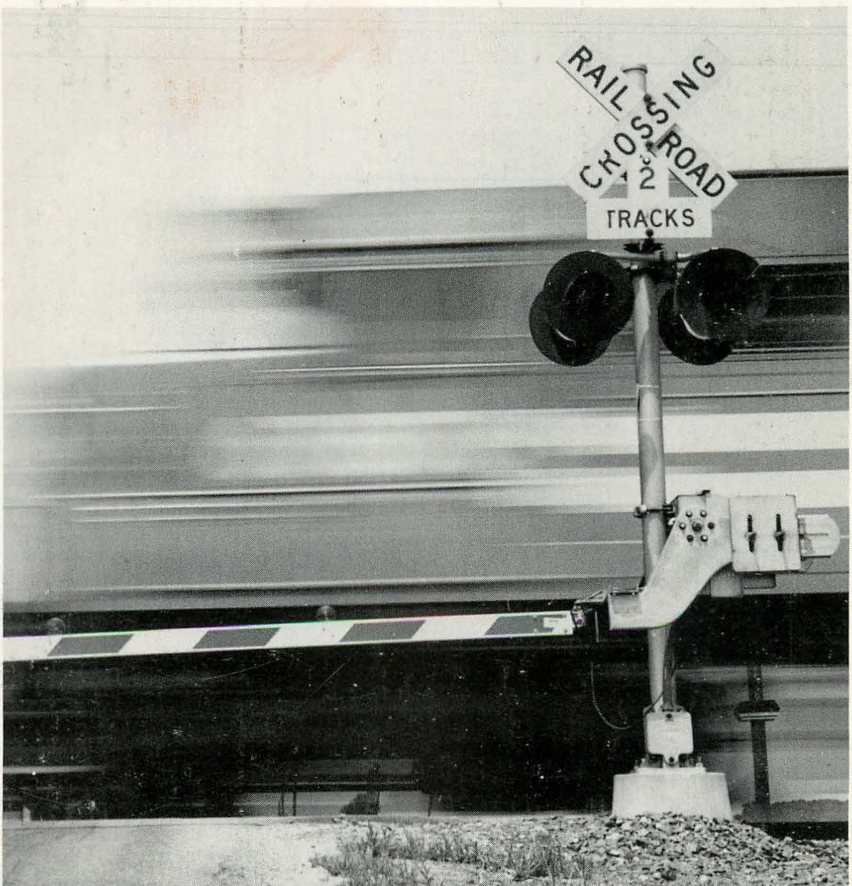
LMOA

Locomotive Maintenance Officers Association

Proceedings of the 54th Annual Meeting
Chicago, September 21-23, 1992



1992 ADVERTISERS INDEX

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We sure to read their ads in the Annual Publication.

INDEX

TECHNICAL PAPERS

KEYNOTE ADDRESS

at Joint Session of Coordinated Associations with the RSA
Monday Morning, September 21, 1992

Given By
MR. EDWARD A. BURKHARDT
President, Wisconsin Central
Transportation Corporation

I want to express a warm welcome to all our out-of-town visitors to Chicago. This city, I think, retains its role as the number one railroad city of the nation although, like many other aspects of our industry, it seems to be a shadow of its former self. Let's hope that a convention the size and obvious success of this is a part of the harbinger of better times ahead.

At a meeting of the RSA and the Coordinated Mechanical Associations, the accent has to be on hardware and we have exhibit halls full of the latest equipment and a large track exhibit with the latest in technology on rolling stock, cars and locomotives.

My talk today is going to concentrate on what I call the software areas. That is, the people who operate this industry and who we rely on to use the modern technology that is available to us.

In the past ten years our people have been beat up, but good. The railroad industry has shrunk in size both from a management standpoint and a rank and file standpoint by about half during that ten-year period.

This all began with a concept called deregulation. The Staggers Act is now over ten years old. The low productivity and excessive wage rates that applied in this industry pre-Staggers could exist only on top of a monopolistic industry which the Staggers Act took away from us. Since Staggers was passed we have seen a major increase in competition. The railroads have had to change or perish. Without a doubt, the Staggers Act and the concurrent motor carrier deregulation, is the most successful piece of consumer legislation that has ever been enacted in this nation. I wish the public had a greater understanding of this.

With this record over the last ten years, where are we now? We look around and we see exceedingly sour labor-management relations. We see a decimated management often spread too thin to operate the properties effectively.

I have mentioned the unrelenting demands of the last ten years. There will be absolutely no let-up in the next ten years or whatever period you might want to look at. In fact, we will have challenges that probably will make the last ten years look mild by comparison.

On top of all this, we have a changing work force. The employees who have entered this industry in the last ten years are different from the people that they followed. They are highly intelligent. They question everything. They are ambitious. And they are people who present a challenge to management. They won't accept a militaristic management style and they shouldn't be expected to.

At the same time the industry has had major service problems, some of which have been overcome, but, as an industry, we still do not have a service image.

We have witnessed nationally an onslaught of women into the work force. The railways, I would say, have a very unenviable record in making use of women as an asset in operating our companies.

We must change to create a cooperative and participative work place. We must recruit the best and see that they have job security and a chance for advancement. We must see the quality people who are available to us do not become alienated as their predecessors often did.

Wisconsin Central has a unique perspective in this major change. In most cases, this change will take place on an evolutionary basis over the years, hopefully not over too many years. On Wisconsin Central we did it in one day. Our story is similar to that of many of the regional railroads that have been created recently. In one day we threw out the old and brought in the new. We had an opportunity to organize the company and begin operating the way we wanted to.

I think largely we have not but there have been a few areas where our history worked against us.

We found that there was a rather easy transition on the part of the rank and file although virtually all of the employees we hired were experienced railroad people. We hired employees from thirty-nine states and railroads all over the nation. These employees, it may surprise you, found an easy transition to our style of operation. The change was more difficult for the management employees. Traditional railroad management style and process is not conducive to participative management. Our management people, all of whom had management experience on the Class I had to overcome this past. This has been a very difficult change for many.

In order to make participative management work we must cede control of major areas of operation to the employees. This industry has a history of overmanagement with management determining down to the last detail how every item of work will be done. We have intelligent employees working out there who, left to their own devices, will do it better than the process we inflict upon them.

We have to communicate our goals, or the results of the company's operation, and our strategy and thinking to our employees. It is not necessary or not effective today to have orders come down from on high with no rationale being there as to why a certain policy is in place. If the employees can understand what management is trying to do with the company and what the strategy is behind what we are doing, they will give it their strong backing. If they don't understand it and they think we are simply issuing instructions for instructions' sake, they will resist and they will question why things are set up the way they are.

At the same time, we have informed employees of the results of our operations. Wisconsin Central started off as a private corporation. Today we are public. During the time we were private there was no reason from a legal standpoint to release our operating ratios or profit and revenue figures but we elected to do so primarily as a tool for educating our employees in what was happening. The employees appreciate this. And I soon found when I went out on quarterly management meetings around the system, we got some very good questions which prepared me for operating a company with public stockholders.

We have to train our employees. Everyone has read about what is probably the biggest scandal in America, and that is the very weak education system that prevails in this country. It is a fact that employees of many companies who have been tested registered very low scores in basic linguistic and mathematics skills which we certainly should expect would be corrected during the years the employee spent in school. The fact is that is not happening in our country. As a result, if we are going to have effective employees, we must redouble and redouble again in-house training efforts in what might be termed remedial education in order to correct this situation.

So I predict that the training efforts which this industry has mounted in the last few years, which are significant, are going to get a lot more attention in the future.

We have to seek the involvement of our employees. They have to be behaving and operating consistently with the goals of the corporation and they will if they understand those goals. They have to be involved in setting up processes locally. For example, we found that we have very little success in getting hold of what initially was a rather poor safety record until we sought and got the close involvement of our employees on the ground. After all, if you are going to have results in safety, the people who are doing the work out there had better become involved. They are the ones who know where the hazards are and know whether the efforts of management are likely to improve the situation. Those people, properly motivated, will tell management what needs to be done and they have an awful lot of good ideas.

We have to motivate the employees toward the common goals of the corporation and we have to tap the large number of ideas that they have. It is absolutely amazing if we can turn loose a bunch of railroad employees with high quality ideas and very good programs what they can come up with.

As management people, we have to mix with our employees. I was taught when I was a young trainmaster, you didn't go out and mix it up too much with the employees. If you passed by a group of employees you nodded at them and walked by. This was school of management that was practiced in those days that in many respects has carried over in this industry. Employees enjoy management people having a one-on-one conversation with them. You would be surprised what you can find out. These are not your enemies.

We have to eliminate the employee fear of innovation and productivity. We have to create a climate of confidence on our properties. We have to eliminate the employees' fear of losing jobs. As long as we are using the words productivity and customer service on the one side and they are equating that to the loss of their jobs, we are not going to have success with our employees, and we will achieve neither productivity nor customer service.

We have to do everything we can from a management standpoint to stabilize employment. We have to seek help where we can from our unions in this regard. That may mean crossing craft lines in order to stablize employment. Wisconsin Central, being in the enviable position of not having craft lines, has the ability to shift employees around which has greatly stabilized employment. For example, we do not hesitate, in the wintertime, to put maintenance-of-way employees into the car shop to utilize their skills when their regular work is closed down.

I think that there is nothing more important in terms of future relations with the employees than taking away the fear that they have that any progress will result in the loss of their work.

We have to put an emphasis on improved service and to produce such service at the lowest possible cost. Many railroads today are operating reduced train crews. As an industry, we have finally achieved proper train crew size. But I don't notice that the railroads are using this as an opportunity to provide better service by running more trains. It is looked at solely as a cost reduction device which it is, but the large freight train is the number one enemy of customer service in this industry. We should be using our new freedom to operate smaller point-to-point trains to improve our service. I look on this as an untapped opportunity.

Today's hardware is the very best. The freight car that is built today is so much better than the cars that were built in days gone by that there is no comparison. The car may look the same but the components in it are so much better. You can make the same statement about locomotives and many of the other hardware devices that we have.

The high tech tools that are available to us have revolutionized this industry and will continue to revolutionize the future of this industry.

We must remember the human element. Management is needed to motivate and get good results out of our work force more than ever. There will be nothing but success for the company that can harness the intelligence, abilities and interests of its people.

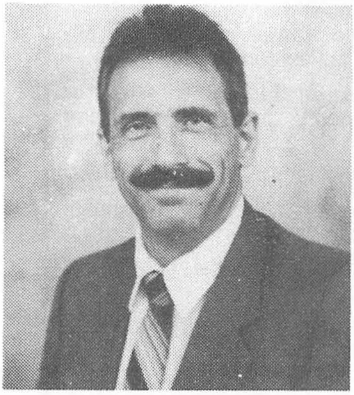
The other side of that coin is if we are not successful in doing so we can't predict a future for this industry.

Thank you for allowing me to speak to you today.

OUR REGIONAL EXECUTIVES

MR. CHARLES MILLER
Mgr. Loco. Plng. Stds. & Prog.
Union Pacific Railroad
Omaha, NE 68179

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



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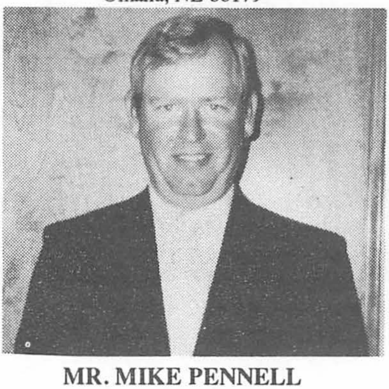
MR. DAVID M. WETMORE
Gen. Mech., Inspector
CSX Transportation
Cumberland, MD 21502



MR. MIKE PENNELL
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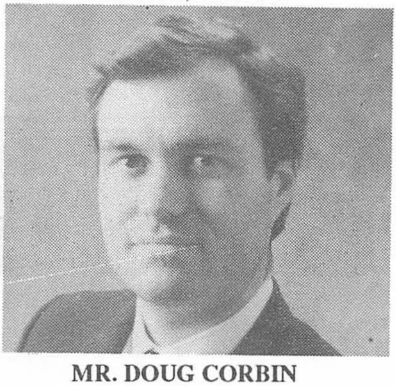
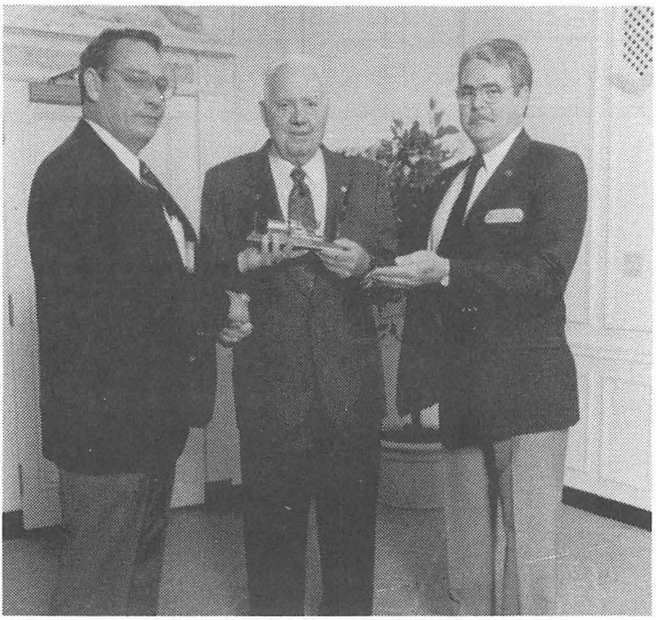


MR. DOUG CORBIN
Asst. Mgr. Loco. Control Center
Norfolk Southern Corp.
Atlanta, GA 30303

Group Photo: Standing-Left to Right: Jack Kuhns, CSX (retired); Past Presidents Dale Propp, Burlington Northern; Bill Brown, Burlington Northern; Darrell Walker, Norfolk Southern; C.P. Stendahl, Burlington Northern (retired). Seated Left to Right: 1st V.P. Weylin Doyle, Union Pacific; 2nd V.P. Mark Coles, Union Pacific; President, Allen Keller, Amtrak; Chairman of the Board, Don Hudgens, Union Pacific.

