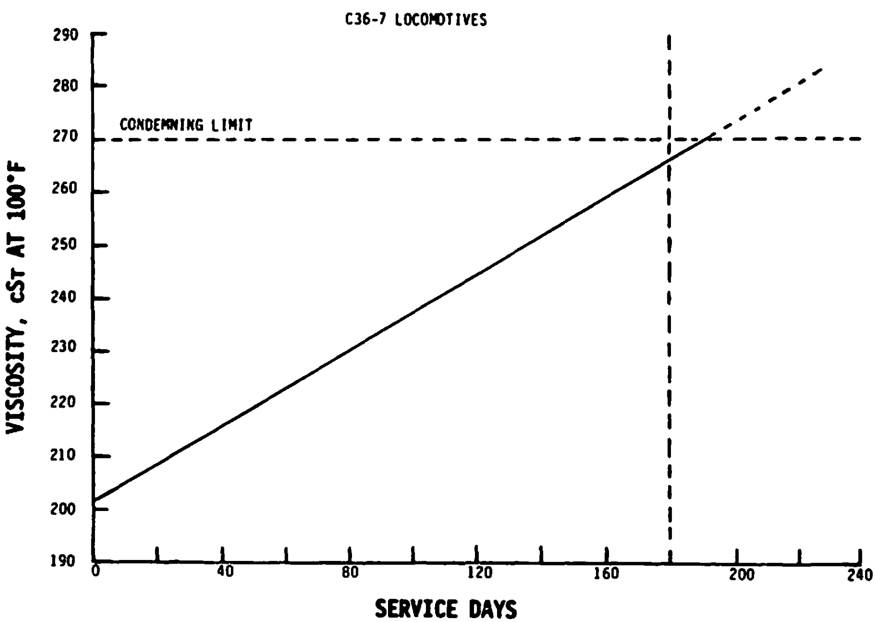


FIGURE 8

FIELD TEST "B"

USED OIL VISCOSITY INCREASE VS. SERVICE DAYS

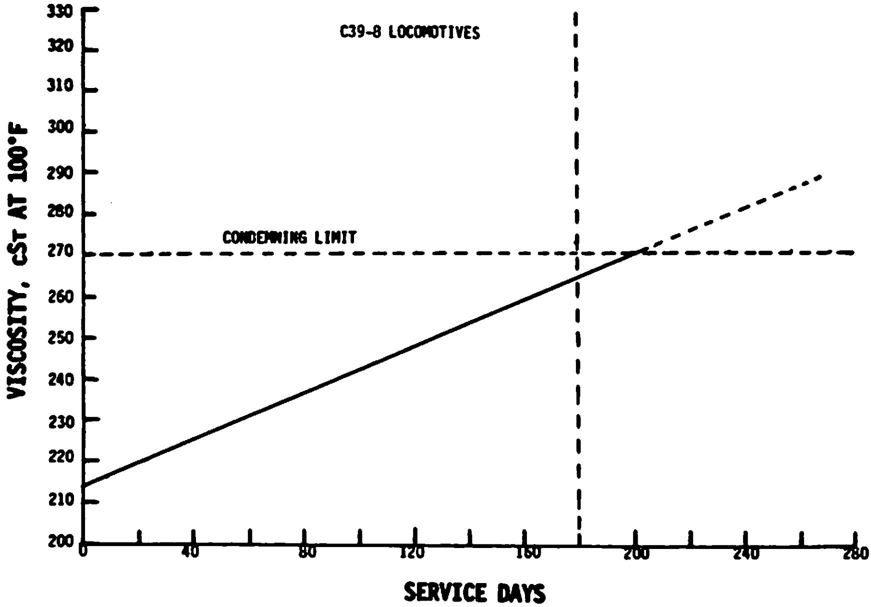


TABLE 4

FIELD TEST "C"

NEW ADDITIVE TECHNOLOGY "Y"

SITE:	EASTERN U.S.
LOCOMOTIVES:	EIGHT EMD SD-50 LOCOMOTIVES 645 F3B
SERVICE:	HEAVY DUTY MAIN LINE FREIGHT
TEST OIL:	HVI BASE STOCKS, 17 TBN, ADDITIVE "Y"
AVG. OIL CHANGE:	NO CHANGE REQUIRED DURING ONE YEAR TEST
AVG. FILTER CHANGE:	80 DAYS

FIGURE 9

FIELD TEST "C"

% VISCOSITY INCREASE VS. SERVICE DAYS

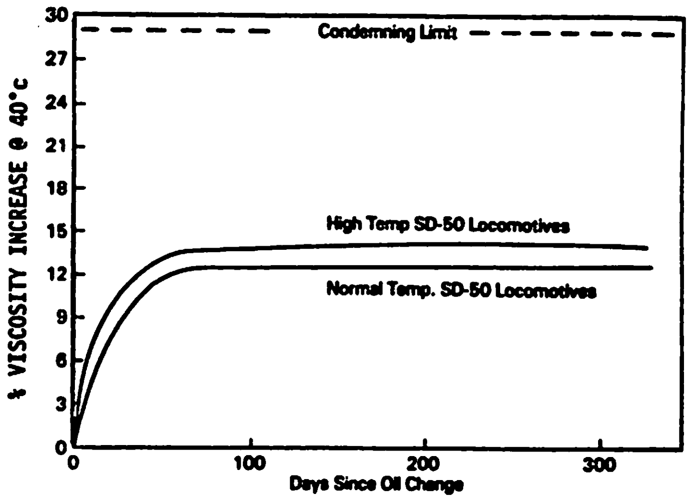


FIGURE 10

FIELD TEST "C"

TOTAL BASE NUMBER (TBN) VS. SERVICE DAYS

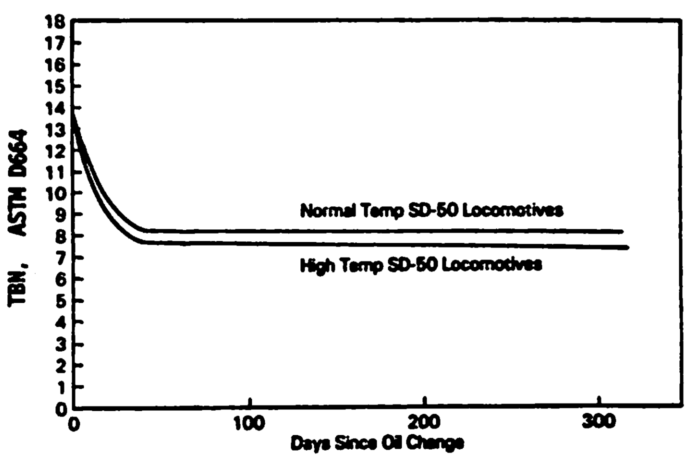


FIGURE 11

FIELD TEST "C"

USED OIL WEAR METALS VS. SERVICE DAYS

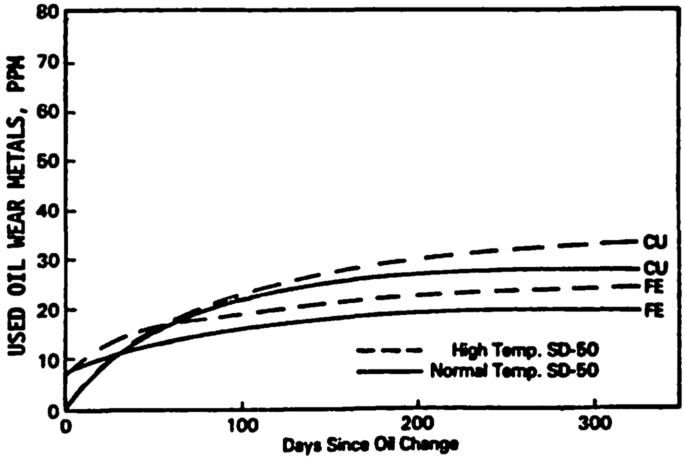


TABLE 5

FIELD TEST "D"

NEW ADDITIVE TECHNOLOGY "Y"

SITE:	SOUTHEASTERN U.S.
LOCOMOTIVES:	5 GE C39-8 14 GE U23-B
SERVICE:	HEAVY DUTY MAIN LINE FREIGHT
TEST OIL:	MVI BASE OIL, 17 TBN, ADDITIVE "Y"
OIL CHANGE:	AT CONDEMNING LIMIT
AVG. FILTER CHANGE:	85 DAYS
TEST DURATION:	CONTINUING

Figure 12

FIELD TEST "D"

Viscosity Increase Vs. Service Days

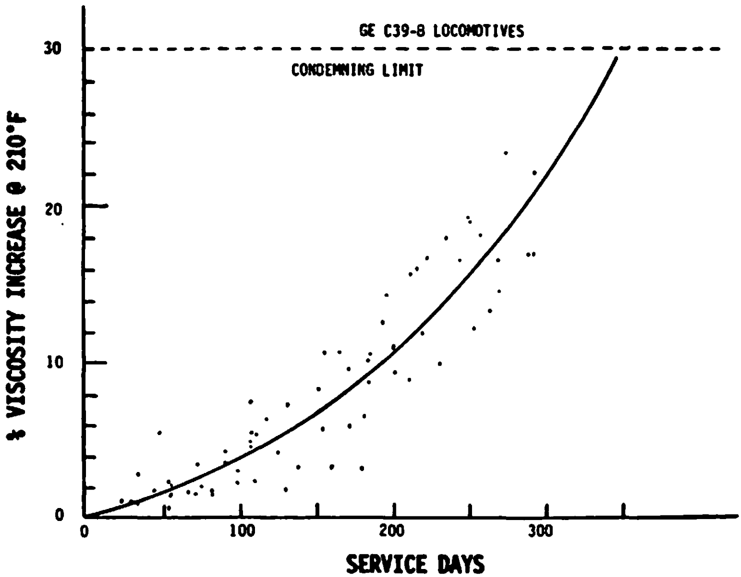


Figure 13

FIELD TEST "D"

Total Base Number (TBN) Vs. Service Days

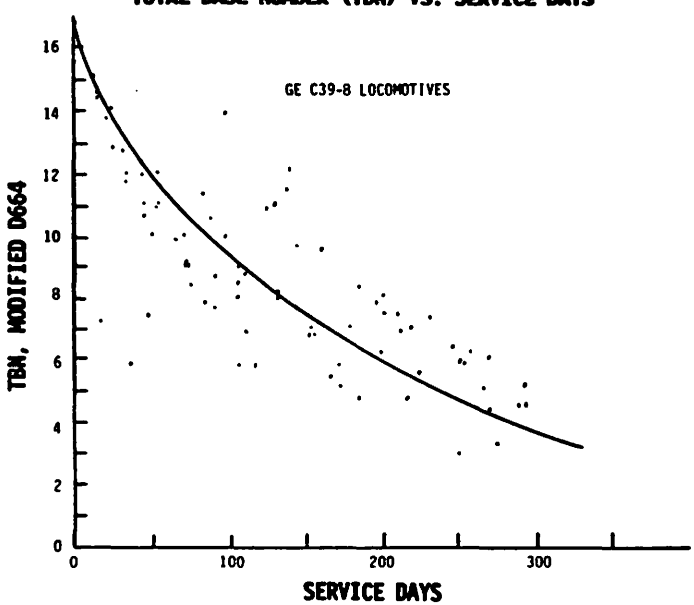


FIGURE 14

FIELD TEST "D"

USED OIL VISCOSITY INCREASE VS. SERVICE DAYS

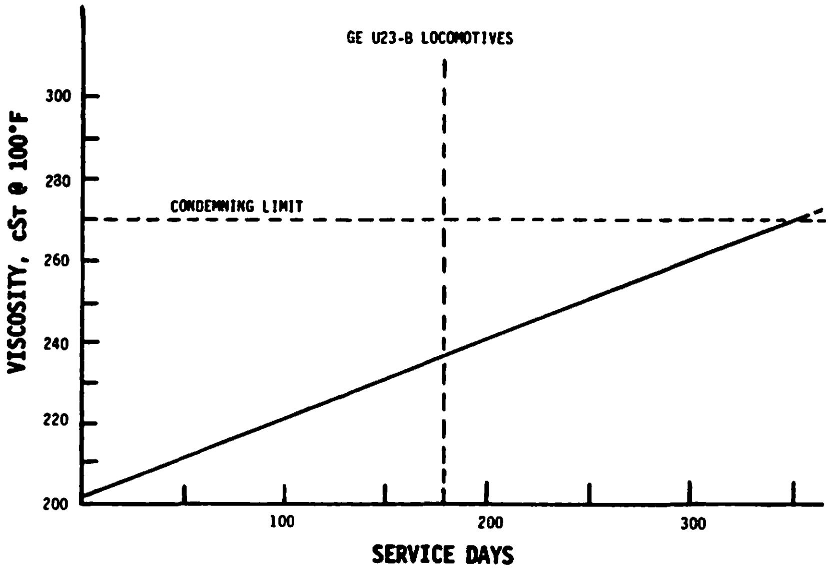


TABLE 6

FIELD TEST "E"

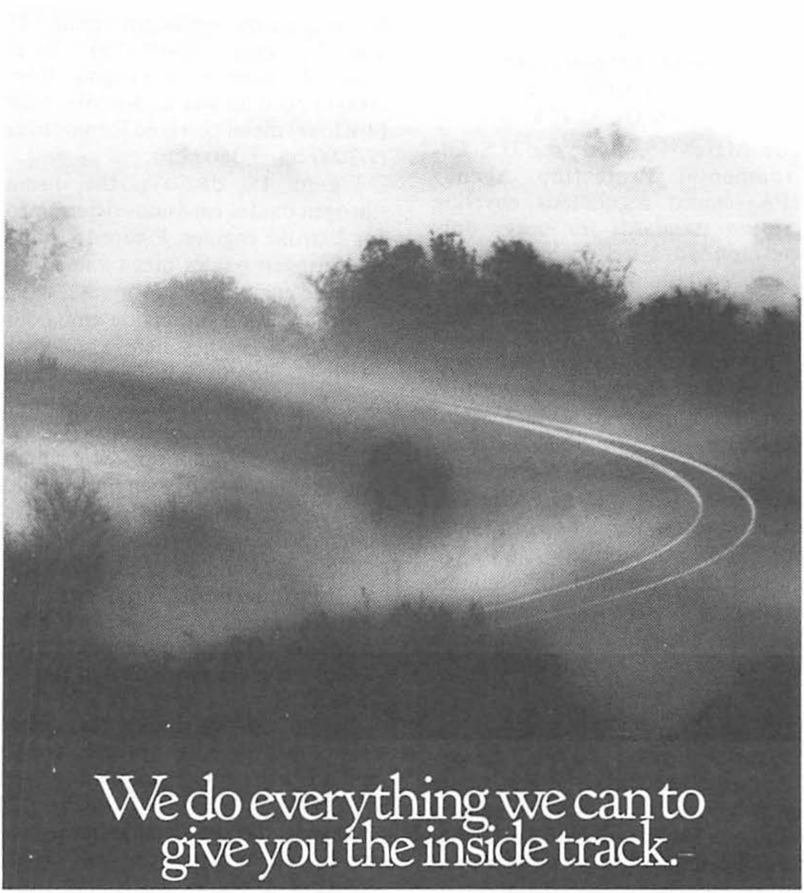
NEW ADDITIVE TECHNOLOGY "Z"

SITE:	SOUTHWESTERN U.S.
LOCOMOTIVES:	ONE GE B36-7 TWO GE B39-8
SERVICE:	HEAVY DUTY MAIN LINE FREIGHT
TEST OIL:	HVI BASE STOCKS, 13 TBN, ADDITIVE "Z"
AVG. OIL CHANGE:	222 DAYS
AVG. FILTER CHANGE:	90 DAYS
AVG. TEST MILES:	130,000
AVG. TEST MONTHS:	15
AVG. OIL CONSUMPTION:	0.69 AS % OF FUEL CONSUMPTION

Table 7
Field Test "E"
Test Oil Performance

Avg. Oil Change:	222 Days
Avg. Used Oil Inspections:	
- Viscosity Increase @ 100°C	14%
- Pentane Insolubles	4.25%
- TBN, D2896	4.5
- pH	4.5(1)
- Wear Metals, PPM	
Iron	26
Lead	21

(1) Only Inspection Exceeding Condemning Limit


We do everything we can to
give you the inside track.

II.
DIESEL EMISSIONS: REGULATIONS & FUEL QUALITY

On March 15, 1985, the U.S Environmental Protection Agency (EPA) issued regulations covering emission standards for heavy duty over-the-road diesel engine vehicles. These regulations will have a very significant effect on the design of diesel engines for this service and on the nature of the fuels and lubricants used in those engines. Subsequently, the California Air Resources Board (CARB) passed new diesel fuel standards in December of 1988 covering diesel fuel to be sold in California. While these new regulations and standards do not directly apply to railroad diesel engines, they almost certainly will affect the quality of diesel fuel available to U.S. railroads and may affect lubricant quality.

1. Emissions Standards

Figures 15 and 16 list the requirements that must be met under the new EPA standards. Regulated pollutants shown are carbon monoxide (CO), nitrogen oxides (NOx), unburned hydrocarbons (HC) and particulates. Emissions are measured under the EPA transient cycle, which includes idle, part-load, and full load accelerations and decelerations. This cycle is based on New York and Los Angeles freeway and city driving cycles. It includes about 35% idling time.

For the purpose of comparison, figures 17 through 18 show the EPA standards and locomotive emissions levels published by AAR in: *Exhaust Emission Testing of In-Service Diesel-Electric Locomotives 1981 to 1983,* Peter C.L. Conlon, AAR Publication R-688, March, 1988. Idle is indicated in these graphs by "NOTCH 0".

The locomotive data were obtained by evaluating emissions from 45 2-stroke cycle (2-stroke) diesel powered locomotives ranging from 2000 to 3600 hp and 12 4-stroke cycle (4-stroke) diesel powered locomotives (7-3000 hp, 5-3600 hp).

Figure 17 displays the mean nitrogen oxides emissions determined for 2-stroke engines. Figure 18 shows the nitrogen oxides mean values for 4-stroke engines.

Mean carbon monoxide emissions for 2-stroke engines, before and after overhaul, are shown in figures 19 and 20. The same data for 4-stroke engines are shown in figures 21 and 22. It would appear that both 2-stroke and 4-stroke engines would be able to meet the EPA carbon monoxide emission requirements.

Figures 23 and 24 display unburned hydrocarbon emissions for 2-stroke engines, before and after overhaul. These parameters for 4-stroke engines are shown in figures 25 and 26.

In the AAR study, particulate emissions were only measured at idle and notch 8, using a modified version of EPA Method 5. Figure 27 describes the particulate emissions for 2-stroke engines.

Figure 28 shows particulate emissions for 4-stroke engines. Only one determination of particulates at idle was made for the 3000 hp 4-stroke engines. This value is not shown, since it may or may not be representative.

Comparing the preceding data to the railroad duty cycles, described in figures 29 and 30, we can see that, while current locomotives burning current diesel fuel should meet the EPA on-highway CO emission requirements, considerable improvement would be required were the regulations governing hydrocarbons, oxides of nitrogen and particulates applied to railroad diesel emissions.

We are not aware of any intention to apply the EPA on-highway emis-

sion standards to railroad diesel engines. However, a recent study performed for EPA concludes that off-highway diesel engines, including railroad locomotive engines, contribute a significant amount of emissions to nationwide inventories. There has been congressional interest in granting EPA authority to regulate emissions from these sources. Some of the steps taken to meet on-highway standards will also affect railroad diesel operation and we will discuss these items in this paper.

Heavy duty diesel engine manufacturers meeting the new emission requirements of the 1990s will require improvements in engine technology, fuel quality, lubricants quality and exhaust aftertreatment.

2. Engine Technology

Improvements in engine technology will include better combustion systems, state-of-the-art fuel injection and control systems, improved air systems, and integrated computer control systems. The consensus among the major on-highway diesel engine manufacturers seems to be that, at least for their most popular engine series, they can meet the EPA 1991 truck requirements through available engine technology improvements. This can be accomplished with existing fuel and without aftertreatment. This is not the case when the 1991 urban bus and 1994 truck standards are considered.

The problem which is not subject to correction through engine technology alone is control of particulates to the 0.1 grams per bhp-hr level. It appears that the 1991 truck standard of 0.25 grams per bhp-hr is about the best that can be achieved without reduction in fuel and lube oil constituents that contribute to particulates and addition of exhaust aftertreatment.

3. Fuel Characteristics

The main fuel characteristic of concern is sulfur content. When burned in a diesel engine, fuel sulfur creates particulate in the form of sulfuric acid, acid bound water and sulfates. At a fuel sulfur level of 0.3 per cent, fuel sulfur alone will account for 70 per cent of the 0.1 grams per bhp-hr of particulate allowed for 1994. Accordingly the diesel engine manufacturers are requesting the maximum fuel sulfur level to be reduced to 0.05 per cent or less. Currently, maximum sulfur allowed under ASTM standard D 975 for number 2D diesel fuel is 0.5 per cent; typical sulfur for number 2D diesel fuel in the U.S. falls between 0.3 and 0.4 per cent. Aromatic content of diesel fuel is also of concern. Reduction of aromatic content will also lessen particulate emissions. A proposal has been made to EPA by a committee comprised of representatives of the American Petroleum Institute (API), Engine Manufacturers Association (EMA), and National Petroleum Refiners Association (NPRA) for a recommended federal diesel fuel specification. The principal elements of this proposal are:

- #2D distillate pool separated into on-highway and off-highway segments.
- On-highway fuel limited to maximum of 0.05% by weight of sulfur.
- On-highway cetane number limited to 40 maximum (freezes aromatic content at current #2D level of about 34%).
- All off-highway # 2D fuel to be dyed at refinery or before importation.
- Regulated fuel available by October 1993. Unregulated fuel prohibited thereafter.

- OEMs permitted to certify 1991 engines with regulated fuel although not generally available in the market until 1994.

In December of 1988 the California Air Resources Board passed new diesel fuel standards which include:

- A provision for lowering fuel sulfur to 0.05% and aromatic hydrocarbon content to 10% by October, 1993.
- A provision to accept the use of alternative fuel strategies if they are shown to provide the same emission level as low sulfur, low aromatic fuels.

In 1987 NPRA completed a survey of 139 refinery respondents concerning the effects of standards reducing diesel fuel sulfur and aromatic hydrocarbon levels. The results of this survey included the following conclusions concerning existing capabilities:

- In 1991 sulfur in diesel fuel would be reduced only modestly by using current or planned facilities to the fullest possible extent.
- Increased segregation among distillate products was not a practical approach to minimizing diesel fuel sulfur.
- Smaller refineries are less able to reduce sulfur content because they are less likely to have hydrodesulfurization (HDS) facilities.
- Almost half (47.5%) of the nation's refineries (about ⅓ of U.S. capacity) do not have a distillate HDS unit.
- Maximum utilization of existing facilities would reduce fuel sulfur by only 0.04% (eg. 0.3% to 0.26%).

In response to questions concerning the reduction of fuel sulfur levels to 0.05% the following conclusions were drawn:

- The amount of additional HDS capacity required would be 1,511,000 B/D. This is a 90% increase.
- Estimated capital expenditure for these facilities is $3.3 billion.
- This capital expenditure plus other increased costs of operation equates to 3.1 cents per gallon if applied to the aggregate of segregated diesel plus common diesel/distillate.
- If the cost is applied to on-highway diesel only it equals 7.7 cents per gallon.
- Capital availability, environmental permitting concerns and other factors would prevent 27% of the responding refineries, with a total diesel/distillate capacity of 415,179 B/D, from implementing the required HDS capacity improvements.
- Due to the cost and impracticality of segregating mid-distillate components within refineries, the sulfur level of all #2 distillate would be decreased, not just on-highway diesel fuel.
- If an aromatic hydrocarbon reduction from 34% to 20% is imposed on top of the 0.05% fuel sulfur specification the cost per gallon of fuel increases by 15.5 cents per gallon.

In view of the above findings, it is very probable that implementation of the 1993 diesel fuel quality standards will result in reduced sulfur levels and increased cost, not only of on-highway diesel fuel, but also of railroad diesel fuel.

Before leaving the area of fuel quality, we should also consider the requirements for fueling 1991 urban buses. Even if low sulfur diesel fuel is available by 1991 the particulate limitation of 0.1 grams per bhp-hr can not be met without exhaust after-treatment in the form of particulate traps and/or catalytic conversion. This hardware is not expected to be available in time to meet the 1991 certification deadline. Therefore, it is very likely that urban bus diesel engines will be converted to burn methanol or natural gas. Methanol will increase both the cost of the engine, due to the special materials required, and the cost of the fuel. Natural gas presents particular problems with respect to storage and handling.

4. Lubricants

In the effort to minimize particulate emissions attention must also be focused on the role of engine oil. While reduction of fuel sulfur will substantially reduce sulfur related particulates, particulate emissions also include soot and soluble organic fraction (SOF) which result from unburned lubricating oil, as well as unburned fuel. Reduction of oil consumption will help to reduce these emissions, but it will increase the stress on the oil itself. Better oxidation resistance detergency and dispersancy will be needed to compensate for low make-up rates. Improved anit-wear performance will be required to ensure good oil consumption control over the life of the engine and the ability to cope with high bmep loading. These improvements in performance should provide lubricants which, while not greatly different from the lubricants in use today, will meet the requirments of 1991 truck engines.

Lubricants for 1994 emission level engines will probably be very different from today's engine oils. Engine oils for 1994 will need to be formulated, not only to minimize SOF contribution, but also to be compatible with particulate traps and/or oxidizing catalysts. These oils will probably be formulated with ashless or very low ash additive systems. This will be facilitated by 0.05% sulfur diesel fuel since the potential for corrosive wear and need for high TBN levels will be greatly reduced. Engines burning methanol will require specially formulated engine oils which are compatible with methanol and its combustion byproducts.

Widespread use of low sulfur diesel fuel by U.S. railroads could eliminate the need for high TBN engine oils in railroad diesel engines, and may require a major shift in lubricant formulation technology.

5. Summary

The period between now and 1994 will be one of major changes in the technology of on-highway engines, fuels and lubricants as engine builders, oil companies and additive suppliers strive to meet the requirements of emission control regulations. While these emission regulations do not directly apply to railroad diesel locomotives, railroads can expect to be affected by these changes in a number of ways. Changes in fuel quality will probably be seen in terms of lower sulfur and aromatic content. Fuel costs may be expected to increase. Lower sulfur levels may result in longer engine oil life, reduced wear and the use of lower TBN oils. As always, we need to remain aware of the interdependence of fuel quality, engine technology and lubricant performance to ensure reliable locomotive engine operation, both now and in the future.

