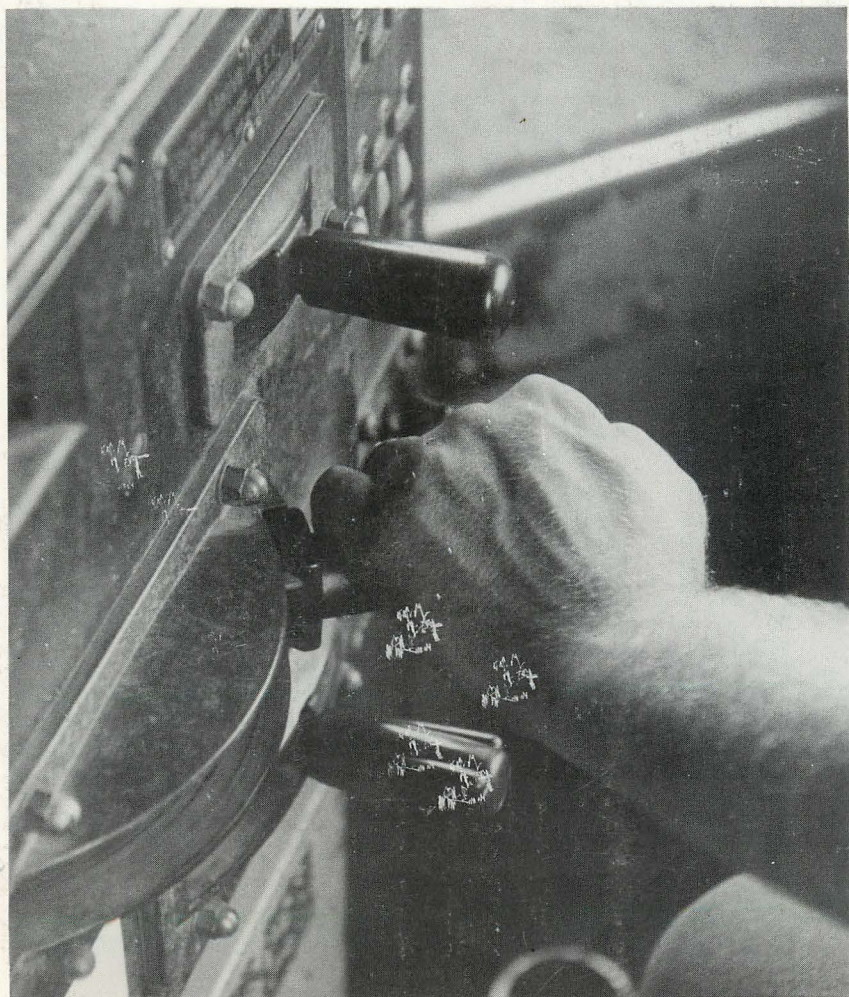


LMOA

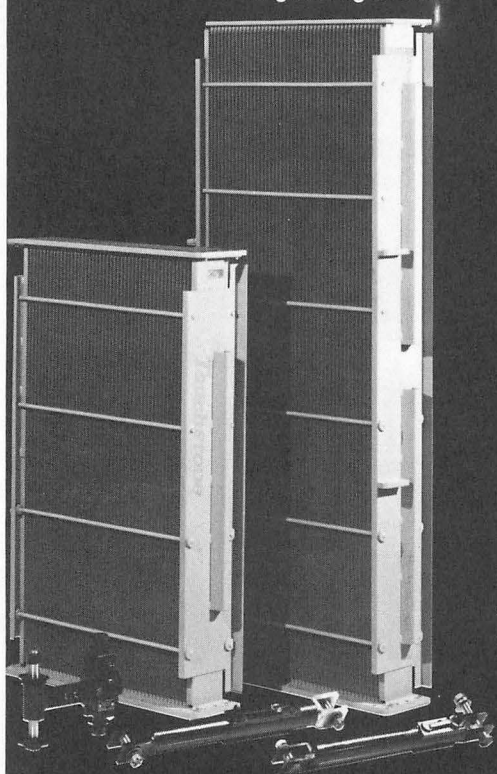
Locomotive Maintenance Officers Association

Proceedings of the 55th Annual Meeting
Chicago, September 13-15, 1993



THE FINE POINTS OF TOUCHSTONE INNOVATIVE QUALITY AND RESPONSIVE SERVICE

- Touchstone products are designed to withstand the tough performance environment
- Touchstone is well known for its innovative problem solving
- Touchstone has the ability to react to the changing requirements of locomotive cooling systems and other mechanical requirements of locomotives
- Touchstone has a well-deserved reputation of "Delivery-When-Promised"
- Touchstone offers complete custom cooling systems engineering services



TOUCHSTONE SOLDERED AND
MECHANICAL BOND RADIATORS AS
WELL AS BRAKE ADJUSTERS ARE
AVAILABLE FOR ALL DIESEL
LOCOMOTIVES AND LOCOMOTIVE
CONVERSIONS



Touchstone Inc.
P.O. Box 7568
Jackson, Tennessee 38308
(901) 424-5060

1993 ADVERTISERS INDEX

LOCOMOTIVE MAINTENANCE OFFICERS ASSOCIATION

AUTOMATIC EQUIPMENT	193
BACH-SIMPSON	209
CAM INDUSTRIES	69
CHEVRON CHEMICAL (ORONITE DIVISION).....	93
CHEVRON USA.....	11
CITATION CHEMICAL.....	183
CLARK FILTER CORP	159
CONOCO.....	101
C & H CHEMICALS	29
DUROX EQUIPMENT.....	15, 17, 19, 21
ELECTRO-MOTIVE DIVISION	41
GENERAL ELECTRIC COMPANY.....	49
GENERAL ELECTRIC-APPARATUS SERVICE DIVISION	27
GRAHAM WHITE.....	33
GRIFFIN WHEEL.....	151
G & G LOCOTRONICS.....	211
HAYNES CORPORATION	163
HUGHES RAILWAY SUPPLIES.....	37
HYDRO DYNAMICS.....	141
INTERSTATE DIESEL	168
JBI, INCORPORATED.....	75
LPI, INCORPORATED.....	77
LYONDELL PETROCHEMICAL	85
JOHN W. MAHON CO.....	74
MILLER FELLPAX CO.....	214
A.T. MOELLER CO.....	79
MORAN ELECTRIC CO.....	197
MOSEBACH MFG. CO.....	145
MOTOR COILS, INC.....	5
NTN BEARING CORP.....	173
PENN LOCOMOTIVE GEAR.....	INSIDE BACK COVER
PRECISION INDUSTRIES	10
PRECISION NATIONAL PLATING SVCS.....	OUTSIDE BACK COVER
PRIME MFG. CO.....	185
PULSE ELECTRONICS, INC	215
Q-TRON	205
RAILROAD FRICTION PRODUCTS	157
SHELL ADDITIVES	229

SHELL OIL CO.....	139
SIMMONS MACHINE TOOL CORP	63
SNAP-ON TOOLS CORP	155
SNYDER EQUIPMENT CO	179
SUNDSTRAND DATA CONTROL, INC.....	201
TAME, INC.....	217
TECHNICAL SERVICE AND MARKETING, INC.....	187
TECHNICAL SERVICES LABORATORIES, INC	97
TEXACO, INC.	89
TOUCHSTONE, INC.....	INSIDE FRONT COVER
TRIANGLE ENGINEERED PRODUCTS.....	71
UNOCAL 76.....	81
VMV CORPORATION	59

COVER PHOTO COURTESY OF

PEAKER SERVICES, INC.

LOCOMOTIVE MAINTENANCE OFFICERS APPRECIATES THESE 1993 SUPPORTING ADVERTISERS

AUTOMATIC EQUIPMENT	GEN'L. ELEC.-APPAR. SVCS. DIV.	MILLER FELLPAX CO.	SHELL ADDITIVES	UNOCAL 76
BACH-SIMPSON	GRAHAM WHITE	A. T. MOELLER CO.	SHELL OIL CO.	VMV CORPORATION
CAM INDUSTRIES	GRIFFIN WHEEL	MORAN ELECTRIC	SIMMONS MACHINE TOOL CO.	
CHEVRON CHEMICAL (ORONITE DIV.)	G & G LOCOTRONICS	MOSEBACH MFG. CO.	SNAP-ON TOOLS CORP.	
CHEVRON USA	HAYNES CORPORATION	MOTOR COILS, INC.	SNYDER EQUIPMENT CORP.	
CITATION CHEMICAL	HUGHES RAILWAY SUPPLIES	NTN BEARING CO.	SUNDSTRAND DATA CONTROL, INC.	
CLARK FILTER CORP.	HYDRO DYNAMICS	PENN LOCOMOTIVE GEAR	TAME, INC.	
CONOCO	INTERSTATE DIESEL	PRECISION INDUSTRIES	TECHNICAL SVCS. & MKTG., INC.	
C & H CHEMICALS	JBI, INCORPORATED	PRECISION NAT'L. PLATING SVCS.	TECHNICAL SVCS. LABORTORIES, INC.	
DUROX	LPI, INCORPORATED	PRIME MFG. CO.	TEXACO, INC.	
ELECTRO-MOTIVE DIVISION	LYONDELL PETROCHEMICAL	PULSE ELECTRONICS, INC.	TOUCHSTONE, INC.	
GENERAL ELECTRIC CO.	JOHN W. MAHON CO.	RAILROAD FRICTION PROD.	TRIANGLE ENGINEERED PROD.	

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**.

We sure to read their ads in the Annual Publication.

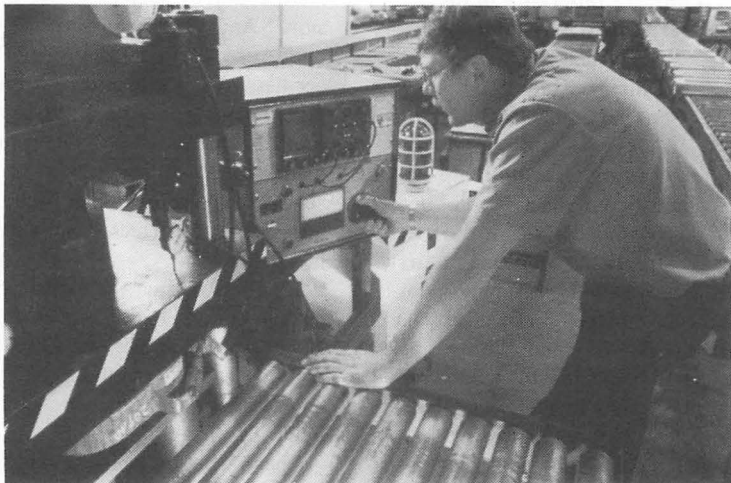
INDEX

JOINT MEETING OF COORDINATED ASSOCIATION - 9/13/93	6
PRESIDENT'S ADDRESS - WEYLIN DOYLE	12
ACCEPTANCE SPEECH - MARK COLES	26

TECHNICAL PAPERS

NEW DEVELOPMENTS COMMITTEE.....	31-58
SHOP EQUIPMENT.....	60-78
FUEL LUBRICANTS & ENVIRONMENTAL COMMITTEE.....	80-142
DIESEL MATERIAL CONTROL COMMITTEE.....	143-158
DIESEL MECHANICAL MAINTENANCE COMMITTEE.....	160-188
DIESEL ELECTRICAL COMMITTEE.....	189-216
RECAP PRIOR TECHNICAL COMMITTEE PAPERS.....	218-228
BY-LAWS.....	230

Our Quality Control Assures You Reliable Operation



Motor Coils has a staff of over 35 quality technicians and engineers auditing and conducting performance tests throughout the manufacturing process. Our quality systems provide verification, traceability and accountability. And once it's installed, this means reliability for you.

Motor Coils' high quality combined with our superior customer service is the reason that we're the primary supplier of traction motors and related components to every U.S. railroad, and independent companies that repair and rebuild locomotives.

So if you need traction motors or related components, call Motor Coils for immediate installation. **1-800-245-0240**

"Quality. Service. Price."



MOTOR COILS

ESTABLISHED 1944
A MURRISON-KNUDSEN COMPANY

100 Talbot Avenue Braddock, Pennsylvania 15104

**REMARKS BY
CHARLES E. DETTMANN
Vice President
Operations and Maintenance
Department
Association of American
Railroads
Before the
Technical Conference of the
Coordinated Mechanical
Associations
Chicago, Illinois
September 13, 1993**

Good Morning! Recognizing that this Technical conference is Joint with the 32nd annual convention of the Railway Supply Association, I first would like to salute the supply industry. You have helped make this industry what it is today and although my remarks will be pointed toward the railroad professionals in attendance, I certainly expect they are equally applicable to you in the supply industry.

The railroad industry has long been notorious for its reluctance to change. This isn't news to any of you who have been around for a while. We once could get and keep customers simply because they had nowhere else to go. We told them what kind of service we'd offer and what we'd charge, and they either went along or didn't move their goods.

That was before the interstate highway system criss-crossed the country, before we were thrown into the competitive arena by the Staggers Act, and before customers started telling us what they wanted or they'd take their business elsewhere -- and did.

In other words, it was before we had to change from standard operating procedures to offering whatever the customer wanted. And, as you know, change doesn't come easily to this industry.

The fact is our industry is steeped in tradition -- but sometimes tradition can blind you to the need for change, even if the need is obvious.

A good example is the story of the battleship captain who one night finds his ship on an apparent collision course with another ship. The captain signals "turn south 10 degrees to avoid collision." And the response comes back, "you turn north 10 degrees." Well, needless to say this infuriates the captain, who signals back, "I say turn south 10 degrees! I am a captain on a battleship."

And the response comes back: "I say turn north 10 degrees. I am an ensign in a lighthouse."

Needless to say, the captain had to change course. He had to give up his stubbornness and become flexible. He not only had to "see the light," but he had to maneuver in response to the light.

That's what the railroad industry has begun to do. In the past few years railroads have come a long way toward flexibility. Productivity has increased, costs have been cut, operations have been streamlined -- all in response to a rapidly changing environment that gets more competitive by the day.

And we've been trumpeting those changes. We've done our best to let the world know that today's railroad industry is better than yesterday's. But all the advertising and public relations in the world won't bring us customers. What brings us customers -- and, perhaps more important, what keeps our customers from straying to the competition -- is reliability. That's what we sell and, if we run out of it, our customers will get it somewhere else -- it's that simple.

That's the railroad industry's bottom line in the 1990s -- reliability. To be reliable we must be flexible. To be

flexible we must be willing to change course to meet the needs of our customers. To meet the needs of our customers, we must move forward into the world of high technology and quality service.

We're riding on a 130-year history that has seen our ranks plummet from 1.5 million 50 years ago to 500,000 10 years ago to 200,000 today. And our challenge is greater than the ones they faced. Their challenge was to get customers -- not difficult at a time in which railroads were the pre-eminent mode of transportation.

But today, we are one among many - we are faced with competition that is hotter than it's ever been, from other modes and from each other. Our challenge is to adapt to this change. And, as survivors of the personnel cuts of the 1970s, 1980s and 1990s, we know how to adapt.

This industry can no longer stay profitable by only cutting costs -- there are very few large costs left to be cut. We have to depend on new technology and on you. Responsibility is being pushed down from management right smack square onto your shoulders, because, frankly, that's the only place we can afford to have it and have a viable business.

We have thinned out our management force and, with it, we have been forced to let go of a lot of traditions. We must create new traditions - traditions of service and reliability. And we're doing our best to come up with new technologies that can help you serve the customer better.

New braking systems will help decrease equipment-related accidents; advanced train control systems will save fuel costs and improve safety; instrumented wheels and bearings should do the same thing.

We are, in short, applying computers

and technology to operations and maintenance issues where we once applied them only to information issues.

We are expanding our use of computers and other high technology beyond payroll and train control. We are now looking at how they can directly benefit the customer.

But, as we reach for the heavens of high technology, we must be careful to keep our feet on the ground. We have to question our motives and our methods.

Let me give you an example of this. A few years ago we began tagging rail cars for Automatic Equipment Identification. We now have tagged 40 percent of our fleet, and those cars are running past 30,000 readers. We went head over heels for this technology.

Why? Now that we have all that information that AEI provides us, what are we doing with it? More importantly, how is that information benefitting our customers? We spend a lot of time and effort convincing our customers that AEI was the way to go, and that we'd prove it.

That was to be the beginning of a new age in care identification -- we could offer the customer a way to get instant access to his shipment location and estimate time of arrival. The railroads did their part -- they created computer software packages to communicate with their customers so the customer could obtain this information quickly.

Only one problem -- more than 60 percent of all railroad traffic crosses two or more railroads. And each railroad created its own software package to enable the customer to obtain information about his shipment.

So, for five years, customers have been asking us this question: "Why do we have to track down our shipments by contacting all the railroads

involved? What happened to one-stop shopping? That's what we get from the truckers."

And do you know what? They're right! Why should they have to deal with every railroad individually? Why shouldn't they be able to make one telephone call or boot up their computer and make just one query and find out what they need to know?

Union Pacific's Dick Davidson has an Industry Customer Satisfaction Team looking into this right now, and I'm confident that they'll solve the problem. But it's ironic that the railroad industry, which prides itself on standardization and cooperation -- time zones, track width, car specifications -- has come very close to shooting itself in the foot with AEI.

AEI is a good example of the power we've invested in technology. But it's also a lesson to be learned -- a lesson about knowing what we are going to do with that technology in order to serve the customer. I think AEI is a great system -- and it will be a great system for years to come. But it's an example that everything we do must be looked at closely, and through the eyes of the customer.

This means we have to challenge everything that we do. We need to ask three questions every time we begin a task:

- 1) Do we need to do it at all?
- 2) Is there a better way to do it?
- and 3) How will doing it benefit the customer?

Every rail car load, trailer load, container load and empty is a customer either coming or going. Every locomotive must be able to pull the 135 customers behind it who are paying the bill -- and our salaries. Every rail car must be treated on the tracks and in the shop as if its safe and timely delivery means money in our pockets -- because

it does.

An example of how money is taken from our pockets is our accident record. Between 1981 and 1986, our accident rate dropped sharply -- almost by half. But sine then, the rate has leveled off. We've been very proud of our 10-year record, but a comparison of the first five years of the 1980s to the last five years calls for less pride. Since the mid-to-late 1980s our accident rate has pretty much remained stagnant.

That's not good enough. Our customers are looking for improvement, not stagnation. And so is the government.

How do we return to the rapidly falling accident trends of the early 1980s? Let's decide quickly and then do it, or Uncle Sam may do it for us. And that's the kind of change we don't need.

I don't have to tell you that, despite deregulation, the railroad industry remains among the most regulated industries in the nation. The last thing we need is for the government to see our accident rate floating instead of dropping. We've always been able to show them that safety is our top priority. We have been able to point to a remarkable safety record as proof. We need to make sure that, in our quest for reliability and flexibility, we don't lose sight of safety as priority number one.

So we must improve our safety record even more. We need to let technology help us -- but we need to think smart and be smart as well. It's best for us and its best for our customers.

We're not asking you to do this alone. We'll continue to search for ways to help you serve the customer better, such as AEI. But as we go in search of new technology, we must not forget the basics. Keeping our track and our rolling stock in shape is the backbone of this industry, and it will

see us through many a storm -- literally.

One need only look as far as the midwest to see how true this is.

This industry weathered the Great Midwest Flood of 1993 with barely a reduction in service for two reasons -- our railroads were in excellent shape and our people responded above and beyond the call of duty.

Railroad workers proved during this natural disaster that our industry stands far and above any other when it comes to dedication and sacrifice. And I dare anyone to challenge that assessment after hearing these examples -- just a few of the many that occurred every day.

-- A Union Pacific dispatcher named Tommy Lightfoot got off work the night of July 24 and, heading home, inspected the main line through Omaha where heavy rain had been falling. His dedication paid off - he spotted a 100-foot section of subgrade on a 40-foot embankment slipping away, leaving little support for the heavy trains he knew would be passing. He phoned the dispatcher center, which stopped a 140,000-ton coal train that had been speeding toward the weakened section -- preventing a sure derailment and probable injury to the crew.

At Norfolk Southern, senior general foreman John Turner spent 20 days of his own time filling sandbags and pumping water in July. He not only helped prevent the washout of a Norfolk Southern roadbed, but he delayed floodwaters from inundating Missouri City -- where Mr. Turner is mayor.

A Monsanto chemical plant in Iowa told Soo Line that its 3,000-foot rail spur was under two feet of water and that the plant would have to shut down. This would be bad news for farmers, who depended on the plant's pesticides

and herbicides. So Soo Line employees devised a plan to lay a new road bed over an existing flooded roadbed so service could be restored. Within four days, the track was lifted more than two feet -- and the plant remained open.

Finally, a bridge on Santa Fe's main-line linking Chicago and Los Angeles was washed away, putting the entire route out of service. But not for long. Incredibly, Santa Fe rebuilt the bridge and reopened the line to 10,000-ton trains in just two weeks. While doing so, Santa Fe detoured many of its trains over Burlington Northern track.

Santa Fe refused to risk any delay in moving time-sensitive trailers for a customer. They paid a competing trucking company to move them to Chicago over Interstates 35 and 80, which had remained open. Altogether nearly 30,000 trains detoured.

This is truly putting the customer first, and these are actions taken not by machines or computers or robots -- but by people. People who care about their work, their company, and their customers. People who have the flexibility to change when it is necessary, to go outside the normal channels in order to get the job done.

And here is where I get into the real reason railroading's future is as bright as that battleship captain's lighthouse beacon: You.

High technology didn't keep our trains moving during the worst flood in the history of the Midwest -- you did. Quality management processes didn't cause competing railroads to cooperate for the good of the customer -- you did.

What happened in the Midwest is a perfect example of what today's railroad industry is and should be -- a stream lined, responsive team of people who know they are the best in the world at what they do, and who prove

it day in and day out.

I could cite many more examples, but you get the point. Each and every one of you should be proud that you are a part of an industry that boasts this caliber of employee. I know I am.

The work our employees did during those floods -- and the work you do every day -- makes me very confident in our ability to meet the challenge of change.

In conclusion, let me do a little math for you. I've been told there are about 400 people here today. I figure each of you probably has, an average, 20 years' experience. That means there is, in this room alone, a combined 8-thousand years' worth of experience.

Multiply that by the experience of the other hands-on railroad workers

around the country and add it to the kind of dedication we witness during the midwest floods and you know what? The future of our industry looks damn good.

That future is, quite literally, in our hands, yours and mine. If we can work together to defeat the most damaging floods in our nation's history, we can certainly conquer the challenges of customer service, reliability and financial strength of the railroad industry. After all, that is the only true job protection you and I have which is something we're striving for.

I want to thank you for letting me share a few thoughts with you and offer best wishes for an enjoyable and successful conference and convention.

Good Luck!



**PRECISION
INDUSTRIES**

Serving The Railroad Industry
Since 1945

**Bearings • Hose & Fittings • Hydraulics • Pneumatics
Electric Motors • Reducers • Couplings • Conveyors
Belting • Fasteners • Chain • Sprockets • Lubricants
Pumps • Pipe Fittings • Valves • Mechanical Seals
V-Belts • Sheaves • Variable Speed • Engineering**

Total Commitment To Quality

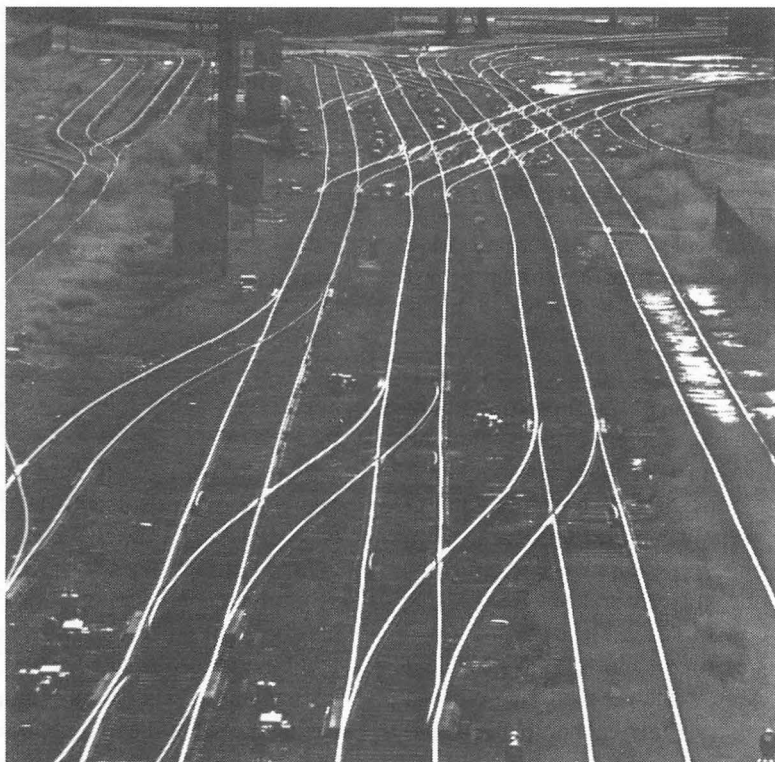
Home Office:

**4611 S. 96th Street • Omaha, NE 68127
402-593-7000 • 800-373-7777 • FAX 402-593-7054**

24 Hour Emergency Service

42 Distribution Centers Nationwide

Introducing an oil that's good for your yard.



To keep extra maintenance and unnecessary breakdowns from stranding your locomotives in the yard, depend on Chevron's Diesel Engine Oil Delo® 6170. The first generation V multi-grade to gain approval from GE and EMD—the two major U.S. locomotive suppliers. □ Compared to single grades, Delo 6170 can help reduce oil consumption by as much as 20%. You'll get extended drain intervals. Better sludge control. And Delo 6170 works as well with yesterday's locomotives as it does with today's technologically advanced engines. □ So pour in some Delo 6170. It'll help keep your locomotives moving instead of sitting in the yard. For more information about Chevron's Railroad Lubricants, just call 1-800-582-3835.



WEYLIN DOYLE
PRESIDENT'S ADDRESS
Monday, September 13, 1993

There are a few things I would like to address to the LMOA. I hope everyone present heard the speech this morning by our keynote speaker (Chuck Dettman, AAR). He had some interesting comments. He talked about change in the railroad industry and I think that is what the LMOA needs to look at. We need changes of our own.

We have seen this organization dwindle in membership the past few years. It is true a lot of this is because we have fewer management people at all levels of the railroad industry. But more importantly, what concerns me is the perceived lack of interest and support by some of the top management people. Because of this, we need to make some changes to address these changes and get the LMOA on track.

We need to be able to provide a service to the people in the railroad industry that they both need and want so that we don't have to constantly go to management and peddle the LMOA and tell them what a great thing it is. They will see that for themselves.

There are three things that we need to address. We need to define who the customers of the LMOA are; what do these customers want, and finally how are we going to reach these customers.

Traditionally, the LMOA customers have been management

people within our railroads (officers). That is what LMOA stands for (Locomotive Maintenance Officers Association). We need to stretch beyond this and reach the shop craft people at all levels of our railroads. We need their input. The people who are on the shop floor are the real backbone of this industry. These are the people that make it happen and we cannot exclude them from the LMOA.

After we have identified our customer base, we need to find out what they want and need and provide a service to them. It has been suggested by members of the LMOA executive committee that we do a formal survey to go out and listen to our customers to find out exactly what they want from the LMOA.

For the railroad people in the audience, who deal with vendors on a daily basis the days are long gone where the vendor walks into your office and says "here's a product, isn't it great, why don't you buy it?" It doesn't happen that way anymore. The supply industry has learned that they come to us to find out just exactly what it is we want (how they can serve us) and then design their products to meet our specific needs.

We need to be doing this as well. We need to develop the LMOA to meet the specific needs of the customers we have identified. The final step is to find out how to convey to them what the LMOA is doing. We need to encourage all of our customers (including the shop craft personnel) to participate in the

LMOA.

Beyond that, we need to look at the way we provide information (via video, book, etc.). As everyone here is probably aware, we publish a book. We need to take a hard look at this publication to see if we can't figure out how to do it better. Is this the right medium to get information to these people? Should we be looking more at the use of video; or, is there some other communication means at our disposal to get the information back to the people who need it?

If we are going to involve all levels of railroads in the LMOA, then I'd like to suggest that we consider changing the name LMOA. This has been discussed in the executive committee as well. Perhaps doing away with or replacing the word "officers" is an alternative. We want to embrace all levels of railroad participation, not just officers, and we do not think it is necessary to cater to just officers. With that in mind, the executive committee has decided to put together a small group to study this situation. We want to make suggestions on what could be done so action can be taken at the next con-

vention.

The presentations, here have been very successful. But, we need to look at doing more. Perhaps we need to invite the supplier/vendor community in to give presentations on particular areas of our specific needs? The shop craft people may have a particular problem they need help with and maybe the vendor community has a solution to share with them through the LMOA. We are looking at expanding all areas of how we handle our operations in the future.

That pretty much wraps it up. I've been involved with the railroad industry for over 17 years. What has really excited me about the railroad industry is the tremendous changes we've gone through. It keeps everyone on their toes and makes everyone's job rewarding and exciting.

We need to bring that same feeling to the LMOA. We need to make some good, strong, positive changes and make sure that we provide an organization that the railroad industry needs and wants so that they will gladly support it.

OUR OFFICERS



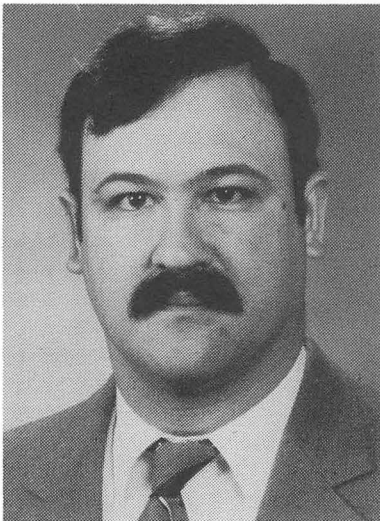
President

WEYLIN R. DOYLE

Mgr.-Maint. Control Systems

Union Pacific Railroad

Omaha, NE 68179



1st Vice President

MARK COLES

Dir.-Loco. Maint. Planning

Union Pacific Railroad

Omaha, NE 68179



2nd Vice President

CHARLES MILLER

**Mgr.-Loco. Planning
Standards & Programs**

Union Pacific Railroad

Omaha, NE 68179

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.*



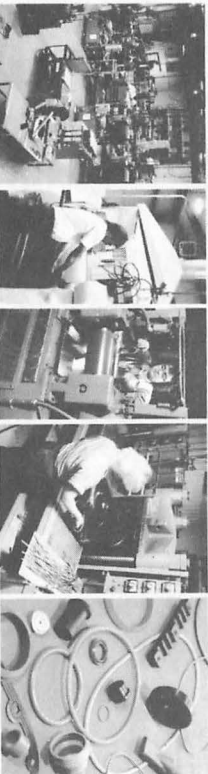
Governor Plug Protector:
Exclusive design using Durox
Green-Guard provides water-
tight seal, eliminates connector
shortouts, helps support cable.

DUROX
COMPANY

We care for railroads.

12351 PROSPECT ROAD, STRONGSVILLE, OHIO 44136
216-238-5360 • 1-800-238-5360 • FAX: 216-238-5773

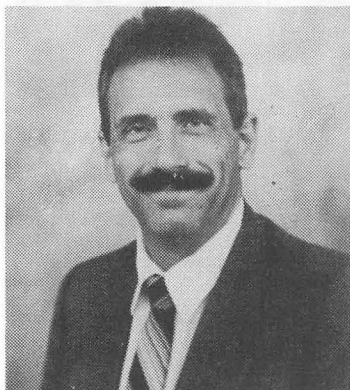
PRODUCTION... COMPOUNDING... MILLING... MOLDING... QUALITY PARTS.



OUR REGIONAL EXECUTIVES



MR. GILBERT BRUNO
 Facility Manager
 National Railroad Passenger Corp.
 Seattle, WA 98134



MR. DONALD TETLEY
 Mgr. Facility Planning
 Union Pacific Railroad
 Omaha, NE 68179



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



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



MR. DOUG CORBIN
 Asst. Mgr. Loco. Control Center
 Norfolk Southern Corp.
 Atlanta, GA 30303

**WE KEEP YOU
ON A ROLL.**



**With quality service
and price from Durox.**

New replacement parts for locomotives, passenger, freight and transit cars. With fast and accurate computerized order/delivery processing.

- Non-stick, non-asbestos GASKETS & SEALS, parts & kits.
- SWELLEX GASKETS and GREEN GUARD SEALS for leak free engines.
- 26L and Transit AIRBRAKE parts & kits.
- Liquid-filled PRESSURE GAUGES with exclusive 3-year warranty.
- ENGINE & COMPONENT REBUILT KITS with SWELLEX GASKETS and GREEN GUARD SEALS...for leak free engines.
- Chicago Rawhide, Garlock and Parker products.

PLUS door & hatch cover SEALS, oil seals, wick lubricators, fuel oil pre-heaters, weather stripping and thousands of stocked items for on-time delivery. We guarantee all our products and services.

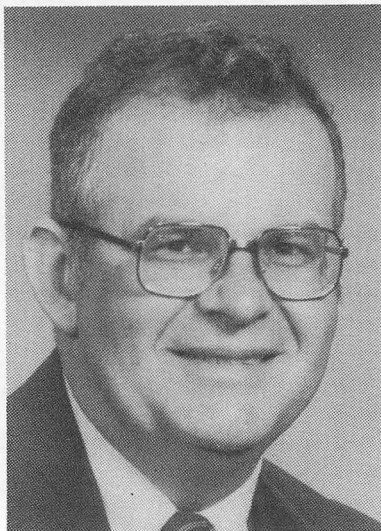
Caring for railroads is not a sideline at Durox. It's our mainline specialty combining 30 years of service performance with unique in-house molding and leading-edge product development technology. Call our toll-free 800 number for catalog and information.

We care for railroads, everywhere!

DUROX
COMPANY

12351 Prospect Rd., Strongsville, Ohio 44136
216-238-5350 • 1-800-238-5360 • FAX: 216-238-5773

OUR PAST PRESIDENTS



Chairman of the Board

MR. ALLEN KELLER

Dir.-Loco. Projects

Reading Railroad

Cleona, PA 17042



MR. DAVE GOEHRING

Supt.-Loco. Maint.

Amtrak

Philadelphia, PA 19104



MR. DON WARD

Coord.-Qual. Safety & Tech. Trng.

Burlington Northern Railroad

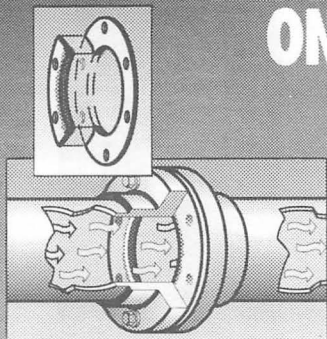
Springfield, MO 65802

WANT TO STOP OIL LEAKS, SAVE MONEY, ADD PROFIT, IMPROVE SAFETY?

Most major American railroads are getting very stingy with oil. They are now making their diesels leak-free with DUROX SWELLEX™ gaskets and Durogard seals. Exposure to oil triggers the unique swelling action of our SWELLEX gaskets. They swell up tight to fill and seal flange connections.

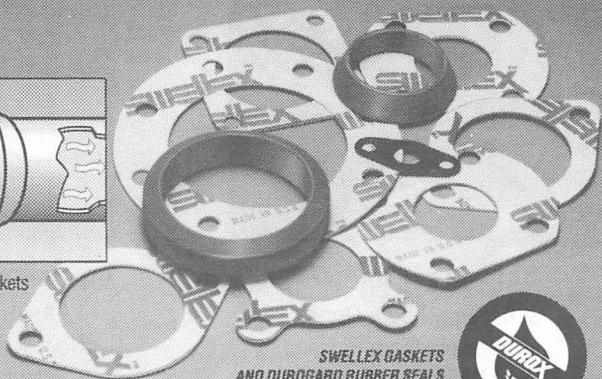
PUT SOME REAL TIGHTWADS ON THE JOB.

Hot drips, drops and dribbles stop. Cold. Oil stays in your engines. Not on the road, maintenance walkways, or shop floors. Call and ask about our factory-direct prices to put some real tightwads on your job. Most railroads already have. The cost is minor. The savings are major. And the proof is convincing.



When DUROX Swellex gaskets replace ordinary original gaskets in diesel engine oil line connections...

exposure to the oil causes Swellex gasketing material to swell, and seal the flange surface imperfections that cause leaks and seepage.



**SWELLEX GASKETS
AND DUROGARD RUBBER SEALS
STOP OIL LEAKS!**

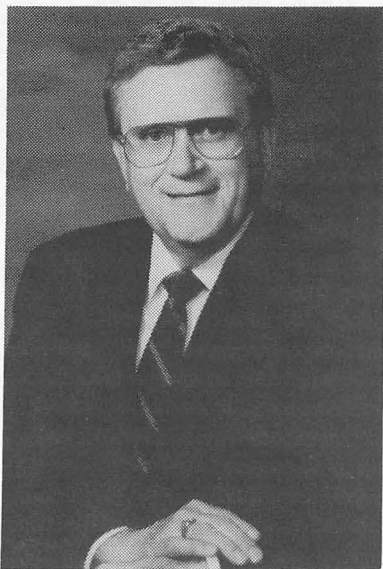


We Care For Railroads®

DUROX
COMPANY

12351 PROSPECT ROAD • STRONGSVILLE, OHIO 44136 • 216-238-5350 • 1-800-238-5360 • FAX 216-238-5773

OUR PAST PRESIDENTS



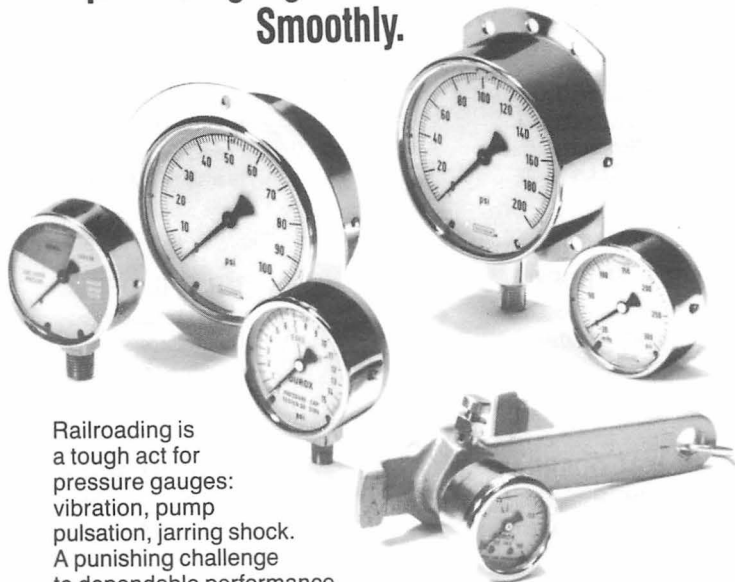
MR. DALE H. PROPP
Gen. Supt.-Loco. Opns.
Burlington Northern Railroad
Fort Worth, TX 76102



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

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, hermetically 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., Strongsville, Ohio 44136
216-238-5350 • 1-800-238-5360 • FAX: 216-238-5773

OUR ADVISORY BOARD

MR. G. W. BARTLEY

Chief Mechanical Officer
CP Rail
Montreal, Quebec, H3C 3E4

MR. V. H. MIZRAHI

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

MR. E. L. BAUER

Chief Mechanical Officer
Burlington Northern Railroad
Fort Worth, Texas 76102

MR. J. R. NUSSRALLAH

Vice President & CMO
Consolidated Rail Corp.
Philadelphia, PA 19103

MR. R. M. BURK

Asst. Vice President & CMO
National Railroad Passenger Corp.
Philadelphia, PA 19103

MR. D. G. ORR

CMO - Locomotive
CSX Transportation
Jacksonville, FL 32202

MR. N. M. DOERR

Vice Pres. Mat'l. Management
Burlington Northern Railroad
Fort Worth, Texas 76161

MR. D. M. SIZEMORE

Asst. Vice President & CMO
Atchison, Topeka & Santa Fe Rwy.
Schaumburg, IL 60173

MR. R. A. KLESS

Asst. Vice Pres. Motive Power
Chicago and North Western Transp.
Chicago, IL 60606

MR. M. L. WALL

Asst. V.P.- Maint. Opns.
Union Pacific Railroad
Omaha, NE 68179

MR. D. W. MAYBERRY

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

MR. D. E. WALLER

V.P. - Engrg. & Materials
Chicago and North Western Transp.
Chicago, IL 60606



Past President Don Ward, Burlington Northern, presents the General Desk Set to outgoing president, Weylin Doyle, Union Pacific.



Outgoing President Weylin Doyle, Union Pacific, presents gavel to newly elected president Mark Coles, Union Pacific.



Past President Dale Goehring, Amtrak, assists Gil Bruno, newly elected 2nd Vice President, Amtrak, with his LMOA blazer.



Past President Dale Goehring, Amtrak, presents Past President Pin to outgoing president, Weylin Doyle, of the Union Pacific.



Newly elected president Mark Coles, Union Pacific, assists Don Tetley, newly elected 3rd Vice President, Union Pacific with his LMOA blazer.



LMOA officers in attendance at the 1993 Annual Technical Conference: Top Row (left to right) Past President, Tom Harley, retired; Tom Shedd, Editor; Past President Dale Goehring, Amtrak; outgoing president Weylin Doyle, Union Pacific; Marvin Varns, retired, Burlington Northern; Jack Kuhns, retired CSX. Bottom Row: (left to right) Past President William Brown, retired - BN; Past President Don Ward, Burlington Northern; newly elected president Mark Coles, Union Pacific; newly elected 3rd Vice President, Don Tetley, Union Pacific; newly elected 2nd Vice President, Gil Bruno, Amtrak.

Mark Coles
Union Pacific
Acceptance Speech
Tuesday, September 14, 1993
2:00 p.m.

This year marks the 15th anniversary of my involvement with LMOA. I think back to when I was first exposed to the LMOA. I was a Diesel Supervisor at North Little Rock, Arkansas and I received a phone call from the Supt. Motive Power at the time, Eldon Dent. I was on the Missouri Pacific as it was known back then. He told me to get a plane ticket, go to Chicago to the Conrad Hilton Hotel and go to room 4G and look for a guy with long hair and moustache. That was all I was told. I walked into the room and it was then that I found out that I was assigned to the New Development Committee for the LMOA. The gentleman with the long hair and moustache was Chris Cox, Chairman of the Committee from Santa Fe.

The LMOA has done a lot for me over the years. The first thing I had the opportunity to do was to write a paper and as I think back at how that paper came out, it wasn't very good. But, by spending the years on the New Developments Committee, I learned a lot about making presentations and doing papers for the committee. I've

worked with a lot of people who put a significant amount of effort into those technical papers. As I worked my way up to the Chairman of the Committee we worked very hard in improving those papers.

The LMOA has changed significantly during the years I have been a member. When I first started, we had tremendous railroad support. We had many people who wanted to get on the committees; so many that there wasn't enough room for all of them. Today, we have to actively request the participation of people. We had a lot of railroad people in the audiences; now we don't have nearly as many. The LMOA is changing and this is why we are contemplating some of the changes that Weylin talked about in his earlier address. I intend on working very hard with Weylin and the rest of the executive committee to come up with the kind of changes we need to make sure that the LMOA grows and becomes more valuable to the railroads. We must come up with a product that will convince railroad management that the LMOA is a valuable asset and to continue to support our participation at these meetings and to get as many people to attend them as we possibly can.

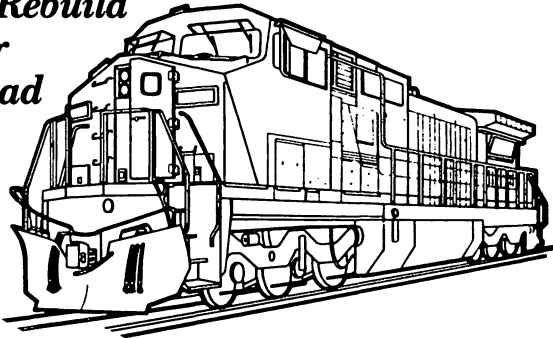
This concludes my acceptance speech. I would like to thank everyone for approving of my elevation to President of the LMOA.



GE Apparatus Service

Driven to Keep Your Business on Track!

***Complete Rebuild
Service for
the Railroad
Industry***



- Traction Components
- Locomotive Rebuilds/Lease or Rentals
- On-Site Locomotive Maintenance
- Repair/Exchange of Major Components
- Service Available on GE and EMD Equipment
- 5 Strategically Located Service Centers in North America

**For more information,
call or write:
GE Apparatus Service
Manager - Transportation
Larry Stephens
2455 Cassens Drive
Fenton, MO 63026
(314) 349-6100**



PAST PRESIDENTS

- 1939 & 1949** - F.B. DOWNEY (Deceased) 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. RENTSCHILLER (Deceased) Chief Mechanical Officer, Bessemer and Lake Erie R.R.
1948 - C.D. ALLEN (Deceased) Asst. C.M.O. - Locomotive, C. & O. Ry. & B. & O. R.R.
1949 - J.W. HAWTHORNE (Deceased) Asst. Vice-Pres.-Equipment, Seaboard Coast Line R.R.
1950— G.E. BENNET (Deceased) Vice-Pres.-Gen. Purchasing Agent, C. & E. I. Ry.
1951— P. H. VERD (Deceased) Vice-Pres.-Personnel, E. J & E. Ry.
1952— H. H. MAGILL (Deceased) Master Mechanic, C. & N. W. Ry.
1953— S. M. HOUSTON (Deceased) Gen. Supt. Mech. Dept. Southern Pacific Co.
1954 & 1955—F. D. SINEATH, Retired Chief of Motive Power, Seaboard Coast Line R.R., 1061 Nelson Ave., Jacksonville, FL 32205
1956— T. T. BLICKLE (Deceased) General Manager-Mechanical, A. T. & S. F. Ry.
1957— J. T. DAILEY (Deceased) Asst. to Pres.-Mech., Alton & Southern R.R.
1958— F. E. 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, (Deceased) Chief Mechanical Officer, Chessie System
1974— C. P. STENDAHL, Retired General Manager M.P.-Electrical, Burlington Northern Railroad, 1052 W. California Ave., St. Paul, MN 55117
1975— L. H. BOOTH, Retired Assistant C.M.O.-Locomotive, Chessie System, 906-13th Ave., Huntington, W.V. 25701
1976— J. D. SCHROEDER, Retired Assistant C.M.O.-Locomotive, Burlington Northern Railroad, 244 Carrie Drive, Grass Valley, CA 95942
1977— T. A. TENNYSON (Deceased) Asst. Manager Engineering-Technical, Southern Pacific Transportation Co.
1978— E. E. DENT, Retired Superintendent Motive Power, Missouri Pacific Railroad, 13500 S. Outer 40 Rd., Apt. 116 East, Chesterfield, MO 63017
1979— E. T. HARLEY, Retired Senior Vice President Equipment, Trailer Train Company, 289 Belmont Road, King of Prussia, PA 19406
1980— J. H. LONG, Retired Manager Locomotive Dept., Chessie System, 5454 Cleander Drive, Cincinnati, OH 45238
1981— R. G. CLEVINGER, Retired General Electrical Foreman, Atchison, Topeka & Sante Fe Rwy., 5802 W. 157th Terrace, Overland Pk., KS 66223



222 Starkey St.
St. Paul, Minn. 55107
1-800-966-2909
612-227-4343

Manufacturing quality chemicals for Railroads for 50 years

IMPROVE YOUR QUALITY

While you save time and reduce maintenance costs
by precisely locating the smallest fuel and water leaks.

PROTECT YOUR INVESTMENT

with proven cooling system corrosion inhibitors.

CLEAN EQUIPMENT BETTER WITH LESS CHEMICAL USAGE

A full line of chemicals for Railroads

Specialities:

- Leak tracers for fuel, water & air
- Radiator water treatment
(liquid & dry)
- Rust preventive coatings for axles
- Electrical Cleaners

Detergents for:

- Spray Cleaners (cabinet type)
- Wash racks
- Pressure washers
- Soak tank cleaning

We will make cleaners to meet YOUR specifications.

PAST PRESIDENTS (Con't)

- 1982 - N.A. BUSKEY (Deceased) Asst. General Manager-Locomotive, Chessie System
 1983 - F.D. BRUNER (Deceased) Asst. Chief Mechanical Officer-R. & D. Union Pacific Railroad
 1984 - R. R. HOLMES, Retired Director Chemical Labs and Environment, Union Pacific
 1985 - D. M. WALKER, Asst. Shop Manager, Norfolk Southern Corp., 793 Windsor St., Atlanta GA 30315
 1986 - D. H. PROPP, Gen. Supt.-Loco. Opns., Burlington Northern, 777 Main St., Ft. Worth, TX 76102
 1987 - D. L. WARD, Coord.-Quality Safety & Tech. Trng. Burlington Northern RR, 1700 N. Kansas Ave., Springfield, MO 65802
 1988 - D.G. GOEHRING, Supt. Loco. Maint., National RR Passenger Corp., 30th St. Station, 4th Floor, Philadelphia, PA 19104
 1989 - WILLIAM A. BROWN (Retired) General Foreman, Burlington Northern RR, 2630 Evergreen, Burlington, IA 52601
 1990 - P. F. HOERATH, Retired Sr. Mech, Engr. Shops, Conrail, Box 134, R.R. 4, Hollidaysburg, PA 16648
 1991 - D. D. HUDGENS, (Retired) Sr. Mgr. R & D, Union Pacific, 16711 Pine St., Omaha, NE 68130
 1992 - K. ALLEN KELLER, Reading, R.R., Cleona, PA

HONORARY LIFE MEMBERS

- KJELL AXELSON, Retired Superintendent Motive Power, Burlington Northern, 36-716 Bluebird Ave. Rancho Mirage, CA 92270
 F. W. BUNCE, Retired Chief Mech. Officer, Milwaukee Road.
 J. J. BUTLER, Retired Chief Mech. Officer, Consolidated Rail Corp., 158 Woodgate Ln., Paoli, PA 19301
 OWEN CLARKE, Retired Vice-President, Chesapeake & Ohio Ry., Cleveland, Ohio
 B. A. CUMBEA, Retired Mgr. Loco. Maint.-Engr., Chessie System, 310 Cherokee Trail, Huntington, WV 25705
 N. C. ECKERLE, Sales Mgr. Specialty Chem., Nalco Chem. Co., 2901 Butterfield Rd., Oak Brook, IL 60521
 W. EWING, Retired, Altoona Gear Co., Calbassas, CA
 W. T. FARICY, Retired Chairman of the Board, A.A.R.
 J. G. GERMAN, Retired V. Pres.-Engr. Missouri Pacific Railroad Co.
 J. J. GREGORY, Retired Project Mgr.-Heavy Repair Shop, Consolidated Rail Corp., 603 Ruskin Drive, Altoona PA 16602
 S. GRAHAM HAMILTON, President, Global Group, Inc., P.O. Box 2024, Winter Park, FL 32790
 E. R. HAFLING, Retired Engineering Assist., Santa Fe Rwy., 2711 James St., Topeka, KS 66614
 W. J. HARRIS, Retired V. Pres., Research & Test Dept., Assn. of American Railroads, Washington, D.C.
 H. W. HAYWARD, Retired Chief M.P. & R. S., CP Rail, Montreal 101, Quebec, Canada
 D. W. HENDERSON, V.P.-Technology, Engr. & Maint. Burlington Northern RR, 9401 Indian Creek Pkwy., Overland Park, KS 66210
 JOHN H. HERTOOG, Retired V. Pres. Operations, Burlington Northern, Inc., St. Paul, MN 55101
 JOHN W. INGRAM, Retired Pres. and Chief Executive Officer, Chicago, Rock Island and Pacific Railroad Co.
 A. W. JOHNSON, Retired, V. Pres. of Opns. and Maint., Assoc. of American RR, Washington, D.C.
 JOSEPH J.T. KOERNER, Sec'y-Treas. (Retired), LMOA, 3144 Brereton Cr., Huntington, WV 25705
 JACK L. KUHN, Retired Mgr. Png. & Maint., CSX Transp., 401 Brookview Rd., Louisville, KY 40207
 R. M. McDONALD, Retired Dir. of Opns., Brd. of Transport, Commissioners for Canada, Ottawa, Ont., Canada
 J. F. McDONOUGH, Retired Asst. V. P.-Mechanical, Union Pacific RR, 12225 Farnum St., Omaha, NE 68154
 F. K. MITCHELL, Retired Asst., V.P., New York Central Sys., Sleights Wildwood, Manitowish Waters, WI 54545
 R. G. RAY BURN, Retired Executive V.P.-Operations, Chessie System, Baltimore, MD
 H.P. RODES, Pres., General Motors Institute, Flint, MI 48502
 F. R. RUSSELL, Retired Chief Mech. Off., Southern Pacific Co., San Francisco, CA
 L. G. SALTS, Retired, AT&SF Rwy., Topeka, KS
 H. L. SCOTT, JR., Retired Sr. V.P. and Chief Mech. Off. Norfolk Southern, Corp. P.O. Box 3609, Norfolk, VA 23514
 C. M. SMITH, Retired Mgr.-Mech. Engr.-Passenger and Loco. Consolidated Rail Corp., 3 Princeton Rd., Strafford-Wayne, PA 19087
 R. D. SPENCE, Retired Executive V.P.-Operations, Seaboard System RR
 J. TAGGART, Retired System Mechanical Officer-Motive Power, CN Rail, 655 Richmond Road, unit 45, Ottawa, Ontario K2A 3Y3
 M. L. VARNIS, Retired, BN RR, Nixa, MO
 R. W. VITEK, Retired, C&NW RR, Chicago, IL
 C.N. WIGGINS, Retired V.P. and Asst. to Pres., Louisville & Nashville R.R., Louisville KY

REPORT OF THE COMMITTEE ON NEW DEVELOPMENTS

MONDAY, SEPTEMBER 13, 1993
10:00 A.M.