Chairman of the Board, Don Hudgens, Union Pacific (left) presents General Desk Set to outgoing President, Allen Keller, Amtrak while Jack Kuhn CSX (retired) looks on.

Past President Dale Propp, Burlington Northern (left) presents Past President's Pin to outgoing President Allen Keller, Amtrak. Presentation was witnessed by C.P. Stendahl Burlington Northern (retired) who was LMOA President in 1974.



Past President Darrell Walker, Norfolk Southern (left) presents General Desk Set to Wayne Ewing (retired President of Altoona Gear) for his support of LMOA. Past President Bill Brown, Burlington Northern assisted in the presentation. Mr. Ewing was installed as an Honorary Life Member in LMOA.

Outgoing President Allen Keller, Amtrak, left, presents gavel to New President Weylin Doyle, Union Pacific.

Address by President Allen Keller

Thank you ladies and gentlemen for your attendance and support here this year as well as the support we have always received from the railway supply industry.

For a number of years, my company has allowed me the privilege of attending and participating in the LMOA. This I greatly appreciate and I believe I have benefited from my jobs within this Association, including the honor of representing the Association this year as its president. The job has allowed contact on a personal level with the vice president, the executive committee, technical committee chairmen and the committee members who are the heart of this Association. Without them and the countless hours they put in of their own time and their companies time, LMOA would cease to exist. Their work is the foundation of this organization.

We need to build on and strengthen this base. A number of your Executive Committee members have recognized this need and are taking steps to do just that. We have sought, in the preparation of our papers, to include good ready reference material on everyday problems of running a locomotive facility and maintaining staff organization; material that can be referred to by those who are charged with the responsibility of operating a locomotive fleet.

One of the most gratifying things we can hear, is that a supervisor will say, "I picked up that information out of the LMOA Handbook."

Many of us keep our annual publications in our offices and have them available for ready reference. We have an ongoing need to progress this education down to the lowest levels of the Mechanical department so that the people who are keeping our railroads running will benefit from this work. We need somehow to bring them closer to the work our groups are doing so that we both may benefit from the knowledge that is to be gained.

Membership is the strength of our Association and we need to enhance and increase that membership. New members bring enthusiasm, new problems, new ideas and solutions to our organization. The challenge is to encourage these new members to participate and become active members of our technical committees.

The railroad industry in this country today is involved in the "quality" issue. We at LMOA need to take this same challenge on quality and work it into our entire program. Part of the quality challenge is keeping your eye on the ball. It's remembering the basics while we seek the holy grail. This growing emphasis among customers on quality has had and will continue to have important implications for today's railroad manager. Just as today's manager must guard against letting the process of quality management become an end itself, so must today's manager recognize what the "price of quality" is. He must ask the question, "Is it possible to provide too much quality?" Our people today must balance their ability to improve the quality of their output against our ability to recoup the increased cost of that quality control. More will be demanded of us than ever before. We must be skilled in our discipline but broad in our knowledge base. We must know the price of everything and the value of everything. We must be good businessmen, as well as technically proficient engineers and managers.

Another area that your officers have been working on in the last year is an effort with the Railway Supply

Association and the AAR to identify areas where there might be duplication of effort and a need to strengthen and reinforce one another's work to provide the railroad industry with a locomotive which requires less maintenance and has higher reliability. This line of inquiry is not yet completed and your officers will continue to work with the AAR in this coming year on this study.

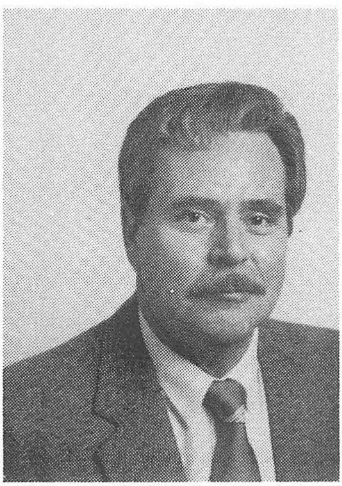
Your organization's finances are in reasonably good shape. There have been no major expenditures in the last year and none are anticipated for this coming year. We anticipate that publication will be released and into member's hands by the end of this year. I would like to personally thank each and every one of the supply industry companies who have so graciously supported our organization over the years. With your help and support, we have published our annual proceedings for over 50 years.

This year we have made a change in the program by dropping the "What's Your Problem" panel session. This change was due partially to lack of questions coming from the floor and partially to a need to provide free time to view exhibits and trackside equipment displays. If this type of session is to return to the program for next year, we must have a show of support from members in the audience that you want this type of panel. If you do, let your officers and Executive Committee know how you feel on this subject, but also be prepared to offer us good advice on how to draw out a stimulating discussion with provocative questions. We do not want to rely on canned questions in the mailbox.

In closing, let me say that I have valued each and every friendship formed through the contacts I have made with this organization. These contacts will continue to help me in the coming years on the railroad as new solutions and answers develop. Thank you again for allowing me this opportunity to address you on behalf of the LMOA and for working to build a stronger, more user-oriented organization. Give your support to Weylin as he assumes the reins of leadership in our organization and give him the backing that he deserves to run this organization.

Our Officers
Past Presidents and
Chairman of the Board

CHAIRMAN OF THE BOARD
MR. DONALD D. HUDGENS
Sr. Mgr. Research & Development
Union Pacific Railroad
Omaha, NE 68179



MR. WILLIAM BROWN
General Foreman
Burlington Northern RR
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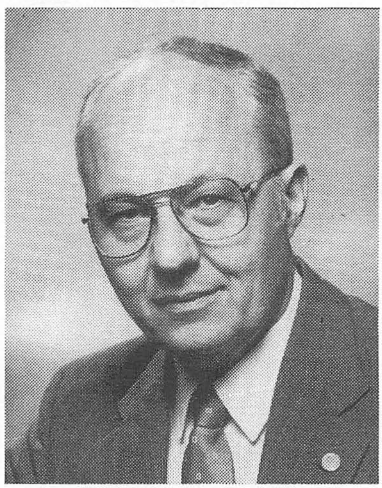

MR. DAVID G. GOEHRING
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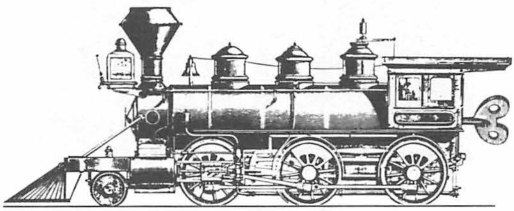
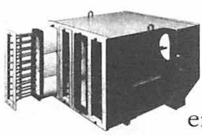
Just about the only locomotive without an AmerKleen filter.





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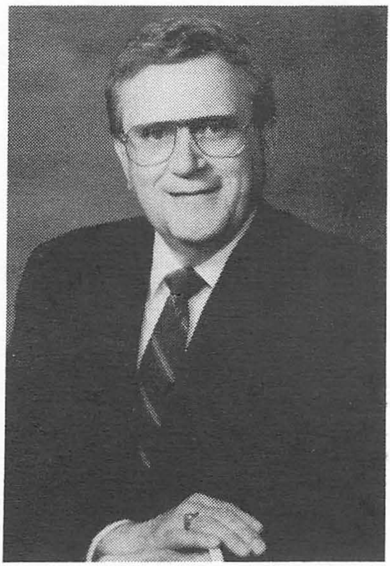

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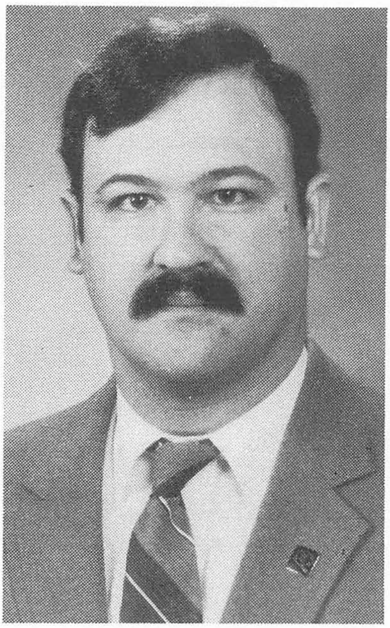

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1948	113	295	1183	1591
1949	134	595	1789	2521
1950	123	595	2101	2822
1951	125	626	2912	3663
1952	135	510	2747	3392
1953	118	597	3288	4003
1954	118	545	2943	3606
1955	81	434	3235	3750
1956	110	419	3257	3786
1957	100	423	2678	3201
1958	82	350	2320	2752
1959	90	387	2395	2872
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1966	163	464	2368	2995
1967	180	408	2327	2915
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1981	114	445	1143	1702
1982	102	440	1261	1803
1983	92	386	1025	1503
1984	95	400	1116	1611
1985	90	386	1006	1482
1986	90	320	702	1112
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1990	67	215	402	684
1991	60	197	405	662

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1948— C. D. ALLEN (Deceased) Asst. C.M.O. — Locomotive, C. & O. Ry. & B. & O. R.R.
1949— J. W. HAWTHORNE, Retired, Asst. Vice-Pres.-Equipment, Seaboard Coast Line R.R., 206 Strongbow Court, Sun City Center, FL 33570
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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.
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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.
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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
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1981— R. G. CLEVENGER, Retired General Electrical Foreman, Atchison, Topeka & Sante Fe Rwy., 5802 W. 157th Terrace, Overland Pk., KS 66223

PAST PRESIDENTS (Con't)

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1983 - F.D. BRUNER (Deceased) Asst. Chief Mechanical Officer-R. & D. Union Pacific Railroad
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1991 - D. D. HUDGENS, Sr. Mgr. R & D, Union Pacific, 605 N. 13th St., Omaha, NE 68179

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C.N.. WIGGINS, Retired V.P. and Asst. to Pres., Louisville & Nashville R.R., Louisville KY

Southwestern Railway Club

Started in 1946, the Southwestern Railway Club this year is celebrating its 46th 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.

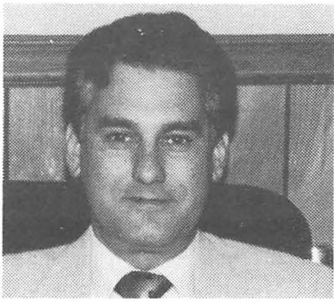
C.T. KUNKEL
President
Union Pacific Railroad
Omaha, NE 68178

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

REPORT OF THE COMMITTEE ON DIESEL MATERIAL CONTROL

MONDAY, SEPTEMBER 21, 1992
10:00 a.m.

Pre-Convention
Presentation
Southwestern Rwy. Assn.



March 18, 1992
La Mansion Del Rio Hotel
San Antonio, TX

LOU CALA, Chairman
Mgr.-Material Control
Conrail
Altoona, PA

Vice Chairman
R. CORDER
Director-Material
VMV
Paducah, KY

COMMITTEE MEMBERS

W.O. Albritton	Mech. Supt.	Paducah & Louisville	Paducah, NY
H. Bailey	Dir-Material Mgmt.	Amtrak	Philadelphia, PA
J. Griffin	Material Analyst	Electro-Motive Div.	Hodgkins, IL
M. Kardos	Supervisor-Material	Conrail	Pittsburgh, PA
P.F. Mastrian	Manager-Material	General Electric	Erie, PA
J. Minnie	Manager-Material	Burlington Northern	West Burlington IA
H.E. Nash	Director of Purchasing	Montana Rail Link	Missoula, MT
D.L. Veron	Mgr-Material-Diesel	Norfolk Southern	Roanoke, VA
W.J. Wewers	Equipment Supervisor	AT&SF Rwy. Co.	San Bernardino, CA

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).

Lou and his wife Joan have three children: Angelo, 28, Vicki 26, Lou, Jr. 6 and one granddaughter. They currently live in Altoona where Lou is Mgr. Material Control for Conrail.

I. WARRANTY OVERVIEW AND ISSUES

Presented by William Albritton
Paducah & Louisville

A. An OEM's View of Warranty

Warranty, by description, is a necessary downside of doing business within a service industry. It is understood that a locomotive and related spare parts are goods. But, if these goods do not function, the owner operator cannot perform the service of hauling freight. Consequently, when a locomotive is out of service for any period of time, there is a loss of revenue which reduces profitability, thereby negatively influencing cash flow and the ability to purchase additional goods.

An original equipment manufacturer (OEM) of these goods has a price of nonconformance called *Warranty*. It is not an option to be purchased, nor an added feature to make the owning of the product more appealing. It is an attempt to minimize the level of dissatisfaction incurred by a customer when a product does not perform as expected.