EPA OVER-THE ROAD
EMISSION STANDARDS

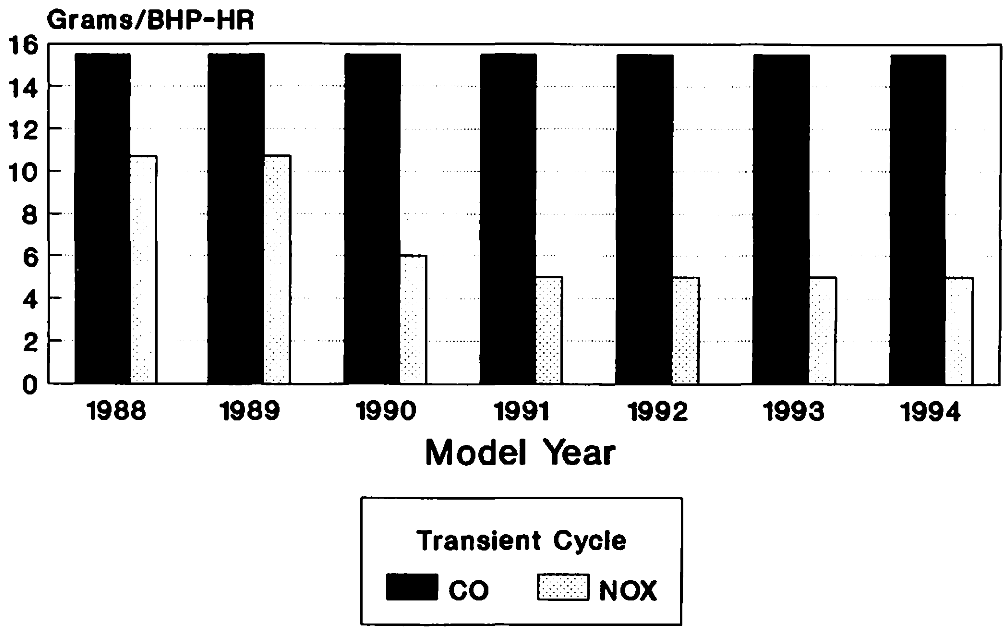


Figure 15

EPA OVER-THE ROAD
EMISSION STANDARDS

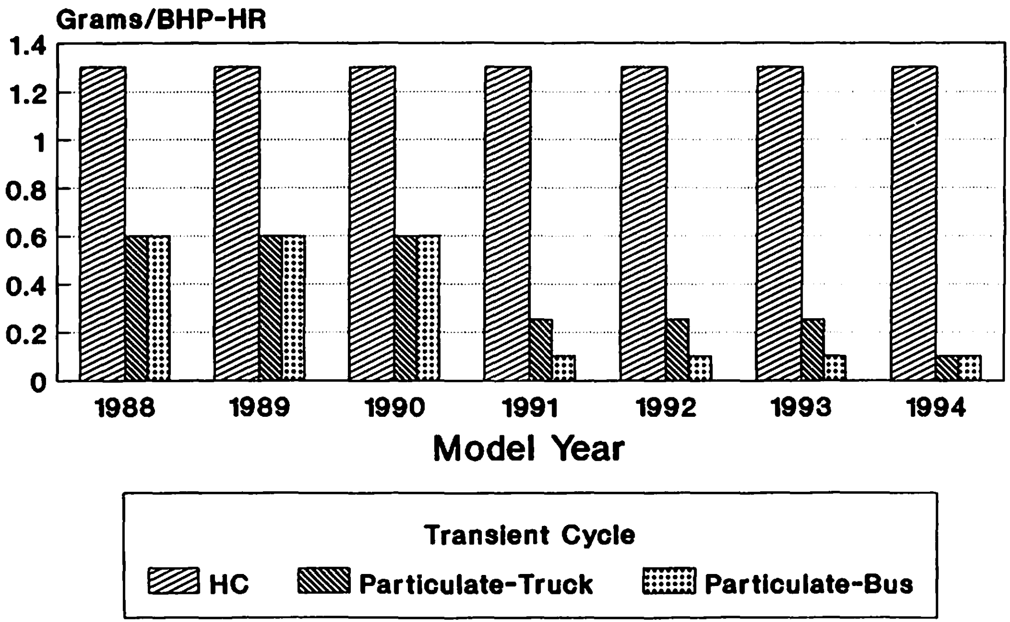


Figure 16

NITROGEN OXIDES EMISSIONS
2 - STROKE

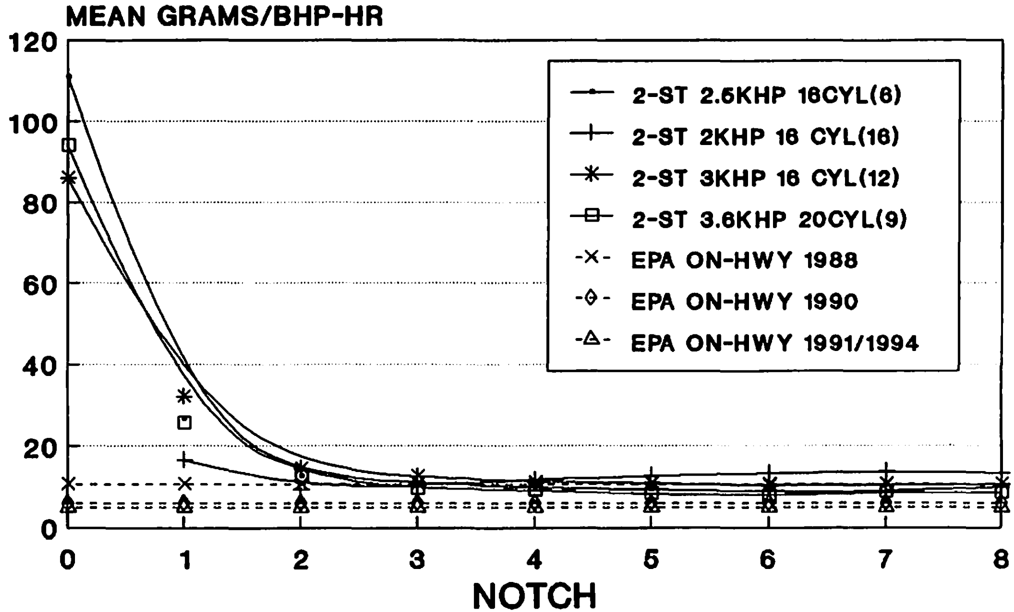


Figure 17

NITROGEN OXIDES EMISSIONS
4 - STROKE

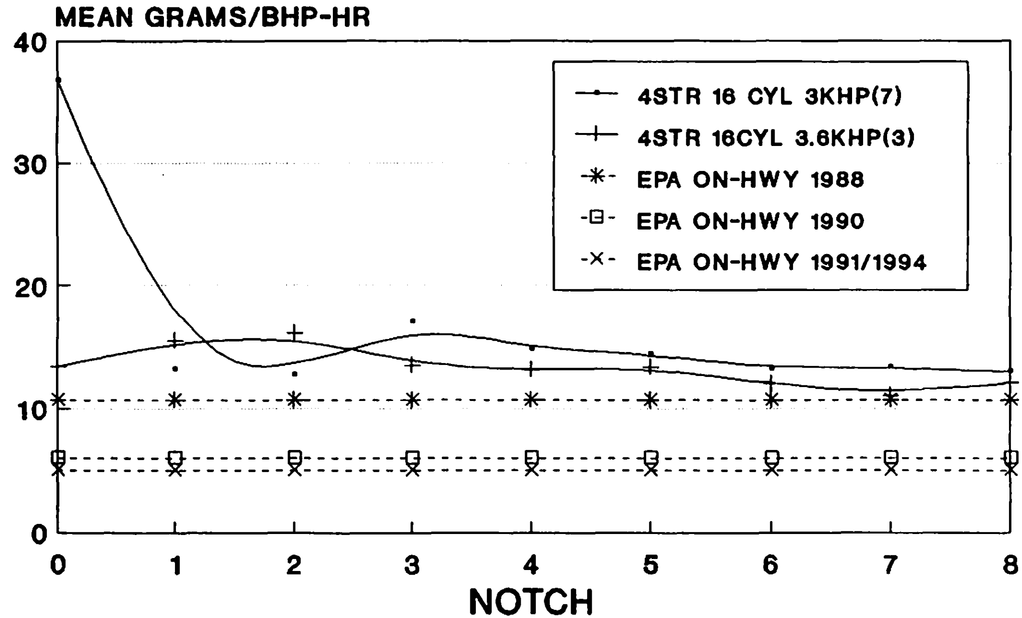


Figure 18

CARBON MONOXIDE EMISSIONS
2 - STROKE BEFORE OVERHAUL

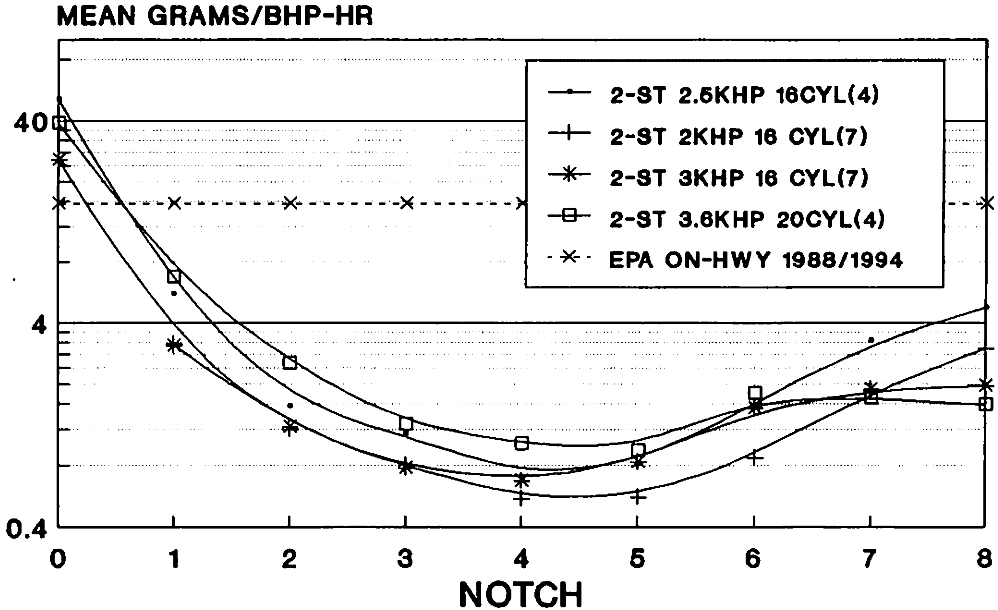


Figure 19

CARBON MONOXIDE EMISSIONS
2 - STROKE AFTER OVERHAUL

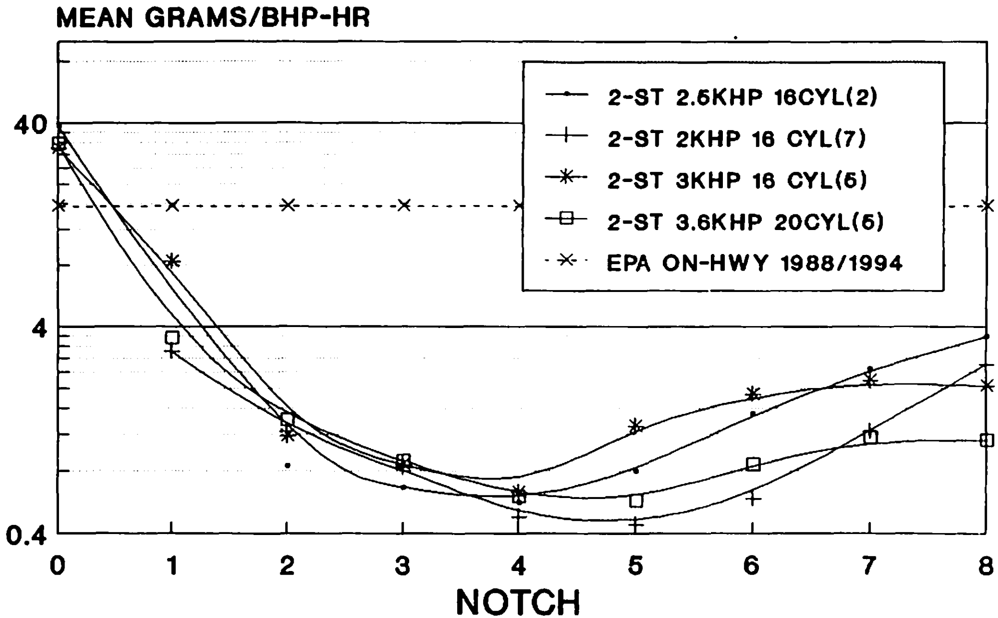


Figure 20

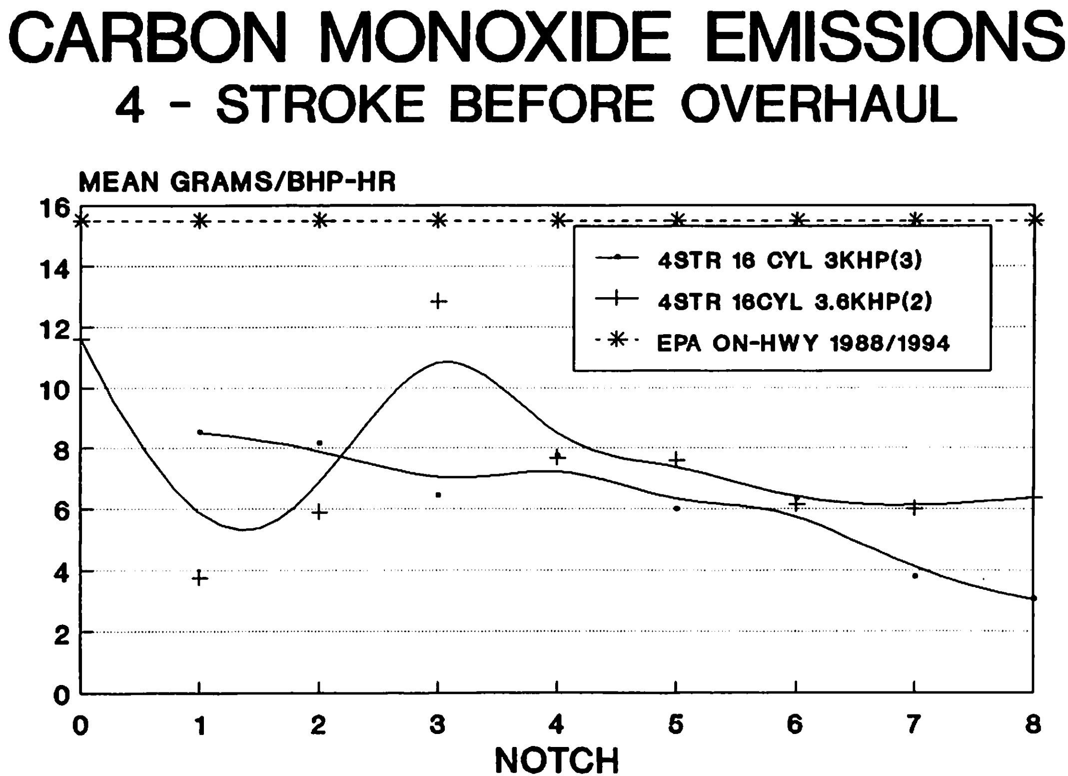

CARBON MONOXIDE EMISSIONS
4 - STROKE BEFORE OVERHAUL
MEAN GRAMS/BHP-HR
16
14
12
10
8
6
4
2
0
0
1
2
3
4
5
6
7
8
NOTCH
4STR 16 CYL 3KHP(3)
4STR 16CYL 3.6KHP(2)
EPA ON-HWY 1988/1994

Figure 21

CARBON MONOXIDE EMISSIONS
4 - STROKE AFTER OVERHAUL

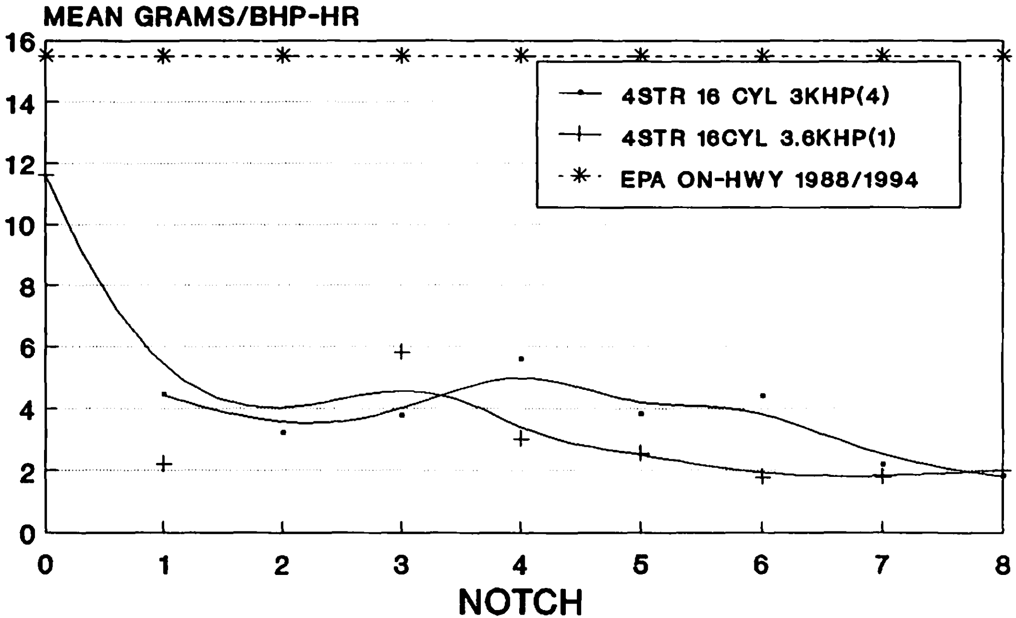


Figure 22

HYDROCARBON EMISSIONS
2 - STROKE BEFORE OVERHAUL

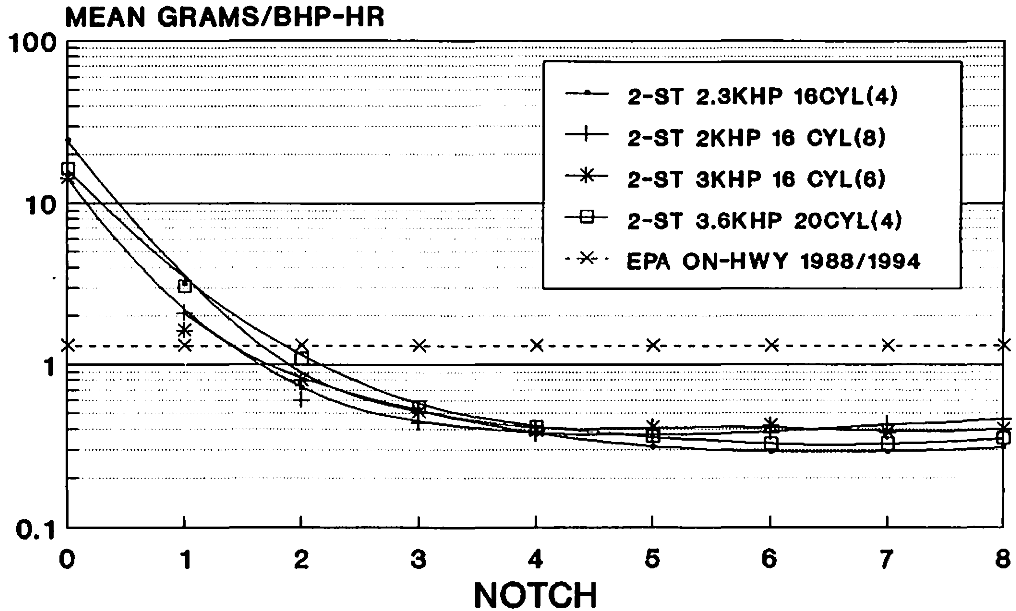


Figure 23

HYDROCARBON EMISSIONS
2 - STROKE AFTER OVERHAUL

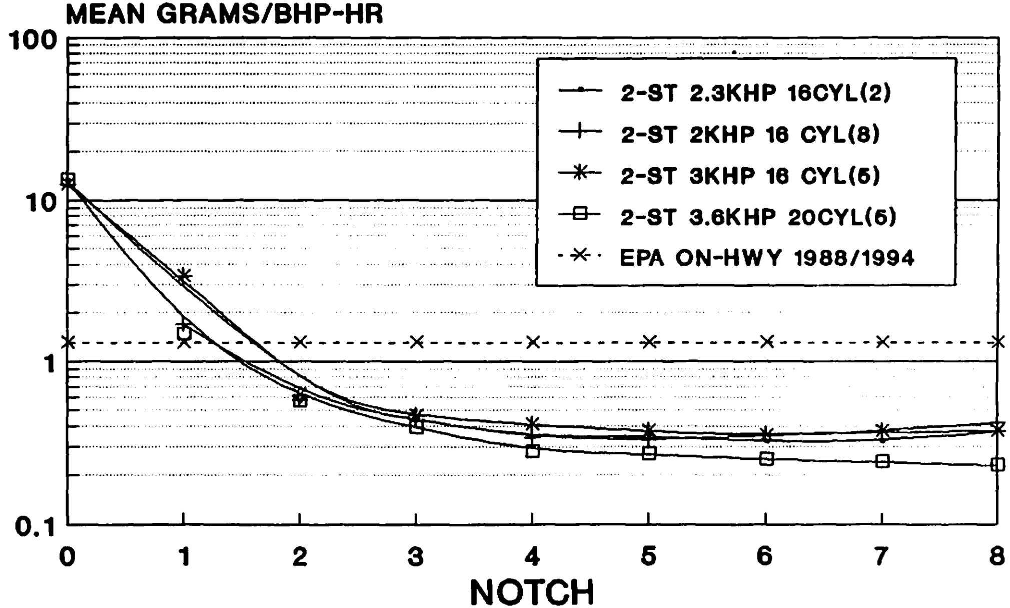


Figure 24

HYDROCARBON EMISSIONS
4 - STROKE BEFORE OVERHAUL

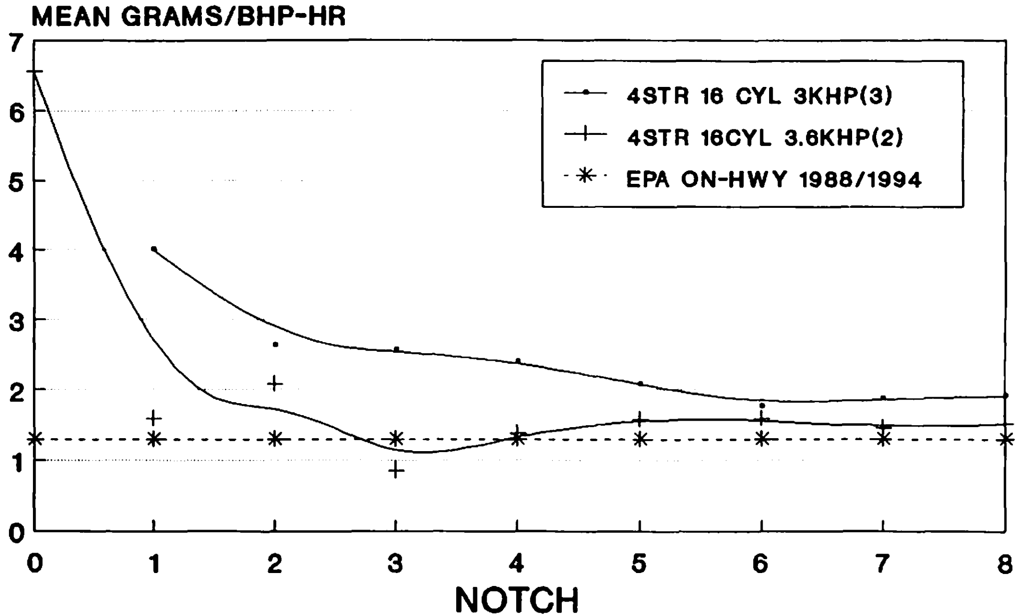


Figure 25

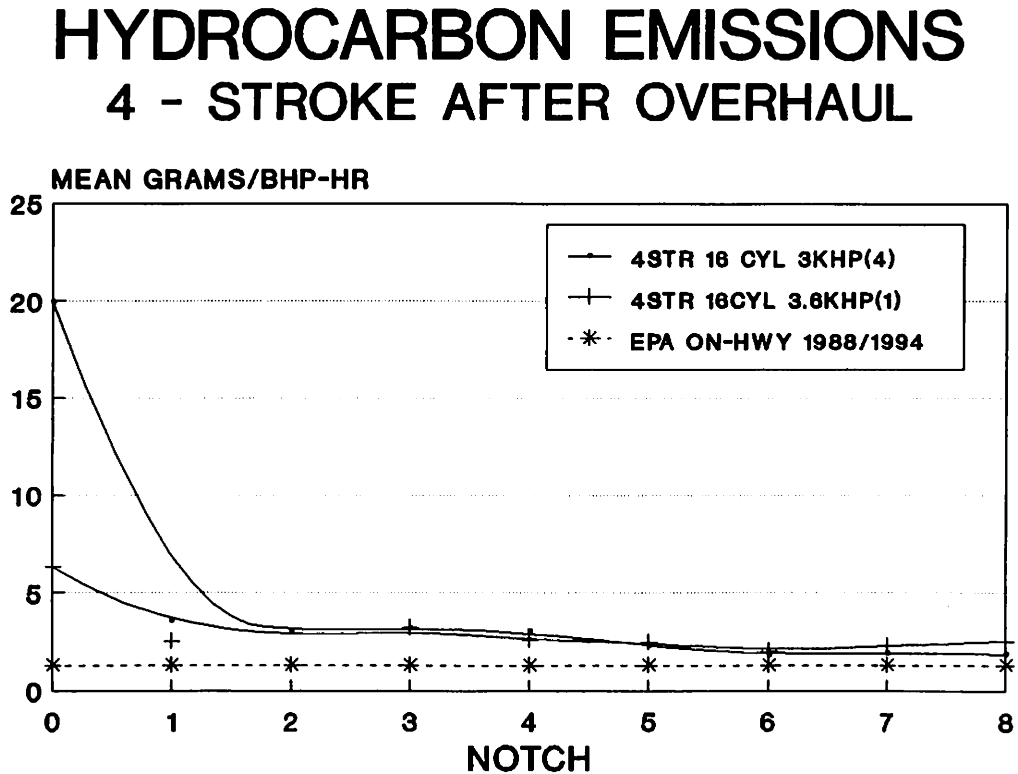

HYDROCARBON EMISSIONS
4 - STROKE AFTER OVERHAUL
MEAN GRAMS/BHP-HR
25
20
15
10
5
0
4STR 16 CYL 3KHP(4)
4STR 16CYL 3.6KHP(1)
EPA ON-HWY 1988/1994
0
1
2
3
4
5
6
7
8
NOTCH

Figure 26

PARTICULATE EMISSIONS
2 - STROKE

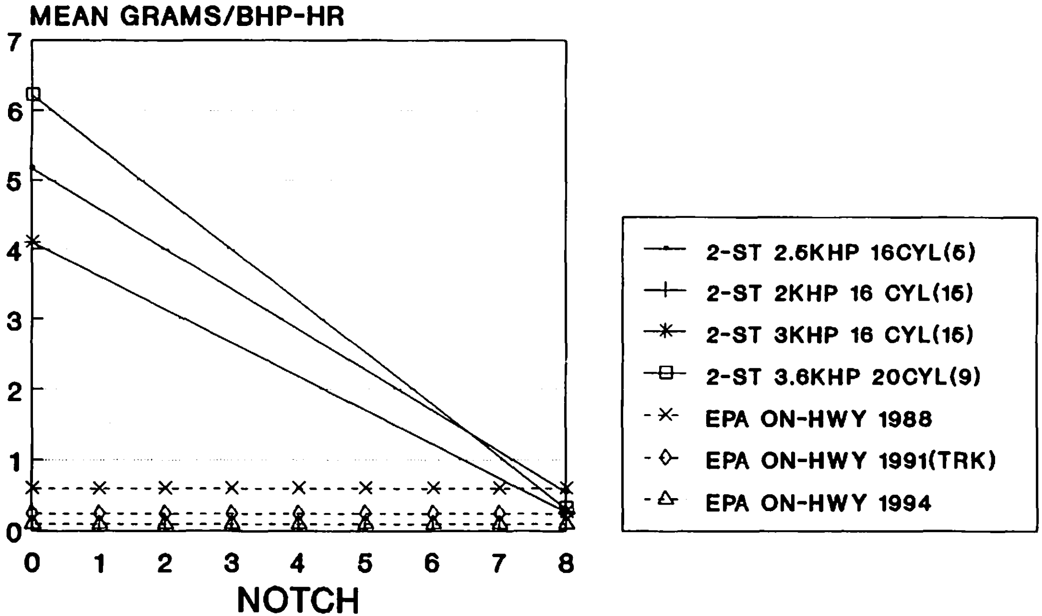


Figure 27

PARTICULATE EMISSIONS
4 - STROKE

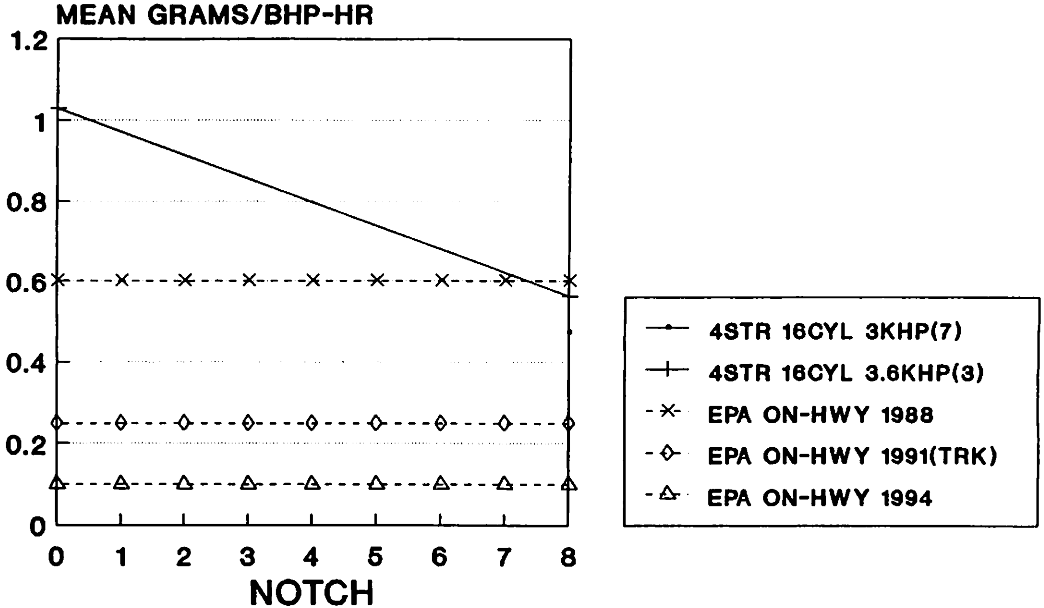


Figure 28

RAILROAD DUTY CYCLES

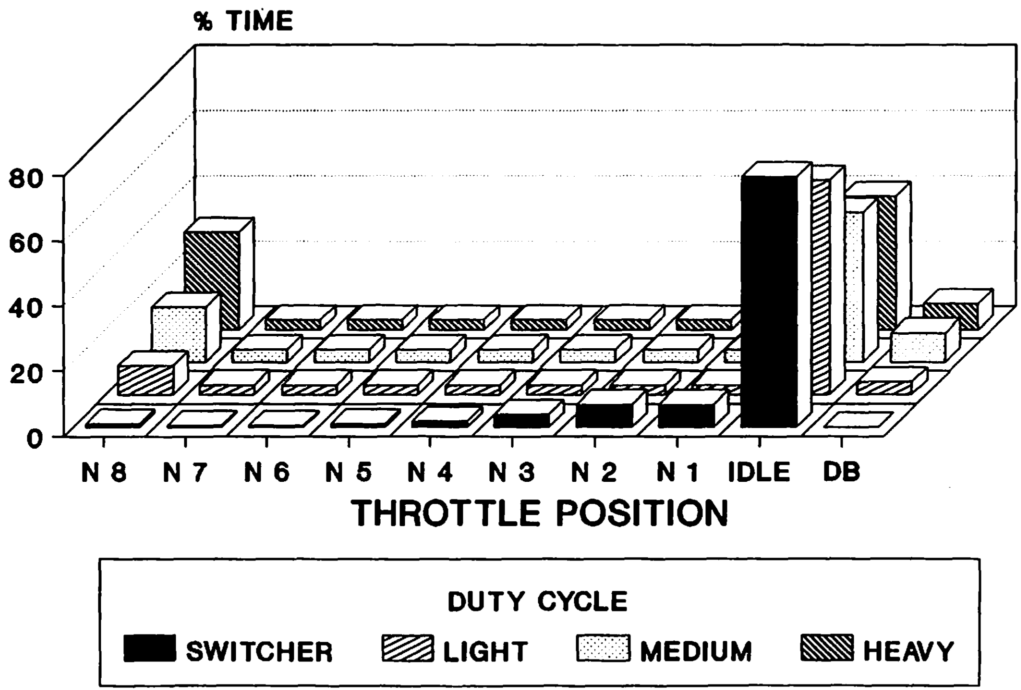


Figure 29

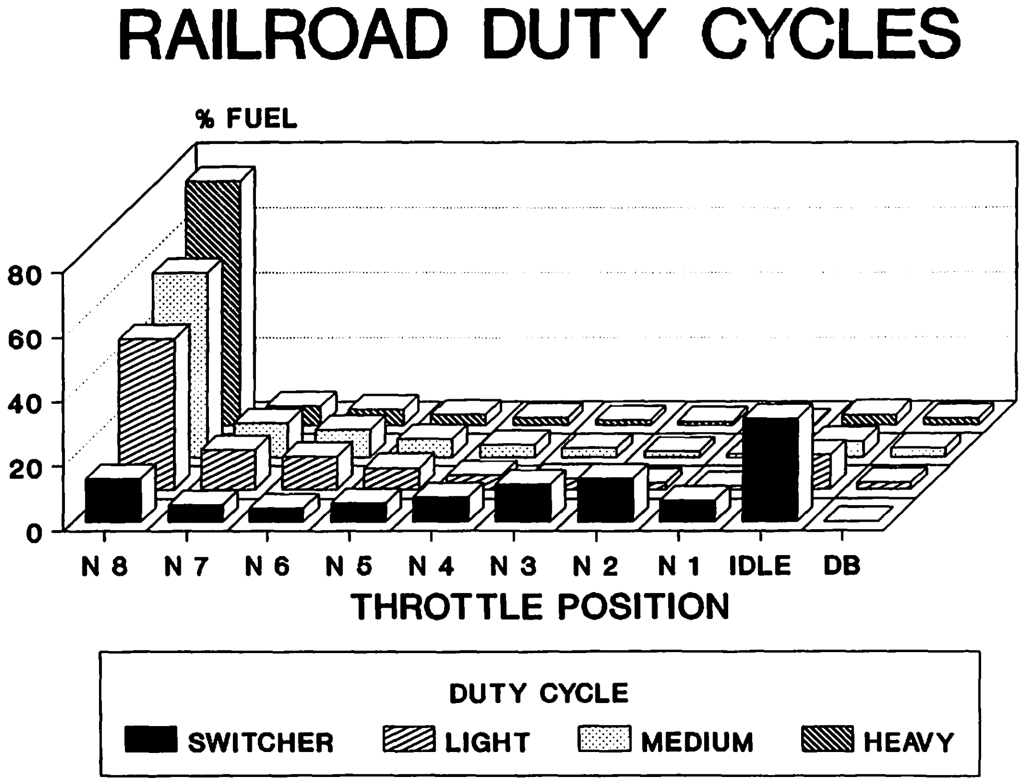

RAILROAD DUTY CYCLES
% FUEL
80
60
40
20
0
N 8
N 7
N 6
N 5
N 4
N 3
N 2
N 1
IDLE
DB
THROTTLE POSITION
DUTY CYCLE
SWITCHER
LIGHT
MEDIUM
HEAVY

Figure 30

GEORGE H. KITCHEN

Mr. Kitchen is a native of Atlantic City, New Jersey. He attended Drexel University, majoring in Chemical Engineering, only to have his studies interrupted during his sophomore year by World War II. After three years of active duty, during which he earned four Bronze Stars, he returned to Drexel as a cooperative student in an accelerated program for veterans. When the university administration decelerated the program, Mr. Kitchen left Drexel, which he considered probably the best engineering school in the world, and accepted a position in the Analytical Research Laboratory at Atlantic Refining Company, where he had been a cooperative student before the War. After a short time, he was promoted to the Process Standards Group. In the meantime, Mr. Kitchen completed the requirements for a degree in Petroleum Refining Engineering at Penn State University. Later, he continued his education in the Masters Program overseen by Lehigh & Rutgers Universities.