Pre-Convention
Presentation
Southwestern
Rwy. Club



April 22, 1993
Green Oaks Inn
For Worth, TX

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

COMMITTEE MEMBERS

J.S. Biln	Mgr-Mech. Engr & Admin.	BC Rail	Vancouver, BC
T. Brunner	Gen. Mech. Supt.- Loco.	Amtrak	Philadelphia, PA
T. Frederick	Asst. Mgr-Loco. Engr.	Conrail	Philadelphia, PA
D. Hamilton	Mgr.-M.P. Maint.	Canadian National	Montreal, PQ
J. Hogan	Natl. Accts. Mgr-Loco.	Caterpillar	Mossville, IL
D. Holland	Gen. Equip. Foreman	AT&SF Rwy.	Barstow, CA
G. Hsu	Sr. Research Engr.	Burlington Northern	Fort Worth, TX
W. Jacobs	Mgr-Locomotive	Union Pacific	North Little Rock, AR
R. Mackowiak	Mgr.-Loco. Opns.	Alaska, RR	Anchorage, AK
C. Olson	Mgr-Engineering	Morrison Knudsen	Boise, ID
C. Prudian	Systems Engineer	Electro-Motive	La Grange, IL
N. Sandberg	Program Manager	General Electric	Erie, PA
B. Smith	Dir. Tech. Supt. & Equip Engr.	New Jersey Transit	Newark, NJ

PERSONAL HISTORY

Robert Runyon

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

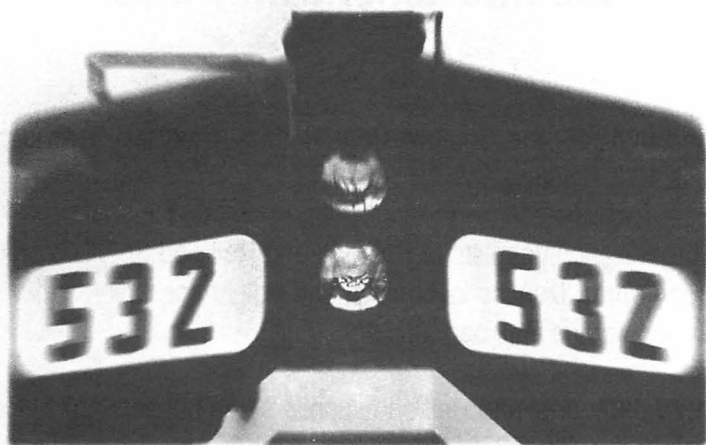
For five years starting in 1962, Mr. Runyon served in the U.S. Army Artillery, assigned to various positions including a three-year stay in Germany and a year in Pittsburgh, eventually holding the rank of Captain. Upon leaving the Army in 1967, he moved to Roanoke, VA and joined ITT in an engineering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

Mr. Runyon's railroad career began on April 16, 1970, when he joined Norfolk & Western Railway Co. as an assistant engineer in Roanoke, VA, with subsequent promotion to gang foreman in 1972. During most of this time he supervised the design and construction of a SEARCH locomotive test

facility, which he operated through the end of 1974, and participated in the design of a fleet of slug locomotives to be used in yard and hump service. After spending a year as assistant foreman supervising one shift at Roanoke Shops, he was transferred to the Locomotive department staff to take on the electrical design phase of a new slug locomotive.

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

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



How Do You Stop A Speeding Locomotive?

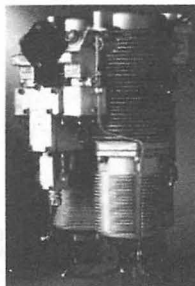
Lots of things contribute to down time of your locomotive...Little things like dirt, oil, and moisture. They all add up to a contaminated air system that decreases service time from brake components and additional air equipment. **Compressor after-coolers will not remove these contaminants completely.**

That's why the Salem 975 Series Air Dryer System makes so much sense. Contaminates, including water vapor, are removed. This results in savings through less down time and the value of greater dependability with the reduction of unscheduled maintenance costs.

With over 5000 in use, our dryer has become one of the most beneficial and dependable options in the industry's quest for safer and more predictable operating systems. How do you keep your powerful locomotive on track?

With absolute confidence using the Salem 975 Series Air Dryer System, a GRAHAM-WHITE quality product.

For more information call our CUSTOMER SERVICE TEAM at 703/387-5620.



GRAHAM-WHITE MANUFACTURING CO.

1242 Colorado Street, P.O. Box 1099, Salem, Va 24153
703/387-5620 FAX: 703/387-5639



80 Years Of Service To The Railroad Industry

Southwestern Railway Club

Started in 1946, the Southwestern Railway Club this year is celebrating its 47th 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.

C.T. KUNKEL

President
Union Pacific Railroad
Omaha, NE 68178

SHARON D. KOCH

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

I. NEW TECHNOLOGY TO SOLVE OLD PROBLEMS

*Presented By: Bill Jacobs
Union Pacific*

Rapid advancement of solid state electronic circuitry in the last decade has brought about numerous technological devices. Many are now economically suited for troubleshooting today's diesel locomotive.

This report will detail a few of the many new devices currently used on the railroads. First we will explain the new devices and their use in troubleshooting which should save time and increase productivity. Then we will detail concerns that railroad maintenance forces face daily and solicit support from OEM's and the aftermarket for solutions.

A. The devices

The new devices we will discuss include the ultra probe ultrasonic inspection device, digital rpm tachometer, pocket digital manometer, infrared non-contact thermometer, and portable laptop computer.

The *ultra probe* is an example of a ultrasonic diagnostic instrument. It provides test capabilities ranging from leak detection to sophisticated mechanical analysis. The instrument can be used in either the contact or non-contact mode. In the non-contact mode a scanning module will receive air borne ultrasound such as that emitted by pressure leaks and electrical discharges. This method of leak detection can be used to find minute air leaks or contactor arcing problems while troubleshooting locomotives.

In the contact mode a module is used as a stethoscope type wave guide device. In this case, it is sensitive to

ultrasound generated internally, such as within a bearing housing or a pipe. As with the scanning module, the sensitivity is adjusted to "gross" and then to "fine" for the most satisfactory sound. This method is currently being used to determine threshold decibel levels for traction motor pinion and commutator bearings.

The system comes with a headset, optional battery charger and tone generator. The tone generator is an ultrasonic transmitter designed to flood an area with ultrasound. A typical example of its use is in fuel tank repair. The tone generator is lowered into the fuel tank and the non-contact scanning module is used to pick up leaking ultrasound at the damaged area after repair. The ultrasound does not permeate any solid wall but easily flows through a fault or void. This device works extremely well with fuel tank and pipe repair work. It is also excellent for air infiltration around doors, windows and hatches.

The *digital hand held tachometer* currently replaces the mechanically driven tachometer. Most railroads have relied for years on mechanical tachs for checking engine rpm. A typical digital device has five digit capability to 30,000 rpm. It uses three AA batteries which are good for upwards of 40 hours of continuous use. The device works within a 1.97 to 5.91 inch range of the rotating device being measured.

A reflective marker is attached to the rotating member and the device, held at a distance within its working range is aimed at the rotating member. The device sends a visible light source from the detector section to the rotating shaft. At the mark it is reflected back to the device, thus providing a simple non-contact method of rpm measurement. The device has a memory recall button which is connected in cases

where it is dangerous to read the display while making measurements. The device's accuracy is ± 1 rpm from 50 - 12,000 rpm and ± 2 rpm from 12,000 to 30,000 rpm. It weighs 4.8 ounces and fits easily in your pocket. There are other types of digital tachometers available including tachs that connect to main generator phase leads.

The next device is the *digital pocket manometer*. How many times has the experienced mechanic wanted to know what the crankcase of a locomotive was doing? Is it positive or is it negative pressure? The water column manometer can currently be replaced by this device.

It is an electronic micromanometer which provides all the capabilities of liquid filled manometers. It is portable and easier to use than the liquid tube manometers. This device may be used to measure positive, negative or differential pressure. It is useful for determining pressure drop of system components such as filters or heat exchangers. The device has a range of 0-20 in. water column with resolution of .01 in. The device weighs 1.6 pounds and uses a 9 volt alkaline battery for up to 150 hours of continuous use. It can be quickly attached to the crankcase, in order to determine crankcase condition.

Digital pyrometers and infrared thermometers are currently used to determine thermal gradients on diesel engines and various other components. Digital contact pyrometers are useful on the diesel engine for measuring cooling water, oil cooler differential, stack inlet temperatures and bearing temperatures. The newest devices are the hand held infrared thermometers. They are used to troubleshoot the aforementioned; they also find a use in electrical contactor problems. They are highly accurate ($\pm 1\%$ of scale reading) thermometers which are responsive

(250 M.sec.) and lightweight (1 pound 4 ounces). They include RS-232 download capabilities for data transfer to Lotus 1-2-3 or ASCII data files.

Their use is simple. First you sight the device, the object of which the temperature is to be determined. The laser sight must be filled with the object. The typical range at one foot is a spot diameter of .09 in. The spot distance varies to 8.0 in at a distance of 10 feet. Pull the trigger and instantly the temperature is displayed on a digital display.

This device saves countless man-hours in finding leaking and non-firing nozzles or injectors on diesel engines. It has also been used with great success in finding hot support and journal box bearings on service track and other yard operations.

The last device in this report is the under-used *portable laptop computer*. Currently both OEM's offer diagnostic computer equipped locomotives. In addition to the onboard computer, many roads use solid state event recorders. These onboard event records can be downloaded without getting on the locomotive to determine the various operating parameters. These items may include speed, loading amperage, direction of travel, both air and dynamic brake usage, along with horn usage.

The information downloaded from locomotives by a laptop computer has proven to be valuable in diagnosing road related failures. The questions routinely asked are: Was the unit loading? Was the air working? Did the signal system work? Was the horn blown? Downloading can answer these questions and can easily be done while maintenance is performed by service tracks and running repair facilities.

Next, let us list railroad concerns and ask that the OEM's and aftermarket suppliers alike help us address

these “new horizons”.

Present day flooring material such as Benelex or plywood are likely to be replaced with honeycombed plastic material with a non-skid surface. The new products will likely exceed the structural and physical qualities such as sound deadening and moisture resistance of Benelex and plywood.

Refrigerators which have been everyone's nightmare should be replaced with solid state maintenance free coolers. We look forward to the future when the size limitations and cooling capacity have been overcome with ultimately a brushless and zero maintenance device. AC fuel pumps are an early example of transition from DC to a brushless environment. We hope this trend continues.

Troublesome right angle drives and axle alternators should be replaced with standardized rpm signals converted to read speed information. This would eliminate axle drive in its entirety.

Locomotive lighting suffers from a lack of coordination, including such matters as the number of bulbs, bulb size and strategic location, along with reliability. We encourage the industry to investigate fiber optics, fluorescent and LED's, leveraging the available technology.

The age old toilet problems should be addressed one more time. Routine cleaning and maintenance related solutions to the problems are long overdue.

These are among a few of our many concerns as we continue the rapid advancement in maintenance technology.

This report represents a quick cross-section of items which use new technology to help us solve old problems; but it is in no way fully representative of all the new electronic instruments used in troubleshooting today's modern diesel engines. The new horizons here are limited only by the imaginations of the OEM's and the aftermarket suppliers.

HUGHES RAILWAY SUPPLIES

**290 King of Prussia Road
Suite 300**

Radnor, PA 19087

Tel: (215) 971-9966

Fax: (215) 971-9544

GEORGE VAN SCIVER

STEVE SMITH

II. DEVELOPMENTS IN OFF-SHORE TECHNOLOGY

Presented by: J.S. Biln, BC Rail, Ltd.

1.0 Rail technology

Current estimates indicate that there are more than 100,000 diesel locomotives in the world, with over 80% of these operating outside North America. Nearly all the world's 50,000 electric locomotives operate off-shore, half of these in the Commonwealth of Independent States alone. Almost 40% of the estimated locomotive demand (2,500 diesels, 1,200 electrics annually) over the next 15 years is expected from CIS and China.

Until the 1980's technical developments in the rail industry overseas had little impact on North American railroads. Off-shore developments and technology transfer between countries was politically aligned and quite diverse. Some countries were experimenting with magnetic levitation while others still operated steam locomotives as the primary motive power. There was little standardization of track gauge, electrification, or even couplers on a world-wide scale.

Over the past decade however, a technical revolution in the rail industry, combined with global competition and recession, has resulted in an increased awareness of international rail technology, and also in its significant impact on locomotive markets and suppliers. The result has been mergers and partnerships that are reducing the number of manufacturers, and creating a few world-wide locomotive suppliers. Specifically, these are G.M.L.G., G.E.T.S., A-B-B, AND GEC-Alsthom, who supply over one-half the world's locomotive production. Manufacturers in CIS, China & India supply nearly 40% of the current production.

The outcome of these changes is that a "melting pot" of technological applications is created. Developments in the

mass transit field impact passenger locomotives that in turn impact freight locomotive development. In addition, railways world-wide are now learning from the specific experiences of others and applying the results to their own operations.

This sharing of innovations and the transfer of technology is beneficial to the railway industry as a whole. The creation of transcontinental land bridges and iron highways, the construction of underwater tunnels, and the continuing standardization of gauges, electrification power supplies, and couplers are bringing us closer to a world-wide rail network. However, it should be noted that the application of certain technologies such as electrification are very site-specific, and are not universally practical.

2.0 Off-shore locomotive developments

Technical developments in off-shore locomotives have primarily involved high-speed electrified operations for passenger service. Nearly every European country operates electric locomotives for passenger service and many at over 150 kmh.

In the past, the North American viewpoint of off-shore technology was that it was not applicable to the heavy tonnages or long distances on this continent. Foreign railroads were generally viewed as short-run passenger services, or light-weight mixed freight operations. There are, however, a number of off-shore developments that are applicable to heavy haul diesel or shunting operations. Several manufacturers, for example, offer "modular" locomotives where the customer chooses or specifies a number of optional components and arrangements. Developments in other areas are summarized below.

2.1 Engines

Keeping with the modular concept,

several European locomotive builders offer choices of engines from more than one supplier. Recent technological thrusts in engine design are focusing on reducing the number of cylinders for lower maintenance and improved fuel emissions.

2.2 Body and cab

European and Japanese carbody construction is typically unitized and streamlined for high speed applications. The visibility and cleanliness requirements, however, carry over to freight applications off-shore. Control console layouts are ergonomically and aesthetically designed for a "white-collar" operator.

2.3 Truck and drives

Innovations in truck and drive technology have resulted from high-speed and electrification applications. Truck configurations include longitudinally placed traction motors, tilt bog designs, and the application of three or four trucks for use on sharp curves. The use of hollow shaft traction motors, and press-on tires continues even on the most modern locomotives.

Static drives have included thyristor technology since the 1970's and the use of GTO's more recently. AC motors have been in use in transit applications for a number of years and applied to locomotives for five years.

2.4 Controls and electronics

Innovations in electronics have included microprocessor control systems, solid-state event recorders, remote locomotive control for yard locomotives, and train control systems.

Developments in braking technology have included electro-pneumatic, electro-hydraulic, and electro-mechanical braking systems with electric control.

3.0 Technology transfer

Rail technology transfer involving North America has been overwhelmingly one-way with North American locomotives operating world-wide for the past 40 years. This has been a result of effective marketing, an excellent product, and to a certain degree, because of aid programs for developing countries.

Off-shore technological presence here has previously centered on transit equipment and industrial locomotives. Applications of mainline locomotives generally commenced in the early 1980's with the AEM-7 electric passenger locomotives and the GF6C electric freight locomotives. Since then, the general thrust has been towards passenger locomotives. Future applications will include high speed passenger trains and electrification.

Increased demand for coal and iron ore transport in the past decade has resulted in significant developments in "heavy haul" railroading. In North America, we have seen significant developments in heavy haul freight diesel locomotives that are now working on every continent of the world. The recent applications of AC traction and radial trucks are major contributions to the industry. The use of alternate fuels such as natural gas is the next area of major impact by the North American industry.

We encourage the suppliers and railroaders to remain abreast of the worldwide innovations in the industry. Individuals and companies should subscribe to some of the international trade publications and participate in conferences. Efforts must continue to integrate and assimilate off-shore technology into the domestic market, for the benefit of the railroad industry.

III UPDATE ON A-C TRACTION DEVELOPMENTS

A. Passenger

*Prepared By: Terrance E. Brunner,
Amtrak*

In the past, some people have thought of AC traction as an expensive, unproven drive system that promised little or no return for the investment and was years away from reality. But they've been surprised.

In passenger applications, the advantages of AC are not just limited to traction. It has many additional positive features that can be incorporated into the system. This was the motivating force behind passenger equipment applications. AC had the potential and is now the traction system of choice. Justification for this premise will be evident when the different applications are reviewed.

Electrification of mainline passenger corridors is presently being viewed as an environmental option and/or as the only efficient means of producing high speed, high horsepower light weight single locomotives or train sets.

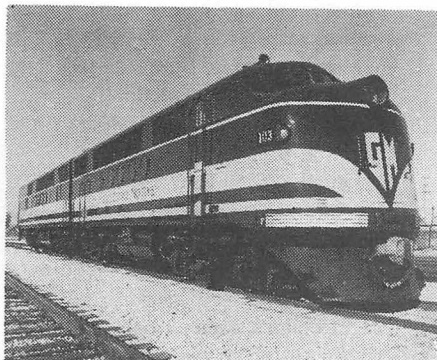
Presently Amtrak is preparing to electrify the Northeast Corridor line between Boston and New Haven. Because of the catenary system, power supply will not be a factor; but delivering the power to the traction motors while conforming to weight limitation is a factor. Indeed, the physical size and weight of the traction motors alone rules out the application of DC traction to produce the tractive effort that will be needed to reduce trip times between Boston, New Haven and New York to three hours. Traction is the main ingredient; but the need to produce hotel power in the same vehicle only adds to the weight problem if the power is not efficiently produced. And hotel power

is equally as important as traction power to meet the requirements for customer comfort.

This past year, two train sets have been brought to the United States for the purpose of demonstrating high speed, light weight train set technology. Before they left their respective European countries, both train sets were configured for the electrified portion of the Northeast Corridor. They were made compatible with Amtrak's catenary voltages and frequencies, cab signals (speed control), event recording and pantograph systems. Both train sets were uncoupled and loaded onto wagons, one locomotive or car per wagon. The wagons were then moved aboard ship for transport to the U.S. The reverse procedure was followed for unloading at Baltimore, the U.S. port of arrival. Both train sets were moved by rail to Washington and energized. What is perhaps unique is that both train sets had no problems being energized and performing flawlessly to the rigorous test and revenue schedules.

Both train sets for this demonstration had AC propulsion drive packages. The first to be tested was the Swedish X-2000, whose propulsion system was manufactured by ASEA Brown Boveri. The second train set was the German ICE, with a propulsion system manufactured by Siemens. Of course other manufacturers - AEG, Krauss Maffei, Krupp and Thyssen Henschel to name just a few - contributed to the train sets' subsystems and car body construction. It's also of interest to note that Siemens equipment was on the X-2000 and ABB equipment was on the ICE. This is typical of large capital projects in Europe today, where all major manufacturing companies are represented.

Both train sets were very stylish, but their operating philosophies were different. The X-2000's approach to high



1939.
Electro-Motive's FT103
Diesel locomotive that
replaced steam forever.



1993.
Electro-Motive's
"RADIALAC™" locomotive:
changing the face of
railroading once again.

At Electro-Motive, we're proud of our continuing major role in the revolution of the railroad industry.

Electro-Motive's new "RADIALAC™" locomotive system converts DC power to AC power to provide maximum horsepower and tractive effort. In revenue service, it has been proven that three RADIALAC locomotives can do the work it previously took five DC locomotives to perform!

At Electro-Motive, *The Future Is Now.*



ELECTRO-MOTIVE

speed was to operate on existing track, while being able to negotiate curves at higher speeds. This is done in order to minimize the deceleration and acceleration required by curve restrictions, thus reducing overall trip times. The ICE's approach was to have ample amounts of horsepower available on demand, to lessen the impact of any civil speed restrictions, as well as to have the capability of operating longer trains.

Mechanical similarities shared by both were the following: utilization of traction motor output through a gear-box to the wheel set via a quill drive tube system; AC traction motors; gate turn-off semi-conductor (GTO) inverters; disc brakes; electronic air brake systems; cab screen displays; track brakes; regenerative brake systems and microprocessor controls.

Items unique to the X-2000's locomotive were:

1. Stainless steel carbody construction;
2. Oil cooled GTO inverters;
3. One locomotive per train set;
4. Hydraulic tilt microprocessor for cars'
5. Chevron primary vertical suspension;
6. Maximum speed (revenue) 125 mph;
7. Traction motors asynchronous;
8. Rating, continuous, 3, 260 kw;
9. Length 16,980 mm;
10. Spring secondary vertical suspension;
11. Two side aisles through machinery room;
12. Operator's stand on left side;
13. Pin and collar arrangement;
14. Brake discs in plates of wheels;
15. No fiber optics.

Items unique to the ICE's locomotives were:

1. Aluminum car body construction;
2. Freon cooled GTO inverters;
3. Two locomotives per train set;

4. No tilt system;
5. Leaf guider rubber mounted primary vertical suspension;
6. Maximum speed (revenue) 160 mph;
7. Traction motors induction;
8. Rating, continuous, 4, 800 kw per locomotive;
9. Length 20,560 mm;
10. Spring secondary vertical with sliding side bearings;
11. Center aisle through machinery room;
12. Operator's stand on right side;
13. Automatic couplers;
14. Brake disc in quill assembly;
15. Fiber optics for train line functions.

Both train sets have toured the United States and have generated much enthusiasm for both high speed rail and the rail industry in general. The publicity and marketing aspects, the public comments, operating characteristics, maintainability, subsystem packaging and diagnostic capabilities have given many railroaders and members of the public the unique opportunity of getting an overview of modern train set technology. All this has made this demonstration project a complete success for all departments within Amtrak. This new knowledge should greatly influence future orders for train set equipment.

Let me focus now on other forms of revenue producing trains and equipment, the conventional intercity long distance trains, commuter agencies, E-60 locomotive replacement and the need for additional locomotives to supplement the AEM-7 fleet when electrification is completed to Boston. An AC-drive, high horsepower, high speed, four-axle locomotive has been determined to be the solution to our present and future requirements for these revenue producers

The general characteristics of this electric locomotive, which would oper-

ate in conventional services, include the capability of producing 10,000 hp, which now can be done efficiently by AC traction drives. Some of the major limiting factors of using DC technology would be wheel adhesion, weight limitation/rail forces caused by operating at speeds up to 150 mph, and the need to produce 800 kw of hotel power with redundancies for reliability.

With AC drives, each wheel set on the high horsepower locomotive would be powered by its own inverter and microprocessor, which will optimize wheel creep and adhesion. Wheel adhesion is the key component for a light locomotive that is required to develop high tractive effort. Hotel power could operate on an inverter that would be similar in design and power to the traction inverters. If a hotel inverter failed enroute, a traction inverter would be electrically configured to supply hotel power to maintain the comfort of the passengers.

Another advantage of an AC drive as compared with a conventional DC drive electric locomotive is its ability, thanks to GTO, to maintain the power factor at virtually unity. This will make all future electric locomotives considerably more efficient. With regenerative dynamic braking systems the new generation of electric locomotives will be the friendliest toward energy consumption when compared with other types of locomotives.

The future is bright both for the electric locomotive and the integration of AC drive systems. However, if the efficiency of these electric locomotives could be combined with the diesel/alternator power supply, then both systems could be used to their optimum system advantages. This concept of having dual-power locomotives isn't new; but with AC drives the reliability of such locomotives increases by

a very significant factor. This is because with AC drive systems it is possible virtually to eliminate the mechanical switch gear in the power circuits.

It is this reliability factor that has motivated Amtrak to proceed with the purchase of ten 3,200 hp dual powered locomotives from General Electric. The second power source will be the 600-volt third rail. On their primary route, these locomotives will operate over Amtrak's West Side connection from Albany, NY., through Penn Station, New York City, and then continuing into Long Island, N.Y. Other routes are contemplated.

Amtrak's dual-powered AC locomotives will optimize the AMD 103's body design. The most important design criterion is once again weight on axles. This locomotive will take full advantage of using one inverter for each axle drive. Hotel power will be rated at 800 kw both on third rail and in the diesel mode. Many operational benefits are anticipated from this type of locomotive.

During construction of Amtrak's first dual powered locomotive, car body weight and equipment weight conformed with or were less than the estimates. This was an impressive verification: with these data it has become evident that a dual powered locomotive using high voltage AC overhead contact systems could also be built. When traction power is supplied by the catenary system, the kilowatts for traction could be equal to or greater than the kilowatts generated by a 12-cylinder diesel powered supply system, and still conform to the rigid weight restrictions. AC drive packages will continue to improve, and the current collection problem that is inherent with DC will be eliminated. This dual power catenary/diesel configuration will become

the standard for commuter agencies that are very sensitive to air quality in station areas, yet still must operate over many miles of non-electrified rights of way.

With electrification comes a substantial capital investment. Other alternatives are also needed to obtain high speed rail operations. Once again, AC drives for both traction and hotel power will play an important role. Presently, New York state is investing money into turbo powered equipment to demonstrate high speed rail services in non-electrified territories. A set of Amtrak's RLT turbos will be overhauled with basically the same horsepower rated turbo engines, but with a new engine modular design concept. The newly designed engine will demonstrate the ability to lower hourly engine operating costs, along with extending the operating hours between engine overhauls. When operational costs are proven to be lowered, this established form of propulsion could be mated to an alternator to produce a DC link buss for adaptation to AC drive inverters.

Presently, the turbo engine is interfaced to a mechanical transmission which mates to a gear box to supply the torsional force to drive the wheel sets. Only one truck per turbo power car is powered in this way. Low wheel adhesion and high maintenance cost are detrimental factors. However, with an AC traction package all wheel sets on the car could be powered with very low maintenance cost AC traction motors. Since turbo equipment is operated into New York City, dual power is a necessity. This requirement again would be addressed by AC inverters, with the option of either third rail or overhead power collection. With lower engine overhaul costs and AC technology, this form of motive power could have potential for high speed rail service.

One of the spin-offs from the new AC technology is the application of the improved, GTO inverters to existing rail equipment. Amtrak has started an enhancement program for the AEM-7 DC drive electric locomotives. The program will feature complete micro-processor traction control, diagnostics and GTO inverters producing hotel power. The traction converters will be physically separated for more positive protection from device flashovers. What has made these redesigns possible is the elimination of one complete SCR controlled inverter for hotel power. It will be replaced with a physically smaller packaged GTO inverter. The new sine wave form produced by the GTO inverter will be appreciably improved. Hotel power output will be raised from 500 kw to 800 kw, now needed because of longer train consists.

As with any AC drive application, this program will take advantage of the flexibility made possible by interchangeable inverters. The auxiliary power supply (used for 480-volt rotating equipment on the locomotive, i.e. traction motor blowers, etc.) will have its inverters electrically capable of being substituted for the hotel power inverter as a redundant backup system.

The ability to change the configurations of inverter systems is one of the many attributes of AC drives systems. This was first noted on the F-69 locomotives, when the reduced engine rpm made possible by the inverters contributed to the 14% plus fuel saving when producing hotel power from the prime mover.

With the projects described here and others, such as New Jersey Transit's retrofit AC program for its heavy rail MU cars, the Market Street subway cars in Philadelphia, and new light rail applications in St. Louis and Norristown, Pa., AC drives are becom-



AMD 103, X2000, ICE



X-2000 ON WAGON

ing very visible. They are becoming the norm rather than the exception in passenger equipment.

Impressive as AC drive systems are, they still will not stand alone. Packaging is still the key to their success. Rail civil engineering projects and properly designed maintenance facilities are also needed to obtain the full potential of AC drives. There are no shortcuts when trying to integrate systems with the goal of improving trip times.

B. Freight

Prepared By: George C., Hsu.

Burlington Northern

While the passenger rail industry has taken advantage of the AC traction technologies for many years, its applications to freight locomotives are not as far advanced. To address this, the AAR's Locomotive Efficiency Review Committee formed an ad hoc subcommittee to study AC locomotives. As a result, the committee recommended assembling a mini-AC fleet of at least 20 units for the AAR to test for about two years based on these requirements: 5,000 hp, 45% starting adhesion (32% for dispatch), and 6,000 hp dynamic brake grids. There are about ten railroads who have shown interest in procuring a total of 22-26 units for testing. However, BN's commitment to buy 350 SD70MACs during the next five years may have made that plan unnecessary. BN will take delivery of the first ten locomotives before the end of 1993. While there is a lot of excitement about AC locomotives because of their many strengths, these strengths may not be profitable if they are not used properly. This paper discusses these issues in the hope that the freight railroads will be better prepared when the era of AC traction locomotive is

ushered in.

More tractive effort to do real work with radial truck

One of the new features built into the AC locomotives is the radial truck, as shown in Figure 1, which directs all of the tractive effort in the longitudinal direction. This means the extra tractive effort delivered by this new breed of locomotive will be performing useful work rather than being diverted to overcome the resistance due to high angle of attack when negotiating a curve. That is why BN is able to run its usual coal train between Denver and Pueblo with only three SD60MACs and one pushing instead of the usual two DC SD60s, two 3,300 HP SD40-2s, and two more pushing. That is a potential saving of up to two units per coal train on that corridor.

Does too much tractive effort hurt the track?

While wheel-slip has always been considered a problem to be minimized if not eliminated all together, normal slips do have a silent side benefit: sometimes they can serve as a relief mechanism when the draft force becomes too high. With the new AC machine wheel slips are practically eliminated. The controlled creep and the variable frequency controlled traction motors create a much more concentrated force. Since there are fewer locomotives with fewer wheels to serve as load bearing points, this question must be asked: Is the concentrated force high enough to cause any concern? In other words, does it create enough force to disturb the track structure? To address this concern, BN and the AAR have set up two test sites in search of the answer. One at Castle Rock, Colorado, tests for tractive force and another at Monument, Colorado,

tests for dynamic brake force; both sites are south of Denver, as shown in Figure 2. Track force was measured for both DC consist and AC consist. Detailed test results were published in the June 1993 issue of the *Railway Age* magazine and will not be repeated here. Basically, the test showed that the AC locomotives performed very well and had minimal effect on the track. They performed especially well in the curve negotiation with the radial truck, much better than their DC counterparts.

Does the micro-creep hurt the wheel tread and rail surfaces?

Since there is so much more force exerted to the rail as a result of the micro-creep and variable frequency control, there must be more wear and tear to the wheel tread and the rail surfaces. The question is: how much? To answer this question, the AAR is planning a research program addressing the issue of adequacy of current wheel and rail material. If it is not adequate, what needs to be done?

Can the train sustain the increased draft force?

With the substantially increased tractive effort, the in-train force is also increased, all at the head end. Will this force be so concentrated that it would "find" all of the weak knuckles for us as shown in Figure 3? Or would there be enough force to actually stretch the car body if all of the knuckles survived? Figure 4 may be an exaggeration, but figure 5 captures the stretch marks which appeared on EMD's test car following a break-in-two during one of the test trips on a coal train, obviously, after an extended "stretch."

Issues concerning unequally yoked AC and DC Locomotives

Generally speaking, it is best to run a

pure AC consist, if possible to avoid complications due to vastly different characteristics of AC and conventional DC locomotives. For example, Figure 6 indicates something the AC locomotive can do that its DC counterpart abhors: the train speed stays at zero while the tractive effort is pegged. While emulation of this act is not encouraged, a coal train could be held on the grade, if there is enough hp, without hurting the AC traction motors.

However, if DC locomotives are allowed to trail behind a leading AC unit, sooner or later, some engineer will get carried away with the extraordinary abilities of the AC unit and forget its weaker DC brothers suffering behind as depicted in Figures 7 and 8. Exaggeration? Not quite. Figure 9 shows a train in trouble led by BN 9502, an SD60MAC. Figure 10 shows its trailing DC brother BN 5569, a GE C33-7. By comparing the two event recorder charts, it becomes clear that while the train is in trouble BN 9502's load is still fairly smooth compared to the trailing unit BN 5569. Circled places in Figure 10 indicate severe wheel slips while there are no noticeable slips in Figure 9 for the AC unit. It is also clear that the train eventually will stall due to the severe wheel slip on the trailing DC unit while the AC unit is left to carry a bigger share of the load.

What if a DC locomotive is used to lead an AC unit to make the engineer aware of the wheel slip conditions and take immediate corrective action? It turns out that the engineer became so conscious of the situation that he attempted to back off the throttle to gain better control of the train every time the wheel slip occurred. That is how we get a bored looking AC locomotive behind a DC unit, as depicted in the cartoon in Figure 11, because the AC unit is being "told" to back off

while it still has literally "tons" of tractive effort to spare.

The test run was conducted using BN 5572, also a GE C33-7, leading the same AC unit BN 9502. In Figure 12, the speed and load current profiles of unit BN 5572 showed clearly that it is experiencing severe wheel slip for an extended time with the engineer trying to modulate the throttle. But the event recorder tape shown in Figure 13 indicates a very smooth speed profile. The load profile is also much smoother. Even the minute sawtooth part of the load profile is caused not by slips but by the constant throttle modulation of the engineer.

Never mix the DC and AC?

Initially, the AC locomotives BN is taking delivery of, will be used strictly in the coal traffic and can easily be kept in a pure AC consist. Sooner or later, however, a DC/AC mixed consist will happen. There are at least three reasons that it will happen: Reality, Reality, and Reality!

Reality 1: Even during the early AC era when most of the AC units will run in pure consists, there will be times when they will be diverted in justifiable situations to run in a mixed consist, although rarely.

Reality 2: When enough AC locomotives are scattered around the country, power balancing will often call for a DC/AC mixed consist.

Reality 3: With 4,000 hp for each AC locomotive, a pure AC consist can only have a combination of consist power of 4,000 hp, 8,000 hp, or 12,000 hp, and so forth. For a bulk commodity train, that may be tolerable. But for a general merchandise train a 4,000 hp increment

is just too coarse to deal with. The power controller must use some 2,000 to 3,000 hp units to fill the gap, so to speak, in order to match the power requirements and train size.

AC-compatible DC locomotives

For these reasons, a more realistic solution takes advantage of the modern electronic technology to improve the older but better performers so that they can work with AC locomotives without destroying themselves. To make these traditional DC locomotives AC-compatible, the following features are minimum requirements:

1. Smart wheel slip/slide control - This feature will allow the DC locomotives to control wheel slip/wheel slide when the MUed AC is grinding away with heavy loads at very slow speeds or under heavy dynamic braking.
2. Automatic traction motor protection - This feature will back off the DC unit automatically and precisely when its traction motors are exceeding its short time rating. It also will automatically increase the power to the same level of tractive effort allowed when the traction motors have cooled down enough to try again for high adhesion operation.
3. Automatic stall burn protection - This feature will cog the drive wheels automatically or create enough creep to avoid stall burns when the locomotive consist is applying power but the train is

The GE AC4400 CW™ . . .

A Significant Advantage in AC Propulsion Technology



The new GE AC4400 CW™ is the future of motive technology. Its dramatic innovations increase power, reduce fuel consumption and lower emissions.

Its individual axle control incorporates air-cooled, inverter per traction motor technology, creating advantages that are not available through other AC propulsion designs.

The AC4400 CW™ is designed to increase reliability, lower maintenance and reduce operating costs — technology that directly impacts your bottom line.



GE Transportation Systems
Dedicated to Customer Success™

standing still longer than the time allowed by a preset limit.

This way, the power of the leading DC unit, in the case of the cartoon Figure 14, will be backed off by the electronics automatically at its peak adhesion level while the trailing AC unit can still put out its full power at throttle 8.

Distributed power

Mixed consist operation is only one of the main issues. Another one, as mentioned before, is over-concentration of drawbar force. This can be taken care of by a long existing solution: distributed power, as show in the cartoon Figure 15. This concept, of course, is not new. In fact, it is being used by many railroads even now. But AC locomotive operations compel us to take this option more seriously. Because the AC locomotive is computer-controlled, remotely controlled operations become much easier. First, the old bulky mechanical actuators become unnecessary. Since both the engine and air brake are electronically controlled, all we need is to send the command to the remote units from the head end. For a four-unit consist, the train can be divided equally into four segments by the four units. The command can be sent from the leading unit to the remote units in a daisy-chained fashion, if RF linked, which would practically elimi-

nate the RF continuity problems which have plagued railroads in the past on rough terrain. Or, the command can be sent by using the same cable the electro-pneumatic braking system may require in the not-so-distant future. Second, any unit can be the master unit. This would simplify the job of power controllers tremendously because they would not have to consider this variable for a lead-qualified locomotive. Third, the operation can be in master/slave mode, or independent mode. This would really open up all sorts of opportunities for optimizing the in-train force to improve train handling through the on-board computer.

AC locomotives present exciting opportunities to the railroad industry. There is so much more we can accomplish because of their power and flexibility. But it is important to keep in mind the many special characteristics of the AC locomotive which are very different from the traditional DC units used in freight services. If we ignore these special characteristics, we will suffer the consequences immediately. Now is the time to prepare ourselves for the coming AC locomotive era so that when they start to show up on our door steps, we will be ready to avoid the pitfalls and reap the benefits to the fullest of their potential: efficiency and safety, which are the cornerstones of better service to our customers.

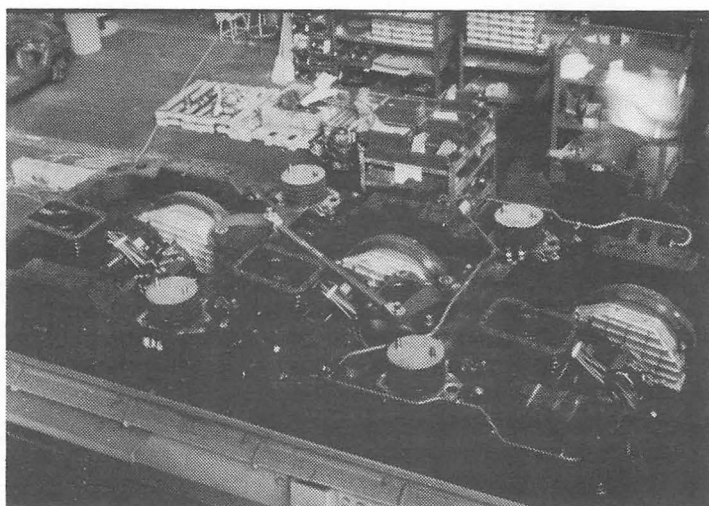


Fig. 1

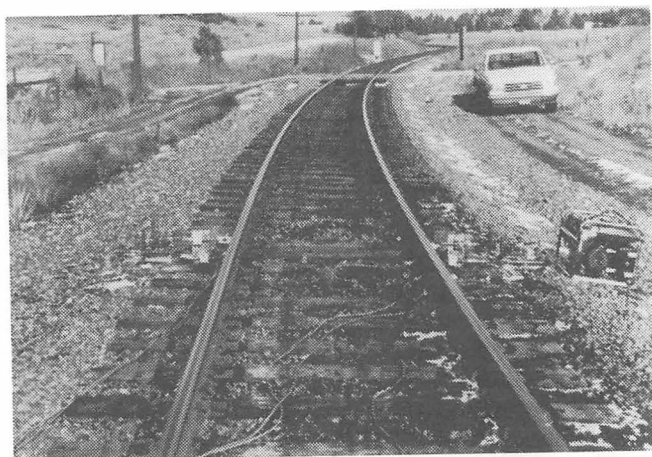


Photo of dynamic braking site (looking North) at Monument, CO, with track-side measurements equipment in foreground.

Fig. 2

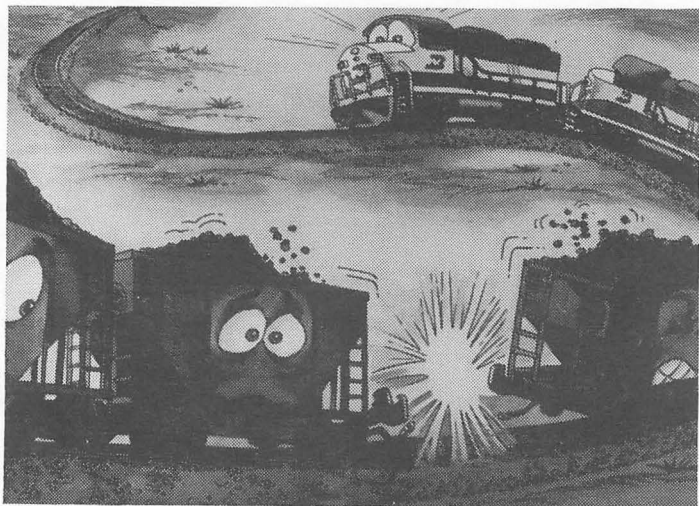


Fig. 3

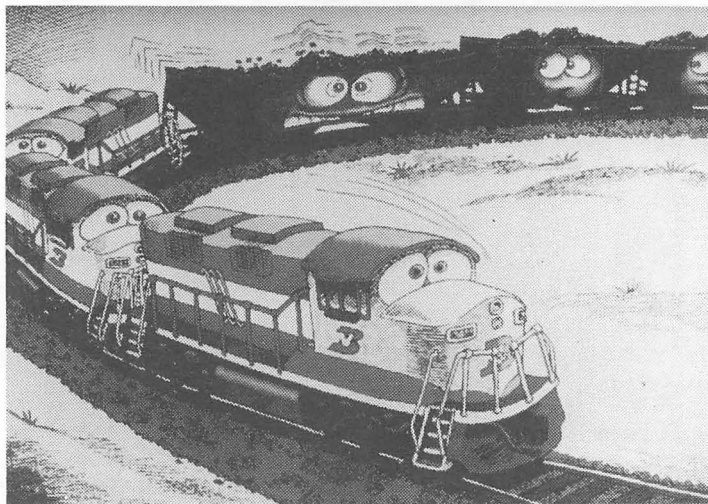


Fig. 4

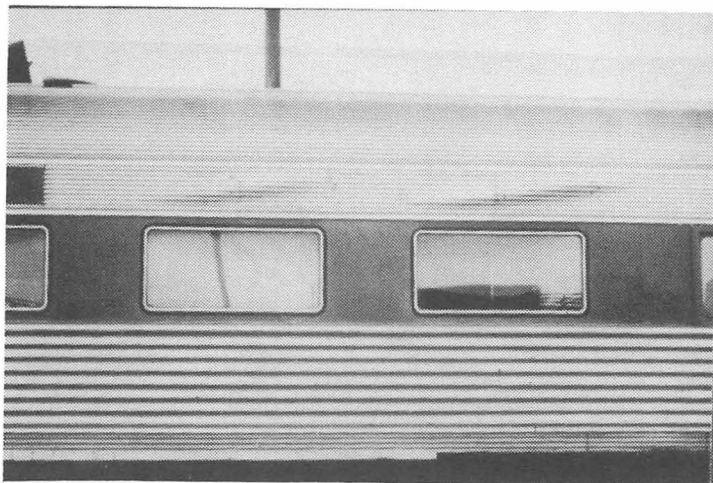


Fig. 5



Fig. 6

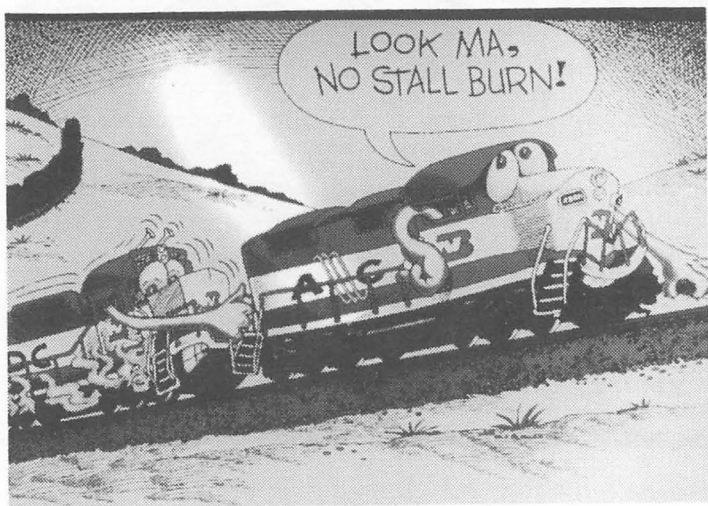


Fig. 7

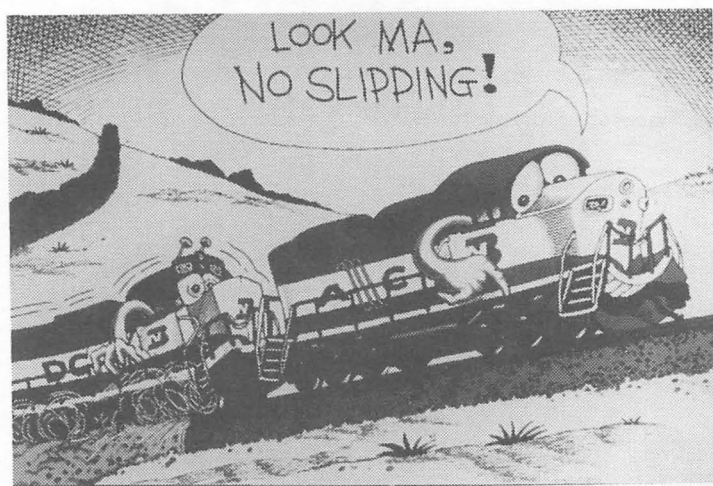


Fig. 8

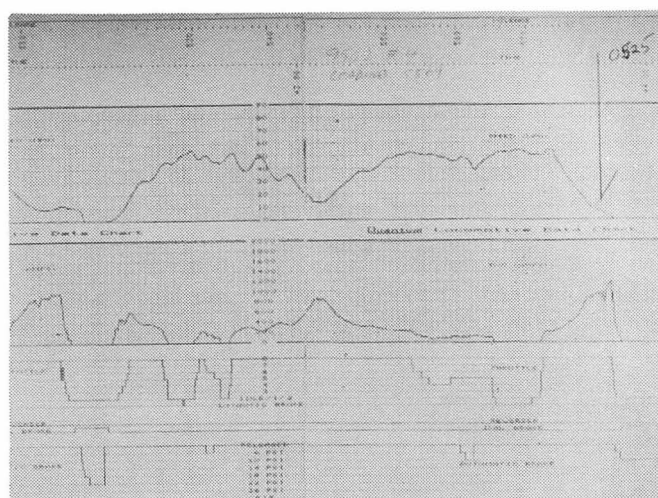


Fig. 9

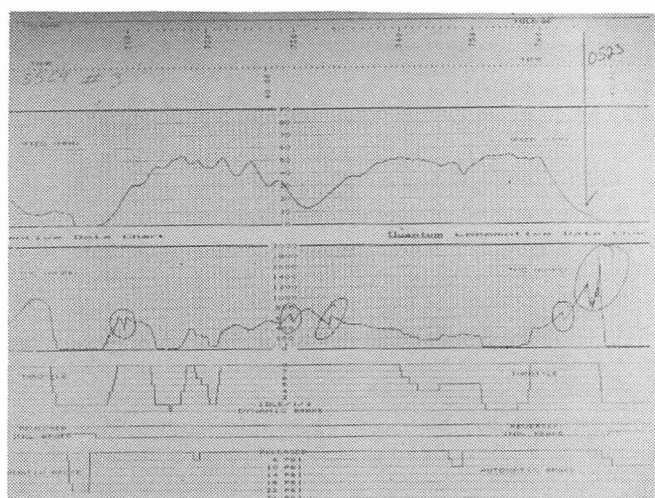


Fig. 10

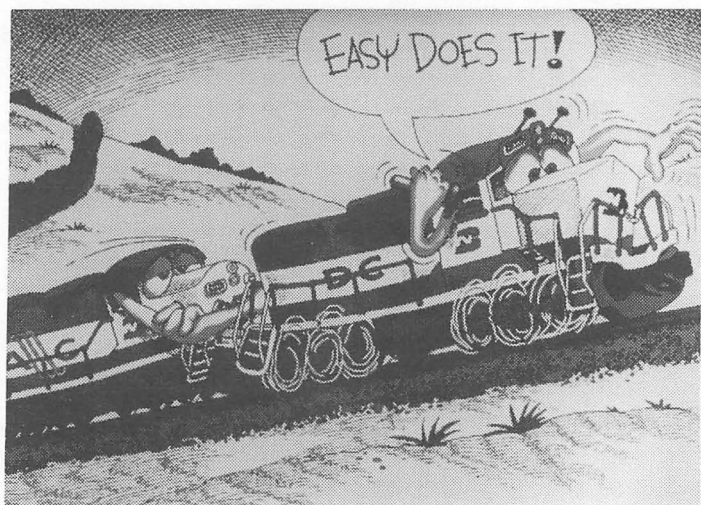


Fig. 11

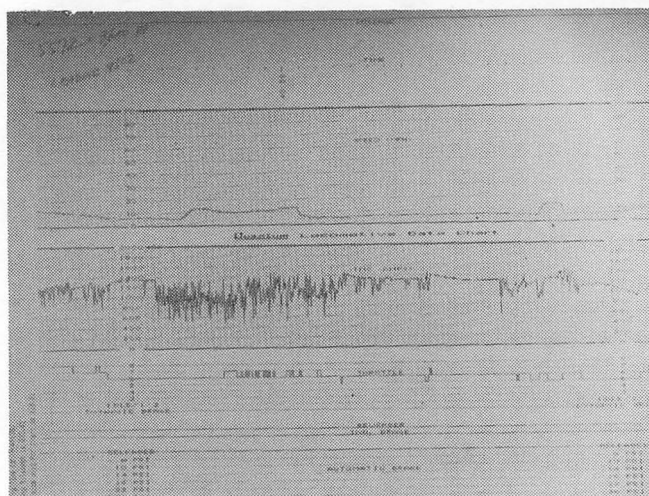


Fig. 12

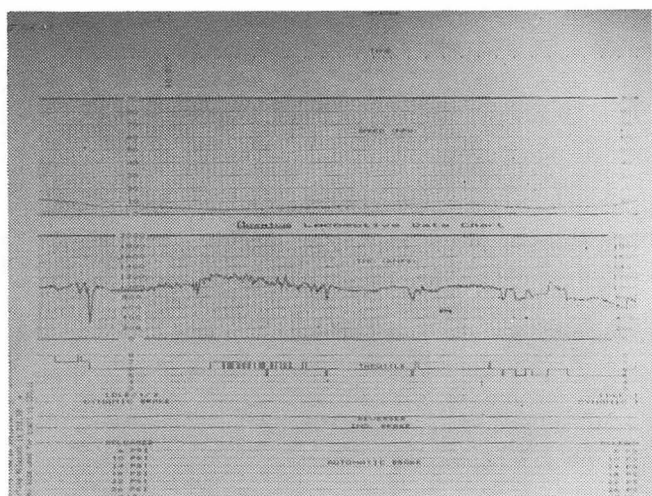


Fig. 13

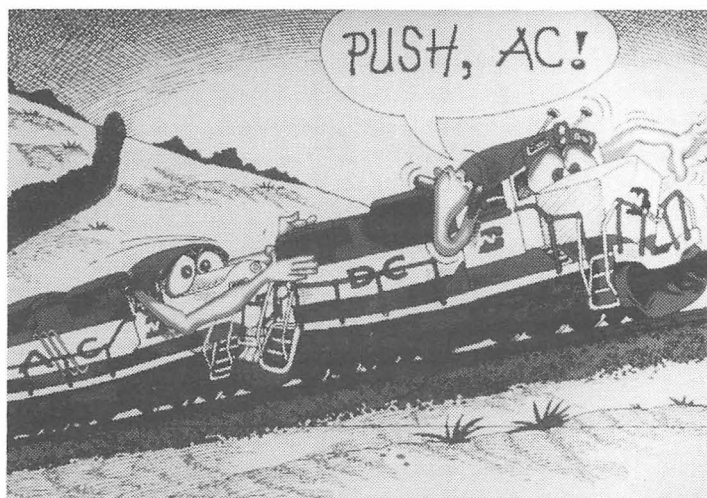


Fig. 14

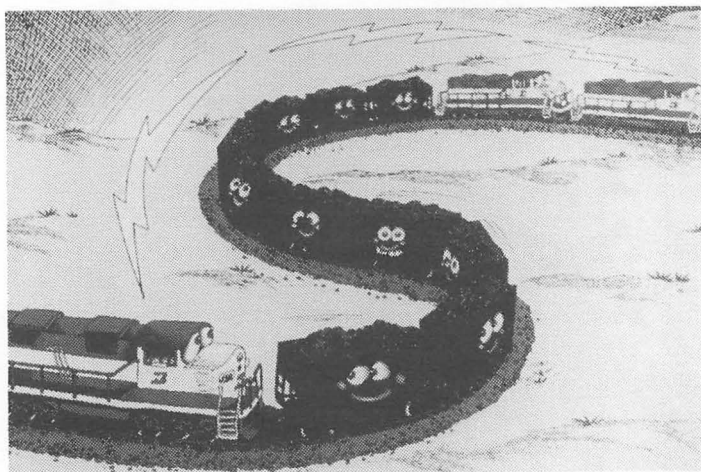


Fig. 15

VMV Paducahbilt



REMANUFACTURED LOCOMOTIVES AND COMPONENTS

- OEM SPECIFICATIONS
- QUALITY SERVICE
- STANDARD WARRANTY
- COMPETITIVE PRICING



- USED LOCOMOTIVES FOR
SALE • LEASING
- LEASE FLEET MAINTENANCE
- WRECK AND DAMAGE REPAIR

VMV ENTERPRISES, INC.
1300 KENTUCKY AVENUE
PADUCAH, KENTUCKY 42003

502-444-4358 • 800-444-8683

AUTHORIZED BUYER OF GM LOCOMOTIVE PARTS

**REPORT OF THE COMMITTEE
ON SHOP EQUIPMENT**

**MONDAY, SEPTEMBER 13, 1993
2:15 P.M.**

**Pre-Convention
Presentation
Chicago RR Mech.
Assn.**



**April 19, 1993
Holiday Inn
Merchandise Mart
Chicago, IL**

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

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

COMMITTEE MEMBERS

R. Collins	Mgr-Wheel Shop	Burlington Northern	Lincoln, NE
S. Fuzail	Dir. Opns Res. & IE	C&NW Trans.	Chicago, IL
J. Gamble	RR Sales Manager	Turbine Specialities	Salina, KS
J. Hunt	General Foreman	Illinois Central	Homewood, IL
D. Kisko	Requisition Mgr.	General Electric	Erie, PA
R. Lynch	Sr. Gen. Foreman	Norfolk Southern	Roanoke, VA
J. Muench	Industrial Engineer	CSX Transportation	Jacksonville, FL
R. Plaughter	Qual. Process Spec.	Union Pacific	N. Little Rock, AR
M. Scaringe	Mgr-Loco. Overhaul	Amtrak	Beech Gove, IN

NOTE: J. Gamble employed by EMD during 1992-1993

PERSONAL HISTORY

John J. Clontz

Superintendent New Technology Implementation, Burlington Northern Railroad

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

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

department.