There are three types of warranties: normal, modification, and policy. Within the last five years, normal and modification warranties together, averaged close to 90 percent of the total warranty expense. The balance of the expense is attributed to policy. This discussion will focus on normal warranty; however, to clearly define what is meant by "Normal", a definition of the other two is required.

Modification warranty allows for alterations to be made to equipment (generally new locomotives) which have been put into service, and which have demonstrated defects. These defects are not necessarily known at the time of delivery. They could have been original engineering errors, a consequence of "locomotive infant mortality", defective components, faulty-workmanship, or problems discovered after tonmiles were incurred. The cases wherein the OEM may decide to make alterations vary, but they all have one thing in common: it is at the OEM's expense, inclusive of labor and materials.

Policy warranty addresses the failures and associated damage not within the normal warranty periods. Policy settlements address customer claims not covered by stated warranty policies or other agreements. These settlements provide the customer an increase level of confidence in the manufacturer's willingness to resolve issues in which the manufacturer shares some responsibility.

Normal warranty covers failure of all equipment: new locomotives, power products, after-market parts, and Utex rebuild material. There are over 20,000 different parts in just a single locomotive. Each and every one of them is covered under a warranty policy. It is not always cost effective, however, to submit a claim for the smaller, less expensive parts. Failures must be examined and consequential damages must be determined. In some instances, a minor part, such as a bolt, could shear and cause a catastrophic failure in a turbo. This is warranted as associated damage, and the OEM would accept responsibility for damages incurred.

The basic warranty is two-years/250,000 miles on new or line rebuild locomotives. Removal of a non- failed component from the original locomotive, and installation by the customer on another locomotive, changes all of this; the customer then become responsible for the installation of the component. In general, non-failed components removed from a locomotive during the warranty period and reapplied elsewhere, revert to the warranty for new service parts. For new service parts, the warranty is one-year/100,000 miles, with a three year shelf life. Therefore, if a service part is purchased and then warehoused for 35 months, it has the standard on-year/100,000 mile warranty

Typically, it is the responsibility of the OEM's field service engineer, in conjunction with the customer to determine the service life of a failed component. With respect to locomotives, the OEM can refer back to the date of installation, and can retrieve the mileage via the wheel sets and microprocessors. The serial number of the major components such as:

Traction Motors
Main Generator
Auxiliary Generator
Governor
Air Compressor
Blower Motor (Inertial & Traction Motor)
Cooling Fan (Radiator & Dynamic Brake)
Engine
Engine Blower
Turbocharger
Crankcase and Oil Pan

are documented and can also be used as reference. But note that not all parts are serialized. Those that are, are not maintained on an on-line database. Therefore, cross references of the date of manufacture, date of purchase, point of delivery, and unit applied to, are not readily available.

There are Utex/Rebuild components which are serial number controlled, such as:

Traction Motors
Traction Motor Armatures
Main Generator
Generator Armature
Governor
Grid Blower Motor
Cooling Fans
Auxiliary Generator
Auxiliary Generator & Blower
Traction Motor Blower Motor
Engine
Engine Blower
Alternator
Modules
Crankcase & Oil Pan
Air Discharge Blower Motor
Head End Power Gear Boxes
Turbocharger

These serial numbers were established mainly for inventory control purposes and can be used to identify if that component was previously rebuilt, but they would not indicate whether or not a rebuild other than the OEM had rebuilt it. So, at best, the serial number, date of installation, actual mileage, and condition of the component are all *factors* considered toward the warranty of a component. No one factor alone can be used definitively.

In cases when a part does fail and the customer decides it should be covered by warranty, he should first contact a field service representative. Based on this contact, the part may be either:

scrapped at the customer's location

or

returned for tear down and decision of responsibility.

Submission of a claim does not automatically replace the failed part. That must be supplied under the new part sales transactions. The warranty procedure only accomplishes monetary compensation for a failure, and if chosen, subsequent repair of that component. If the decision is to return the material, it is imperative that the customer provide adequate protection to prevent shipping and handling damage. Damage to a failed item subsequent to the failure may destroy evidence indicating cause of failure and may result in rejection of a warranty claim.

B. How Railroads Identify Warranty Items

In today's world, the thought of manually maintaining records for items covered by manufacturer's warranties on a fleet of locomotives operated by a Class I railroad is enough to create nightmares and sleepless nights! Yet, with the almost unlimited capabilities of current generation computers, the ability to record, monitor, and identify items covered by manufacturers' warranties is now a reality. Warranty still, however, remains a major problem for all concerned.

Proper handling of warranty items with the manufacturer is one way for railroads to reduce their operating costs. This also allows the railroads the opportunity to review handling and installation procedures, and allows the manufacturers to inspect their products to determine ways to improve product reliability.

Some railroads have established a department or have assigned individuals the task of establishing policies and procedures for tracking and monitoring warranty items. One major railroad has saved several million dollars through warranty tracking in the past year alone. Surely, we can all agree that this is a step in the right direction.

In most cases, manufacturers' warranties begin on the date of installation and extend for a period of up to one year or 100,000 miles. Shelf life for products is something that must be considered and monitored if warranty begins on date of purchase. Inventory control plays a major part in controlling warranty.

How Do Railroads Identify Warranty Items and the Manufacturer:

1. Each vendor is assigned a number or code. This information must be recorded at time of installation. Components must be identified by vendor's name or vendor's code number for tracking.
2. Identify component by use of code number or abbreviation of name and serial number, if applicable.
3. Identify shop that installed component by code number or abbreviation of shop name.
4. Identify date component was installed.
5. Identify warranty expiration date.
6. Locomotive number.
7. Position or location in which component was installed.
8. Supervisor's or employee's name to verify component was installed as recorded.
9. Some on-board computers have the capability of maintaining this information.

C. Compensation For Warranty Items

What is the most economical way for your company to be compensated for warranty items? The following are several items for consideration:

1. Replacement of failed component.
2. Credit toward future component.
3. Cash reimbursement for failed component.

Other items for consideration include:

1. Who is responsible for freight charges for return of warranty item?
2. Inspection procedures and time intervals for joint inspection on return components.
3. Return time on replacement components.

D. Information Needed For Input

Into The Warranty System

Mechanical, Materials Management, and Purchasing all need to be informed about failed components covered by warranty. The same information is required as when components were installed except for minor changes:

1. Identify shop that removed component.
2. Identify date component was removed.
3. Identify reason component was removed by use of code numbers or brief written explanation.
4. Ensure that failed component is tagged with warranty tag.
5. Ship component to location that will notify manufacturer, make necessary arrangements for joint inspections, and handle paperwork.

You can maintain the most complete locomotive component records, but two simple questions must be answered to make these records useful:

1. How do your shop employees and supervisors identify items removed, and whether they are covered by a manufacturer's warranty?
2. How soon do you move warranty material to a strategic location for handling?

E. Problems encountered between railroads and suppliers when dealing with Warranties.

Some problems faced by the railroads are:

1. Misprinting: Misprinting of the serial numbers on the paperwork corresponding to the items under warranty creates a problem for the material and accounts payable personnel proper identification and processing.
2. Extended Warranty: Extended warranty programs are not offered unless asked for. These programs are available and may not involve extra costs, but information is not offered unless we request it.
3. Time Lag: The response time from completion of warranty work to receipt of paperwork explaining the breakdown of warranty acceptance or rejection is too long. The decisions on warranties need to be made while the work is being done so parts can be checked on and problems resolved.
4. Settlements: The time involved in claim settlements is too long.
5. Identification: Warranty items need a better identification system so they can be immediately recognized upon arrival from supplier and not mixed in with other non-warranty items. Large items have serial numbers for identification, but small items do not. There should be some means of identification to prevent these parts from getting lost in the shuffle.
6. Expiration Date: The warranty expiration date and additional warranty time for shelf life need to be clearly identified.

We are certain that the above-mentioned items are not all the problems to be noted, but are only a random sample from both Class I and shortline railroads. The goal of both suppliers and railroads should be to have better communication and 100 percent customer satisfaction.


ACCEPTING
the
CHALLENGE
Comfort Cab
Advanced Technology Microprocessor
Radial Truck
WARRANTY
We accept your challenge to provide cost-effective solutions to some of your toughest problems. And in today's economic environment, that's no easy task. We're still continuing our research and development activities so we can provide you with new products, processes, and technologies to help you meet the competitive challenge.
GM
ELECTRO-MOTIVE

II. RECYCLING - 1992

Presented by John Minnie, BN

Last September this committee presented its paper on recycling. The emphasis at that time was that we all generate similar types of waste and that, from an environmental standpoint, railroads should be responsible for what they generate. Recycling is a large part of the answer to how we responsibly handle our waste. Today, not only is it good to recycle to comply with the regulations and environmental issues but it is also becoming much more attractive from a financial standpoint.

Because of the tremendous amounts of waste generated in the United States and the environmental problems associated with landfilling and incineration, the Environmental Protection Agency under the Resource Conservation and Recovery Act has established a list of preferred methods of handling waste. Most of us are familiar with this act as it pertains to hazardous waste but it only makes sense with any type of waste we generate. Basically what we are mandated to do, to reduce the generation of waste is a follows:

1. Source reduction-reduce the amount of waste generated at the source. Find alternative methods for how we do business.
2. Recycle-remove and recycle recyclable materials out of the waste stream.
3. Incinerate-for recovery first and volume reduction secondly.
4. Landfill-last option.

Aside from the state and federal regulations there are other good reasons for recycling. First and foremost, we are running out of space. The EPA estimates that 75 percent of all existing U.S. landfills will close within the next 10 years and there are many areas of the U.S. that are already experiencing severe disposal problems. A number of Eastern States have less than five years left before their landfills reach capacity and a considerable amount of the waste now generated in the East is being landfilled in the Midwest. Again the problem here is that many midwestern states will also close their landfills within the next 5 to 10 years. Through recycling, we can reduce the amount of waste being landfilled and extend the life of the landfills that we use.

Financially it is also important to look at alternative methods to landfilling due to rising disposal cost. As the number of landfills diminishes and as regulations become more stringent, our costs will continue to increase. One railroad's, cost for compacted waste has increased by 94 percent and loose waste has increased by 111 percent this year.

To review our discussion from last year, what waste are we talking about?

1. Office Waste

A large railroad will generate over 1.25 million pounds of white paper per year, paper which can be recycled or reused. This paper can be shredded to make packing or it can be recycled. If recycled, not only do you reduce paper going to the landfill, but the paper can be sold, which helps offset recycling cost.

In addition to the standard white paper, we should also look at the forms we use. Do we need multi copy and multi-colored forms and how many copies are really needed? Can we utilize carbonless paper in our forms, thereby eliminating another piece of paper?

Excess magazine and brochures are also another source of paper waste which needs to be addressed. Take a look at what you are receiving and eliminate excess copies. Sharing reading materials will also reduce waste. While the advent of computers has reduced the amount of paper that we generate, computers also produce waste that requires handling. Printer paper can usually be recycled as part of the white ledger paper stream and printer cartridges can also be recycled instead of landfilling.

2. Packaging

Besides waste paper, cardboard packaging is probably the second largest source of bulky waste in our business. A large railroad will generate in the neighborhood of half a million pounds of cardboard annually. This is probably one of the easiest items to recycle - it can be reused, such as in the repackaging of other materials or it can be recycled by bailing or compacting. Basically all that is required is that you separate it from your other wastes.

The other problem associated with packaging is filler. Alternatives to styrofoam and styrofoam peanuts includes shredded paper, newspaper, magazines, corn starch based peanuts, popcorn, and other materials not harmful to the environment.

3. Operational Waste

Rags, shop towels, paper towels? What's the answer. Each of us needs to examine this situation to determine what is the best method to satisfy our employees and create less impact on the environment. Laundering of shop towels, jackets, and cloth gloves is becoming more appealing. Recycling these items reduces the cost of replacement and landfill cost.

Millions of oil filters are used by railroads annually resulting in another enormous problem of how to dispose of the used filters. Alternatives to landfilling include, incineration, filter crushers, and the use of a centrifuge. In the case of the last two alternatives, oil and the filter are separated with the filter going to the landfill and the oil being recycled.

Wicks are also another item that railroads have found to be recyclable. Wicks can be recycled on a unit exchange basis with the waste pad being incinerated and the rest of the assembly reused to make new wicks.

Finally, a number of railroads are already recycling pedestal liners. In this scenario the pedestal liner material, a type of plastic, is ground up and reused in the manufacture of new pedestal liners or other new products. On a large railroad this equates to approximately 24,000 lbs of non biodegradeable plastic which won't be buried in a landfill.

Last year we also asked for suggestions on railroad related materials that we felt were a problem; materials that have traditionally been landfill because there were no other alternatives.

4. Composition Brake Shoes

It is estimated that a large railroad would use over 1/2 million brakes shoes and a small railroad would use over seventeen thousand shoes early -- which equates to four million pounds of waste. When you consider the total number of railroads in this country, this is a tremendous amount of material to throw into a landfill. A number of railroads are now recycling shoes with certain manufacturers who will accept their own composition brakes shoes back for reclamation. The metal backing is stripped off the shoe and recycled and the composition material is ground up and used to make new shoes.

5. Rubber Hoses

Many landfills now restrict the dis posal of rubber products such as air hoses, tires, and other rubber items. The good news is that air brake hoses can now be recycled with the hoses being ground up and remelted and used for other products and the metal ends recycled in the manufacturer of new hoses. To a large railroad this means 250,000 lbs. of rubber saved from the landfill each year.