While working in the Process Standards Group, Mr. Kitchen compiled a pamphlet entitled "The Standardization of Steam Pumping in a Petroleum Refinery." This pamphlet came to the attention of George Harbach, the President of Engineering for Worthington Pump Company. Mr. Harbach mentioned Mr. Kitchen to Herb Arlt of Bell Telephone Laboratories, since Mr. Arlt was setting up a department to standardize materials and was looking for talent. George Kitchen joined Bell Labs in 1955.

After a short stay in the Standards Group, he was promoted to the Supervisor of the Lubes & Fuels Study Group. His first project was the development of Thixotropic lubricants for the switches in a dial telephone exchange. One of his most notable accomplishments at Bell Labs involved the use of molybdenum disulfide as a sapping compound. It was first used on the mating surfaces on the teeth of the Telstar antenna. Today, the same antenna with the same gears is still being used.

George Kitchen retired from Bell Labs in 1982. Afterwards, he and his wife Nancy, who is also retired from Bell Labs, formed a consulting firm called International Lubrication & Fuel Consultants, Inc., which is based in Rio Rancho, New Mexico. This company has three patented families of materials and has developed TEP^{tm} (Tank Environment of Profiling), which is a program for detecting leaking underground storage tanks.

It is my great pleasure to present to you, Mr. George H. Kitchen.

III. UNDERGROUND STORAGE TANK REGULATIONS

This section of the report was prepared by George Kitchen of International Lube and Fuel Consultants, who was a guest speaker and presented this material at the annual meeting.

Why do we have these regulations?

Millions of underground storage tank (UST) systems in North America contain petroleum or hazardous chemicals. A significant percentage of these systems are leaking. Many more will leak in the future. Some of these leaks have caused fires and explosions, but more importantly these leaks continue to contaminate local ground water. Because most of us in this hemisphere depend on groundwater for our water supplies, regulations have to be enacted to protect our water resources.

What are the goals of these regulations?

The regulations have been promulgated to insure that the following goals are attained:

1. To prevent future leaks and spills.
2. To locate current leaks and spills.
3. To remedy the damage caused by current leaks and spills.
4. To guarantee that owners and/or operators can pay for this remediation.
5. To force local agencies to be as strict as the national agencies.

Why do these problems exist?

Most of the UST systems currently installed are bare steel. Bare steel in an unfavorable environment, if it is not protected, will become corroded and will leak. Tanks and piping also leak if they are improperly installed. Non-homogenous backfill and inadequately attached pipe fittings are typical of non-approved tank installations. Spills and overfills result from nonchalant delivery practices and unfortunately these are not uncommon.

What do new petroleum USTs need?

You must meet four requirements when you install a new UST system:

1. You, the owner, must certify that the system is installed in accordance with all industry and local codes.
2. You must equip the UST with devices that prevent spills and overfills. In addition you must install proper tank filling processes.
3. You must protect the tank and piping from corrosion.
4. You must equip the tank and piping with leak detection.

There are a number of ways to provide leak detection, which must be performed monthly.

a. Automatic tank gauging;
b. Monitoring for vapors in the soil;
c. Interstitial monitoring;
d. Monitoring for liquids on the ground water.
e. You have one additional leak detection choice, but only for 10 years after you install your UST. You can use monthly inventory control combined with tightness testing every five years. After the tenth year you must use one of the monthly monitoring methods listed above.

What do existing USTs need?

Any tank installed before December 1988 must be retrofitted to

meet spill and overfill protection requirements and must be equipped with corrosion protection and leak detection. In the U.S., what you must do and when are as follows:

LEAK DETECTION

New tanks

a. Monthly monitoring*
b. Monthly inventory control and tank tightness every 5 years (You can only use this choice for 10 years after installation.)

Existing tanks

a. Monthly monitoring*
b. Monthly inventory control and annual tank tightness testing (This choice can only be used until December 1998.)
c. Monthly inventory control and tank tightness testing every five years (This choice can only be used for 10 years after adding corrosion protection and spill/overfill prevention or until December 1998, whichever date is later)

New & existing pressurized piping

a. Automatic flow restrictor
b. Automatic shutoff device
- and -
c. Continuous alarm system
d. Annual line testing
e. Monthly monitoring* (except automatic tank gauging)
Choice of a or b and c or d or e.

New & existing suction piping

a. Monthly monitoring* (except automatic tank gauging)
b. Line testing every three years

Corrosion Protection

New tanks

a. Coated and cathodically protected steel
b. Fiberglass
c. Steel tanks clad with fiberglass

Existing Tanks

a. Same options as for new tanks
b. Add cathodic protection system
c. Interior lining
d. Interior lining and cathodic protection

New Piping

a. Coated and cathodically protected steel
b. Fiberglass

Existing Piping

a. Same options as for new piping
b. Cathodically protected steel

SPILL/OVERFLOW PREVENTION

All tanks

a. Catchment basins
- and -
b. Automatic shutoff devices -or-
c. Overfill alarms -or-
d. Ball float valves

*Monthly Monitoring includes: automatic tank gauging, vapor monitoring, interstitial monitoring, groundwater monitoring, other approved methods.

WHEN DO YOU HAVE TO ACT? Important Deadlines

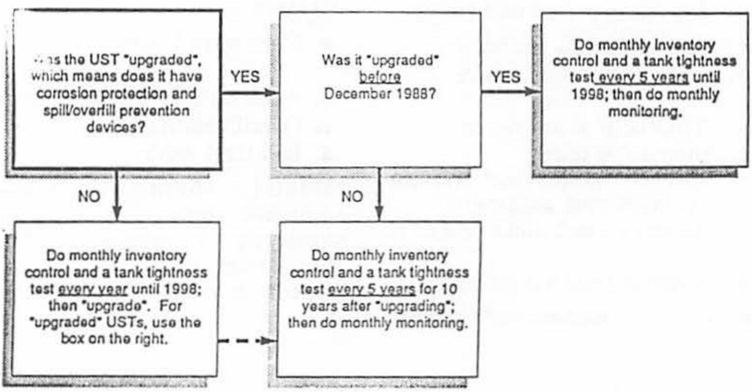
TYPE OF TANK & PIPING	LEAK DETECTION	CORROSION PROTECTION	SPILL / OVERFILL PREVENTION
New Tanks and Piping*	At installation	At installation	At installation
Existing Tanks** Installed:	By No Later Than:		
Before 1965 or unknown	December 1989	December 1998	December 1998
1965 - 1969	December 1990	December 1998	December 1998
1970 - 1974	December 1991	December 1998	December 1998
1975 - 1979	December 1992	December 1998	December 1998
1980 - December 1988	December 1993	December 1998	December 1998
Existing Piping**			
Pressurized	December 1990	December 1998	Does not apply
Suction	Same as existing tanks	December 1998	Does not apply

* New tanks and piping are those installed after December 1988

** Existing tanks and piping are those installed before December 1988

IF YOU CHOOSE TANK TIGHTNESS TESTING AT EXISTING USTs . . .

If you don't use monthly monitoring at existing USTs, you must use a combination of periodic tank tightness tests and monthly inventory control. This combined method can only be used for a few years, as the chart below displays.



WHAT IS THE REAL CORROSION STORY?

The corrosion of underground fuel tanks is affected by many variables such as: conductivity, chemical composition, compaction and pH of the soil; yearly precipitation; deterioration of the coatings by physical, lightning and biological activity; stray currents; galvanic coupling with other buried metallic structures.

Corrosion from these sources may lead to leakage of the fluids contained in the underground fuel storage tank and/or its associated piping.

THEORY

1. Electrolyte

Corrosion of metals is an electrochemical process that can occur whenever the metal is in contact with an electrolyte. A corrosion cell develops when an anode (corroding electrode) and a cathode (noncorroding or negligibly corroding electrode) are in direct or indirect contact through an electron-conducting medium and both are in contact with an electrolyte. For exterior corrosion of buried fuel tanks, the electrolyte is moist soil. Generally, the corrosive effect of soil increases with: (1) increasing soluble salt content (e.g. chlorides, sulfates), (2) increasing wetness, (3) increasing oxygen content, and (4) decreasing pH.

2. Stray currents

When buried or underground plant components are subjected to stray current, the current will follow a low resistance metal path, and generally use the earth as a path to return to its source. Accelerated corrosion takes place where the current leaves the structure. An underground fuel tank and/or its associated piping can be such a metallic structure from which stray current leaves. Since the rate of corrosion is directly proportional to the current leaving the metal per unit surface area, and the level of stray current can be orders of magnitude higher than the corrosion current from any source, it is potenitally the most dangerous contributor to corrosion of buried fuel tanks.

3. Galvanic corrosion

Two or more different metals or different components of an alloy in contact with an electrolyte are at different potentials. The Galvanic Series lists metals and conductive nonmetals in order of their potentials respective to each other. The farther apart two metals are in the Galvanic Series, the larger their potential difference. This potenial difference generates galvanic corrosion currents through the electrolyte and causes the more active metal to corrode. Underground steel fuel tanks can corrode if direct or indirect contact exists between them and copper pipes, copper ground electrodes, lead cable sheath, reinforcing steel in concrete, or cinder. Direct contact with cinder is particularly corrosive because it leaches acid into the electrolyte. Galvanic corrosion may also occur between bright new metal pipes and older, tarnished pipes of the same metal.

4. Concentration cell corrosion

A metal in contact with an electrolyte that at various areas contains different concentration of ions and/or dissolved oxygen can corrode by this mechanism. The corroding anode is the area in contact with the lower concentration of ion and/or oxygen. For underground steel fuel tanks locally mixing backfill with native soil can lead to the formation of such cells. The weight of the tank can compact the soil in contact with its bottom more than the soil at its side or on the top, and suffer concentration cell corrosion at the bottom. Similar corrosion (crevice corrosion) can take place under lap joints, gaskets, and bolt heads, due to the low relative oxygen concentration in the crevice.

5. Bacterial corrosion

Bacteria can cause changes in the soil/metals interface that result in a corrosive condition. Often bacteria consume oxygen at one location leading to concentration cell corrosion. Their metabolic products are often highly acidic, and increase the corrosiveness of the soil. They can also destroy the protective polarization film at the cathode. Bacteria often thrive in the absence of oxygen (anaerobic bacteria, sulfate-reducing bacteria), so dense mucky soils and soils of high organic content (in swamps, near septic tanks) make good breeding grounds. Black discoloration in the soil, and hydrogen sulfide (rotten egg) smell partially indicate their presence. To be certain have soil sample analyzed in a biological laboratory.

6. Inside fuel tank corrosion

Water often enters the fuel tank with the fuel, and further accumulates by the entry of humid air through vent pipes. The accumulated water layer at the bottom of the tank contains oxygen and pollutants from the air that may corrode the tank bottom. Local formation of corrosion products (rust) can establish oxygen concentration cells which accelerate the corrosion at the tank bottom. Bacteria may contaminate the fuel and can lead to bacterial corrosion.

WHAT CAN YOU DO TO DETERMINE THE CORROSIVE STATE OF YOUR TANK?

SITE EVALUATION

Field engineers work from the site plan, if one is available, to perform a Tank Environmental Profile (TEP). If unavailable, the engineers will locate and map all buried piping, conduit and other structures which may affect the tank or the testing.

1. Measurements

Holes are drilled at the appropriate locations around the tank in order to (a) make half-cell measurements of the soil to tank potential (in order to make a determination of the corrosive state of the tank); (b) make soil to tank resistance measurements (to determine effectiveness of tank coating, if any); (c) measure earth resistivity of the soil (in order to determine the insulating qualities of the soil); (d) collect soil samples for laboratory analyses (in order to analyze soil for moisture content, pH, sulfate reducing bacteria, and hydrocarbons).

2. Soil analysis

Soil vapor analysis - The presence of fuel (hydrocarbons) absorbed on the soil is normally evaluated by gas chromatography (GC) which often gives nonspecific results. ILFC's hydrocarbon analysis is performed by headspace gas chromatography/mass spectrometry (HS/GC/MS). This computer-interfaced analytical instrument together with methods developed by our firm is used to characterize soil vapors both qualitatively and/or quantitatively between various hydrocarbons found in fuels such as diesel, gasoline, dry cleaning, solvents, or possibly between your gasoline and your neighbors. The quantitative analysis permits us to determine the amounts of soil vapor in parts per trillion.

Property can be certified by performing soil vapor analysis to verify either that the soil is contaminated or not contaminated. If fuel contamination is present the analysis will indicate the type of hydrocarbons found and usually how long they have been present.

Soil resistivity: Soil resistivity, which varies with moisture, reveals soil insulating capacity. A computer data analysis of soil resistivity and moisture content reveals how the soil's makeup will affect metal structures underground.

It has been established as a general criterion, that above a resistivity of 12,000 ohm/cm (at normal operating moisture content) cathodic protection is not necessary. Furthermore, if sulfate reducing bacteria are present and/or pH of the soil is less than 4 the cathodic protection should be -0.95V; otherwise cathodic protection should be -0.85V.

Soil moisture content: This test is performed in a controlled environment to obtain the changes in soil resistivity at various moisture contents.

Soil pH: This is a measurement of the acidity and alkalinity of a system. pH in soil is governed by factors such as chemical composition, bacteria and moisture content. Acidic soils (pH less than 7) accelerate corrosion of ferrous materials, such as metal underground storage tanks and piping. While alkaline soils (pH greater than 7) cause corrosion of amphoteric materials such as aluminum and lead found in electrical installations. Furthermore, the pH of the soil is a factor that selectively regulates the growth of bacteria.

Sulfate reducing bacteria: The type of bacteria present in the environment of a tank is largely determined by the chemical composition of the soil. Sulfate reducing bacteria reduce the pH and increase sulfur content in the soil, also work against tank protection by breaking down the hydrogen polarization film that is generated by corrosion protection systems.

Aerobic microbe count: This is an indirect evaluation of the oxygen content in the environment of a tank. Aerobic bacteria cause local oxygen starvation on the surface of an underground tank, which causes corrosion.

3. Interpretation of results

Poor soil homogeneity and/or soil containing bacteria and/or low pH are indications of possible accelerated direct current (DC) attack. If these soil conditions are combined with low soil resistivity, accelerated corrosion will definitely result.

If all tests are negative, the chances of the tank being badly corroded or leaking are remote. If the results are mixed, a precision pressure test is in order before spending money to protect or monitor the tank.

These tests provide the tank owner with the following information: (1) the tank is satisfactory as installed; (2) the tank is in need of some type of cathodic protection; (3) The tank should be replaced.

IS PERMANENT TANK CLOSURE THE BEST WAY TO COMPLY WITH THE REGULATIONS?

If you really do not need any or all of your underground tanks, probably the best move financially is to close them permanently.

HOW DO YOU CLOSE YOUR USTs?

You can close your UST permanently or temporarily.

Closing permanently

If your tank is not protected from corrosion and it remains closed for more than 12 months or you decide to close it permanently, you must follow requirements for permanent closure:

- You must notify the regulatory authority 30 days before you close your UST.
- You must determine if leaks from your tank have damaged the surrounding environment.
- You can either remove the UST from the ground or leave it in the ground. In both cases, the tank must be emptied and cleaned by removing all liquids, dangerous vapor levels, and accumulated sludge. These potentially very hazardous actions need to be carried out carefully by following standard safety practices. If you leave the UST in the ground, you must also fill it with a harmless, chemically inactive solid, like sand. The regulatory authority will help you decide how best to close your UST so that it meets all local requirements for closure.

Three exceptions to permanent closure

The requirements for permanent closure may not apply to your UST if it meets one of the following conditions:

- If your UST meets the requirements for a new or upgraded UST, then it can remain "temporarily" closed indefinitely as long as it meets the requirements below for a temporarily closed UST.
- The regulatory authority can grant an extension beyond the 12-month limit on temporary closure for USTs unprotected from corrosion.
- You can change the contents of your UST to an unregulated substance, such as water. Before you make this change, you must notify the regulatory authority, clean and empty the UST, and determine if any damage to the environment was caused while the UST held regulated substances.

WHAT ABOUT REPORTING AND RECORDKEEPING?

What do you need to report?

In general, you will only need to report to the regulatory authority at the beginning and end of your UST system's operating life:

- When you install an UST, you have to fill out a **notification form** available from your state. This form provides information about your UST, including a certification of correct installation. (You should have already used this form to identify your existing USTs. If you haven't done that yet, be sure you do so now.)
- You must report suspected releases to the regulatory authority.
- You must report confirmed releases to your regulatory authority. You must also report follow-up actions you plan or have taken to correct the damage caused by your UST.
- You must notify the regulatory authority 30 days before you permanently close your UST.

You need to check with your regulatory authority about the particular reporting requirements in your area including any additional or more stringent requirement than those noted above.

What records must you keep?

You will have to keep records that can be provided to an inspector during an on-site visit that prove your facility meets certain requirements. These records must be kept long enough to show your facility's recent compliance status in four major areas:

- You will have to keep records of **leak detection** performance and upkeep.
  --The last year's monitoring results, and the most recent tightness test.
  --Copies of performance claims provided by leak detection manufacturers.
  --Records of recent maintenance, repair, and calibration of leak detection equipment installed on site.
- You will have to keep records showing that the last two inspections of your corrosion protection system were carried out by properly trained professionals.
- You must keep records showing that a **repaired or upgraded UST system** was properly repaired or upgraded.
- For at least 3 years after closing an UST, you must keep records of the site assessment results required for permanent closure. (These results show what impact your UST has had on the surrounding area.)

You should check with your regulatory authority about the particular recordkeeping requirements in your area. Generally, you should follow this useful rule of thumb for recordkeeping: When in doubt, keep it.

WHO IS AFFECTED BY THESE REGULATIONS?

Do you have to show financial responsibility?

Either the owner or the operator of the tank must show financial responsibility, but not both if the owner and operator are different individuals or firms. It is the responsibility of the owner and operator to decide which of them will show financial responsibility.

Federal and state government and their agencies that own USTs are not required to document financial responsibility. Local government, however, must comply with the new rule.

If you owned or operated a tank that was properly closed before the date for compliance that applies to you, then the financial responsibility requirements will not apply to your closed tank.

What do you have to do?

The new financial responsibility regulations require you to show that you have one of the following:

> at least $1 million to cover the costs of a leak or spill from your underground storage tank if you are a **PETROLEUM MARKETER** (Page 43334 of the Federal Register of October 26, 1988); or at least $500,000 if you are **NOT A MARKETER** (Page 43330 of the Federal Register of October 26, 1988).

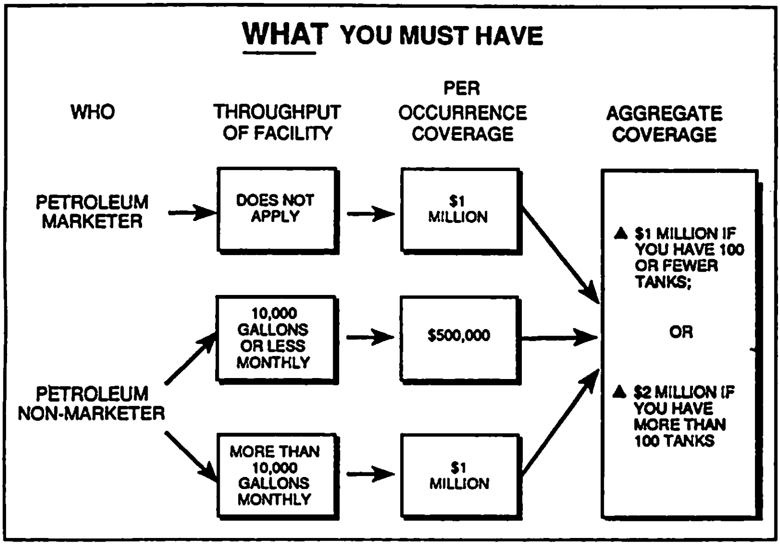
You may show that you have this coverage by using insurance or any of the other methods of coverage explained on following pages. The amount of financial responsibility that you must show does not limit your total liability for damages caused by a leak from your tank system.

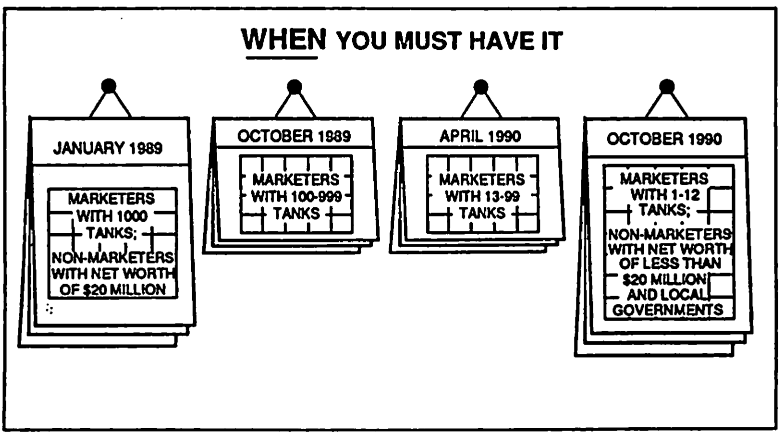
When must you comply with the financial responsibility requirements?

The rule takes effect 90 days after its publication in the Federal Register (i.e., January 24, 1989). The date when you will have to show financial responsibility, however, depends on the compliance category that you fall into, as shown below:

- If you fall into one of the following groups, you must show financial responsibility on the same day that the rule becomes effective on January 24, 1989: 1) petroleum marketing firms that own 1,000 or more USTs; and 2) any other UST owners that report a tangible net worth of $20 million or more to the SEC, Dun and Bradstreet, the Energy Information Administration, or the Rural Electrification Administration.
- If you are a petroleum marketing firm that owns 100 to 999 USTs, you must show financial repsonsibility by April 26, 1989.
- If you fall into one of the following groups, you must show financial responsibility by October 26, 1990: 1) petroleum marketing firms owning 1 to 12 USTs or those having fewer than 100 USTs at one site; 2) all other UST owners with a tangible net worth of less than $20 million; and 3) local governments.

IMPORTANT REQUIREMENTS AND MINIMUM DEADLINES FOR YOUR FINANCIAL RESPONSIBILITY





HOW DO YOU COMPLY WITH THE FINANCIAL RESPONSIBILITY REQUIREMENTS?

How can you show financial responsibility for your USTs?

You can determine financial responsibility for your USTs in several ways:

- Show that your firm can meet the costs of potential releases. If you firm has a tangible net worth of at least $10 million, you can prove your financial responsibility by passing one of two financial tests.
- Show that someone else is responsible for cleanup and damage costs. You may arrange to have someone else be responsible for paying the costs of leaks from your USTs. This may be done in a number of ways (all are described in detail in the rule):
  1. Obtain insurance coverage from an insurer or a risk retention group; or
  2. Obtain a guarantee for the amount you are responsible for from a corporate parent, grandparent, sibling, or from another firm with whom you have a substantial business relationship.

     \- or -
  3. Obtain a surety bond for the amount you are responsible for; or
  4. Obtain a letter of credit for the amount you are responsible for.
- Use state funds. If your state has established a state fund that will pay for the cleanup costs of a leak from your tank systems, then you may not need additional coverage to show you can pay for the same costs. You need to check to see if the state fund covers your tanks. You may also still need to show financial responsibility for the costs of compensating those injured by leaks, unless the state fund would also pay for those costs.
- Use state approved methods. You may also use any method of coverage approved by your state.
- Set up a trust fund. You may set up a fully-funded trust fund to cover your financial responsibility requirement.

Can you use a combination of methods to show financial responsibility?

You may also use a combination of methods to show financial responsibility. The methods you choose must cover all the costs that you are responsible for (both third-party liability and corrective action) and add up to the amount of coverage you are required to show. If the methods you choose cover different costs (for example, the insurance policy covers damages to the other people and property and the guarantee covers cleanup costs), then each method must provide the total amount of responsibility that you must demonstrate.

What about state funds?

Some states establish programs to pay for cleanup costs from petroleum leaks. These state funds often may be used by owners and operators of USTs to demonstrate financial responsibility. In most states, however, funds will pay only part of the cleanup costs. In addition, few states will pay for third-party damages caused by petroleum leaks.

You should contact your state environmental agency to determine if the state has a fund that you may use to show financial responsibility. Find out what the state will pay for and what amount of financial responsibility you must obtain. In several states, for example, you must demonstrate financial responsibility for the remaining costs. Most state funds will not pay more than $1 million per occurrence.

If you don't know how to reach your state coordinator, call EPS's hotline for the phone number of your state coordinator (1-800-424-9346)

What happens if your coverage is cancelled?

If your method of financial responsibility is cancelled, you must find another mechanism to replace it within 60 days after you receive the notice of cancellation. If you cannot get another mechanism in that time, then you must notify the implementing agency or the state.

Your coverage or insurance contract must specify that the provider of coverage or insurance may only cancel your coverage by sending you a notice by certified mail. For guarantees, surety bonds, or letters of credit, cancellation can only occur 120 days after you receive the notice. Insurance policy coverage can be cancelled 60 days after you receive the notice.

Can you get private insurance coverage for your USTs?

Private insurance coverage for USTs is still limited, but there are several major insurers who offer policies. Insurers are often selective in the tanks they will cover. If you want to purchase insurance, you may be required to meet certain conditions for coverage. For example, your insurer may ask you to test your tank for tightness, or he may require certain improvements in your tank system, such as liners, cathodic corrosion protection, and leak detection. Some insurers simply will not provide coverage for certain types of tanks, like tanks that are more than 20 years old.

You may also be able to get insurance coverage through a risk retention group. A risk retention group is an insurance company formed by businesses or individuals with similar risks to provide insurance coverage for those risks. To join a risk retention group, you will probably be asked to make a one time payment--called a capital contribution-- and thereafter pay annual premiums as with any other insurance policy.

If you are interested in purchasing insurance through either a private insurer or a risk retention group to show financial responsibility for your USTs, you should contact your insurance agent. You may want to take with you the sample endorsement or certificate of insurance. These documents are examples of policies that meet EPA financial responsibility requirements. If you belong to a trade association, it may also be able to provide you with information about insurers and risk retention groups that cover USTs.

FINANCIAL TEST OPTIONS

Test I

a. Your firm must have a tangible net worth of at least $10 million; and
b. Your firm must have tangible net worth of at least 10 times the amount of aggregate coverage that you are required to demonstrate plus any other liability to demonstrate financial responsibility to EPA; and
c. Your firm must file the firm's annual financial statements with the Securities and Exchange

Commission (SEC), or annually report the firm's tangible net worth to Dun and Bradstreet and receive a rating of 4A or 5A. Utilities may file financial statements with the Energy Information Administration, or the Rural Electrification Administration instead of The SEC; and

d. Your firm must have audited financial statements that do not include an adverse auditor's opinion or disclaimer of opinion.

Test II

a. Your firm must have a tangible net worth of at least $10 million; and
b. Your firm must have a tangible net worth of at least six times the amount of aggregate coverage that you are required to demonstrate; and
c. Have U.S. assets that are at least 90 percent of total assets or at least six times the required aggregate amount; and
d. Have net working capital at least six times the required aggregate amount; and
e. Have a bond rating AAA, AA,A, or BBB from Standard and Poor's or Aaa, Aa, A, or Baa from Moody's; and
f. Your firm must have audited financial statements that do not include an adverse auditor's opinion or disclaimer of opinion.

SAMPLES OF FINANCIAL RESPONSIBILITY FORMS

CERTIFICATION OF FINANCIAL RESPONSIBILITY

[Owner or operator] hereby certifies that it is in compliance with the requirements of Subpart H of 40 CFR Part 280.

The financial assurance mechanism[s] used to demonstrate financial responsibility under Subpart H of 40 CFR Part 280 is [are] as follows:

[For each mechanism, list the type of mechanism, name of issuer, mechanism number (if applicable), amount of coverage, effective period of coverage and whether the mechanism covers "taking corrective action" and/or" "compensating third parties for bodily injury and property damage caused by" either "sudden accidental releases" or "non-sudden accidental releases" or "accidental releases."]

[Signature of owner or operator]

[Name of owner or operator]

[Title]

[Date]

[Signature of witness or notary]

[Name of witness or notary]

[Date]

The owner or operator must update this certification whenever the financial insurance mechanism(s) used to demonstrate financial responsibility change(s).