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

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

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

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

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

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

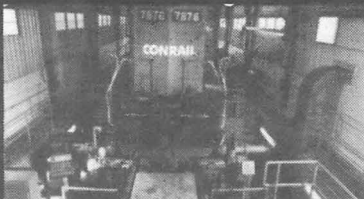
If you have never been a member of our Club or Clubs and would like to see what we are about first hand, just contact our Secretary, Don Brooks (708-258-9660), and we will be happy to provide you with complimentary tickets for one of our meetings. We'll look forward to seeing you at the next meeting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

**The Board of Directors
The Chicago Railroad
Mechanical Association**

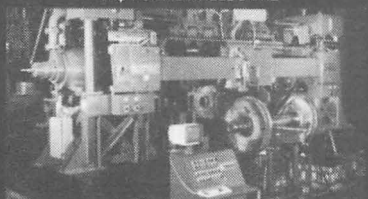
S HIGH PRODUCTION SYSTEMS FOR THE RAILWAY WHEELSHOP



SIMMONS-FARREL HIGH PRODUCTION CNC PORTAL WHEEL LATHE



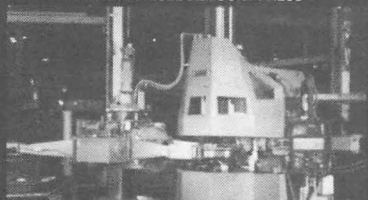
SIMMONS-STANRAY AUTOMATIC UNDERFLOOR WHEEL PROFILING MACHINE



SIMMONS-NILES 600 TON AUTOMATIC CAR AND DIESEL DEMOUNT PRESS



SIMMONS-NILES SINGLE END WHEELSET OR AXLE TURNING AND BURNISHING LATHE (AJTB)



SIMMONS-NILES CNC DIESEL WHEEL MACHINING CENTER



SIMMONS-FARREL 300 TON AUTOMATIC CAR AND DIESEL WHEEL MOUNTING PRESS

- THE BROADEST PRODUCT LINE WORLDWIDE OF SPECIAL MACHINE TOOLS FOR WHEELSET, WHEEL AND AXLE MAINTENANCE WORKSHOPS OF RAILWAYS, METROS AND TRANSITS.
- CONVENTIONAL OR CNC CONTROL SYSTEMS FOR MACHINES AND MATERIAL HANDLING UNITS.
- NILES UNIVERSAL CNC SLANT BED TURNING CENTERS WITH TURRET HEAD AND POWER TOOLING.



SINCE 1833

NILES-SIMMONS
INDUSTRIAL EQUIPMENT GMBH
 ZWICKAUER STR. 335
 0-9030 CHEMNITZ-GERMANY
 TEL. 0371-8020 FAX. 0371-850328
 AN AFFILIATE OF
SIMMONS MACHINE TOOL CORP.



SIMMONS
MACHINE TOOL CORP.
 1700 N. BROADWAY
 ALBANY, NEW YORK 12204, USA
 TEL. (518) 462-5431
 TELEX 592999 (SIMMONS)
 FAX: (518)-462-0371

I. DYNAMIC BALANCING FOR GE DASH 8 MODEL LOCOMOTIVES

Presented by: J.F. Muench - CSX

Dynamic balancing is a product improvement procedure performed on Dash 8 models of GE locomotives. The purpose is to insure that vibrations caused by the alternator/engine assembly's rotating equipment are maintained within acceptable limits. It is a proactive procedure that addresses vibration - one of the root causes of locomotive failure.

1. Scope

Three categories that dynamic balancing currently encompasses are:

- The dynamic balancing procedure that has been standard on all Dash 8 locomotives since January of 1991. It is provided by the OEM on all engine-mounted Dash 8 alternators now being delivered.

- A field modification for the 1,125 Dash 8 locomotives, manufactured and delivered prior to January 1991, have not had the benefit of being dynamically balanced. The field modification to achieve this balance state is available from the OEM. In it, metal is trimmed from standard weights, as needed, to achieve the balanced condition of rotating assemblies.

- Dynamic balancing also should be considered for Dash 8 locomotives that have had the alternator and/or engine assemblies replaced.

2. Benefits

The rotating armature and crankshaft assemblies initiate vibrations that are transmitted through the various locomotive structures. Vibration can cause uncontrolled movement of component pieces which may ultimately result in their failure by cracking, breaking or loosening.

Vibration related failures include:

- Engine piping and fittings
- Lube oil filter tank cracks
- Platform associated mechanical failures
- Bulkhead cracks
- Water piping
- Fuel and lube oil piping
- Cab structures.

The reduction of vibration related failures attributable to dynamic balancing has been quantified by a comparison of similar fleets of dynamic balanced versus non-dynamic balanced Dash 8 locomotives. Research, which was compiled by the OEM, revealed that the dynamic balanced fleet experienced 34% fewer incidents related to vibration.

Although a measurable reduction of vibration is documented during the dynamic balancing procedure, one interesting observation noted by the workmen working on the locomotives is the coffee cup effect. This effect is one in which the ripples in the coffee cup are observed to be diminished after the Dynamic Balancing procedure is accomplished.

It is anticipated there will be an increase in service life for major engine and alternator components such as bearings and power assemblies.

The bottom line is that the reduction of vibration will reduce locomotive failures, and the reduction of locomotive failures saves money through fewer locomotive repairs, fewer train delays and fewer penalties for FRA violations.

3. Special equipment needs for dynamic balancing

The following equipment is needed:

- Spectrum analyzer
- Tandy 1400 computer or equivalent
- Accelerometer with magnetic base and lead
- Test panel (cover) for the alternator

- Dynamic balancing software
- Speed sensor
- Reflective tape.

Individual items may be secured from third parties and the software from the OEM or a kit can be obtained from the OEM containing all of the necessary equipment. The kit is currently available for under \$15,000.

Other needed parts may include an accelerometer mounting block, weights, spacers and bolts utilized in achieving the proper balance of the rotating assembly.

4. Procedure

At first, the procedure may detain the locomotive from revenue service for about eight hours because of the initial "learning curve" for the craftsmen. Ultimately the procedure should require three to four hours.

During the procedure, data regarding vibrational amplitude are sent by the accelerometer to the spectrum analyzer, which coordinates the vibrational information to the position and speed of the armature. The speed sensor supplies both the armature speed and position. The spectrum analyzer then compiles the information for processing by the computer running the balancing software.

Lateral vibrations are determined by detecting the average vibration at four phase angles while running at throttle notch 2, and then the vertical vibrations are determined in like manner running in throttle notch 8. A balanced state, or

the adjustments needed to achieve it, are determined by the available software. A balanced state is achieved by the strategic placing of weights on the alternator's auxiliary yoke outside diameter. If adjustments are needed the procedure is repeated until a balanced condition is realized.

One of the following criteria must be met for the alternator to be considered balanced:

- Notch 2 and notch 8 vibrational amplitude must be 4.00 mils maximum.

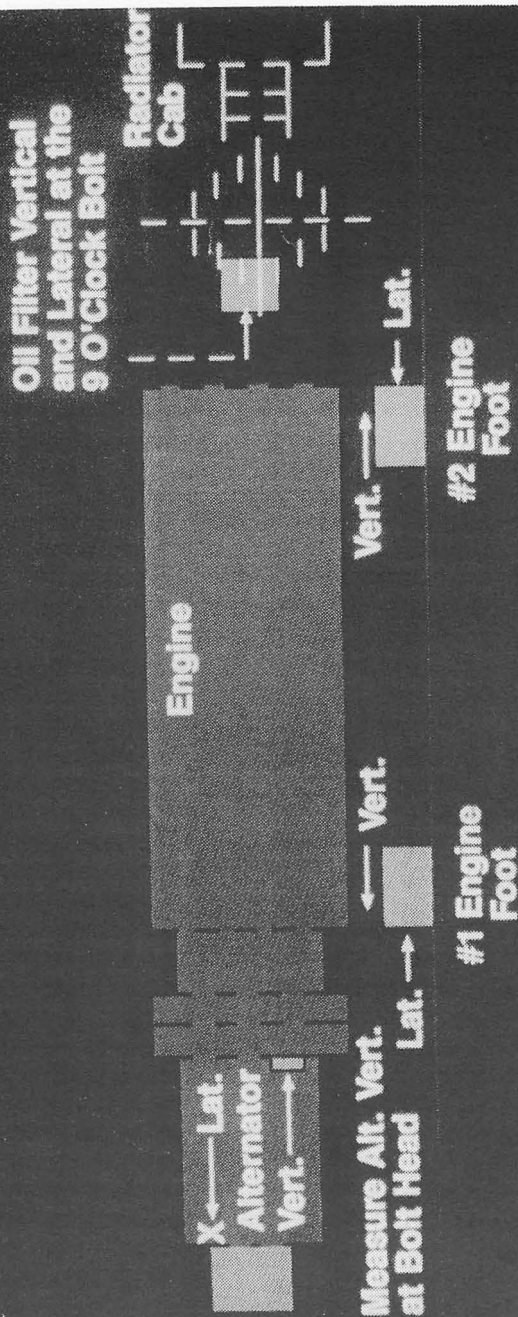
- Vibrational amplitude must not exceed 6.00 mils and the difference between notch 2 and notch 8 vibrations must be 1.00 mil or less.

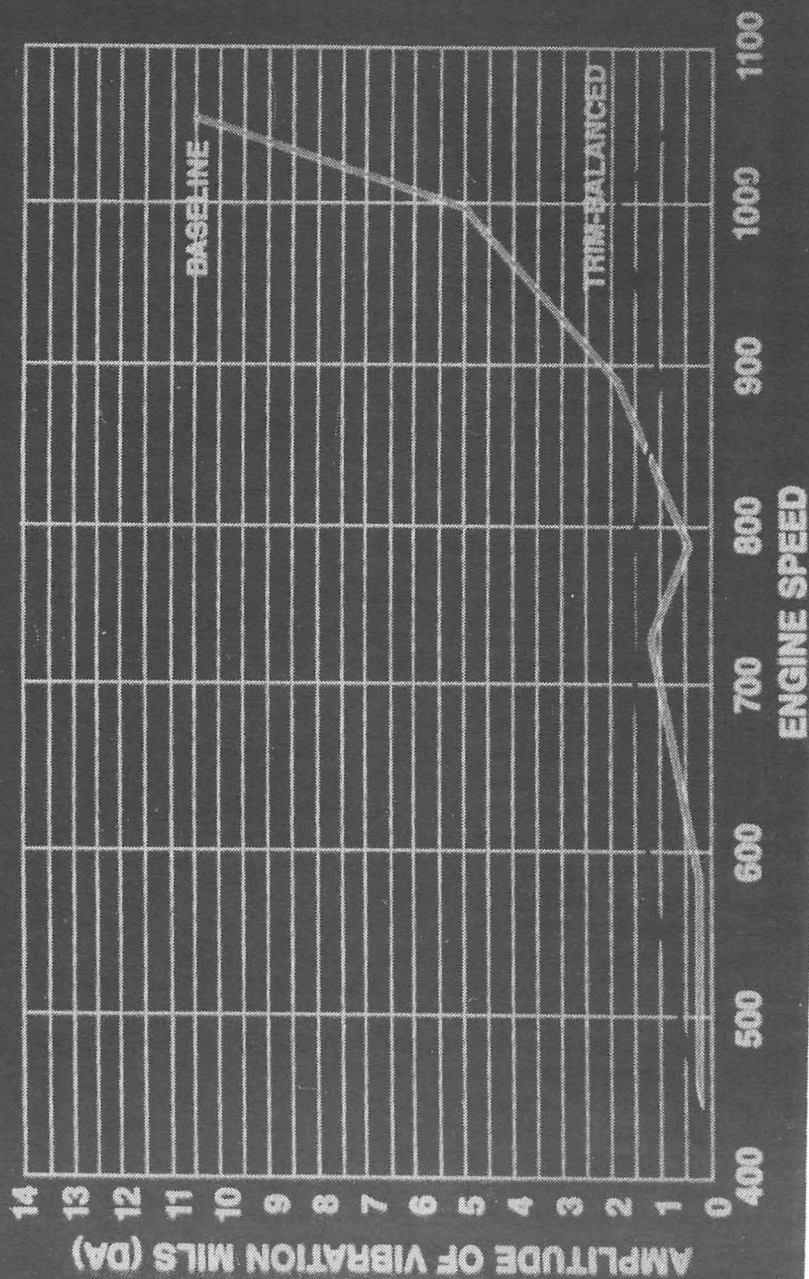
The dynamic balancing procedure also offers an opportunity to secure baseline vibrational data. Monitoring deviation from the baseline may indicate excessive wear on internal parts of components. Vibrational locomotive analysis projects at CSX Transportation this year are to include analysis of locomotive main generators and main alternators. Currently CSX is monitoring turbochargers and air compressors and has in place criteria for removal of those components that deviate from vibrational standards.

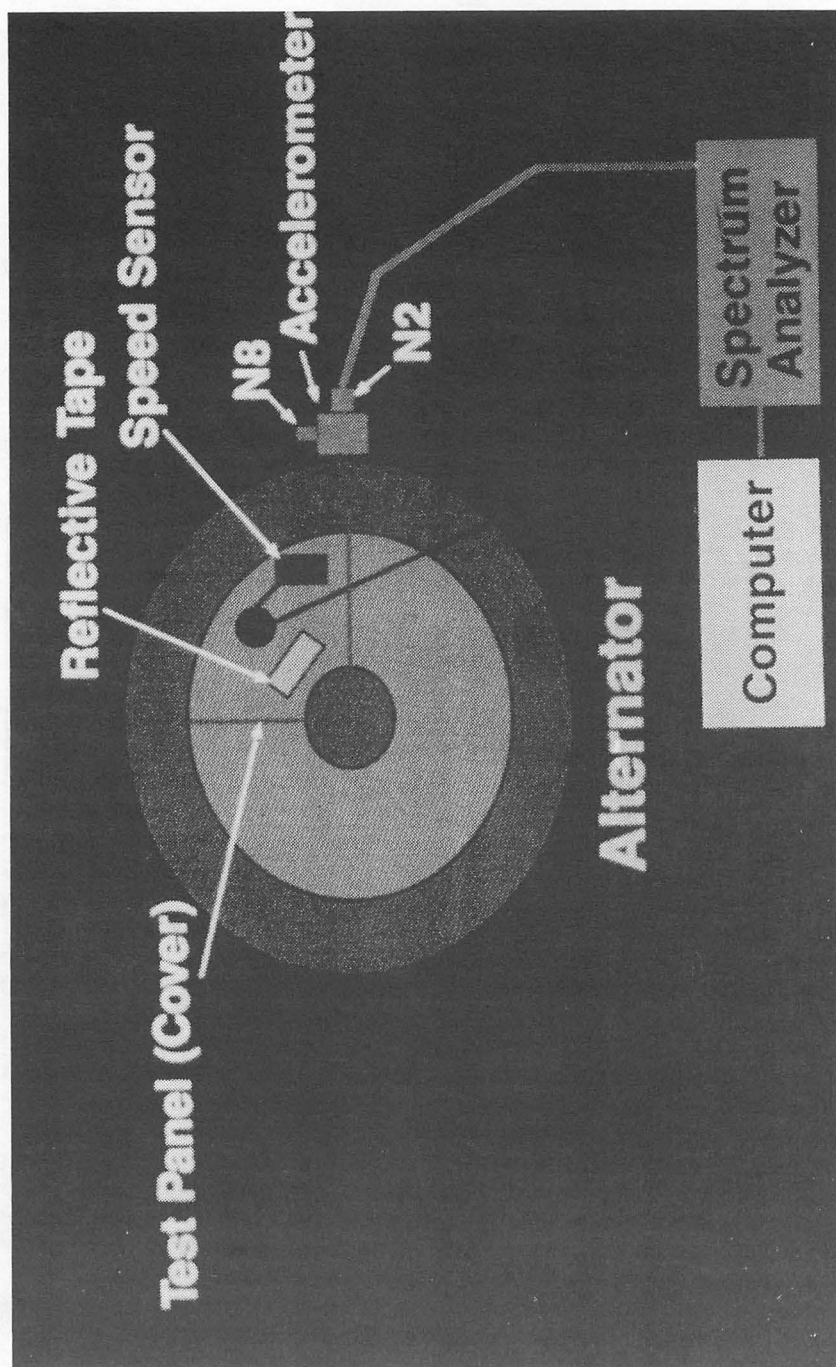
5. Summary

Dynamic balancing is a procedure that attacks one of the fundamental causes of failure - vibration. It offers tangible benefits for Dash 8 fleets and their owners.

LOCOMOTIVE VIBRATION MEASUREMENT POINTS

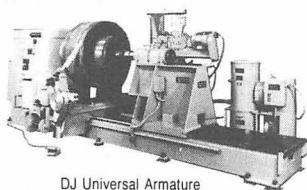


ALTERNATOR MIDDLE, 3 O'CLOCK VERTICAL

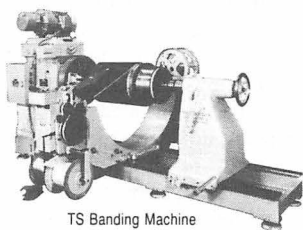




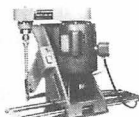
QUALITY COUNTS - ESPECIALLY IN YOUR ELECTRIC MOTOR SHOP



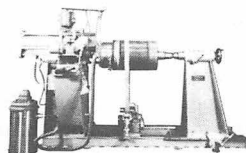
DJ Universal Armature
Machine



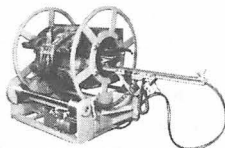
TS Banding Machine



UL Undercutter



MDU Automatic Mica
Undercutter



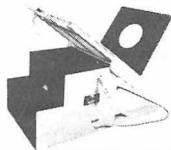
TFR Traction Motor
Frame Stand

CAM machines produce
quality results.

CAM

INDUSTRIES, INC.

215 Philadelphia Street • P.O. Box 227
Hanover, PA 17331 USA
Phone (717) 637-5988 / / telex 840-470



DG Traction Motor
Uppender



II. AIR COMPRESSOR AUTOMATED STATION

*Prepared by Bob Lynch, NS
and John Clontz, BN*

1. Introduction

As a major locomotive overhaul shop downsized to meet current and future demands in efficiency, one area of concern was the air compressor rebuild area. Previously, the air compressor area was located on the second floor of the building. Parts had to be handled either on a freight elevator or by a crane through a hole in the balcony floor. Reductions in manpower, both labor and supervision, along with increased efficiency in work areas and material handling were all objectives when planning for the new rebuild area. It was decided to locate all the mechanical component rebuild, including GE power assembly in the west end of the shop. One supervisor would be responsible for this area. Each work area would be designed for safety and efficiency, utilizing the latest in ergonomic work processes. Material handling would be greatly reduced by keeping all material on the first floor and utilizing an overhead conveyor system for parts cleaning.

2. Construction

Construction of the new air compressor area began with foundation work. A hoe-ram was used to break up old floor to make way for new foundations and drainage trenches to help keep the floor clean. Once the floor was finished, the Proceco wash system was installed along with the overhead conveyor system which runs through the spray wash. While the major construction was in progress, planning for the individual work areas continued. Both the overall plan and individual equipment were designed with the aid of computer aided design software on a

personal computer. Most items were designed, fabricated, and installed using in-house personnel.

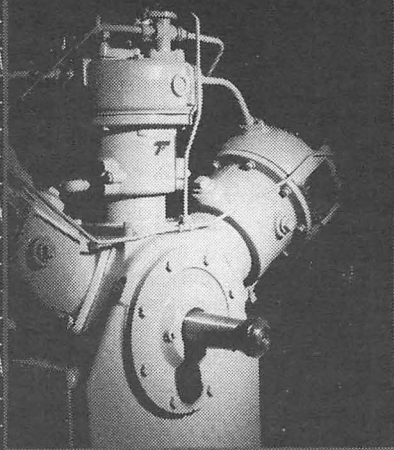
Some of the significant new items were the air compressor tear-down fixture, air compressor buildup stand, and air compressor test stand.

3. Operation

Air compressors to be reworked arrive from running repair shops or from locomotives shopped for overhaul. After the air compressor is removed from the locomotive being overhauled, it is delivered to a mechanical component tear-down area. The air compressor is loaded onto a tear-down stand by a Demag hoist system. To enhance the stripping process, the stand is designed to rotate 90 deg on the x-axis and 360 deg about the Z-axis. This motion is controlled by a joystick connected to the hydraulic system containing both hydraulic cylinders and a rotary actuator for rotation on two axes. (The stand can also be used for stripping GE turbochargers.)

The fixture is now positioned to remove the various air compressor parts: fan shroud, intercooler, fan hub, compressor drive hub (which is removed with the aid of a hydraulic cylinder connected to the main hydraulic system at the tear-down fixture), air lines, and cylinder head valves. Next, oil is pumped out of the air compressor by an Enerpac pump to a waste oil storage tank. Then other parts are removed: cylinder heads, cylinders, rings, pistons, covers, rods, and crankshaft. Most components are loaded onto a monorail which travels through a Proceco washer. However, the air compressor crankshaft is first qualified at the stripping area and either scrapped, sent out for repair and returned, or sent through the wash.

After being cleaned in the Proceco washer, the components are inspected and qualified for reuse. The cylinder liners are either sent out to be bored



Triangle Remanufactured Compressors

The Triangle Clean Air Act.

- Reduces Contaminants in Air System
- Extends Life of Air Dryers and Air Brake Valves
- Highest Quality Products...Certified by Class 1 Railroads
- Products Developed and Manufactured to Meet Today's Higher Performance Requirements
- For Over 30 Years...Triangle has a Proven Record of Quality and Service to the Railroad Industry
- Keep Your Locomotives On Track with the Triangle Clean Air Act

**Triangle
Engineered Products Co.**

701 Maple Lane
Bensenville, Illinois 60106
(708) 860-5511

and sleeved or are honed and then sent back through the wash. After the rewash, the liners are queued on roller conveyor where they wait until time for reassembly. The cylinder heads, rods, and pistons each go to their respective rework areas. At the cylinder head area, the valves are inspected, lapped for flatness, and then assembled. After the head casings are inspected and cleaned of any gasket material, the valve assemblies are applied, and the complete head assembly is stored on the roller conveyor until required. The air compressor rods and pistons are inspected, rebushed, and assembled. The piston rod assembly is then mated to a cylinder liner and stored on a conveyor until required. The air compressor buildup area was designed to have all the reworked parts converge on the rebuild stand. The stand can be angled in any direction using four hydraulic cylinders connected to the rebuild platform with universal couplings. The crankcase is bolted to the platform. Then, the crankcase can be positioned as required to apply the various components: air compressor crankshaft, end plates, cylinder with piston rod assemblies, complete head assemblies, and control and cooling lines.

Once the air compressor is completely assembled, it is loaded onto an automated test stand. All the line connections are equipped with quick dis-

connects. The drive belt is automatically tensioned. The complete test procedure requires approximately 4 1/2 hours. The test stand is controlled by an Allen Bradley programmable controller through a TCP Smart Screen. The air compressor is initially run unloaded for the break-in time period. The air compressor is then loaded, and the speeds are varied while monitoring reservoir pressure, oil pressure, crankcase vacuum, discharge air temperature, intercooler pressure, and water temperature. Upon completion of a successful test, a printout of the test is received.

The air compressor is disconnected and shipping to the paint booth. After painting, the air compressor is covered with shrink-wrap and stored until required by a locomotive overhaul or running repair shop.

4. Summary

During the rebuild process, information is stored in a data base file concerning critical components, test stand data, and personnel performing the work. The air compressor is tracked by serial number when it is applied to a locomotive. Analysis of these data is used when making process improvements to increase the reliability of this product, the locomotive air compressor.

III. ERGONOMICS IN THE WORK PLACE

*Prepared by: Rick L. Collins
Burlington Northern RR,
Bill W. Peterman,
Canadian Pacific Railroad*

With the increased emphasis on employee safety and health, the rail industry is faced with yet another major obstacle in its battle to win back market share. Conditions such as cumulative trauma disorder and carpal tunnel syndrome are typical of the new generation health issues with which the railroads are dealing. An aging work force, with a median age in the mid 40s, further complicates the equation. How can the rail industry adjust to these complex issues?

For some, the answer is *ERGONOMICS*, an applied science concerned with the characteristics of people that need to be considered in the designing and arranging of things that they use, in order that people and things will interact most effectively and safely. Ergonomics can help address many of the safety and health issues now facing the railroads.

Recognizing the potential that ergonomics can provide, one Western railroad has initiated an ergonomic team at a major repair facility. The focus of the team is to identify ergonomically deficient work processes. The team surveyed all work areas and employees, soliciting feedback. Collected data were consolidated to develop initiatives and goals. Ergonomically designed tools were then tested. Work station redesign was begun, based on employee feedback and ergonomic design. Ergonomic training for employees was designed. Training in proper body mechanics, work station design, use of back and wrists supports, as well as the use of antivibration equipment was provided to employees.

An increased awareness of ergonom-

ically correct tool designs and proper body mechanics has sparked new optimism for the work force. Heavy tools that were once held by hand are now being supported by mechanical tool balancers. Material is no longer stored on the floor near the work site. Ergonomically designed storage tables allow the employee to pick up material without bending. Specially designed pallet racks rotate and adjust to the proper lifting height for reduced employee stress. Material storage racks are redesigned to eliminate bending. Bins with ends shortened reduce the bending and extended reaching once required. Mobile carts allow for material to be stored at ideal height. Rollers on the material carts provide for easy movement to the work station.

Improved work station design leads to increased efficiencies. Proper working height eliminates employee fatigue. The use of inspection pits and automated material handling devices reduces employee exertion. Ergonomically designed material delivery stations provide easy access for parts. Devices both move and retard the movement of material eliminate the handling by employees. In the case of rolling wheel assemblies, for example, the extreme weight can cause undesired body mechanics.

Proper body mechanics benefit the employee by reducing overexertion. The use of back belts is encouraged. Back belts remind the user of proper lifting techniques and mechanics. Antivibration gloves provide protection from tools with high levels of vibration. The glove is designed with padding that absorbs the shock. Keyboard rests eliminate the wrist fatigue experienced when entering data. Training in the area of neutral wrist position with regard to proper tool choice has lessened potential carpal tunnel syndrome cases. Voluntary stretching is practiced by many employees in preparation for the day's activities.

Ergonomically designed tools have been secured to reduce or remove stress that employees once encountered. Specially designed tools that address unique railroad applications and incorporate multiple function processes are now common. Pneumatic, electric, and hydraulic tools now replace manual tools in the workplace. Repetitive manual activities are now being replaced by automatic machinery.

Although ergonomics is not new to the industrial society, the incorporation of ergonomics in railroad shops has

been slow. Rapid changes in the transportation industry dictate that innovations must be made by railroads in order to compete. The increased efficiencies and lower cost realized by ergonomic changes are supporting this effort. The benefits of ergonomics are beginning to be realized. Employee injuries are on the decline. Improved productivity and employee awareness are direct results of the ergonomic changes being made. The future looks bright for the railroads. Ergonomics will be an important factor.

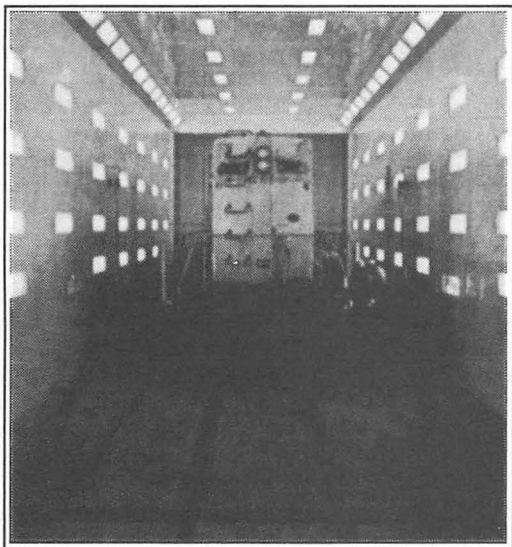
**BEST WISHES
FROM**

JOHN W. MAHON CO.
(Manufacturers' Representative)

JOHN MAHON
Cleveland, OH 44145

(216) 899-9975

Manufacturers of Custom Designed and Engineered Spray Booths and Systems



Quality Performance
by *Design*

JBI INCORPORATED

P.O. BOX 38 • 801 NORWAY ROAD
OSSEO, WISCONSIN 54758
715-597-3168 • TOLL FREE 1-800-848-8738
FAX 715-597-2193

JBI SPRAY BOOTHS AND SYSTEMS

IV. HYDRAULIC TRACTION MOTOR SHIMMING TABLE

*Prepared by: Ray Plaugher
& Don Tetley
Union Pacific*

The replacement of locomotive traction motor assemblies and truing of wheels are maintenance procedures that are performed at our repair facilities on a daily basis. Current FRA requirements stipulate that the wheel diameters within a set of three-axle trucks must be within tolerances of 6/16s of an inch after completion of traction motor/wheel set replacement or wheel re-profile. This tolerance is necessary to prevent wheel slip on any given traction motor.

These tolerances may be obtained by three methods: insertion of traction motors having wheelsets that are of the same approximate diameter; truing of remaining wheels to obtain the correct diameters; or shimming of the traction motor to achieve the desired wheel contact result.

In the real world, it is not always possible to find wheels that are of the correct, similar diameter to the other existing wheels in the truck. Stocking a variety of wheel sets in various diameters is not a viable option because of increased inventory costs and material handling requirements. Truing the wheel to obtain the correct diameter has obvious disadvantages. Along with the increased labor costs involved with the truing processes, wheel truing to obtain correct diameters unnecessarily removes service metal from the wheels. This decreases wheel life, and causes premature replacement of the wheel set and traction motor. Finally, the wheel true machine is tied up changing diameters rather than performing its assigned task of re-profiling worn wheels.

The final option provides a much less costly solution to the wheel diameter requirement. This solution involves

the shimming of the traction motor assembly in order to obtain the correct match-up of wheel contact within the truck. Wheels may be shimmed during the traction motor replacement process by using the traction motor drop table. They may also be shimmed using a drop table after the wheel true process has been completed. This is usually a costly, time consuming proposition since the locomotive must normally be removed from the wheel true to the drop table track. Portable jacks have sometimes been used to lift the truck frame and insert shims after wheel truing operations. While being the least costly alternative, it is sometimes the most awkward, and movement of the heavy jacks into and out of position also poses various safety concerns.

A Wester railroad realized that shimming was the best, but not necessarily safest way to meet FRA requirements. There was a drop table on the property; but using this table for shimming required moving the locomotive between two separate shop tracks, resulting in unnecessary switching and availability delays. To eliminate this problem, the railroad designed, constructed, and installed the hydraulic traction motor shimming table that is the subject of this report. The table is set up on the outbound side of the wheel true machine.

The table is basically a hydraulic lifting mechanism that raises an entire section of track to lift the traction motor and wheel. In effect, it may be considered a mini-drop table. Locomotives going through the wheel true go directly to the table for shimming by wheel true personnel. With the locomotive positioned over the table, the truck is blocked so that it cannot move downward, ensuring that only the traction motor will move when the table is lowered. The table is then raised hydraulically, forcing the traction motor upward. The spring pack is blocked by using a specially designed horseshoe shaped retention device.

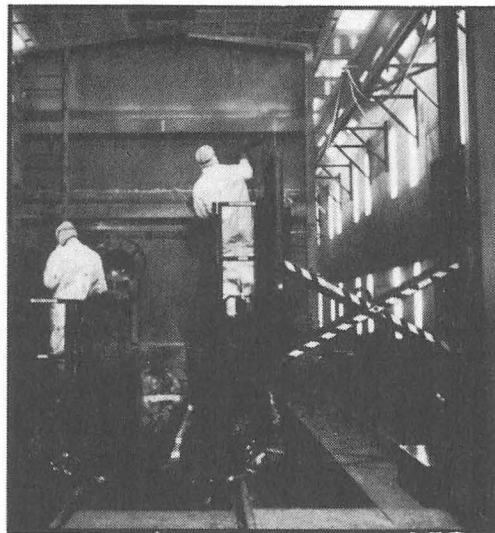


LPI INC.

P.O. BOX 37
OSSEO, WI 54758
(715) 597-2376
1-800-657-6956
FAX 715-597-3680

**"Products for
Better Industry"**

Increase Your Production Efficiency



PNEUMATIC PERSONNEL LIFTS

- 3 Axis Travel
- Fully Pneumatic
- Increased Productivity
- OSHA/ANSI Compliance
- Custom design capabilities

FLUORESCENT LIGHTING

- Front & Rear Access
- Listed for hazardous locations. Class 1, Div. 2, Groups A, B, C, & D; Class 2, Div. 2, Groups F & G

IDEAL FOR SPRAY BOOTH APPLICATIONS

Locks that normally retain the rail in position are then released, allowing the rail to move downward with the traction motor and wheelsets. A space is now opened between the journal block and the spring assembly, allowing for the insertion or removal of shims as necessary to obtain the correct wheel match dimensions.

Once shimming is completed, the traction motor is hydraulically raised back up into the frame. The horseshoe spring retention device is removed, the rail is locked back into place, and the shim table is lowered back down into the locked position. The blocks for the truck are then removed, and the unit is ready to be returned to service. The

total elapsed time for this shimming procedure is typically less than four minutes. All of the movements of the table, including movement up and down, and locking and unlocking of the rail section are safely and easily controlled by push button operated hydraulic solenoid valves.

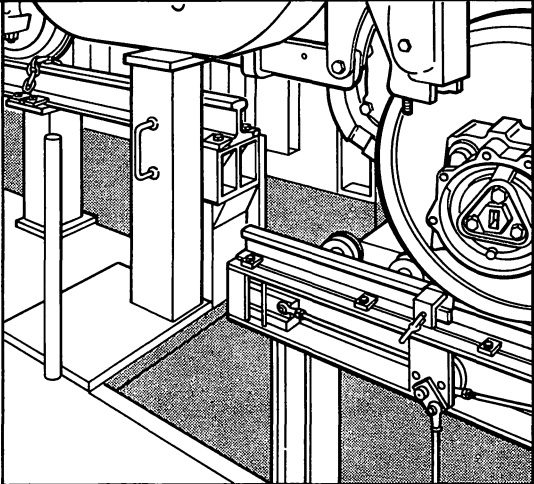
Through the ingenuity of employees at this locomotive repair facility, a hydraulic shimming table has been invented that enhances safety, increases productivity, and improves locomotive availability. Perhaps it can provide you with another method of increasing the flow of locomotives through your own repair facilities.

GET OUT OF THE PITS WITH AN A. T. MOELLER CORP. DROP TABLE

Servicing single axle or full truck the **A. T. Moeller** drop table is engineered for reliability and efficiency. Features include: High-speed hoisting on covered long-life ball screws or covered machine screws, electrically controlled continuous lubrication system, automatic track spotting and programmable controls for "select and forget" operation.

For application engineering assistance contact:

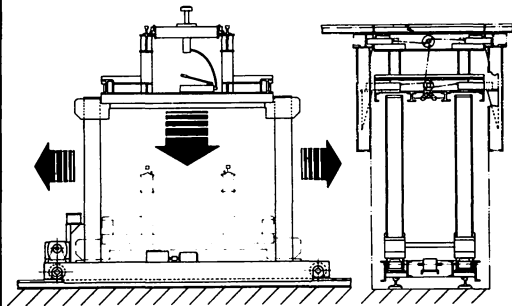
Arnie Moeller
(817) 441-7779



Available in single axle or full truck

ADDITIONAL PRODUCTS AND SERVICE

- UPGRADE AND MODERNIZE EXISTING DROP TABLES
- LOCOMOTIVE SANDING SYSTEMS
- RETROFIT FUEL LOADING ARMS
- LOCOMOTIVE WASHERS
- SPECIALTY EQUIPMENT AND PROJECTS



A. T. MOELLER CORPORATION
RAILROAD PRODUCTS

P.O. BOX 470996 — Fort Worth, Texas 76147-0996
(817) 441-7779 — FAX (817) 441-6815

REPORT OF THE COMMITTEE ON FUEL, LUBRICANTS & ENVIRONMENTAL

TUESDAY, SEPTEMBER 14, 1993

9:00 A.M.

**Pre-Convention
Presentation
Conrail**



**May 12, 1993
Ramada
Altoona, PA**

RONALD R. LODOWSKI, Chairman
Manager-Oil Control Labs & Environmental Opns.
Conrail
Selkirk, NY

Vice Chairman
JOHN T. JACKSON
Manager-Engineering
Amtrak
Wilmington, DE

COMMITTEE MEMBERS

R. Bartunek
Z. Bolt
T. Brown
K. Brinker
G. Bowen
D. Carlson
F. Cuifo
K. Davis
T. Dunn
G. Hamilton
W. Harris III
B. Hilgenberg
R. Hohl
C. Kunkel
R. Lindenmuth
T. Nowak
S. Pearson
D. Pridemore
J. Reber
G. Schafer
M. Schlauch
P. Schackelford
E. Shamah
J. Thompson
C. Tincher
D. Watson
M. Wierucki

Mgr.-Purchasing
Sr. Tech. Spec.
Sr. Research Engr.
Sr. Mgr.-Environ.
Mgr.-Laboratory Svcs.
Staff Engineer
Mgr.-Environ. Quality
Mgr.-Tests & Lab Svcs.
Mgr.-Analy. Svcs.
Sr. Staff Res. Engr.
Mgr.-Chem. & Enviro.
Technical Engr.
Mgr.-Equip. Plng. & Lab
Sr. Mgr.-Res. & Dev.
Manager of Testing
Fuels & Lub. Engr.
Product Engineer
Supv.-Auto. & Comm. Lub.
Product Engineer
Senior Technologist
Sr. Research Engr.
Manager of Tests
Sr. Engr. Assoc.
Consultant
Product Manager
Staff Engineer
Engineer of Test

Burlington Northern
Exxon Co.
AAR
CSX Transportation
AT&SF
Shell Development
Conrail
CSX Transportation
CANAC International
Petro-Canada
Norfolk Southern Corp.
Electro Motive Div.
CP Rail System
Union Pacific
Chgo. & North Western
General Electric Co.
Mobil Oil Corp.
Ashland Oil, APAL
Conoco Incorporated
Texaco, Incorporated
AAR
Paducah and Louisville
Chevron Research
Ethyl Petroleum Addit.
Lyondell Petro. Co.
Morrison Knudsen Corp.
CP Rail System

Ft. Worth, TX
Houston, TX
Washington, DC
Jacksonville, FL
Topeka, KS
Houston, TX
Philadelphia, PA
Waycross, GA
Saint Laurent, PQ
Sheridan Pk., Ont.
Alexandria, VA
La Grange, IL
Minneapolis, MN
Omaha, NE
Chicago, IL
Erie, PA
Fairfax, VA
Ashland, KY
Houston, TX
Beacon, NY
Washington, DC
Paducah, KY
Richmond, CA
Wheaton, IL
Houston, TX
Boise, ID
Winnipeg, MB

UNOCAL 

*Serving the
American Railroad
Industry
Since 1894*

MIKE HUDSPETH
MGR. NATIONAL ACCTS.
(213) 977-6509

DICK CLARK
MGR. TECHNICAL SVS.
(510) 277-2338

Go with the Spirit. The Spirit of 76.

PERSONAL HISTORY

Ron Lodowski

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

He began his railroad career with the Penn Central as a Freight Carman in 1975. In March 1977 he transferred to the Locomotive Department and was promoted to General Foreman in Buffalo. In July 1984 he was trans-

ferred to Selkirk, New York and was promoted to Manager-Environmental Operations. In August of 1989 he was given the additional duty of Supervisor-Oil Control Labs.

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

He has been married for 24 years and his wife's name is Susan. They have two children, Michael, 23 and Nicole, age 7.



MR. J.R. NUSSRALLAH

Asst. Vice President & CMO
Consolidated Rail Corp.
Philadelphia, PA 19104

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

Our Fuel, Lube & Environmental Committee was well received in what we trust was a mutually beneficial experience.

Our thanks to Mr. J.R. Nussrallah and others responsible for and participating in the program.

I. USED OIL ANALYSIS OF MULTIGRADE OILS AND CONDEMNING LIMITS

Presented By: Cline Tincher - Lyondell

Major railroads have changed from SAE40 monograde locomotive engine oils to SAE 20W-40 multigrade engine oils. This change was made to take advantage of the fuel and lube oil savings and longer oil life provided by multigrade oils. The longer life of the multigrade oil allows for the greater build-up of oxidation products and contaminants. In addition to changing to multigrade oils, some railroads have increased maintenance intervals, and have lengthened filter changes. Because of these changes the lubricating oil in the locomotives is under much greater stress. As the operating severity of the locomotive service increases, analysis of the lubricating oil becomes more important to insure that the oil is in satisfactory condition.

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

Analytical testing of a lubricating oil can indicate that the oil is in acceptable condition, that there is a problem and the oil needs changing, or there is a mechanical problem in the engine that requires the locomotive to be brought into the shop. Oil analysis can also be used to determine if the proper lubricating oil has been added to the crankcase.

Viscosity analysis gives an indication of the degree of oxidation a locomotive's engine oil has experienced,

but can also indicate fuel contamination. Oxidation increases viscosity and can cause "viscous drag" in the engine which reduces power, increases the operating temperature and consumes more fuel. If the oil becomes so thick that it will not flow to the moving parts, a catastrophic engine failure can occur. On the other hand, fuel diluting can reduce the viscosity of an oil to the point where an oil film is not maintained between the moving parts, causing wear and ultimately engine failure. After changing to multigrade oils, railroads are seeing far fewer oil changes due to high viscosity.

When a railroad switches from an SAE 40 monograde oil to an SAE 20W-40 multigrade oil the viscosity is measured in centistokes (cSt.) or Saybolt universal seconds (SUS) at 100°C or 210°F instead of SUS at 100°F as had been done in the past. This change was made because an SAE 20W-40 multigrade oil is prepared from lower viscosity base oils than an SAE40 monograde railroad oil. The lower viscosity oils are thickened with a polymer that is temperature sensitive. At higher temperatures, 100°C or 210-F, both the SAE 20W-40 multigrade oil and the SAE 40 monograde oil have the same viscosity.

Polymers in a multigrade oil can permanently shear, that is break into smaller pieces, and reduce the viscosity of the oil. Therefore, initial viscosity of multigrade railroad oils was increased from 14.5 cSt. to 15.0 cSt. This viscosity increase was made to prevent locomotive crankcase oil from being drained prematurely because the viscosity loss due to polymer shear was mistaken for fuel dilution.

At lower temperatures (100°F) the polymer contracts and the viscosity of the SAE 20W-40 multigrade oil is lower than the viscosity of the SAE 40



An
Industry Leader
in **Railroad Engine**
Oils and Lubricants

- ◆ **Gascon Supreme XL**
18 TBN 20W-40 multi-grade locomotive Engine Oil
 - ◆ **Lyondell Supreme XL Additive**
The **ONLY** additive developed specifically for a multi-grade locomotive engine oil.
 - ◆ **Gascon Supreme Plus**
18 TBN mono-grade SAE 40 locomotive engine oil
 - ◆ **Lyondell Supreme Plus Additive**
 - ◆ **Journalube SBO**
Formulated specifically for the demanding service of newer high torque locomotives.
 - ◆ **Duro Hydraulic and Compressor Oils**
 - ◆ **Jet Lube TM**
Traction motor gear grease
-
-

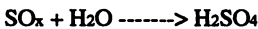
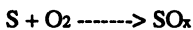
To place an order, or obtain product information, call
***the*Customer Connection, 1-800-447-4572.**

Lyondell Lubricants, Railroad Sales Representative
Ric Smies, 708/798-9269, Fax 708/798-8921

monograde oil. This is caused by lower viscosity of the base oil used to blend the multigrade railroad oil. Since the viscosity of the multigrade railroad oil is lower than the monograde railroad oil at 100°F, premature oil drains for fuel dilution could occur if the viscosity of the railroad oil was measured at 100°F. Therefore, the viscosity of the lubricating oil is measured at 100°C or 210-F where the viscosity of the SAE 20W-40 multigrade oil and SAE 40 monograde oil are the same.

Total base number and/or pH measure the acid neutralizing power of a lubricating oil. Oxidation of the lubricant creates acids which corrode metal and cause wear. Nitration or nitro-oxidation is the result of the reaction of oxygen and nitrogen in the combustion chamber to form nitrogen oxides (NO_x). These gases react with unburned fuel oil to form acids and insoluble products. Acids can also be formed from sulfur in the fuel oil.

Sulfur oxides are formed when fuel sulfur is burned in the combustion chamber. Sulfur oxides in the blowby gases can react with water to form sulfuric acid which must be neutralized by overbased additives in the engine oil.



As the lubricating oil ages in the locomotive, alkaline overbased additives are depleted. Alkaline additives are used as they neutralize nitro acids, sulfur acids and organic acids formed during the combustion of fuel and the oxidation of the lube oil. When the alkaline reserve falls below the minimum safe level, more rapid ring and cylinder wear can occur. Therefore, pH and/or total base number (TBN) condemning limits are set at levels where corrosive war is minimized.