6. Wood Products

Pallets and wood reels, again, are a big problem. Whether paying by the ton or cubic yard, wood products eat up valuable space in the dumpster and results in more trips to the landfill. Alternatives included repairing and reusing pallets and reels or crushing or chipping the wood for reuse. In the past it may not have been economically feasible to look at repairing pallets but with landfill costs rising, it's time to look at the situation again.

7. Drums

Drums, both metal and plastic, are recyclable. Some suppliers will accept return of their own empties; if not, there are drum recyclers willing to buy most types of used drums. Another alternative to handling large volumes of drummed products is to look at the use of totes. Totes can be used and returned for refilling. Not only does this alleviate the hassles of disposing of empty drums but it also saves the time and money involved with rinsing, cleaning, storing, and moving of drums. Totes, in a lot of instances are also safer and easier to handle.

8. Glass

As we look into recycling we see different opportunities and challenges that need to be addressed. One recent success story involved the reclamation of passenger car side windows. The windows involved were a double pane polycarbonate window. Damage to the exterior pane required replacement of the entire window, until the railroad looked into recycling. Now the exterior pane is replaced and the rest of the window is reused, resulting in an estimated annual saving of approximately $200,000 and less material going to the landfill.

In conclusion, as landfills reach capacity and costs soar, the ideal of recycling becomes a much more viable solution to a serious problem. Interestingly enough, it is a program that works. Most employees eagerly buy into it and it perpetuates itself. Once you start looking at the way you are doing business you begin to see more opportunities to recycle.

III.
BAR CODING

Presented by Dave Veron, NS

The technology available to us from the electronics industry has come a long way over the past few years. Improvements have been made, increasing speed and accuracy and giving us the opportunity to make management decisions with very close to real time information.

Many major railroads and manufacturing companies are utilizing bar code systems in the day to day activities of material control. Today's world also includes a large number of short line and regional railroads. Many of these companies are trying to decide if bar coding is the correct path to follow in controlling inventory. The investment in time and money can be large, depending on the depth of the system, or as little as a few thousand dollars and a couple of months with a scanning device, a telephone, a line and a modem, a quality printer, bar coded labels and a PC.

We would like to update the industry on where we are and where we are going in the future, while giving the regional and short lines an idea of the opportunities available.

The major contributing factor in bar coding is improving accuracy and controlling inventory throughout the entire organization. The real time factor allows us to make decisions based on valid, up to the minute information. When installed properly and utilized to the greatest possible extent, the return on investment can be great.

The speed of data entry is 2-3 times faster and can often be 7-10 times faster than keying. One major U.S. company, to prove a point, whipped a frisbee, with bar codes containing data stuck on the rim, past a stationary camera lens. The date was recorded. That test gave credit to just how far machine vision has progressed in the past few years.

Some of the decisions required to get into bar coding have been simplified by the railroads. A specific symbology has been selected. Code 39 (three wide bars for every nine) is universal in the U.S. rail industry. We do not have to look at the many varied formations and structures of bar codes in selecting a system. It can be very confusing for a new person on the block when we are bombarded with a symbology list that includes two of five, interleaved "3852", AIAG, Logmars DOD Military Standard 1189, Codabar, UPC/EAN, code 93, code 128, code 16, code 49 and code 39.

Code 39 is the most widely used alpha-numeric code in this country.

Printers are almost as varied as the symbology. When researching we must choose the printer best suited for our requirements. The list to choose from includes dot matrix, drum/formed characters, thermal direct, thermal transfer, electrostatic, laser etcher and ink jet to name a few. All have advantages and disadvantages and the cost and quality vary. We must carefully choose the printer that gives us the quality required at the cost we can afford.

Input devices include wands and laser scanners. Some of the advantages of wands are:

Relatively inexpensive
Rugged
Lower power consumption
10 year old technology
Reads any length bar code label
Good for menus
Compact and lightweight.

Disadvantages of wands include:

Requires flat hard surface

Requires user training
Constant speed and pressure
Density dependent
Contact Scanner
Wears out labels.

Laser advantages include:
Non-contact
Reads multiple densities
Easy to learn
Multiple automatic scanning
Reads codes on irregular surfaces
Does not wear out labels.

Lasers disadvantages:
Infrared only reads carbon
Large power consumption
Heaviest and largest hand-held scanner
More expensive
Most fatiguing.

Radio frequency (RF) hand held scanners that are capable of almost instantaneous response time are available at a considerably lower cost than five years ago. These systems can read data from tags that are not visible to the system. A radio signal is transmitted toward the tag, and it responds with a radio signal that is modulated with information stored in the tag.

Opportunities for bar coding include:
Receiving
Inventory management
Material movement
Production
Packaging
Warehouse distribution
Shipping
Administration.

The use of bar code systems has been substantially improved over the past four or five years. For example, four years ago a Southern railroad would count and bar code an item in its stocked location and download the data into the mainframe. A paper purchase order was then generated using EOO on hand, and on order quantities. The paper order was reviewed, signed and mailed.

Today, the item is still scanned in its stocked location, but much more takes place. The same data are downloaded into a stand-alone system, where the calculations using EOO, on hand and on order are performed. This data are then reviewed on a CRT by the material control staff at the using location, and if the material is required, the information is downloaded into the mainframe.

The mainframe checks the actual item against all other stocking locations, and if there is surplus available, a "pick list" is sent to the overstocked location, requesting shipment of the surplus item to the requisitioning location. If there is no surplus, and if new material must be purchased, a purchase order is generated using factors available in the system. The order is then transmitted and reviewed by the appropriate individuals, where the "buy" decision is confirmed. When confirmed an EDI purchase order is transmitted to the vendor. If the vendor is not on EDI, a paper order is prepared, signed and mailed.

Receipts are being processed with the use of bar codes at one location at the present time on this same railroad. The manufacturer is putting a bar code label on the package, and the label is read with a wand connected directly to the stocking location's stand-alone system. The computer then advises the bin location. After a wanding session, the information is downloaded into the mainframe and the material is receipted. The data processed includes the recalculation of the on hand stock counts, and the on order quantities. It also advises accounts payable that it is permissible to pay the invoice.

There are plans to expand this receipting system to more shops in the near future. Another major railroad is testing a new, coin shaped data carrier that records simply with a touch. Information stored in the "coin" is read by computer with a momentary contact. The chip is programmed in the same way. The stainless steel obviously has more durability than a paper label.

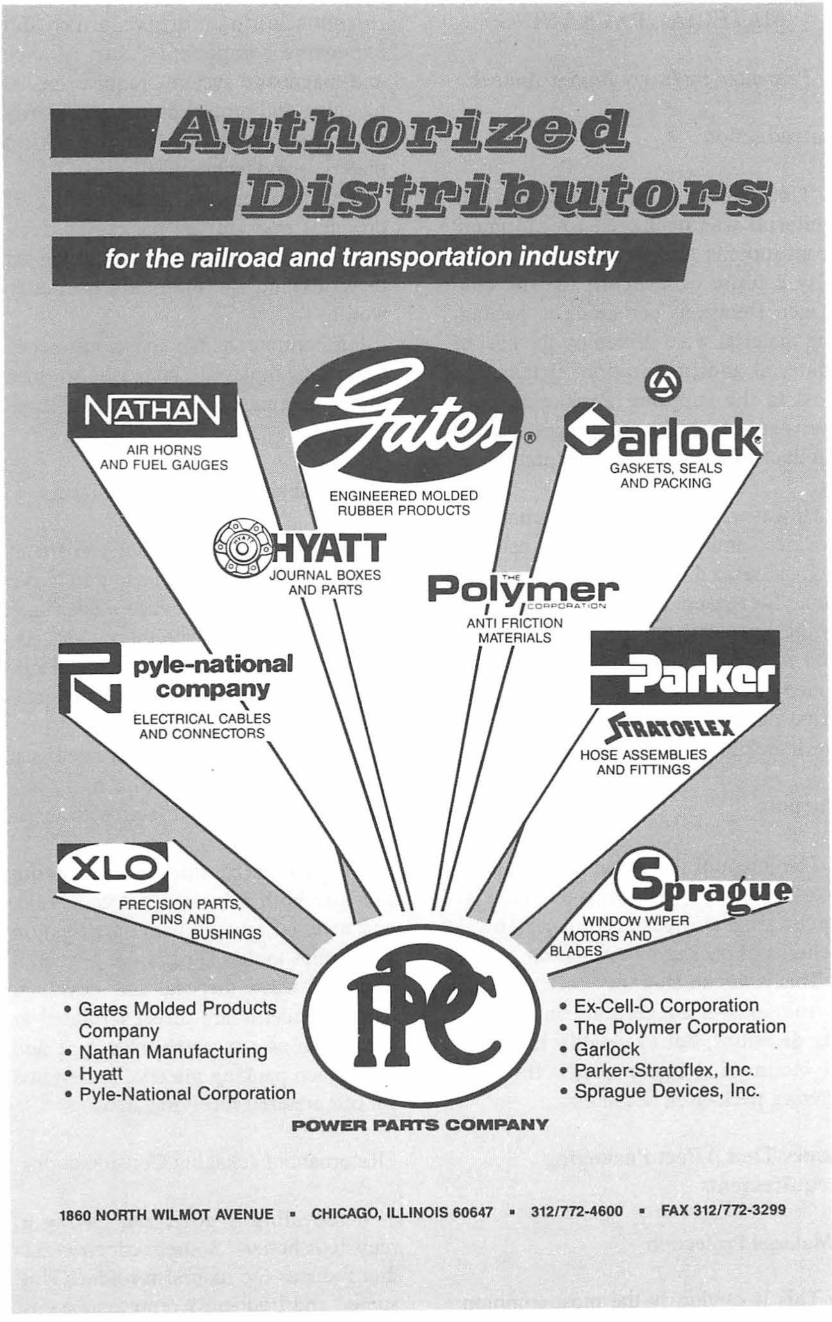
Touch memories are available with adhesive backing to attach to virtually anything. These data carriers move up-to-date information with the objects to form a very flexible network without wiring.

Touch memories can be read and written. Whereas bar codes have a fixed identity, touch memories are dynamic, and they can be reprogrammed while attached.

Still another major railroad is looking at bills of material and the analysis of supply and demand for a given piece of material. The data gathered show the forecasted date, the amount of material on order, a running total of usage and orders, and the forecasted amount of orders required to meet the forecasted requirements.

This railroad is not presently utilizing bar code in this process, but it is a definite possibility.

In conclusion, bar coding has come a long way during the past few years, like everything connected with electronics industry. Hardware costs have decreased, and the products available to us are more advanced than ever before. Accuracy, speed and efficiency in data entry are increased substantially with the use of bar coding, if the capital investment is available. Labor forces may be freed up to do more production work and fewer clerical functions with better controls in force than ever before.



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IV.
MATERIAL PACKAGING

Presented by Harry Bailey, Amtrak

Introduction

Until recently, the manner in which material was packaged for shipment from supplier to customer was not usually a topic of concern for the customer. Decisions pertaining to packaging material were driven by the cost of material and preparation; that is, the cost to the supplier. Packaging concerns ended with the assurance that the product would reach the customer safely.

However, in today's rapidly changing business atmosphere, material packaging and related issues are gaining attention. Increased focus on the cost of doing business, environmental topics, and warehouse and distribution productivity all combine with new and innovative packaging options to warrant a fresh look at material packaging.

Purpose

The intent of this paper is to provoke consideration pertaining to material packaging and associated potential benefits of packaging evaluation.

This is *not* an attempt to offer specific solutions or suggestions on packaging decisions, but to identify the areas of business that can profit through altering packaging decisions.

Issues That Affect Packaging Requirements

· Material Protection

This is obviously the most common concern in the packing requirement decision process. Technical advances in the railroad industry have led to the introduction of more sensitive and expensive components. Surveillance and diagnostic systems require special handling and protection not necessarily provided by conventional packing materials and techniques.

The storage and warehousing of products may impact packaging decisions. Packaging which is not designed to withstand the elements normally won't.

Furthermore, as the consciousness of hazardous materials increases so does the packaging considerations of these materials.

· Disposal and Environmental Issues

But regardless of whether you are an environmentalist or not, you have incentives to reduce waste. There are opportunities to reduce the rapidly rising cost of waste disposal at your facility or company through innovative and alternative ways of packaging.

The last thing companies need is a black eye with the public and consumers who are concerned with environmental issues.

Consequently, there is increasing pressure both internal (cost concerns), and external (government agencies) on companies to do the right thing when it comes to waste disposal and recycling. These concerns are directly related to the decisions governing what type and how much packing material is destined for our material receiving areas.

· Returnable Packaging Considerations

If recycling is good, not having to recycle is better. "Source reduction further reduces the natural resources consumed and frequently represents a cost reduction." says Robert Rothfuss, vice president of marketing for Buckhorn, Inc., manufacturer of reusable plastic shipping storage and handling containers. He continues, "The simplest approach is one with more impact potential is shipping in reusable containers."

The use of reusable containers often eases the task of accumulating and shipping repairable components and standardizes containers. This lends itself to potential warehouse efficiencies such as space utilization and safer handling.

· Ergonomics, Transportation and Distribution

Everyone in the railroad industry is aware of the importance and impact of the issue of safety. The dollars associated with FELA payout will further escalate the importance of this topic. The difficulty of handling materials relates directly to the potential for injury not only during the receipt and stocking process but in distribution. Packing considerations effect safety.