ENDORSEMENT

Name: [name of each covered location]

Address: [address of each covered location]

Policy Number:

Period of Coverage: [current policy period]

Name of [Insurer or Risk Retention Group]:

Address of [Insurer or Risk Retention Group]:

Name of Insured:

Address of Insured:

Endorsement:

1. This endorsement certifies that the policy to which the endorsement is attached provides liability insurance covering the following underground storage tanks:

[List the number of tanks at each facility and the name(s) and address(es) of the facility(ies) where the tanks are located. If more than one instrument is used to assure different tanks at any one facility, for each tank covered by this instrument, list the tank identification number provided in the notification submitted pursuant to 40 CFR 280.22, or the corresponding state requirement, and the name and address of the facility.]

for [insert: "taking corrective action" and/or "compensating third parties for bodily injury and property damage caused by" either "sudden accidental releases" or "nonsudden accidental releases" or "accidental releases"; if coverage is different for different tanks or locations, indicate the type of coverage applicable to each tank or location] arising from operating the underground storage tank(s) identified above.

The limits of liability are [insert the dollar amount of the "each occurrence" and "annual aggregate" limits of the Insurer's of Group's liability; if the amount of coverage is different for different types of coverage or for different underground storage tanks or locations, indicate the amount of coverage for each type of coverage and/or for each underground storage tank or location], exclusive of legal defense costs. This coverage is provided under [policy number]. The effective date of said policy is [date].

2. The insurance afforded with respect to such occurrences is subject to all of the terms and conditions of the policy; provided, however, that any provisions inconsistent with subsections (a) through (e) of this Paragraph 2 are hereby amended to conform with subsections (a) through (e):

a. Bankruptcy or insolvency of the insured shall not relieve the ["Insurer" or "Group"] of its obligations under the policy to which this endorsement is attached.

b. The ["Insurer" or "Group"] is liable for the payment of amounts within any deductible applicable to the policy to the provider of corrective action or a damaged third-party, with a right of reimbursement by the insured for any such payment made by the ["Insurer" or "Group"]. This provision does not apply with respect to that amount of any deductible for which coverage is demonstrated under another mechanism or combination of mechanisms as specified in 40 CFR 280.95-280.102.

c. Whenever requested by [a Director of an implementing agency], the ["Insurer" or "Group"] agrees to furnish to [the Director] a signed duplicate original of the policy and all endorsements.

d. Cancellation or any other termination of the insurance by the ["Insurer" or "Group"] will be effective only upon written notice and only after the expiration of 60 days after a copy of such written notice is received.

[Insert for claims-made policies:

e. The insurance covers claims for any occurrence that commenced during the term of the policy that is discovered and reported to the ["Insurer" or "Group"] within six months of the effective date of the cancellation or termination of the policy].

I hereby certify that the wording of this instrument is identical to the wording in 40 CFR 280.97(b)(1) and that the ["Insurer" of "Group"] is ["licensed to transact the business of insurance or eligible to provide insurance as an excess or surplus lines insurer in one or more states".]

[Signature of authorized representative of Insurer or Risk Retention Group]

[Name of person signing]

[Title of person signing], Authorized

CERTIFICATE OF INSURANCE

Name: [name of each covered location]

Address: [address of each covered location]

Policy Number: ______

Endorsement (if applicable): ______

Period of Coverage: [current policy period]

Name of [Insurer or Risk Retention Group]: ______

Address of [Insurer or Risk Retention Group]: ______

Name of Insured: ______

Address of Insured: ______

Certification:

1. [Name of Insurer or Risk Retention Group], [the "Insurer" or "Group"], as identified above, hereby certifies that it has issued liability insurance covering the following underground storage tanks(s):

[List the number of tanks at each facility and the name(s) and address(es) of the facility(ies) where the tanks are located. If more than one instrument is used to assure different tanks at any one facility, for each tank covered by this instrument, list the tank identification number provided in the notification submitted pursuant to 40 CFR 280.22, or the corresponding state requirement, and the name and address of the facility.]

for [insert: "taking corrective action" and/or "compensating third parties for bodily injury and property damage caused by" either "sudden accidental releases" or "nonsudden accidental releases" or "accidental releases"; if coverage is different for different tanks or locations, indicate the type of coverage applicable to each tank or location] arising from operating the underground storage tank(s) identified above.

The limits of liability are [insert the dollar amount of the "each occurrence" and "annual aggregate" limits of the Insurer's of Group's liability; if the amount of coverage is different for different types of coverage or for different underground storage tanks or locations, indicate the amount of coverage for each type of coverage and/or for each underground storage tank or location], exclusive of legal defense costs. This coverage is provided under [policy number]. The effective date of said policy is [date].

2. The ["Insurer" or "Group"] further certifies the following with respect to the insurance described in Paragraph 1:

a. Bankruptcy or insolvency of the insured shall not relieve the ["Insurer" or "Group"] of its obligations under the policy to which this certificate applies.

b. The ["Insurer" or "Group"] is liable for the payment of amounts within any deductible applicable to the policy to the provider of corrective action or a damaged third-party, with a right of reimbursement by the insured for any such payment made by the ["Insurer" or "Group"]. This provision does not apply with respect to that amount of any deductible for which coverage is demonstrated under another mechanism or combination of mechanisms as specified in 40 CFR 280.95-280.102.

c. Whenever requested by [a Director of an implementing agency], the ["Insurer" or "Group"] agrees to furnish to [the Director] a signed duplicate original of the policy and all endorsements.

d. Cancellation or any other termination of the insurance by the ["Insurer" or "Group"] will be effective only upon written notice and only after the expiration of 60 days after a copy of such written notice is received by the insured.

[Insert for claims-made policies:

e. The insurance covers claims for any occurrence that commenced during the term of the policy that is discovered and reported to the ["Insurer" or "Group"] within six months of the effective date of the cancellation or other termination of the policy].

I hereby certify that the wording of this instrument is identical to the wording in 40 CFR 280.97(b)(2) and that the ["Insurer" or "Group"] is ["licensed to transact the business of insurance or eligible to provide insurance as an excess or surplus lines insurer in one or more states".]

[Signature of authorized representative of Insurer]

[Type name]

[Title], Authorized Representative of [name of Insurer or Risk Retention Group]

[Address, of Representative]

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

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

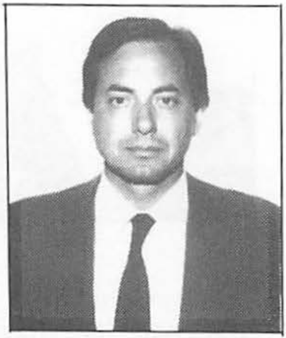
Our thanks again to Mr. J. R. Nussrallah and others responsible for and participating in this activity.

Tuesday September 19, 1989

1:45 P.M.

REPORT OF THE COMMITTEE ON DIESEL ELECTRICAL MAINTENANCE

Pre-Convention Presentation: Conrail



May 10, 1989 Sheraton-Altoona Altoona, PA

MAURO PASINI, Chairman
Mgr.-Elect & Electronic Systems
Via Rail Canada
Montreal, PQ

VICE CHAIRMAN

M. W. Polsgrove, Electrical Engineer, C&NW, Chicago, IL

COMMITTEE MEMBERS

R. E. Blanchard	Manager Loco. Tech. Services	Conrail	Conway, PA
D. C. Gezon	Asst. CMO-Motive Power	GTW	Battle Creek, MI
T. J. Johnson	Supv. Locomotive Maintenance	DM&IR	Proctor, MN
T. C. Leary	Mgr.-Loco. Maintenance-Electrical	UP	Omaha, NE
J. W. Nixon	Asst. Manager-Locomotives	ATSF	Topeka, KS
A. J. Payne	Locomotive Electrical Engineer	CSX	Jacksonville, FL
J. W. Popp	Manager-Quality Control	AMT	Wilmington, DE
J. R. Spiegel	Technical Engineer	EMD	LaGrange, IL
J. Vasquez	Supv. Loco. & Car Maintenance	AAR-TTC	Pueblo, CO
R. E. Wickstrom	Senior Service Engineer	GE	Erie, PA
C. S. Wilkerson	Diesel Supt.-Mech. Dept.	NS	Roanoke, VA

PERSONAL HISTORY

Mauro Pasini

Mr. Pasini was born in Perugia, Italy on January 13, 1944.

He attended public school in Genoa, Italy and obtained a technical diploma in the electrical field in 1963.

His involvement with railroad equipment started in 1963 in the test room of a major Italian locomotive builder.

In 1967 he emigrated to Canada where he worked as a maintenance technician for the Montreal subway.

In 1972 he moved to the engineering department as a technical assistant, subsequently promoted as technologist while continuing his university studies at Cocordia University of Montreal where he graduated in 1978.

In 1984 he moved to Via Rail as an electrical engineer in the Operation department and he was promoted to Equipment Manager in 1986.

Mauro is married and has one son. He enjoys mostly outdoor sports such as bicycling, skiing and tennis.

I. MODERN TOOLING FOR ELECTRICAL TROUBLESHOOTING

In this section of our paper we will present a catalog of meters and testing devices used to troubleshoot diesel electric locomotives. We have contacted over 100 manufacturers and suppliers for their support in compiling this listing. It is our intent to provide the electrician with a ready reference of the tools available to assist him in the troubleshooting of locomotive problems. Unfortunately this list is by no means a complete listing of all that is available. The response from the vendors was poor, with only about 35 percent answering our query. It is our hope that this section of the paper will prove useful and that we can continue to update this section as a part of future papers. If we do this, we will need the support of the manufacturers. If you find this information helpful, you can help by alerting the manufacturers or their representatives of the LMOA Electrical Committee's intent.

INDEX: A. **Frequency Testers/Tachometers**
1. Frequency To Voltage Converter
2. Frequency Calibrator
3. Portable Tachometer

B. **Electro-Motive Division (EMD)**
1. Radar Calibration Tester
2. Card Extenders
3. SD-50 Dynamic Brake Tester
4. 60 Series Computer Download

C. **General Electric**
1. 17TM14 Test Kit
2. CHECKIT
3. Engine Speed Measuring Kit
4. DASH*STAR

D. **Hypot/Leakage Testers**
1. Automatic Equipment Co.
2. Megger Insulation Testers
3. Hypots

E. **Speed Recorders/Indicators**
1. Aeroquip VF-86 Verifier
2. Pulse RV-X and RSV-X
3. Ogontz Corporation Speedometer Reference

F. **Cab Signal/Speed Control**
1. Rimsco Cab Signal Tester
2. Rimsco Model 13054–00 Speed Control Tester

G. **End of Train/Telemetry**
1. Digitar Model 6631 Telemetry Transmission Monitor
2. Digitar Model 6625 Auxiliary Display Unit
3. Digitar Model 6630 Rear End Emulator
4. Pulse Portable Trainlink Receiver
5. Pulse Trainlink Tower Transmitter

H. **Miscellaneous**
1. AC/DC Tong Test
2. Houston Electronic Fuel Fill Tester
3. M.U. Jumper Cable Tester
4. Power Inverter
5. Quest HVD-100/1 Voltage Divider

A. FREQUENCY TESTER/ TACHOMETER

A1. Frequency To Voltage Converter

The TESCO #T70201FC FREQUENCY CONVERTER can be used to accurately measure engine speeds on both EMD and GE locomotives. This is accomplished by positioning a three position switch which is marked TACH, GE CRANK, and EMD CRANK. It also has battery check and calibration features. The tester is designed to be used with a digital meter (Beckman 3000 or equivalent).

To use the frequency to voltage converter on an EMD locomotive, you need only to find a source of D-14 or D-18 output. The converter will convert the output of the auxiliary alternator to engine crankshaft rpms when it is placed in the EMD crank position and the digital meter is placed on the 2 volt DC range. The crankshaft rpm readings will appear on the DC voltage scale in direct relation to millivolts. That is 900 mv DC = 900 rpm. For example, when checking the overspeed setting on an EMD locomotive, you may want to attach the converter to the AC cooling fan busses located in the AC cabinet. Only one person may be required to check the overspeed setting using this method, and the reading will be more accurate than any achieved with a handheld mechanical tach. The converter is best used to check no-load engine rpms. It has been found that the firing of the silicon controlled rectifiers, in the SCR panel, on some locomotives, causes erratic readings.

To use the frequency to voltage converter on General Electric locomotive to determine engine speeds, you need a pulse generator (TESCO part #T70200PG). The pulse generator complete with drive tank is screwed into the governor output speed boss. The output of the pulse generator is fed to the frequency to voltage converter which is now set to the GE crank position. The digital meter is set to the 2 volt DC range, the crankshaft rpms will have the same millivolt to rpm relation as with the EMD locomotive.

The price of the frequency converter is $162.00 and the price of the pulse generator is $128.00. Both prices FOB Erie, Pa.

For further information:

Transportation
Equipment Supply Co.
6850 Peach Street
Erie, Pa 16509
Phone: 814-866-1952

A2. Frequency Calibrator

The Panalarm Model 251FRQ Frequency Calibrator is a portable, hand-held, battery powered frequency standard for calibration of frequency monitoring instruments. The Model 251FRQ can be connected to most any instrument requiring a frequency input signal. The unit has a frequency range of 1Hz to 9999 Hz, selectable in 1 Hz increments by four 10-position bi-directional push-button indexing switches.

The square wave signal output is provided on two standard banana jacks. Mating test leads with convenient alligator clips are furnished with each calibrator. A crystal controlled timing reference provides high accuracy and stability. A flashing LED indicates the status of the power switch and the battery.

For further information:

Ametek, Panalarm Division
7401 N. Hamlin Ave.
Skokie, IL 60076
Phone: 312-675-2500

A3. Q-Tron Ltd. Q-82095 Portable Tachometer

The Q-Tron Ltd. Portable Tachometer is a lightweight, ruggedized self contained, solid state, test meter designed for servicing of General Motors Locomotives with type D14 and D18 Alternators.

The Tachometer is housed in a rugged plastic housing and comes complete with test leads, adaptors and instruction plate in a leather carrying case. The Tachometer has no internal batteries requiring regular replacement or recharging. The tachometer is designed to pick up both the input signal and power source with the same set of test leads to simplify operation.

The engine rpm is displayed on a 3½ digit liquid crystal display to within +/- 1 rpm. The test leads can be connected directly to the EMD locomotive test panel (Alt. volts AC) or with the alligator clips to the NVR coil, or AC buss bars in the AC electrical cabinet for over-speed checks.

A special adapter supplied with the tachometer allows the tachometer to be plugged into 120 volt 60 Hz. outlet to check calibration and operation of the tachometer.

The solid state design of the Q-Tron Ltd. Q-82095 Portable Tachometer makes it a reliable test meter requiring no scheduled overhaul or calibration.

Features/Specifications:

- Warranty: Two years parts and labor, shipping not included.
- Overhaul: No scheduled overhaul required.
- Calibration: No scheduled calibration required, however full range calibration should be checked every three years.
- Operational and Calibration Check: With supplied adapter, plug into a standard 110 volt 60 Hz. outlet for 450 rpm +/- 1 rpm.
- Accessories (Supplied):
  - Test leads
  - Test clips
  - AC adapter
  - Leather carrying case with shoulder strap
  - Instruction Card
  - Dimensions: Including carrying case
  - Height 17.1 cm. (6¾")
  - Width 18.4 cm. (7¼")
  - Depth 7.6 cm. (3")
- Weight: Including carrying case and accessories approx. 0.68 Kg. (1½ Lbs.)
- Display: 3½ digit 0.5" liquid crystal display.
- Operating Range: 224 to 1200 rpm
- Resolution: +/- 1 rpm
- Accuracy: +/- 0.15%.
- Display Update: Constant.
- Warm Up/Stabilizing Time: Approx. 30 seconds.
- Input: 50 to 230 Volts AC. 30 to 160 Hz.
- Input Current: Less than 100 ma.
- Storage Temperature: -35 deg. C to +70 deg. C.

For further information:
Q-Tron Ltd.
No. 9.7003 - 30th St. S.E.
Calgary, Alta., T2C 1N6
Phone: (403) 279-0805

B. ELECTROMOTIVE DIVISION (EMD)

B1. EMD Radar Calibration Tester

A radar speed simulator/calibrator has been developed by Edwin Bohr Electronics for use with radar transceivers 9523758 and 9532097. Radar is used on all EMD Super-Series locomotives and is also used on other locomotives as the input to a speed indicator/recorder system.

The calibrator system consists of

the tester itself which is operated from the locomotive cab, a transponder which attaches to the radar face under the locomotive, and a connecting cord which is detachable at both ends. Operation of the control switch will cause the radar to produce speed signals of 10, 20, 40, 60, and 80 mph. A variable position of the control switch allows setting of overspeed and other similar functions.

Features of the calibrator are:

— The unit is completely self contained.
— Operated from three ordinary flashlight D cells.
— Simple operation, only two knobs, no adjustments.
— Step-speed calibrations are all crystal controlled.
— continuous, variable-speed output allows smooth run up tests.
— Rugged formed-aluminum inner case.
— A leather-type carrying case is easily replaceable, has full-opening snap-back front covers, and contains a compartment for the antenna and lead.
— A battery check function is included with the front panel indicating light.
— The antenna of the tester produces no electromagnetic radiation to interfere with other electronic devices.

The tester and replacement parts can be ordered from Electro-Motive parts centers under the following part numbers:

— Radar Tester: 9543733
  (Includes cable, transponder and case)
— Transponder Only: 9543736
— Cable Only: 9543735
— Carrying Case: 9543734

For further information and prices:

Electro-Motive Division
General Motors Corp.
LaGrange, Illinois 60525

B2. Card Extenders

EMD has card extender/extension board assemblies available for both the Dash 2 and Super-Series locomotives. To use the extension board you first remove the module to be tested and plug the appropriate extension board into the module slot. The module removed is then plugged into the extension board. This allows the electrician to make checks on the circuit boards of the modules and at pin connections which may not be brought to the front of the modules.

The extension board assemblies can be ordered from Electro-Motive parts centers under the following part numbers:

— Extension Board Dash 2: 8482259 Fuse
— Extension Board Super-Series: 9539635 Fuse

For further information:

Electro-Motive Division
General Motors Corp.
LaGrange, Illinois 60525

B3. SD-50 Dynamic Brake Tester

The EMD locomotive SD-50 dynamic brake tester was developed by the Metro Railway Supply Co. and a major railroad. The tester qualifies the dynamic brake control system on SD-50 locomotives as well as other systems including: the load ammeter, the motor simulator (MS) module, and the open motor protection circuit.

The tester supplies a signal to the traction motor feedback module (FM) simulating traction motor armature/braking grid current. This signal is interpreted by the rest of the electrical system as actual armature/grid current such as would be seen by the locomotive moving in dynamic braking. You are able to observe the functions of the dynamic brake regulation (DR) module, the dynamic brake protection (DP) module, and the extended range (DE)

dynamic brake module by varying the inputs and observing the load ammeter and built-in digital voltmeter.

The load ammeter is tested for accuracy by comparing the input of the tester to the actual load ammeter reading. The load ammeter should read 150 amps per volt input from the tester. Motor simulator (MS) module functions may be checked in the same manner. Locomotives equipped with the MS102 module and the traction motor blower shutter will open the shutter at approximately 6.2 volts as read on the tester or 925 amps as observed on the load ammeter.

The tester is self contained and gets its power from the power supply (PS2) module on the locomotive. Connections for the various modules are clearly marked, indicating the module and faceplace connection terminal. Most connections are indexed so they may not be improperly connected.

For further information:

Metro Railway
Supply Company
100 Crown Point Road
Thorofare, New Jersey 08086
Phone: 609-848-5429

B4. 60 Series Computer Download

The EMD 60 Series microprocessor locomotives have built-in software which allows for information transfer between the on-board computer and a portable computer or printer. You have the three options: you may transmit the locomotive history; you may transmit the running totals, duty cycle, trip monitor, and KWHRs per month data; or you may dump the display to a portable computer or printer. The Radio Shack TRS80 Model 100 or Model 102 computer is used quite extensively by the EMD service personnel. Contact your EMD service representative for compatibility with other computer models.

In the history to printer function, fault information is printed or stored in the same format as used when it appears on the display. The information is printed in chronological order, last-in-first-out, just as it appears in the history to display function. To use this function, proceed as follows:

1. The printer or computer must be equipped with an RS232C connector receptacle. The CPU module in the locomotive display computer includes the same kind of receptacle on its faceplate. Using a ribbon cable having RS232C plugs at each end, connect the portable computer or printer to the locomotive display computer CPU module. The receptacle is marked RS232 PORT on the CPU module.
2. Turn on operating power for the printer or portable computer, and set it up with the following communication parameters:
   Baud Rate: 1200
   Word Length: 7 Bits
   Parity: Ignore
   Stop Bit: 2
   Line Status: Enable (XON)

For the Radio Shack TRS80 Model 100 portable computer, set up the communication parameters in the following manner:

A. Select TELCOM on the TRS80 main menu, then press enter.

B. If the first portion of the first line on the TRS80 display reads 5712E (may or may not be followed by .10PPS) the parameters are already correct: proceed to step 3. If the parameters are not correct, press the F3 key (STAT), type in 5712E, then press ENTER key. Confirm that the parameters have been corrected by pressing the F3, then ENTER.

3. Prepare the printer or portable computer for downloading, that is, for functioning as a data receiving terminal. On the TRS80, do so in the following manner:
   A. Press Key F4 (TERM)
   B. Press Key F2 (DOWN)
   C. Type in a file name for the fault history to be stored. File should not exceed 6 letters.
   D. Press ENTER.
4. Select "History to printer" on the fault data menu on the locomotive display. The archive dump process will proceed automatically. You will be able to observe the process on the display; the last recorded fault will be displayed first, then the fault data (if any) for that fault, then the second-last fault, etc.
5. To stop the process before the entire archived history has been printed or recorded, press the RUN CLEAR key on the locomotive display keyboard. The word ABORT will appear at that point on the external equipment, and the main menu will appear on the locomotive display.

   On the TRS80 you can skip recording a fault or group of faults by pressing key F2 (DOWN) and not pressing RUN CLEAR on the locomotive display: The locomotive computer will continue downloading faults, but the TRS80 won't record them until you press key F2 on the TRS80 again. Type in a new file name and press the ENTER key. (You must open a new file to prevent deleting your original file.)
6. If the dump process is allowed to end normally, the phrase "there are no more faults" will be printed or recorded after the last fault message, and the main menu will appear on locomotive display.
7. Electronically disconnect the printer or portable computer. Do so on the TRS80 by:
   A. pressing key F8
   B. pressing key Y
   C. pressing key F8 again.
8. Unplug cable from locomotive display CPU module RS232 receptacle.

The copy to printer function, when selected from the run data menu, allows you to transmit the running totals, duty cycle, trip monitor, and KWHRs per month data to a printer or portable computer. Connect the printer or portable computer to the locomotive computer and set the equipment as instructed for the history to printer function, steps 1 through 3 above. In step 4, you should select "copy to printer" from the run data menu. All the run data will be transmitted, a screen at a time, to the external equipment, then the display will return to the run data menu. At that point follow steps 7 and 8 as listed above.

The display to printer function is not listed on the main menu. It is automatically selected by plugging the cable from a piece of external equipment, such as a printer or portable computer, into the display computer CPU module RS232 port when the locomotive menu program is operating. (Set up the external equipment as described above.) The locomotive computer will light the PROCEED key on the display keyboard whenever data appearing on the display can be sent to the external equipment. Pressing PROCEED will then cause the display computer to send the data to the external equipment. This process is sometimes called display data dumping or taking a display data snapshot because the data are all recorded at the same instant. The operation is most commonly used in combination with the METER/IOL functions to record signals under various operating conditions. These data differ from archived fault data because you can record them at any moment you choose: In contrast, the archived data are recorded automatically by the computer only when a fault occurs. Also, when you record the data, you can choose which signals you want by using the SELECT METER portion of the METER/IOL function: In contrast, archived fault data are always in predetermined signal packs.

C. GENERAL ELECTRIC

C1. 17TM14 Test Kit

The TM-14 test kit is a portable, externally powered, static-component device which is used to check and calibrate wheelslip/slide detection, speedometer, transition and speed sensing systems on locomotives. The TM-14 test kit can be used in place of the MM37, MM26, or the MM28 test kits. It has attached to its cover a list of condensed operating instructions for quick reference.

The TM-14 test kit will operate on any DC voltage between 24 and 74 (including locomotive batteries). The test kit calibration procedure consists of two self checks. There are no adjustments to make. The following components may be tested with the test kit:

Wheelslip Detection Panel
(with axle alternators)
*Wheelslip troubleshooting
* Functional check of Wheelslip Detection Panel
* Balance adjustment of axle circuits
* High speed sensitivity check
* Low speed sensitivity check
Speedometer Setting
Automatic Transition Setting
Check 17MM24 Axle Alternator Output
Type MM54 Speed Sensor Simulation and Monitor
Type MM102 Speed Sensor Monitor and Simulation
Turbo Speed Sensor Monitor

Further information about the TM-14 test kit can be obtained from General Electric Publication GEK-6141A.

C2. Checkit

The CHECKIT is designed as a diagnostic analyzer to troubleshoot the FL-138 CHEC (Constant Horsepower Excitation Control) panel. It can be used to simulate locomotive operation when the engine is shut down, or it may be used to observe system operation for analysis with the engine idling and the E.C. switch in the isolated position. Used in conjunction with a multimeter, the CHECKIT can be used to test virtually all phases of the CHEC system except actual turbo performance, which requires a full load test.

C3. Engine Speed Measuring Kit

The pulse generator provides a highly accurate mechanical/electronic method of engine speed measurement. It is actually a small alternator with a rotating permanent magnet which supplies six pulses per revolution. A drive tang is inserted into the pulse generator, then the unit is engaged into the tach drive fitting on the governor drive gear box.

The frequency converter furnished with this kit converts the signal from the pulse generator so the engine rpm can be read directly on digital multimeter 41A288473G1. A switch is incorporated in the frequency converter to allow a direct output

reading or a reading that is electronically corrected to read crankshaft rpm. No calculations need to be done. The frequency converter plugs into digital multimeter 41A288473G or any multimeter with banana plugs spaced at ¾ in.

The converter uses a common 9-volt battery and has a battery test switch. Minimum reading for a good battery is 7.5 volts.

The pulse generator, drive tang and frequency converter are available as a kit (2X2795) or may be ordered separately.

C4. DASH*STAR

DASH*STAR (Diagnostic Access Service Help STorage Analysis and Retrieval) provides Dash 8 customers high technology support for improved maintenance productivity and locomotive availability. This support includes on-line help for all Dash 8 fault codes, a data depository for, and selective retrieval of, locomotive fault logs, data packs and statistics, and locomotive date converter.

To access DASH*STAR the railroad uses a portable test set (Tandy/Radio Shack model 1400 portable computer, available thru GE renewal parts) with software developed and provided by GE to download the locomotive's history file. Each Dash 8 customer is given an account on the GE host computer in Erie. The railroad uploads the locomotive history to the GE Erie computer. The railroad then may do selective retrievals of locomotive history data (for its own locomotives only). The same portable test set may be used for troubleshooting help and date conversion.

DASH*STAR was first field tested on Conrail and has been expanded to include the Norfolk Southern, Southern Pacific, Susquehana, and Union Pacific Railroads. User training is provided at the GE Dash 8 schools and by GE field service engineers. DASH*STAR has recently been functionally increased to include data packs and statistics.

Future improvements to DASH*STAR include enhanced troubleshooting help via VAX, adding data pack decoding and troubleshooting help to the portable test set, and implementing GE information centers in railroad shops with a PC for DASH*STAR. The first information centers are currently being installed on Conrail.

D. HYPOT/LEAKAGE TESTERS

D1. Portable Dielectric Tester

The Model 5210 Portable Dielectric Tester is a DCX, limited high voltage, non-destructive dielectric tester. It weighs only 21 lbs. including the carrying case and leads. Voltage and current are limited to protect personnel and equipment. The voltage can be set as desired to read leakage in microamperes and the meters are protected against shorts, surges, and transients.

This unit is self-contained, powered by its own rechargeable battery, with a built-in charger. It is designed for industrial use where dielectric testing and portability are necessary or desired. Portability permits use of the unit to search for wiring faults, as well as to test individual components such as traction motors, fan motors, etc., to quickly determine fitness for service. Accurate microampere readings at a fixed voltage over a period of time will disclose cases of failing dielectric strength, permitting replacement of such components prior to destructive failure.

Specifications of Model 5210

Dielectric Tester:
- Input: *12 volt battery-operated. Complete with charger.
- Output: *0-1.5 kv DC continuously adjustable. *.010 kva. *5 milliamperes, operating; 20 ma short circuit. *Current sensitive overload relay with fixed sensitivity of 5 ma; override system to bypass overload relay when microammeter switch is in 50,000 microampere position.
- Voltage Control: *Manually operated with zero return interlock system to avert misapplication of high voltage. *For safety, operator must hold push button depressed to maintain voltage output.
- Kilovoltmeter: *Analog --0-1.5 kv equipped with fixed high limit to shut off high voltage should 1.5 kv be exceeded.
- Microammeter: *--500./5000/50,000 microamperes.
- Charging Circuit: *five foot, 3 conductor power cable terminated in 3 prong grounding type plug 110/1/60, removable.
- High Volt Cable: *Receptacle with disconnectable 15 ft. cable terminated in insulated clip.
- Return Cables: *One metered and one ground cable disconnectable, 15 ft. long, terminated in insulated clips.
- Cabinet: *Portable style.
- Weight: *21 lbs.

D2. Megger Insulation Testers

The Megger tester is used to test motors, generators, wiring, control equipment, electronic, and communications equipment. This instrument uses the step voltage method of determining the presence of excessive moisture or other contaminants in wiring insulation. This instrument comes equipped for operation on 115 volts AC or can be purchased as a portable with a built-in brushless AC hand driven generator which supplies a constant test voltage with a stability of +/- 3%. These Megger testers have a continuity range of 0-20,000 ohms. The insulation voltage ranges from 250 volts. 0-500 megohms to 1000 volts, 0-2000 megohms.

These Meggers may be ordered from General Electric Co. under the following part numbers:
- Megger Insulation Tester 115 VAC 2X1957
- Megger Insulation Tester crank model 101x910

D3. Hypot

The Hypot is used for high-potential insulation testing when high output current is required. Both bench models and mobile units are available. The bench model has a capacity of 2 kva and a continuously adjustable output voltage of 0-10,000 volts. It comes with a 4½ in. rectifier-type kilovoltmeter connected directly across the HV output and accurate to 3% of full scale. Readings are of actual test voltage applied, irrespective of regulation. A mobile AC Hypot is also available. It is continuously adjustable from 0-10,000 volts and has a capacity of 5 kva.

These Hypots may be ordered from the General Electric Co. under the following part number:
- Hypot, bench model 0-10 kv at 2kva - 2x2838
- Hypot, mobile unit 0-10 kv at 5kva - 2x2837

E. SPEED RECORDERS

E1. Aeroquip VF-86 Verifier

The Aeroquip VF-86 Verifier is a self-contained test device used on board locomotives and other rail vehicles. It is designed to check or verify the operation of magnetic tape speed-and-event recording equipment and traction motor load current indicating meters (load meters).