One railroad raised the pH condemning limit of its oil analysis, because four to six weeks could elapse between the time a locomotive was called for an oil change and the oil was drained. The longer time from call to oil change was caused by the elimination of small shops that previously drained the locomotive's lube oil. Now locomotives do not get to a shop that can change the oil as frequently as they once did.

Test Kits are available that are used to measure the TBN of railroad oils. This is a "quick and dirty" test method that gives a TBN value that is intermediate between the ASTM D664 and ASTM D2896 test methods. The cost of each kit is approximately \$3.00.

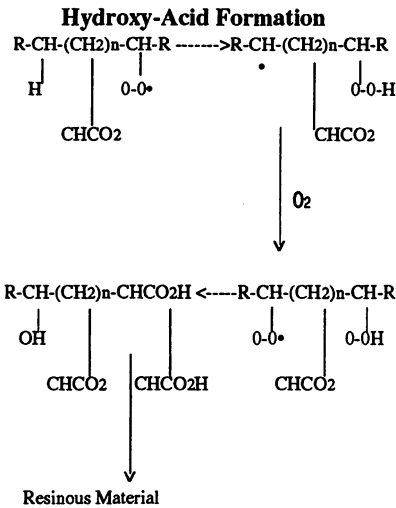
Pentane insolubles measures the amount of soot and resinous materials in the lubricating oil. Soot is formed during the combustion of fuel. When soot finds its way into the lubricating oil it causes the viscosity of the oil to increase.

Partial oxidation of the fuel results in the formation of hydroxy-acids that react to form resinous material that acts as a binder for soot in the formation of deposits in the piston ring zone area. In addition this resinous material can form deposits on the hot surface of the engine, such as top deck or cylinder covers.

Dispersants function by suspending deposit forming compounds until they can be removed from the engine when the oil and filters are changed.

There are limitations to the work these additives can do. Once the dispersant has reached its load carrying capacity, any additional sludge, soot or resin can cause the dispersant to be pulled out of solution, dumping the previously suspended load and causing a rapid build up of deposits in the engine. This problem can be minimized by not allowing the pentane insolubles

to go past the condemning limits.



Contamination of the lube oil with water can cause problems with the additive package and the oil's performance. Some water can find its way out of the combustion chamber into the crankcase oil. Water can also get into the oil through a variety of mechanical problems, such as: leaking head gaskets, cracked heads or liners.

Excessive water in the locomotive oil can cause several problems:

- Water can disrupt the oil film on heavily loaded bearings and cylinder liners causing increased wear and premature failures.
- Water can cause rust and corrosion that lead to high wear and bearing failures.
- Water can combine with contaminants in the oil to form sludge, which can plug oil lines and filter.
- Water can combine with blowby to form corrosive acids.
- Water can have an antagonistic effect on oil additives and, in extreme cases, can cause them to separate.

The longer life of multigrade oils allows for a greater build up of soot and resinous material in the oil. Therefore, the detection and repair of water leaks is important to prevent the build up of sludge in locomotives.

One railroad uses infrared spectroscopy to analyze their locomotive crankcase oil. It evaluates viscosity, pentane insoluble, fuel dilution, water, oxidation and pH/TBN using this method. The railroad has developed call limits and condemning limits using infrared spectra to make sure the lube oil in its locomotives is in good condition.

Infrared Spectroscopy Analysis

Band	Problem	Absorption /cm	Action taken
450 CM-1	Fuel leaks	5	Call for fuel leak
3150 3600 CM-1	Free water	6	Call to Correct water leak
		14	Change oil
590 - 640 CM-1	Oxidation	7	pH 5.5 and low TBN

The locomotive engine builders have established recommended condemning limits for viscosity, pentane insolubles, total base number (TBN) and pH. When condemning limits are exceeded, changing the lube oil is recommended. If mechanical problems such as fuel leaks are indicated, check the engine to locate and correct the problem. The published condemning limits from the Electro-Motive Division of General Motors (EMD) are listed in Table 1, and the published limits from General Electric (GE) are listed in Table 2.

Metal analysis is used to monitor

engine component wear and outside contamination, such as dirt and dust, for preventive maintenance. Mechanical problems can be corrected before they can escalate to cause serious damage to the locomotive engine. High limits have been established above which the locomotive should be shut down, the lube oil drained, and the mechanical problem located and repaired.

Intermediate limits have been developed by EMD, where the progress of the wear metals in the lubricating oil should be monitored. EMD's recommended warning limits for the interpretation of Lube oil analysis are listed in Table 1. GE has not issued recommended warning limits for wear metal analysis. It recommends that railroads follow the trend of the metal analysis, and upon any sudden increase in wear metal levels, the locomotive engine should be inspected to locate and repair the indicated mechanical problem.

Railroads have established analytical condemning limits for their used lube oil based on a combination of the locomotive manufacturers' recommended warning limits and limits derived from their own operating experience. The limits listed in Table 3 for viscosity, pentane insolubles, TBN and pH are the values at which corrective action must be taken, which include shutting down the locomotive and draining the oil. If a mechanical problem, such as a fuel leak, is indicated the appropriate repairs are made.

Many railroads use GE's recommended procedure for the interpretation of lube oil analysis by using a sudden rise in the wear metal values as a warning to inspect the locomotive engine components rather than use a single value as a condemning limit. Likewise, many railroads have used EMD's condemning limits and inter-

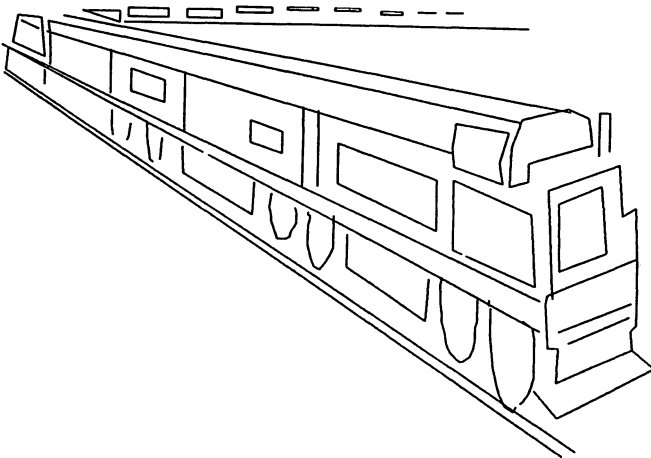
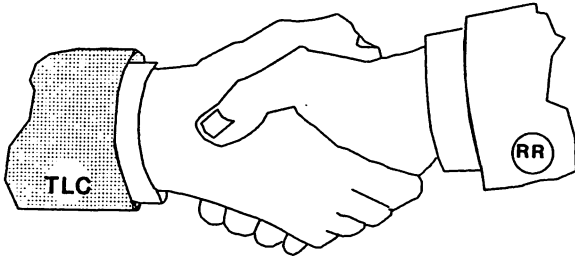
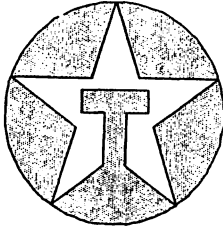
mediate warning limits as an indication of fuel leak, water leaks and mechanical problems to be checked and corrected before they escalate. These warning limits are usually determined from operating experience by using a value at which the problem, such as a water leak, can be located by maintenance personnel.

In summary, railroads changed from SAE 40 monogrades to SAE 20W-40 multigrade railroad oil to take advantage of fuel savings and lube oil economy. The longer oil life of multigrade oils puts more stress on the oil because fuel combustion products and oil oxidation products have more time to build up in the oil.

With the newer, drier locomotives and the use of multigrade oils, many railroads are finding that they are condemning lube oil more frequently on pentane insolubles and pH or TBN and less frequently on viscosity. With the longer service life of multigrade oils, oil analysis becomes more important to make sure contaminants do not build up in the oil causing wear or deposits. Used oil analysis can help keep locomotives in service by uncovering problems before they cause serious damage to the engine and require major shop time.

The condemning limits listed here can serve only as guidelines. Locomotives operating in a specific environment may require higher or lower condemning limits and even though suitable condemning limits have been established, factors that affect the condition of the lubricating oil interact, making interpretation of the analytical results a matter of judgment. The more that is known about the service history of the locomotive, the better the decision that can be made about the engine's condition.

*Railroads and Texaco Lubricants Co.
Together On The Move Again*



**For More Information Contact
George Olondo at (614) 785-0059
6600 Busch Blvd., Suite 137
Columbus, Ohio 43229-1753**

Table 1
Interpretation of Lube Oil Sample Analysis
EMD Locomotives

LUBE OIL ANALYSIS	BASIS FOR ANALYSIS	NORMAL No Action Required	BORDERLINE Take Extra Oil Samples	HIGH Correct Condition	RECOMMENDED ACTION
					<input type="checkbox"/> Shut Down Engine. Drain Lube Oil. <input type="checkbox"/> Change Filters. <input type="checkbox"/> Change Filters Only.
Fuel Leak	Viscosity & Flash Point - Check for dilution if flash point less than 400° F or oil viscosity drops 15% or more at 100° F	0 to 2%	2 to 5%	Above 5%	Borderline - find and fix fuel leak. High - check main bearings per maintenance manual.
Water Leak	Free Water	None		Any	Resample with dry container. Find and fix leak. Check main bearings per maintenance manual.
	Chromate Inhibitor	0 to 20 ppm	20 to 40 ppm	Above 40 ppm	Find and fix water leak. Check lube oil filter tank pressure.
Air Filtration	Boron Inhibitor	0 to 10 ppm	10 to 20 ppm	Above 20 ppm	
	Silicon	0 to 5 ppm	5 to 10 ppm	Above 10 ppm	Improved air filter maintenance required.
Excessive Oxidation	TBN (D-664) TBN (D-2896) Viscosity Rise pH Pentane Insolubles				Change oil filter, cool the passages, check the condition of the cooling system, oil cooler efficiency, engine temperature controls, power input governor and rack settings, engine condition (worn rings, cracked pistons, poor combustion), oil filtration, or oil pump suction leak.
Contaminated fuel (cracking catalyst)	Aluminum, Silicon, and/or Magnesium		Above 5 ppm		Check fuel cleanliness. Notify fuel supplier. If engine smokes, check injector calibration and tip erosion. Check if piston rings are excessively worn.
Oil Contamination	Zinc	0 to 10 ppm	Above 10 ppm becomes more dangerous with increasing values.		Check if oil is contacting galvanized or zinc plated surfaces. Check if make up oil in stock is within specifications. Notify lube oil supplier. Check for silver bearing failures.
	Silver	0 to 1 ppm	1 to 2 ppm	Above 2 ppm	Check if oil contains zinc or is corrosive to silver. Check for broken piston cooling tubes, inefficient oil cooler, or improper temperature control. Feel loaded areas of piston pins for signs of distress. Measure piston to head clearance with lead readings. Oil draining is not mandatory. Check air filter and bottom of oil pan for debris. Consider turbo bearing conditions.
Abnormal Wear Or Corrosion (Rapid increases within normal range should be considered borderline condition)	Chromium (Not applicable if chromate coolant inhibitor is used)	0 to 10 ppm	10 to 20 ppm	Above 20 ppm	Check for rapid wear of rings & liners.
	Copper	0 to 75 ppm	76 to 150 ppm	Above 150 ppm	Measure piston to head clearance with lead readings to locate worn piston thrust washers. Check connecting rod bearing blade thrust faces for distress.
	Iron	0 to 75 ppm	76 to 125 ppm	Above 125 ppm	Check for rapid wear of rings & liners.
	Lead	0 to 50 ppm	50 to 75 ppm	Above 75 ppm	Most likely lead flash is dissolving off bearings. Premature lead removal, before bearings are broken in, can lead to bearing distress. Inspect and replace upper con rod bearings in service less than 6 month if lead flash has been removed from the unloaded area of the fishback bearing surface on turbocharged engines. If con rod bearings require replacement, wrist pin bearings should also be checked and replaced if lead flash has been removed.
In Combination	Copper Iron Lead		Two out of three elements in borderline or high range	Check for debris under crankshaft gear indicative of gear train pushing distress. Check die/cast bearing clearances. Check main and con rod bearings per maintenance manual. Oil draining is not mandatory.	

* In applications where fuel sulfur content is 0.5 to 1.0%, the TBN level should not be allowed to drop below 1.0 (D-664) or 2.0 (D-2896); and where fuel sulfur content is greater than 1.0%, TBN should not be allowed to drop below 3.0 (D-664) or 4.0 (D-2896).

‡ Due to carbon buildup on both the fire face of the cylinder head and the crown of the piston during service life, lead wire readings should not be used as a basis for power assembly changeout. Lead wire readings may continue to be used to indicate wear trends. Significant clearance increases should be investigated as possible component failures.

TABLE 2

CONDEMNING LIMITS OF ENGINE LUBRICATING OIL

GENERAL ELECTRIC LOCOMOTIVES

PROPERTY	RECOMMENDED METHOD	LIMITS FOR GENERATION 3 <u>USE WITH NO. 2 DIESEL FUEL ONLY</u>	LIMITS FOR GENERATION 4 LONG LIFE *
Viscosity Max. at 100 °C at 210 °F Min. at 100 °C at 210 °F	ASTM D445	19.7 cSt 100 SSU 12.5 cSt 70 SSU	19.7 cSt 100 SSU 12.5 cSt 70 SSU
Total Base Number (Min.) (Units are mg. KOH per gr.)	ASTM D664	0.5	0.5 2.0 For Class C Fuel
Water Contamination (Max.)	ASTM D95	0.2%	0.2%
Pentane Insolubles	ASTM D893	3.0%	5.0%

* General Electric does not recognize Generation 5

TABLE 3
RAILROAD USED OIL CONDEMNING LIMITS
SAE 20W-40 MULTIGRADE RAILROAD LOCOMOTIVE OILS

TEST	BURLINGTON NORTHERN		UNION PACIFIC		SANTA FE Monograde		NORFOLK SOUTHERN		AMTRAK		CSX		CONRAIL	
	EMD	GE	EMD	GE	EMD	GE	EMD	GE	EMD	GE	EMD	GE	EMD	GE
FUEL LEAK														
Fuel Oil † max.	5	5	5	5	-	-	5	5	3	3	-	-	-	-
Vis. Dec 100 C cSt min.	-	-	-	-	-	-	11.5	11.5	-	-	12	12	12.4	12.4
Vis. Dec 210 F SUS min.	69	69	-	-	71	71	-	-	67.5	67.5	-	-	67.9	67.9
WATER LEAK														
Free Water †	Any	Any	Any	Any	Any	Any	0.2	0.2	Any	Any	Any	Any	Any	Any
Born Inhib. ppm (max)	200	200	250	250	25*	25	-	-	100	100	100	100	20	10
AIR FILTERS														
Silicon ppm (max.)	25	25	10	10	10	10	10	15	13	13	15-20	15	25	25
EXCESSIVE OIL OXIDATION														
pH (min.)	5	5	5	5	5	5	5	5	4	4	-	-	5.5	5.5
TBN (D664)	-	-	-	-	0.5	0.5	6	6 +	0.5	-	-	-	1	1
Viscosity														
SUS 100 F max.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cSt 100 C max. (210 F)	(100)	(100)	20	20	(95)	(95)	18.6	18.6	96.3	96.3	19	19	19	19
Pentane Insol. † (max.)	3	5	5	5	4	4	4	4	3	5	2	5	3	5
WEAR METALS ppm (max.)														
Lead	150	35	High	High	100*	30*	150	25	High	High	50	30	150	70
Copper	150	35	High	High	100*	100*	120	40	50	50	70	40	80	80
Iron	120	50	High	High	50*	50*	120	75	High	High	75	50	100	100
Aluminum	20	10	4	4	10	10	25	25	-	-	10	15	20	20
Silver	6	-	1	-	2	-	2	-	13	-	5	-	12	-
Chromium	80	80	High	High	-	-	-	-	-	-	50	40	-	-
CONTAMINATION														
Zinc	25	-	10	-	25	-	20	50	-	-	10	25	40	-
Calcium (min.)					-	-							2000	2000

* Plus 15† greater than the average of last four analysis 1 High + Above Normal range (a sudden jump)
† Back titration with HCl

Multigrade OLOA 2990— it keeps proving itself, year after year.

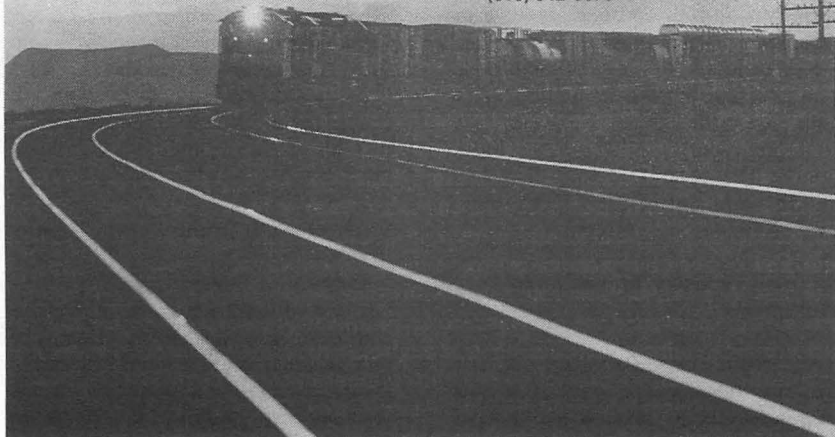
Commercially adopted in 1989, this additive system is saving the railroad industry millions of dollars. Fleet usage data from Class I railroads has proved it. After switching from single-grade products to multigrade using OLOA 2990, they saved 1% fuel and 20% oil.

When you use multigrade oils based on OLOA 2990, you're using a proven performer.



ORONITE

Chevron Chemical Company
Oronite Additives Division
6001 Bollinger Canyon Road
San Ramon CA 94583
(510) 842-5970



II. INSOLUBLES DETERMINATION WITH THE ADVENT OF MULTIGRADE DIESEL ENGINE OILS

*Presented by: M.R. Logan
Oronite Additives
Division of
Chevron Chemical Co.*

Introduction

Over the last three years, most of the major railroads in North America have switched from single-grade to multigrade diesel engine oils. Because of their inherent ability to limit viscosity increase, oil drains for high viscosity have virtually been eliminated where multigrade's are used. As a result, insolubles and pH/TBN measurements must be used to detect when the oil should be drained for oil degradation. However, the methods being used for measuring these properties vary widely, setting the stage for field problems including engine sludge (Figure 1) and corrosion.

In an effort to prevent these types of field problems, the Fuels, Lubricants, and Environmental Committee is developing standard methods for measuring insolubles and base reserve in locomotive diesel engines. This year, we completed the development of a standard insoluble test method. It is described in this paper. Next year, we will focus on a method for base reserve. The rest of this paper discusses the development of the LMOA standard insolubles test procedure.

Railroad Industry Transition to Multigrade

In 1989, the railroads in North America used single-grade, SAE 40 engine lubricants in their locomotive diesel engines. Since then, most have switched to multigrades, SAE 20W-40 oils because of the oil and fuel savings they provide (Table 4). Concurrent

with the switch to multigrade, railroads have experienced a significant change in their used oil viscosity pattern (Figure 2). With Generation 5 single-grade oils, the used oil viscosity would typically rise approximately 30% within six months in severe applications. Multigrade, on the other hand typically decrease about 8% and then rise up to a level close to their fresh oil viscosity.

This difference is attributed to the composition of multigrade oils (Figure 3). First, they are blended with paraffinic (HVI) base stocks, while single-grades in the USA have traditionally used naphthenic (MVI). The HVI stocks allow for improved oxidation resistance. Second, they include an extra component called a viscosity index improver (VI improver). This component typically shears somewhat in service, causing the initial reduction in viscosity noted in Figure 2.

Together, these aspects of the multigrade oil's composition limit viscosity increase, virtually eliminating this cause for unscheduled oil drains. In addition, both hardware and maintenance practices have been improved to reduce fuel and water leaks, so oil drains for these reasons have been reduced as well. To quantify the overall effect on oil drains, the FL&E Committee conducted a survey (Table 5) of major railroads in the U.S. and Canada asking them to summarize causes for oil drains before the switch to multigrade (1989), and 1-2 years later (1992).

Causes for Oil Drains Survey Results

Because of limited records, the survey was difficult for some railroads to complete. However, surveys from four railroads representing about 25% of the locomotives in the U.S.A. and Canada were returned. Details of the results are given in the Appendix. The number of unscheduled oil drains was lower in 1992 than in 1989 at three of the railroads and higher at the fourth. (Figure

4). The average number of unscheduled drains was down 14% (Table 6). The largest number of unscheduled oil drains for both periods evaluated was for water leaks, followed by oil degradation and fuel dilution. The number of drains related to these causes was 10-20% lower in 1992 than in 1989. The number of drains for high wear metals was insignificant.

The number of drains due to oil degradation was investigated further. Oil degradation is defined in this paper as high viscosity, high insolubles and low pH/TBN. The survey confirmed that oil drains because of high viscosity have been virtually eliminated at railroads using multigrades. Conversely, the number of drains for high insolubles and low pH/TBN has increased (Figure 5). The pH/TBN data is dramatic and emphasizes the need for developing a standard test method for base reserve.

Although these averages help give a macro view of the way oil drain patterns are changing in the railroad industry, the survey also showed that the experiences of the individual railroads have varied depending on their used oil monitoring program. For example, when railroads 1 and 4 switched to multigrade, both experienced a sharp drop in drains for high viscosity. At railroad 1, this was coupled with a nearly equal increase in drains for pH/TBN. But at railroad 4 it was coupled with an increase in drains for insolubles instead. This is explained by railroad 1 using a stricter methodology for deciding when an oil should be drained for low pH/TBN.

Although they were not able to complete the survey, there were several other railroads that had experiences similar to railroad 4 when they switched to multigrades; the drains for high viscosity went down while the drains for high insolubles went up.

The survey helped confirm that the causes for oil drains have changed significantly since the switch to multi-

grade oils. Because drains for high viscosity have been nearly eliminated, insolubles and pH/TBN measurements are required for detecting when the oil should be drained for oil degradation. However, these properties are much more difficult to measure.

To help illustrate this point, we reviewed the results of the 1992 railroad industry round-robin. This is an annual event conducted to evaluate how well participating labs agree on oil property measurements. One of the samples evaluated was a used oil taken from a locomotive engine. Fifteen labs measured viscosity at 100 C on the sample, and 19 measured insolubles level. We made a statistical evaluation of these data, calculating the average and the 95% tolerance interval. This interval represents the range encompassing 95% of the individual test results. The results (Figure 6) verify that labs are very good at measuring viscosity but give widely different results on insolubles.

Current Insolubles Measurement Methods

A review of the methods used in the railroad industry for measuring insolubles helps account for the wide discrepancy (Table 7) in insoluble test results. Of eight Class I railroads surveyed, two do not measure insolubles and the other six use five different methods. Several railroads use methods related to the engine builders', but further review shows that they are not using the same procedure. For example, railroads 4 and 5 use coagulated filtration procedures, but they use different sample sizes, solvent amounts and coagulant mixtures than the filtration procedure specified by General Electric (Table 8).

With single-grade oils, this situation was tolerable because oils would generally be drained for high viscosity, water, or fuel leaks before the insolubles concentration reached excessive

levels. But with multigrade oils in today's railroads, they run the risk of overloading the engine oil with insolubles if inadequate or no insolubles tests are used. This can cause engine sludge and has recently been cited as a contributing factor in bearing failures.

Standard Insolubles Measurement Method

Recognizing the need for a standard insolubles test method, the FL&E Committee reviewed the options for railroad labs. The preferred option would be for them to use the engine builder's procedures. This was deemed impractical since EMD's procedure uses a centrifuge, and GE's a filtration apparatus. We then reviewed the criteria for developing a test. First, the method should measure the total insolubles rather than any specified fraction of them. Second, it should use low-cost apparatus so that it could be implemented by most railroad laboratories. And third, it should have good reproducibility so that results from different laboratories could be compared.

It is preferred that the method be quick and simple so that it could be used to measure large numbers of used oil samples routinely. However, we recognized early in the process that this would not be possible for a standard procedure requiring good reproducibility. So a fourth criterion was included that the method be practical for railroad oil labs to run when used with an additional screener test to reduce the number of samples evaluated.

The committee decided to proceed with the development of a standard insolubles test based on a coagulated pentane filtration apparatus. A fine filter of 0.45 microns was selected to ensure that all insoluble material was captured, and a small sample size of 0.25 grams to prevent filter plugging. The same coagulant was specified by most centrifuge and filtration procedures was selected (1% n-

butyldiethanolamine). We chose not to include isopropyl alcohol in the mixture as this was found to contribute to filter plugging at one laboratory. The procedure is provided in the Appendix.

Round-Robin

A round-robin program was conducted to further define the procedure and establish its precision. The program included six phases. These are discussed below:

Phase I - Procedure review: In this phase, six industry participants reviewed the procedure and endorsed continuing with a round-robin.

Phase II - Oil collection: Seven railroads gathered a total of 42 oil samples for selecting oils for the round-robin. These represented three different additive chemistries and two engine builders.

Phase III - Sample selection: Lab 18 ran the LMOA procedure on all samples and selected six samples referred to as the "calibration series" for the round-robin. These included labeled samples with high and low insolubles from EMD and GE engines, as well as a blind sample from each. This sample series included oils with three additive chemistries.

In addition, eight samples were selected for laboratories to run in other test methods (such as OEM, ASTM, and potential screener methods) to evaluate procedure correlation. These were referred to as the "screener series". They covered a range of insolubles concentrations from about 0.5 to 6.5%, and included oils with three additive chemistries.

Phase IV - Procedure reproducibility: In this phase, 15 industry participants ran the "calibration series" (labeled 1-6) using the proposed procedure. During this phase, several labora-

TSL INC.

Technical Services Laboratories, Inc.

PHONE:

417-864-3176

417-864-8924

FAX:

417-864-4337

1612 North Lexington Avenue
Springfield, Missouri 65802

- *Oil Analysis & Petroleum Products Evaluations*
- *Metallurgical Testing*
- *Environmental Chemistry*
- *Protective Coatings Evaluations*
- *Instrumented Product Testing*

SPRINGFIELD'S FULL SERVICE COMMERCIAL LABORATORY

tories reported problems with filter plugging, high results and poor repeatability. The cause of these problems was determined in most cases, and used to improve the procedure. Improvements included specifying a minimum vacuum, providing a guideline for the amount of pentane to use in the rinsing step, and lowering the sample size to 0.10 grams for heavily contaminated oils.

Phase V - Correlation of OEM and other methods: In this phase, 10 labs ran the "screener series" (labeled 7-14) in other insolubles tests to evaluate their correlation with the LMOA test.

Phase VI - Report results to FL&E Committee: The final results were reported to the committee on September 13th, 1993. Further detail of the round-robin program is provided in the Appendix.

Results of Round-Robin on Calibration Series

Fifteen industry participants evaluated the "calibration series" in the proposed LMOA procedure. Results from two labs were rejected from the analysis since they ran the test with earlier versions of the test procedure and had problems with filter plugging. One additional lab was rejected because results indicated serious problems with coagulant rinsing. Results from the remaining 12 labs were used in the statistical evaluation to establish test precision. Individual results from each of these 12 labs is given in the Appendix.

To give a general impression of the test precision, the average results from the 12 labs on each of the six samples is shown in Figure 7, along with the 95% tolerance intervals. The tolerance intervals were similar for both locomotive types, as well as for labeled and blind samples. The interval range is best for low insolubles concentrations, and grows wider for high levels.

Although not shown in the chart, the range of data from individual laboratories was generally about half of this, indicating that individual laboratories were able to repeat results very well.

These results look like an improvement over the present situation. But a quantitative evaluation of the LMOA test's advantage can be made by calculating the tolerance interval of a sample with the same average level of insolubles as was used in the 1992 industry round-robin discussed earlier in Figure 6. The results (Figure 8) show that the LMOA test reduces the tolerance interval by about a factor of 2. This is a substantial improvement over the present situation where widely different results are obtained on the same sample.

Other useful statistics for evaluating results from the LMOA test are its repeatability and reproducibility. These help assess if results on different samples are significantly different from each other or from a condemning limit. A statistician has provided the following definitions and results for these terms, consistent with ASTM guidelines (refer to ASTM publication RR D-2-1007):

Repeatability: The difference between two successive tests obtained by the same operator with the same apparatus under constant operating conditions on identical test samples would, in the long run, in the normal and correct operation of the test method, exceed the following value only one case in 20:

0.115 times (x plus 2%)

Reproductability: The difference between two single and independent test results obtained by different operators working in different laboratories on identical test samples would, in the long run, in the normal and correct operation of the test method, exceed the following value only one case in 20:

0.263 times (x plus 2%)

where x is the average of the two results being compared.

Table 10 summarizes these precision values for a range of insolubles concentrations. As expected the repeatability is considerably better than the reproducibility. At an average insolubles concentration of 4%, the repeatability is 0.69%, while the reproducibility is 1.58%. The precision is better at lower levels of insolubles. By comparison, the repeatability at an average insolubles concentration of 1% is 0.35%.

The last column in the table, referred to as the condemning limit tolerance, provides an adjustment to subtract from the limit to be reasonably sure that a single result is in fact below the limit after test error is taken into consideration. For instance, if a condemning limit of 4% is established, an operator could be reasonably sure that a sample does not exceed the limit provided a result under $(4.00 - .94) = 3.06$ is obtained. This value is computed from the reproducibility equation by multiplying the result by 0.59.

Correlation of LMOA standard insolubles test with other methods

Samples from the "screener series", and in some cases those from the calibration series as well were evaluated in a number of other procedures. These included EMD, GE, ASTM D893, ASTM D4055, and the Union Pacific insolubles tests to establish correlation with these methods. In addition, a number of quick and easy tests currently being used by railroads were evaluated as potential screeners. These included lab 1's IR tests, the Anolizer test (run at three labs), lab 10's Spectronic 21 light transmission test, and the blotter spot test. A number of industry participants also evaluated other potential

screener tests not currently used by the railroad industry including lab 13's light transmission test, Savant's "particulate sensor" test, and another light transmission method referred to as "LEM".

Plots showing the data and "best fit" line correlating each test and the standard LMOA test are given in the Appendix. Table 11 groups the tests according to type, and lists the coefficient of determination (r^2) for each line. This value ranges from 1 for a perfect correlation to 0 for no correlation.

The centrifuge test methods (ASTM D893, UPRR and EMD) ranged in r^2 from 0.71 to 0.79, with the best correlation obtained by the ASTM D893 test (Figures A1, A2, and A3). However, all the centrifuge test results were a factor of 1.4 to 2.4 times less than those from the LMOA test. It also appears that the centrifuge test lose their ability to discriminate between oils over about 2% insolubles by the LMOA method. For these reasons, results from these tests can be considerably lower than those from the LMOA test.

The filtration methods correlated reasonably well with the LMOA method (Figure A4). The GE 1.2 micron method gave the best r^2 of all the tests evaluated with a value of 0.89. However, it should be noted that this method may give lower values if the insolubles in the used oil are very small.

Of the potential screeners evaluated, the "Anolizer", which measures the oil's capacitance, provided the best r^2 of 0.88 (Figure A5). Independent results were reported from three laboratories, and they were in good agreement. However, a glance at the plot shows that the instrument has a difficult time discriminating between samples containing from 2% to 5% insolubles. Still, it may be useful as a screener with oils giving readings over 20 being selected for further evaluation

in the LMOA test.

The IR method used by lab 1 involves measuring absorbancy at both 3800 and 1980 $1/\text{cm}$ (Figure A6). The r^2 for both wavelengths were similar at 0.75 and 0.73, respectively. This method also had some difficulty discriminating between intermediate insolubles levels.

Four light transmission methods were also evaluated (Figures A7-A10). These ranged in r^2 from 0.65 for the "LEM" method to 0.80 for the Savant "particulate counter" and 0.79 for the Spectornic 21 method. It is interesting to note that they all grouped the samples in similar patterns, indicating they are measuring similar features. Again, the methods do not discriminate between intermediate levels well.

It should also be noted that lab 10 did correlation work on additional samples secured from locomotives on its railroad (Figure A11). These provided a slightly better r^2 than those from the LMOA sample series shown in Figure A10, and indicate that results on samples from a single railroad may be more consistent than those from different railroads. The explanation for this is not clear.

Several laboratories also evaluated the blotter spot method for its ability to rank the samples with a visual evalua-

tion of the spot darkness. Differences between the samples could be distinguished up to about 2% insolubles, but above this level the spots became too dark to detect differences reliably. However, it is a very simple method, and may have some use as a screener.

Conclusions

1) Based on a survey of 4 major railroads in the U.S.A. and Canada, oil drains were reduced 14% between 1989 and 1922 because of improved hardware, maintenance practices, and multigrade oil.

2) The causes for oil drains related to oil degradation have shifted from viscosity to insoluble and pH/TBN.

3) Focusing on insolubles, test methods and results in use presently vary widely, giving the potential for over-extended drain intervals.

4) The FL&E Committee has developed a standard test method to determine the total insolubles content of used railroad diesel engine oils.

5) Several quick screening tests have also been evaluated.

6) Because of its growing importance, the Committee recommends a similar program to establish a base measurement method.



**WITH CONOCO, A
CHANGING FUEL MARKET
WON'T STOP YOU IN
YOUR TRACKS.**

You buy a lot of fuel, and you buy it on a tight budget. But without price protection, a bull or bear swing in the oil market could stop you in your tracks.

That's why you need to buy your fuel from Conoco. Pioneers in price hedging, we offer breakthrough price risk management programs designed to satisfy a wide range of financial requirements. Plus, these flexible, portfolio-driven programs can be customized to meet your specific fuel budgetary needs.

Conoco has the innovative fuel price programs you need, plus the people who'll do whatever it takes to keep trouble off the tracks.



FOR DETAILS CALL:

JIM HAMILTON 713/293-1530 • ED ELLES 713/293-5371 • TOM HOWARD 713/293-1867

ACKNOWLEDGEMENTS

The Committee would like to recognize the contributions of the following companies in securing samples, running tests or providing other assistance during this program:

Atchison, Topeka, and Santa Fe Railway

Burlington Northern Railroad

CANAC

Chevron Research and Technology

Chevron Chemical

Chicago and North Western Transportation

Conrail

CP Rail

CSX Transportation

Cleveland Technical Center

Ethyl Petroleum Additives

General Electric Transportation Systems

General Motors Electro-Motive Division

Exxon Research and Engineering

Herguth Laboratories

Norfolk Southern

Paducah and Louisville Railway

Savant

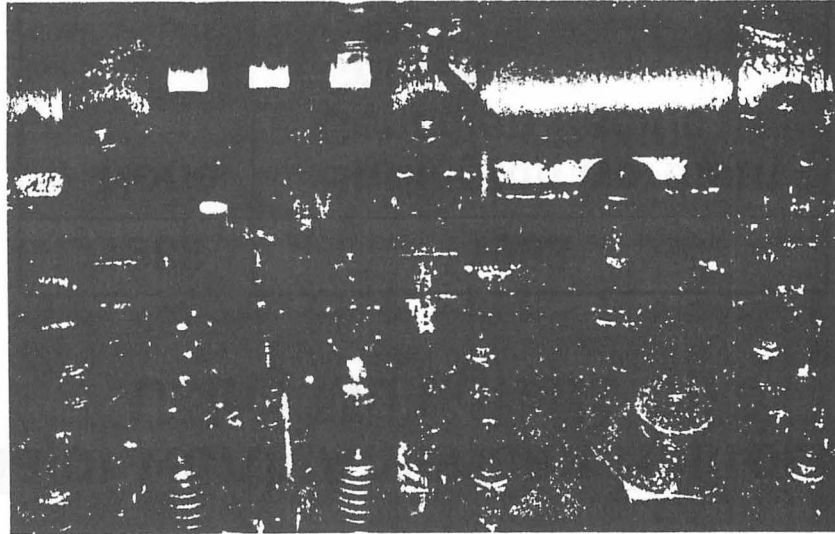
Shell Chemical

TSL

Union Pacific Railroad

Figure 1

Locomotive Engine Top Deck Deposit



Rating 7.3

Table 4

Major North American Railroads Using Multigrade Oil

1989	1993
None	Burlington Northern Canadian Pacific Conrail CSX Norfolk Southern SOO Line Southern Pacific Union Pacific

Figure 2

Generation 5 Viscosity Characteristics

Modern GE Locomotives

Change in Kinematic Viscosity at 100°C, % (D445)

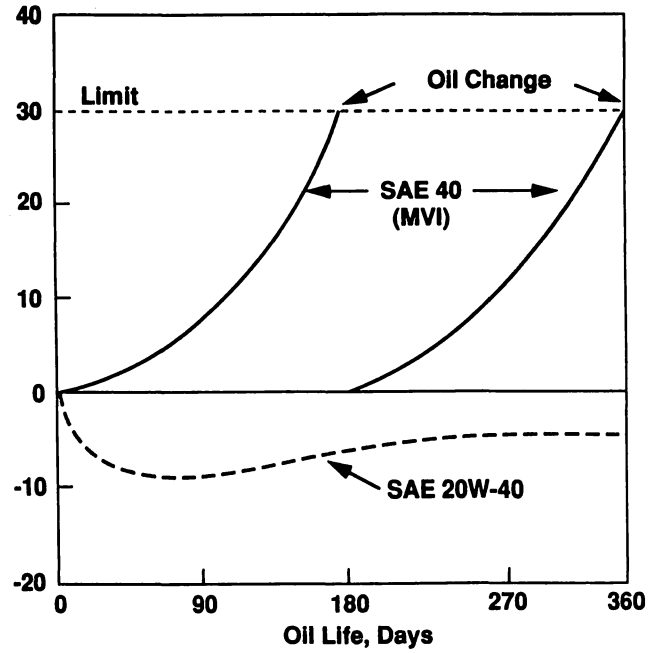


Figure 3 Railroad Diesel Engine Oil Composition

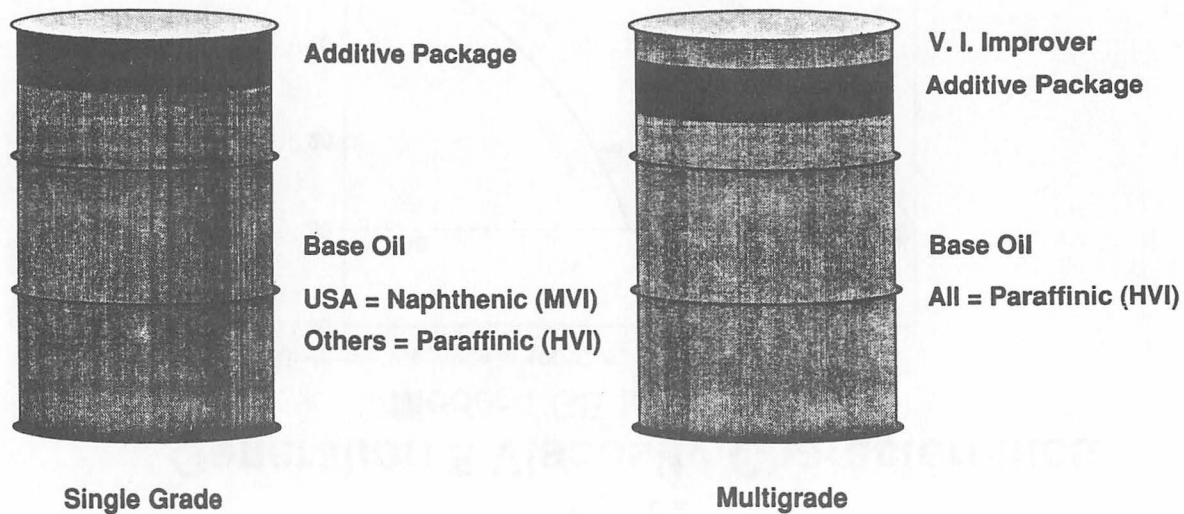


Table 5

**LMOA FUELS, LUBRICANTS AND ENVIRONMENTAL COMMITTEE
SURVEY**

CAUSES FOR OIL DRAINS AND FILTER CHANGEOUT PRACTICE

DATA	EMD		GE	
	1989	1992	1989	1992
NO. LOCOS IN FLEET				
OIL DRAIN INTERVAL (1)				
CAUSES FOR DRAINS (2)				
FUEL DILUTION				
WATER LEAKS (HIGH Na OR B)				
WATER LEAKS (FREE WATER)				
HIGH WEAR METALS				
MECHANICAL				
HIGH VISCOSITY				
HIGH INSOLUBLES				
LOW PH/TBN				
OTHER				
TOTAL				
FILTER DATA				
FILTER CHANGE PERIOD (DAYS)				
FILTER SIZE (MICRONS)				

(1) SPECIFY DAYS IF FIXED INTERVAL IS USED, OR "UO" IF DRAINED
BY USED OIL ANALYSIS

(2) SPECIFY NUMBER OF DRAINS FOR ENTIRE FLEET IN YEAR.

PREPARED FOR THE LMOA F&L COMMITTEE

BY _____ RAILROAD (OPTIONAL)

RECEIVED FIRST SHIPMENT OF MG IN _____ (MONTH) _____ (YEAR)

RETURN TO M.R.LOGAN, 100 CHEVRON WAY, RICHMOND, CA., 94802 (FAX NO. 510-242-3392)

CALL WITH QUESTIONS AT (510)242-5645

FILENAME:DRDRAHS

Figure 4

Average Number of Oil Drains - 4 Major Railroads

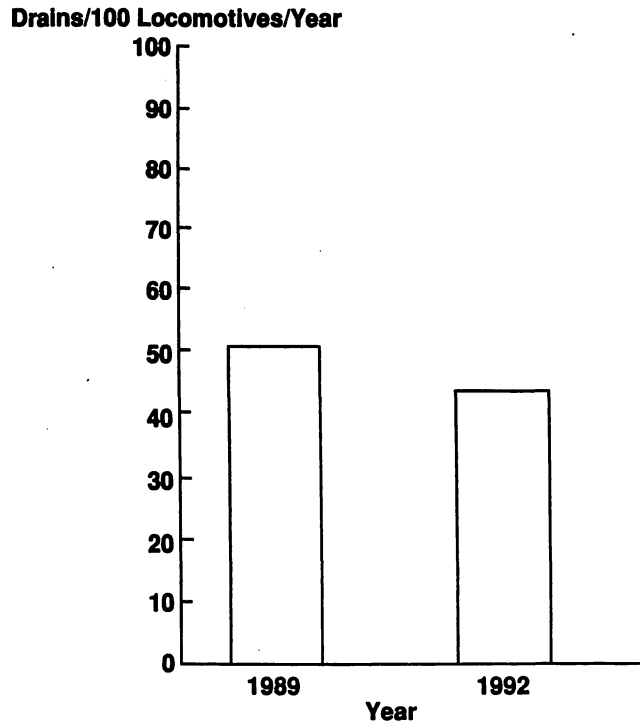


Table 6

Causes for Unscheduled Oils Drains Called by Oil Laboratories

Drains/100 Locomotives/Year

Cause	1989	1992	% Change
Water Leaks	20.8	18.5	-11
Oil Degradation	15.6	12.6	-20
Fuel Dilution	11.1	9.0	-19
High Wear Metals	2.5	3.1	
Total	50.0	43.2	-14

Figure 5

Oil Drains From Oil Degradation Generation V Oils

Drains/100 Locomotives/Year

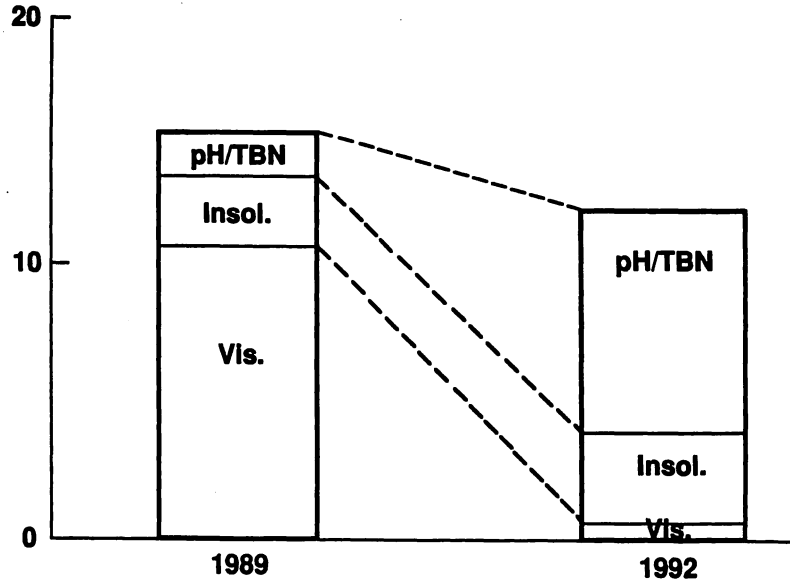
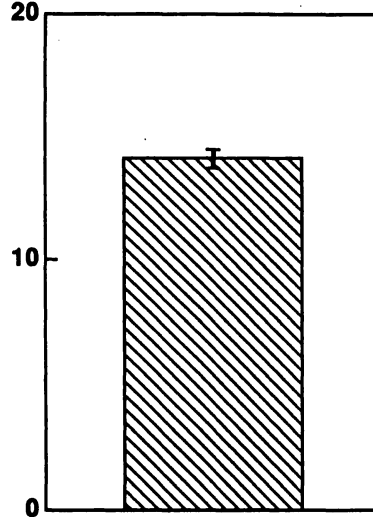


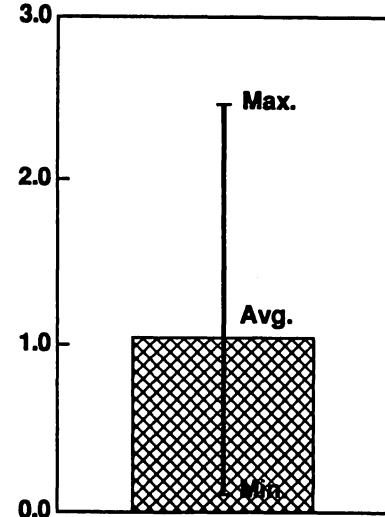
Figure 6

Railroad Lab Results Comparison Viscosity Versus Insolubles

Viscosity, cSt at 100°C



Insolubles, %



Source: Industry Round Robin

Table 7

Insolubles Test Methods Used by Railroads

- 1. Transmission IR**
 - 2. Coagulated Centrifuge**
 - 3. Anoilizer**
 - 4. Coagulated Filtration**
 - 5. Coagulated Filtration**
 - 6. None**
 - 7. None**
 - 8. Blotter Density**
- EMD Coagulated Centrifuge**
GE Coagulated Filtration

Table 8

Filtration Test Procedures Used by Railroads

RR	Filter Size, μ	Sample Size	Solvent		Coagulant		Condemn Limit, %
			Type	Vol, cc	Type*	Vol, cc	
4	1.2	EMD - 1.1 cc	Pentane	50	BD	0.2	4
4	1.2	GE - 0.6 cc	Pentane	50	BD	0.2	4
5	1.2	0.5 g	Pentane	50	IPA	0.2	5
					BD	0.25	
					IPA	0.25	
GE	1.2	1.0 g	Pentane	100	BD	1.0	5
			Pentane	20	IPA	10.0	

*BD = N-Butyldiethanolamine

IPA = Isopropyl Alcohol

Table 9

LMOA FL&E Committee Standard Insolubles Test Round Robin Program

Phase	Objective	Industry Participants
I	Procedure Review	6
II	Oil Collection (42)	7
III	Sample Selection (14)	1
IV	Procedure Reproducibility	15
V	Correlation of OEM and Other Methods	10
VI	Report Results to FL&E Committee	1

Figure 7
Standard Insolubles Test Round Robin Results
(Based on 12 Labs)

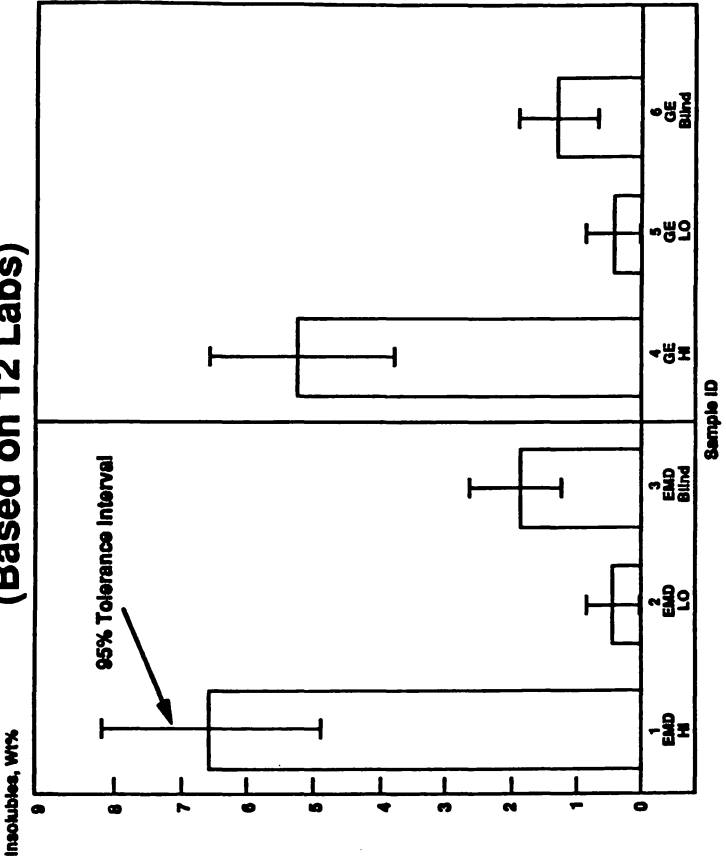


Table 10

Statistical Analysis of Round-Robin Test Results

Standard LMOA Insolubles Test

Insolubles, Wt %	Within-Lab Repeatability	Between-Lab Reproductivity	Condensing Limit Tolerance
1	0.35	0.79	0.47
2	0.46	1.05	0.62
3	0.58	1.32	0.78
4	0.69	1.58	0.94
5	0.81	1.84	1.09
6	0.92	2.10	1.25
7	1.04	2.37	1.40

Table 11

Correlation of Standard Insolubles Test with Other Methods

Type	Procedure	Source	Correlation (r ²)	Figure
Centrifuge	ASTM D 893	Lab 10	0.79	A1
Centrifuge	UPRR	Lab 15	0.71	A1
Centrifuge	EMD	Lab 19	0.75	A1
Filtration	ASTM D 4055	Lab 10	0.75	A2
Filtration	GE 1.2 Micron	Lab 17	0.89	A2
Capacitance	Anoilizer	Lab 1, 3, 8	0.88	A3
Infrared at 1980	Lab 1	Lab 1	0.73	A4
Infrared at 3800	Lab 1	Lab 1	0.75	A4
Light Transmittance	Lab 13	Lab 13	0.68	A5
Light Transmittance	Savant Particulate Sensor	Lab 22	0.80	A6
Light Transmittance	LEM	Lab 18	0.65	A7
Light Transmittance	Spectronic 21	Lab 10	0.77	A8