Some basic observations have resulted in changes impacting packaging and related safety issues. For instance, some roads require suppliers to discontinue using metal banding in their packaging process in an effort to avoid the associated risks inherent to this type of banding material.

Related to the handling and safety issue is the effort and cost of distribution. The introduction of new operating programs such as just-in-time and cycle-time reduction, has given rise to distribution systems. It is estimated that order picking accounts for approximately 62% of the average distribution facilities operational costs. The packaging of a product can significantly impact the effort required to pick and distribute material.

A product in its package is the lowest common denominator in a distribution system. It threads its way through the system on material handling equipment, storage devices, and transportation equipment. Efficient operation of any system requires that two package related distribution rules be adhered to:

1. Utilize available space and all system hardware to eliminate wasteful movements and labor.

2. Build a system that is adaptable to a wide range of needs.

The package interface is crucial in system operation because it has a direct bearing on these points.

General Guidelines and Observations

· Employee Involvement

In material packaging probably the single most important consideration is employee input and involvement. The benefits are twofold:

· The employee closest to an issue or problem normally possesses the most comprehensive understanding of the circumstances surrounding the problem.

· When an employee has input regarding a decision he/she has a greater tendency to support the resolution. Employee involvement is just plain good business.

· Flexibility

Site specific packaging considerations are very common. It is not unrealistic to specify multiple packaging requirements for a given item depending upon individual facility considerations or requirements.

· Customer Satisfaction

This consideration is often over-looked since it frequently occurs after the material has passed the materials management area and is in the hands of the user. What impact does the manner of packaging have on the user/customer? Could the user be more productive if a kit were developed instead of supplying individual components? Users should have an opportunity to input into packaging decisions.

Conclusion

The numerous operational concerns-facing our industry today-protection of valuable material, waste disposal, economics, ergonomics, etc - all combine to necessitate a fresh and continuing evaluation of packaging options and associated benefits. We can no longer afford not to view packaging decisions as a critical aspect of our business environment.

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The Board of Directors
The Chicago Railroad
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REPORT OF THE COMMITTEE ON FUEL, LUBRICANTS & ENVIRONMENTAL

MONDAY, SEPTEMBER 21, 1992
1:45 p.m.

Pre-Convention
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Chicago RR Mech. Assn.

April 13, 1992
Union League Club
Chicago, IL

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PERSONAL HISTORY

Ron Lodowski

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

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

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

He has been married for 23 years and his wife's name is Susan. They have two children, Michael, 22 and Nicole, age 6.

I. ENVIRONMENTAL ISSUES RELATING TO MULTIGRADE RAILWAY OILS

Prepared by Jerry Thompson
Assoc. Research Scientist Consultant
Ethyl Petroleum Additives
Wheaton, IL

Introduction

The energy crunch of the 1970s brought home the realities of fuel shortages and escalating prices to North American railroads. Boundless supplies of inexpensive high quality fuels were no longer taken for granted and a new era of conservation dawned. For the remainder of the decade and throughout the 80s, energy conservation and increased operational efficiencies were vigorously pursued throughout the rail industry. During this time period, more fuel efficient locomotive engine designs and modifications evolved. In fact, today's fuel efficient EMD and GE locomotives offer fuel savings of 15 to 20% compared to a typical road locomotive of 15 years ago. In addition, locomotive reliability has increased, resulting in less downtime and fewer repairs. Railroads now utilize power more effectively and locomotive duty cycle has gradually increased.

Although conservation emphasis was initially directed toward energy or fuel savings, it soon expanded to include a variety of environmental issues that have become increasingly important to the rail industry. Federal regulatory initiatives like the Clean Air Act, the Resource Conservation and Recovery Act (RCRA) and other federal and state mandates have broadened conservation and environmental concerns beyond fuel and energy issues to include storage tank maintenance and monitoring, exhaust emission control, spill containment plans, storm/waste water discharges and disposal/recycling of used oils, oil filters, brake pads, drums and other materials. For the rail industry, the 1990s may well be known as the "environmental" decade.

A new generation of railroad diesel lubricating oils, featuring unique new additive chemistries, has emerged to serve the needs of this environmental decade. These lubricants provide the long life, excellent wear protection and superior performance needed to accommodate increasingly severe locomotive duty cycles resulting from more efficient utilization of motive power. As an example, one railroad reports that locomotives that formerly logged about 130-140,000 miles per year may now cover 200,000 miles in the same time period. Development of these improved lubricants has been reported in previous LMOA Fuel and Lubricant papers dated from 1988 through 1991.

These improved lubricants are now available in both SAE 40 and 20W-40 viscosity grades. Several major railroads have switched to the use of multi-grade railroads lubricants over the past few years, and by the end of 1992, most Class I North American railroads will have converted to use of SAE 20W-40 viscosity grade lubricants.

Fuel Savings

The conversion to use of multigrade oils has been driven by several important advantages that have been documented in field and closely controlled load box and stationary engine tests. Improved fuel economy is by far the most significant economic advantage associated with use of multigrade railway oils. Burning less fuel also reduces exhaust emissions released to the atmosphere. Table 1 summarizes fuel savings reported in the literature for multigrade railway oils in closely controlled locomotive engine tests.

Table 1 - Multigrade Fuel Savings (vs Throttle)

Engine	Type Test	% Savings - Throttle Setting		
		Low (N1)	Medium (N4)	High
2 Cycle	Stationary	4.1	1.5	0.5
2 Cycle	Load Box	4.6	1.4	0.5
4 Cycle	Stationary	6.5	0.7	0.2
4 Cycle	Load Box	8.5	3.6	Nil

These studies show that fuel savings for multigrade oils vary with notch or throttle setting and are greatest at low throttle setting and are greatest at low throttle settings, gradually tapering off to about 0.5% or even less at #8 notch.

Table 2 - Multigrade Fuel Savings (vs Duty Cycle)
NR - Not Reported

Engine	Type Test	Duty Cycle, % Savings		
		Switcher	Medium	Heavy
2 Cycle	Stationary	NR	0.9	NR
2 Cycle	Load Box	3.3	1.1	0.9
2 Cycle	Load Box	NR	0.9	NR
4 Cycle	Load Box	5.5	1.1	0.5
4 Cycle	Load Box	6.4	1.3	0.8

Expected duty cycle fuel savings calculated from data like that in the previous table are shown in Table 2 and range from a high of 5 to 6% for switcher or yard duty locomotives to about 1% for medium duty road locomotives and 0.5 to 0.9% savings for heavy duty service. Fuel savings of this magnitude are difficult for a railroad to verify in the field for a large fleet of locomotives. Hence, savings are often accepted on faith derived from the fact that all studies conducted under controlled conditions in locomotive engines have clearly indicated some degree of fuel saving for multigrade railway oils. However, several large North American railroads have recently documented and reported savings of 2 to 4.5% for multigrade oil use over an extended time period. These savings exceed that predicted from stationary engine and load box tests and, even if overestimated, further support the significant savings claimed for multigrade railway oils.

It is also important to remember that any improved fuel economy derived from use of multigrade lubricants is "additive" or "in addition to" savings already realized from more efficient engine designs and/or use of track lubricants.

Lube Consumption Savings

In addition, multigrade lubricants offer another resource conserving and cost saving benefit: *reduced oil con-*

sumption. Oil consumption data culled from field tests and reported fleet service experience are summarized in Table 3.

* *Comparisons per million gross ton miles freight.*

Table 3 - Oil Consumption Savings

Railroad	Test Type	Oil Consumption* % Reduction	Oil Consumption % Reduction In Lube/Fuel Ratio
A	Controlled Field Service Test	18-22%	22%
B	Fleet Field Service	23.5%	-
C	Fleet Field Service	15.8%	12.5%
D	Fleet Field Service	16.4%	17.1%
E	OEM Field Test	-	16.4%
F	OEM Field Test	-	22.9%

These data indicate that multigrade oil consumption compared on a million gross ton mile or lube/fuel ratio basis can be reduced more than 20% compared to that observed for medium viscosity index (MVI) railway oils used almost exclusively by U.S. railroads prior to the introduction of multigrades. The improvement in oil consumption can vary depending on the age and mechanical condition of locomotives but significant, demonstrable reductions in oil consumption have been documented. At least four large railroads (A thru D) have reported that oil use dropped about 16 to 23% during the year after switching to multigrade lubricants. These data agree with field test data reported by two other Class I railroads (E,F). These significant reductions in oil consumption can justify a switch to a multigrade railway oil -- even if fuel savings are not considered in the decision. The best way to assess oil consumption savings is in back to back tests in a few closely monitored locomotives. However, lube consumption savings are substantial enough that inspection of oil inventory and purchasing records may suffice to verify oil consumption savings on a gross tonmile basis if duty cycle, power interchange and other consumption factors are relatively constant. In other words, oil consumption savings are large enough that they can readily be documented in field service, but fuel savings are more difficult to demonstrate.

Lower oil consumption for multigrade oils is due to improved upper cylinder oil control that reduces the amount of oil burned in the combustion process. The more viscous nature of the multigrade oil at combustion temperatures and (to a lesser extent) the good volatility characteristics of high viscosity index base stocks tend to minimize the amount of oil thrown into the combustion chamber from the rings or volatilized from cylinder walls, thus reducing oil consumption.

Impact On Exhaust Emissions

Multigrade oils may also pay a dividend with respect to exhaust emissions control, if lower oil consumption results in reduced emission levels. An AAR sponsored project at Southwest Research Institute (SWRI) is comparing exhaust emissions for monograde and multigrade railway oils in 2 and 4 cycle stationary engines. Table 4 summarizes some data available from this study.

This table compares emissions in a 2-cycle engine for a monograde and multigrade oil formulated with the same additive package. The data from a three-mode (idle, N5, N8) test cycle show lower hydrocarbon (HC), NOx and particulate emissions (PM) for the multigrade lubricant with carbon monoxide concentration unchanged. The percentage reduction in hydrocarbons and particulates is fairly large, but on an absolute basis, only the change in hydrocarbon emissions is significant when test repeatability is considered. When a second multigrade oil was tested, (data not shown) similar directional improvements in hydrocarbons and NOx were documented. This study was extended to 4-cycle railway engine and test results for the same monograde and multigrade oil consumption are shown in Table 5.

Table 4 - EMD Multigrade Oil Emission Effects (GMS/Bhp-Hr)

Lube Oil	A-SAE 40	A-SAE 20W-40	% Change
Hydrocarbons (HC)	0.34	0.25	-26.5
Carbon Monoxide (CO)	1.0	1.0	0
Nitrogen Oxides (NO_x)	10.9	10.5	-3.7
Particulates (PM)	0.21	0.19	-9.5

This table also shows reduced particulate, NOx and hydrocarbons emissions for the multigrade lubricant in the same three-mode test cycle in a 4-cycle railway engine. However, in this case, the reduction in hydrocarbon emissions was minimal.

It is still too soon to precisely quantify what benefits may be realized by multigrade oils with respect to lower exhaust emissions, but initial results are encouraging and this committee will continue to follow developments in this area.

Related Environmental Issues

Still other cost and environmental benefits may accrue to railroads using multigrade lubricants. Improved viscosity control afforded by multigrade

Table 5 - GE Multigrade Oil Emission Effects (GMS/BHP-HR)

Lube Oil	A-SAE 40	A-SAE 20W-40	% Change
Hydrocarbons (HC)	0.38	0.37	-2.6
Carbon Monoxide (CO)	1.7	1.7	0
Nitrogen Oxides (NO_x)	12.2	11.9	-2.5
Particulates (PM)	0.28	0.26	-7.1

oils can extend oil life and reduce the frequency of oil changes, thus conserving natural resources.

In addition, railroads may find it more convenient to recycle non-chlorine containing multigrade lubricants now available in the market. Used railway oils are not considered to be hazardous waste by the EPA, but this ruling is being reviewed, with a decision expected soon. Four states (California, Rhode Island, Massachusetts and New Jersey) already consider all used oils as hazardous waste. However, under the Federal EPA's presumptive mixing rule (40CFR-Part 266, Subpart E) used oils containing more than 1000 ppm total halogen must be presumed hazardous due to possible contamination with chlorinated solvents, unless this is rebutted by conducting specified tests and maintaining appropriate records.

It should be emphasized that chlorinated additives, like those used in railway oils, are *not* considered hazardous, but rebuttal is still required, and increased costs may therefore be incurred. Hence, chlorine-free multigrades can make used oil disposal or recycling more convenient and may reduce disposal and documentation costs, in addition to saving fuel and reducing oil consumption as do all multigrade oils.

Summary

In summary, multigrade diesel lubricants are environmentally friendly products. They conserve resources by reducing fuel and lubricant consumption, have a directionally favorable impact on exhaust emissions and can facilitate used oil disposal and recycling. Furthermore, use of multigrade lubricants reduces railroad operating costs. This is truly a win-win situation for both the rail industry and the environment.

II. READILY BIODEGRADABLE AND LOW TOXICITY RAILROAD TRACK LUBRICANTS

Prepared by P.R. Grives, R.J. Kamenick, M.T. Benkinney, N.J. Novick, J.A. Keller, Mobil Oil Corp.