The verifier is housed in a rugged, two-piece fiberglass case. Required attachment cables and set of operating instructions are stored in a compartment of the VF-86's removable cover. The lower half of the case contains the verifier itself which features a LED indicator array, and LCD digital voltmeter, and voltage adjustment controls.

The LED's when lighted in specific sequences, confirm proper operation of event recording input circuits. The LCD voltmeter and adjustment controls are used in checking the calibration of load meters. The VF-86 operates on 74 VDC power obtained from the equipment under test so that batteries are not required.

The VF-86 verifier was specifically designed to test Aeroquip SIS//// MTR magnetic tape speed-and-event recording systems and those of another manufacturer. In addition to train speed, distance traveled, and elapsed time, these systems frequently are used to record the following events as well as others:

Automatic air brakes - 4 or 8 levels
Throttle and dynamic brake - 8 levels
Traction motor current
Coded cab signals - 5 levels
Independent brake
Reverser
Horn
Alertness control cut-in/cut-out
Fuel savings systems
Cab signal acknowledgement.

Cable connections to the recorder for system test and to the load meter for calibration checks are the only ones necessary. Maintenance personnel can run a full set of verifications in an hour or less.

Once connections between the verifier and the magnetic tape recorder are established, systems checks are performed by operating the locomotive controls that are being monitored and noting that red LED indicators on the VF-86's panel light up according to specified patterns.

It should be noted that, while magnetic tape recording systems that include components manufactured by another company can be tested as a whole in the same manner as Aeroquip SIS////MTR equipment, the recording circuits of the non-Aeroquip recorder itself cannot be fully checked.

Load meter calibration can be tested whether a magnetic tape system is installed in the locomotive or not. This is done by determining the load meter shunt value and setting the verifier voltage adjustment controls to the proper value and comparing the load meter reading to a charted rating. In the absence of a load meter shunt a setting representing a 0-12 volt control signal can be used.

For further information:

Aeroquip
U.S. Industrial Group
Industrial Products Division
755 Industrial Drive
Cary, IL 60013-1900
Phone: (312) 516-5353

E2. Pulse RV-X and RSV-X

Pulse Electronics, Inc., manufactures two types of verifiers (RV-X and RSV-X) for checking out and verifying the Pulse recording system and other compatible recorders. The recorder verifier (RV) is a hand held portable model enclosed in a rugged metal enclosure. The RV is an on-board locomotive tester. The RV simply checks the wiring on the locomotive to the recorder; it verifies that the wiring is correct and the proper signals are being sent to the recorder. The recording system verifier (RSV-X) is designed specifically to enable shop personnel to thoroughly bench test the Pulse recorders, air manifolds, and current modules. Also it will test compatible recorders. This prevents unnecessary repair and return of fully operational equipment. The RSV is a useful device to train shop personnel in the application of the RV on board the locomotive.

The RV is plugged into the recorder by means of the test connector inside the recorder on the front plate. The RV is powered by the recorder, therefore eliminating the need to have 110 VAC present. The RV receives and checks the various signal inputs from the locomotive to the recorder (ie. direction of travel, speed, load, etc.). When receiving the electrical signals from the locomotive, an array of LEDs inside the RV will light up according to each channel allocation.

The RSV is a self-contained bench tester and simulator of the various electrical inputs on the locomotive (ie. direction of travel, speed, load, throttle, etc.). The RSV allows the user to set a particular parameter on a recording component, which may be suspected as being defective, therefore allowing the personnel to troubleshoot or research the problem. The simulated inputs are controled by various lever and rotary switches on the front panel. Like the RV, the RSV also contains LED's on the front panel to indicate that the proper signals are being sent to the recorder.

Benefits/Features:

Recorder Verifier
*Portable
*Lightweight and rugged
*Checks locomotive wiring
*Requires no external power source
*Cost effective.

Recorder System Verifier
*Bench top
*Self contained tester
*Simulates various locomotive inputs
*Saves unnecessary shipment of suspected components
*Can be used to troubleshoot equipment

Pulse offers many different varieties. Please consult Pulse or your regional sales representative for the most appropriate application.

For further information:

Pulse Electronics Inc.
5706 Frederick Ave.
Rockville, MD 20852
Phone: (301) 230-0600

E3. Ogontz Speedometer Reference

The Ogontz Corporation Speedometer Reference (part no. 2-3-4-68-039) was developed as a small, lightweight replacement for the large, bulky test devices currently used by most railroads to test electronic speed indicators and recorder systems.

The Ogontz unit is designed to test speed indicators and/or recorder systems that utilize a 20 pulse per revolution axle alternator or pulse generator.

The speedometer reference develops an output of 10 to 12 VAC at 3 frequencies: 112 Hz, 56 Hz and 168 Hz. These frequencies relate to 40 mph, 20 mph, and 60 mph respectively with a nominal 38.5" wheel diameter.

Power is developed from 8 D-cell batteries. Features of the unit include a crystal time base, a low-battery indicator, and a 20-foot cord. The unit weighs 5½ lbs. The outside case is of a heavy cast aluminum which is rugged and impact-resistant so that it will survive in the railroad shop environment.

For further information:
Ogontz Corporation
141 Terwood Road
P.O. Box 479
Willow Grove, PA 19090
Phone: (215) 657-4770

F. CAB SIGNAL/SPEED CONTROL

F1. Rimsco Cab Signal Tester

The Rimsco Cab Signal Tester is a portable device used to check the operation of onboard cab signal pick-up coils, receivers, decoding relays and other associated cab signal components. Input power to the cab signal tester is derived either from 120 VAC line power or from 38 VDC from the rail car or locomotive. Output power from the tester is fed to an external test loop (supplied by customer) which is placed under the pick-up coils on the car or locomotive. The current passing through the test loop is adjustable and is monitored by the digital ammeter on the front panel. Other front panel controls provide AC or DC operation, code rate and output current level. LED indicators are provided for "Power on," "Fuse Open," "Code Rate," and 100 Hz or 60 Hz carrier frequency.

The test unit is housed in a rugged enclosure with the electronic circuitry, except for the power supply and power amplifier, on three removeable, plug-in modules. These modules slide into the front of the test set and are protected by a Lexan cover. A carrying handle has been provided which tilts to support the test set when used on the bench.

Specifications:

	Model 13063-00	Model 13439-00	Model 13421-00
AC Input	120 VAC, 60Hz 1PH @ 1 amp max.	120 VAC, 60Hz 1PH @ 1 amp max.	120 VAC, 60Hz 1PH @ 1 amp max.
DC Input	38 VDC Nominal 26-50 VDC @ 1.5A	38/72 VDC Nominal 29-85 VDC @ 1.5A	38/72 VDC Nominal 29-85 VDC @ 1.5A
Output** Current	Variable: 0 to 4.5 Arms	Variable: 0 to 4.5 Arms	Variable Locking: 0 to 4.5 Arms
Metering	3½ Digit Digital Meter	4½ Digit Digital Meter	4½ Digit Digital Meter
Carrier Frequency	60 or 100 Hz Internal switch	60 or 100 Hz external switch	60 or 100 Hz external switch
Code Rates	0, 75, 120, 180 IPM* with LED Indicator	0, 50, 75, 120, 180, 420 IMP*w/LED Indicator	0, 75, 120, 180 IPM* with LED Indicator
Protection	OUTPUT: Fuse w/External LED Indicator INPUT: Reverse Polarity & Fuse	OUTPUT: Fuse w/External LED Indicator INPUT: Reverse Polarity & Fuse	OUTPUT: Fuse w/External LED Indicator INPUT: Reverse Polarity & Fuse
Dimensions	5''Hx10''Wx12''D	5''Hx10''Wx12''D	5''Hx10''Wx12''D
Weight	15 Pounds	15 Pounds	15 Pounds

*Interruptions per minute
**Based on Loop Resistance of 200 milliohms maximum.

F2. Rimsco Model 13054--00 Speed Control Tester

The Rimsco Model 13054-00 Speed Control Test Units have been designed to provide a means of quickly and accurately determining the condition of the automatic train control equipment installed on many locomotives and transit vehicles. By integrating two variable oscillators with a cab signal test generator and then providing a digital frequency meter and a digital ammeter, Rimsco has brought together, in one unit, all the pieces of test equipment required to test the reaction of the car or locomotive at various speeds and track signal conditions.

The two variable oscillators are used to simulate the speed signal normally generated by the speed sensors located on each axle. By changing the frequency of these oscillators, wheelslip/slide control equipment can be verified.

The cab signal generator can be used to simulate the actual track signals received by the onboard cab signal receivers. By selecting various code rates, proper operation of the cab signal equipment can be verified by the operator. The carrier frequency of the cab signal generator, as well as the frequencies of the two variable oscillators, can be monitored with the built in frequency meter, while the output current of the cab signal generator is monitored by the built-in digital ammeter.

— Sturdy equipment case with carrying handle and protective cover.
— Test unit operates from 120 VAC or 38 VDC nominal.
— Plug in modules for easy maintenance.
— Digital frequency meter.
— Digital loop current ammeter.

For further information:
Rimsco Incorporated
20 Austin Ave.
Greenville, RI 02828
Phone: (401) 949-2900

G. END OF TRAIN/TELEMETRY

G1. Digitair Model 6631 Telemetry Transmission Monitor

The Digitair Telemetry Transmission Monitor (TTM) enables the monitoring of all AAR-compatible and end-of-train telemetry equipment operating within range. Its uses include:

* Monitoring the state of air brake systems of trains in a yard. (monitor mode)
* Observing the status of a single, selected train. (normal mode)
* Serving as a training tool for train crews and radio shop personnel.
* Verification of end-of-train units by radio technicians.
* Verification of locomotive telemetry antenna and cabling.

The TTM has two modes of operation:

1. Monitor mode — this feature monitors all telemetry transmissions; then displays train ID and status.
2. Normal mode — in this mode the TTM behaves like a receiver display unit, showing the status of only the chosen train's rear unit.

The TTM operates on 13.6 VDC +/- 20%. The antenna connection is external.

G2. Digitair Model 6625 Auxiliary Display Unit

The Digitair Auxiliary Display Unit (ADU) enables the thorough and complete testing of the end-of-train unit (STU). The following tests are initiated using the three toggle and one push button switch.

Radio Deviation Adjustment
* Transmit carrier number modulation
* Transmit carrier with 1200 Hz
* Transmit carrier with 1800 Hz
* Transmit carrier with preamble.

Radio current check
Pressure measurement and complete RF transmit cycle
Battery check
Temperature measurement often used to adjust reference voltage
Pressure measurement used to calibrate STU
Complete RF transmit cycle each second.

The ADU plugs directly into a DB25 connector in the STU battery compartment and is powered by the STU battery. It provides the capability to turn the STU on and off, and has a 16-character LED display of user information.

G3. Digitair Model 6630 Rear Unit Emulator

The Rear Unit Emulator (RUE) provides field support for rear-of-train telemetry systems to:
* Verify proper operation of a new locomotive installation before the locomotive is released into service
* Diagnose system performance problems on trains, at intermediate terminals, without delaying departure
* Thoroughly check equipment fault reports
* Support operational and technical training.

The available modes of operation satisfy the needs of all departments requiring a source of Digitair radio messages - Operating, Locomotive Maintenance, Communications, Training.

The RUE is based on the Digitair sense and transmit unit (STU) but without the air hose, the HVM light or the mounting hardware. All STU functions, including HVM light messages and motion messages are generated electronically and transmitted. This allows for checking reception and display on locomotive cab-mounted receiver display units, either Digitair or other makes of AAR-compatible telemetry.

The RUE operates in one of five selectable modes:
1. Automatic continuous sequence of all possible STU messages
2. Automatic single sequence of all messages
3. Manual single step sequence transmission of any message
4. Manual selection and single transmission of any message
5. Continuous transmission of one selected message.

The power of the RUE is normally adjusted down to about 100 mW for shop operation, but may be increased when desired to the full 2W output.

The RUE operates from its own internal battery which can be trickle charged with an external 12V power adaptor. Alternatively, the unit can be operated without the battery using a larger capacity 12V power supply.

For further information or ordering for Digitair items:

Dynamic Sciences Limited
4279 Canada Way
Burnaby, BC, Canada
V5G 4P1
Phone: (604) 437-1600
In U.S.: 800-663-8667

Dynamic Sciences Limited
1421 Fishburn Road
Hershey, PA 17033
Phone: 800-544-8879
FAX: (717) 533-4468

G4. Pulse Portable Trainlink Receiver

The Portable Trainlink Receiver (PTR) consists of a Trainlink

Receiver, specially formatted for test purposes, mounted in a rugged carrying case with an internal rechargeable battery.

The PTR will also emulate a Smartpack and, thru a supplied cable arrangement, supply power to a Trainlink transmitter for test purposes.

The PTR provides the following standard receiver displays:

Brake pipe pressure in 1 PSI intervals
Last car - moving/stopped
Marker light - on/off
Battery low
Charge unit (CU) used
Rad Brk (radio break time is one minute)
Above 45 PSI
Below 45 PSI

In addition the PTR displays the number of transmissions received (transmissions count).

Charge units (CU) used can be displayed by depressing and holding the TEST button. The CU's used will then be displayed in the PSI window.

Releasing the TEST button will light all status displays and segments. The audible alert will also sound. This provides a check of the PTR's display.

The DIM Button can be used to adjust the display brightness. Four levels of brightness can be selected.

The Last ID RCVD/Operate switch can be used to display the transmitter ID code of all incoming transmissions. In the Last ID RCVD position, the ID code of the transmitter which was last received will be displayed. The first three numbers of the ID code will be displayed in the count window and the last two numbers of the code will be displayed in the PSI window.

NOTE: If power is turned on with this switch not in the operate position the PTR will assume this mode anyway. Return the switch to the operate position to restore switch function.

Low battery detection for the internal battery is provided by the PTR. When the internal battery becomes low, the display will flash a marching zero across the display. The Low Bat status will also light. Normal operation can be regained by pressing the TEST button. The display brightness will be held to its lowest level and will not be adjustable until the battery is recharged. A complete shut-down will occur in approximately one hour of continuous use after the low battery warning.

The PTR is supplied with a cable, to provide a connection to transmitter, for test purposes. A check of the transmitter's functions can be made while observing the PTR display. The PTR will provide the transmitter with a charge unit reading of 50.

NOTE: The PTR's low battery cutoff is 11.00 volts. This is before a transmitter connected to the PTR wil sense low battery. Leaving a transmitter connected to the PTR for long periods could cause damage to its internal battery.

The PTR is provided with a short, flexible antenna. Connection can be made via the PL-259 connector to a roof mounted or locomotive mounted antenna for better reception. The PTR can be recharged by the Pulse Model 17015 or Model 17016 Trainlink, Smartpack charger. Recharging time will vary but should be no more than 8 hours. The PTR will operate for at least 12 hours on a full charge.

SPECIFICATIONS:
Environmental
Temperature Range
Operation 0 deg. C - +70 deg.C
Storage -40 deg.C - +70 deg.C
Humidity at 50 deg. C
95% non-condensing

Physical
Case Size — 8"x8"x4"
Weight — 12.5 lbs.
Power
12 volt internal battery
12 hours operation min.
Radio
Frequency — 457.9375 MHZ
Frequency Stablility +/- , 0005%
-40deg.C - +70 deg.C
Sensitivity — .5uV
Maximum transmissions
count 19999

G5. Pulse Trainlink Power Transmitter PPN 17080

The Tower Transmitter (TOWTX) is designed for installation in a yard or shop to provide a known Trainlink transmitter signal. This signal will aid the installation and checkout of receivers when being installed on locomotives. The TOWTX transmits both Pulse and AAR formats simultaneously.

The TOWTX can be mounted to any surface, in any position. Connection to an external antenna (not supplied) is made via the PL-259 connector. RG-8U coax should be used with no longer than a 50-ft. run.

The TOWTX uses 115 VAC power supplied via the line cord. A 1 amp slow-blow fuse is provided for circuit protection. The TOWTX has two modes of operation — auto or manual. In the auto mode the TOWTX will transmit once every 30 seconds. It will also transmit when the TEST button is pressed. In the manual mode the TOWTX will transmit only when the TEST button is pressed. The test function can be operated by means of a remote test switch, as shown on the top plate of the tower transmitter.

Information transmitted by the TOWTX is:
125 PSI
Low battery
Marker on
Stopped
100 Charge-units used
Test Bit
The ID code is 07000 for Pulse format and 90000 for AAR format.

The RF transmitter adjustments are available through the top plate. Pressing the test button twice within one second will "key" the radio for 10 seconds to allow adjustments. The brake pipe pressure display will light when the test button is pressed and simply provides a method of indicating that the unit is operational.

SPECIFICATIONS:
Power requirements
115 VAC +/- 10% @ 1 amp
Dimensions 13.5"x12.0"x5.12"
RF power output 2 watts
Frequency 457.9375 MHz
Frequency stability
+/- .0005% from -40 deg.C to +70 deg.C ambient
Spurious and harmonics
More than 60db below the carrier
FM noise 50 db
FM deviation 3 KHZ at mark and space frequencies
Antenna requirements
Impedance 50 ohm nominal 457 MHz
DC ground for lightning protection
For further information:
Pulse Electronics Inc.
5706 Frederick Ave.
Rockville, MD 20852
Phone: (301) 230-0600

H. MISCELLANEOUS

H1. AC/DC Tong Test

The Columbia AC/DC Tong Test Ammeter provides an instant reading of both AC and DC current simply by encircling the conductor with the tongs and closing them. It is a compact precision-made instrument weighing only 2½ pounds allowing for one hand operation.

Tong Test cannot be burned out because it contains no rectifiers, moving coils, switches or electrical windings of any kind. Tong Test measurements are made without the use of transformers, ammeters, shunts and millivoltmeters. It can be left continuously around a conductor without fear of overheating.

The Tong Test is flexible and easy to read. Quickly interchangeable ranges are available, which insures accurate readings over the entire range of a given instrument. Inasmuch as separate, individual ranges are used, the operator sees only one scale at a time. There is no confusion as to the correct reading, no multi-range scales to interpret. Tong Test can be used on all commercial alternating frequencies of 25 to 400 cycles, as well as on direct current.

Tong Testers are available with a wide variety of range and several Tong configurations. Ranges extend from low ranges of 0-20 amps DC and 0-50 amps AC/DC to a high of 0-1000 amps AC/DC. Accuracies (depending on model) can be as exact as 2% on both AC and DC. Prices start at $235.00 FOB factory, Cleveland, Ohio.

For further information:

Columbia Electric Mfg. Co.
4519 Hamilton Ave.
Cleveland, Ohio 44114
Phone: (216) 361-8060

H2. Houston Electronic Fuel Fill Tester

This is a device used to test the Houston electronic Fueling System on diesel locomotives. It is used in conjunction with the test-rod equipped fuel level sensors. It tests the coupler valve, the fuel level sensor, and the associated circuitry.

To test the fueling system, one has only to remove the dust cap from the coupler valve and apply the tester in its place. If the locomotive is low on fuel, the red LED on the test cap will light, indicating that the system is calling for fuel. You then simply depress the test-rod until it contacts the float, slowly allow the spring loaded test-rod to raise approximately ½ inch and the LED should go off, indicating that the tank is full and the auto-fuel system should shut off. Releasing the test rod disengages the float and allows it to return to its prior position.

The LED should remain off when the test cap is applied to locomotives with full fuel tank. Depressing the test-rod should light the LED, and again it should go off when the test-rod is released.

For further information:

Transportation Equipment
Supply Co.
6850 Peach Street
Erie, PA 16509
Phone: (814) 866-1952

H3. Jumper Cable Tester

The Power Parts Company's MU Jumper Cable Tester automatically tests up to 27 wires for grounds, shorts, and incorrect wiring. After plugging in jumper cable, depress the start button until no. 1 light is lit, then release. Each wire is then automatically tested in sequence and loaded to 15 amps, DC. Each lamp must light in sequence and an ammeter reading of 15 amps must register for every wire.

If a wire is faulty due to grounding, the ground buzzer and light will activate, as soon as you start the cycle. When the tester reaches the grounded wire the indicator will not light.

When two or more wires are shorted together those lights will be activated at the same time.

If a jumper cable is wired incorrectly the lights will be illuminated out of proper sequence. The tester itself can be checked on a separate circuit provided, which tests all functions.

It is imperative that a circuit be provided for the jumper cable tester that delivers 15 amps at 110 VAC. If an extension cord is necessary it should be a minimum of 14 AWG wire and should be minimal in length as line drop will occur.

For further information:
Power Parts Company
1860 North Wilmot Ave.
Chicago, IL 60647
Phone (312) 772-4600

H4. Portable Power Inverter

The Model 500 Portable Power Inverter is designed for use on board the locomotive to drive AC power tools, drills (up to 3/8"), soldering irons, lights, hypots, meggers, and other AC equipment. It provides 117V, 60 Hz, single phase AC. The inverter will provide 500 watts for 15 minutes or 250 watts continuous, enabling it to run two power tools or a tool with a light simultaneously.

The power inverter is housed in a rugged polyethylene carrying case and weighs only 15 lbs. Its portability permits work to be performed on the locomotive anywhere on the property. There is no need to move the locomotive into the shop.

DC connection on the locomotive can be made to either the 74 VDC receptacle or to the battery switch. The inverter will draw up to 9 amps DC. Minimum voltage is 60 VDC.

The unit is protected by an input fuse and output circuit breaker. Short circuit and surge pulse protection are provided as well as overtemperature shutdown with auto reset.

For further information:
Automatic Equipment Co.
6547 Avondale Avenue
Chicago, IL 60631
Phone (312) 775-4104

H5. Quest HVD-100/1

The Quest Corporation has developed a voltage divider at the request of the Union Pacific Railroad. The 100:1 voltage divider was designed, manufactured, tested and calibrated for use with Beckman HD-110 digital multimeters.

When locomotives are being routinely load tested, the Beckman 110 may be subjected to voltages exceeding its maximum rated capacity, 1500 volts. Meter damage is unavoidable. With the ruggedly constructed Quest HVD-100/1 divider, the meter is subjected to only one-hundreth of the actual locomotive produced voltage. Overvoltage of, for example, 5% would only produce 15.75 volts at the meter.

The dividers have an accuracy of .01% of reading at 1000 volts. All dividers are checked against a standard traceable to the U.S. Government National Bureau of Standards.

In use, the HVD-100/1 is plugged into the meter; the leads from the HVD-100/1 are plugged into the locomotives voltage jacks. No potentially hazardous metal components are exposed. The HVD-100/1 sells for $64.55 each, FOB Brooklyn Hts., Ohio.

For further information:
Quest Corporation
950 Keynote Circle
Brooklyn Heights, Ohio 44131
Phone: (216) 398-9400

II. SOUND ELECTRICAL REPAIRS AND PRACTICES

A. Traction Motors

This year the Electrical Committee will focus on those traction motors that have successfully survived both the operation and the environment and have accumulated both time and mileage, but were removed prematurely from service, for other than motor problems.

Cleaning, inspection, and testing determine traction motor acceptability for continued dependable service which is the purpose of our review of the practices currently used to requalify motors. Over the years each of the major railroads has improved upon the OEM maintenance and service recommendations by identifying problem areas, and developing individually tailored maintenance instruction to improve operating reliability; but, what works for one railroad may not necessarily work for another. Operating characteristics, types of service, maintenance, all have a definite impact on the service life, and over the last 15 years, LMOA Electrical Committee presentations have provided considerable information about the EMD D77 traction motor. Suggested maintenance procedures, overhal specification, testing procedures, quality, are but a few of the topics covered.

Appropriately, a quote, taken from the 1983 LMOA publication states: "On many, if not all railways, the traction motor is the largest contributor to the maintenance costs of a locomotive electrical system. Of all the electrical components of a diesel electric locomotive it deserves and probably gets more attention than any other part. We are constantly investigating our traction motor failures." This may or may not be a fair analogy since locomotive problems have caused traction motors to fail and many locomotive problems are written off as traction motor failures.

Six years later, traction motors remain the largest contributor to maintenance costs, and demand premium attention.

Discussions with remanufacturers of the D77 traction motor relate that railroads, especially over the last five years, are continuing to focus more attention on the quality of the unit being purchased. Mechanical condition, upgrade of stator frames to new OEM standards, stress relieving, critical dimensions, core losses, commutator size and insulation qualities remain the center of attention.

This is an excellent opportunity to analyze performance results to determine areas requiring specification changes. With respect to individual maintenance instructions consider this as a preventative maintenance program that extends service life and reduces operating costs.

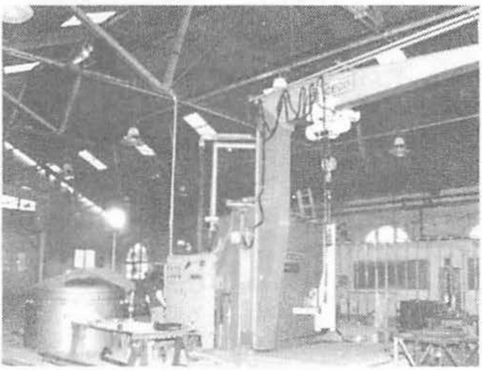
This following practices can or may contribute to attaining those desired performance results.

1. **Records**
   Maintain a record of change-outs by serial number, manufacturer, model, date of inspection, locomotive and position removed from.
2. **Cleaning**
   Each railroad has an approved list of recommended cleaning fluids and practices which aid in cleaning the motor. The exterior should be scraped clean of heavy dirt and grease accumulation. (Reference LMOA, Committees on Diesel Electric Maintenance presentation, 1986, Rotating Equipment, page 245, Cleaning Handling and Storage of Electrical Rotating Equipment.)

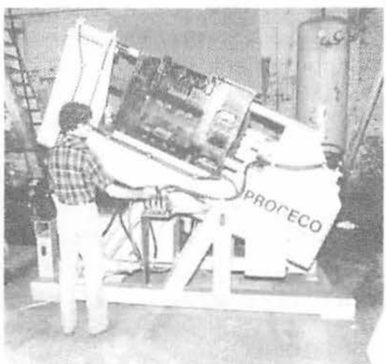
DEVELOPING
NEW PRODUCTS

Locomotive Traction Motors and Main Generators

⑦ TM and MG Spray Washer and Vacuum Dryer with Integral Jib Crane.



⑧ Vacuum Dryer. Can keep up with production of spray washer.

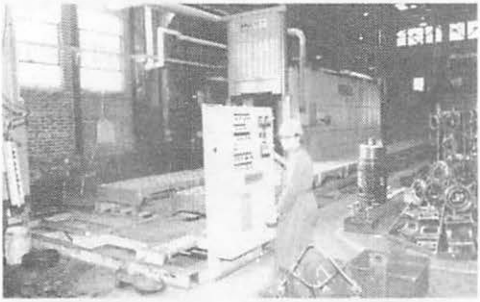


⑨ TM Stripper and Upender.

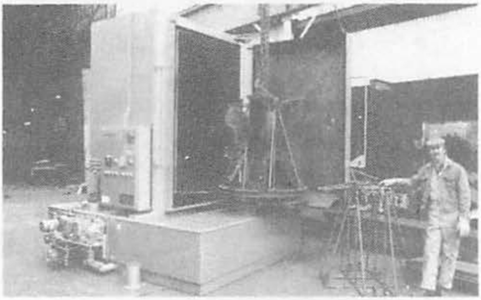
PROCECO INC. 1020 East 8th St./Jacksonville, Florida 32206
Telephone: 904-355-2888

SEE OUR ADS ON PAGES 52-53 — 286-286

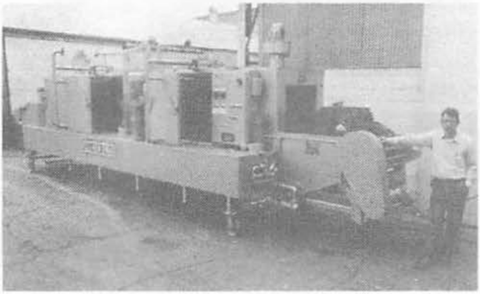
In Both US & Canadian Manufacturing Locations.



(10) TM Varnish Curing Oven With Automatic Material Handling.



(11) Batch Type Gear Case Spray Washer. May also be used to wash other components.



(12) Conveyor Gear Case Spray Washer. May also be used for washing other components.

MACHINERIE INDUSTRIELLE LTEE
PROCECO
INDUSTRIAL MACHINERY LTD

1243 rue Dorion/Montreal, Quebec H2K 4A2
Canada/Tele: 514-527-1335/Telex: 055-62262

The axle caps, oil reservoir and axle bore must be completely clean of all RTV and the crater lubricant from the pinion gear so a thorough inspection can be performed. All inspection covers should be in place during external cleaning. Axle caps may be cleaned with solvent vapor degreaser or steam to remove dirt and oily residue. (EMD MI 3900 G.)

3. Mechanical inspection

- Frame - examine for cracks or unusual wear (Attachment A)
- Frame Measurements - go - no go gauges (Attachment B)
- Retorque - end plates and bearing housing bolts (Attachment C)
- Air and inspection openings -covers (Attachment D)
- Pinion - examine and measure (Attachment E)

4. Electrical inspection

Perform the following:

- Megger-Hi-Pot - Measure insulation resistance (Attachment F)
- Internal inspection - condition of armature, commutator, coils, connections, cables (Attachment G)
- Clean -remove contaminants (Attachment H)
- Brush holders, string band, cables - qualify condition and repair (Attachment I)

5. Final test

- Seat brushes - commutation (Attachment J)
- Air cure - removal of burnt out particles. (Attachment K)
- Test run - performance inspection, monitor temperature, vibration, noise. (Attachment L)
- Apply reconditioned covers and pinion guard. Preparation for shipment. (Attachment M)

Attachment A

Frame Inspection:

- Derailment damage
- Missing or damaged nose support wear plates
- Support caps and frame serial number correspond
- Axle cap bolt threads
- Axle cap nuts for broken welds
- Blower duct threaded holes
- #4 main field coil bolt welds in axle bore
- Support cap drain threads and safety wire strap
- External cable clamp
- Oil fill valve load spring and "O" ring
- Proper length bolts and spacers for axle support bearing caps (EMD MI 3900 G)
- RTV sealing material around #3 main, #2 and #3 interpole, external bolt cavities
- Loose bolts and damaged threads.

Cracks:

- Gussets - inside motor, pinion end and above axle bore
- Inspection cover openings
- Support bearing bores and outside collars - cracks may appear horizontally or vertically
- Internal brush pads and brush holder block to frame weldments
- Support bearing key welds
- Support arm
- Body of axle caps
- Modified wick windows

Attachment B

Frame Measurements:

- Gauge gear case arm(s) for cracks or wear — minimum width 3-31/32" (3.965)
- Gauge gear case support hole(s) 1 1/16" diameter, maximum 1/64" oversize, maximum 1/64" out of round.