Appendix

LMOA FL&E COMMITTEE SURVEY RESULTS
CAUSES FOR OIL DRAINS AND OIL FILTER CHANGEOUT PRACTICE

RAILROAD 1

DATA	EMD		GE		TOTAL	
	1989	1992	1989	1992	1989	1992
	DRAINS/YEAR					
NO. LOCOS IN FLEET	1815	1438	458	477	2273	1915
OIL DRAIN INTERVAL	UO	UO	UO	UO	UO	UO
CAUSES FOR DRAINS						
FUEL DILUTION					466	295
WATER LEAKS (HIGH Na OR B)					420	504
WATER LEAKS (FREE WATER)					130	173
HIGH WEAR METALS					0	0
HIGH VISCOSITY					322	17
HIGH INSOLUBLES					106	62
LOW PH/TBN					130	482
TOTAL					1574	1533
FILTER DATA						
FILTER CHANGE PERIOD (DAYS)	45	45	90	60	---	---
FILTER SIZE (MICRONS)	18	18	25	25	---	---
	DRAINS/100 LOCOS/YEAR					
FUEL DILUTION					20.5	15.4
WATER LEAKS (HIGH Na OR B)					18.5	26.3
WATER LEAKS (FREE WATER)					5.7	9.0
HIGH WEAR METALS					0.0	0.0
HIGH VISCOSITY					14.2	0.9
HIGH INSOLUBLES					4.7	3.2
LOW PH/TBN					5.7	25.2
TOTAL					69.2	80.1
	SUMMARY - DRAINS/100 LOCOS/YEAR					
FUEL DILUTION					20.5	15.4
WATER LEAKS					24.2	35.4
HIGH WEAR METALS					0.0	0.0
OIL DEGRADATION					24.5	29.3
TOTAL					69.2	80.1

NOTE: RECEIVED FIRST SHIPMENT OF MG IN JANUARY 1990

LMOA FL&E COMMITTEE SURVEY RESULTS
CAUSES FOR OIL DRAINS AND OIL FILTER CHANGEOUT PRACTICE

RAILROAD 4

DATA	EMD		GE		TOTAL	
	1989	1992	1989	1992	1989	1992
	DRAINS/YEAR					
NO. LOCOS IN FLEET	1659	1473	413	477	2072	1950
OIL DRAIN INTERVAL	UO		UO		UO	
CAUSES FOR DRAINS						
FUEL DILUTION	81	50	8	11	89	61
WATER LEAKS (HIGH Na OR B)	137	13	82	7	219	20
WATER LEAKS (FREE WATER)	81	83	13	24	94	107
HIGH WEAR METALS	0	0	0	0	0	0
HIGH VISCOSITY	4	1	305	10	309	11
HIGH INSOLUBLES	0	38	34	36	34	74
LOW PH/TBN	0	0	15	11	15	11
TOTAL	303	185	457	99	760	284
FILTER DATA						
FILTER CHANGE PERIOD (DAYS)	84-92	84-92	84-92	84-92	---	---
FILTER SIZE (MICRONS)	18	18	28	28	---	---
	DRAINS/100 LOCOS/YEAR					
FUEL DILUTION	4.9	3.4	1.9	2.3	4.3	3.1
WATER LEAKS (HIGH Na OR B)	8.3	0.9	19.9	1.5	10.6	1.0
WATER LEAKS (FREE WATER)	4.9	5.6	3.1	5.0	4.5	5.5
HIGH WEAR METALS	0.0	0.0	0.0	0.0	0.0	0.0
HIGH VISCOSITY	0.2	0.1	73.8	2.1	14.9	0.6
HIGH INSOLUBLES	0.0	2.6	8.2	7.5	1.6	3.8
LOW PH/TBN	0.0	0.0	3.6	2.3	0.7	0.6
TOTAL	18.3	12.6	110.7	20.8	36.7	14.6
	SUMMARY - DRAINS/100 LOCOS/YEAR					
FUEL DILUTION	4.9	3.4	1.9	2.3	4.3	3.1
WATER LEAKS	13.1	6.5	23.0	6.5	15.1	6.5
HIGH WEAR METALS	0.0	0.0	0.0	0.0	0.0	0.0
OIL DEGRADATION	0.2	2.6	85.7	11.9	17.3	4.9
TOTAL	18.3	12.6	110.7	20.8	36.7	14.6

NOTE: RECEIVED FIRST SHIPMENT OF MG IN JANUARY 1991

LMOA FL&E COMMITTEE SURVEY RESULTS
CAUSES FOR OIL DRAINS AND OIL FILTER CHANGEOUT PRACTICE

RAILROAD 8

DATA	EMD		GE		TOTAL	
	1989	1992	1989	1992	1989	1992
	DRAINS/YEAR					
NO. LOCOS IN FLEET	565	422	10	77	575	499
OIL DRAIN INTERVAL	UO	UO	91	182/91*	MIX	MIX
CAUSES FOR DRAINS						
FUEL DILUTION	41	27	0	0	41	27
WATER LEAKS (HIGH Na OR B)	44	38	0	1	44	39
WATER LEAKS (FREE WATER)	19	6	0	0	19	6
HIGH WEAR METALS	35	17	0	0	35	17
HIGH VISCOSITY	0	3	0	3	0	6
HIGH INSOLUBLES	6	15	0	0	6	15
LOW PH/TBN	0	0	0	0	0	0
TOTAL	145	106	0	4	145	110
FILTER DATA						
FILTER CHANGE PERIOD (DAYS)	91	91	91	91	---	---
FILTER SIZE (MICRONS)	20	20	28	28	---	---
	DRAINS/100 LOCOS/YEAR					
FUEL DILUTION	7.3	6.4	0.0	0.0	7.1	5.4
WATER LEAKS (HIGH Na OR B)	7.8	9.0	0.0	1.3	7.7	7.8
WATER LEAKS (FREE WATER)	3.4	1.4	0.0	0.0	3.3	1.2
HIGH WEAR METALS	6.2	4.0	0.0	0.0	6.1	3.4
HIGH VISCOSITY	0.0	0.7	0.0	3.9	0.0	1.2
HIGH INSOLUBLES	1.1	3.6	0.0	0.0	1.0	3.0
LOW PH/TBN	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	25.7	25.1	0.0	5.2	25.2	22.0
	SUMMARY - DRAINS/100 LOCOS/YEAR					
FUEL DILUTION	7.3	6.4	0.0	0.0	7.1	5.4
WATER LEAKS	11.2	10.4	0.0	1.3	11.0	9.0
HIGH WEAR METALS	6.2	4.0	0.0	0.0	6.1	3.4
OIL DEGRADATION	1.1	4.3	0.0	3.9	1.0	4.2
TOTAL	25.7	25.1	0.0	5.2	25.2	22.0

NOTE: 1989 GE'S SHOWN AS 30/3 SINCE RECEIVED IN AUG

NOTE: RECEIVED FIRST SHIPMENT OF MG IN AUGUST 1992

* RECEIVED 1ST GE'S AUG 1989. INITIALLY 91 DAY DRAINS

SWITCHED TO 182 DAYS WHEN ADOPTED 17 TBN GEN V SG

THEN REVERTED BACK TO 91 DAYS WHEN ADOPTED 13 TBN MG IN AUG 1992

LMOA FL&E COMMITTEE SURVEY RESULTS
CAUSES FOR OIL DRAINS AND OIL FILTER CHANGEOUT PRACTICE

RAILROAD 11

DATA	EMD		GE		TOTAL	
	1989	1992	1989	1992	1989	1992
	DRAINS/YEAR					
NO. LOCOS IN FLEET	1076	1059			1076	1059
OIL DRAIN INTERVAL	UO	UO	0	0		
CAUSES FOR DRAINS						
FUEL DILUTION	70	106			70	106
WATER LEAKS (HIGH Na OR B)	276	107			276	107
WATER LEAKS (FREE WATER)	48	46			48	46
HIGH WEAR METALS	116	149			116	149
HIGH VISCOSITY	0	0			0	0
HIGH INSOLUBLES	16	5			16	5
LOW PH/TBN	0	0			0	0
TOTAL	526	413			526	413
FILTER DATA						
FILTER CHANGE PERIOD (DAYS)	90	90			---	---
FILTER SIZE (MICRONS)	13	13			---	---
	DRAINS/100 LOCOS/YEAR					
FUEL DILUTION	6.5	10.0			6.5	10.0
WATER LEAKS (HIGH Na OR B)	25.7	10.1			25.7	10.1
WATER LEAKS (FREE WATER)	4.5	4.3			4.5	4.3
HIGH WEAR METALS	10.8	14.1			10.8	14.1
HIGH VISCOSITY	0.0	0.0			0.0	0.0
HIGH INSOLUBLES	1.5	0.5			1.5	0.5
LOW PH/TBN	0.0	0.0			0.0	0.0
TOTAL	48.9	39.0			48.9	39.0
	SUMMARY - DRAINS/100 LOCOS/YEAR					
FUEL DILUTION	6.5	10.0			6.5	10.0
WATER LEAKS	30.1	14.4			30.1	14.4
HIGH WEAR METALS	10.8	14.1			10.8	14.1
OIL DEGRADATION	1.5	0.5			1.5	0.5
TOTAL	48.9	39.0			48.9	39.0

NOTE: FIRST RECEIVED MULTIGRADE IN NOV OF 1991 .

LMOA FL&E COMMITTEE SURVEY RESULTS
CAUSES FOR OIL DRAINS

NORTH AMERICAN RR AVERAGE

DATA	RR 1		RR 4		RR 8		RR 11		TOTAL		PERCENT CHANGE
	1989	1992	1989	1992	1989	1992	1989	1992	1989	1992	
					DRAINS/YEAR		DRAINS/YEAR				
NO. LOCOMOTIVES IN FLEET	2273	1915	2072	1950	575	499	1076	1059	5996	5423	-9.8
CAUSES FOR DRAINS											
FUEL DILUTION	466	295	89	61	41	27	70	106	666	489	-26.6
WATER LEAKS (HIGH Na OR B)	420	504	219	20	44	39	278	107	959	670	-30.1
WATER LEAKS (FREE WATER)	130	173	94	107	19	6	48	46	291	332	14.1
HIGH WEAR METALS	0	0	0	0	35	17	118	149	151	166	9.9
HIGH VISCOSITY	322	17	309	11	0	6	0	0	631	34	-94.6
HIGH INSOLUBLES	106	62	34	74	6	15	18	5	162	156	-3.7
LOW PH/TBN	130	492	15	11	0	0	0	0	145	493	240.0
TOTAL	1574	1533	760	264	146	110	526	413	2479	1927	-22.3
					DRAINS/100 LOCOMOTIVES		DRAINS/100 LOCOMOTIVES				
FUEL DILUTION	20.5	15.4	4.3	3.1	7.1	5.4	6.5	10.0	11.1	9.0	-18.8
WATER LEAKS (HIGH Na OR B)	18.5	26.3	10.6	1.0	7.7	7.8	25.7	10.1	16.0	12.4	-22.8
WATER LEAKS (FREE WATER)	5.7	9.0	4.5	5.5	3.3	1.2	4.5	4.3	4.9	6.1	26.1
HIGH WEAR METALS	0.0	0.0	0.0	0.0	6.1	3.4	10.8	14.1	2.5	3.1	21.5
HIGH VISCOSITY	14.2	0.9	14.9	0.6	0.0	1.2	0.0	0.0	10.5	0.6	-94.0
HIGH INSOLUBLES	4.7	3.2	1.6	3.8	1.0	3.0	1.5	0.5	2.7	2.9	6.5
LOW PH/TBN	5.7	25.2	0.7	0.6	0.0	0.0	0.0	0.0	2.4	9.1	275.9
TOTAL	69.2	60.1	36.7	14.6	25.2	22.0	48.9	39.0	50.1	43.1	-13.9
	SUMMARY - DRAINS/100 LOCOMOTIVES										
FUEL DILUTION	20.5	15.4	4.3	3.1	7.1	5.4	6.5	10.0	11.1	9.0	-18.8
WATER LEAKS	24.2	35.4	15.1	6.5	11.0	9.0	30.1	14.4	20.8	16.5	-11.4
HIGH WEAR METALS	0.0	0.0	0.0	0.0	6.1	3.4	10.8	14.1	2.5	3.1	21.5
OIL DEGRADATION	24.5	29.3	17.3	4.9	1.0	4.2	1.5	0.5	15.8	12.6	-19.5
TOTAL	69.2	60.1	36.7	14.6	25.2	22.0	48.9	39.0	50.1	43.1	-13.9

FILENAME: DRAINNA

**LOCOMOTIVE MAINTENANCE OFFICERS ASSOCIATION
FUELS, LUBRICANTS AND ENVIRONMENTAL COMMITTEE**

**STANDARD INSOLUBLES TEST METHOD
REVISION 3**

Scope: Filtration procedure for the determination of coagulated pentane insolubles in used railroad diesel engine oil.

Equipment:

Smooth tip forceps millipore cat# XX6200006.

Graduated cylinders, 50ml with stopper.

Filtering flask 1 liter capacity.

Pyrex Filter holders Millipore cat# XX10047

Filter membrane 0.45 μ m Millipore Cat# HAW P047 00

Aluminum weighing dish.

Balance capable of weighing to the nearest 0.0001 grams with a range to 160 grams.

Vacuum capable of maintaining 15 inches Hg min.

Reagents

Coagulant - N-butyldiethanolamine 98%

N-pentane 98% if industrial grade pentane is used filter using 0.45 μ millipore prior to use.

Pentane coagulant solution 1.0% by volume.
10ml N-butyldiethanolamine to 1 liter pentane.

**STANDARD INSOLUBLES TEST METHOD
REVISION 3****Procedure:**

1. Prepare oils to be tested by warming in an oven at 120°F for 1/2 hour prior to use.
2. Use dry filters. Store filters in desiccator or heat for 15 minutes in 100°C oven prior to use.
3. Place 0.45 μ m filter into identified aluminum dish or other suitable container, weigh several times or until the weight stabilizes record to the nearest 0.1mg.
4. Place 50ml graduated cylinder on balance and tare.
5. Remove oil from oven. NOTE: since some settling of the insoluble material may have occurred during storage it is advisable to vigorously shake the sample, preferably with an automatic shaker for several minutes or by hand for a minimum 30 seconds.
6. Using a medicine dropper weigh 0.25 grams into the graduated cylinder. Record weight to the nearest 0.1mg.
7. Add 10ml pentane and agitate gently until oil sample dissolves in pentane.
8. Bring the volume in the graduate up to the 50ml mark with the 1% coagulant solution. Stopper and shake gently. Allow to stand for (minimum) 15 min. Shake solution periodically during the 15 minutes.
9. Mount the filter on the holder and apply the vacuum. Mount and securely clamp the filter funnel to the filter holder. Ensure a minimum vacuum of 15 inches Hg is attained.
10. Shake the sample one last time and pour into the funnel*.
11. Rinse the graduate twice using 30-40ml pentane from a squirt bottle and pour into the funnel. Rinse the funnel wall using a stream of pentane from the squirt bottle.

**STANDARD INSOLUBLES TEST METHOD
REVISION 3**

12. Remove the funnel from the filter holder and rinse the filter membrane with a stream of pentane from the squirt bottle. Ensure that the edges are rinsed well to remove any oil trapped beneath the funnel.

NOTE: The amount of pentane used for rinsing can vary; however, it has been found that repeatability improves with a thorough rinsing. (You can't use too much pentane).

13. Release the vacuum, and using a smooth tip forceps transfer the filter its original weighing dish.
14. Dry at 100°C for minimum of 15 minutes.
15. Cool to room temp in desiccator for 15 minutes.
16. Weigh and record stabilized weight to the nearest 0.1mg.

Calculation for determination of Mass% insolubles:

$(\text{Wt. of filter \& deposit}) - (\text{Wt. of filter}) / (\text{Sample wt.}) \times 100$

- * **NOTE:** If filter plugs or solution has not completely filtered within 2 minutes discard and repeat the above procedure using a smaller sample size (0.10 gms).

Troubleshooting:

During the development of the test, a number of observations were made that helped operators recognize problems. These are described below:

- 1) Repeatability was found to be best if the samples filtered in less than one minute. With extended filter times, the weights tend to be high, since the insolubles on blocked filters cannot be rinsed enough to remove oil and coagulant residue.

- 2) The following were found to indicate the presence of residual coagulant: Curling of the filter edges when drying, a yellow ring around the edge of the insolubles, or a blotchy surface appearance that is tacky. Residual coagulant will give high results.

- 3) In humid climates, the cooling caused by pentane evaporation may cause frost to form on the filter while rinsing. If this happens, continue rinsing until it disappears. Dry the filters well.

STANDARD INSOLUBLES TEST ROUND ROBIN RESULTS

LAB 1		SAMPLE NO.					
TEST NO.	1	2	3	4	5	6	
1	5.17	0.52	1.78	6.97	0.72	0.72	
2	4.95	0.63	1.70	7.70	0.56	0.68	
3	5.04	0.50	1.72	7.40	0.64	0.76	
4	6.80	0.42		6.28	0.64		
AVG	5.5	0.5	1.7	7.1	0.6	0.7	
SD	0.9	0.1	0.0	0.6	0.1	0.0	
CV, %	16.0	16.7	2.4	8.7	10.2	5.6	

LAB 3		SAMPLE NO.					
TEST NO.	1	2	3	4	5	6	
1	8.39	0.90	2.53	6.74	0.87	1.59	
2	7.40	0.79	2.59	5.51	0.72	1.31	
3	7.37	0.74	2.84	5.54	0.65	1.90	
4	7.71	0.44	2.52	6.00	0.53	1.52	
AVG	7.7	0.7	2.6	5.9	0.7	1.6	
SD	0.5	0.2	0.1	0.6	0.1	0.2	
CV, %	6.1	27.4	5.7	9.7	20.5	15.5	

LAB 4		SAMPLE NO.					
TEST NO.	1	2	3	4	5	6	
1	5.79	0.31	2.01	5.00	0.31	1.85	
2	6.45	0.50	1.84	4.25	0.41	1.71	
3	6.73	0.38	1.90	4.43	0.38	1.68	
4	6.47	0.34	2.20	4.91	0.28	1.60	
AVG	6.4	0.4	2.0	4.6	0.3	1.7	
SD	0.4	0.1	0.2	0.4	0.1	0.1	
CV, %	6.3	21.8	8.0	7.8	17.5	6.1	

LAB 5		SAMPLE NO.					
TEST NO.	1	2	3	4	5	6	
1	6.48	0.26	1.95	4.90	0.36	1.04	
2	6.69	0.30	2.16	5.38	0.40	1.04	
3	6.66	0.32	1.94	4.86	0.42	1.05	
4	6.47	0.34	2.00	4.91	0.38	0.98	
AVG	6.6	0.3	2.0	5.0	0.4	1.0	
SD	0.1	0.0	0.1	0.2	0.0	0.0	
CV, %	1.8	11.2	5.1	4.9	6.6	3.1	

STANDARD INSOLUBLES TEST ROUND ROBIN RESULTS

LAB 6		SAMPLE NO.					
TEST NO.	1	2	3	4	5	6	
1	7.60	0.27	1.46	5.57	0.53	1.91	
2	8.10	0.34	1.55	5.43	0.43	1.79	
3	7.90	0.27	1.67	5.68	0.49	1.64	
4	7.90	0.36	1.49	5.65	0.41	1.61	
AVG	7.9	0.3	1.5	5.6	0.5	1.7	
SD	0.2	0.0	0.1	0.1	0.1	0.1	
CV, %	2.6	15.1	6.0	2.0	11.8	8.0	

LAB 10		SAMPLE NO.					
TEST NO.	1	2	3	4	5	6	
1	7.18	0.22	1.64	6.76	0.23	2.34	
2	6.65	0.35	1.77	5.08	0.25	1.70	
3	7.00	0.22	1.69	5.29	0.27	1.55	
4	6.75	0.26	1.58	5.08	0.25	1.74	
AVG	6.9	0.3	1.7	5.6	0.3	1.8	
SD	0.2	0.1	0.1	0.8	0.0	0.3	
CV, %	3.5	23.4	4.8	14.6	6.5	19.0	

LAB 11		SAMPLE NO.					
TEST NO.	1	2	3	4	5	6	
1	6.28	0.22	1.93	4.63	0.26	1.46	
2	6.40	0.26	1.94	4.59	0.25	1.38	
3	6.30	0.25	1.88	4.57	0.26	1.49	
4	6.40	0.25	1.96	4.54	0.25	1.48	
AVG	6.3	0.2	1.9	4.6	0.3	1.5	
SD	0.1	0.0	0.0	0.0	0.0	0.0	
CV, %	1.0	7.1	1.8	0.8	2.3	3.4	

LAB 13		SAMPLE NO.					
TEST NO.	1	2	3	4	5	6	
1	6.23			4.20			
2	6.16			4.24			
3							
4							
AVG	6.2	ERR	ERR	4.2	ERR	ERR	
SD	0.0	ERR	ERR	0.0	ERR	ERR	
CV, %	0.8	ERR	ERR	0.7	ERR	ERR	

STANDARD INSOLUBLES TEST ROUND ROBIN RESULTS

LAB 18		SAMPLE NO.					
TEST NO.	1	2	3	4	5	6	
1	5.94	0.24	1.48	4.52	0.24	1.10	
2	6.33	0.28	1.62	4.59	0.32	0.96	
3	6.20	0.22	1.56	4.48	0.30	0.76	
4	6.26	0.16	1.35	5.10	0.26	1.11	
AVG	6.2	0.2	1.5	4.7	0.3	0.9	
SD	0.2	0.1	0.1	0.3	0.0	0.2	
CV, %	2.8	22.2	7.8	6.2	13.0	17.8	

LAB 19		SAMPLE NO.					
TEST NO.	1	2	3	4	5	6	
1	7.09	0.60	2.32	5.18	0.75	1.34	
2	6.92	0.63	2.24	5.37	0.73	1.47	
3							
4							
AVG	7.0	0.6	2.3	5.3	0.7	1.4	
SD	0.1	0.0	0.1	0.1	0.0	0.1	
CV, %	1.7	3.4	2.5	2.5	1.9	6.5	

LAB 20		SAMPLE NO.					
TEST NO.	1	2	3	4	5	6	
1	6.06	0.33	1.62	4.63	0.47	0.89	
2	6.00	0.27	1.56	4.49	0.45	0.96	
3					0.43		
4					0.47		
AVG	6.0	0.3	1.6	4.6	0.5	0.9	
SD	0.0	0.0	0.0	0.1	0.0	0.0	
CV, %	0.7	14.1	2.7	2.2	4.2	5.4	

LAB 21		SAMPLE NO.					
TEST NO.	1	2	3	4	5	6	
1	6.30	0.63	2.30	5.45	0.55	1.17	
2	6.59	0.66	2.53	5.41	0.56	1.13	
3		0.62					
4							
AVG	6.4	0.6	2.4	5.4	0.6	1.2	
SD	0.2	0.0	0.2	0.0	0.0	0.0	
CV, %	3.2	3.3	6.7	0.5	1.3	2.5	

STANDARD INSOLUBLES TEST ROUND ROBIN RESULTS

RESULTS OF LMOA FL&E COMMITTEE ROUND ROBIN
LAB AVERAGES

LAB	SAMPLE NO					
	1	2	3	4	5	6
LAB 1	5.49	0.52	1.73	7.09	0.64	0.72
LAB 3	7.72	0.72	2.62	5.95	0.69	1.58
LAB 4	6.36	0.38	1.99	4.65	0.35	1.71
LAB 5	6.58	0.31	2.01	5.01	0.39	1.03
LAB 6	7.88	0.31	1.54	5.58	0.47	1.74
LAB 10	6.90	0.26	1.67	5.55	0.25	1.83
LAB 11	6.35	0.25	1.93	4.58	0.26	1.45
LAB 13	6.20			4.22		
LAB 18	6.18	0.23	1.50	4.67	0.28	0.92
LAB 19	7.01	0.62	2.28	5.28	0.74	1.41
LAB 20	6.03	0.30	1.59	4.56	0.46	0.93
LAB 21	6.45	0.64	2.42	5.43	0.56	1.15
AVG	6.59	0.41	1.93	5.21	0.46	1.31
SD	0.69	0.18	0.37	0.79	0.18	0.38
CV %	10.4	43.3	19.3	15.1	38.3	29.2

FILENAME: RRSTATS2

Figure A1
Correlation of Centrifuge and LMOA CPI Methods

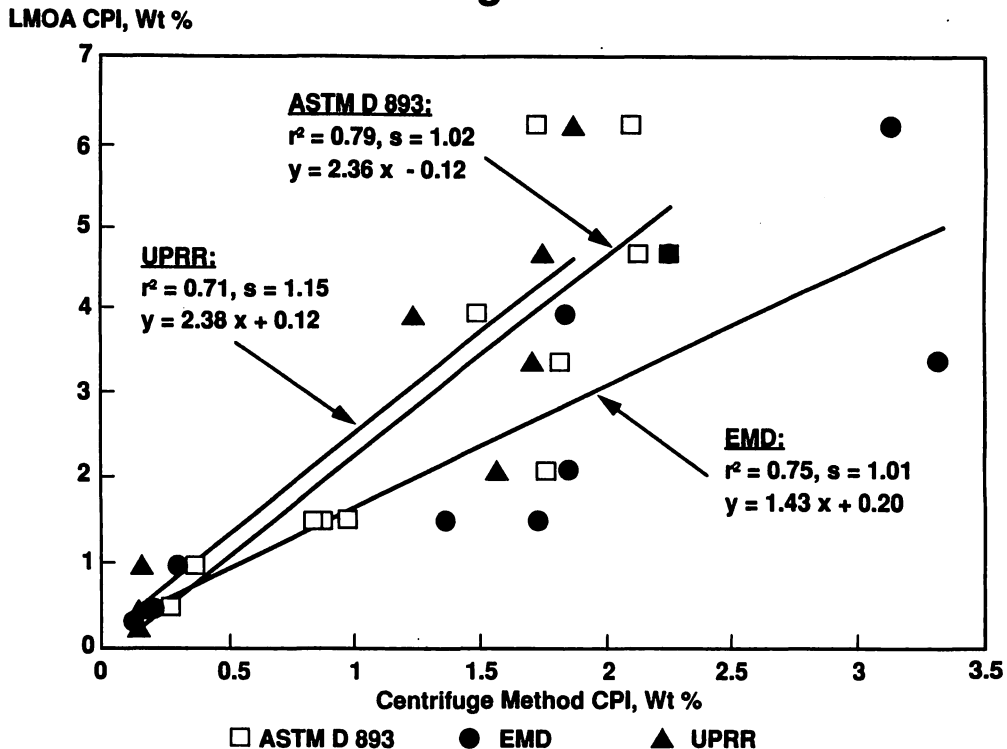


Figure A2 Correlation of Filtration and LMOA CPI Methods

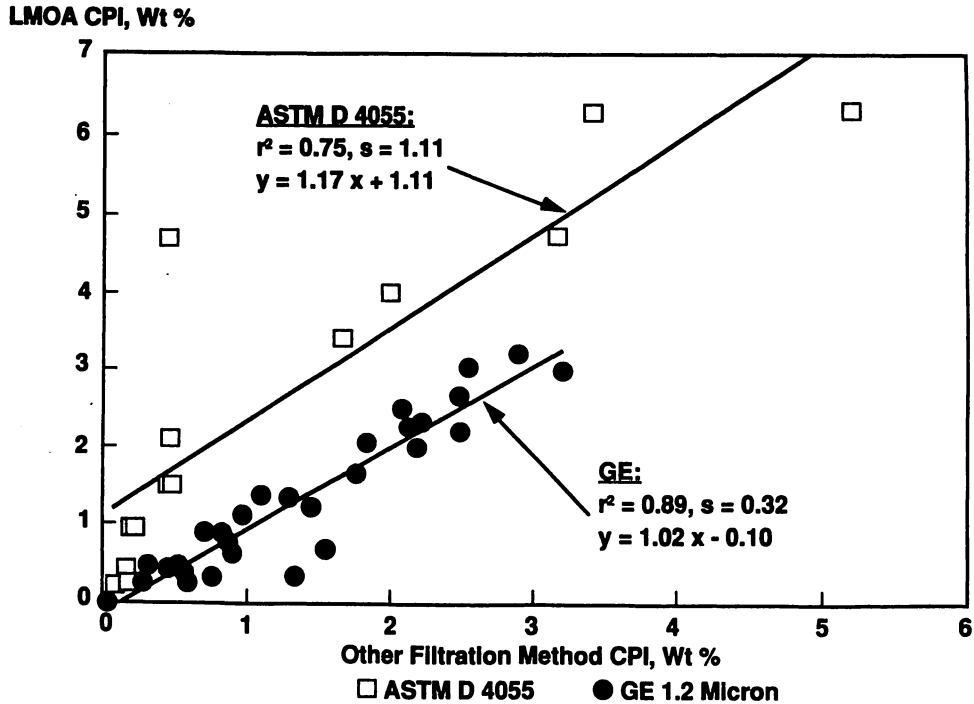


Figure A3
Evaluation of "Anoilizer" as a Screener
Results From 3 Labs

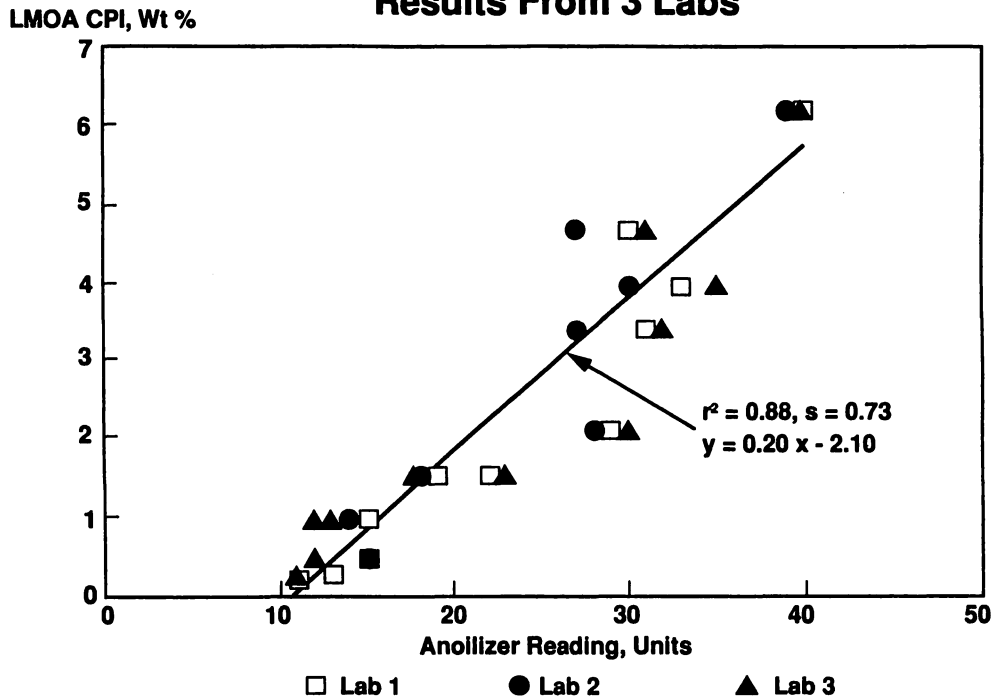


Figure A4
Evaluation of Lab 1 Infrared Method as a Screener
Absorbance at 3800 and 1980 1/cm

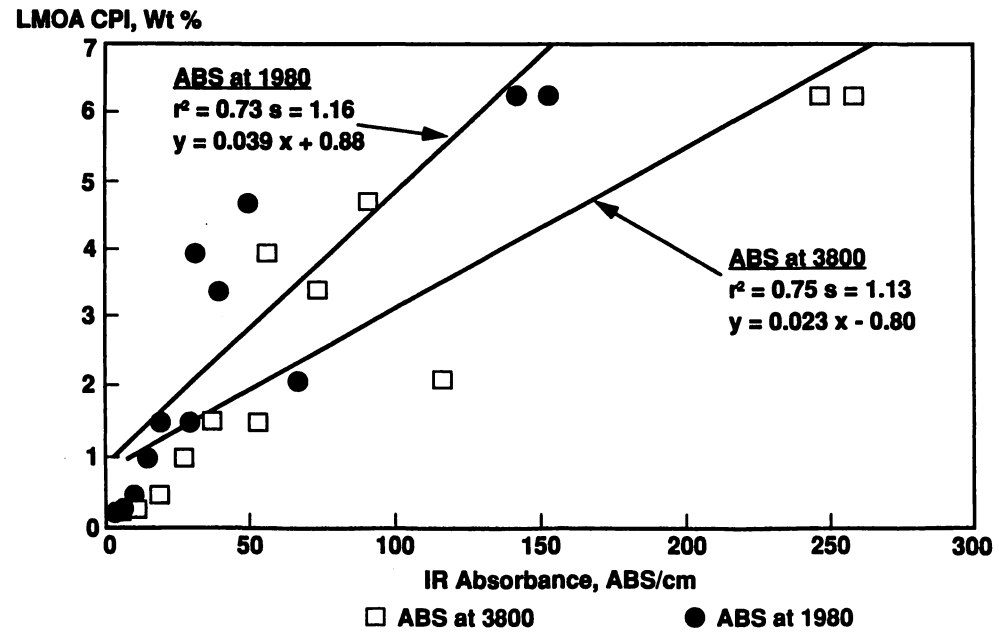


Figure A5
Evaluation of Light Transmission Method as a Screener
Lab 13

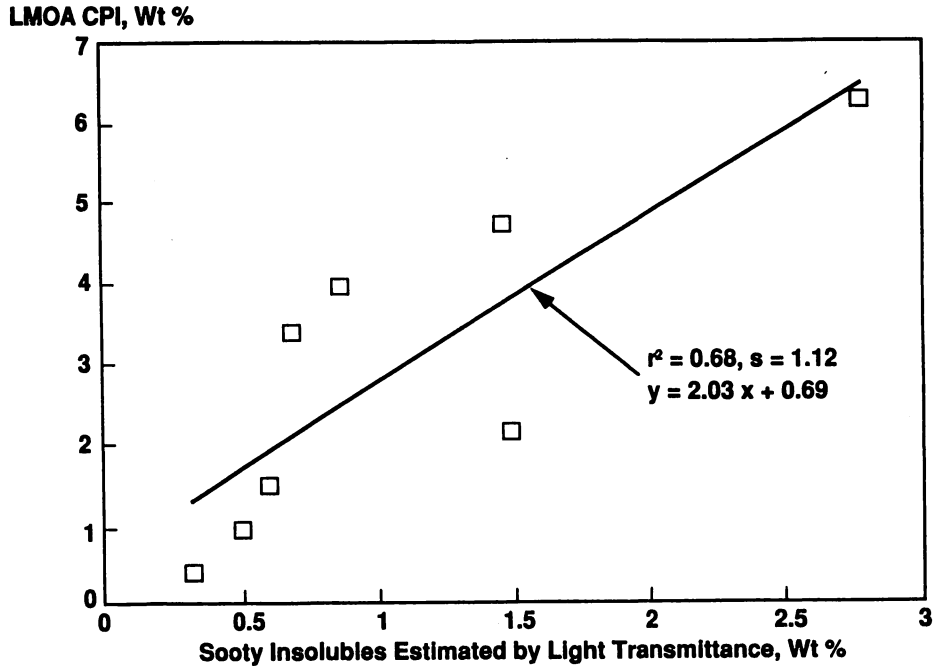


Figure A6
Evaluation of Savant "Particulate Sensor" as a Screener

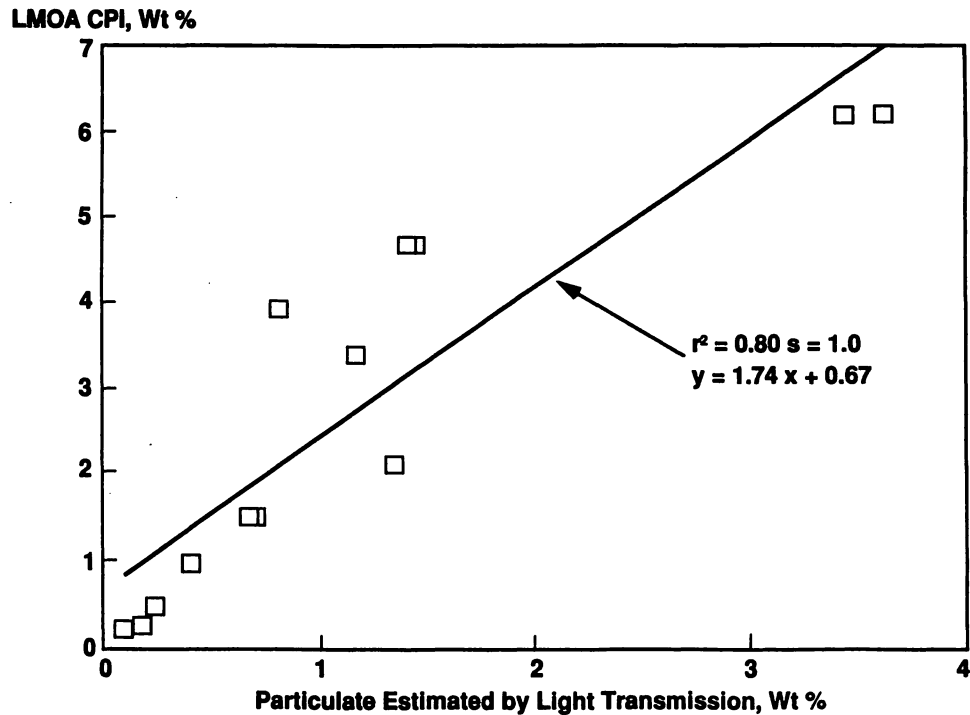


Figure A7
Evaluation of "LEM" Light Transmittance Method as Screener
Lab Code 18

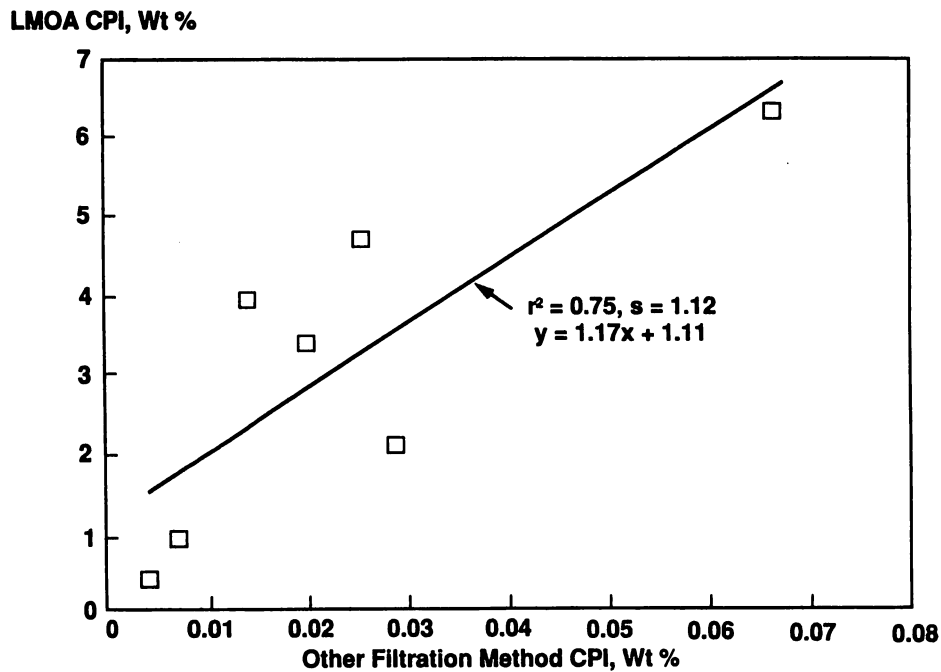
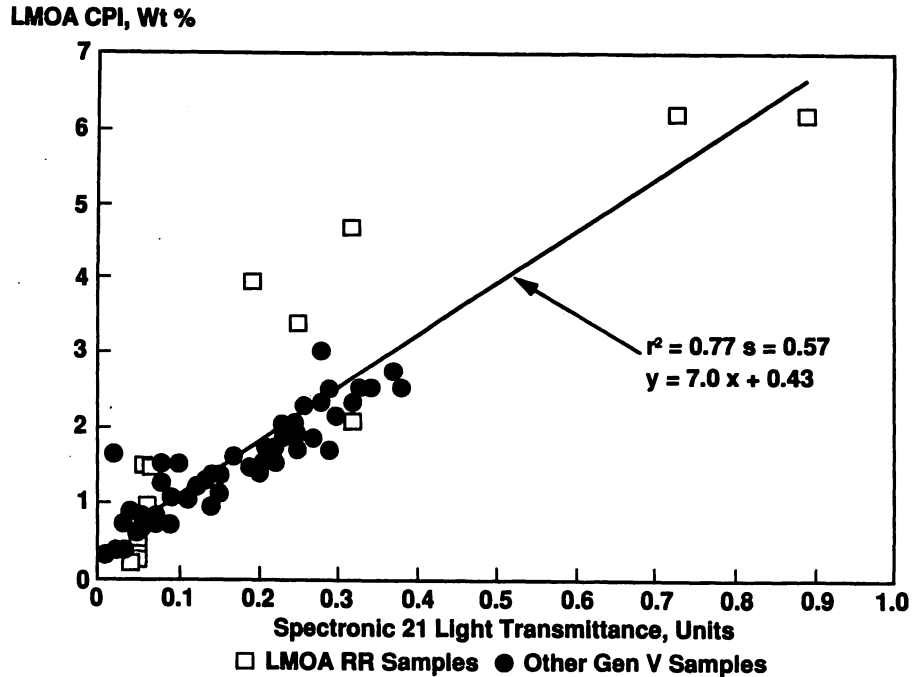


Figure A8
Evaluation of Spectronic 21 Light Transmittance
Method as a Screener



CAPRINUS® U 20W-40 Multigrade

**To help you save fuel
and oil and extend drain intervals
in locomotive engines**

CAPRINUS U 20W-40 blends exclusive Shell additives, a 13 TBN, and Shell's 34 years of multigrade oil experience. The result is an oil designed to protect locomotive engines to the maximum while reducing fuel and oil use and extending oil drains. Approved by EMD, approved by GE Generation and Long Life, exceeds LMOA Generation 5 requirements.

OSSAGOL® V Grease

**Shell's easy-to-apply track and wheel
flange lubricant**

Railroads using track lubricants significantly reduce locomotive fuel use, rail wear and wheel wear. Shell OSSAGOL V Grease is a semifluid NLGI Grade 000 grease that can be pumped and applied over wide temperature ranges. It is approved and recommended by major manufacturers of mobile mounted lubricators.



**1-800-745-2469
Fax 1-800-745-4559**

III. BIOREMEDIATION

*Prepared By: Warren Johnson
(708-629-7930)*

Select enzymes are cultured from naturally occurring bacteria found in soil and water contamination. These enzymes are stored available for use until like conditions of contamination are found. With this in mind we can now go forward in our discussion on applications and benefits of BIOREMEDIATION.

The bioremediation process consists of four steps:

1/ Defining and characterizing the problem.

2/ Selecting a site specific application & method.

3/ Initiating and propagation of the contaminated site.

4/ Monitoring and follow-up applications, if required.

We will pass on number 1/ since by some method you may have already defined and characterized the problem.

Step 2/ requires we be allowed a representative sample of the conditions which will allow us to make a compatibility analysis for selecting the proper enzyme from the 33,000 available. Working in concert with you, we can then select the method of applications available, whether the contamination needs moving, what clean-up levels we are to attain and time constraints, if any.

Under Step 3/ consideration is given to whether the contamination can be treated with dry enzymes as in lakes, ponds, tanks or containers; or blended in a catalytic solution which assists the enzymes until they create larger colonies and stimulates their appetites. Where heavy concentrations of diesel fuel or journal oils have accumulated over the years, we would recommend surfactants be applied either prior to or

blended with the other solutions.

The best reasons for selecting BIOMEDIATION are usually low cost, ease of application and can be done in place or on your property. The work can be performed by your people or ours with little or no down time or relocation. There are no safety risks involved in handling or storing. If the site has to be moved, the treated soils can then be stored for reuse at the same or other location. Ballast washing would be an area where we excel, hazardous response is another.

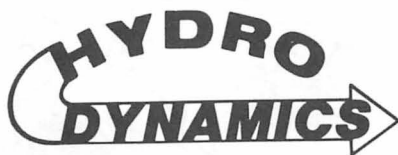
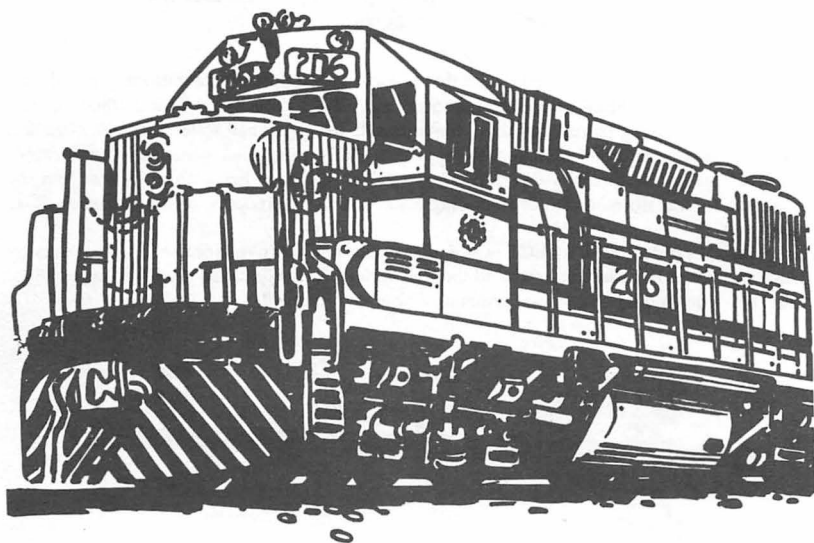
Methods of application can include farming in-situ or removed to bio-cells or piled for treatment. If groundwater contamination is the problem, we will pump, inoculate and return up-stream of the plume where the contaminant is reduced to carbon dioxide and water. Residue left, if the contamination is in tanks, is a bio-mass which can be handled without documentation in any land fill. We might also suggest the use of our products within system as a part of the waste stream for removal of contamination prior to discharge.

As a service group and in compliance with Step 4/, we will monitor the project until we have achieved your goal. Under our system of remediation, we hope to eliminate some of the record keeping and any of the paper trail which occurs when contaminated soils are moved to land fills, (if any can be found). Included in our group are Registered Environmental Attorneys and Engineers capable of resolving your specific needs or constraints.

While we cannot remediate overnight what has taken decades to build, we do feel we can do the required job at the lowest cost and with the least disruptions of service and in a reasonable time frame. We welcome the opportunity to become a valued member of your company's environmental team.

HYDRO DYNAMICS

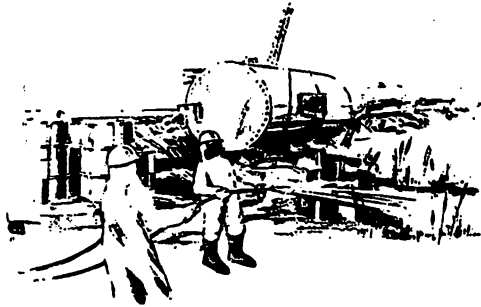
DIESEL COOLING WATER TREATMENT



DIVISION OF TRICORN INC.

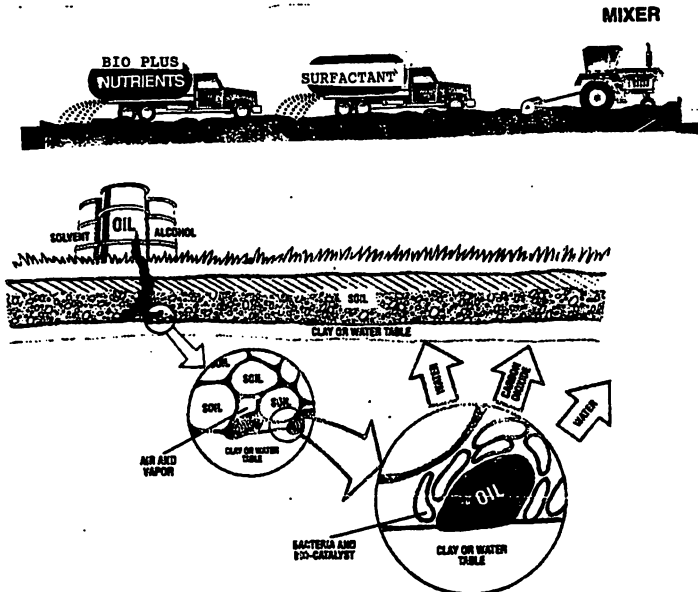
P.O. BOX 220
TEMPLE, PA 19560
(215) 921-3063

BIOREMEDIATION



Bioremediation is a cost-effective process that reduces or eliminates contaminants through scientific application of naturally-occurring microbes, nutrients and catalysts. This method is especially useful in removing petroleum-based contaminants from soil and water. Contaminants are, in effect, "de-manufactured" by scientific application of natural (not genetically engineered) microorganisms and a specially-developed bio-catalyst. Oil together with nutrients from the environment are transformed into cell-building material and by-products, then into carbon dioxide and water.

The microbial product used by ECT is to date the only one approved for use in U.S. waters by the U.S. coast Guard. It can be introduced through various forms - dusting, hydrated application, layering, etc. - depending on the requirements of your environment.



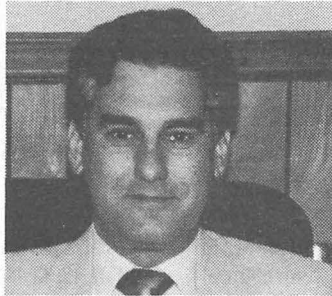
Bioremediation benefits our environment and your company. Rather than physically moving hazardous organic compounds to another site, which may just extend your liability, bioremediation converts these compounds into innocuous substances on-site.

ECT has found bioremediation to be a cost-effective, timely solution to serious problems at many sites all over the world. Its effectiveness will vary according to local conditions, and bioremediation is not recommended in all cases. But this remarkable, responsible solution is well worth considering, and ECT can offer you expert assistance in its implementation.

**REPORT OF THE COMMITTEE
ON DIESEL MATERIAL CONTROL**

**TUESDAY, SEPTEMBER 14, 1993
2:15 P.M.**

**Pre-Convention
Presentation
CN / CP**



**May 12, 1993
Le Chateau Champlain
Montreal, PQ**

LOU CALA, Chairman
Mgr-Reman. Components
Conrail
Altoona, PA

Vice Chairman
BOB CORDER
Director-Material
VMV
Paducah, KY

COMMITTEE MEMBERS

W. Albritton	Mech. Supt.	Paducah & Louisville	Paducah, KY
H. Bailey	Dir-Material Mgmt.	Amtrak	Philadelphia, PA
R. Faulconbridge	Manager-Materials	CP Rail	Montreal, PQ
R. Florczyk	Mgr-LoCo. Parts Sales	General Electric	Philadelphia, PA
W. Lechner	General Forman	Conrail	Altoona, PA
J. Minnie	Manager-Material	Burlington Northern	West Burlington, IA
L. Murphy	Mgr-Supply Opns.	Union Pacific	N. Platte, NE
H. Nash	Director-Purchasing	Montana Rail Link	Missoula, MT
J. Szczesniak	Material Analyst	Electro-Motive Divn.	Hodgkins, IL
D. Veron	Mgr-Material-Diesel	Norfolk Southern	Roanoke, VA
W. Wewers	Equipment Supvr.	AT&SF Rwy. Co.	Topeka, KS

PERSONAL HISTORY

Lou Cala

Lou Cala began his railroad career in 1974 as a laborer with the Penn Central Railroad in Cleveland. Later he held positions in the Stores Department and worked as chief clerk in 1977 at the Distribution Center. Several promotions followed: Supvr. of Materials (1977); Material & Purchasing System Auditor (1979); Gen. Supvr. Material

(1980); Material Spec. Program-Car Material (1981); Mgr. Material Control for the Mechanical Dept. (1983), Mgr. Reman. Corp. (1992) for Conrail.