Presented by P.R. Grives

Abstract

The use of lubricants to separate wheel flanges from railway track yields economic benefits to the railway operator in the form of reduced wear, of both track and wheel flanges, and reduced fuel consumption. Track lubrication is a total loss system, with an estimated 10,000 tons of lubricant consumed in North America each year. While most of the grease is consumed or destroyed by the friction between the wheels and rails, some of the grease remains trackside; therefore this is an application where the environment should be considered. A developmental program was initiated with a target to formulate a track lubricant that is both readily biodegradable and low in toxicity to aquatic organisms, while continuing to provide good lubrication performance. Extensive work was required to identify and develop a special additive system to impart acceptable performance to the finished lubricant while remaining low in toxicity.

This paper reviews work to develop such a lubricant. Test methods to determine biodegradability and aquatic toxicity are reviewed and performance data on candidates are shown compared to mineral oil based rail lubricant performance properties.

Introduction

Track Lubrication - When a consist (train) travels through a curved section of tract, the wheel flanges slide against the gage face of the rail (See Figure 1, Wheel/Rail Geometry). Similarly, when a consist travels along a section of straight, or tangent, track, the wheel flanges intermittently contact the rail gage face as the train hunts from side to side. Without proper lubrication both wheel flanges and rails wear rapidly. The practice of lubricating the wheel/rail interface around curved track had its roots in the early part of this century. The object was to reduce wheel and track wear, thereby extending the operational life of both the wheels and the rails. Later, it was found that lubricating the wheel/rail interface or tangent track not only increased the service life of both the wheel and the rail, but produced significant fuel savings. It has been noted in prior publications,[1,2] that such lubrication can be translated into a 5% to 15% fuel saving.

Lubricant Application - There are three basic methods by which grease (track lubricant) is applied:

· By a wayside (trackside) Lubricator
· From an on-board system
· From a hy-rail vehicle.

Of the three, wayside and on-board are the most popular.

In *wayside lubrication,* a lubricating grease is applied to the gage face of the rail by a trackside lubricator. This lubricator is activated, either electronically or physically, by the passing wheels. Grease is then transferred from rail to the wheel flanges as they come in contact. Grease is carried down along the track by flange-to-rail contact to a distance that is dependent upon the properties of the particular grease employed and the amount of grease applied. Lubricators can be spaced at curves or at intervals to ensure continuous lubrication of the wheel/rail interface.

In *on-board lubrication,* the lubricators are usually located on the locomotive. Grease is applied to the wheel flanges of the locomotive and transferred to the rail as the wheels come into contact with it. Unlike with trackside lubricators, the grease does not need to be carried along the track, but needs to cling to the flange on application and stay put on the rail gage face to lubricate the wheels of all the cars being pulled by the locomotive. Application of the grease to the locomotive wheel flanges can be either intermittent or continuous dependent upon the specific grease used and the amount required for lubrication.

Hy-rail lubrication, the least popular method of track lubrication, employs lubricators mounted on highway automotive equipment modified to permit operation on the railway. This method of track lubrication is used where track time is available and can incorporate track inspection while lubricating track.

This paper specifically describes the development of a readily biodegradable, low toxicity railroad track lubricant. Extensive work was required to identify and develop the functional, low toxicity additive system employed in our candidate, EA Track Lube. A novel test for determining the aquatic toxicity of a grease is discussed, as well Mobil's environmental awareness lubricant criteria. Direct comparisons are made with a conventional mineral oil based track lubricant, covering both lubrication performance and environmental characteristics.

Environmental Considerations

To understand the concept of biodegradability, a distinction must be made between *inherently biodegradable* and *readily biodegradable.* Most synthetic and mineral oils, as well as additives, are inherently biodegradable. That is, with time they degrade and do not persist in the environment. However, there are some applications, such as track lubrication, where a more rapidly degrading material could be beneficial. These materials are defined as readily biodegradable.

Additionally, whenever a material is discharged into the environment, its toxic effects on indigenous life are important. Mobil has chosen to use juvenile rainbow trout in its aquatic toxicity studies because they are very sensitive to toxicants and are considered a good indicator of environmental toxicity in general. Testing with other aquatic species including daphnia and mysid shrimp confirm that the fish studies can be used to predict toxic effects on these and other aquatic organisms.

The *aquatic toxicity* of a material is determined by dispersing the material to be evaluated in a fish tank and exposing the fish to the material for a specific period of time. After the exposure period the number of survivors are counted and the Lethal Concentration (LC50) necessary to kill 50% of the test group is determined. Greases, being generally insoluble in water, create a testing problem in aquatic toxicity tests. In this program a modified version of the standard aquatic toxicity test was developed to evaluate greases.

Test methods and results for ready biodegradability and aquatic toxicity pertaining specifically to greases are discussed below. An indepth discussion of biodegradability and aquatic

toxicity pertaining to lubricants can be found in the paper "Biodegradable and Nontoxic Hydraulic Oils", by V.M. Cheng et al[3].

Ready Biodegradability

Laboratory Test Methods - The EPA Shake Flask Test[4] was used to assess the ultimate biodegradability of the test material. Biodegradability of a carbon substrate (test material) is determined by following the evolution of carbon dioxide from an aqueous minerals salts medium seeded with a sewage and soil inoculum. Sewage inoculum is obtained from a municipal wastewater treatment plant which has no industrial inputs. In no case were the inocula preacclimated to the test material prior to the test initiation. The test material provides the only source of carbon substrate for bacteria growth.

The EPA Shake Flask test employs a 2-liter Erlenmeyer flask closed with a neoprene stopper from which are suspended alkali traps (used to determine CO_2 evolved). The medium is then purged with CO_2-free air to maintain aerobic conditions and fresh traps are placed back in the flasks. Several blank controls, run alongside the flasks containing the test materials. At each sampling point, the CO_2 evolved from the blanks is subtracted from CO_2 values obtained on the test material flasks. A positive control is also run with each test to ensure inoculum viability.

Aquatic Toxicity

Laboratory Test Methods - The insoluble nature of grease poses a problem when trying to determine its toxicity. Standard aquatic toxicity tests determine the LC_{50} of a material by exposing a known number of fish to the test material, and observing the number of fatalities after a 96 hour period. The concentration necessary to kill at least 50% of the fish is reported as the result. Rainbow trout are the fish of preference for this test since they are ubiquitous in the environment and are very sensitive to toxicants.

To overcome the water insolubility problem with greases, a modification of the Oil - Water Dispersion (OWD)[4] test has been developed. The oil-water dispersion apparatus used as a basis for the grease studies was similar to that developed by the Ministry of Agriculture, Fisheries, and Food (MAFF), England. Standard OWD studies are conducted in 10-gallon glass aquaria containing 30 liters of water. The test chambers are fitted with a removable PVC cylinder that houses a stainless steel shaft and three-bladed propeller. The propeller produces flow in the cylinder by drawing a small quantity of water into the top of the cylinder and expelling it through apertures near the bottom of the cylinder. The motor speed is adjusted such that the vortex extends ~1/2 inch below the water surface, resulting in a speed of approximately 1500 rpm.

Modifications were made to this standard OWD procedure to allow for evaluation of insoluble greases. Glass plates (3x12 in.) with applied test material are suspended from a metal beam structure resting on each test aquarium. The amount of test material added to each plate was determined by initially weighing the plates, adding the approximate amount desired, spreading this material on the plates to a 1-mm thickness, and then re-weighing the plates. Exposure concentrations were back-calculated using the actual amount of test material spread on the plates. Each plate hung approximately two inches above the bottom of the aquarium, and was no closer than two inches to any other plate, allowing free movement of the test fish around the plates. Water circulating through the OWD apparatus passed around the test material covered plates to maximize exposure and leaching. The test material in each aquarium was not renewed during the duration of the study. After a 96 hour exposure period, the number of fatalities was counted and recorded. Currently, 2000 ppm is the highest concentration which was evaluated using this procedure.

Mobil Environmental Awareness (EA) Lubricant Criteria

At the present time there are no regulations in the U.S. which define criteria for lubricants used in environmentally sensitive areas. Therefore, biodegradability and aquatic toxicity criteria for railroad track lubricants that will be used in environmentally sensitive areas were developed based upon the current European legislation for new product registrations, marine transport regulations, and the German Blue Angel requirements. Based on these regulations Mobil has developed the following criteria for environmental awareness (EA) lubricants:

- Aquatic Toxicity LC50>1000 ppm with rainbow trout
- Ready Biodegradability >60% (conversion of test material to CO_2 in 28 days by EPA Shake Flask test).
- Less than 5% additives.
- No chlorinated materials or heavy metals.
- No materials on EPA priority pollutant list.

For reference, Table 6[3] shows a comparison of Aquatic Toxicity and Biodegradability results for several formulated hydraulic fluids comprised of different base oils.

Formulation and Development

This program has focused on the development of an EA Track Lube comprised of a vegetable base oil, lithium 12-hydroxystearate soap thickener, and a virtually nontoxic additive system which are combined to meet the environmental criteria outlined above. Extensive screening was required to identify the additives employed in EA Track Lube, as they needed to be functional in addition to being virtually nontoxic. Lubricant performance targets were based on conventional mineral oil track lubricants. Table 7 summarizes the typical physical properties of the vegetable base oil used in the EA Track Lube:

EA Track Lube was formulated to meet ready biodegradability and aquatic toxicity criteria while providing the same level of performance obtained with a conventional mineral oil track lubricant. Bench tests commonly used to evaluate mineral oil greases were used to judge the performance of the EA grease. Table 8 shows typical grease characteristics of EA Track Lube compared to a commercial mineral oil track lubricant, conventional track lube. Table 9 compares the performance of EA Track Lube and conventional track lube.

Discussion of Key Performance Properties

Development of EA Track Lube poses several challenges. Not only does the grease need to meet environmental criteria, it has to perform at a level equivalent to commercial mineral oil greases. Key performance properties that caused some challenges during development were low-temperature pumpability, EP/antiwear performance, and grease adhesion. Each of these will be discussed separately.

Low Temperature Pumpability - A very important property for a track lube is good low temperature pumpability. A track lube must flow at low temperatures so that the grease can be used over a wide temperature range. It would not be feasible for a locomotive to carry two different types of track lubricants, one for cold climates and another for warmer climates. Figure 2 shows the U.S. Steel low temperature grease mobility for EA Track Lube against the mineral oil reference.

This test measures how much grease, in grams/min, will flow through a capillary at - 18°C (O°F) and -28°C(-20°F) under 150 psig. The low pour point of the base fluid and optimization of the additive system enable EA Track Lube so far exceed the performance of the mineral oil reference in this test.

Grease Adhesion - As discussed earlier, in both trackside and on-board track lubrication, grease is applied and carried down along the track, through rail/flange contact. To ensure adequate lubrication, a track lube must be adhesive enough to stick to the rail for lubrication, as well as the flange for transfer along the track, without creeping up to the top of the rail. Grease adhesiveness can be improved by increasing the amount of thickener used and/or using a higher viscosity base oil.

There are several ways to measure the adhesiveness of a grease. A modified version of an exisiting adhesion test used for open gear lubricants was used to evaluate the track lube candidates. in the test a specified amount of grease is applied to an aluminum plate which is suspended in an oven for 45 hrs at a specified temperature. After the test, the amount of grease remaining is determined, as well as the condition of the grease film left on the plate. A good adhesive grease should have very low loss and should form a smooth, uniform film on the plate. Figure 3 shows EA Track Lube and the mineral reference after test at 175°F.

As shown in the figure, EA Track Lube performs better than the conventional track lube in the grease adhesion test.

EP/Antiwear Properties - Another important property an acceptable track lubricant must possess is good EP/antiwear. No matter how pumpable and adhesive a track lubricant is, without EP/antiwear it will not prevent wear of the wheels and rails. Extensive work was done to identify additives which were virtually nontoxic while providing acceptable levels of EP/antiwear. Figures 4, 5 and 6 show extreme pressure (EP), wear, and load carrying performance for EA Track Lube compared to a conventional mineral oil track lube. In every case EA Track Lube performs acceptably compared to conventional mineral oil track lube.

Conclusions

A biodegradable, low toxicity railroad track grease, EA Track Lube, has been developed with performance properties approaching conventional mineral oil based track lubricant. This new EA Track Lube has the following environmental characteristics:

- Aquatic Toxicity: LC_{50} >2000 ppm as determined in a 96-hour acute exposure test using rainbow trout as the test species.
- Ready biodegradability: 80% of the carbon in the test material converted to CO_2 withing 28 days using an unacclimated inoculum as measured in the EPA Shake Flask test.
- No chlorinated materials, heavy metals, or EPA priority pollutants.

The next phase of this program will be to optimize the EA Track Lube formulation to exceed the performance of conventional mineral oil based track lubricants. Following this optimization, performance benefits of EA Track Lube will be demonstrated in commercial applications.

Acknowledgements

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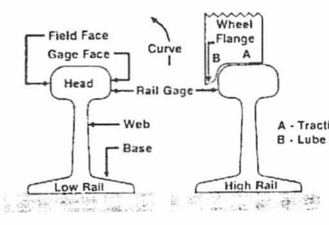


Figure 1: Wheel/Rail Geometry

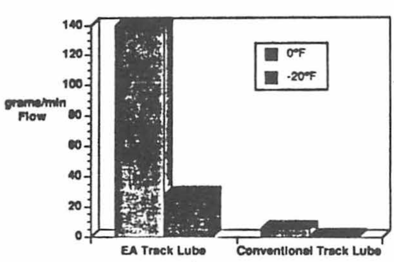


Figure 2: Low Temperature pumpability of EA Track Lube in g/minat 150 psig.