- Gauge distance between nose support plates — maximum distance passenger 12-1/8" (12.120"), maximum distance freight 12-3/16" (12.188").
- Concentricity and parallelism of bores — apply standard set of support bearings to axle bores with .010" shims, torque caps to 1100 ft lbs (mandrel diameter 8.014"). Mandrel must pass through both bores simultaneously without binding. Center mandrel in bores and measure bearing to mandrel (axle clearance.001" to .032" max.). Maximum space between the bearing flange and axle cap face is .005" with axle cap bolts tightened.
- Width of axle bore faces 41.815" minimum.

Attachment C

Retorque:
- Retorque end plates and bearing housing bolts. Tighten in clockwise sequence.
- Pinion end bearing cap bolts to 125 ft - lbs.
- Pinion end bearing house bolts 590 ft - lbs.
- Commutator end bearing cap to 125 ft - lbs.
- Commutator end bearing housing 270 ft - lbs.
- #1, 2, and 3 main field coils 600 to 700 ft - lbs.
- #4 field coil torque to 600 ft - lbs. Loosen below 300 ft - lbs and retorque to 300 - 325 ft. lbs.
- Interpole coils - torque to 600 to 700 ft - lbs.

Attachment D

Air and inspection openings:
- Inspect pinion end openings for debris or damage
- Inspection cover bolt holes
- Inspection cover hold down buttons and latch assembly
- Missing or damaged rock guards
- Ventilating screen condition
- Cover gaskets renewed.

Attachment E

Pinion Gear: Examine gear teeth for:
- Pitting and spalling
- Broken or chipped teeth
- Overheated
- Cracked or excessively worn teeth.

Measure the gear:
- Maximum involute profile deviation with gauge and .010" feeler wire.
- Land or tooth top thickness 1/8"

Reference EMD maintenance instructions MI 1518 and MI 3900.

Attachment F

Megger-hi-pot test:
- Measure insulation resistance to ground with 1000 VDC megger on armature, field coils, and related circuity. If greater than one megohm, hi-pot circuits using 1000 VAC for one minute. Maximum leakage current must not exceed 1 ma. Replacing or cleaning brush holders, string band, creepage surfaces and oven drying (175°F) may be required to obtain acceptable megohm reading.

Attachment G

Internal Inspection:
- Remove covers and thoroughly inspect motor for obvious break down of materials.
- Baffle or coil movement
- Overheating or evidence of dusting
- Burnt or damaged insulation and connections
- Cable and buss bar securement
- Commutator - dial indicate; with magnetic base dial indicator take

readings on all three brush tracks. A deviation of more than .002" in 6 bar span will require grinding of the commutator. Grinding will also be required if a stepup exists between brush paths when wear has taken place in the brush path. Commutator irregularities, rough surface, flat spots and scratches may require grinding. Reference EMD maintenance instruction MI 3900 for grinding procedure.

- Armature lateral - dial indicate; maximum lateral .048" to .050" permitted.
- Copper rollover on trailing edges of commutator should be removed with EMD tool #8270339.
- Slots between copper bars on commutator should be clean of carbon and copper, minimum depth 1/32" maximum depth 5/64"
- Tap test commutator for loose bars by gently tapping with clean non-metallic hammer.

Attachment H

Clean:

Blow the traction motor out with dry compressed air. Do not exceed 70 PSI pressure or damage to the insulation could result. Remove accumulated dirt from insulators, string band creepage surfaces by wet method using an approved electrical cleaner or dry wipe with clean rags.

Attachment I

Brush holders:

Brush holders, insulators, boots, springs must be free of dirt accumulations. Brushes must move freely; remove any burrs caused by arcing. Brush holders should be replaced if loose or broken insulator conditions exist, overheated or burnt cable connection exist with a reconditioned brush holder assembly, or every two years. Measure space between brush holder and commutator 1/8" to 3/16".

- Retorque brush holder clamp to 150 ft - lbs max.
- Retorque brush holder cable to brush holder 75 ft - lbs max.
- Install new brushes if necessary ensuring spring fingers are in place on brushes.
- Torque brush shunt bolts to 15 ft -lbs max.

String bands:

Teflon bands may be cleaned with a specified electrical cleaner or wiped clean with a clean dry rag to remove carbon film. Do not use sand paper or paint over a teflon band.

Epoxy bands should be replaced if cracked directly across the band from the commutator to outside ring. Other cracks may be repaired with epoxy after expanding to remove; surface may also be sanded and painted over with red insulating paint.

String bands may be cleaned with an approved electrical cleaner, sandpapered to remove carbon or flash tracks, and painted over with a red insulating paint.

Cables:

All cables and connectors should be free of oil and dirt. Examine cables for tears, nicks, or cracks which can be readily repaired with heat shrink tubing. Apply RTV compound into tear, nick or crack before applying heat shrink tubing. Minimum cable length is 49 5/16" with lug. Sleeves applied to cables going through cable clasp should extend 2" minimum beyond both sides of clamp.

Replace missing or damaged ground lead cable. The ground cable may go through the cable cleat with the FF lead and be held in place on the FF lead with three evenly spaced 2" long heat shrink sections.

Inspect connectors for proper alignment clamping surface, nicks, and burrs. Alignment pin should be replaced if damaged. Replace connector if burnt, badly bent, or showing indications or overheating.

Reference EMD MI 3950-4

Attachment J

Seat Brushes:

Seat brushes using an EMD brush seating stone #1473686. When 100% brush fit is accomplished blow with dry compressed air, 70 PSI maximum, to remove brush and stone residue from motor interior.

Attachment K

Air Cure:

- Following seating operation, the commutator must be air cured to prevent flashovers. Blow dry compressed air on the commutator going back and forth covering entire commutator. Hose should be nonmetallic or have a fiber, insulated, nozzle held ½" away from commutator surface. Sparking will occur due to blowing out and burning out of small particles of carbon and possibly copper slivers. Start motor run at low armature voltage, increasing in steps to maximum of 500 volts. Do not preceed to next higher voltage step until all sparking has stopped.
- Megger armature and field circuits with 1000 VDC megger, minimum reading 1 megohm.
- Hipot test entire electrical circuit. 1000 VAC for one minute - maximum leakage 1 ma; or 2000 VDC leakage test - maximum leakage 2ma.

Attachment L

Test run:

- Run the motor for approximately 30 minutes in each direction monitoring brush riding characteristics, bearing temperature, vibration with an instrument or by checking for unusual noise. The noise is checked when the power is cut off and motor runs down to zero rpm.

Reference EMD MI 3900-G

Attachment M

Apply reconditioned covers and pinion guard:

Apply new or reconditioned inspection covers. Ensure gaskets are in place and that proper sealing is obtained.

Apply pinion guard to protect pinion gear from damage during shipment.

Coat axle bores with a rust preventative tape, air blower duct with waterproof tape.

Traction Motor Cables

The traction motor cable is located in a very hard environment, constantly subjected to oil and dirt contamination, adverse weather and temperature conditions, abused by rock and debris, tormented by twisting and high vibration.

The manufacturers of traction motors have a maintenance instruction which states that cable insulation should not be damaged, frayed or worn and advises making a careful check of areas where cables are clamped or subject to abrasion. With these thoughts in mind let us present some practices that extend cable service life.

Replace motor grommets that are torn, cracked, deteriorated or loose. Seal with caulking compound.

A significant number of cable failures occur in the cable clamp area on the traction motor frame. The cable insulation wears through by rubbing on the steel plate located directly under the block supporting the cable clamp. This can be remedied by simply extending the boot material used to protect the cable through the block. The use of rubber or neoprene support blocks in the frame cable clamp is also highly recommended.

A condition of cable knotting or twisting frequently appears just before the cable clamp. This condition leads to premature insulation failure and will subsequently require cable replacement due to improper application of the connector. Upon application of the connector to the cable, the pins should be crimped or soldered facing the pinion end in the same plane as opposing connector on the locomotive. This also provides a smooth unsupported cable sweep from locomotive body to motor.

Cables that have cracked with age should be replaced. Cable insulation that has minor damage; frayed, nicked, or worn through can be repaired using a heat shrink tubing.

Heat shrink tubing available for traction motor cable repair comes in various wall thicknesses and shrink ratios. To have the optimal insulation/dielectric build up, the tubing chosen for this application should be the largest diameter expanded that will still recover firmly on the diameter of the cable. Thick wall heat shrink tubing has a 3:1 ratio.

Heat shrink tubing is available with or without sealant. The sealant will make the application waterproof provided it is heated properly and consistently around the circumference.

Another type of heat shrink tubing features a double wall design with an entrapped lubricant making installation quick and easy. A sealant material is applied to the cable jacket on both sides of the tubing to make it waterproof.

To remove heat shrink tubing from a cable, cut through from one end to the other, apply heat and it will pull itself away.

Following the manufacturer's instructions for use of these materials is recommended; the tubing will survive the life of the motor.

When using a crimp type connector as a replacement for a solder lug it is mandatory the manufacturer's instructions be followed implicitly. Failure to do so may result in burnt off connectors.

B. Grids and Fans

1. Introduction

In the opinion of at least one manufacturer, "A properly maintained dynamic brake grid system will provide a grid life equal to the life of the motive power equipment." In this section of our paper, we will review some maintenance and repair practices to help us achieve this long, trouble free, life for dynamic braking systems.

2. Grids

a. Preventive maintenance

All grid resistors require a large amount of ventilating air to properly cool them when operating at rated value. To ensure an ade-

quate air flow, visually inspect grids and remove all foreign material from resistor. This can be accomplished by blowing compressed air through the ribbons. Using a light, inspect the grid, looking for warped or burned ribbons, ribbons out of the clips, loose terminal connections, broken or missing baffles, broken insulators, and check the condition of cable insulation. A problem detected at this time can usually be repaired inexpensively compared to the resulting damage of a grid failure.

After a good visual inspection, the next procedure should be a megger and DC hypot test. The most desirable time for a megger/hypot test is soon after the locomotive has completed a run. At this time, equipment is most likely to be warm and dry.

The megger should be used first to ensure that the reading is over one megohm. Any readings below one megohm may lead to insulation breakdown if subjected to the higher voltages of the hypot, and therefore the cause of the low reading should be found and corrected. In many cases low megger readings can be corrected by cleaning and drying the affected area.

To avoid undue amounts of cable disconnecting, when meggering and hypoting the dynamic brake section on periodic inspections, the locomotive may be set up into dynamic braking and the motor-grid network can be tested exclusive of other electrical components. Due to the many and varied types of locomotives in service today, it will be necessary to refer to the appropriate blue print to determine megger connection points. When testing grids and motors "onboard" in this manner, hypot voltage should be limited to 1100 volts DC and held for one minute.

One of the most critical tests used to qualify the dynamic braking system is the calibration of the dynamic brake regulator (DBR). Depending on the make and model of locomotive, this regulator may be a module or a unit mounted in the high voltage cabinet. Instructions for the testing of these regulators can be found in the appropriate locomotive service manual.

It is recommended that the regulator be qualified once a year, and it is essential to check and calibrate the regulator and feedback and protective systems before returning a unit to service after a grid failure.

b. Repairs

1. EMD

EMD no longer offers half box grid replacements; therefore, the only option appears to be replacement of the entire grid even if only one half is damaged. The undamaged half may be saved for possible use as a replacement half later.

3. Grid Blower Motors

a. Preventive Maintenance

1. Motors should be cleaned by using dry compressed air at a reasonable pressure, (so as not to loosen varnish, etc.) Brush holders and insulating devices should be wiped clean.
2. Visual inspection of motors should include all cabling, connections, brush length, and commutator condition.
3. Depending on the vintage of the motor, it may or may not require lubrication, although most blower motors are greased at overhaul, and do not require greasing between teardowns. Brushes should

be checked for free movement in their holders. Lift the springs and raise and lower brush to release any dirt that may be accumulating in the holder. Replace brushes that are chipped, have loose shunts, or are less than 1" in length. New brushes should be "sanded in " using 00 sand paper between brush and commutator.

If the commutator requires minor stoning or if a motor is to be checked for proper operation, the fan motor may be run by disconnecting the motor from the grids and connecting to a battery or battery charger capable of producing 6 to 12 volts at 15 to 25 amps. This will rotate motor at a speed suitable for stoning commutator or checking for bearing noise, etc. Again, clean with dry low pressure air.

b. Repairs/overhaul

When it becomes necessary to remove a motor-blower unit for reconditioning, disassembly instructions can be found in EMD MI 4104.

Once disassembled, the armature and the frame and coil assembly must be thoroughly cleaned. A common method is to dip these components into a solution of hot water and caustic cleaner. Care must be taken not to dissolve varnish at this point. When dirt and grease are sufficiently loosened, rinse components with hot water. The motor then can be baked dry, revarnished, and reassembled per MI 4104-D for EMD motors.

Some of these instructions will require special tooling such as a commutator undercutter, brush tension, scale, and oven. Dynamic balancing is also recommended, but if this equipment is unavailable, a portable vibration tester may be used while test running motor after overhaul.

When the motor is finally reassembled, the final steps recommended by the manufacturer, to be followed should include megger/hypot test (EMD 2400v for 10 sec.); adjusting brush holder clearance above commutator (EMD 1/8"); adjusting brush tension (EMD 2¾ lb.); and determination of proper brush location (EMD kick neutral method). Manufacturer's instructions for this process are very detailed, and if followed, will result in a very dependable dynamic brake system.

III. PREPARING ELECTRICIANS FOR THE 1990's

Fifty years have elapsed since railroads began to use and maintain diesel electric locomotives as part of their motive power fleets. In this half century locomotives have undergone a relentless evolution of increasing horsepower and tractive effort, using more electrical components for non traction functions, and increasing the numbers and complexity of monitoring and feedback systems. They have adopted advancing technologies from amplidyne to vacuum tubes to rectifiers to transistors and now microprocessors.

Locomotive maintenance personnel had to learn how to maintain these locomotives and to re-learn every time technology changed. For machinists, life was remarkably less difficult than for electricians. Air compressors, power assemblies, roots blowers, wheels and trucks haven't changed much, if at all, in basic design, shape or function. When components were improved the "new" style always resembled the old with some changes so slight only the men on the bench could tell the difference. Not so for our electricians. They have been confronted with changed technologies at least four times in 50 years, from split pole and battery field excitation to microprocessor controlled SCR's. This ongoing evolution and resulting changes in hardware and now software are confronting motive power departments everywhere with the problem of obtaining, training and retaining competent locomotive maintenance electricians. Today we are universally short of knowledgeable trouble shooters and the situation is not getting better.

Shortages of skilled technicians result in improperly functioning locomotives which lead to increased costs of operation. This problem is the subject of this report.

First we should understand what the situation is today and how we got here. A short summary of our past will suffice for the concerns of this paper.

Fifty years ago when the diesel electrics first appeared in numbers, only mechanics that were the youngest or in the dog house with their supervisors were assigned to work on them. Shop foremen didn't like them, didn't have any knowledge about them and from most stories weren't interested in learning anything about them. A lot of this attitude was caused by fear of the unknown. The few electricians that were available were basically trained to do shop wiring and to repair steam dynamos that powered the headlights of steam engines. All too often the electricians of the era were belittled when they asked for instruction or were inquisitive of factory service men. This certainly was not a promising beginning.

Along came World War II. Diesels proliferated. To handle the huge war traffic volume railroads hired everybody they could including women, boomers, mental cases and even fugitives, I have been told. The prime qualification required was a warm body with all hands, feet and eyes. Training consisted of being given a safety rule book and then assignment as a helper. Unfortunately many of the lesser talented and less enterprising remained on rosters until age removed them in the 1960s and '70s.

By 1949 under the pressures of trucking, airlines, and automobiles our industry was in full retreat. No one was hiring. Layoffs trimmed thousands from railroad rolls. A few supervisors were sent to schools in the hope that they would pass down the knowledge they gained. Few electricians could use a print and fewer still understood the workings of electrical components.

Locomotive fleets of F and E units, PA's, FA's, RS3's, C-liners, and shark-nosed Baldwins were fast replacing steam. Locomotive maintenance forces were reeling under the impact of downsizing, dieselization and changing technology. All too often our systems broke down and we had trouble shooting by hi-pot or the copper bar in the fuse holder. The cost was astronomical. Our electricians knew how to brush and blow motors. They learned to trouble-shoot by watching contactors and relays and when one didn't work to go back to the last set of interlocks. This was the time of flag sticks in carbon pile voltage regulators and broom handles in shunt field contactors. Amplidyne was complete mystery to all but a handful of electricians. Often the only recourse was to bad order the unit to somewhere else or hook it in consist and get it out of town. All too often neglect ended in catastrophic failure.

A decade later, 1959, was probably the high water mark of our proficiency. GP9's ruled the rails. GE was telling people they were entering the domestic locomotive market. Alco 251's were still available but losing market share. La Grange and Schenectady offered classes in maintenance practice and trouble shooting that would benefit anyone who attended (if they were willing to learn and avoided extracurricular activities). DC traction generators, switches and motors had a high degree of dependability and we had learned how to maintain them. However, we were not educationally prepared for the onslaught of the 1960s. Type "E" excitation, silicon rectifiers, oscillators and saturable core reacters did add mystery to our jobs.

By 1969 we had experienced the agony and ecstasy of U-boats, vane motors and field shunting on GP35's and the wonders of air starting Centuries. We had a new lexicon of terms such as magnetic amplifier, transductor, silicon controlled rectifier and a whole host more. By now our electricians had been merged, purged, downsized, consolidated, transferred, laid off, recalled and reorganized. Now we had to retrain. The response was underwhelming. Most electricians had 20 years of experience. They told us they didn't need training, they knew dry batteries had to be watered. Defective voltage regulators? Are you kidding, just see how bright the lights are before they burn out. For the most part we did not have new people in the force. Unfortunately those we did have often learned many bad habits. Quantity was more important than quality. We were measured and time studied. We had to keep our efficiency up, whether or not the locomotive was fixed.

However, in the 60's we had been making some attempts to help ourselves. Having determined that a railroad apprentice program was not capable of fully training and qualifying a new electrician some railroads sent apprentices to LaGrange and Erie for several weeks of training, theory and trouble shooting. This investment in education was repaid a hundred fold in rapid order. Unfortunately this practice was the exception and not the rule. Budget constraints and the loss of apprentices to other industries diminished the benefit.

New problems soon reflected back to our shops and personnel in the form of bankruptcies, abandonments and liquidations, reorganizations and more mergers and consolidations. Again people were being furloughed, apprenticeships suspended or terminated, shops closed and there seemed to be no end in sight.

It is a well demonstrated fact that if you lay people off the most talented and ambitious ones will be the first to find employment elsewhere and not return to the railroad when called back. Such is always the case with talented electricians.

By 1979 the situation had stabilized. We had weathered Penn Central becoming ConRail, two energy crises, and the pending shut down of the Rock Island. Dash two locomotives simplified the problem of trouble shooting so that even if you couldn't diagnose the problem you could cure it by changing cards. Both locomotive manufacturers had improved their products and reduced required maintenance as we had requested. We realized then that we needed to upgrade mechanics and so we tried to train our people. Classes, financial aids, schools, and a variety of programs were being offered. We did make progress. The impact was not unnoticed but circumstances beyond our control were conspiring to undo what progress was being made.

Altogether if our skills and techniques weren't adequate, none-the-less we were all getting along rather well or so it seemed. Little did we realize what the '80's had in store for us.

From our 1989 vantage point we know that Class I railroad employ ment is 40 percent of what is was a decade ago, that we weathered a major recession and 18 percent prime rates. Major components of the nation's locomotive repair capacity are not operating. Livingston, Omaha, Paducah, Louisville and others are not repairing locomotives or have been sold and are operating for new companies. The past decade we experienced downsizing and rationalizing at unprecedented rates. Across the board employees were eliminated. Seniority ensured that our youngest and often most talented were let go first. With closing shops and transfers we have fewer places where maintenance and trouble shooting can occur. For our industry to survive in the deregulated competitive environment, this Draconian surgery was unavoidable. Planning for the long term by locomotive maintenance officers was postponed while we devised programs to survive the present. Our ranks where thinned with major reductions in staff assistants, managers, supervisors, and other support positions. Mechanical and electrical engineering functions became an endangered species. This has put increased burdens on those supervisors and managers that remain. The need to provide skilled electricians for our shops is just one of those burdens.

Both GE and EMD brought to market new series of locomotives using microprocessors. These units are now in use in increasing numbers. To make repairs possible these new locomotives have on-board capability to tell us what is wrong and what to do to repair it. These are truly remarkable locomotives with increases in horsepower, tractive effort and fault detection. It should be easier for railroads to effect repairs and keep availability higher on these units than with older locomotives But is not always happening this way.

All railroads have closed smaller repair shops, eliminated many enginehouses and terminals at crew change points, concentrated locomotive repair at major terminals, and with run-through agreements are sending units off line in increasing numbers. These changes have reduced the number of places locomotives can be repaired, increased the time necessary to get locomotives to a shop and certainly reduced the number of people available to repair units. Today it is not uncommon to

hear of locomotives sent over 1000 miles to be repaired. This is the configuration of railroading today and will be into the '90s.

Our present situation finds most of our maintenance capability concentrated at major terminals. At these shops there is always pressure to get units repaired and back in service. Typically we have a computer report describing what the problem is supposed to be. If the information is wrong, the wrong function is checked, no defects found and the unit may continue in service without being repaired or is tied up waiting for someone to find out what is really wrong. The ability to make a correct determination of the defect and correctly repair the unit is directly proportional to the skill of our electricians. Too many of our electricians are technically restricted to doing federal tests, brushing motors and changing starters and are not effective for trouble shooting. We all are paying the price of lost availability for a lack of fully trained electricians.

We need better educated and better trained electricians. For a bright, qualified young man we have the inducement of working nights with Wednesday and Thursday off for 75 percent of the full wage. For this he gets to work in a pit with an oil dripping locomotive over him, changing brushes. Often we don't keep the talented three months.

Under national contracts, many shops located in areas with high cost of living are simply not paying high enough wages to permit a man to move into the area to take a job even if he wanted to, thus restricting the pool of available hires to the immediate area. Is it any wonder that jobs go begging? All too often standards are lowered and a person is hired with the result we have another employee capable of routine work only. We have not been successful in hiring, training and retaining a fully qualified force.

What needs to be done to improve our electricians' skills?

First, we need to get serious about training our existing employees. Very few railroads today still have in-house training staff that can provide instruction in basic electricity, magnetism, generation of electricity, alternator construction and characteristics, motor connections and switching, transition, excitation, use of schematic wiring diagrams, circuit tracing, trouble shooting, transistors and the uses of electronic components in locomotive circuits. Vocational schools and junior colleges usually have courses suited to provide this instruction. EMD and GE offer instruction at LaGrange and Erie and at railroad shops usually in the features of a particular locomotive. More electricians should be sent to these courses. Employees should be required to attend and be paid for attending instructional courses and seminars. Incentives and rewards for doing well can be made available.

Second, competitive wages are required to attract and keep talented people. As we all know, locomotives are million dollar machines. It just is not realistic to entrust the repair and maintenance of these machines to unqualified or unskilled technicians. Our national economy no longer enables a uniform standard of living for uniform wages throughout the country. Presently we do not have the wage mechanism in contracts to address this problem. If area costs of living continue to widen provisions for adjustments will have to be negotiated.

In addition to providing the necessary material satisfactions to retain good people we need to provide a work environment that meets intrinsic needs. Job satisfaction, performance recognition, security, input in decisions and many other factors are needed to engender the positive morale which is always present in well performing shops.

Third, we need new employees trained in basic electricity and electronics and key boarding skills. Such people can be instructed in locomotive circuits and trouble shooting in a few weeks. If they have had previous work experience repairing electrical systems we find they are often better trouble shooters, within 30 days, than many 10 year employees.

Our competition for this caliber employee is no longer an automobile assembly plant or a local steel mill but IBM, Boeing, GTE and all the other sophisticated technology companies. We can not escape the reality of the scarcity of qualified candidates. The *Wall Street Journal* has had first page articles about this very problem. If our competition for people is willing to acknowledge the scarcity and offer attractive packages, for railroads to do less will leave us with less qualified candidates.

We don't like to hear stories about electricians unable to repair locomotives, or sometimes even to tell what is wrong, but it is happening today. Hundreds of millions of dollars worth of locomotives are at risk of substandard performance and to some extent additional damage expense because electrical failures are not being promptly and completely corrected. With motive power fleets once again in full utilization we cannot escape the economic penalties of failed locomotives and substandard repairs.

We as locomotive maintenance officers have a responsibility to do all in our power to raise the skills of our existing forces, hire only quality applicants and retain those that demonstrate talent and initiative. We are all under pressure to reduce costs. Yet money spent for training pays big dividends. We cannot afford to tie a unit up for three days for a loading problem while we change one part after another because we don't understand the symptoms. We cannot afford to drag locomotives dead or isolated in consists hundreds of miles and countless days because we just didn't repair it.

We know what our situation is, we know what can be done to help. We need to do what is within our power to implement programs and policies that will result in having a well trained and knowledgeable work force maintaining our locomotives.

We are being challenged by technology more than ever. If we do not master the situation it may be that railroad maintenance people will give way to contractors that do have the required skills. In the competitive, freewheeling climate of today railroads can not afford and will not tolerate institutional shortcomings. We will either do the job or get pushed aside. By striving for a skilled technical work force we can secure the role of locomotive maintenance officers in the '90s, the lowest cost of locomotive operation and the best deal for our railroads. Let us hope we are equal to the task.

THE SOUTHERN AND SOUTHWESTERN RAILWAY ASSN.

717 Pinecliffe Drive
Chesapeake, Virginia 23320

PURPOSE

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

The Southern and Southwestern Railway Association holds four (4) meetings per year at important railroad cities in the southeast. The format of the meeting is to gather on Wednesday evening for dinner followed by a speaker. The next Thursday morning, business is handled and additional presentations are made.

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

M. A. Carney President
Data System Engineer
Norfolk Southern Corporation
Roanoke, Virginia 2402-0078

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

Wednesday, September 20, 1989
9:00 A.M.

REPORT OF THE COMMITTEE ON DIESEL MATERIAL CONTROL

Pre-Convention Presentation: Southern & Southwestern Rwy. Club

April 20, 1989
Holiday Inn-Gateway
Huntington, WV

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

VICE CHAIRMAN
L. J. Cala, Mgr.-Material Control — Loco, Conrail, Altoona, PA

COMMITTEE MEMBERS

P.S. (Skip) Carstensen	Material Dist. Mgr.	C&NW	Clinton, IA
R. Corder	Director of Materials	VMV	Paducah, KY
R. F. Early	Purchasing Agent	ATSF	Topeka, KS
T. R. Gerbracht	Senior Engineer Tech. Supt.	GE	Erie, PA
E. L. Harris	Director of Materials	IC	Chicago, IL
H. H. Pennell	Director-Material	BN	Overland Park, KS
D. G. Schonauer	Parts Materials Manager	EMD	Hodgkins, IL

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. INTRODUCTION

Time was when we railroads had all the knowledge and expertise necessary to run our businesses. We designed our shops, we trained and developed our people, we custom built our parts and repaired anything that needed repair, we even set up hospital associations to take care of our employees. We were family, we depended on each other, we were self reliant.

Things have changed!

Perhaps the biggest change in our industry is the fact that we went from 112 Class I railroads in the late 1950s to 16 Class I railroads last year.

Improved technology and a reduction of resources due to increased competition in the transportation industry have made it impossible to remain isolated today.

Today we find that economics is the key to survival and we are constantly being tested in our ability to keep costs down by working smarter and communicating more effectively; and by downsizing.

In 1968 the railroad industry supported 340,000 miles of track with 27,376 locomotives. Twenty years later we counted 220,000 miles of track and 20,028 locomotives — one third less tract, and one fourth fewer locomotives. These changes are a direct result of the improvements in technology, working smarter, and downsizing.

Incidentally, 1968 was a significant year for the railroad industry; it was the year of the merger between the Pennsylvania and the New York Central railroads. That event, perhaps above all others, set the standard for future mergers and restructuring.

Reductions in the labor force through buyouts, and other cost reduction and cost control measures were initiated in this historic merger. Yes, downsizing was on the scene before the Staggers Act. As a matter of fact, since 1968 the seven largest railroads have sold or closed 70% of their shops.

The railroad industry of today is a lean and cost effective machine with immense market share opportunitites. But the battle is still being fought. For example, from 1980 to 1986, the intercity freight market grew by 34 billion dollars, a 27% growth. The rail industry did not get any of this extra business; it all went to truckers.

We know that some of the supply industry infrastructure, the very underpinning of the railroad business is gone, probably forever. We have fewer vendors, and they have fewer vendors. For example, there were once three U.S. vendors for locomotive trucks; now there is one. At one time there were 13 freight car builders; now there are three. The list could go on and on but we know that the amount of captial required to start a business makes it doubtful that new vendors will come forward.

The topics we present in this year's report are representative of the changes made by railroads to sharpen their competitive edge and go for a bigger piece of the transportation pie. They are:

1. Innovations in material distribution resulting from shop consolidations and outsourcing;
2. Packaging and containerization for today's railroads;
3. Outsourcing; and finally
4. "Stuff happens" a skit about the necessity of feedback between and among suppliers and end users.

II. INNOVATIONS IN MATERIAL HANDLING RESULTING FROM DOWNSIZING AND SHOP CONSOLIDATION

When we think of material handling, we think of material being moved from one location to another, either by an individual moving small packages or an operator on lift truck moving larger, heavier items. We will expand that to include Materials department as a whole, including the purchasing functions.

In the past, railroads depended on these "material handlers" working at distribution centers and in distribution networks to supply most items to repair locations scattered across the rail systems. This meant large inventories at distribution centers and storehouses, with materials being physically handled two, three, and even more times before the material arrived at the using locations. These distribution networks were very labor and inventory intensive. Even when no freight was being moved or repairs were being made to equipment, these labor and inventory requirements still had to be met. The results were high labor cost, surplus inventories and obsolete materials that had to be sold off at greatly reduced values as equipment was upgraded or eliminated.

Now let's look at what has happened in the past few years in the rail industry. With the passage of the Staggers Act and the increase in competition, all railroads have felt the crunch of reduced revenues per load shipped. This has meant that even if tonnage hauled has risen the revenue taken in may have declined. There has been a sharp need to reduce costs and increase productivity. As a result we have seen reductions in forces across the rail systems and the consolidation of maintenance functions at larger repair facilities. As this consolidation has occurred two things have happened that have changed the way we look at materical handling and distribution.

First, these across the board force reductions have left Materials departments struggling to cope with the reality of fewer hands to do the material handling. Second, with the shop consolidations and the climination of much excess trackage, the need for a distribution network has been greatly reduced. We can see the result of these two occurrences. With reduced forces new methods of material procurement are necessary to make up for the lack of hands to move material. And, as the distribution networks are dismantled more and more material moves directly from the vendor to the repair facility.