Lou and his wife Joan have three children: Angelo, 29, Vicki 27, Lou, Jr. 7 and one granddaughter. They currently live in Altoona.

WHEN REPLACING DYNAMIC BRAKE GRIDS

M O S E B A C H

Fleet Proven - Dependable Products
Environmentally Safe

For further information please contact one
of our representatives.

RADNOR, PA (215) 971-9966.....HUGHES RAILWAY SUPPLIES
LAKE ELMO, MN (612) 770-8720.....ROBERT J. WYLIE COMPANY
ST. LOUIS, MO (314) 645-8262.....ROSS RAILWAY SUPPLIES
KANSAS CITY, MO (816) 474-9833.....MELLS CARGO SUPPLY, INC.
SACRAMENTO, CA (916) 925-2015.....MELLS CARGO SUPPLY, INC.
MONTREAL, QB (514) 738-1403.....DAVANAC INDUSTRIES, LTD.
OMAHA, NE (402) 498-0949.....THE GALVIN COMPANY
ORINDA, CA (510) 254-1515.....INTERMODAL TECHNICAL
SUPPORT, INCORPORATED

M O S E B A C H
Manufacturing Company

818 Manton Way
Pittsburgh, PA 15210
(412) 488-5043
FAX: (412) 488-5243



V.H. MIZRAHI
Chief of Motive Power
& Car Equipment
CN Rail
Montreal, Quebec



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 Diesel Material Control Committee in Montreal on May 12, 1993.

The attendance and interest exhibited was most gratifying.

I. TECHNOLOGY TRANSFER

*Presented By
Rick Swenson - Genwest*

In the United States, as in almost every other country, the transportation of goods and commodities is becoming very competitive. Trucks and other modes of surface shipping are competing daily to move the same goods we in the railroad industry do.

Fortunately, or unfortunately, continuing global forces will constantly restructure the way all of us in North America, as well as the rest of the world, do business now and in the future. New and ever-changing economic factors will affect the way we usually conduct this business. New technologies will mold the way we operate just as they have in the past several years. The global economy will truly become a hyper-competitive marketplace due to these ever-changing technologies.

The one major question for all of us in the railroad industry, whether in the U.S., Canada or any other country, is "How can the railroad industry effectively and successfully compete in such an ever-changing business environment?"

I'm certain this sounds like a tough question for anyone to answer; but I do have some potential good news and the good news that I do have is that there is a partial answer that will offer us in the railroad industry some future possibilities and this is the concept of technology transfer.

First, let me say that technology transfer is the term used now almost universally for the concept of taking certain technology from one source and "transferring" it for another use. This source can include technology developed already or technology in the process of experimental development from a university, federal laboratory, another company, or any other source.

Technology transfer, as you may

have read lately, is now a very hot topic in the U.S. and other countries as more and more companies realize the need for improved products and services through new technology and development.

Many different, recently developed products of very different types have one common theme between them. Every single one was developed by private industry using the concept of technology transfer and from one source, in this case, NASA, the U.S. National Aeronautics and Space Administration. Actually, NASA is only one of many sources of new technology; and this information is available not just to U.S. citizens, since there are now mechanisms in place to share such technological information with companies and individuals in other countries.

Today, in the era of shrinking budgets and reduced research and development departments, especially in our railroad industry, I believe the concept of technology transfer offers a good opportunity for many industries, ours included, to become more competitive through the use of improved technology. This will not necessarily be easy but it does offer at least some alternative opportunities.

It is important to point out that vast sums of research and development dollars have been spent over the last 25 years by the U.S. government and most other countries' governments, as well as the private sector, on all different types of technologies, some of which offer opportunities for technology transfer to companies both large and small.

As an example, take my small, entrepreneurial company based in Colorado. I chose to locate technology that can assist railroads, transit agencies, and other similar companies in a comprehensive warranty control and management system to track and identify the various parts and components used in railroad equipment, such as locomotives, freight cars, maintenance of way

equipment, etc. The system would successfully determine whether a specific part or component was under warranty from the manufacturer, as well as complete information on the "life cycle history" of that part including detailed reliability information. At the same time, I wanted our system and program to be able to track a company's fixed assets and materials such as tools, equipment, furniture, etc., so that a railroad would be able to determine quickly where a certain asset was located and specifically in which facility.

In order to begin my own process of technology transfer, I first contacted one of the U.S. government agencies whose primary mission is to act as a "central clearing house" or locator of certain technology services that most suitably apply to what someone is looking for.

Within several weeks, this agency, the Federal Laboratory Consortium for Technology Transfer, or FLC for short, directed me to certain U.S. Navy and U.S. Air Force installations that had developed a program utilizing advanced automatic identification technologies that could be used to solve the problem of warranty tracking even on non-serialized parts and components. In addition, as a very fortunate side benefit, these technologies, when combined with the use of U.S. Navy artificial intelligence and object oriented software, would easily track part and component reliability statistics and MTBF (mean time between failure) information. It also had the potential capability of providing satisfactory statistical information so that a railroad or transit property could develop a "conditioned based" maintenance program as opposed to simply a scheduled maintenance program.

So in my project, I used the concept of technology transfer with both the government and private sector sides, as well as certain technology used overseas.

However, the success I experienced

with technology transfer also can be realized by other companies; sometimes very easily and inexpensively. Since, as I have mentioned, railroads have significantly downsized their research and development departments, it would be my suggestion that several of your departments be advised of what technology transfer is and how it can be used by both a railroad and supplier. These departments might include: Mechanical; Purchasing, Material Supply, and Maintenance.

They in turn can pursue technology transfer directly, or talk with their suppliers and suggest how technology transfer can be used to improve existing products or even come up with new ones. If your railroad is still one that has a research department or laboratory left, these individuals can be advised as to how to use the concept of technology transfer to their benefit.

This brings up the next question: how does one begin the "process" of technology transfer? My suggestion, based on the results of my success, is that unless you are relying solely on the services of a "technology broker" (much like a real estate broker in that it charges a fee for locating the technology(ies) you want to find) or relying on your manufacturer/supplier to accomplish this task, you start with one or two of the primary government agencies, such as the FLC, responsible for technology locating services. For those of you in other countries, there are already several transfer arrangements that can be utilized fairly easily, depending on the technology you are looking for.

A word of caution, however: the process is made considerably easier when you are able to detail specifically what the problem you are trying to solve is; in other words, be as specific as you possibly can. As an example, if you were looking for technology to improve certain parts in railroad equipment using rotating parts; you might want to ask for technology in the area

of new metallurgy or composite materials. When I asked for technology in the area of tracking parts and components, I started with several major topics:

- (1) part identification and tracking technology;
- (2) logistics support and control;
- (3) distribution and inventory control; and
- (4) life cycle analysis programs.

Although at first, the concept of technology transfer may seem difficult, actually the government has made it quite easy to accomplish - much easier than, say, trying to deal with many government agencies such as the IRS. In fact, Uncle Sam has made it very easy for anyone to access one or more agencies whose objective is to facilitate the matching or pairing up of the specific government agency, laboratory or military branch that most closely matches the type of research and development you are looking for. In other words, if you know what you are looking for, these agencies will be able to better assist you and in a more timely fashion.

The best news of all is that all of this initial locating service is free and there is no charge to you until you are able to take and develop this technology to a commercial and developable stage. Then, the charge is usually only on an annual royalty basis which is quite reasonable. A good recent description of technology transfer is that it's a "contact sport." So the aspect of networking really plays a large part in the potential for your success.

As for potential research and development ideas that you might consider, I would like to suggest some examples of how technology transfer could be used for our industry. These might include:

- (1) Advanced lubricant technology for locomotives;
- (2) New "high tech" metallurgy for locomotive rotating components such as turbos, power assemblies, etc.;

(3) Advanced "heads up" display panels for locomotive crews similar to U.S. Air Force and Navy jet aircraft;

(4) Safety and fatigue performance testing systems to determine employee suitability prior to job assignments;

(5) Advanced aerodynamic testing and design procedures for train consist rolling and resistance performance.

The following are the primary government agencies involved with locating and matching up your request for specific technology that might assist you in your efforts. The first and best place to start any technology transfer project is the Federal Laboratory Consortium for Technology Transfer or FLC for short.

1. Federal Laboratory Consortium for Technology Transfer
P.O. Box 545
Sequim, Washington 98382
Tel: (206) 683-1005
Fax: (206) 683-6654

The FLC was formerly chartered by the Federal Technology Transfer Act of 1986. Currently there are six FLC geographical regions, each with a regional coordinator. These regional FLC representatives provide an entry point for accessing the member labs, regardless of what agency they are under. This networking mechanism effectively provides rapid communications for interlaboratory cooperation.

2. National Technology Transfer Center (NTTC)
316 Washington Avenue
Wheeling, West Virginia 26003
Tel: (800) 678-6882
(304) 243-2513
Fax: (304) 243-2539

The goal of this newly established National Technology Transfer Center is to become the one central clearinghouse for information on federal technology with commercial potential.

The NTTC was created by Senator Robert Byrd and is located at Wheeling Jesuit College in West Virginia. It provides toll-free access to electronic data and has up to 30 people on staff trained

to answer inquiries and direct callers to the lab most likely to be of assistance. NASA has the management role in developing this project, with plans to integrate access to nonsensitive parts of its own Technology Utilization Network System (TUNS).

3. National Technical Information Service (NTIS)

U.S. Department of Commerce
Springfield, Virginia 22161

Tel: (703) 487-4650

Fax: (703) 321-8547

Virtually every agency that supports or conducts research has a significant data base holding information about research completed and, often, research in progress. Most federal agencies report this information to the National Technical Information Service (NTIS), a government-wide repository operated by the Department of Commerce. Currently, the NTIS claims to have more than 2 million entries of federally

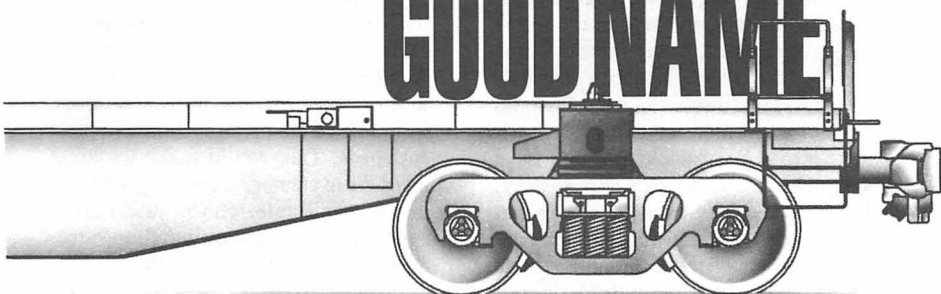
conducted or sponsored research.

In addition to the government sources available, there is now developing a whole new industry of "technology brokers," companies whose sole business mission is to match up the exact technology sources you are looking for. There is, of course, a charge for this, but in most instances it is very reasonable for the time-saving and valuable information you receive.

Each of the above agencies either have a monthly newsletter and/or brochures, catalogs, etc. and these are normally free or available at a nominal charge and can be obtained simply by requesting them.

In addition to government sources and private technology brokers, there are several good books on the subject of technology transfer, I have a bibliography of these available and, should you have an interest in the use of a broker, I will assist you in any way I can.

**YOUR
GOOD NAME
RESTS ON
OUR
GOOD NAME**



When the railroads really got rolling in the 1880's, it was on Griffin wheels. Ever since, Griffin has proven to be one of the industry's most dependable names in providing the finest rolling and stopping dynamics for railcars and locomotives. Staying on the cutting edge of technology got us there. You keep us there. And we never forget it.



GRIFFIN
Wheel Company

200 West Monroe Chicago, IL 60606 312.346.3300
IN CANADA: GRIFFIN CANADA, INC., 514.774.5311

**AND
WE NEVER
FORGET IT**

ONE OF THE **Amsted**
INDUSTRIES

II. ELECTRONIC CATALOGING FROM A MATERIAL PERSPECTIVE

Written by: John Minnie - BN

The main objective of all Material Management groups is to have the right material on the shelf or to be able to supply the right material at the right time for application to a locomotive or for the repair of a component. To accomplish this task, the Material department must have the correct information to work with, in order to avoid confusion and delays.

It all seems fairly simple at first glance, but the process takes the involvement of a lot of individuals working together and communicating a particular need. The using department has a need for a part. Via a phone call, a requisition, a fax request or various other means, it requests a specific part.

Unfortunately, in the current working environment, other factors come into play that affect the above scenario. The individual requesting the material may not know the part number; the part number may be obsolete or it may have been upgraded to another part number; the individual may have the wrong part number or the part number may be invalid. In all of these situations there can be delays in delivery times, loss of production, tensions between departments and additional costs as more people become involved in the process. Additional communication between the supplier, Purchasing, Material and the using department must take place to correct what should have been a simple transaction.

Why does this happen? First, over the years suppliers and railroads have made vast improvements on locomotives, and it has been difficult always to communicate these improvements via the catalog systems that we are currently using. Part number changes, reflective of part upgrades, are not easy to communicate to the vast number of

individuals, both in the using departments and on the Material side, involved in the ordering process. Catalogs are complex, bulky and time consuming to keep updated, even under the best conditions. Often part number changes from the suppliers are sent out as a printed list stating that part number "XXYZ" has now been superseded by part number "XXYZ 2", but this information is separate from the catalog. Consequently, the catalog is not updated at all locations. As a result, the using department orders a part, the Material department processes the order unaware of a part change and the mistake isn't caught until the supplier receives the order. These lists of upgrades, superseded numbers and obsoleted numbers are supposed to suffice until upgraded catalogs can be supplied, but they are difficult for railroads to deal with and are not effective.

Secondly, the shop environment itself is not conducive to maintaining catalogs and looking up part numbers. At a large shop it would not be unusual to have 20 or more sets of catalogs from one of the major locomotive parts suppliers. This would make updating all of these catalogs extremely difficult, if not impossible. The physical environment of a locomotive shop, also, makes maintaining written catalogs extremely difficult. The equipment noise, the grease, and the dirt associated with a locomotive shop makes it difficult to utilize a catalog and adds to the potential of making a mistake. Because of these factors, many individuals maintain their own individual parts books, "the little brown book", which they use to order the parts for their own specific work area. Obviously, these books don't get updated in a timely fashion; again, resulting in the possibility of an error in ordering.

What are the consequences of all of this? First and foremost is the loss of productivity. Whether the part costs \$1.00 or \$5,000, there is the potential

to shut down production if the right part is not delivered on time. In the scenario where an obsolete part number or an invalid part is ordered, the supplier must communicate this error back to the Material department, which in turn must relay the information to the using department, which determines what part is really needed. If a railroad uses EDI to transmit data, the delay may be minimal. But if orders are generated and mailed to the supplier, the error may not be discovered for days resulting in lost production and credibility between the user and those that are processing the order.

The other scenario involves the ordering of a valid part, which when received turns out to be something other than what was required – possibly because a number was transposed (by either the using or ordering department) or because of some other reason. Again, the correct part has to be reordered, which causes further delays and the incorrect part has to be dealt with by either requesting return authorization from the supplier, using it in its proper application or scrapping the material. This creates additional paperwork on behalf of the railroad and the supplier and additional cost associated with restocking charges, transportation, handling and storage, and if the material can't be used or returned, the cost of writing the material off as scrap.

From the standpoint of the Material Management group the use of "electronic cataloging" could substantially reduce the problems mentioned above. Instead of thumbing through a big bulky potentially outdated catalog, an individual could access a computer terminal for the required information. Ideally, through electronic cataloging, the individual would be able to access a screen that would give him or her a menu of specific parts of the locomotive or component, an enlarged or

exploded view of the part or component referenced and a list of the current part number and superseded part numbers. After finding the required part, the individual could then generate a demand to the Material department by adding a few further details such as quantity required, date required and delivery location. The problems of transposed numbers, obsolete numbers, illegible writing, etc., would be eliminated and the delivery and/or ordering process could be completed.

Not only would "electronic cataloging" be beneficial from a user standpoint, but it would also aid in the updating of information. Instead of sending out thousands of written updates to the various railroads and hoping that the corrections would be made, a supplier could upgrade parts information electronically. This would ensure that everyone involved with the ordering process is looking at the same information from the supplier, to Purchasing, to Material, to the end user, resulting in fewer delays and allowing everyone to do their jobs more effectively.

Electronic cataloging is a "win/win" situation for everyone involved in the ordering and supplying of material. Time and money can be saved by both the company buying the material and the supplier by eliminating ordering errors. The supplier will realize major savings by selling the correct product and avoiding the damaging customer relations involved with refusing to accept the return of misordered materials and the hassles involved with restocking these parts. The customer benefits by having the right part at the right time. Computers are now utilized throughout the railroad industry in our offices and out on the shop floors. With electronic cataloging their value can be expanded even further.

III. COMPUTERIZED REORDERING FROM THE MECHANICAL EMPLOYEE'S POINT OF VIEW

Presented by: Bill Wewers - AT&SF

The employee in the diesel shop has the responsibility of repairing defective locomotives and/or defective locomotive parts. With today's demand for high utilization of our locomotive fleets the employee on the shop floor becomes a very important part of the wheel that makes a railroad operate. When this employee spends a portion of his work day chasing material and trying to determine which part number is correct this could be considered non-productive time. How many times have you or your employees spent hours looking up a part number, then ordering this number only to find that the number is obsolete, and then had to start over from square one?

Many of the older employees maintain small books in their pockets containing part numbers of items they use a lot or have had difficulty in finding the right part number for in the past. With the OEM's continually changing part numbers and with the different types of locomotives now in use, the little brown book has become a part of history, while today's computers have come of age.

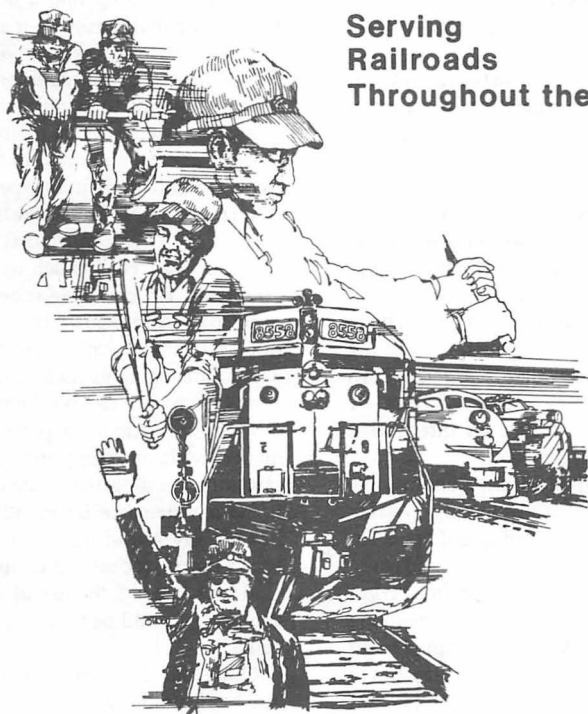
These employees are still responsible in many cases for furnishing the part numbers of the material they need. To do that they need a computer system that is both user friendly and not cumbersome to use. It is important to understand that the time he spends trying to find the correct part number is time he will not have to repair and maintain the locomotives. The system must be designed to show a parts picture that is readily identifiable with the parts list and be easy to read and work with. If in-house part numbers are used the system must show both OEM and in-house part numbers. A description of the part should be shown with each part number and should show all possible applications. The system must be designed to show changes in part numbers and should be maintained until that part is no longer available from the OEM or other suppliers. The same procedure would be followed for in-house part numbers as well.

The employees on the shop floor have always been left out when it came time to modernize systems to control the movement and inventory of locomotive parts. It is time that they were included in the solution to the problem.

We realize that the problem is not only unique to the Mechanical department but is compounded throughout the ordering process with the Material and Purchasing departments.

Snap-on Tools

**Serving
Railroads
Throughout the Nation**



**FOR ALL YOUR RAILROAD
TOOL APPLICATIONS**

**Snap-on Tools Corporation
Kenosha, Wisconsin**

IV.
**ELECTRONIC CATALOGUES:
 OEM/SUPPLIER
 POINT OF VIEW**

Presented by:

Jennifer Szczesniak-EMD

Written by: Robert Florczyk - GE &

Jennifer Szczesniak-EMD

Locomotive manufacturers, or OEMs, have competitive yet similar goals for the future. Both locomotive manufacturers and locomotive after-market parts suppliers would love to increase their respective market shares. However, suppliers would also like to move to paperless manufacturing, sales, and distribution. The OEM's also look to building long range partnerships with key customers by solving cost-reduction problems together. All of these long range goals can be accomplished through an integrative electronic catalog system.

Several companies have entered the field of computerized imaging systems by writing and designing software for electronic catalog applications. Software possibilities range from completely unique designs to personalizing pre-written packages. Computerized imaging systems also require basic hardware often in the form of a personal computer. Initial installation of an electronic imaging system consists of an image workstation (personal computer with high resolution color monitor), a laser printer, and data storage. Workstations can be operated by a traditional keyboard or by a touch screen directly on the monitor. Local printers are almost a necessity because they allow convenient on-site printing of parts lists, parts diagrams, or schematics which can then be carried to the locomotive under repair. Data storage can be accomplished through various hardware configurations, but all systems have quick and easy methods to update and add information.

The imaging system can handle all

types of technical information including text, illustrations, engineering drawings, wiring diagrams, and photographs. Graphics, such as line drawings or charts, can be keyed to the text or can be displayed on screen alongside the text.

Before plunging into a new way of conducting maintenance, or even a new way to conduct business altogether, North American railroads must decide whether or not to computerize. Plant engineers, maintenance managers, purchasing agents, and materials managers must look at their own operations to determine if computerization is the way to go. "They must first ask questions such as 'How much more are we spending on maintenance than we spent five years ago?' 'Is our information in usable form?' 'Are traditional paper parts catalogs really that cumbersome to use?' 'Do we know what it costs to maintain each piece of equipment?' and, most important, 'Will an electronic catalog really save money?' If the maintenance information system is basically sound but the information is not easily accessible or more information is needed, the use of a electronic catalog should be thoroughly investigated."¹

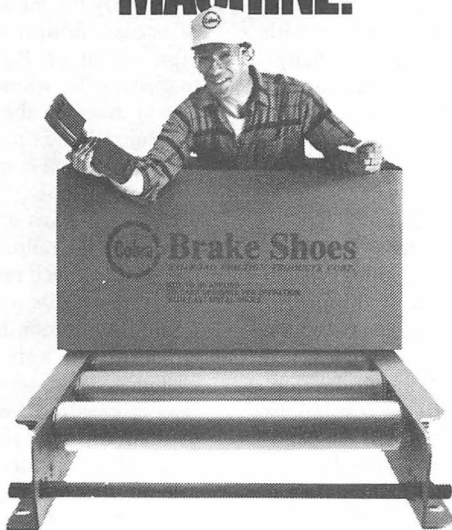
Once the decision to computerize has been made, each railroad should conduct a thoughtful search for an appropriate person to lead the conversion. The data gathering responsibility should be assigned to one person. This person should have the authority to:

- Set up and convene an advisory board, consisting of personnel from Mechanical Management, Materials Management, Purchasing, and Data Processing.

- Obtain from Data Processing preliminary background about the current computer system's capabilities and software requirements for easy interface with existing software.

- Audit present maintenance practices and paperwork requirements (and project future plans) regarding work

THE SECRET BEHIND THE COBRA MANUFACTURING PROCESS IS THE WORLD'S MOST REMARKABLE MACHINE.



What makes COBRA® Brake Shoes last longer? Is it that COBRA Brake Shoes are derived from special formulations and mixing processes? Is it the exacting quality control measures taken throughout each phase of the process? Or could it be the multi-million dollar



investments we've made to upgrade our operation? It's no big secret. It is all of the above. But most importantly, the driving force behind the industry's finest brake shoes is its most vital component—our people. Call a COBRA sales representative today and unlock the secret.

Railroad Friction Products Corporation
Post Office Box 1349 • Lenoir, NC 28352 • (919) 844-5349 • FAX (919) 844-3107
In Canada: Cobra Canada Inc. • 475 Seaman Street • Stoney Creek, Ontario L8E 2R2 • (416) 561-8700

orders, planning and scheduling, cost data, maintenance stores, preventive maintenance, documentation, communication, and feedback.

- Seek information on software and hardware from consultants in the electronic imaging industry.

Before each individual railroad decides whether electronic catalogs are a technology for it, the railroad industry should collectively decide whether this is a technology for us. Perhaps the North American railroads should establish a multi-firm committee to discuss details such as industry standards for hardware and software interfaces, industry standards for interface with existing electronic data interchange (EDI) systems, or even a shared data base. Creating and abiding by an industry standard cannot be stressed enough. Use of an industry standard will save money and allow for greater integration possibilities in the future.

Regardless of the database configuration, if an electronic catalog system is developed how are development costs going to be allocated between the OEM's, the computer consultants, and the end users? In addition to development costs, there will be continuous maintenance costs. How will the ongoing maintenance expenditures be allocated? What if railroad participation is not as high as originally projected; how are the development and maintenance costs now allocated? Is the increased cost passed along to those railroads who use the system, thereby driving up their own costs and driving total usage down even further?

Imagine how much more thorough, or perhaps more complex, electronic catalogs would be if all North American image workstations tapped into a central data base! This data base could contain information on every locomotive running today; including those manufactured by GM, GE, and hybrids created by the rebuild market. When a manufacturer made a parts change the system could be updated and all users would have new information instantaneously. However, there are cost trade-offs with a shared system. How do you charge users for access? By the minute? By the number of access terminals? By the number sign-on id's? By the number of inquiries? To whom do the railroads pay to maintain the shared data base? Do the railroads pay the OEM's? An outside software consultant?

But what one gains in information access, one gives up in customization. How does the railroad industry address the needs of each railroad to customize the system to its own specific liking? Can customization be accomplished at any level with a shared data base? Is a customized data screen more important than reduced cost or access to up-to-date information? If a railroad chooses to develop an individual system what role do the OEM's play, if any, in the development process? If a road develops an individualized system what, if any, costs are borne by the OEM's?

1 *Plant Engineering*. July 18, 1992. pg 218.

FILTERS CAN BE ONE BIG PAIN IN THE CABOOSE.

When you're trying to keep a railroad up and running smoothly, dealing with filters can be a real nuisance.

CLARK FILTER's *Extra Mile Possession Cycle Services* were designed to save you time, money and headaches by helping with all your transportation, receiving, inventory, handling and disposal needs. Here's how:

- **Just-In-Time/On-Time Delivery** eliminates interruptions to scheduled maintenance and reduces inventory costs.
- **Filter Kits** combine the proper lube, fuel and air filters to expedite complete changeouts.
- **Multi-Vendor Single Truckload Deliveries** provide single-source ordering, receiving, billing and payment for all your filtration needs.
- **EarthGuard Recycling** demonstrates ways to reduce disposal problems.

For more information about CLARK's money-saving Extra Mile Possession Cycle Services, call **1-800-55-CLARK**.

You'll have one less pain to worry about.



CLARK FILTER

a member of the CLARCOR filtration products group

3649 Hempland Road, Lancaster, PA 17601 • Phone: (717) 285-5941 • FAX: (717) 285-3039

**REPORT OF THE COMMITTEE
ON DIESEL MECHANICAL MAINTENANCE**

**TUESDAY, SEPTEMBER 14, 1993
10:30 A.M.**

**Pre-Convention
Presentation
Norfolk Southern**



**April 21, 1993
Radisson Patrick Henry
Roanoke, VA**

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

Vice Chairman
T. H. VOLKMAN
Shop Manager
C&NW Transp.
Marshalltown, IA

COMMITTEE MEMBERS

D. Anderson	Mgr-Mech. Engr.	Morrison Knudsen	Boise, ID
J. Baranko	Shop Supt.	Conrail	Altoona, PA
F. Cowan	Asst. Mgr-Assy. Shop	Norfolk Southern	Chattanooga, TN
C. Dathan	Sr. Spec.-Maint. Dev.	Via Rail	Montreal, PQ
M. Dinius	Chief Mech. Officer	Montana Rail Link	Missoula, MT
J. Fisk	Supt. Locomotives	Wisconsin Central	Stevens Pt., WI
R. Gates	Gen. Equip. Forman	AT&SF Rwy. Co.	Kansas City, KS
W. Hobart	Director-A.C. Tech.	Burlington Northern	Ft. Worth, TX
J. Holley	Mgr-Opns & Data Control	CSX Transportation	Jacksonville, FL
K. Mahalik	Mgr-North American Field Svc.	Electro-Motive	La Grange, IL
A. Mallette	Facility Manager	Amtrak	Los Angeles, CA
P. Millar	Nat. Accts. Mgr.	Caterpillar	Mossville, IL
L. Olson	Mgr-Energy R&D	Burlington Northern	Overland Park, KS
F. Pantel	Asst. Supt. Engrg. Maint-MP	Canadian National	Winnipeg, MB
B. Sweeley	Mgr-Int. Locos	General Electric	Erie, PA

PERSONAL HISTORY

Eugene L. Oviatt

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

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

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

He left the Burlington Northern in

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

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

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



D.W. MAYBERRY

Vice President-Mechanical
Norfolk Southern Corporation
Roanoke, VA

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

Our Diesel Mechanical Maintenance 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.

H

**WE OWN THE BEST NAMES
IN THE
DIESEL FUEL INJECTION INDUSTRY**



FUEL SYSTEMS



FORMERLY AMERICAN BOSCH



FUEL INJECTION SYSTEMS



New fuel injection systems & component parts for ALCO®, EMD® & GE® Locomotives

- Factory Rebuild Unit Exchange Program
- Complete In-house Engineering and R & D Facilities
- EDI (Rail Link) Telecommunications
- JIT "Just in Time" Delivery Programs
- Made in the USA

H

HAYNES Corporation

3581 Mercantile Avenue • P.O. Box 7547 • Naples, Florida 33941
(813) 643-3013 • FAX (813) 643-5311 • 1-800-299-0111

Member of:



*ALCO, EMD & GE are Registered Trademarks.
Haynes Corporation is not a part of or related
to these corporations.

I. ELECTRO-MOTIVE'S THREE-AXLE RADIAL STEERING TRUCK

Presented by: Keith Mahalik - EMD

A. Introduction

The standard locomotive truck because of its pedestal design, confines the axles to be held parallel to each other within the truck frame. Upon entry into a curve, the rigid positioning of the axles causes the wheelsets to develop what is referred to as an "angle of attack" (between the rail and the actual position of the wheel). This development of an angle of attack leads to the generation of a force, by the rail, against the flange of the outer wheel, known as the "wheel flange force". The results of this misalignment and its corresponding forces significantly impact the wheel and rail wear life for the railroads.

Over the years, many steering truck designs have been proposed to provide a means of reducing the angle of attack and the resulting wheel flange forces. Such designs have included both self-steering truck (axle yaw, or rotation, is not coupled to truck frame yaw) and forced steering trucks (axle and truck frame yaw are coupled). Since the goal of these designs is to align each of the axles within the trucks in a radial configuration in a curve, they are all categorized as radial truck designs. Electro-Motive has been actively pursuing the development of high traction self-steering radial trucks for heavy haul locomotives.

B. Design requirements

Now the question may be raised "What benefits would a radial steering truck offer for heavy haul loco-

tives?". The following list provides just a few of the advantages.

- Lower wheel and rail wear;
- Lower weight shift;
- Greater adhesion in curves;
- Reduced truck maintenance;
- Improved safety.

C. Design features

Figure 1 shows a schematic of the EMD radial truck designated "HTCR" (high traction, three-axle, radial). The two outer axles are provided with a yaw degree of freedom through a pair of steering beams which are pivoted to the truck frame. The steering beams are coupled in a counter-yaw configuration, through an inter-axle link, to facilitate the negotiation of curving. Axle traction rods are used as the transmission paths for both the steering and tractive forces developed by the wheelsets. The center axle is allowed to move laterally but does not steer separately from the truck frame.

The locomotive body is supported directly on four rubber compression springs per truck - the truck bolster, used in conventional trucks, has been eliminated! Low weight shift between axles within a truck under adhesion can be expected due to the stiff properties of the rubber springs and the relative positioning of the traction motor nose reaction points. Excellent ride quality can be expected due to the relatively soft primary coil springs suspension and the incorporation of vertical and yaw damping.

D. Periodic maintenance

Special detail has been given to make this truck design a low maintenance assembly. Friction and wear components normally found on con-

ventional rigid trucks have been virtually eliminated. These include: pedestal liners (replaced by traction rods), bolster chafing plates, and traction motor nose pack wear plates (replaced by traction motor nose links). By eliminating these high maintenance items from the truck design, truck overhaul intervals will be greatly increased.

The only components that require periodic replacement are the hydraulic dampers. Replacement intervals of the hydraulic dampers are similar to that of conventional trucks. EMD recommends checking vertical dampers at 250,000 miles and replacement at 500,000 miles. Yaw dampers are expected to operate between 500,000 and 750,000 miles before requiring a rebuild.

The AC or DC traction motors installed in the radial truck are also designed for reduced maintenance intervals. Roller support bearings and oil filled gearcases are standard equipment.

Standard wheel truing equipment and most standard drop tables (those having fully adjustable support arms to reach all underframe jacking pad locations) will service the radial truck. The truck's weight is similar to that of a standard HTC.

If field replacement of a traction motor combination is required, a Timken bearing idler is required. In the event of a derailment, rerailing is often simpler due to the self-centering nature of the truck. If rerailing is required on curves greater than three degrees, porta-powers are required in order to maneuver the truck frame into position.

E. Test program

1. Test Site Description

The field performance testing of the HTCR truck was performed in three phases: (1) initial shakedown and evaluation of stability performance on the

Burlington Northern Railroad near Somonauk, Illinois; (2) extensive service-worthiness and adhesion testing at the AAR Transportation Test Center (TTC) in Pueblo, Colorado; and (3) subsequent adhesion and rail lubrication testing on the Union Pacific Railroad in Reno, Nevada.

2. Test Consist Description

The test consist was comprised of one EMD SD60 test locomotive, which was modified at La Grange to include a pair of three axle radial steering trucks, an engineering test and instrumentation car, three dynamic braking locomotives, and a Union Pacific SD60 locomotive. The three dynamic braking units served to simulate heavy drag operation without the need for a large trailing load. The Union Pacific SD60, with current production HTC trucks, was used for adhesion testing comparison with the EMD test locomotive.

3. Test Overview

The following phases of performance evaluation were undertaken during the 1990 field test:

- Stability
- Ride quality
- Steady state curving
- Service worthiness
- Adhesion in curves
- Rail lubrication compatibility.

In heavy drag applications, such as coal service, locomotive speeds may not exceed 45 or 50 mph. At these speeds, lateral stability or hunting thresholds generally are of little or no concern. However, as the speeds increase towards 60-70 mph, speeds typically found in piggyback freight operation, the requirement for having a "stable" operating locomotive becomes essential. Hunting can, if not addressed, cause crew ride

discomfort and lead to premature wear of truck components.

The HTCR radial steering truck has been designed to operate without instability up to 70 mph with fully worn wheels. Tests run at the Transportation Test Center (TTC), with modified AARIB wheel profiles, demonstrated fully stable operation in excess of 77 mph (+10%) under a wide range of track conditions including switches, crossings, and gauge variations.

Since most all of the friction interfaces commonly found on three axle conventional trucks (pedestal liners, bolster chafing plates, etc.) have been eliminated on the radial truck, much of the truck's inherent friction damping has been removed. To counter this, highly reliable, hydraulic yaw dampers have been designed into the radial truck to provide the necessary damping to maintain stability.

4. Ride Quality

One area of performance criteria that has been receiving a great deal of attention lately has been locomotive ride quality. As the railroads seek to improve productivity through the reduction of crew sizes and the lengthening of crew runs, the issue of "crew comfort" has become important. The expectation of the ride performance of locomotives has risen to new levels.

To address this issue, the HTCR radial steering truck has been designed to provide superior ride performance compared to the HTC truck. The four rubber secondary springs between the truck frame and carbody help to isolate the crew from various track inputs. Additional vertical shock absorbers have been added to the primary suspension to provide enhanced vertical damping. Primary and secondary yaw dampers have been added to improve the lateral ride quality of the locomotive.

The net result is a better riding locomotive compared to a conventional SD60 locomotive equipped with standard HTC trucks. Comparative tests between EMD3 and a conventional SD60, equipped with HTC trucks, showed peak lateral accelerations were reduced by 50 percent at speeds of approximately 70 mph.

5. Steady-state Curving

Much of the initial three-axle radial steering truck test program centered around comparisons of curving performance of conventional vs. radial steering trucks. The term flange wear index is used to compare wheel flange wear performance. Flange wear index is the angle of attack multiplied by the resulting flange force. This index was chosen as a simple wear performance between various truck designs for similar curving conditions.

Figures 2 and 3 summarize the curving performance of the HTCR radial truck vs. the conventional HTC truck. During power operation in a 10 degree curve, the flange wear index can be reduced by 33 to 67 percent depending upon the adhesion level. Depending upon the size of the curve, the flange wear index can be reduced as much as 67 percent during coasting conditions. Dynamic brake performance, although not directly measured, is expected to have improvements similar to that measured in power. These data have been used to project at least a 20 percent reduction in flange wear.

6. Service Worthiness

During the past several years, a large amount of effort has been expended by the AAR to define test criteria for the evaluation of the service-worthiness of new freight car designs. The results of this effort are contained in the Chapter XI criteria of the AAR Manual of

Standards and Recommended Practices, Specifications M-1001. Any new freight car vehicle design must satisfactorily pass each criteria listed in order to be considered for service.

Since locomotives and freight cars generally travel over the same types of track conditions, and since the HTRC radial steering truck is considered a "new" design, it was decided to test EMD3 against the same Chapter XI criteria.

The following test phases were selected to evaluate compliance:

- Lateral stability (hunting);
- Constant curving;
- Spiral negotiation;
- Twist & roll;
- Pitch & bounce;
- Yaw & sway.

In all phases of the test regime, EMD3, equipped with the HTRC radial steering trucks, met every established service-worthiness criteria.

7. Adhesion Performance in Curves

One of the most significant performance enhancements that EMD's radial truck offers is in the area of adhesion performance in curves. It is a proven phenomenon that conventional rigid locomotive trucks, while negotiating a curve, lose a portion of their adhesion capability when compared to tangent track operation. This is caused by the angle of attack which develops while entering the curve and remains throughout the traversing of the curve. Under any adhesion conditions, there exists a relationship between the lateral and longitudinal creep components of the wheel/rail contact patch. As lateral creep is increased with greater angles of attack, less longitudinal creep is available to "pull" the train through the curve. Thus, the adhesion capability is

reduced for rigid trucks negotiating a curve.

The radial steering locomotive truck, however, by lowering the angle of attack which the wheels experience during curving, reduces the lateral creep component of the wheel/rail contact patch. Thus, the longitudinal creep component becomes greater, resulting in improved adhesion capability in curves.

Extensive adhesion tests run at both the TTC and on the Reno branch of the Union Pacific, showed a 6 percent gain in obtainable adhesion with the HTRC radial steering truck as compared to the conventional HTC rigid truck.

8. Rail Lubrication Compatibility

Over the years, there has been a great amount of emphasis placed on the use of rail lubrication as a means of reducing wheel/rail wear and lowering rolling resistance, thereby improving the fuel consumption of train consist. Virtually every major railroad in existence today operates some form of rail lubrication, whether it be track or vehicle mounted.

For the radial steering HTRC truck to be accepted, it was recognized that it would have to be compatible with these configurations of rail lubrication systems. Performance tests were run with both a mechanical wayside lubricator and a locomotive-mounted Kipp lubrication system on the Union Pacific Reno branch. No unsafe behavior or performance degradation was noted for normal operating conditions. However, once excessive top of rail contamination with lubricant was applied, the steering of the truck was inhibited, but the lateral forces were still limited to very low values.

9. Reliability and Durability

In the area of reliability and durabili-

ty, the requirements that have been established for the design are as follows:

The truck assembly shall have a mean time between unscheduled shoppings of 120 months, and the truck shall run at least one million miles between major overhauls.

Thus far, extensive static and fatigue structural tests have been completed on the truck frame and various steering components. All components have met EMD's yield and fatigue requirements based on this testing. The first phase of reliability growth fatigue testing, with the use of hydraulic actuators, has been completed.

At the time of this writing, EMD3 has completed six months of performance testing, has undergone a tear-down inspection, and has subsequently experienced 26 months of revenue service. It is currently in revenue service on the Burlington Northern. The SD60MAC's, which have been built with radial steering trucks, are currently operating on the Burlington

Northern in revenue service with outstanding tractive effort performance.

F. Conclusion

As we look to the future of the railway industry, radial steering trucks for locomotives have arrived on the scene to meet the new challenges and demands which the railroads face in their competitive markets. With a greater emphasis being placed on improved performance at lower operating costs, the railroads are seeking products which will allow them to achieve not only greater productivity but also greater profitability. Electro-Motive's HTRC truck, which is basic on all 70 Series locomotives, significantly improves locomotive performance by improving adhesion potential in curves. Reduced wheel/rail wear performance and lower truck maintenance costs result in lower overall operating costs for the railroads. Radial steering trucks for locomotive truly do provide "more performance for less overall operating cost".



SINCE 1947
 Manufacturers of NEW Parts
 and UNIT INJECTORS for the
 ELECTROMOTIVE, BENDIX,
 BRYCE & DETROIT DIESEL
 ENGINES.

*Remanufactured Exchange
 INJECTORS and PARTS
 also Available.*



Interstate Diesel
 4901 Lakeside Avenue
 Cleveland, Ohio 44114
 (216) 881-0015 Telex 212579
 Toll Free 1-800-321-4234 FAX: (216) 881-0805

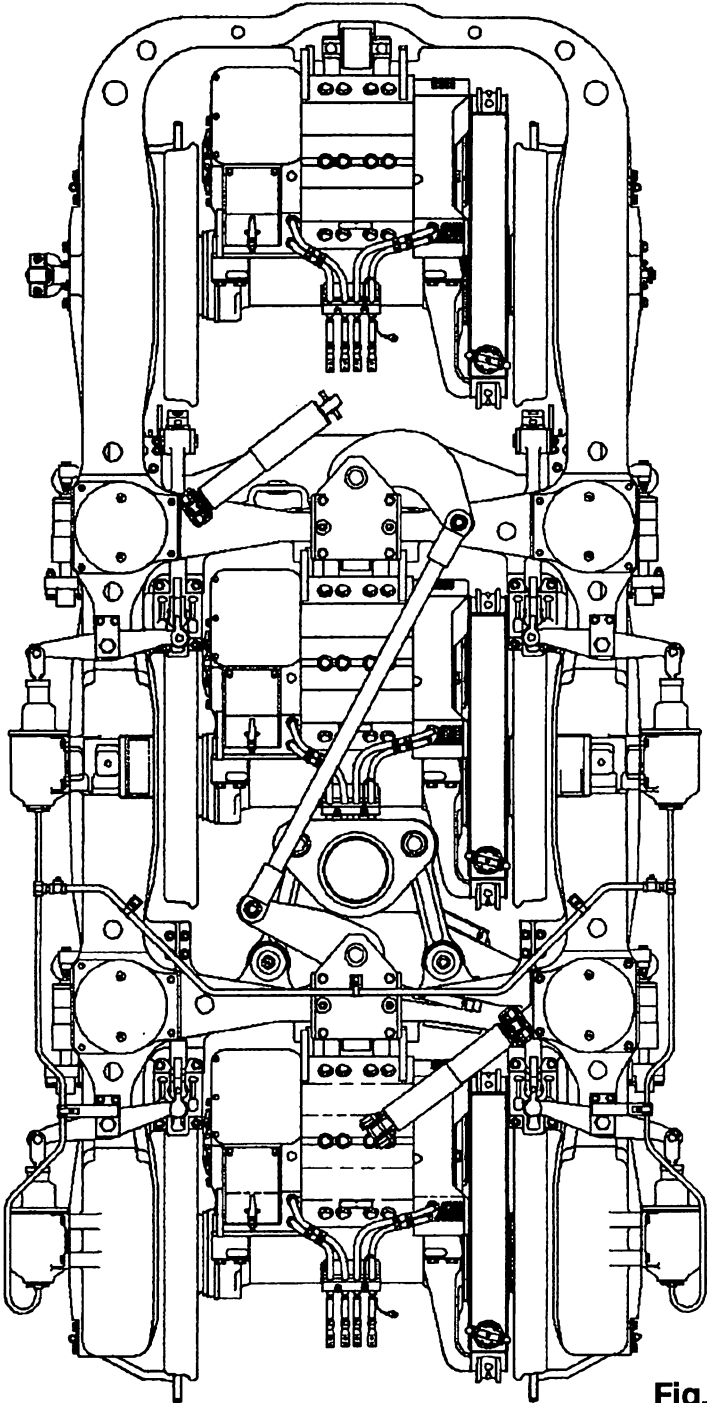


Fig. 1

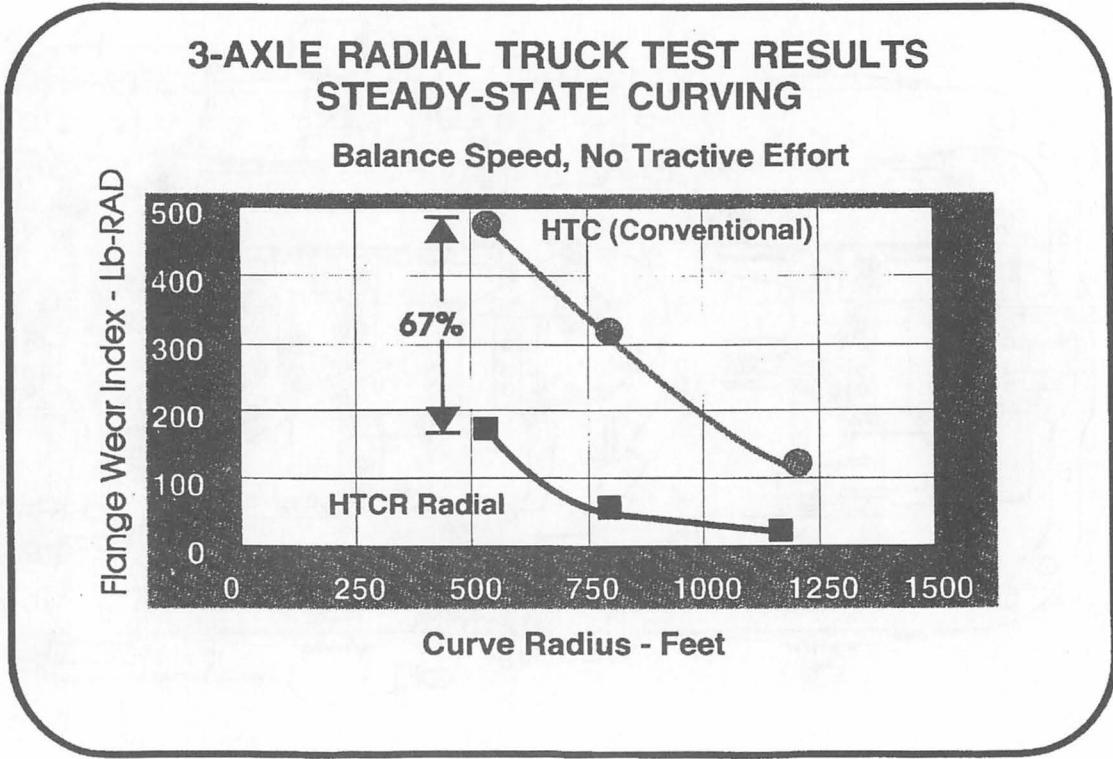


Fig. 2

3-AXLE RADIAL TRUCK TEST RESULTS

STEADY-STATE CURVING

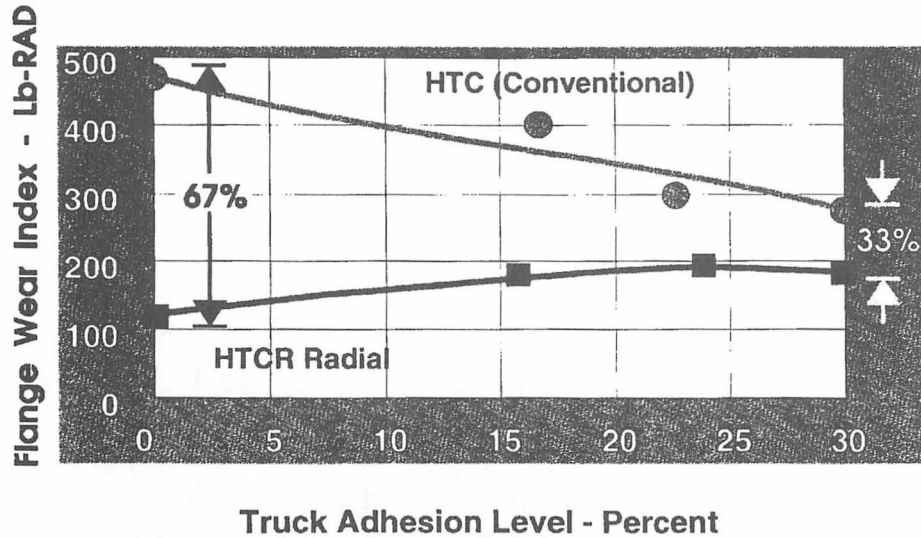


Fig. 3

II. THE NATURAL GAS LOCOMOTIVE AT BURLINGTON NORTHERN RAILROAD

*Presented by: Leslie E. Olson
Burlington Northern RR*

Abstract

Burlington Northern Railroad set up its Research and Development Department in 1982. One of its first charges was to develop an alternative locomotive fuel that was safe, economical, with an abundant domestic supply, and as socially acceptable as diesel fuel to prepare for the Federal Emergency Domestic Transportation Fuels Rationing Plan. BN, along with others, investigated many alternative fuels. By the end of 1984, BN had decided that the only near term alternative fuel that satisfied all the criteria was natural gas. A standard locomotive diesel engine manufactured by the Electro-Motive Division of General Motors has been successfully converted to use natural gas as its primary fuel. In August 1987, BN and Air Products and Chemicals, Inc. (APCI) came to an agreement to develop natural gas-based alternative locomotive equipment, tender cars, and fueling stations. The development program successfully undertaken worked with technology developed by APCI and Burlington Northern, Inc.

This paper describes methane, the principal fuel component of natural gas. It also discusses the principal reasons for BN's pursuit of NG as a viable alternate fuel; the major hurdles and solutions during development of the system; the system operation; and the primary hardware and its care in the use of refrigerated liquid methane (RLM)TM as a locomotive fuel.