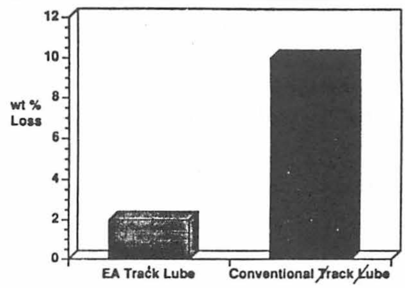


Figure 3: Grease adhesion test, 45 hrs @ 175°F.

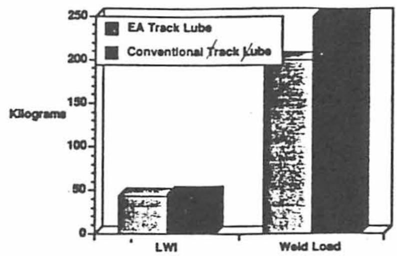


Figure 4: Extreme Pressure (EP) Performance 4-Ball EP test load wear index (LWI) & Weld Load

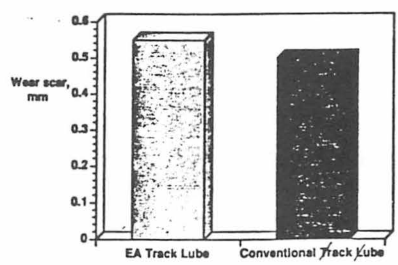


Figure 5: Wear Performance 4-Ball wear test

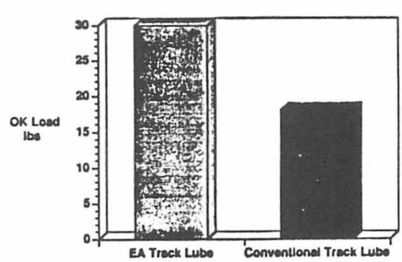


Figure 6: Load carrying performance, Timken OK load, lbs

Table 6
Ecotoxicological Data for Several Hydraulic Fluids

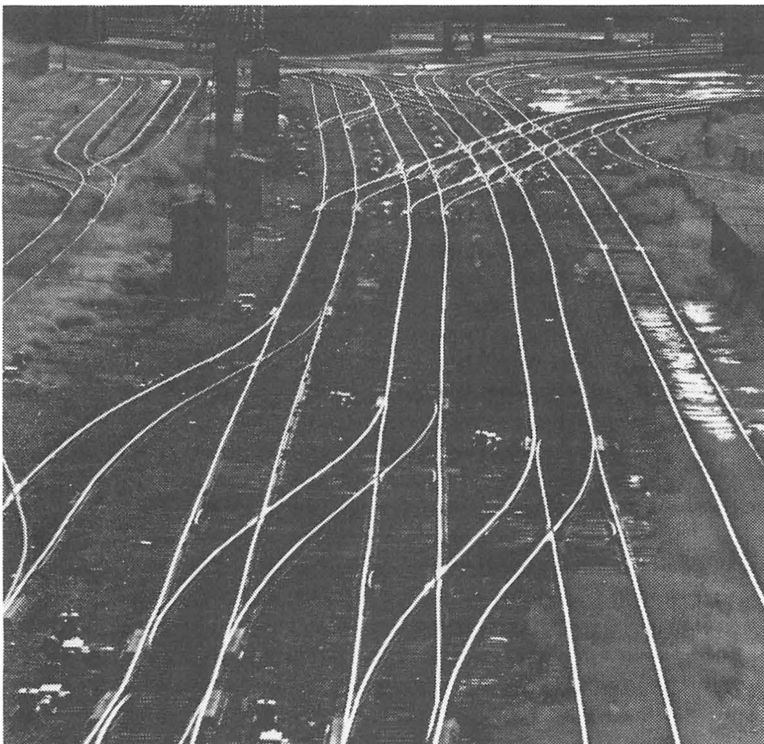
Base Stock	Trout LC50 (in ppm)	% Biodegradable EPA Shake Flask Test
Mineral Oil	389 - > 5000	42 - 48
Vegetable Oil	633 - > 5000	72 - 85
Polyglycol	80 - > 5000	6 - 38
Synthetic Ester	>5000	55 - 85

Table 7
Physical Properties of Selected Vegetable Base Oil

Viscosity, cSt @ 40°	32 - 40
ASTM Color	<1.0
Saponification Number	180 - 198
Specific Gravity	0.91 - 0.92
Pour Point °C/°F	-20/-4
Flash Point °C/°F	260/500
% Biodegradable	75% - 80%
LC_{50}, ppm	>5000

Table 8
EA Track Lube
Typical Grease Characteristics

Characteristic	EA Track Lube	Conventional Track Lube
Appearance		
Color	Gray-Black	Gray-Black
Texture	Smooth	Smooth
Composition		
Thickener, type	Lithium 12-Hydroxystearate	------->
Thickener, wt %	12.5	6.0
Solid Additives	Yes	Yes
Base Fluid		
Type	Vegetable	Mineral
ISO VG Grade	32	150
NLGI Grade	1	1



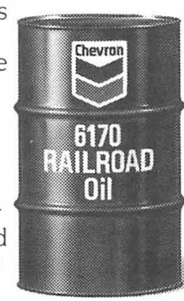

Chevron
6170
RAILROAD
Oil

Table 9
Typical Laboratory Performance Tests

Test	Test Method	EA Track Lube	Conventional Track Lube
Consistency			
Pen. UW/Wx60	ASTM D217	310/334	305/335
Pen, Wx10,000	ASTM D217	354	340
Pen, UW/Wx60 @0°F	ASTM D217	155/300	148/250
Structural Stability			
Dropping Point, °F	ASTM D2265	328	400
Roll Stability	ASTM D1831		
% Pen Change		+ 42	+5 max
Water Resistance			
Water Washout, wt %	ASTM D1264	98	3
Water Sprayoff, wt%	ASTM D4049	100	74
EP/Antiwear			
4-Ball EP	ASTM D2596		
LWI, kg		43	46
Weld Load, kg		200	250
4-Ball Wear	ASTM D2266		
scar, mm		0.55	0.50
Timken OK Load, lbs	ASTM D2509	30	18
Pumpability			
USS Mobility	USS DM-43		
g/min @ 0°F		140	5.5
g/min @-20°F		23	0.6
Adhesion			
Grease Adhesion Test	Proprietary		
45hrs @ 175°F, wt% loss		2	10
Environmental Characteristics			
Biodegradability, %		80	<50 *
Aquatic Toxicity, LC_{50}, ppm		>2000	<300 *

* - Estimate based on previous experience with mineral lubricants

III. SUPPORT BEARING OILS

Presented by Cline Tincher, Lyondell Petrochemical

New high horse power locomotives are putting increased stress on traction motor support bearings. Recently, failures of the support bearings of the new computerized locomotives have raised the question whether the AAR M-963-84 journal bearing oil is suitable for higher torque traction motors with more horsepower per axle. The AAR M-963 specification was last changed in 1984 to make railroad car oils an "all weather" product with better low temperature properties. Since car journal bearings are being replaced by roller bearings, consideration should be given to changing the AAR M-963-84 specification so that it is applicable to traction motor support bearings.

Railroads have been experiencing increasing numbers of traction motor support bearing malfunctions. One difficulty encountered in a traction motor support bearing failure is determining the cause of the problem. This is due to the fact that the evidence of the cause of the breakdown is usually destroyed during the bearing failure.

The purpose of this paper is to investigate the causes of traction motor support bearing failures, to determine to what extent the support bearing oil contributed to these failures and if necessary recommend changes to the AAR M-963 specification.

Numerous oils have been used by railroads in traction motor support bearings (Tables 13 and 14). Only two of these meet all the AAR M-963 and GE specifications. These specifications are listed in Table 10. In addition, General Electric has three performance requirements, a stationary journal bearing test, a one year field test and a compatibility test. Currently, there is only one oil that is formally approved by or recommended by the locomotive manufacturers.

Lubricating Oil Incompatibility

One problem that has received considerable attention is the incompatibility of support bearing oils. Incompatibility of oils can contribute to traction motor support bearing failures. There is some consideration that a compatibility specification should be added to the AAR M-963 specification.

A large Class I railroad investigated the water compatibility of five journal support bearing oils with the approved General Electric journal oil as a reference. The following test procedure was used: 50 mls of the test oil and 50 mls. of the reference oil and 10 mls of water were poured into a graduated cylinder and shaken by hand. These cylinders were placed in an oven for 4 hrs at 180°F and then in a cold box for 16 hrs at -35°F. After the cylinders had warmed to room temperature the amounts of free oil, free water and cream emulsion were measured. Results of the tests are presented in Table 14. Three of the test oils formed an emulsion with the reference oil. The compatibility tests were repeated with another commercial oil and the results were also summarized in Table 14. The same three oils formed an emulsion with the second oil as they did with the reference oil.

A second test was conducted which evaluated a different commercial oil and the reference oil in a traction motor support bearing wicking test. The apparatus approximates a locomotive journal bearing and consists of a 12 in. steel drum driven by a 1.5 hp motor through a pulley at 538 rpm (equivalent to 62 mph locomotive speed). Surface finish of the drum is 12-18 micro inches. The lubricator wick assembly is located and mounted so that the felt wick is in the same position on the journal bearing surface as it would be in the locomotive support bearing. Oil is fed to the bearing surface by the wick which is immersed 4 in. in the test oil, and the oil level is held constant by an automotive feed mechanism. The oil wicked by the lubricator is removed from the drum by a spring loaded blade and is collected in a weighed pan for use in determining a wicking rate.

The support bearing wicking test is started by presoaking a dry wick in the test oil (AAR M-963) for 20 min and draining the wick for 10 min. before mounting the wick in the test assembly. To allow the test assembly to reach equilibrium the apparatus was started and run for 24 hrs. at 72°F. Oil collected during this 24 hr. period was weighed and discarded. A second 24 hr. run was made with the oil depth maintained at 4 in. Oil collected during this 24 hr. interval was weighed and reported as a wicking rate.

The test was repeated using one of the oils from the water compatibility test. A mixture of approximately 45% test oil, 45% reference oil and 10% water was heated in an oven for hour hrs. at 180°F and then placed in a cold box for 16 hrs. at -35°F. The oil was allowed to warm up to room temperature and was used in the test. The results for the AAR M-963 oil and water compatibility mixture are reported in Table 11.

The wick test results indicate that the sludge formed by the incompatibility of journal oils can reduce the amount of oil that will migrate through the wick. In this experiment the wick tester was run for 48 total hrs. If the test were extended, a further decrease in the oil flow would be expected.

It should be noted that the wick tester is an experimental apparatus designed to determine the oil flow rate in traction motor wicks. Because the traction motor lubricator in this test does not experience the loading and motions associated with locomotive operation, the oil flow rates determined in the test are not representative of the actual wicking rates developed in locomotive service.

One Class I railroad experienced some traction motor failures that were attributed to lubricating oil incompatibility. In December 1990, a broken rail forced locomotives to stand in -45°F weather for 12 hrs. After the locomotives started to move, the support bearings in five locomotives ran hot and failed. Grease-like deposits found on the wicks were attributed to lube oil incompatibility. In addition, high calcium levels were found in the lubricating oil storage tank. During further investigation of the problem, it was determined that the oil in the support bearing reservoir had a pour point of -15°F and did not meet the AAR M-963 pour point specification of -35°F.

Several other major railroads have experienced traction motor support bearing failures that they attributed to lube oil incompatibility. Grease or soap-like deposits on the wicks were the reason the failures were identified as incompatibility failures. There are two possible sources for the deposits that were plugging the wicks: 1) calcium soaps are formed from the saponification products of the fatty oils in the journal oil and 2) the cream formed by the emulsion of the journal oil and water plugs the wick, preventing the flow of oil.

In 1980, two Canadian researchers reported that at low locomotives speeds

(18 mph) in temperatures of -35°C, the temperature of the reservoir could remain below the pour point of the oil for as long as five to six hrs. Because the bearing is subject to changing loads, varying speeds, misalignment conditions, lateral motions and vibrations, increased oil consumption of the bearing is likely. So if the lower part of the wick and reservoir do not warm up sufficiently, then it is possible that oil starvation might occur and bearing failure might result.

To obtain an idea of oil flow requirements to hydrodynamically lubricate a locomotive traction motor support bearing, the oil flows through the support bearings of the locomotive builders were calculated using the equations in the Cast Bronze Bearing Design Manual published by the Cast Bronze Bearing Institute. The calculations were made assuming no seals were present on the bearing and using the locomotive manufacturers' maximum bearing clearance. The results are shown in Table 12. In addition, the oil usage determined by the Canadian researchers is also included in the table.

In 1982, the National Research Council of Canada concluded that, "The wick lubricator is an extremely effective means of lubricating journal bearings at very low temperatures." At low temperatures the oil can become very thick making lubrication by splashing very difficult; however, journal oil has been shown to flow through wicks down to temperatures of -29°C.

Calculating the amount of oil needed for a full hydrodynamic oil film using a Lincoln Pump Co. bearing lubricator slide rule calculator indicates that 8.2 grams of oil are needed to lubricate one locomotive manufacturer's bearing.