As this material is being delivered direct, new purchasing methods must be devised to enable the shop to better control the flow of material. One railroad now is using four new purchasing methods:

(1) Blanket Purchase Orders — These are purchase orders placed by a corporate purchasing agent with a vendor for a number of high usage items for estimated yearly usage. Local repair facilities can make releases against the blanket order as material is needed.

(2) Contracts — The corporate purchasing agent will contract with vendors to have material available based on prior usage patterns. Repair facilities will place local purchase orders against the vendors to request material delivered direct as needed.

(3) Preferred Vendors — The corporate Purchasing department will identify preferred vendors based on past performances of service and pricing. Repair facilities wil again

place local purchase orders against these vendors to request material delivered direct as necessary.

(4) Consignment — This is material placed at a using location by a vendor with the vendor retaining ownership until the material is either used or taken into the inventory. The material can be controlled by either the vendor or by the railroad.

Since material is now coming direct to the repair facilities, consideration can be given to the specific packaging and storage needs of the shop. In the past, package quantities needed to be more suited to distribution centers and their distribution methods. Now the needs of the shop are paramount.

Packaging — With the elimination of the distribution network, material can be packaged for ease of handling during usage. Quantities are adjusted and package shape and volume are changed to better meet the storage requirements of the shop.

Kits — This is the packaging of material necessary to perform on repair function. It may be as simple as the repair part for an air valve, or as complex as the parts for a 92-day inspection or a truck rebuild.

Point-of-Usage Storage — This is the delivery of material directly from the vendor to the point of usage. The material is controlled at the point of use by the user who sets the quantity to have on hand and is responsible for accurate usage figures.

Just-In-Time Inventory — This is one phrase that can quickly evoke panic in a shop manager who has had problems with the timely receipt of material. This tool has proven to be useful in eliminating high inventories and point-of-usage storage concerns.

Finally, let's look briefly at information control and transfer. This is the proper gathering and reporting of inventory, usage, and purchasing information for quick response to the material needs of the repair facility.

Bar Coding — This committee has discussed bar coding for several years. Now, several railroads are beginning to make use of it in tracking inventories and usage figures, and are considering it for tracking repairs to locomotive and freight cars.

Real Time Material Control — This is the ability to know what material is where at all times. In the past, usage figures usually lagged from many hours to several days or even weeks due to the methods for logging usage. Now with computerized inventories and bar coding, information can be as current as the last pass of the wand over the bar code.

Electronic Data Interchange — Railroads are now using EDI as a common form of ordering and being invoiced for material.

Facsimile Machines — The fax machine has quickly replaced the mail and courier as a method of transferring hard copies of important documents across the nation. This committee has used fax for notifying members of progress on reports and meeting dates. The rail industry uses fax along with the new methods of purchasing and EDI to confirm data on purchase orders and material specification.

With the increased productivity at these consolidated shops more time can and must be allotted to materials requirements planning. We repeat because it is so important: **more time can and must be alloted to materials requirements planning!** That is the ability to predict what material is to be used and when that material will be needed. As shop consolidation occurs, larger programs can be run at each shop. With this comes a better handle on what parts are needed and where they will be used in the shop. As programs become more specialized, bills of material can be more exact, with an opportunity for both JIT inventory and point of usage storage.

Now, instead of operating as an outsider that supplies material to the shops, the Materials department becomes an integral part of each repair facility. Some Material departments have even been incorporated into the entire maintenance structure. One railroad now has a vice-president of motive power and materials, with more integration yet to occur.

As railroads continue to downsize, watch for more material shipping from vendors direct to points of use. Commodity modules will be set up at the corporate level to monitor inventories and local purchase orders at the shop level; and, more authority will be given to shops for purchasing shop needs.

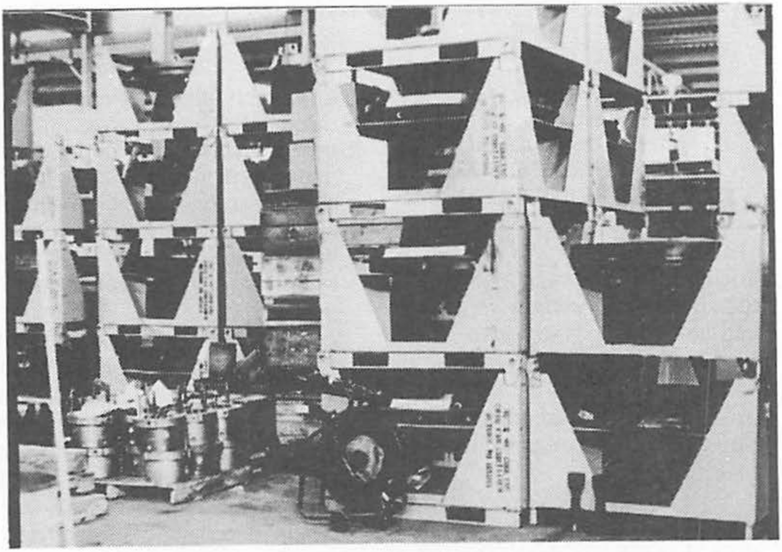
III. PACKAGING AND CONTAINERIZATION NECESSARY TO MEET MATERIAL REQUIREMENTS

This section of our report will discuss the packaging and containerization of certain components and how these physcial areas of concern become problems when it comes to downsizing, plus the outshopping of components and the corporate direction your company wants to take.

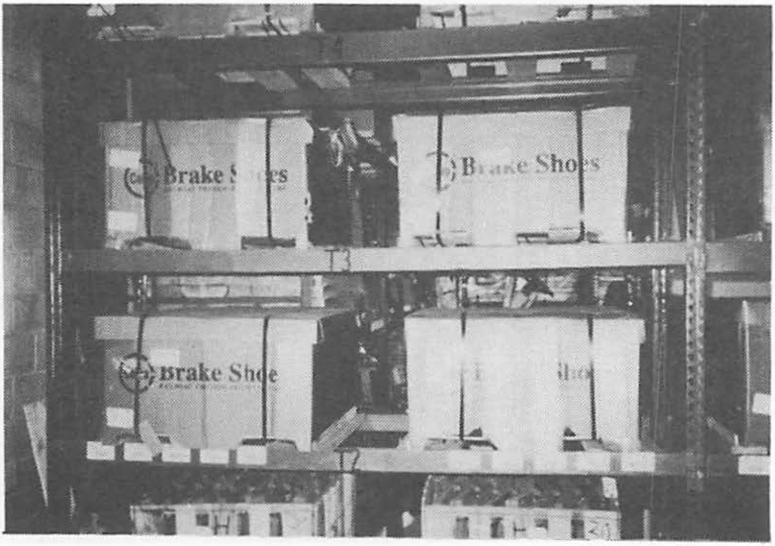
Most of us make every effort to capture all locomotive component activity through inventory. This not only includes just the receipt of items and their subsequent disbursement through the accounts but also the automatic generation of repairable items and their addition into inventory, plus the tracking of items through the repair process or UTEX arrangements with vendors to enable us to keep a perpetual vendor outshop inventory control system. This allows us not only to know what we have on hand, but also what we have to work with in terms of various component pool sizes. Packaging and containerization are important through all these phases of inventory whether in the shop, in the warehouse or at the vendor. Be cautious; depending on your location and vendor agreements, freight cost could be substantial. Reusable skids are excellent if freight is cost effective at your operation and location.

The following photos cover aspects of containerization and packaging when using vendor outshop to repair components.

"Fabricated Containers Systems"



"Stacked"



"Pallet Rack"

IV. OUTSOURCING: UTEX VS. REPAIR AND RETURN

Generally speaking, there are seven ways in which railroads can obtain material for locomotive maintenance. They are:

1. Buy new from vendor.
2. Buy remanufactured from ven dor.
3. Lease agreement (which could include option to buy).
4. Repair in-house
5. Buy — sell.
6. UTEX with vendor (Unit exchange).
7. Repair and return with vendor (remanufacture).

This paper will primarily focus on the subject of UTEX and repair and return.

Many factors influence the decision to outsource, especially in today's environment. One factor is the emphasis toward downsizing. In many instances, downsizing has created a situation in which there simply is not enough manpower to do the work. Another factor involved in the decision to outsource centers around the fact that there are now more vendors in the marketplace who can perform quality work at competitive prices. This increase in the number of vendors in the past few years is perhaps the main reason for the improvement in quality, as well as lower cost in outsourcing. The investment needed by the railroads in technical equipment and the cost to maintain that equipment in order to produce a quality product are also factors in the decision to outsource. The increased use of flat rate pricing, which has helped reduce the administrative costs associated with outsourcing, has helped make outsourcing more popular.

It is in the railroad's best interest to thoroughly investigate these sources for possible monetary savings, as well as improved quality. The National Association of Purchasing Managers state that it takes from 12 to 18 dollars of revenue to equal every dollar saved in the purchase of material.

Research by our committee reveals many items previously repaired in-house are now being done by outside vendors. Some of these items include the following:

Locomotive starter batteries
Radiators
Cards and modules
Fuel injectors
Traction motor armature rewinding
Power assemblies
Locomotive engine overhaul
Various electrical items such as power contactors, switches and starter motors
Compressors
Vibration dampers
Exhaust manifolds
Governors
Water pumps
Fuel pumps
Starter motors
Alternators
Grid blowers.

Once the decision has been made to outsource an item, there are basically two methods of repair to consider. Namely, should the item be UTEXED or repaired and returned?

The term UTEX mean unit exchange. Locomotive builders and other after-market vendors provide remanufacturing services for several locomotive components. For many major components, vendors maintain a "pool" of repaired units, which can be shipped upon receipt of an order. After the repairable unit is received and repaired by the vendor, it is then placed into the vendor's "pool" for subsequent orders. This arrangement is called unit exchange. It is this quick turnaround that makes UTEX so popular and is one of the advantages UTEX has over repair and return.

Over the years, UTEX has become a buzz word used by railroaders and vendors alike in describing transactions involving the return of repairable material to vendors. As a result, many in the industry fail to realize and therefore fail to take advantage of another method, namely repair and return. Repair and return means material is forwarded to the vendor for repair and after being repaired, is returned directly to the railroad for use.

Under repair and return, the repaired material is not shipped from the vendor's inventory of previously repaired material. Railroads receive the same item from the vendor that was originally sent in for repair. Many argue that UTEX has an advantage over repair and return because of the quicker availability. However, they may fail to realize that frequently the vendor does not have an inventory of repaired material readily available. When this happens, as it frequently does, railroads do not receive the full benefits of UTEX. In this case, the transaction, for all practical purposes, becomes the same as repair and return. In addition, the quick availability of UTEX often is not that important to railroads, because they frequently have their own inventory of repaired material from which to draw.

Because of the cost involved and the environment in which they operate, some items naturally lend themselves to UTEX handling. One of these is turbochargers. Assuming the vendor has an adequate supply of turbos on hand, it usually is in the railroad's best interest to utex this item on running repairs. Another item that is a logical UTEX candidate is power assemblies.

One advantage that repair and return transactions have over UTEX that many are unaware of relates to the application of state sales and use taxes. Because locomotives and freight cars are considered rolling stock operating in interstate commerce, railroad Purchasing departments claim rolling stock tax exemptions when buying material used on this type of equipment. Therefore, in states which recognize this tax exemption, railroads are not obligated to pay state use or sales tax on material purchased or used in that particular state. However, some states do not recognize this tax exemption and therefore tax the railroad accordingly.

As an example, the State of California charges railroads operating in that state a 6% sales tax on material purchased in that state and a 6% use tax on materials purchased outside the state for use within the state. This applies to purchase of new, as well as utex. For example, if a railroad were to UTEX a traction motor armature in California at a flat rate cost of $6,000 each, after adding the 6% tax, the total cost involved would amount to $6,360. If, however, the armature were to be handled on a repair and return basis instead of UTEX, the tax would only be applicable to the material cost involved in the repair of the armature and not the labor. If material cost in this example was 50% of the $6,000, the tax liability would have been 6% of $3,000 or only $180, a savings of $180 per amature. If the railroad repaired and returned 1,000 armatures per year, a savings of $180,000 would be realized. Obviously, the higher the labor cost in relation to the material cost in a repair and return transaction, the less the tax obligation.

Another way to save money on the purchase of material consigned to states not recognizing the rolling stock tax exemption is to request the vendor to ship the material on an f.o.b. vendor's plant basis. If for some reason it is less expensive or more appropriate to ship the material f.o.b. destination, then the vendor should be requested to separate the freight cost on his invoice. Otherwise, freight and material costs will be combined together and the railroad would pay state tax on freight, as well as material. using the earlier example of traction motor armatures, if the armature price of $6,000 includes $150 for freight, then your railroad would be paying a state use tax on $150 worth of freight. As in the previous example, if your railroad used 1,000 armatures per year, you would be paying a tax on $150,000 of freight. At a 6% tax rate, this would amount to $9,000 of unnecessary taxes.

Just as there are examples of items that lend themselves to UTEX, there are also items that lend themselves to repair and return. One such example is the repair of engines. In most cases, it would be impractical to handle locomotive engines on a utex basis. Here again, it is important to be aware of any state tax laws applicable to repair and return. One railroad recently saved over $60,000 in state taxes by requesting the vendor to separate his material cost from his labor cost on the invoice covering the repair of a large number of engines. Since labor represented over half the invoice cost of repairing these engines, this railroad was able to significantly reduce its tax liability.

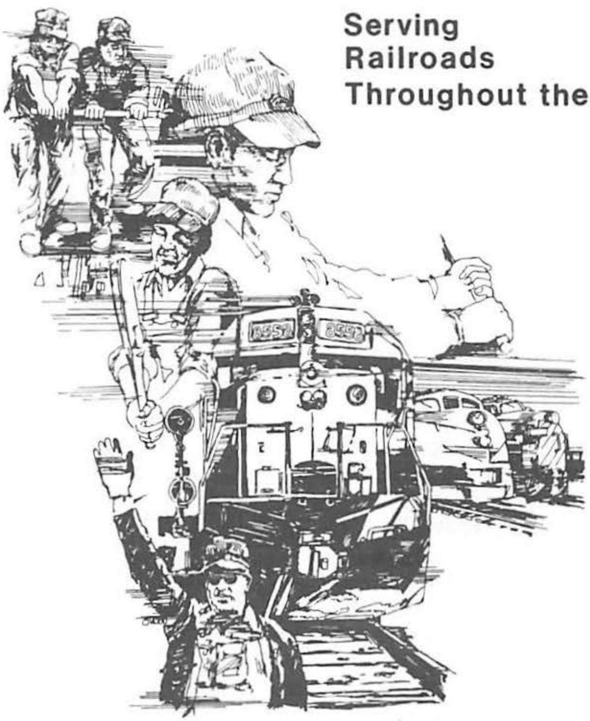
Research by our committee has found the following states do not recognize the rolling stock tax exemption:

Oklahoma	5.8% tax
California	6% tax
Nevada	5.75% tax
Colorado	3% tax
Utah	6.25% tax
Arkansas	5% tax
Louisiana	7% tax
New Mexico	Min. of 4.75% tax
Massachusetts	5.6% tax
Connecticut	7.5% tax
New York	7 to 8.25% tax

Even though states in which your particular railroad operates may not currently be assessing use or sales tax on the purchase of material, that could quickly change. All states are constantly searching for new sources of revenue. As an example, it is our understanding that bills are being debated in the Texas and Missouri legislatures to adopt state use and sales taxes in those states.

In conclusion, it appears the railroads are still in a period of transition concerning outsourcing. However, there is clear evidence that for a variety of reasons, railroads are more involved in outsourcing than ever before. Evidence also indicates this trend will continue. Each railroad must decide which commodities to repair in-house and which to outsource. On outsourced items, a decision then needs to be made concerning UTEX vs. repair and return.

Regardless of whether the decision is to continue to repair in-house or to outsource, railroaders should give strong consideration to maintaining their own pool or inventory of material. Because of the constant fluctuation in lead time on material furnished by vendors, it would be unwise to rely on the marketplace to maintain inventory for you.



V. SUPPLIER FEED BACK

A. What can go wrong.

The following material is presented as a short skit, with the following cast of characters:

Mechanical officer: Charlie Miller, Union Pacific; Purchasing agent: Mike Pennell, Burlington Northern; Supplier: Dave Schonauer, Electro Motive Div.; Supplier's supplier: Bob Corder, VMV Co.

Mechanical officer: Say Mike. I've got the three locomotives out here on the shop "Q" track on the east end. They're the ones we've talked about doing the classified overhaul on. The six axle, 3,000 horsepower locomotives. Do you remember that?

Purchasing agent: Yes, Charlie.

Mechanical officer: I called operation control and after fighting with them for a while they said something clever like, "They're out there working. They're hauling freight. What do you want to stop and shop them for? Leave them alone. They're not broke." Anyway, were they scheduled to come in. I also talked to the shop foreman. We've got the labor scheduled. We got the track space set aside. We're ready to go Monday morning. Now in working with you, we sat down and gave you a bill of material for the overhaul. We also told you our start time, our stop time, what shops and what we are going to need. Now the only thing we are missing is the material. Can you help me with that? Are we ready to go?

Purchasing agent: Charlie, I saw those locomotives setting outside, as a matter of fact, I saw them setting them in awhile ago. As soon as I saw them, I knew that it was part of that 150 locomotives that we've been talking about. We've scheduled the material, we've used EDI to order the material just as quickly as possible. So it was very easy for me to go into the system and see what the status of the material was. We've gotten all of the material in with the exception of one item. That is a part number 12345 widget.

Mechanical officer: You're kidding! That's the main gear to this whole thing.

Purchasing agent: I knew that's what you were going to say. And I have already placed a call to Dave Schonauer. As a matter of fact, I believe that's him right now. Dave. How are you doing?

Supplier: Hi, Mike! All right, thanks.

Purchasing agent: Dave, you know the program that we have for the 150 3,000 horsepower locomotives that you and I have had numerous conversations about.

Supplier: That's a great program. Incidentally, I meant to tell you about that. You gave us the lead time. You gave us an accurate count of what you needed and we had the time to not only do the planning, but executing a set plan. That's the kind of communication we really need.

Purchasing agent: Well Dave, something has fallen through the cracks. I just checked on the order and I found that part number 12345 widget has not been received. What can you tell me about that?

Supplier: Wait a minute Mike. I personnaly checked that two weeks ago and I have had the assurance that that was going to ship to you and I believe that it has already shipped. You're sure that it hasn't?

Purchasing agent: Damned right I'm sure it hasn't.

Supplier: I'd better check. Let me

check and get back to you, if you will. I'll be back to you shortly.

Purchasing agent: Okay, thank you, Dave.

Supplier: Hello, Bob!

Supplier's supplier: Yes, Dave!

Supplier: What the hell happened?

Supplier's supplier: Uh, uh, uh.

Supplier: Remember the widget number 12345. You were supposed to ship that directly to the customer. You told me that you were going to ship it last week. Where is it?

Supplier's supplier: Dave, didn't anyone tell you about the fire we had in our plant?

Supplier: What fire?

Supplier's supplier: We had a major fire and our widget 12345 machine was severly burned. You know this machine is a one of a kind. It's the only one like it in the United States and there's only one other in Germany where it's manufactured. But, I do have some good news for you. The technician is going to be over here. He is coming with the part and will be here in only two weeks.

Supplier: Two weeks!

Purchasing agent: Two weeks!

Mechanical officer: Two weeks!

B. Discussion

As we've just demonstrated, there is a tremendous need for feedback. All of us, not just vendors, are each other's supplier and must become involved in the feedback loop. This feedback we should supply may take the form of services, materials, or information.

When there is any type of glitch in our systems, we as suppliers have the responsibility to communicate the disruption. This communcation may pertain to but is not necessarily limited to the following:

1. Material Availability — At one time or another I'm sure we all have inherited problems generated by someone else's decisions. They may involve **less than lot size shipments** where the quantity available doesn't meet our needs or conversely where the quantity available will meet our needs but the supplier is holding back shipment until the full amount is available. Or how about when we are waiting for a particular part that is ready to ship but it is waiting for the filling of a **bulk box?** There is also the possibility of **capacity constraints** in which case the supplier may decide the importance of the material to be made as opposed to asking the user's preference. And lets not forget **human error**. Sometimes we make decisions based on our experiences which do not necessarily result in the best choice.

2. Designated Carriers — One of these 'best choices' may involve using a carrier chosen by the customer. The specified carrier may provide **excellent service** to a **particular region** of the country, but not to all of them. With good intentions, they accept the challenge of delivery outside of their area of efficiency, and unfortunately, sometimes they may fall short. In their efforts to remain in the good graces of the customer, they may **fail to communicate** the **delays,** and in some cases, may avoid telling the customer that their shipment has been **temporarily lost.**

3. Quality Adjustments — No one has quality problems...everything is perfect. Sometimes though, we make minor improvements which turn out to be major catastrophes. A better grade of **material** may be **substituted,** when in fact its use may demand requalification or testing. Someone may spend alot of time **correcting a problem that has existed for years** but is one which everyone has accepted as the norm. And unfortunately there is still the **buyer beware syndrome** — where a problem won't be admitted until the other guy figures it out.

4. **Exchange of Statistical and Technical Information** — Historically, and just because of the nature of the business, everyone should be and is protective of vital information. **Premature failures** and **modifications** - both functional and **safety** related **issues** are nothing to be proud of. But one railroads change in material composition, handling or even packaging could have an affect on the entire industry.

Lastly, there are,

5. **Budgetary** and **Financial Constraints** — Current **market conditions** and **legislation** directly affect our business. They determine the industries' spending patterns, and influence our impact on the transportation industry. Consequently our **cash flows** determine our rebuild and maintenance programming.

But we are not here to tell you how or what to communicate. We are just trying to emphasize its necessity, and to encourage you to communicate your objectives to others who have the need to know.

SEE OUR ADS ON PAGES 52-53 — 249-250

WHAT'S YOUR PROBLEM PANEL

Moderated by Mr. Allen Keller — Mgr. Motive Performance, National Railroad Passenger Corp.

Allen Keller: So we'll open the floor to any questions at this time.

Mr. Bill Brown
(Burlington Northern Railroad)

I have a question for the Materials Committee.

In their presentation this morning, they had a lot of pictures of plastic banding or packaging of pallets versus steel banding and that type of thing and talked about the savings in terms of labor.

My question is,

"Isn't the plastic material today considered a hazardous waste? And what about all of the ramifications of disposing of that?"

Charles Miller (UP)

Hazardous waste, I'm not sure of. Scrap or waste problem in the shop floor, yes, it is a problem.

But the liability reduction of getting away from the metal banding, because of numerous accidents is more than offset by using the stretch wrap.

It really keeps the loads from shifting if it's done properly, as opposed to the banding.

The nylon banding is another alternative however it seems to be set aside in favor of the stretch wrap.

As far as the environment, I cannot answer that question. Maybe Keith can.

Mr. Keith Brinker (CSX)

Currently, plastics are not considered a hazardous waste. They don't meet any of the four characteristics and/or listing of a hazardous waste, as identified by the Resource Conservation Recovery Act.

Reading into your question, recent newspaper artices have addressed landfilling of plastics. Plastics are not biodegradeable and will remain in a landfull (in its original state) forever.

But as far as being considered a RCRA hazardous waste, plastics are not.

Mr. Bill Brown
(Burlington Northern Railroad)

Well, that prompts another questionw "If you can't dispose of them in the dump, what do you do with them? You've got to pay somebody to handle it then, I would think.

You just can't throw it in the trash. I guess that's really what my question was. It's a disposal thing. Whether it's hazardous or not, if you can't throw it away in a trash facility in your city, what do you do with it?

Mr. Keith Brinker (CSX)

Well, the states that I'm familiar with, we're currently not having a problem with disposal of plastics.

Is that a state requirement at one of your particular locations; that they're not accepting plastics?

Mr. Bill Brown
(Burlington Northern)

No, it just brought to mind what we've seen in the news recently about disposal of materials that won't break down.

And that really is what my concern is, whether the material is hazardous or not, it can be or could be, I guess, a disposal problem in some areas.

And what do we do about that? Do we pay somebody to dispose of it. Maybe it's something the committee could research for next year.

Mr. Keith Brinker (CSX)

Well, one area to investigate is what's known as waste reduction or waste minimization. And that's where recycling comes into play.

I believe within the next year, states will be required to develop and initiate recycling programs.

Just recently, I heard a newscast in Pittsburgh, Pennsylvania where the Mayor, Sophie Mazlov, is going to set up collection sites for glass, plastics, and paper within the city. By segregating the waste glass, plastic, metal and paper, the city will be able to reduce the amount of waste going into landfills and recover the value of recyclable wastes.

So that's probably a lot of what you're hearing too.

Charles Miller

The Diesel Materials Committee has chosen several topics, for next year dealing with hazardous waste, hazardous material handling and several other things having to do with hazardous material.

Allen Keller

Do we have any more comments on that subject?

If not, we're ready for the next question.

Mr. John Sefakis
(Farr Filter Company)

My question is in connection with the new generations of lube oil.

"How much can improved filtration help control viscosity and oxidation so that end result you get 92 day service out of your filters?"

Allen Keller

Keith, would you like to field that?

Mr. Keith Brinker (CSX)

Okay, I'll try to make a few comments on that subject.

As far as lube oil thickening goes, particulate matter can contribute to that, but with our newer, low oil-consuming engines, the majority of the viscosity thickening, I believe, is due to thermal oxidation.

So that the answer to your question, I think filtration would probably play a minor role in reducing viscosity increase.

Mr. John Sefakis
(Farr Filter Company)

My thinking is that with a new engine, the first year or two, what you're saying would be very accurate. But as the engines get older and you do have more blow by then you would have a higher particulate matter which would destroy the 92 day cycle as far as filter changes are concerned, if I'm correct.

Mr. Keith Brinker (CSX)

I'm sorry, but I didn't get all of your question. Could you repeat it again, please?

Mr. John Sefakis
(Farr Filter Company)

My question is that, as the engines get older and they get up into the two and three hundred thousand mile range and more and at that time while the blow by becomes more, particulate matter becomes a lot more in a crankcase also. At that time, wouldn't you be getting to the point where the filters load may not be able to make 92 days?

Mr. Keith Brinker (CSX)

Okay, I really don't have an

answer to that. Maybe somebody from one of the engine builders or oil companies in the field could assist me with the question.

Mr. Don Hudgens (Union Pacific)

There probably could be a potential for stopping viscosity increase due to particulate blow by in an older engine.

Although when you'd start having more blow by, you'd probably also start having more oil consumption, so you'd have increased makeup and it may be a wash.

I don't know of any studies that have been done, but it does seem somewhat intriguing. I think there may be the potential for stopping viscosity increase by filtration.

I see Dennis Bachelder over there. Do you have a response to that or something else?

Mr. Dennis Bachelder (Chevron Research)

It's been my observation based on field experience that frequently, with the modern oils, you seldom approach the pentane insoluble limits that are required to condemn the oil.

In other words, the modern railroad diesel engine oils are highly dispersant and correspondingly tend to pass all the particulate through the filter by keeping it from agglomerating.

In observation of actual samples from the field, we do not find that, as the locomotives get older, particulate contamination of the oil leads to sludging of the engine; sludging would be something where the filters might aid in keeping the engine clean.

It seems when the oils are changed frequently enough that particulate contamination does not become a problem.

Mr. Tom Savage (EMD)

I'm a Supervisor in the Engine Development Group.

I'd just like to make comment on the insolubles in lube oil in EMD engines. They typically don't rise above one percent.

We have a two percent maximum pentane insoluble limit, so we don't believe that insolubles are a large factor in thickening the lube oil and would not have a big effect on lube oil filter life in our engines.

Allen Keller

Are there any other comments on this subject?

If not, we'll go on to the next question.

Mr. Bill Brown (Burlington Northern)

I want to compliment the Mechanical Committee for what I thought was an excellent, informative paper this year and I fully agree with the concern that they expressed about the effect on traction motors that worn gearing has and that they mentioned in their presentation about the addition of lubricant, based on a judgement of color of the gear.

To my knowledge, there's no other viable method of determining how much grease is in the gear case, but how to do we get our mechanics in the pits to make the judgement without some kind of a guideline.

My question is,

"Why can't either the builders and/or the grease lubricant suppliers make up a shirt pocket sized, color code chart that takes any of the judgement out of it where they become familiar with the color?" Light tan takes three bags or something like that.

"Is that possible to get something like that for the industry?"

Mr. Doug Corbin
(Norfolk Southern)

I think your comments are excellent, Bill. In this day and age of videotape presentations, that might be something that the engine builders or the lubricant manufacturers might look into.

I don't know if any of them would care to comment at this point on that.

I think all shops nowadays are into the video presentation. That might be a help and then the pocket guide would probably help.

Mr. Dick Pekins
(GE Manager of Production Engineering, Erie)

As far as the color being an indication of the condition of the gear, one of the problems is that different gear lubricants might present a different visual picture to whoever is looking in the fill opening.

The ideal situation is that the gearing is covered with lube that is very black, very dark and if you see anything other than that, it would indicate that something is wrong in the gear case.

More gear lube would be a solution, possibly. If it's reached the point where you can see the color of the gearing, it may be blue, due to overheating, in which case more gear lube would not solve the problem.

But I think generally the lubes we're using now, the intention is to keep the gears covered and that's about all you should see when you look in the gear case.

Mr. Bill Brown
(Burlington Northern)

That prompts another question as to, "If a pound is good, isn't ten better?"

The color coding, from my experience, is the only way that I know of to really determine how much grease to put in the gear case after it changes from dark black to some other color.

The Committee did mention the colors and I thought that it (chart) would be a handy thing for a mechanic to have in his tool box or carry in a shirt pocket so he would know, at all times what he should be looking for. I think overcharging a gear case is as bad as undercharging.

You can cause yourself some other problems with a traction motor.

Allen Keller

I have one question myself on this subject, if I can. I don't know if this is legal, but I'm going to take the advantage of it.

"Does anybody care to make comments about what you do when you find traction motor gears that have run dry, where there is no lubricant left on them. Is that an immediate cause to remove that wheel set from service?"

Mr. Dick Pekins (General Electric)

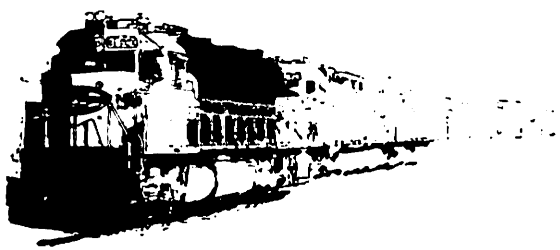
I think the question was, I didn't catch all of it, but I think the question was, if the gearing doesn't have any gear lubricant on it, is it enough concern so that it requires changing out right away.

Allen Keller

That's correct. That's the question.