1. Introduction

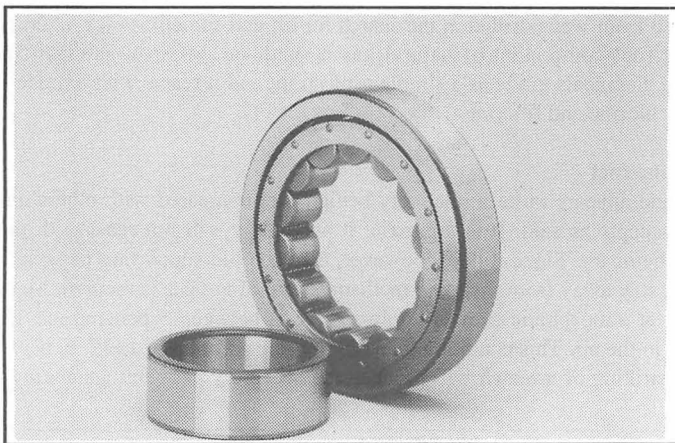
The development of natural gas as a locomotive fuel began in 1982 as a cooperative effort between Burlington Northern and several natural gas companies. Obviously, a gas company would gain a significant market if a railroad shifted its fuel usage from No. 2 diesel to natural gas. But why, in 1982, would a railroad be interested in switching fuels? Especially to a fuel perceived to be a greater hazard such as natural gas? Other alternatives must have been as available, cost effective, more convenient, and potentially safer than natural gas.

In 1981, BN obtained upper level management from outside the railroad industry. This new management recognized early that Burlington Northern Railroad had no contingency plan to ensure continued operation if the national transportation fuel rationing plan was instituted after another major oil embargo. The stated charge for BN's Research and Development Department was to develop an alternative fuel which was:

- abundant,
- domestically available,
- safe,
- less expensive than, or only slightly more expensive than No. 2 diesel, and
- cleaner burning.

Electricity, run-of-mine coal, and methanol were each considered as viable alternatives and then discarded. Electricity had the most attractive rate of return, but required a tremendous initial capital investment. Run-of-mine coal was set aside after the initial development costs and risks were evaluated. The third choice, methanol, was discarded when it became clear that, it was not an abundant fuel nor was it

Let Us Solve Your Bearing Problems



To best serve our customers, NTN devotes all resources to a single objective: production of the finest quality ball and roller bearings. All of our plants use advanced processing and high speed automated production equipment, engineered and built by NTN, to support our capacity for ultra-high quality bearings. Our Statistical Process Control programs ensure that during the production run, every bearing produced meets or exceeds AFBMA and ISO standards.

NTN's rigid quality standards originated with the company in 1918, and is the basis for every product innovation and corporate decision made today. Let us supply your traction motor bearings -- call NTN today!

1600 E. Bishop Court
Mt. Prospect, IL 60056

(800) 468-6528
(708) 297-2552 FAX

Meeting Your Concerns

NTN

NTN Bearing Corporation

less expensive than No. 2 diesel in the quantities required for railroad fuel usage. The remaining viable alternative fuel was natural gas.

2. Natural gas properties

What is natural gas? Natural gas is, as its name implies, natural. (See Figure 4.) It is pumped from wells drilled in the search for oil and sometimes for natural gas. The principal fuel component of natural gas is methane. Methane is classified in the industrial chemicals guide as a simple asphyxiant and it reacts with oxidizers such as oxygen, chlorine and fluorine.

3. Methane fuel

Methane appears to be a relatively benign fuel compared with others our society readily accepts as safe. It is nontoxic; it absolutely will not react with the human body's chemistry. Since it does, however, displace life-supporting oxygen, it is necessary to stay away from escaping methane gas until the gas is secured. Methane will not burn at atmospheric pressure unless there is between 5 percent and 15 percent methane in the air. This condition then requires the addition of 1325° F. heat.

The striking of a match will produce the necessary heat, but a smoking cigarette will not.

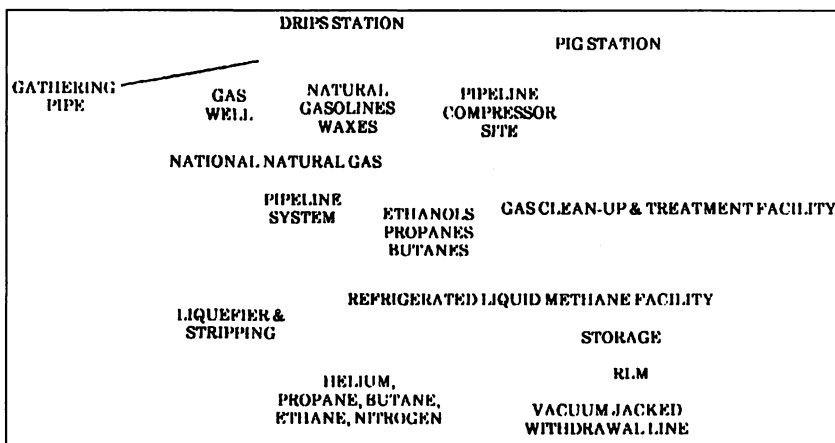


Figure 4. The path of natural gas from its source to the end user

The relative size of the methane molecule makes safety a major concern when using it as a mobile fuel. Methane is nature's smallest natural hydrocarbon. Figure 5 compares some commonly known molecular sizes with each other: hydrogen (H₂), helium (HE₂), methane (CH₄), pentane nature's smallest liquid hydrocarbon fuel, (C₅H_x); and decane (C₁₀H_{xx}), a liquid fuel close to diesel fuel.

The small size of the methane molecule presents the potential for fuel fitting leaks where other familiar liquid fuels are readily contained.

With this in mind, consider how leaks are encountered and corrected in diesel and oil line fittings. The correct wrench is applied by the machinist and given a snugging pull. Methane's very small molecular size allows it to go by the familiar mechanical

¹ Quarterly Review, 4:153, 1950.

seals and joints as if they were open valves. Unless care is taken in assembling and subsequent maintenance of all methane fuel line joints, leaks will occur. The generally accepted practice for methane fuel line joints is to use a welded joint, double-flared fittings for hard tubing, 36 degree flare fittings for flexible hoses and o-ring seals with double shut-offs for quick disconnect fittings. Traditionally acceptable, soft copper tubing lines and fittings must never be used for methane in mobile applications like a locomotive retrofit. Wherever practicable, avoid threaded pipe or joints. Additionally, certain materials are acceptable while others are not. For example, stainless steel pipe is appropriate wherever there may be pipe flexure in a dynamic mode. If solid pipe cannot be used, requiring flexible line, exercise care in selecting appropriate materials for the conditions prevalent in the environment of the line.

4. Gas Detection Systems

With this very basic information about the care required to contain methane, consider what safety concerns are necessary if the fuel inadvertently escapes. Major consideration should be given to keeping any non-welded joint from an enclosed space. When this is impractical due to operational considerations, exercise care where potentially leaking joints are installed in enclosed spaces. No non-welded joint should be located in an area that can feed air into an area with electrical arcing, an area which feeds combustion air to the engine, or especially in an area with air supply to the locomotive cab. With the exception of the cab, where no potentially leaking joint is allowable, any joint area with potential leaks requires a non-overridable combustible gas detection system

interlocked to the gas fuel supply control system. Combustible gas detectors need to be installed near the fuel system's entry to the long hood, over the methane fuel control equipment, and in the combustion air supply stream. It is particularly important to locate combustible gas detection near any rotating stem valves in the gas supply line in the long hood enclosure. Electronic combustible gas detection in the open air, outside an enclosure area, is extremely difficult under the best of conditions, and nearly impossible while moving a train at 50 mph.

BN has attempted to use mechanical methods (i.e., temperature change, electrical control signals, etc.) to determine if a leak is occurring. Because these systems are not 100 percent effective, we also use portable handheld combustible gas detectors whenever operating personnel are on the ground around this equipment. BN requires any operating personnel leaving the cab of a methane-fueled locomotive to carry a working, portable combustible gas detector. All methane-fueled locomotives in BN's fleet currently have, and any new additions will also have, two working detectors at all times. Fuel pits and inspection areas where TY&E personnel might encounter methane-fueled locomotives, also have two working detectors immediately available. All combustible gas detectors currently used on BN in conjunction with methane-fueled locomotives are of the ionization type and have minimum response time of 6 milliseconds.

5. Safety Training

When considering implementing methane alternative fueled locomotives, management's commitment to safety and safety training must be absolute. The training necessary to use

methane is significantly more involved than the training generally provided for other new technology or commodity shipments initiated by railroads. BN also provided extensive information sessions for non-BN personnel when implementing our testing program. In the past, emergency response and law enforcement personnel, city officials, news media and interested citizens were invited to attend scheduled information sessions about our proposed use of methane. BN shippers and consignees were asked to attend additional information sessions. BN train crews, and yard and shop forces were required to attend information and training sessions. These information sessions about safety have been critical for the public acceptance of this fuel.

The safety presentations contained practical information regarding the nature of methane (i.e., methane is lighter than air, so the gas rises rather than lies on the ground). Demonstrations of correct fuel-to-air ratio were presented, along with too-rich fuel situations that do not support combustion. We have shown large-scale field demonstrations of the flame-speed of a cryogenic methane spill as it might apply in a railroad environment. BN has a videotape containing the basic information about methane in both the gaseous and cryogenic phases, *The Fundamentals of Cryogenic Methane*. Ignition characteristics of methane are demonstrated in the video along with diesel fuel, in side-by-side comparisons showing the resulting fires from these fuels. Tracer fire from a high-powered weapon is demonstrated on these fuels as well.

After the audience learns about cryogenic and gaseous methane, additional information and training and a demonstration of the actual converted equipment and support equipment is necessary. BN has prepared audience-specific

video presentations. The general public is shown a general presentation that discusses the locomotive and tender car safety devices and presents some background on BN efforts to ensure a safe, reasonable and sound business decision.

Our prepared video presentation for emergency responders is significantly more detailed to prepare them for a train mishap involving methane-fueled equipment. The intent is to thoroughly familiarize emergency responders regarding specific and general characteristics of methane as BN understands them. BN guides emergency responders with directions to obtain specific information they might need if they respond to an emergency in the field. BN does supply MSDS sheets, equipment configuration and layout, physical familiarity, and directions to the actual location in official emergency response guides for liquid methane. We do not hesitate also to allow the general public to attend emergency responders' sessions if room is available. Our experience has shown an open discussion environment is achieved when emergency response sessions are limited to 18 attendees.

6. Locomotive Modifications

The application of the low pressure lean-burn gas conversion equipment to the typical 3,000 hp two-cycle locomotive engine requires properly trained personnel to ensure correct installation. The conversion equipment includes patented dual-fuel heads with electronically controlled and pneumatically actuated gas admission valves, a new, reverse Mexican hat combustion bowl dual-fuel piston, (Figure 6) and the patented electronic control system.

Significant wiring additions and modifications are also required. A gas piping and manifold system is installed

on the outside of the head deck frames. This system is clean and yet easily fits within the existing confines of the locomotive's long hood, allowing the doors to remain unmodified. The supplier has been aware of the need to make the system and its applications compatible and readily serviceable by railroad shop personnel. Included in the dual fuel kit supplied by the manufacturer is a gas control valve, a gas shut-off valve, and a gas measurement system; all are critical in the fuel supply piping system on-board the locomotive and located in the long hood.

A new electrical troubleshooting system is installed in the AC cabinet, which pinpoints gas supply problems from the tender up to the kit manufacturer's gas shut-off valve. The pilot fuel control system and the patented low emission idle (LEI) systems are both electrically controlled and pneumatically actuated. The standard overspeed and low oil pressure shut-down systems are also electrically monitored by the dual fuel system's ECU. All of these additional functions require new wire harnessing and air supply.

The water cooling system was modified for compatibility with the gas fuel requirements of the engine. New aftercoolers were installed on the engine. A new aftercooler radiator system was developed to supply additional heat exchange capability. The engine and all other heat exchange media use a 60:40 mix of ethylene glycol to water. This is necessary because of heat exchange carried on with the fuel supply from the tender. This supply is also controlled by the ECU. Three valves are located in the coolant system and return lines allowing system temperature control while operating in the dual-fuel mode. These valves, along with the necessary temperature sensors, also require additional electrical wiring and pneumatic plumbing for control.

The locomotive is equipped with electronic combustible-gas detectors strategically placed in the long hood to ensure detection and appropriate system response to gas leaks. A total of five detectors are in the system. The gas detectors on board the locomotives have proven to be both safe and reliable. The detectors will detect any amount of gas and air mixture. BN has set the detectors to warn of a leak at 20 percent of the lower flammability limit (LFL) in air and to lock the gas system fuel supply off if a 40 percent LFL is detected. In both cases, lights on the detector control panels indicate the level detected and which detector was activated. The gas detectors are inspected daily with the regular locomotive inspection and any detection is reported. If a detectable leak occurs, the locomotive will continue to operate on gas or diesel, as appropriate until it returns to its home shop for service. Additionally, the complete gas detection system is serviced and calibrated at every 92-day federally required locomotive inspections.

Because reliable detection of methane leak is a difficult problem when operating in the open air, BN uses various mechanical methods to detect possible leaks on board the tender car. These methods include wide and rapid pressure changes or temperature swings that relate to leaks. This approach focuses on detecting major or significant leaks from the tender. We have found this approach only minimally successful and we are continuing to review other possible approaches.

The locomotive will not operate in the dual fuel mode without a solid supply of adequate methane. We have elected to incorporate the use of a tender car containing enough fuel to supply two 3000 hp locomotives with fuel for a complete round trip from the coal mine to the coal customer and return to

the mine. Capacity is approximately 22,300 gallons of RLM_{TM}. The tender is designed to meet or exceed all of the requirements of a type 113 tank car. The principal variances between the type 113 car and the tender car are shown in Table 1.

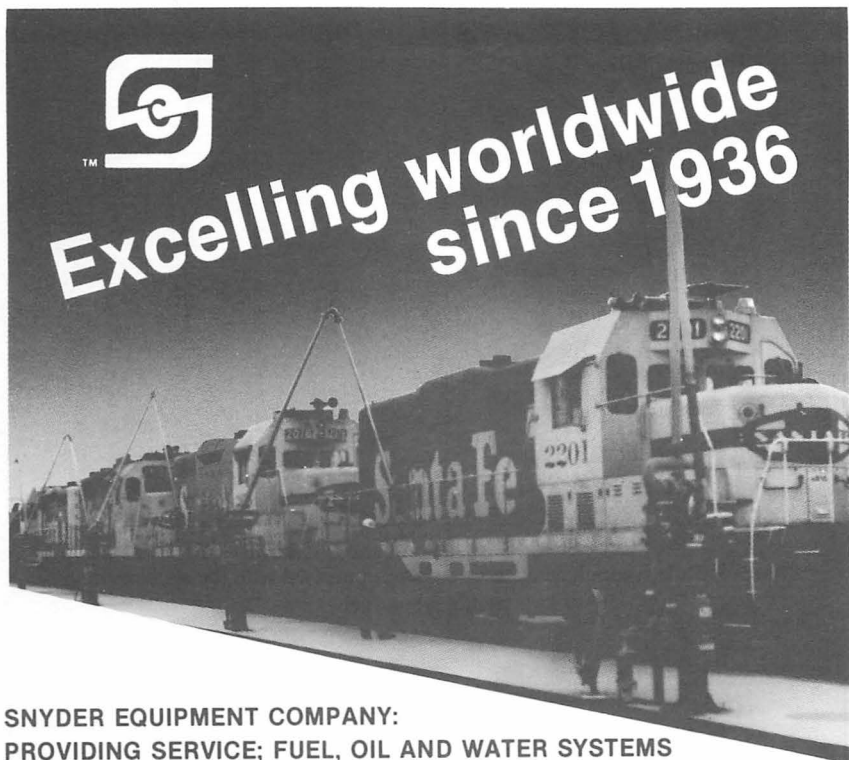
The fuel tender does have operating equipment on board for fuel delivery. Unlike the commercial tank car, however, we have endeavored to keep the tender operation as passive as safety considerations allow and still maintain operability. All active operation of the tender car is carried out with air. All operational valves are spring loaded closed valves. If air or electrical signals to the tender car are lost or interrupted, all valves will close to the full off position. If this occurs while the locomotives are operating on gas, they revert to straight diesel and train handling is not affected.

These units are serviced at BN's normal diesel fuel service tracks. In addition, Air Products operates an RLM fuel station for BN at Staples, Minnesota. The tender is fueled by a transloading operation at this facility. This facility is designed to transfill two tenders at each occurrence. The current transfill operation requires one hour and forty-five minutes from start to finish of the operation, providing there are no equipment failures during the opera-

tion. BN's operating personnel are pleased with the continuing safe and secure operation of this fuel station by Air Products.

7. Conclusion

Burlington Northern's efforts to develop an alternative fuel to maintain operational viability if another liquid fuel shortage occurs continue. We have taken a major step toward our goal in operating units BN7890, BN GT 101, and BN 7149 while working daily hauling coal and producing equivalent diesel locomotive horsepower. However, we are not yet able to make the call whether or not our development is a success. We continue to evaluate the developed technology and will not end our evaluation prior to June of 1994.



**SNYDER EQUIPMENT COMPANY:
PROVIDING SERVICE; FUEL, OIL AND WATER SYSTEMS
FOR THE RAILROAD INDUSTRY.**

- Fuel & Water Cranes
- Unloading Cranes
- Hose & Hose Reels
- Hose Reel Cabinets
- Hose Reel Columns
- Iron Hand Tool
- Fuel & Lube Oil Pumps
- Hand & Air Barrel Pumps
- Hi-Pressure Wash Pumps
- Sanitary Water Hydrants
- Meters, Valves, Fittings
- Diesel Water Couplings

Over half a century working with and supplying railroad industries has enhanced the knowledge and skills of Snyder Equipment Company's workforce to a degree that enables us to meet your requirements with dependable equipment and service.

To earn and keep your trust in our equipment, every innovation of the Snyder Equipment Company is subjected to extensive field-testing; assuring superior performance before it is offered to the railroad industry.

Snyder Equipment Company offers turn key installations and has established a comprehensive field-service network for your convenience.

 **SNYDER**
EQUIPMENT CO., INC.

PO BOX 381 NIXA MO 65714 USA

417-725-4067

WATTS: 1-800-641-4512 FAX: 417-725-4846

Put your trust in Snyder Equipment Company; established & reliable since 1936

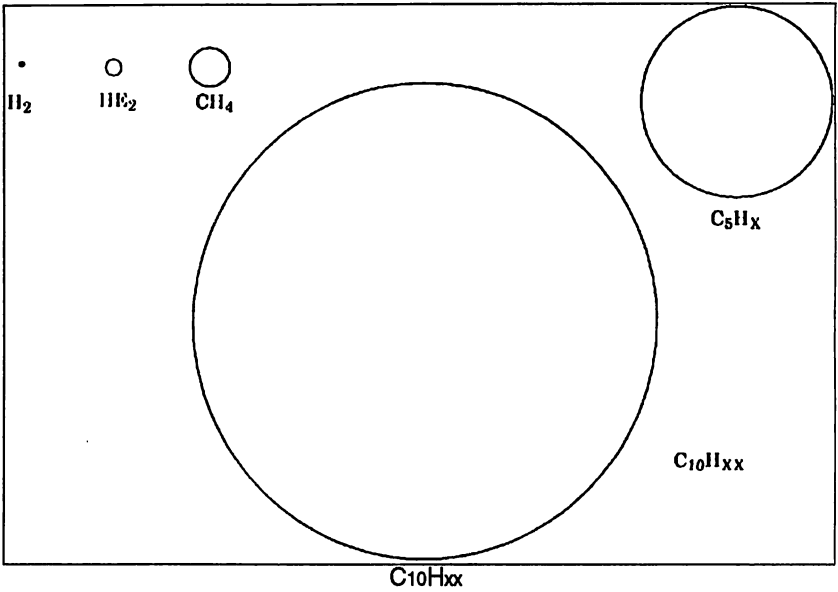


Figure 5. Relative molecular sizes of gases compared with the smallest liquid hydrocarbon fuel

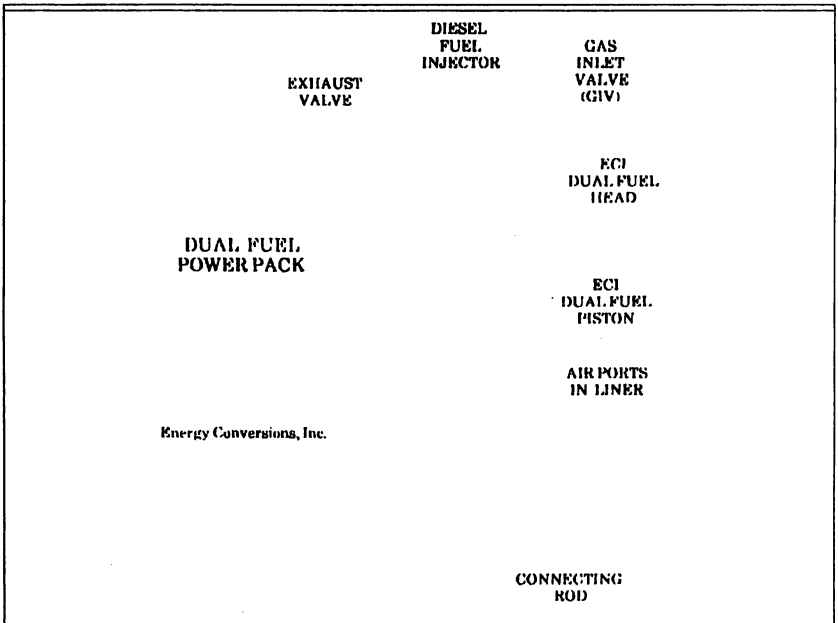


Figure 6. Engine hardware

CHARACTERISTIC	TYPE 113	BNGT
Maximum allowable working pressure (A)	30	185
Safety relief valve setting (B)	25	145
Delta pressure between A and B	5	40
Pressure relief regulator valve setting (C)	N. R.	125
Delta pressure between A and C	N. A.	60
Delta pressure between B and C	N. A.	20
Relief valve capacity – full flow	Allowable heat leak	Allowable heat leak
Allowable heat leak through insulation system (hold time)	30 days at operating pressure	10 days at operating pressure
Separation between integral head shield and inner vessel hemisphere	5"	25"
Inner vessel thickness	CFR	ASME
Outer shell	1/8"	1/2"
Sill design	Gen'ly Stub	Through
Truck	AAR Standard	Frame-braced
Coupler	Double Shelf	Double Shelf
Brakes	Train	Train
Insulation system	Fiberglass/ Vacuum	Perlite/ Vacuum

Table 1

III. LOCOMOTIVE WASTE OIL RETENTION

Presented by: J.R. Baranko - Conrail

U.S. and Canadian Railroads are now in the process of equipping their locomotive fleets with the means to capture lubricating oils and diesel fuel that might leak during operation. The U.S. Railroads are retrofitting existing locomotives and purchasing new locomotives with retention tanks in order to meet the Environmental Protection Agency regulations located in Federal Register, Code 40, Part 110 "Discharge of Oil". The definition of discharge of oil means any spilling, leaking, pumping, pouring, emitting, emptying or dumping.

This regulation covers the discharge of oil into all navigable waters including lakes, rivers, streams, mud flats, sand flats and wetlands. Therefore all oil discharged by the locomotive diesel engine and lube oil system must be captured or a means provided to prevent any oil discharges from contaminating waterways or soil that may eventually contaminate waterways.

Railroad interpretation and handling

Railroads began addressing the soil contamination issue by upgrading existing fueling stations and holding areas with concrete pads or track spill pans and purchasing new locomotives and retrofitting older locomotives with onboard waste oil tanks. Along with reducing soil contamination was the idea of promoting safety by the elimination of slippery and unsafe conditions and reducing the cost of removing and disposing of oily ballast.

Track spill pans

Service tracks and locomotive holding areas on many railroads are being upgraded, from ballast or sand areas with fueling stands that required the fueler to drag the fuel nozzle and hose to the locomotive, to more efficient and safe modern fueling areas. Adequate drainage with non-skid walking surfaces is the key to making the job as safe as possible.

Waste oil and spilled fuel are then piped to waste oil holding tanks or settling ponds, where the waste fuel and oil are separated from any water and sold to a recycler or disposed of in a safe, ecological acceptable manner.

On board locomotive retention tanks

Domestic locomotive builders have been equipping new locomotives with retention tanks, at the customer's request, since 1985. VIA and CN Rail, in Canada, have been equipping new or remanufactured locomotives with retention tanks since 1980. Most railroads specify that retention tanks that hold about 100 gallons of waste oil or fuel be built into the fuel tank on all new locomotives.

Many railroads are in the process of equipping older switch engines and road freight locomotives with retention tanks. Some retention tanks are mounted externally either attached to the outside of the fuel tank or on the locomotive underframe. Where room does not allow external mounting, other retention tanks are designated to mount inside the fuel tank.

In all cases, tanks are designed with an overflow mounted in the top of the tank, in case large oil or fuel leaks exceed the capacity of the retention tank.

In most retention tank designs,

RAILROAD SPECIALTY CHEMICALS

DIESEL COOLING WATER TREATMENT

- Powdered
- Powdered in Water Soluable Bags
- Liquid



CLEANERS

- Exterior of Locomotives
- Exterior of Cars
- Interior of Cars
- Spray Type
- Steam Type
- Tank Type
- Proceco Type
- Window
- Electrical
- Degreasers
- Other Specialty Items..

MANUFACTURING FACILITIES IN: Atlanta, Cincinnati, Cleveland, Dallas, Denver, Houston, Indianapolis, Los Angeles, Milwaukee, Omaha, Phoenix, Portland, St. Paul, Salt Lake City, San Jose, Seattle & Toledo.

PLEASE CONTACT: JIM SECRETARSKI

6910 Dorn Road
Hartland, WI 53029

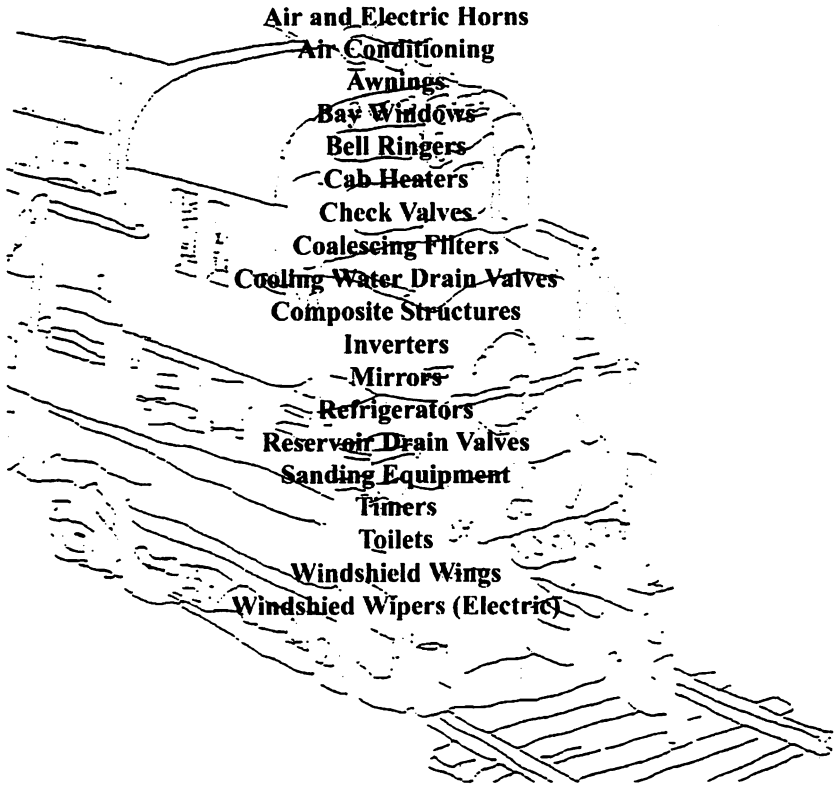
Phone: (414) 538-1616
Fax: (414) 538-1623

access doors are provided to allow cleaning of oil and other debris that is not expelled during draining and accumulates in the bottom of the tank. An easy-to-open drain valve is also required for easy attachment of a drain hose for spill-free emptying of the tank at scheduled maintenance intervals. A pump can also be used to reduce the draining time.

The configuration of the retention tank is limited only by the imagination of the designer, the room available on

board the locomotive, and as always, what the budget will allow. Approximate cost, material, fabrication, assembly and labor is around \$3,000 for some typical retention tanks.

For the safety of our employees and the preservation of the environment for our future and the future of our children, locomotive waste oil retention tanks are a means to prevent additional contamination of our soil and waterways.



**Making a more productive locomotive environment today
and tomorrow is our entire focus at . . .**

PRIME MANUFACTURING COPORATION

1-800-657-0707

IV. FRAGMENTED MAINTENANCE

Presented by: Jay Holley - CSX

Railroads and airlines have much in common, serving as common carrier mainstays in the fabric of the North American transportation network.

One characteristic common to both airlines and railroads today is that their respective fleets of motive power, airplanes in the case of air lines, and locomotives for the railroads, are extremely expensive machines that tie up huge amounts of capital.

It is imperative to the success of both airlines and railroads that their expensive motive power assets be used as productively and efficiently as possible.

One tool many airlines utilize to maximize asset utilization of their planes is a maintenance concept called fragmented maintenance. Under a fragmented maintenance system, an airliner receives all required minor maintenance and inspection between scheduled flights, in small "bites" as terminal time will allow. Fragmented maintenance is defined as the performance of inspections and maintenance a few work items at a time, and is conducted at the unit's work location between scheduled assignments.

The net effect of a fragmented maintenance system is virtual elimination of the detention time required by airliners for minor scheduled inspections and maintenance, and resultant improvement in asset utilization. One major railroad has studied and partially implemented fragmented maintenance on its locomotive fleet. This carrier has divided its fleet into 4 categories:

1. Dash 8's and SD60's - The newest power, equipped with on board micro-processors.

2. Dash 7's and Dash 2's.
3. Pre-Dash 2 EMD Road units and U-Boats.
4. Low horsepower units and slugs.

Category 1,2, and 3 units are used for manifest and coal hauling, compiling hundreds of miles per week. These units make regular visits to major shop locations as a normal pattern in their manifest and coal hauling travels, and are efficiently handled for routine maintenance and inspection by high volume spot maintenance lines, which minimize detention time.

The category 4 units, used for switching, way freight, and branch line operations, are a completely different story. These low horsepower units frequently work constantly at the same location, usually hundreds of miles from a maintenance shop, but only a few miles from a service facility where they come in about once a week for fuel and servicing.

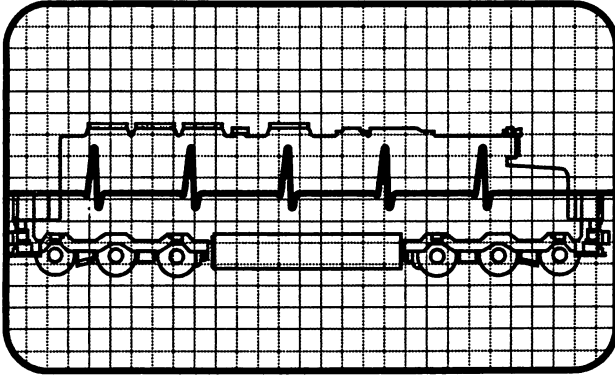
When a category 4 units had to be dispatched to a maintenance shop every 92 days, they were frequently gone for 5 to 6 days before arriving back on station after routine inspection and maintenance. A "spare" unit would be tied up for this time period while the regular unit was away from its work location.

The railroad implemented the fragmented maintenance concept on its category 4 units for several good reasons.

(1) The large maintenance shops would not have to devote their resources for routine, minor inspection and maintenance on this type of unit. The shops are now able to concentrate on enhancing the quality of the higher category units.

(2) Ownership. When the 5 to 10 yard engines at a servicing location are assigned to that location's employees

In Today's World...It Takes More Than Just Oiling A Squeaky Wheel.



It Takes An Affordable Locomotive Health Monitoring System.

TSM's new Locomotive Health Monitoring System lets you increase the availability of your locomotive fleet, while reducing your maintenance costs. Collecting and analyzing key locomotive health information enables you to:

- Detect problems before they become costly repairs;
- Accurately diagnose the root cause of problems;
- Efficiently perform the necessary repairs.

Maximum manpower utilization and locomotive availability are the result. And that translates directly into higher profits.

Whether you need an inexpensive active tag based system or a more capable data radio based system, call **(816) 891-6544** today for more details.



Technical Service and Marketing, Inc.

10765 Ambassador Drive, Kansas City, MO 64153
Phone (816) 891-6544 • Fax (816) 891-9329

for most maintenance, those employees build a sense of pride in the units they are maintaining and pride creates quality.

(3) Asset utilization and detention time. When the units receive most maintenance at or close to their actual work stations, these criteria are enhanced.

(4) The category 4 units have a relatively light duty cycle and require less intensive maintenance than road units.

The first step in implementation was to decide which would be assigned to what service centers for maintenance, after working with the Transportation department and analyzing work station patterns.

The second step was to enhance the annual maintenance the category 4 units received during their annual, and only, trip to a large maintenance shop. All brushes are renewed in all rotating electrical equipment, all air equipment is checked to be sure that the air portions will be good for one year, etc. Then the following three 92 day maintenances will be performed on-station on fragmented basis by the designated service center.

Fragmented maintenance starts with

a work report that is generated with all the work items that must be processed for the 92 day inspection and maintenance. Each time the locomotive arrives at the service center a few items are selected to be completed. This will allow all the work items to be finished by the end of the 92 day period. The locomotive can then be inspected for FRA defects, air gauges tested, and when all FRA requirements are met the blue card can be signed.

The locomotive can be dispatched and when it returns in a few days the process starts all over again for the next 92 day maintenance cycle.

At the end of one year, the unit is sent back to a large maintenance shop for a heavy annual maintenance.

The carrier has a file on each unit that is assigned at a particular service center. When the unit comes in for servicing, its file is removed and various work items are signed off. At the end of the 92 day cycle that work report is then filed as per FRA requirements.

Strategic application of the fragmented maintenance concept has helped this carrier improve its asset utilization and minimize detention time related to locomotive maintenance. Could fragmented maintenance be used as a tool in the success of *your* railroad?

REPORT OF THE COMMITTEE ON DIESEL ELECTRICAL MAINTENANCE

WEDNESDAY, SEPTEMBER 15, 1993

9:00 A.M.

Pre-Convention
Presentation
Southern &
Southwestern Rwy.
Club



April 16, 1993
Holiday Inn
Center City
Philadelphia, PA

T. J. VASQUEZ, Chairman
Asst. Mgr-Test Opns.
AAR-TTC
Pueblo, CO

Vice Chairman
JOHN NIXON
Equipment Foreman
AT&SF
Kansas City, KS

COMMITTEE MEMBERS

N. Anderson	Mgr-Elect. Engrg.	Morrison Knudsen	Boise, ID
R. Blanchard	Mgr-Loco. Maint.	Conrail	Conway, PA
J. Chessario	Prod-Analyst-Loco Control	General Electric	Erie, PA
R. Gill	Mechanical Engr.	US DOT	Cambridge, MA
B. Hathaway	Gen. Mech. Foreman	Florida East Coast	New Smyrna Bch, FL
R. Labold	Loco. Elect. Engr.	CSX Transportation	Jacksonville, FL
T. Leary	Mgr-Loco. Prog, Stds & Procedures	Union Pacific	Omaha, NE
D. Gezon	Retired	CN-North American	Battle Creek, MI
G. Parsons	Mgr-Mech. Training	Burlington Northern	Overland Park, KS
M. Pasini	Sr. Spec. Elect-MP	Via Rail	Montreal, PQ
J. Popp	Mgr-Quality Control	Amtrak	Wilmington, DE
D. Smith	Mechanical Foreman	Montana Rail Link	Arvada, CO
D. Thomas	Supt.-M.P. Passenger	C&NW Transp.	Chicago, IL
L. White	Tech. Officer-Elect.	Canadian National	Montreal, PQ
C. Wilkerson, Jr.	Asst. Mgr. Mech-Maint.	Norfolk Southern	Roanoke, VA
J. Youngwirth	Sr. ServiceTech. Engr.	Electro-Motive Boise, ID	La Grange, IL

PERSONAL HISTORY

T. Jake Vasquez

Jake was born on June 21, 1949, in Paola, Kansas. He has a degree in Associate of Arts in Pre-Business which he received from Kansas City, Kansas Community College. Jake additionally attended Kansas University.

He started his railroad career at the Santa Fe Railroad in June 1970 as an electrical apprentice at Argentine, Kansas. In addition to his employment with the Santa Fe he has held various

jobs on three shortline/regional railroads. While on these railroads he has handled a variety of duties to include Chief Mechanical Officer, Manager of Locomotive Operations, Supervisor, Traction Motor Shop, etc.

Jake is currently Assistant Manager Test Opns. of the AAR/Transportation Test Center in Pueblo, Colorado.

He is married with two children.

THE SOUTHERN AND SOUTHWESTERN RAILWAY ASSN.

717 Pinecliffe Drive
Chesapeake, Virginia 23320

PURPOSE

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

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

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

I. AUTOMATIC ENGINE SHUTDOWN AND RESTART SYSTEM

By: *Mauro Pasini, VIA Rail, Canada*

This is a fuel saving device that has come into the market very recently. Again, the use of microprocessor based electronics has made such system technically and economically possible.

Its purpose is to save energy and, at the same time, to reduce pollution by eliminating unnecessary engine idling during locomotive parking. This is particularly true for switcher locomotives where estimates indicate parking in idle of 75 to 90 percent of the time. For road locomotives the idle time factor is considered to be between 50 and 75 percent. Table 1 gives an indication of the savings that can be achieved when idling times are reduced. These results are valid for a locomotive availability of 95 percent, idle fuel rate consumption of four gallons per hour and fuel cost of \$0.75 per gallon.

Of course, manual shutdown of parked units by the operating crews would result in equivalent savings. In reality, bad habits are difficult to overcome and a consistent shut down policy is very difficult to enforce. Moreover, in marginal weather conditions, i.e. low ambient temperature, it would be practically impossible.

The system consists of the following components:

1. The microprocessor controller which is housed in a sturdy enclosure of 12 x 15 in.
2. A sensor to measure outside ambient temperature.
3. A sensor to measure the engine coolant temperature.
4. A device to measure brake cylinder pressure.

5. A battery charging current measuring device.

6. A device to override the crankcase pressure/low water protection during the starting sequence of EMD locomotives.

The system is also provided with safety features such as audible and visual warning devices, dedicated circuit breaker for system enabling and disarming, and clearly recognizable warning labels to be placed in vital locations on the locomotive.

As with most of today's microprocessor based devices, the system has additional useful features. It is self diagnostic for self testing and troubleshooting guidance and provides data for compilation of operational and management reports to help optimize the efficient use of the system itself.

The information for the compilation of such reports is obtained through the downloading of the microprocessor memory with a laptop computer or with an optional hand held memory reader.

System Operation

For the system to operate safely for both the personnel and the equipment, the following conditions must be met for each operating mode:

1. System Enable

The system is enabled when

- The "Engine Autostart" breaker is ON
- The unit is in idle
- If unit is off, it was shut down by the system
- The reverser is centered
- PCR relay is picked up
- Batter switch has not been pulled
- System cranking attempts have not exceeded 5
- A prelube timeout has not occurred

(turbo).

2. Auto shutdown

- System is enabled and engine has been running for at least 10 min.
- Water temperature is above:
 - 155 deg F (CAT engines)
 - 120 deg F (EMD engines)
- Brake pressure is above 20 psi
- Battery voltage is above 72 volts
- Ambient temperature is above 32 deg F
- Battery charging is below 20 Amps.

3. Auto restart

- System is enabled
- Any one of the following occurs:
 - a) Water temperature is below:
 - 140 deg F (CAT engines)
 - 100 deg F (EMD engines)
 - b) Brake Pressure is below 18 psi
 - c) Battery voltage is below 64 volts
 - d) Ambient temperature is below 28 deg F
 - e) A directional signal is present.

This system will require some additional maintenance on the starting circuit and related equipment. Starting motors and contactors are the components that will necessitate particular attention together with the locomotive battery which will need to be in good condition at all times.

As with all new technological developments and related equipment, the LMOA feels that each potential user should test and evaluate the proposed equipment before the implementation on its locomotive fleet is initiated. Only actual in service experience is the final test for economy and reliability of any new available devices.

DC LEAKAGE TESTING EQUIPMENT

PORTABLE MODEL 5210



EXCELLENT FOR TROUBLE SHOOTING
 SELF CONTAINED - PORTABLE
 INTERNAL BATTERY POWERED
 WITH VOLTAGE & CURRENT METERS
 OUTPUT 1500 V DC at 5 ma

Complete Line of
**HIGH VOLTAGE TESTERS, AC OR DC
 MEGGERS, AC POWERED OR MANUAL
 TRACTION MOTOR TEST EQUIPMENT**

AUTOMATIC EQUIPMENT CO.

411 Business Center Drive - Suite 103

Mt. Prospect, Illinois 60056

Phone: (708) 298-1450

Fax: (708) 298-1456

AUTO START FUEL SAVINGS PROJECTION

EXPECTED AUTO START IDLE TIME REDUCTION

Idle as % of duty cycle	50%	60%	70%	80%	90%
90	\$11,235	\$13,482	\$15,729	\$17,976	\$20,222
80	\$ 9,987	\$11,984	\$13,981	\$15,978	\$17,976
70	\$ 8,738	\$10,486	\$12,233	\$13,981	\$15,729
60	\$ 7,490	\$ 8,988	\$10,486	\$11,984	\$13,482
50	\$ 6,242	\$ 7,490	\$ 8,738	\$ 9,987	\$11,235

Estimates assume 95% availability, idle fuel consumption of 4 G/h and cost of \$0.75/G

Table 1

II. LAYOVER SYSTEMS/ STANDBY POWER SYSTEMS

Presented by: John Nixon - AT&SF

A. Introduction

The price of fuel continues to be a major expense on all railroads. We are all constantly looking for ways to conserve fuel in an economically advantageous way. Isolating locomotives in trains when the power is not needed, more efficient locomotives, and locomotives shut-down when ambients permit are just a few of the ways railroads are conserving fuel.

The climate in which one operates determines how much fuel one can save by shutting locomotives down. The longer and harsher the winter, the less fuel one will save. Several manufacturers have developed products designed to increase the amount of fuel savings in those harsher climates. Studies by several railroads indicate such a system could produce an economic benefit for the railroad. One such product is manufactured by Kim Hotstart.

The following paper focuses on Kim Hotstart but the logic can be applied to any potential supplier in this area. The electrical committee is not recommending the purchase of any of these products, nor are we endorsing the product manufactured by Kim Hotstart. It is up to the individual railroads to determine if this product is viable for their operation.

B. Operational characteristics

In order to shut down a locomotive in a cold climate, one must keep the water and/or oil warm and the locomotive battery must be in good condition to allow one to restart the locomotive. This is the goal of any shutdown system. The system that performs this function must be reliable and inexpensive to operate.

The complete system consists of an on-board system and an off-board power supply of three phase 480 AC volts. The power supply is fixed and the locomotive must be parked in close proximity to the power supply. The on board equipment can be divided into four different systems. They are the locomotive cooling water system, the lube oil system, the locomotive battery charging, and alarm systems.

C. Engine cooling water system

The water system consists principally of a pump, pump motor, off-board power supply, heater element, flow indicator, control circuitry, and associated piping and wiring. The operation is as follows:

The power supply is plugged into the system on board the locomotive. A temperature sensor measures the temperature of the water and if it falls below a preset point, the pump is activated. The flow indicator senses the water movement and activates the control circuitry to allow current to pass through the heater element. The heater element stays on until the temperature sensor turns it off. The cycle is repeated until the system is deactivated.

D. Lube oil system

Same as the engine cooling water system.

E. Battery charging system

The three phase 480 volts AC is stepped down, rectified to DC and used to charge the locomotive batteries.

F. Sentry control system

This feature monitors the complete system to ensure it is working properly. The sentry system looks for faults such as:

Power supply failures

Flow fault (oil or water)
 Battery charger
 Heating system (low temperature)

Whenever a fault is detected, an audible alarm will sound. The system can also be set up to dial a phone to notify someone of the failure.

G. Locomotive requirements

The one feature that we feel is essential to ensure the locomotive is not damaged in the event of a failure is an automatic cooling water drain valve. This will prevent freeze damage if the system fails.

H. Labor support

Labor will be needed to connect and disconnect the Kim Hotstart to the locomotive. Annual and regular maintenance must also be performed to keep the system fully operational. One will also need to check on the system while it is in operation. There is a feature in the sentry control alarm system that will initiate a phone call in the event of a system failure, but it is not completely fool proof.

I. Seasonal checks (winterization)

1. Perform a complete operational check of the sentry control system:

- A. Apply power.
- B. Turn test switch on. This applies AC voltage to the circuit.
- C. Red LED should be on.
- D. Turn reset switch on. This applies battery voltage to circuit.
- E. System is now activated.
- F. Turn test switch off. The alarm signal is activated. Red LED will go off.
- G. Return test switch to on. Signal will stay on.
- H. Turn reset switch to off. Signal will stop.
- I. Return reset switch to on.

System is in sensing mode.

2. Electrical leakage test.

Electrical current passing through the coolant to ground can cause a premature engine failure (pitted liners, oil coolers, radiators, etc.) therefore this test is critical.

3. Flow detection switch test.

A. Shut off fluid supply to the heating system.

B. Remove the bonnet nut and lift out the entire switch assembly.

C. Clean the switch body of all sediment and material that may have accumulated during operation.

D. Check the switch for proper operation by sliding the shuttle magnet up over the main shaft. If movement of the shuttle is rough, or the shuttle hangs up, remove the lock ring from the bottom of the switch assembly and slide the shuttle magnet and spring off.

E. With a piece of emery cloth, clean the shaft of all foreign matter and rough spots.

F. Reassemble the switch assembly and test again for ease of movement of the shuttle magnet.

G. To ensure that the flow control switch is operating properly, energize the main power, when the shuttle magnet is slid up the shaft. The magnet contactor which operates the heating element should close. *Caution: Do not energize the heating system any longer than 5 seconds when testing the flow switch or damage to the heating element may result.*

4. Check the setting of the time delay relay to ensure it is set properly.

5. Activate the system and ensure all water and oil temperatures are within specifications. Also check the battery charger for proper operation if equipped. This should be done every time the system is activated.

Moran *Electric Service, Inc.*

1401 East 20th Street • P.O. Box 55594
Indianapolis, Indiana 46205
(317) 632-5551
Fax Number: (317) 632-6596
Toll Free Number: 1-800-382-9886

ACCOMMODATING THE RAILROAD INDUSTRY

REBUILDING

- **Main Generators**
- **Head End Power Generators**
- **Auxiliary Generators**
- **Gear Boxes**
- **Grid Fans**
- **Engine Cooling Fans**
- **Inertia Motors**

We offer a complete rewinding service and manufacture our own armature, field or stator coils, form or random style. We use only the highest quality of insulating materials available and our varnish treatment process includes vacuum impregnation. We offer you a total and complete machine shop service with high quality mechanical staff. We invite you to take a tour of our facility to inspect our capabilities and observe different repair operations that are in process.

J. Troubleshooting

What to look for when

1. Fluid is not delivered.
 - A. Power supply defective.
 - B. Control circuitry defective.
 - C. Suction leak.
 - D. Leaks.
 - E. Pump defective.
 - F. Relief valve setting too low.
 - G. Pump not primed
 - H. Pump motor defective.
2. Capacity is too low.
 - A. Suction leak.
 - B. Pump speed too low.
 - C. Strainer obstructed.
 - D. Pump defective.
 - E. Pump motor defective

F. Power supply problems.

3. Fluid is not maintained at proper temperature.
 - A. Power supply problems.
 - B. Control circuitry problems.
 - C. Thermostat control defective.
 - D. Heater element defective.

K. Conclusion

This type of system can save fuel, reduce overall noise emissions, and reduce overall exhaust emissions. The question becomes, is it economical for you to implement? That is a question only you can answer.

III. CN NORTH AMERICA ELECTRONIC TEMPERATURE CONTROL

*Presented by: Les White
CN North America*

In mid 1985 CN began working with suppliers to develop an electronic temperature control for locomotives and by early 1986 the first prototypes were installed. These early prototypes were a microprocessor control system with Euro card modules. The prototype units were quite large and required approximately a 24-hour installation time. At the end of the test period it was concluded that these units had the capability of being molded to many control functions, being a programmable device. This flexibility was appropriate for testing fan rotation etc; but the price, complexity and size did not justify it as a replacement for the existing temperature switches.

Although the original prototype panels proved to be unacceptable, much was learned through the testing process and it became evident that it would be beneficial to pursue the further development of electronic temperature control. To avoid some of the pitfalls experienced with the original prototypes it was decided to set up some guidelines for the development of a second generation panel. Some of the guidelines were:

- 1) Keep system design to a minimum.
- 2) Standardize on temperature settings.
- 3) Panel must be easy to install or remove.
- 4) Design in fail safe features.

Working closely with the supplier and following the four main guidelines, a panel was designed that met the criteria. While in the process of design it was decided to develop a functional specification that could be used to

develop alternates. We will step through some of the specifications and in doing so you will be able to see some of the fail safe features that are incorporated into the design. Once the fail safe features are understood, the trouble shooting on board the locomotive becomes straight forward. I should point out that the first set of specifications is written around a panel that uses discrete electronic components with no microprocessor. A micro based system allows for some additional features that I will cover with the addendum that was written for the micro.

Functional Specification

- 1) The main sensor controls the high idle, fan #1, fan #2, fan #3, HES, and ETS.
- 2) The backup sensor controls the ETS activation only. In this way either sensor can activate ETS.
- 3) In the event of a sensor open circuit, the ETS is activated.
- 4) In the event of a power failure, or electronic failure, the ETS and HES is activated.
- 5) A short circuit in the main sensor, (equivalent to high temperature) causes all fans to go on as well as ETS and HES.
- 6) A short in the backup sensor causes an ETS activation only.

In reviewing items 1-6 of the functional specifications we can see that the system utilizes two sensors, a main and a backup. The main reason for this is to ensure that if one of the sensors should drift the system will recognize the one reading the highest temperature. This is done to ensure that the engine is not operated at temperatures above normal. When trouble shooting, the key point to remember is that the main sensor controls all functions and the backup sensor controls ETS only. Should a unit arrive with all fans picked up, ETS and HES activated, this would indicate that the main sensor has shorted. If the

unit only showed ETS this would indicate the back-up sensor is defective. In the event the unit arrived with ETS and HES activated this would indicate there is a power failure either from the source or within the panel itself. The panel is also equipped with a series of test buttons that will check all outputs. Once the electrician becomes familiar with the system, trouble shooting time is cut to a minimum.

The sensors are fabricated with an internal thermistor that is detailed in our specification. This ensures us of a sensor that has a very tight interchangeability tolerance, and that any supplier's panel we use will work properly without having to change the sensors. The thermistor works on a resistance curve that can be used to check the condition of the probe vs temperature by using an ohmmeter. To check the accuracy of the panel we use a precision trimmer pot that can be dialed to the specific resistance value that matches a particular temperature. This method of testing has eliminated the old method of blocking the shutters and throttling up the engine to verify temperature settings.

Temperature settings

Sensor 1 control settings.

High idle	contacts closed	110 deg F
	contacts open	145 deg F
Fan #1	contacts closed	180 deg F
	contacts open	168 deg F
Fan #2	contacts closed	185 deg F
	contacts open	175 deg F
Fan #3	contacts closed	190 deg F
	contacts open	182 deg F
ETS	contacts closed	215 deg F
	contacts open	205 deg F
HES	contacts closed	223 deg F
	contacts open	210 deg F

Sensor 2 control settings.

ETS	contacts closed	215 deg F
	contacts open	205 deg F

In order to meet one of the main guidelines of standardized temperature settings it was decided to use the fan and ETS settings being used on our remanufactured GP-9 locomotives. These settings were selected for two reasons:

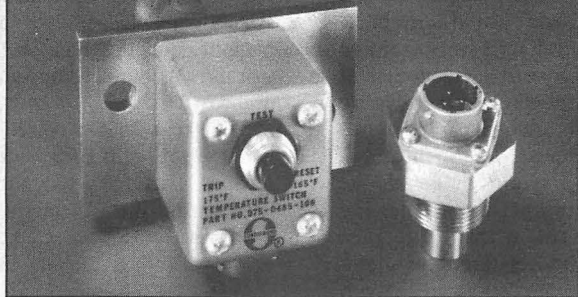
1) Standardization of temperature settings allows for one panel to be used on the majority of the fleet.

2) Tests conducted on a SD40-2 locomotive at our fuel test center and independent articles such as "Improved Fuel Economy Through Lubricant Technology in Medium Speed Railroad Diesel Engines, *Journal of the American Society of Lubrication Engineers*," indicated that by raising our operating temperatures an average of 6 deg F a fuel saving from a minimum of .1% to a maximum of 1% could be realized.

In addition to the normal fan and ETS settings we have added a high idle feature for cold weather conditions and and HES feature that will be used to return the unit to idle at 223 deg F. It was found that if a unit went into hot oil detection there was in most cases engine damage. i.e. head seals. With the ability to monitor water temperature accurately we could return the unit to idle at 223 deg F in an effort to reduce engine damage.

To meet the guideline of easy installation and removal, the logical location for mounting was on top of the AC cabinet. This however placed physical size limitations on panels. The diagram of the electronic temperature control panel shows size and physical location of plugs to facilitate an easy installation. The Fan 1,2,3, and ETS plug are mounted on the left side so that the existing cables can be disconnected from existing temperature switches and reconnected to the Dash 2 type connectors on the panel. The AUX connector on the right side has the high idle and

Precise Temperature Control.



Only Sundstrand Data Control's thermal switches offer these built-in features:

- ▶ Factory Calibration
- ▶ Shock and Vibration Resistance
- ▶ Mounting Flexibility
- ▶ Crisp Contact Action
- ▶ Insensitivity to Atmospheric Pressure Changes
- ▶ Stable Temperature Setpoint
- ▶ Rugged Welded Construction

These features, combined with more than 16 years of proven reliability in service, offer your locomotive improved performance and less downtime.

For more information, please contact the Instrument Systems Marketing Department at (206) 885-8010.

Sundstrand
Data
Control

SUNDSTRAND
AEROSPACE



REDMOND, WASHINGTON 98073 Sundstrand Corporation

HES connections. This can be wired in at installation or left for the main shop as it requires extra wiring. The mounting plate is shaped so that it can be easily welded to the top of the AC cabinet and at the same time allow for air flow under the panel. This panel must operate under high ambient conditions and the maximum amount of air flow around the panel will only help to retain the integrity of the electronics. It is recognized that when electronics are exposed to high ambient temperatures their life is reduced. To retain a high level of reliability on our panels we have introduced a policy of renewing the control board, if the panel goes defective and is over three years old. The three year policy will also apply to locomotives receiving a schedule repair.

As the acceptance of electronic temperature grew, some suppliers began to offer microprocessor controlled panels. This again raised issues of standardization and testing parameters for a microprocessor controlled system. In order to retain interchangeability and have a standard method of operation an addendum was added to our specification. Some of the key items added were:

- All micro systems must be equipped with a watch dog circuit or equivalent to ensure fail safe operation.
- Systems that offer fan sequencing as an option are to be arranged so that fan sequencing can be enabled by placing a jumper between pins A & C of the fan 2 output plug.
- Actual operating conditions will override test functions except for high idle. Due to the limited temperature range of this function this test will be allowed to operate up to 168 deg F. (fan #1 drop out). This is to allow for practical testing on shop track. Under actual operating conditions the high idle function will operate between 110 & 145 deg F.

Microprocessor panels are to be

equipped with a series of LED's or digital display or both, indicating functions and faults.

Operating enhancements for Microprocessor control

1) If either probe opens or shorts, the system will detect and display the fault. Note: If neither probe is faulty, the routine uses the higher temperature signal of the two.

2) Once a fault is detected, the system will operate ETS function for 5 seconds. This is due to latch hot engine function on the AN module (Dash 2 locomotives). On locomotives not equipped with a latching circuit the 5 seconds will allow sufficient time for the engineer to note the fault and report it on the defect form.

3) Once the 5 sec alarm has been given the system will revert to the operational probe and allow the locomotive to return to normal operation. The fault remains displayed on the temperature control panel.

4) If the remaining probe goes open or short, fail safe operation to occur as previously outlined for sensor 1 failure.

In the majority of cases when a locomotive equipped with electronic temperature control arrives with a hot engine problem the fault lies in the cooling fans, contactors or shutters. In order to keep testing sequence to a minimum time and allow for practical testing by one person our specification detailed two separate test sequences:

Test sequence #1 (fan 1,2,3 and ETS) Test LED solid on. Activated by a press and release of test button.

Test sequence #2 (HES and hi idle) Test LED flashing. Activated by pressing and holding test button for 3 seconds.

In conclusion, electronic temperature control can offer the railroads substantial improvements in reliability and savings in the areas of:

1) On line failures (34% reduction in hot engines since implementation of program in 1990).

2) Cooling fans (guaranteed differentials).

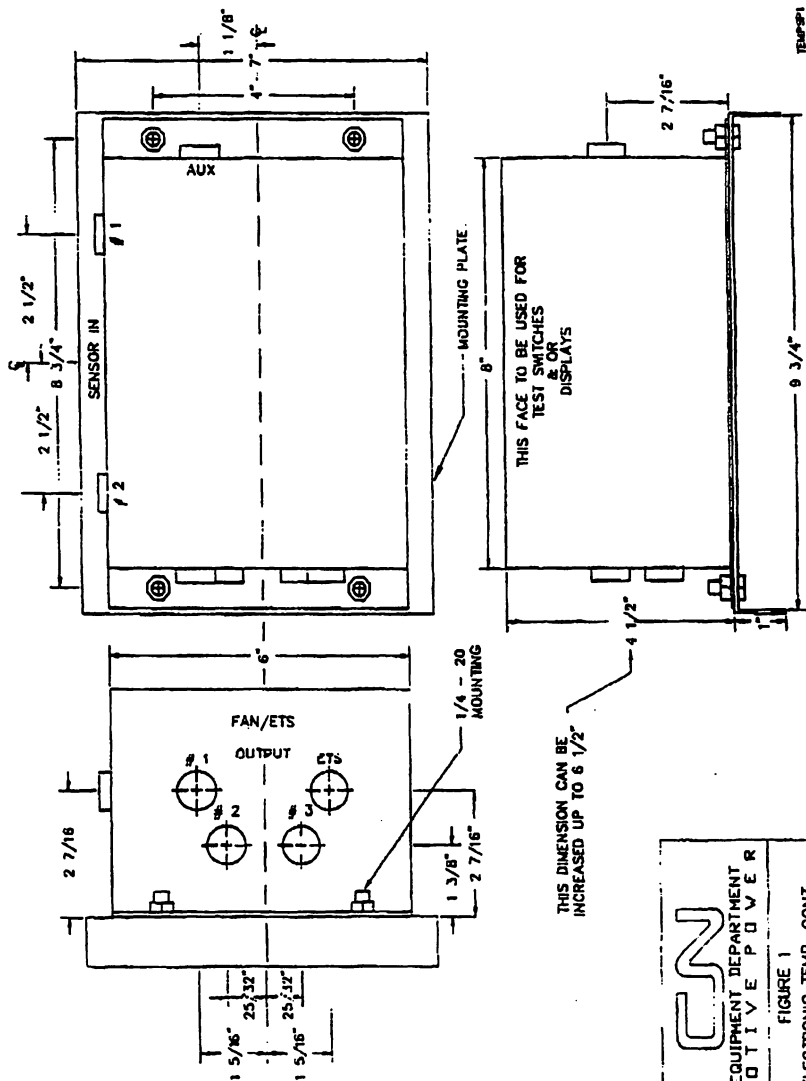
3) Temperature switch ch/outs.

4) Inventory (one panel fits all).

5) Fuel savings.

6) Test time greatly reduced.

It is evident that these panels can offer numerous advantages over the old temperature switches, but each railroad should evaluate all systems available and decide on which system best suits its needs and reliability requirements.



CAN
 EQUIPMENT DEPARTMENT
 MOTIVE POWER
 FIGURE 1
 ELECTRONIC TEMP. CONT.



Your Railroad Electronics specialists for:

- **QES-1000** Locomotive Control Systems
- **DATACORD** Event Recorders
- Locomotive Health Monitoring Systems
- Radio Location Systems
- **Q-TRAC** Adhesion Control Systems
- Slow Speed Controllers
- EP Brake Control Systems
- Axle Generators and TM Speed Probes
- Speed Signal Amplifiers & Distribution Panels
- Speedometers & Integrated Speed Displays
- Engine Fan Controllers
- Crew Alertness "Vigilance" Systems
- Transition Panels

For more information call:

Corporate Headquarters: 3855-64th Avenue S.E.
Calgary, Alberta T2C 2V5
(403) 279-0805

Branch Office: 92 Queen, Greenfield Park
Quebec J4V 1R3
(514) 923-9433



IV. SPEED SENSING DEVICES

*Presented by: Brian Hathaway
Florida East Coast Rwy.*

Electric speed indicators, with their companion axle alternators, were a relief to the rail industry. Their onset alleviated the labor intensive mechanical systems of the past. With the electrical models, it was no longer necessary to lubricate up to 20 feet of revolving cable in between the times we were changing them for breaks....or when a roadside hazard removed them altogether. All in all, the electrical axle drives have made life a little easier for the Mechanical departments.

Axle generators have been around for some time. In general, their purpose is to provide an electrical signal whose characteristics are direct measures of locomotive wheel rotational speed, for various locomotive functions. The axle generator has been greatly improved to increase dependability. Most of the improvements have had to do with bearing and /or seal integrity, a few with better termination design and sealing of the unit. Some units have a little lower profile, but essentially the basic design of the axle generator has remained intact since its origin. It is located in one of the harshest environments, constantly subjected to vibration, accident damage, trackside debris, and extremes of temperature. In spite of these obstacles, the generator performs remarkably well.

Basically, there are two forms of signal generation, end of axle or the traction motor probe concept. The standard end of axle generator, either magnetic or optical, is what we all have been familiar with. It is comprised of a mechanical drive shaft or coupling between the generator and the axle, some form of housing attached to journal box, and a rotor to generate some

type of electrical signal. A traction motor probe system generally consists of a probe assembly, which may include its cable, a toothed-gear doubling as the traction motor bearing retainer, and some sort of power supply. Whatever type of signal generator used, some of its signals are sent directly to the device for which it is intended. On some other applications, the signal is first sent to a panel mounted transformer, rectifier, then filtering assembly. Aside from speed indicating and/or recording systems the output can be used to initiate transition, detect wheel slip, or other accessory functions.

General Electric's MM24 alternator uses the magnetic concept of 40 bar magnets, 40 steel laminations and one random-wound coil. As the rotor turns the laminations make and break magnetic circuits around the stator coil, producing two half cycles at a 20 cycle frequency per revolution. The obtained variable single-phase AC voltage is fed into a panel-mounted transformer, rectifier, filter and load resistor. The output signal is DC and is used to initiate transition, detect wheel slip, or other necessary functions.

The Bach Simpson axle alternator uses components of a fixed magnetic pickup and a rotating spur gear. The teeth of the gear pass the permanent magnet pole piece of the pickup. As each tooth "cuts" through the flux field of the pickup, one cycle of sine wave AC voltage is generated by the pickup. No external electrical power is required by the axle alternator.

Pulse Electronics has its "Zero Speed" AD 60 axle generator. It provides 60 cycles per revolution using the inductive system. It uses an eight output expansion module to supply accessory devices such as recorders, alerters, lubricators, etc. It is fully isolated and short circuit / reverse polarity protect-

ed. It has an optional directional capability.

Vapor offers a 120 pulse generator which is relatively noise free. For this reason it is frequently used on locomotives equipped with Positive Traction Control. This is an improved version from the earlier Vapor models. An internal reinforcing ring has been added and various other changes have been made to improve ruggedness and reliability.

Q-Tron has taken a little different approach to axle speed signals. Its offering is an optical generator. One model provides a dual signal so that direction may be calculated from the phase relationship. This unit has the ability to generate a full amplitude signal down to a complete stop. It supplies a square wave digital signal compatible with today's microprocessor based equipment. With the optical sensors requiring a power source, Q-Tron contends that this is no problem since some form of signal distribution is required of most systems. Its latest model has shifted from the reflective style to a laser trimmed disc. The sensors have an isolated input so grounds are not usually a problem.

Axle generators, excluding minor improvements over the years, have remained fairly constant in design and function. One departure from this system of signal retrieval has been the axle probe configuration. Vapor, GE, and Q-Tron offer axle probes that may tend to reduce some of the inherent drawbacks of the end of axle applications. In general, speed sensing probes are located inboard, with the sensing portions mounted within the traction motor where they are sheltered from some of the temperatures, humidity, and vibration extremes. They have virtually no moving parts and may not be as subject to damage from trackside debris. Their hazardous obstacle could

well be the mechanic who forgets to disconnect them for motor changeout.

Traction motor speed sensing probes are classed in two types, active and passive. The active probe incorporates signal conditioning and amplification circuits within the probe assembly. Conversely, the passive has the signal conditioning and amplifier mounted in a remote location, customarily in the electrical cabinet. Some common weaknesses of the early probes were the breakdown of the jacketing due to constant vibration and the separation of the conductors caused by the failure to disconnect the probe during truck removal. Over the years, these shortcomings have been addressed to some degree.

GE utilizes both active and passive probes where Vapor and Q-Tron have concentrated on passive probes. They contend that this simplifies the probe assembly which is the only element of the system subjected to the environment. Their standard probe assembly incorporates a magnetoresistive sensing element in a stainless steel housing. Both suppliers use a 29 tooth gear which produces a 120 pulse per revolution signal, and some form of amplifier panel and/or distribution network.

To expand a little on each supplier, Q-Tron's stand probe housing is molded to the cable assembly. A polyurethane jacket is used to reduce mechanical failure, due in part to its superior cold weather performance, along with heavy gauge conductors and electrical shielding. The cable connector end features a pullaway design to reduce damage caused by failure to disconnect. The Q-Tron probe and cable assembly may be changed independently in the event of failure.

Q-Tron provides several interface/amplifier panels depending on the application. One model accepts one standard probe input signal and

provides one 60 and one 120 pulse per revolution output. Another provides up to four isolated speed signal outputs. On this model each output signal frequency is operator selectable for 20, 60, or 120 pulse per revolution. The 91244 model accepts six input signals and provides one 60, and one 120 pulse symmetrical square output, plus six 120 pulse signals for wheel slip control. This panel includes monitor circuits which open if the amplifier panel should fail. This feature is intended to shut off power to wheel slip systems if the amplifier panel is not functioning.

Vapor uses a preamplifier panel for its applications. This panel contains an isolating DC power supply, six preamplifier circuits and a power supply check and indicator. The power supply is a transformer isolated DC chopper type. It is immune to transients on its 74 volt input and need not be disconnected when megger testing. It provides stable voltages of plus or minus 15 volts for the preamplifier circuits and a precision regulated supply of about 4 volts to energize the probes. The "common" of these supplies is fully isolated from the locomotive battery and frame. A power supply check circuit verifies that the supply voltages are correct.

When the teeth pass in front of the traction motor probe, its resistance changes, causing a change in current

flow through the probe. This change in current causes a slight change in the voltage drop across the supply resistor. This change in voltage is coupled through a DC blocking capacitor into the preamplifier circuit.

At locomotive speeds over 5 mph the preamplifier output is a sine wave of about 1.5 volts rms with a frequency proportional to the traction motor speed. At lower speeds the preamplifier output becomes smaller. This is similar to the reduced output obtained from a 120 pulse axle generator at low speeds. Therefore, at all locomotive speeds the preamp panel provides axle speed signals which are similar in size and identical in frequency to those provided by axle generators. This system is frequently used in conjunction with PTC applications.

As we have seen, there is quite an array of products to fit your particular needs. Considering the degree of reliability demonstrated by electrical speed signal devices over the years, the selection process may well come down to only two questions. First, how noise free does your signal need to be? . . . and second, do you prefer inboard or outboard mounting? It doesn't get much easier than that. I would like to thank all the suppliers who assisted in the preparation of this report with technical and support information.

Advanced Technology **Instrumentation, Support Systems and Control Devices for the Railroad and Transit Industries**

- Solid state locomotive speed and event recording equipment.
- Recording analysis support systems.
- Crew alertness control devices.
- Train speed indicators.
- Transition controls.
- Axle alternators and speed sensors.
- Transit car alarm message systems.
- Isolation amplifiers.
- Locomotive and transit car control devices.

 **BACH-SIMPSON.**

Serving The Transportation Industry For Over 47 Years!

BACH-SIMPSON, INC.
760A Industrial Drive
Cary, Illinois 60013-1989, U.S.A.
(708) 516-5353, Fax: (708) 516-5373

BACH-SIMPSON (U.K.) LTD.
Trenant Estate
Wadebridge, Cornwall PL27 6HD, England
(020 881) 2031, Fax: (020 881) 4593

BACH-SIMPSON, LTD.
1255 Brydges Street, P.O. Box 5484
London, Ontario N6A 4L6, Canada
(519) 452-3200, Fax: (519) 452-3165



V. ADHESION ALTERNATIVE

*Presented by: Dan Smith,
Montana Rail Link*

One subject that seems to draw universal interest is anything related to adhesion levels. We are all aware of the improvements that have been made over the years. During the last few months, three new players have been added to the list. Before I begin a review of the new systems, the Electrical Committee would like to make it clear this should not be construed as an endorsement of any one product over another. With this in mind, let us take a look at some new developments in adhesion control.

A little background may be helpful. Dating back to the middle 1960's, the design philosophy of wheel slip systems had been to maintain wheel speed as close as possible to actual ground speed. With the technology available at the time it was felt that unless a slip was corrected instantaneously, the result would be an uncontrolled loss of adhesion. With these limitations, dispatch levels were restricted to about 18% for reliable train performance. The traction motors and support components however, were capable of maintaining adhesion levels of a little over 22% for an hour or 23½% for fifteen minutes. A control system that would allow these higher operating levels would provide 20% more pulling power per unit.

During the summer of 1972 Electro-Motive put together a team of personnel with backgrounds in control circuitry, truck and underframe design and rotating equipment design later known as the Adhesion Committee. A paper was presented to the American Society of Mechanical Engineers detailing the data generated by literally thousands of hours of testing by this group. Among

the information presented was an indication that one way to achieve improved adhesion was to develop a system that would allow the wheels to creep. "Wheel creep" would permit the wheels to rotate faster than ground speed and therefore generate the extra friction desired. The advent of microprocessor control made possible new components that do just that. The older analog wheel slip systems have been asked to give way to a new, more efficient means of slip control. The new offerings we will discuss here are all designed to replace the WS10 module, as we know it, on EMD Dash 2 locomotives. They all incorporate microprocessor technology in a module format. We will present the highlights of each system for your consideration.

There are several systems available which completely retrofit older locomotives to microprocessor applications. These systems range from those of the major locomotive builders to offerings of a few after-market suppliers. The systems we will discuss are designed to specifically upgrade only the wheel slip system on Electro-Motive's Dash 2 locomotive.

The first system we will look at is called Maxitrax. This newcomer in the rail industry was just beginning to become available during last year's convention. Some of you may have seen or heard of its impending release. For those that did not, Maxitrax was developed by a new company in the adhesion field, G & G Locotronics. At this time testing is being provided by several railroads across the country.

As mentioned, this system is designed with the Dash 2 locomotive in mind. The new wheel slip device was fabricated to utilize the standard module rack. It is the same double wide module format as the WS10 and takes the place of the existing card. The new apparatus contains two groups of signal

G&G Locotronics, Inc.



MAXITRAX

Increased Dash 2 Locomotive Adhesion by 25%

G&G Maxitrax

Maxitrax is a dash 2 enhancement system designed to provide a 25% increase in dispatchable adhesion.

Maxitrax uses state-of-the-art microprocessor technology to replace the WS10 module—with an easily retrofit plug in system.

Retrofit to existing dash 2 locomotives is accomplished in less than 8 hours, while retaining the capability to use WS10 as a back-up.

All system hardware is conveniently located in the high voltage cabinet. No axle generators or traction motor probes.

"After installation, MAXITRAX is fully-interchangeable with WS10. Simply remove the WS10 module and plug in MAXITRAX!"

600 Wheat Lane. Wood Dale, IL 60191

708-766-6947

conditioners, an input and output amplifier, an output driver, a display indicator, and a microprocessor. The module appears similar to the original equipment device with the exception of some hard wiring protruding from the side of the circuit boards. This wiring is connected to various locomotive channels via a plug connection.

The system receives a signal proportional to motor current from four to six current transducers depending on GP or SD application. These current sensors, called ACTS's, are doughnut shaped devices with control wiring projecting from the varnished covering. To install these devices, one disconnects a traction motor lead inside the cabinet and slides an ACT over the existing cable. The control circuits also monitor voltage being developed across the motor paths. To accomplish this, a tap to all motor circuits is provided to the module. These high voltage signals are fed in through the hard wiring and plug assembly mentioned during the module review. The signals are presented to the module in this individual format theoretically to provide a very accurate data foundation for the microprocessor to base its reactions upon. Differential motor amperage and voltage are fed in through these input signals. With this system, rate of change is the first derivative for corrective action.

The Maxitrax system utilizes the original control circuitry of the Dash 2 locomotive for any situation deemed out of tolerance by the program algorithms. In such instances, the microprocessor executes varying degrees of reference circuit modulation based on the severity of the adhesion loss. The Maxitrax system intervenes in such a way that it maintains governor override capability, through load regulator movement, in kind. Neither rate control discharge nor overriding solenoid

activities are utilized in this system. Reference voltage remains at a constant optimum level while very small, rapid adjustments are made downstream of the load regulator. It is believed that in this way very accurate and subtle changes in the reference string allows for wheel creep capability without major power level fluctuations. It is contended that a side benefit of this approach is reduced requirements for sanding during correction modes due to less severe adjustment demands.

The developers of this new wheel slip system make these comments concerning their product. Maxitrax utilizes the latest processor technology featuring a Motorola 68HC11 microcontroller and advanced algorithms. The software technologies maximize adhesion under all rail conditions. The system allows for motor cut-out feature and provides complete wheel slide protection in dynamic braking. Optimum current levels are maintained throughout the locomotive's power curve. Finally, an RS232 port and miniature viewing screen are built into the face of the card to allow for effective review and downloading of module activities as well as a real time display of adhesion.

A second system is from Q-Tron Limited. Its new offering is called QTRAC and again is designed to replace the WS10 module. It too is a double wide module format installed in the space vacated by the WS10 with some modification. A new connector arrangement replaces the original pin configuration. The QTRAC module also features a keypad, a 4 line by 20 character display screen and 232 port. In addition to this, with the QTRAC system the RC module is no longer necessary. The remainder of this system includes eight current transducers, four neutral tie inductors, and a cabling kit. Axle speed sensors of some

description are required with this system. Software for data analysis of stored information is supplied as part of the system.

The control system allows wheel creep and controls wheel slip by sensing wheel speeds on all axles. Control and correction are achieved by reducing the main generator field current enough to eliminate adhesion loss and still maintain wheel creep. This is accomplished by taking over the function of RC module. The input, as well as DR signals in braking, are routed into the QTRAC module. The system acts in response to the severity of the wheel slip and adjusts the RC rate for creep control.

In addition to sensing axle speeds, QTRAC also measures traction motor currents to provide control system and motor protection in the event of a slipped pinion, open traction motor or other failure. This is accomplished using six of the eight current transducers mentioned. The remaining two are used in conjunction with the neutral tie inductors. The neutral tie circuit is utilized during series connections and theoretically helps stabilize the motors during wheel creep.

The developers of this system make these comments concerning their product. QTRAC delivers significant gains in adhesion over conventional WS10/RC applications. Analysis software is provided with the system for diagnosis. "Time of fault" snapshot information of all the I/O's are stored for review at the maintenance facility. This review can be accomplished either on the built in module viewing screens via the keypad, or by download onto a lap top for remote review.

The third system we will look at is from Elcon Inc. Its development is based on obtaining the best possible performance with the least possible modification. Elcon's approach elimi-

nates the need for additional hardware to measure traction motor current or axle speed.

At present, its offering is completing the development stage. Locomotive simulations using mathematical models are being used to predict performance of this system. Elcon feels that empirical tests depend on a specific locomotive and/or track conditions. By using models, any desired condition can be inserted into the test criteria to confirm performance under any circumstance.

As with the other systems we have discussed, the Elcon system, which is unnamed at present, is designed to replace the WS10 module. The module incorporates microprocessor technology which meets locomotive environmental requirements. Other components include an isolated power supply, isolated inputs and outputs and short circuit protection. The new module provides wheel slip and creep control by direct control of the SCR. Status of the locomotive is monitored in 8-millisecond control updates which enables tight main generator current regulation.

Installation of this system can be accomplished by an electrician in approximately one hour. Two wires need to be added from existing module terminals to two unused pins on the WS module rack. Input and output connections are taken from existing module positions without any disruptions. Aside from that, you only change modules. No cabinet alterations are necessary.

Elcon anticipates the following claims about their new offering. It is a direct replacement for WS10 modules. In the event of an emergency, the WS10 can be reinstalled instantly. The adhesion goal is the equivalent of 60 Series technology. The system rapidly adjusts to track conditions for optimum creep levels in power and slide protection in braking. The systems can also

replace the IDAC control panel but without the instant change back ability and a little longer installation time. Mathematical model simulations are currently under way. Elcon anticipates field testing by late fall and production soon thereafter.

In conclusion, the one constant since the beginning of the railroad industry

has been the quest for increased tonnage with fewer locomotives. That industrious groups continually strive to improve our motive power, is in itself progress. Whether these particular systems interest your road or not, the search for new technology for the railroads is a credit to our industry and our society as a whole.



The diagram consists of two parts. The upper part shows a cross-section of a locomotive traction motor lubricator with two oil levels indicated: 'A' for the former wick and 'B' for the new Hi-Lift wick. The lower part shows a test setup with two wicks, 'C' (Hi-Lift) and 'D' (standard), in a tray of oil. Wick 'C' is fully saturated, while 'D' is only partially saturated.

How Miller Hi-Lift Wick Lubricators cut maintenance costs

Here's a locomotive traction motor lubricator that offers 40% greater oil lift and doubled oil capacity. Upper picture shows increased oiling efficiency provided by Miller Hi-Lift wick lubricator. Lower picture illustrates simple test that proves greater oil-lifting ability of Hi-Lift felt. Hi-Lift felt segment ("C") is completely saturated to top with oil. Standard felt ("D") has unsaturated, white area at top. Both are same size and were placed in tray before oil was added. Details available from your locomotive builder or write direct to:

MILLER FELPAX, CORP.
Winona, Minn., Ph. 507, 452-2461

TRAIN TRAX™

SOLID STATE LOCOMOTIVE RECORDER

- TAPE RECORDER EXCHANGEABLE
- NO MOVING PARTS
- EXPANDED INPUT CAPABILITY
- MORE RECORDING TIME
- REMOVABLE MEMORY MODULE
- USE WITH PULSE PLAYBACKS
- DATA ANALYSIS SOFTWARE

For a prudent and conservative transition to today's high technology, rely on the proven experience of:

PULSE[®]
Electronics, Inc.

5706 Frederick Avenue
Rockville, MD 20852 USA

Phone (301) 230-0600
Fax (301) 230-0606
Telex WUI 650 22118919

MODERN TOOLING UPDATE

To facilitate quick, easy and quality repairs on the wiring of modern micro-processor equipped locomotives, General Electric has developed the DASH-8 connector tool kit. The kit contains all the necessary tools and parts to repair the various connectors found in the control compartment and on remote sensors and plugs. There are nine different sizes of crimp style pins and sockets covering a wide range of wire sizes and applications. These pins and sockets are used in the connectors on the CAB, EXC and AUX micro-processors, display panels, computer power supply, static exciters, and blower/radiator regulator panels. The pins are also used in the connectors for the governor, manifold air pressure and crankcase overpressure sensors, all temperature sensors, traction motor speed sensors, governor rack position sensors and the air compressor and grid blower motor speed sensors.

Two pairs of crimpers are included. One contains a combination turret head that accommodates a variety of pin and socket sizes. The other crimper fits those styles not covered by the combination turret. Insertion, removal and

guide pins are also included, as is an extraction tool to remove pins from connectors without damaging them.

For those repairs requiring a bit more persuasion a portable butane soldering iron and a roll of solder are included. The components are all housed in a 16 in. plastic toolbox with a lift-out top tray. A snap-tight plastic utility box with adjustable compartments is used to store the pins, sockets and small tools.

This tool kit may be ordered from the General Electric Co. under part number 170X1222.

Also available from GE is a portable static dissipative field service kit. This kit can be used to eliminate the danger of electro-static damage when working on sensitive components, cards and panels. The kit contains a static dissipative work surface (.015 x 15 x 20 in.), an adjustable wrist band and an insulated grounding clip. Three five-foot ground cords are included for the ultimate in flexibility and mobility. The work surface also doubles as a carrying case so the entire package can be folded up and carried in a shirt pocket. This kit can be ordered from the General Electric Co. under part number 3X5457.

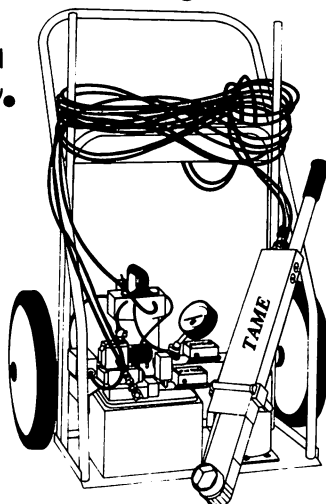
***TIME-SAVING Tools and Machines
for Locomotive Maintenance, Parts
Reclamation, and testing***

TAME, INC.

**INCREASE
SHOP PRODUCTIVITY**

**REDUCE
LOCOMOTIVE DOWNTIME**

**IMPROVE YOUR QUALITY
ASSURANCE PROGRAM**



Model 2000 MB Hydraulic Ratchet Wrench

MAIN BEARING WRENCHES – EMD & GE engines

CRAB NUT TORQUE WRENCHES – EMD engines

BAR-OVER MACHINES – EMD engines

TRACTION MOTOR SUPPORT BEARING

CAP TORQUE WRENCHES – EMD & GE Traction Motors

***LOWER LINER INSERT PULLER/INSTALLER –
EMD engines***

***CYLINDER HEAD & LINER WATER TEST
MACHINES – EMD engines***

***EXHAUST VALVE SPRING DEAD WEIGHT TESTER –
EMD engines***

**and OTHER SPECIAL TOOLS & MACHINES
designed to **SAVE YOU MONEY****

For information call 706/820-0397 or write
TAME, INC., 2523 Chattanooga Valley Drive

P.O. Box 250

Flintstone, GA 30725

DIESEL MECHANICAL MAINTENANCE COMMITTEE TWELVE YEAR INDEX

1992

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

1991

1. Recommended Practices for upgrading 567 to 645 Design.
2. Conversion of SD40 Locomotives to SD 40.2 on CSX.
3. Update: Diesel Engine Emission Controls.
4. Stationary and dynamic test procedure for locomotive fuel efficiency measurement.
5. Personal training on New Technology.

1990

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

1989

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

1988

Theme: "Locomotive Mechanical Officers Developing Extended Maintenance Programs - The Vital Link."

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

1987

Managing Productivity and Quality For Cost Efficiency

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

1986

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

1985

Maintaining Today's New Technology For Quality Performance.

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

1984

**Will Today's New Technology
Simplify Tomorrow's
Maintenance?**

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

1983

**Cost Control and Extended
Service Through
Improved Maintenance**

1. Leaks: Cooling Water, Lube Oil, Fuel Oil and Air.

1982

**Quality Maintenance -
The Key To Fuel Conservation**

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

1981

**Increased Service Life
Through Improved Technology**

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

DIESEL MATERIAL CONTROL COMMITTEE TWELVE YEAR INDEX

1992

1. Warranty Overview and Issues
2. Recycling - 1992
3. Bar Coding
4. Material Packaging

1991

Theme: Environmental Issues

1. The World of Recycling.
2. Problems with Solutions.
3. Problems with Opportunities.

1990

Theme: Be a Part of the Solution Not a Part of the Problem

1. Waste Minimization.
2. Hazardous Materials End Cost
3. The Role of the Suppliers.

1989

1. Packaging and Containization for Today's Railroad.
2. Innovations in Material Distribution Resulting from Shop Consolidations.
3. Outsourcing! Does Anyone Really Understand the Difference Between UTEX and Repair and Return and the Affect on the Budget?
4. "Stuff" Happens! - A Skit About the Necessity of Feedback from Suppliers - Suppliers to the end User.

1988

Theme: "Communications - The Vital Link in Material Acquisition."

1. Communication - The Vital Link in Materials Acquisition.
2. Quality Assurance Through Communications and Feedback.
3. Paperless Requisitions.
4. A Practical Application of Bar Coding in the Railroad Industry.

1987

Materials - The Link Between Productivity and Quality

1. Suppliers Selection for Component Failure Analysis.
2. Vendor Performance or Service Level.
3. Bar Codes.
4. Bar Coding - Railroads
5. Material Handling Innovations by the Airline Industry.

1986

Electronics: New Methods for Handling Material - With Proper Quality and Sources

1. The In-House Electronic Requisition System.
2. Electronic Data Interchange.
3. RAILING and Electronic Purchasing.
4. Quality Evaluation of Material Sourcing Decisions.

1985

Controlling the Material Investment - A Requirement for Deregulation

1. Evaluating Locomotive Maintenance Projects.
2. Reconditioning Material: In-House vs. Vendor.
3. Identification and Disposition of Surplus Material.
4. Cost of Carrying Surplus.
5. Evolution and Future Directions of Material Handling Equipment in Railroad Use.

1984

Material Control In A Changing Environment

1. Bar Coding of Material.
2. Forecasting Material Requirements.
3. a. Fuel Security - Are You Getting What You Pay For?
b. Fuel Oil Is Expensive.
4. Pros and Cons of Material Purchasing Contracts (Single Source - Just In Time Inventory).

1983**Material Systems - Action
Through New Ideas**

1. Improved Locomotive Productivity Through Computerized Data.
2. Inbound Material Inspection.
3. Minimize Maintenance Cost Through Material Management Sstems.
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. Locomotive Held for Material: an Update for the 80's.
4. The Best Approach to Procuring Material; New, UTEX, Repair and Return or Shop Repair.

**SHOP EQUIPMENT COMMITTEE
TWELVE YEAR INDEX**

1992

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

1991

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

1990

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

1989

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

1988

**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. Locomotive Wash System - 1986.

1985

**Improved Methods of
Maintenance Management and
Material Movement**

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

1984
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.

**DIESEL ELECTRICAL MAINTENANCE COMMITTEE
TWELVE YEAR INDEX**

1992

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

1991

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

1990

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

1989

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

1988

Theme: "Locomotive Data Acquisition and Its Relationship to Maintenance"

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

1987

Maximizing Fuel Efficiency Through Quality Electrical Maintenance Program

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

1986

Cleaning, Handling and Storage of Electrical Equipment

1. Solid State Components.
2. Rotating Equipment

1985

Innovations, Maintenance and Troubleshooting Locomotive Electrical Systems

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

1984

Electrical Technology To Improve Performance

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

1983

New Solutions To Locomotives Electrical Problems

1. Ground Relay Trouble Shooting.
2. Traction Motors.
3. Locomotive Storage (Electrical).
4. Water Cooling and Refrigerating Methods for Locomotive Cab Application.

1982

Quality Maintenance - Assuring Thorough Repairs.

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

1981

Innovation: Past and Present Traction Motors

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

NEW DEVELOPMENTS COMMITTEE TEN YEAR INDEX

1992

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

1991

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

1990

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

1989

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

1988

Theme: "The Link To Reliability and Productivity."

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

1987

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

1986

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

1985

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

1984

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

1983

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

**FUEL, LUBRICANTS AND ENVIRONMENTAL COMMITTEE
TWELVE YEAR INDEX**

1992

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

1991

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

1990

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

1989

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

1988

**Theme: "Lubrication '88 -
The Vital Link to
Successful Railroadings"**

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
 6. Locomotive Engine Lube Oil and Lube Oil Filters.
- Speaker on Overview of Environmental Requirements for The Use of Petroleum Products in The Railroad Industry. - Peter Conlon-AAR.

1987

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

1986

1. **Fuel and Lubricants - Effect on the Bottom Line**
 2. Extended Performance Lubricants Through Better Chemistry.
 3. Fuels and Lubricants handling Hygiene.
 4. Fuels Availability and Price Outlook.
- 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 Analysis.
4. Traction Motor Gear Lubrication.
5. Multi-Viscosity Oils as an Energy Conservation Technique.

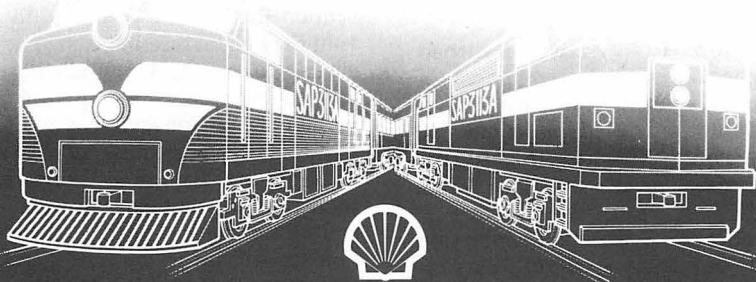
SAP 3113A professional technology for locomotive diesel oils

Shell additive package SAP 3113A is the universal answer to the challenge of diesel engine lubricants effectiveness.

SAP 3113A technology is ideal for current G.E. Generation 4 Long Life and LMOA Generation 5 engine oils, and it anticipates future demands, however stringent.

Heavy duty engine oils (including multigrades) blended from SAP 3113A keep engines cleaner, control wear and provide durability — thus substantially reducing maintenance costs.

For further information please contact Jack Perini, Marketing Manager, Shell Chemical Co. (Shell Additives) 1 Shell Plaza, P.O. Box 2463, Houston, TX 77252, (713) 241-5627.



Shell Additives

CONSTITUTION AND BY-LAWS LOCOMOTIVE MAINTENANCE OFFICERS ASSOCIATION

Article I - Title:

The name of this Association shall be the Locomotive Maintenance Officers Association (LMOA).

Article II - Purpose of the Association

The purpose of the Association, a non-profit organization, shall be to improve the interests of its members through education, to supply locomotive maintenance information to their employers, to exchange knowledge and information with members of the Association, to make constructive recommendations on locomotive maintenance procedures through the technical committee reports for the benefit of the railroad industry.

Article III - Membership

Section I - Active Railroad Membership shall be composed of persons employed by a railroad company and interested in locomotive maintenance. Membership is subject to approval by the Board of Directors.

Section 2 - Associate Membership shall be comprised of persons employed by a manufacturer of equipment or devices used in connection with the maintenance and repair of motive power, subject to approval of the Board of Directors.

Associate members shall have equal rights with active members in discussing all questions properly brought before the association at the Annual Meeting, but shall not have privilege of voting or holding elective office.

Section 3 - Honorary Membership: Honorary Membership may be issued at the discretion of the President, subject to the approval of the Board of Directors. Honorary Members may not vote or hold elective office; all Honorary Membership shall expire at the end of the current membership year.

Section 4 - Life membership shall be conferred on all Past Presidents. Honorary life memberships shall be conferred on others for meritorious service to the Association, subject to approval by the General Executive Committee.

Section 5 - Dues and Fees: Membership dues for individual active and associate membership shall be set by the Board of Directors and shall be payable on or before September 30th of each year. The membership year will begin on October 1 and end September 30. Life and honorary life members will not be required to pay dues. Members whose dues are not paid on or before the opening date of the annual convention shall not be permitted to attend the annual meeting, shall not be eligible to vote and/or shall not be entitled to receive a copy of the published Pre-Convention Report or the Annual Proceedings of the annual meeting. Failure to comply will result in loss of membership at the end of the current year. A registration fee will be set by the Board of Directors for those attending the annual meeting. Life, life honorary, and honorary members will be entitled to receive a copy of the Pre-Convention Report and Annual Proceedings.

Article IV - Officers

Section 1 - Elective Officers of the Association shall be President, First Vice President, Second Vice President and Third Vice President. There

will be one Regional Executive for each technical committee. Each officer will hold office for one year or until successors are elected. In the event an officer leaves active railroad service, he may continue to serve until the end of his term.

Section 2 - Board of Directors: There shall be a Board of Directors composed of the President, Vice Presidents, and all Past Presidents in active official railroad service. In the event a member of the Board of Directors becomes inactive, he may continue to serve until the end of his term of office.

Section 3 - General Executive Committee: There shall be a General Executive Committee, composed of the Board of Directors, the Regional Executives, and the Technical Committee Chairpersons.

Section 4 - Secretary-Treasurer: There shall be a Secretary-Treasurer, appointed by, and holding office at the pleasure of the Board of Directors, who will contract for his or her services with appropriate compensation.

Section 5 - Advisory Board - There shall be an Advisory Board composed of at least nine members, who are Senior Mechanical Officers, Assistant Vice Presidents or Vice Presidents. They will be invited by the Board of Directors and serve as ex-officio members of the General Executive Committee without vote.

Article V - Officer, Nomination and Election of

Section 1 - Elective officers shall be chosen from the active membership. The nominating committee, composed of the Board of Directors, shall submit the slate of candidates for each elective office at the annual convention.

Section 2 - Election of officers shall be determined by a voice vote,

or if challenged, it shall require show of hands.

Section 3 - Vacant offices. Vacancies in any elective office may be filled by presidential appointment, subject to approval of the Board of Directors.

Article VI - Officers - Duties of

Section 1 - The President shall exercise general direction and approve expenditures of all affairs of the Association.

Section 2 - The First Vice President, shall in the absence of the President, assume the duties of the President. he shall countersign all expenditures of the Association and be responsible for preparing and submitting the program for the Annual Meeting.

The Second Vice President shall be responsible for selecting advertising. He will coordinate with the Secretary-Treasurer and contact advertisers required to underwrite the cost of the **Annual Proceedings**.

The Third Vice President will be responsible for maintaining a strong membership in the Association. He will ensure that membership applications are properly prepared and distributed, monitoring membership levels and reporting same at appropriate time to the General Executive Committee.

Section 3 - The Secretary-Treasurer shall:

A. Keep all the records of the Association.

B. Be responsible for the finances and accounting thereof under the direction of the Board of Directors.

C. Perform the duties of the Secretary of the Board of Directors, Nominating Committee, and General Executive Committee, without vote.

D. Furnish surety bond in amount of \$5000 on behalf of his/her assistants directly handling Associa-

tion funds. Association will bear the expense of such bond.

Section 4 - The Board of Directors shall be responsible for the following duties:

A. Assist and advise the President in long-range Association planning.

B. Contract for the services and compensation of a Secretary-Treasurer.

C. Serve as the Nominating Committee.

D. Serve as the Auditing and Finance Committee.

E. Determine the number and name of the Technical Committees.

F. Exercise general supervision over all Association activities.

G. Handle all matters of Association business not specifically herein assigned.

H. The Vice President shall perform such other duties as are assigned them by the President.

I. Those present at any meeting called on not less than thirty days advance written notice, shall constitute a quorum.

Section 5 - There will be one Regional Executive officer assigned to each technical committee. Their duties will consist of:

A. Participate in the General Executive Committee meetings.

B. Monitor material to be presented by the technical committees to ensure reports are accurate and pertinent to the goals of the Association.

C. Represent LMOA in their respective regions.

D. Promote Association activities, especially those held within their assigned region and monitor membership activities on those railroads so assigned.

E. Promote and solicit support for LMOA by helping to obtain

advertisers.

Section 6 - Duties of General Executive Committee:

A. Monitoring technical papers for material considered unworthy or inaccurate for publication.

B. Approve topics for the Annual Proceedings and Annual Meeting program.

C. Approve the schedule for the Annual program.

D. Administer all Association activities not specifically assigned to the Board of Directors.

Section 7 - The Advisory Board shall act in a consulting capacity. Past Presidents still in official active railroad service shall automatically become members of the Advisory Board.

Section 8 - The Board of Directors are entrusted with all public relation decisions within LMOA and coordinated associations with confidentiality.

Article VII - Technical Committees

The technical committees will consist of:

Section 1 - A chairperson, appointed by the President and approved by the Board of Directors.

Section 2 - A vice chairperson, selected by the chairperson and approved by the President.

Section 3 - Committee members will be made up of:

A. Representatives of operating railroads and regional transit authorities submitted by their Senior Mechanical and Materials Officers and approved by the President of LMOA.

B. Representatives of locomotive builders designing and manufacturing locomotives in North America.

C. The Fuel and Lube Committee will include members from major oil companies or their subsidiaries as

approved by the General Executive Committee.

D. At the discretion of the General Executive Committee, non-railroad personnel may be allowed to participate in committee activities, subject to annual review.

E. All individuals who are on technical committees must be LMOA members in good standing. (See dues and fees, Article 3, Section 5).

Subjects for technical papers will be selected and approved by the General Executive Committee.

Article VIII - Proceedings

The Locomotive Maintenance Officers Association encourages the free interchange of ideas and discussion by all attendees for mutual benefits to the railroad industry. It is understood that the expression of opinion, or statements by attendees

in the meeting, and the recording of papers containing the same, shall not be construed as representations or statements ratified by the Association.

Article IX - Rules of Order

The proceedings and business transactions of this Association shall be governed by Roberts Rules of Order, except as otherwise herein provided.

Article X - Amendments

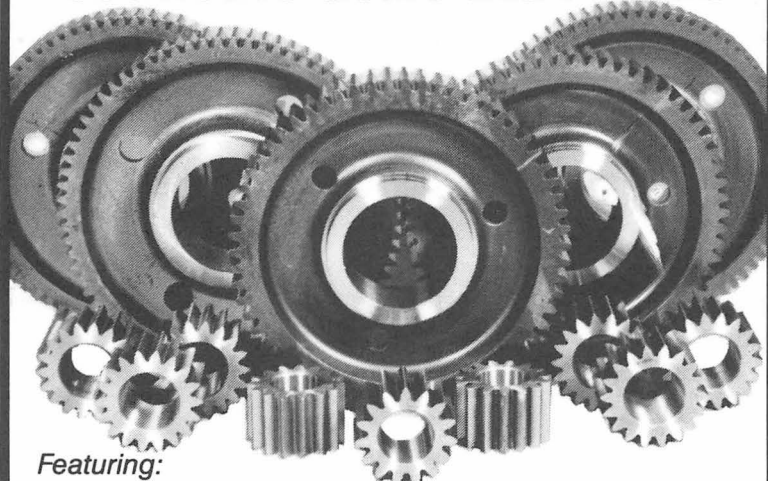
The Constitution may be amended by a two-thirds vote of the active members present at the Annual Meeting.

Article XI - The Constitution and By-Laws have been amended at the Annual Convention on September 19, 1988.

NOTES

Penn Precision

Locomotive Gears and Pinions



Featuring:

★ *Triple Alloy Forged Steel* ★ *Carburized and hardened*
★ *Cubic Boron Nitride Grinding* ★ *CBN Gear Reprofil-*
ing ★ *Qualified Recycled gears* ★ *Over 70 years of*
Gear manufacturing experience and quality.

CALL TODAY Forging BLANKS stocked for Fast Delivery

Penn Locomotive Gear

Division Penn Machine Co.

106 Station St., Johnstown, PA 15905



Since 1920

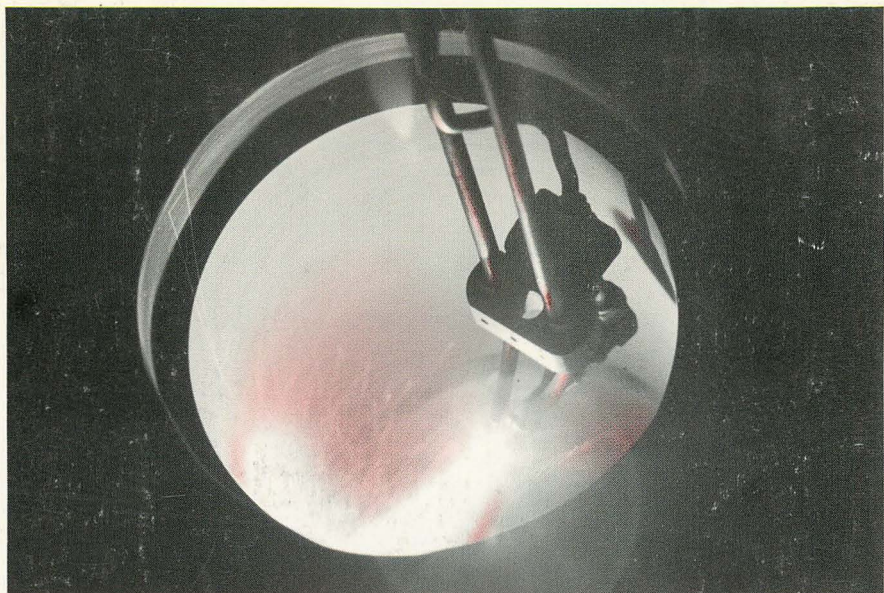
814/288-1547 FAX: 814/288-2260

Pittsburgh: 412/279-4460

FAX: 412/279-4465

Louisville, KY: 502/367-4858

FAX: 502/367-4911



THE *Permaspray II*™ PROCESS.

The most economical development in cylinder-liner remanufacturing since chrome plating.

The bottom-line facts about Precision National Plating Services' Permaspray II™ Process are simple, to the point, and totally convincing... Permaspray II™ cylinder-liner remanufacturing is considerably less expensive than the traditional chrome-plating process...and you still get all of the service-life benefits you need and expect, plus you get the added advantage of be-

ing able to run with chromeplated, ductil iron or pre-stressed stainless steel rings. Your overall operating costs will drop dramatically because Permaspray II™ processed liners result in lube oil savings of as much as 20% to 50%.

Ask for our detailed brochure including technical information and independent research data.

We stock NEW REPLACEMENT CRANKSHAFTS and RECONDITIONED CRANKSHAFTS for EMD and GE ENGINES

PRECISION NATIONAL PLATING SERVICES, INC. Sam Fleri - President

3333 South Valley Mills Drive, P.O. Box 7157

Waco, Texas 76714 - 817-772-8370

198 Ackerly Road, Clarks Summit, PA 18411-USA

Call Toll Free 800-327-3041