Mr. Dick Pekins (General Electric)

If the gearing has been running very long without any gear lube, the



heat generated will soften the gears to the point where they'll start wearing very rapidly and it won't be too long before you don't have enough mesh left to carry the load.

The pinion will normally go first and you can't see that looking in the gear case. So if you see that the gear is without any gear lube, the pinion has probably reached the point where some action has to be taken immediately.

Mr. Ralph Robinson (Electromotive)

I generally concur with the comments that are being made about the gears and if there is sufficient material in there to keep them operating satisfactorily, they tend not to be in a situation that you can look at it and it's brown or anything else. It's dark. It's got sufficient lubrication.

And if it doesn't have, the heat that results can be a problem and that assembly is suspect. Nothing magic about it.

Mr. Willis Melgren
(TSD, Burlington Northern Contract Lab)

Reverting back to a question Bill Brown raised about the possibility of too much grease being a problem. We just recently addressed this in a meeting where I believe the BN had consumed something like six hundred thousand pounds of gear grease in the past year.

I think this does raise a question of the possible future environmental concern about where this grease is going. If a bag is applied every time it comes across a service track, regardless of looking at the conditions of the gears, is this overfill being purged out along the right-of-way as it operates?

This is a problem that, from an environmental standpoint we also need to address, not only the lack of grease, but possibly overlubrication.

Allen Keller

A related question on this subject from the mailbag concerns the presentation on vibration caused by profile deviation.

"Does vibration occur as a result of gear imbalance? Is there any available information on this subject?"

Mr. Doug Corbin (NS)

When they say gear imbalance, I'm not sure I understand exactly what they're speaking of.

Allen Keller

I think what they're referring to are gears that are put on a balancing machine and then finding that they're out of balance by "X" number of ounces or pounds.

Mr. John Madsen (EMD)

Our experience has been that the vibration due to gearing is almost invariably a result of worn gearing and it can be even made worse if you have a worn gear and pinion and change only one of them.

That can lead to even worse vibration than both of them having worn in together, so the ideal situation is to change them both at the same time. Or at least make sure you qualify them both by checking the wear.

Mr. Jim Manley
(CMC Manufacturing)

We reprofile gears. On one member's railroad gears, we had found that when the gear was sent to us for reprofiling, it was out of balance by 11.2 ounces, so there is some imbalance there.

How that would affect the operation, we have not looked into it any further. We found out that after grinding, it appears to improve, but not so much so that there's a standard that we could name at this time.

Mr. Bill Brown (Burlington Northern)

I've enjoyed hearing the discussion on gears and apparently we have a problem in the industry with worn gears, excessive grease, not enough grease. It all relates back to the root cause, which I think, is a gear case. There's been some improvements made in recent years on them.

And my question is to the locomotive builders,

"When are we going to get a gear case lubricant that won't leak?"

Mr. Dick Pekins (General Electric, Erie)

We're testing such a gear case right now and the results have been good. The gear case uses oil and not gear lube and it doesn't leak and it will go for ninety days without any service.

The problem in introducing such a gear case is having a group of locomotives with two different types of gear cases on them; one requiring the traditional gear lube, which is thick like a grease and the other using an oil, which is also a high viscosity oil, but it has no thickener in it.

The problem of needing two gear lubes will come up shortly, because we're going to be introducing some of those gear cases on new locomotives later this year.

They will go ninety days between service and with very low leakage.

Mr. Laurie Hunt (Railtech)

We manufacture the fiberglass gear case and we have a number of roads that are presently using grease and are availing themselves of the 90 day time interval between inspections.

With the one-piece wheel and motor seal and with the separator seal plate now being covered so that you don't get leakage from the pinion area and a better pinion seal and a better part-line seal, the member roads which are using the fiberglass gear case are now enjoying a 90 day service interval using grease.

Mr. John Madsen (EMD)

EMD is also working with oil as a gear case lubricant. We have a number of locomotives in the field now. We're monitoring those closely to pin down what kind of service life we expect.

At the moment, things are looking good.

Allen Keller

If there are no further comments on this subject at this time, I'll take a question from the mailbag here. The question is,

"What consideration has been given to the use of statistical process control to demonstrate if suppliers, individually, and, as a group, are getting better or worse in terms of quality, delivery and communication with the railroads?"

Charles Miller (UP)

If the question is about supplier evaluations and what is learned from the accumlated data, I can relate one railroad process to you.

All evaluations for purchasing and materials purposes, i.e. shipping to schedule, packaging properly, billing and pricing accuracy and all user evaluations for quality of the components are fed through a computer network to the Purchasing department. In other words, one single source for evaluations.

This allows for complete feedback to the supplier on an individual basis. I'm sure overall supplier analysis can be done very easily, and perhaps is being done, but I am not aware of it. I will mention to Purchasing the possibility of statistically evaluating all our vendors and making a ratings chart.

Mr. Tom Bump
(EMD-Quality Assurance)

At EMD, we've been actively involved with SPC since 1978.

In fact, Dr. Deming spent at least a couple of days training all our managers in the use of SPC.

We use it extensively in evaluating our ability to serve our customers on time. We try to identify exactly the root causes of any kind of delays, any type of quality problems.

It's used extensively throughout the company and if there's any particular questions that our customers have, we normally respond to them with information in a statistical way.

Mr. Doug Corbin
(Norfolk Southern)

We are presently looking at a system to put into our shop in Chattanooga that each mechanic, instead of filling out his production report for the day at each work station on our component rebuild, will be using a hand-held computer unit to input this information. And there'll be no paper at any of the work stations.

The idea being that as we have many suppliers in different parts, we'll be able to track the history of each piece, done completely through our local computer at the shop.

And that should not, we hope, add any time to the gathering of this information, plus it'll provide a way of correlating it instead of just turning in these work sheets and filing them somewhere.

So we should have, by the time we've overhauled the majority of our fleet, a history of whose components are in whose engine and which engine, how many times have they been reused, what are they dropping out of the reclamation line for, (what reason) and the whole intent of this system is to evaluate each supplier's product and how it's performing on our railroad.

Hopefully, we are going to be able to do this without adding any manpower or any real expense to the system, so that's presently being done on Norfolk Southern.

Allen Keller

Entertain some new questions from the floor?

Let's not be bashful now. Step right up to the microphone.

We have one here from the mailbag that looked kind of interesting to me. I'll read it. The question is,

"What corrective action is recommended to alleviate the constant problems with the General Electric exhaust manifold system?"

Mr. Robert Fischer
(Manager, Engine Engineering, GE)

Yes, we've been in and out of problems with the single-pipe manifold for a number of years and we've taken some very significant efforts recently.

A year ago, we looked in depth at

the single-pipe manifold and they had a lot of quality improvements and also some design changes to fix some of the leaking (the gaskets).

And that resulted in a new, basically a new single-pipe manifold with many changes that went into production the early part of this year. And to date, it has been performing very successfully.

The other major development. We've designed a totally new manifold that's what we call a dual-pipe manifold that improves both transients response and also built for reliability. It's basically a casting versus the previous fabricated manifold.

It's been on test in our engine lab for the past five months and by the end of the year, we're going to have quite a number of them out in the field.

Allen Keller

Another question from the mailbag.

"What is the probability of the EPA emission regulations being applied to railroad locomotives?"

Keith, do you want to become a wagering man here, a bookie and lay odds on that question?

Mr. Keith Brinker (CSX)

I just got word yesterday from the AAR that proposed regulations were made in Washington, D.C. yesterday afternoon (9-19-89) to include railroads in diesel emission regulations.

Mr. Doug Corbin (NS)

An additional comment to that. The Mechanical Committee has decided to try and take on this emissions topic from the rebuilding standpoint of the engine for next year.

So we're hoping to get some information on what you're going to have to do in overhaul to get a clean-running engine, anything in addition to what we presently think of now.

So we're going to try and hit that topic.

Mr. Keith Brinker (CSX)

In addition the Fuel and Lube Committee will be addressing diesel emissions; updating the recent proposed regulations and also addressing NIOSH-OSHA statement of diesel fumes being a potential occupational carcinogen.

Allen Keller

There's a related question, Keith, in this same letter in the mailbag that asks,

"What is the relationship between low sulphur, low aromatic diesel fuel and a reduced need for oil total base number?"

Mr. Keith Brinker (CSX)

Okay, I can touch on that.

As far as low sulphur fuel goes, that would reduce the acidic production of combustion byproducts, therefore, it could reduce the need for your TBN requirement.

A reduction in aromatic constituents affects your cetane value. The cetane value would be locked into a higher value such as the current ASTM spec of 40. Also, there's the potential to reduce particulate matter.

There may be some people from the oil companies on the floor that would like to comment on that also.

Mr. Dan Meyerkord (Project Engineer, EMD)

My comment regarding sulphur in diesel fuel is that in the combustion process sulphur is oxidized and can generate sulfurous and sulfuric acid, which are corrosive and contribute to engine wear.

The TBN portion of the lube oil serves to neutralize those corrosive acids. So reducing the sulphur content in diesel fuel may allow oil suppliers to lower the TBN content.

I offer that as a comment.

Allen Keller

Do we have any comments from any oil suppliers, oil company representatives, on that subject?

Mr. Bill Runkle (Ashland Oil)

I think Keith has pretty well covered most of the area. I guess there's one maybe additional observation that if the reduction in aromatics reduces the particulate going into the air, it also reduces the particulate going into the oil, so you need less detergent for control of deposits.

And that also will impact the need for a higher base number, which comes mostly from detergents.

Allen Keller

Need some more questions from the floor.

Mr. Dave Goehring (Amtrak)

I was sitting beside Bill Brown. Since he's left, I got the bug.

Al, one of the things that we've been having problems with at Amtrak is the delivery of dirty fuel to our locomotives and the resulting plugging of filters and problems with injectors.

"I noticed on a recent Via Rail locomotive that it had dual primary filters. Are there any other railroads going to that kind of filtration system on their locomotives or are they retrofitting existing locomotives?"

It seems to me that the quality of fuel that we're getting from vendors is not of the same high standard it had been ten years ago.

Allen Keller

Doug, would you want to make any comments about that subject, on secondary filters, the spin-ons on Norfolk Southern?

I understand that you people do use something that's not quite the same as manufacturer's standards on the secondaries or spin-ons.

Doug Corbin (NS)

Well, we do use the longer filter. I don't know what the model or number of it is, but we do use the extra long spin-on filters on the engine across the board, except where you have the problem with interference with the engine on some of the older models.

Mr. Henry Marta (EMD)

I believe all freight locomotives we have supplied in the recent past have dual fuel filters. Furthermore, any locomotives that Amtrak or other passenger railroads got in recent years, at least since 1988, may have the dual fuel filters if this was ordered.

Mr. John Sefakis (Farr Filter Company)

I have personnally been involved directly with quite a few railroads, working to improve fuel filtration and fuel conditions on board the locomotives.

Some railroads right now are swinging over to our two-stage filtration system for waysides, which is the beginning of the cycle of improved filtration toward the end result of secondary filters on the engine mak-

ing 92 days in service.

If you correct your wayside problems, then you can look at a primary filter on board the locomotive to do the job, which again, should be a two-stage filter.

The end result, your secondary problems are eliminated and you can make 92 days between filter changes, plus extend engine life.

Allen Keller

I have another question from the mailbag that's on a subject, I'm sure, is of interest to a lot of us who have to try to keep locomotives running from day to day.

And the question is going to be directed to the Electrical Committee initially for some answers. The question is,

"What can be done to eliminate moisture grounds in rebuilt traction motors?"

Mauro Pasini (Via Rail)

It is my feeling that if the question was intending to say that before installing the traction motor you have to eliminate the moisture, the only way you can do that, in my view, is to inject hot air in the traction motor.

When the traction motor is installed, I guess that is too late to do that.

Mr. Joe Turvolgyi (Canadian National)

I wonder if anybody heard about washing traction motors.

We put them in a Proceco washer, armature facing upward. We remove the caps, (the axle caps) and wash them, and then we dry them out. We tried various means of drying them by hot air, from an electrically-fired source. We found that if you used a gas heater like you have in the football games behind the benches, you loaded up the motor with all kinds of grease.

Where the other thing is even better is to use a couple of welders to heat the motor internally, but we have, in two of our shops now, a traction motor washer.

So when we change wheels and we take a motor off and the motor is dirty, but perhaps very low in resistance, we put it in the washer without disassembling it, wash the whole thing and then dry it internally with the use of two welders.

Mr. John Madsen (EMD)

Regarding moisture grounds on motors, the Proceco washer and I suppose similar equipment gives good results. There have been some amount of problems because some of the washing compounds are hygroscopic.

If you leave any residue of this type of compound in there it will tend to absorb moisture out of the air right back into the motor.

So one of our recommendations has been to make sure the motor gets two rinses. In a Proceco machine, you have three parts to the cycle. We recommend using the detergent or the cleaner in the first part of the cycle and following that up with two rinses to ensure that you get all of the residue of the cleaning compound out of there.

Then, of course, you need to dry the motor out and previous comments are applicable there. You don't want to add any contamination to the motor. Depending on what caused the moisture ground, the procedure may or may not be effective. To avoid putting reconditioned motors that are still susceptible to moisture grounds back into locomotives, the motor can be tested first by spraying its interior with tap water. If the motor passes, it is not necessary to dry it again since it will get wet numerous times in service anyway. You can also check motors in locomotives this way to avoid unpleasant winter surprises.

Allen Keller

Are there any other comments on this subject?

I have one question for Mr. Travolgyi on this matter yet.

You found apparently that this is cost effective; that when you go through this procedure, "The motor will go out and last and will not get into trouble in the next snowstorm or the next two snowstorms?"

I'm sure you've kept some good records on your railroad.

Mr. Joe Turvolgyi (Canadian National)

The next two snowstorms in our case means the next two days.

No, we believe in it. We're putting it into our major running shops and we feel that it's quite cost effective. It reduces the number of motors that you have to take back into the motor shop.

And as I say, we stand the motor up, remove all the inspection covers all around and give it a thorough washing.

And then about two or three hours of drying from the inside out by applying current into the armature, into the fields.

Allen Keller

Maybe you have the secret up there in Canada as to what you can use to wash the motor.

Mr. Turvolgyi (Canadian National)

Well, I haven't got the name of the detergent that we're using just at hand, but the most concentrated part of this stuff has to be removed by suction truck.

Some of the rinse water gets down into the drain.

Allen Keller

You just use a normal household type detergent then. It's no exotic chemical or degreaser.

Mr. Joe Turvolgyi (Canadian National)

It's an industrial-type detergent. I'm sorry, I think Oakite makes it, but I don't know the number.

Allen Keller

Thank you for your comments.

Mr. Keith Brinker (CSX)

I may be able to comment a little on the type of cleaner you're asking for. CSX is currently using a very mild alkaline cleaner with no free caustics. It's primarily sodium metasilicate, which can be compared to industrial strength Tide. The cleaner does a very good job.

With the Proceco washers the majority of the cleaning is from the high pressure spray and hot water.

Allen Keller

Any other comments on this subject?

Mr. Bill Cammack (C&H Chemical)

We also have a product, like Keith mentioned, it is sodium metasiliacate based and falls into the category of industrial strength Tide.

We have another railroad that is using a caustic soda based product with equal success. It seems to be somewhat of a user preference.

One thing to remember in all of these alkaline-cleaning processes is that you're washing with an electrolyte solution.

And if it's not rinsed properly, as the EMD representative said, the residue that's left behind can be electrically conductive, as well as in some cases being hygroscopic.

So the need for rinsing is very definite from a couple of standpoints. But there's a number of manufacturers, (we are one) and we have a couple of products that are used for traction motor washing.

There's a number of my competitors that also have good products.

Mr. Glen Peters (Santa Fe Railway)

We've had the unforunate circumstance in the last thirty days or so that we have overfilled some of our flange lubricator reservoirs. The engine heat has expanded the lubricant and ruptured a hose on the bottom of the reservoir.

My question to this panel is,

"Can anyone give us some insight on how you clean graphite grease up off the floor of a carbody?" The only solution, at present, seems to be the use of lots of paper towels and hand rubbing.

Mr. Keith Brinker (CSX)

Glen, have you tried a petroleum solvent?

Mr. Don Hudgens (UP)

Glen, have you tried something like oilsorb (the clay material)? Kind of thicken the whole mess up and then use a grain scoop.

Mr. Glen Peters (Santa Fe Railway)

I'm going to turn this over to Mr. Jim Hensley of Santa Fe who has first-hand experience at Barstow on this.

Mr. Jim Hensley (Barstow, Santa Fe)

Is there any thought to making a water soluable grease or oil that could be washed out of these carbodies.

Now, I know everybody I've talked to has said, yes there is no problem, we fill them, we don't have any spills, we don't have any leaks.

I can't really believe that. What I need to know is, "Is there any thought to anything that would be water soluble; that we could use that would be as effective?"

We're having a terrible problem cleaning them. We're having to steam them, we're having to use whatever it takes. It is very time consuming and very costly to clean up these spills that are there.

Mr. Keith Brinker (CSX)

My comments concerning a water soluble cleaner would be from the environmental standpoint.

Water soluble cleaners will emulsify the oil and greases in your waste water and that plays havoc with your waste water treatment plants and the potential civil and criminal penalties for continuous violations of your waste water discharge, I think, probably would outweigh the use of those products. Also, you would not want to use a product that requires special handling and disposal practices.

Glen Peters (ATSF)

Don, your suggestion on the oilsorb. We have not tried it, but that sounds like something that would be worth a try.

Allen Keller

The floor is open to additional questions.

I have one from the mailbag for you, Keith. You seem to be a popular fellow this morning.

It's a two-part question. The first part is probably easy to answer.

"When does the new Generation V definition become effective?"

And the second part of the question is,

"Does the new Generation V definition cover 20W40 and if so, how would a Generation V 40-grade weight oil compare with a Generation V Multi-visc 20W40 in terms of TBN depletion, viscosity increase and wear?"

Mr. Keith Brinkley (CSX)

Well, the answer to the first question, Generation 5 became effective yesterday morning (9-19-89) and applies to both 40 and 20W-40 grades. I would like to refer your second question to one of the oil companies for answering.

Jim Turner (Exxon)

When comparing a 40 grade with a 20W-40, you must first consider the fact that these two oils are blended to the same viscosity at 100°C (212°F) and contain the same amount of a detergent additive. Therefore, if they contain the same additive concentration, you would expect the TBN or total base number depletion to be the same or very similar.

The second part of the question was related to viscosity increase. Here is the area where a 20W-40 will differ somewhat from a 40 grade. This is due to the fact that a 20W-40 oil is blended with a lower viscosity base stock. Then you add the detergent additive plus a high molecular weight polymer called a viscosity index improver.

I do not believe that the lower base oil viscosity will influence the oil film thickness to an extent that you would see differences in the engine wear rates. I would fully expect the wear characteristics of the 20W-40 to be essentially the same as that of the 40. But the organic polymer or viscosity index improver is going to be subjected to shear in the engine. This shearing action will cause the polymer to partially break down which will result in a 5 to 10% loss in the 20W-40 viscosity during the first 500 miles of operation. This viscosity loss should not be confused with fuel dilution of the oil.

The polymer breakdown will affect the used oil viscosity increase. This will cause the percentage viscosity increase to be smaller for a 20W-40 versus a 40 grade.

Allen Keller

I don't know who the originator of the question is. If he's here and we didn't answer his question, he's free to step up to the microphone and ask for clarification.

The floor is open for additional questions.

Mr. Blair Smith (CSX)

I have a question on traction motors.

"Since everybody seems to be washing traction motors, do we drill holes in aluminum baffles. Can we get the vendors and builders to do this?"

The aluminum field coil baffles in EMD traction motors tend to hold water.

Mr. John Madsen (EMD)

I've seen railroad shops put holes

in the baffles to help drain the water out. We haven't found it to be necessary.

On the other hand, I don't think it's harmful, except if you drill both ends of them with a rather large hole which lets air go through the baffle instead of going around the baffle and cooling off the windings.

Blair Smith (CSX)

We also have problems with the varnish. When we flood the frame with varnish, the baffles will want to fill up with varnish and you have to have a longer drain time, unless you have holes drilled in the baffles. The holes let excess varnish drain out.

I think the vendors and the manufacturers should incorporate the baffle holes in their traction motors.

Mr. John Madsen (Electromotive)

With the insulation systems that we currently use on stators, we haven't seen evidence that varnishing them does any good.

Again, if you had a hole in the appropriate end, that would solve the varnish problem too.

Allen Keller

Any further comments on that subject?

I have another one from the mailbag here that might be of interest.

The question makes a statement first and it's a compliment to the Mechanical Committee.

Two fine videos were presented on the merits of barrier versus impingement filters for secondary locomotive air filtration.

The writer asks first,

"Would any engine builder or railroad care to comment on the ability to get twelve-month life on paper filters?"

And while you're thinking about that one, his second question is,

"Are manometer pressure readings really used to monitor filter conditions?"

Doug Corbin (NS)

From a railroad with all baggy filtration, I kind of have to refer some of that to anyone that might want to comment from a railroad that has a mixed bag.

Allen Keller

Come on, all you filter users. Get up here and get you licks in.

Mr. John Sefakis (Farr Filter Company)

Being that the railroads won't speak up, I guess I'll help a little bit.

There is one railroad right now that has bought all their SD 60 power with RC300 paper filters and there's only been one instance in three years that they didn't make twelve months.

And if you ask around, you can find out who it is. It's not for me to say.

Another railroad has had good success with paper filters. The fact is that the railroads have had tremendous business during the last year or so and the mileage has doubled on locomotives.

When that happened, the filters paid the price along with everything else. But that should include also all filters, not just air filters.

Mr. Don Hudgens (UP)

As far as the second part of the question is concerned about doing manometer readings; a manometer could certainly tell you if the filters are plugged. You would have a big pressure differential.

But if you don't have a big differential, you may still have problems. If the filters are not seated properly or ruptured or torn, the manometer would look fine, and yet, you could still be sucking a lot of dirt into your engine and causing considerable damage.

Oil analysis can pick up that and you'll know from high silicon and iron readings in the oil that you have problems. But, manometer readings can tell you something.

Allen Keller

Something tells me that the writer of this particular question lives out there in the real world and I think he's one of these fellows that, when an engine comes in and it's got loading trouble, one of the easiest things to do is change the filters.

And I think that may be from the corner of the woods is where he's coming from.

His second question kind of leads me in that direction too.

Anybody want to make any comments about that?

Maybe we're the only one that changes paper filters for a loading trouble.

Mr. John Sefakis (Farr Filter Company)

It sounds like I'm making a sales pitch, but being that I'm out there in the field, I see answers for some of these questions that I should bring up.

For example, there is a filter indicator on the market now that gives you increment readings in inches. So if a railroad wanted to use that indicator, they wouldn't have to rely on manometers and still get good answers as far as whether they should change filters when they come in reported not loading properly and so forth.

Mr. Mark Coles (UP)

On the UP, we do have quite a few locomotives that have paper filters on them.

As to whether they'll make a year or not and what you have to do, there's a lot of things you have to look at and the manometer reading is part of the real world. Getting it done is extremely difficult.

A lot of times when you get on a locomotive, you find that the crewmen have plugged little ports where the manometer is attached rendering them useless.

Problems with the filters sealing against the back of the housing can give you a false reading. Knowing that in the past we've had a very difficult time getting to a year with the filters, depending upon the service the locomotive is in, where it's been running, whether Mount St. Helens blew up or not, where filters don't last more than a couple of days.

We've gone to a scheduled changeout at a time early enough to make sure that the filters aren't plugged.

One of the things you have to think about is why the filters get dirty in the first place and one of the things you always have to look at on your locomotive during your maintenance is the air filter compartment itself.

It's essential that when you do maintain the locomotive or go through an inspection, that you make sure your air compartment door seals are good, because if those seals are bad, they're not sealing. If there's holes in the compartment, you're just going to be sucking a lot of extra dirt into that compartment.

Another thing is the condition of your inertial filters. Regular cleaning of your inertial filters and the condition of your blower motor, (filter blower motor) is going to have a tremendous effect on how long those filters last, both the paper type and the bag type filters.

So there's a lot of factors that can effect it. And like I say, what we have done is gone to a six-month interval. I realize it may be somewhat more expensive by changing them out when they may not need it, but in effect, I can't afford the road failures either. So it's a little cheaper to throw away a paper filter than have a road failure.

Mr. Tom Savage (EMD)

I think it's difficult to make a definitive statement about the life of filters.

As Mark has explained, there are many factors that influence the life of filters and it's something that needs to be monitored and when the filters need to be changed out, they need to be changed out.

Manometer readings are certainly a way to get after that, although they do have some difficulties of their own, as Mark has explained.

Doug Corbin (NS)

Just as a comment from the Mechanical Committee. It definitely was not our intent to recommend one over the other, but we felt like there's a lot of history in this secondary filtration that a lot of the newcomers are not aware of.

We wanted to get a lot of facts and information out there and with all the varied environments present, each member road has to make their own decision. There's no question there, based upon the facts that we tried to relate in our presentation.

So I think the people that came forward and helped us out did an excellent job (the suppliers) and they put a lot of information out there.

It's up to you at this point and that was our intent.

Thank You, Allen.

Allen Keller

Any further comments on this subject?

The floor is open for questions.

We're getting close to the wire. I have an interesting one here from the mailbag yet and this seems to be your day, Keith.

The question is,

"What are the mechanical concerns of purchasing diesel fuel at or near the current #2 maximum fuel sulphur level of .5% if these fuels can be purchased at significantly lower costs?"

Mr. Keith Brinker (CSX)

To answer that question, when using a #2 diesel fuel approaching .5% or just higher percent sulphur levels of your current fuel, you need to be concerned about corrosive wear and TBN retention. Also, sulpher is a major contributor to particulate emissions, which is becoming more of a concern.

Allen Keller

Any comments from any of the builders about that? Running fuel with higher sulphur levels and I don't know if anybody's ever tried to document any increased wear; increased cost from increased wear.

Mr. Ralph Robinson
(Service Manager EMD)

There has been work done to try and document the effects of increased quantities of sulphur and fuel on engine wear.

Much of that information was made available to everyone here years ago in the documentation that comes out of Electromotive.

There was a Pointer's article several years ago that gave indications as to the amount of increase in sulphur and the effect in the component life of the power assembly.

A lot of our export customers in foreign countries, because of the lack of availability of as good a quality fuel as we have in North America, use high sulphur fuels. There are special things that can be done to accommodate them. But that is usually at the cost of more expensive components and shorter life as well.

So in essence, it's an economic tradeoff. If you want to use higher sulphur content fuel, the life of the components will be reduced and the cost for the maintenance of the locomotive will be increased.

And depending on the tradeoff that is found, some customers may find it to be worthwhile and some not.

Allen Keller

Are you at the point where you can say that 1/10th of one percent is going to cut this much life off of an assembly or are you at that point yet?

Mr. Ralph Robinson
(Service Manager Electromotive)

The Pointer's article that I mentioned dates back several years, but the basic information, I believe, is still applicable and it gave orders of magnitude.

At the time that article was prepared, the types of oils now available were not available, so that has an affect as well, both with respect to performance and economic tradeoff.

Tom Savage, in our Engineering Group, may have some additional comments specifically with the newer experiences we have with that.

Mr. Tom Savage (EMD)

My first reaction is that .5% sulphur in diesel fuel is not too high. We deal with sulphur levels that are significantly higher than that.

My second reaction is, with a proper TBN level oil in the engine, there shouldn't be any adverse effects of having .5% sulphur fuel.

I believe EMD engines will operate well with 13 TBN oils. And certainly with the newer (17-18) TBN oils, there should not be any detrimental effects of using fuels with sulphur up to .5%.

Mr. Robert Fisher
(General Electric Company)

I'd like to also mention that we did studies many years ago looking at the same issues and have some amount of data.

But again I'd like to also say, with the newer oils it's not as much a problem. Running .5 sulphur fuel should be no problem at all.

The other point I'd like to make is it depends a lot on the maintenance. In other words, you have to run the engines at proper temperatures, because if you let the radiator systems and the engine run cold, then you get into a lot of problems.

And we found, in the export where we generally run the higher sulphur

fuels, if they do maintain the units properly, keep the temperatures right and maintain the radiator systems, generally there's no problems.

Mr. Eli Shamah
(Oronite Technology Division of Chevron Research Company)

The question is how fuel sulphur affects corrosive wear. We, at Chevron, have done a lot of work with fuels having a wide range of sulphur levels.

Fuel sulphur will not cause corrosive wear so long as the oil in the crankcase has some TBN left to neutralize the effects of acidic components from combustion. By the way, not all the acids come from fuel sulphur. Since combustion involves nitrogen, hydrogen and oxygen you have nitric acids, also, other complex reactions form acids all of which have to be neutralized by the oil.

As long as there is TBN left in the oil, it will minimize corrosive wear. It's when the oil TBN is reduced to zero or very low levels that corrosive wear takes place.

Using high fuel sulphur levels, in the 2% to 3% range, will deplete oil TBN faster, so you have to use 20 or 30 TBN oils in order to get reasonable oil life.

So its a question of balance; fuel sulphur, by itself, will not cause corrosive wear unless the oil has no TBN left to counteract it.

Allen Keller

Thank you, Eli.

Our time is up. If there are no further questions from the floor, I want to thank everyone here who has participated; oil company representatives, engine builders and railroad members alike and other suppliers.

Thank you for your help and participation. I'll now turn the meeting back over to Don Hudgens.

Mr. Hudgens

Any comments you made today were recorded by our Secretary. He is going to be sending you a copy of what you said and he would like you to review it, make corrections, if necessary and let him know as quickly as possible; otherwise, he's going to go ahead and publish as it's stated.

I'd like to thank the "What's Your Problem Panel" and you folks for your participation.

SHOP EQUIPMENT COMMITTEE
EIGHT-YEAR INDEX

1988

Theme: "Streamlined Systems for Locomotive Servicing"

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

1987

Productivity and Quality Improvement in Shop Facilities

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

1986

Low Cost Through Quality Tools and Equipment

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

1985

Improved Methods of Maintenance Management and Material Movement

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

1984

More Productivity At Lower Cost

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

1983

Training and Tools Will Do The Job

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

1982

Quality Maintenance Through Modern Tools

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

1981

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

FUEL AND LUBRICANTS COMMITTEE
EIGHT-YEAR INDEX

1988
Theme: "Lubrication '88 — The Vital Link To Successful Railroading"

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

1987
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
SIX-YEAR INDEX

DIESEL ELECTRICAL MAINTENANCE COMMITTEE
EIGHT-YEAR INDEX

DIESEL MECHANICAL MAINTENANCE COMMITTEE
EIGHT-YEAR INDEX

DIESEL MATERIAL CONTROL COMMITTEE EIGHT-YEAR INDEX

Diesel Material Control Committee (Cont'd.)

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.