From the data above it can be determined that:

1. Lubrication of traction motor support bearings is not a full flow situation. The seals reduce the side leakage.

2. As temperatures decrease oil flow through the wick is reduced.

3. Lower oil flow through the bearing due to low temperatures and low speeds, can result in boundary lubrication and metal-to-metal contact.

4. Deposits caused by the incompatibility of bearing oils reduce the flow to the bearing surface making maintenance of the hydrodynamic film very difficult.

Lubricity agent and EP additives are needed to protect bearings in boundary lubrication conditions. With oil incompatibility and low temperature bearing failures as potential problems, railroads must choose the journal oil they put in the reservoirs of their traction motors with care. First the oil needs to meet the AAR M-963-84 and locomotive manufacturer's specifications.

In light of the problem with incompatibility of journal oils the following additions to AAR M-963 specification are recommended:

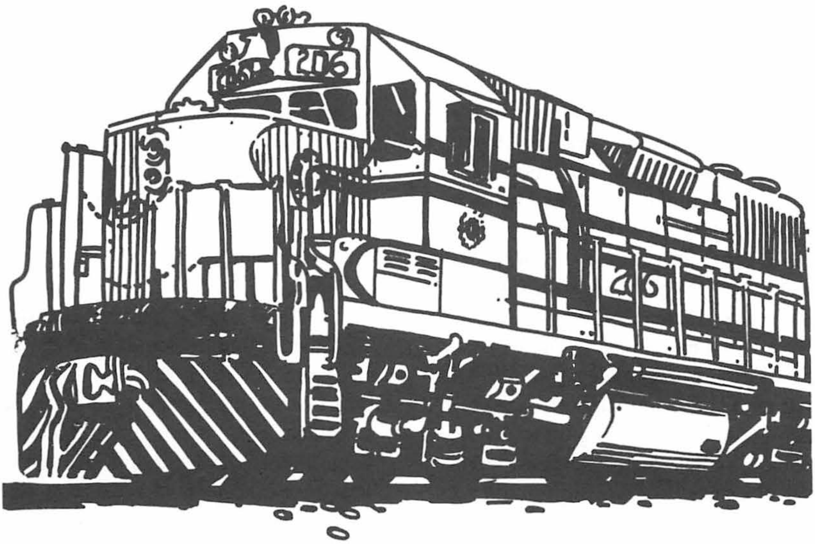
1. Journal oil must de-emulsify water;

2. Adopt GE extreme pressure specification;

3. Evaluate and select a standard compatibility test.

Surface Finish

A Class I railroad has substantially reduced the number of support bearing failures from 80 in 1985 to 19 in 1990 by paying close attention to axle surface finish. The surface finish of an axle journal can exhibit both roughness and waviness. Roughness is the irregularities in the surface texture caused by the production process of grinding and rolling. Waviness is the component of surface texture upon which the surface



roughness is superimposed. Waves on the axle may result from machine or axle deflection, vibrations, chatter or metallurgical defects in the axle. Surface texture is also characterized by the lay, the primary direction of the significant wave pattern, the spacing and height of the principal waves and the spacing and height of the surface roughness.

The standard method of assessing surface texture is based on drawing a stylus across the surface of the axle to produce an electrical signal. This results in a surface profile viewed as a chart, such as the one obtained from a Rank Taylor Hobson Ltd. meter. The best surface roughness should be maintained between 3 to 7 micro-in. to insure satisfactory journal bearing performance. Rough axles with a surface roughness greater than 7 micro-in. will cause the temperature to increase and the bearing to consume more oil. This will result in a hot support bearing. If the wicks stop providing oil to the axle surface, failure of the support bearing could result. However, minimum surface roughness may be required to carry oil on the axle.

In 1986, one railroad had several axles break on its GP-50 locomotives. It checked 100 GP-50 locomotives' traction motors through the windows and found the babbitt had been pulled on the bearings. Traction motors on GP-40 locomotives did not have the problem. The railroad discovered that it was rolling waves in its axles because the burnishing wheel was not aligned properly.

Traction motors in higher horsepower locomotives are more vulnerable to axle and bearing problems caused by waves in the axle due to the greater torque and pressure exerted on the bearing.

Another Class 1 railroad experienced numerous traction motor support bearing failures in locomotives in service too short a time to have oil compatibility problems. Some of the failures were determined to be axle finish problems.

In the railroad shop where the traction motor support bearing failures were reduced from 80 to 19 in 6 years, each axle had the surface finish measured on the gear side and trace was attached to the paper work accompanying the wheel set. Railroads who are not doing this should consider having the surface finish on each traction motor measured either in-house or at a rebuild shop to minimize support bearing failures due to poor axle surface finish.

Human Error

One large Class 1 railroad had over 100 traction motor hotboxes in the last six months of 1991. Many of these support bearing problems were attributed to human error, since the railroad has department policies in place that outline the requirements for the rebuilding of the support bearing and the measurement of surface axle finish and wave index on all traction motors rebuilt in its shop.

One problem it encountered was not adding journal oil to the traction motor reservoir prior to the locomotive leaving the shop. Another problem was loose or missing wicks. This problem was caused by using wrong sized bolts (ie. too long), bolts with stripped threads, cap screws with worn threads and bearing caps with holes not completely drilled. These problems can be minimized by not reusing bolts and by having the people at the service track check the lubricant levels and the traction motors before the locomotive leaves the yard.

Traction motor support bearings can

be requalified and reused. However, the railroad required that the bearing be reused only once on the free (non-gear) end of the axle. It was reported that brass bearings were being used more than once on both the gear and free end of the axle. Other problems experienced were mismatching the top and bottom of the bearing and mismatching the bearing to undersized axles.

In the past, many railroads would clean and reuse old wicks. Occasionally dirty wicks would be reused. Now most railroads feel it is cost effective to use new wicks exclusively.

The traction motor support bearing caps of the locomotive builders fit securely so they will not move and cause bearing damage. When the caps are put in place and bolted down, dirt or metal debris can be left on the bearing surface if protection is not provided, or if the dirt is not vacuumed out.

One Class 1 railroad determined that traction motor support bearing failures had been caused by metal debris imbedded in the babbitt on the bearing surface. Investigation disclosed that cleaning of metal parts had been conducted in the shop area where the traction motors were assembled. Therefore, care should be taken to prevent material from getting onto the support bearing surface during the rebuilding of the traction motor to prevent damage to the bearing surface and failure of the traction motor.

Even though a railroad has policies in place for the rebuilding and inspection of traction motors, workers can omit important procedures. One Class 1 railroad found that the surface finish was not being measured on all traction motor axles as was required by its guidelines.

Occasionally when the oil level gets low in a traction motor reservoir and a hotbox develops, the locomotive crew will fill the reservoir with motor oil. This can lead to bearing failures due to oil incompatibility.

Mechanical Problems

In addition to surface finish and human error, the breakdown of mechanical parts in traction motors may contribute to support bearing failures. As mentioned previously, bearing failures, especially those due to mechanical failures, are extremely difficult to diagnose because of the severe damage that occurs. This makes very challenging the task of determining whether a broken part caused the bearing to fail or whether the part was broken by the bearing failure.

One short line railroad reported that traction motor gear grease migrated through the seals and plugged the wick, causing a bearing failure. Changing wicks every six months appears to have solved its problem. Another railroad reported that plastic wick holders had melted, causing support bearing failures. Using these wick holders is not recommended by the locomotive manufacturers.

One Class 1 railroad has trains that have guaranteed arrival times. One of these trains experienced a derailment that was caused by a traction motor support bearing failure. Axle finish was within acceptable limits and the railroad has instituted a system whereby the supervisor and general supervisor check the employees' work. A mechanical failure was suspected. While investigating the problem, they tested felt wicks on a wicking machine and found some wicks where insufficient oil to lubricate the bearing migrated through the wick. Also a partially burned wick with varnish-like deposits was found. At this time, no definitive cause for the bearing failure has been determined.

Several railroads reported that the springs on some lubricators had vibrated loose, preventing the felt wick from contacting the axle, causing the bearing to fail.

From the previous discussion, it can be seen that lubricating wicks can fail for a variety of reasons, which include glazing, plugging and insufficient spring tension.

Railroads should maintain and follow a practice of changing wicks and draining reservoirs as their duty cycle and weather conditions require. In addition, the springs on rebuilt lubricators should be checked to make sure they are working properly.

Conclusion

As horsepower has increased in new locomotives, increased stress has been placed on traction motors. Railroads have been experiencing increased numbers of traction motor support bearing failures.

With four possible failure modes-surface finish, human error, oil incompatibility and mechanical failure it is often difficult to determine the actual cause of a bearing failure. This is especially true when the bearing and wick are destroyed. With railroad customers demanding faster more reliable delivery, a large number of traction motor bearing failures cannot be tolerated.

In order to reduce the number of bearing failures, railroads need to determine the number of bearing failures they are experiencing and their causes. Some railroads are not aware of the level of traction motor failures on their railroad because the job of tracking mechanical failures had been eliminated during railroad employee downsizing.

One railroad was able to dramatically reduce its traction motor bearing failures by closely watching axle surface finish. Other railroads should require that every axle have its surface finish measured whether the traction motor is built in-house or outside.

Railroads can reduce support bearing failures by having supervisors review their employees' work, followed by a final inspection at the service track before the locomotive leaves the yard.

Next, railroads should use an oil that meets the AAR and OEM journal support bearing oil specifications. In addition, it is recommended that the AAR M-963-84 specifications be modified to include the General Electric oil specifications, which include an oil compatibility test and EP requirements. This will reduce oil incompatibility as a cause of bearing failures. EP protection is needed because a journal bearing rides on a film of oil. If a journal turns too slowly, the oil film is not thick enough to prevent metal-to-metal contact. When a locomotive moves at crawl speed the oil film is not thick enough to prevent the axle from contacting the bearing. Extreme pressure additive and lubricity agents would provide extra protection for locomotives operating at low speeds and high torque.

As traction motor horsepower has increased, it has become more important to insure proper friction performance in the support bearing.

Finally, all railroads must develop a practice of changing critical traction motor parts, such as wicks, and performing routine maintenance, such as draining the suspension bearing reservoir relative to their duty cycles and weather conditions.

In summary, as long as human beings are involved there is very little chance of completely eliminating traction motor support bearing failures.

With many possible failure modes, and with the evidence for causes of the problem often destroyed along with the bearing, it is very difficult to pinpoint the cause of a specific bearing failure so the problem can be eliminated. However, railroads can greatly reduce the number of traction motor support bearing failures they have by:

1. Paying close attention to axle surface finish.

2. Having supervisors inspect their employees' work followed by a final traction motor inspection at the service track before the locomotive leaves the shop.

3.Using oils that meet the AAR M-963-84 and manufacturers' specifications and have been tested for compatibility in traction motors.

4. Changing critical traction motor parts at regular interval to reduce mechanical problems.

Table 10 AAR M-963-84 & General Electric Specifications

Specification	AAR M-963-84	General Electric
Viscosity SUS 99 •C	53 - 58	8 -9.4 cSt. 100 •C
Viscosity SUS 210 •F	-	260 - 340
Viscosity Index	100 Min	100 Min
Water	0.10% Max.	-
pH	6.5 - 9	-
4 Ball Scar Dia. 40 kg	-	0.35 Max
Load Wear Index, kg	-	37 Min
Weld Point, kg	-	200 Min
Pour Point •F	-35 Max	-35 Max
Ash (Base Oil), Wt. %	0.10% Max	0.10% Max

Table 11. OIL COMPATIBILITY WICK TEST RESULTS

WEIGHT OF WICKED OIL	FIRST 24 HOURS	SECOND 24 HOURS
1. AAR M-963 OIL	816 grams	791 grams
2. 50/50 OIL MIXTURE FROM WATER COMPATIBILITY TEST	762 grams	464 grams

Table 12

JOURNAL BEARING LUBRICATION CALCULATIONS

TEMPERATURE •F	LOCOMOTIVE A	BUILDER B	CANADIAN RR USAGE GRAMS/HR
	GALLONS	PER MIN	
210	6.2	5.3	-
100	4.6	4.9	-
70	3.3	4.6	7.5
35	1.7	4.1	-
15	0.4	2.9	-
0	0.2	1.8	-
-15	0.07	1.0	0.5
-35	-	-	0.1 *

* -29• C

Table 13

SUPPORT BEARING OIL SURVEY

JOURNAL OIL	AAR M-963	A	B	C	D	E	F	G	H	I*
APPEARANCE	----	CLEAR AMBER	CLEAR PALE	CL LT PALE	CLEAR AMBER	DARK RED	CLEAR PALE	DARK RED	HAZY PALE	DARK RED
ASTM COLOR	----	<5.5	3.5	<2.0	<5.0	8.0+	3.5	8.0+	<4.5	7.5
VIS cSt 40 C	----	71.4	57.0	73.1	97.0	102.8	44.1	53.2	48.9	58.6
VIS cSt 100 C	----	8.56	9.51	9.30	11.8	12.7	8.58	8.93	8.72	8.06
VIS SUS 100 F	53-58	55	58	58	67	70	55	56	55	53
VISCOSITY INDEX	100 Min	89	150	103	111	117	176	147	158	104
METALS										
CALCIUM	----	36	21	110	5	7	482	8	181	3
PHOSPHOROUS	----	10	76	7	208	24	11	220	23	84
ZINC	----	4	3	3	4	3	3	3	6	2
SODIUM	----	3	1	19	1	0	33	5	23	3
4 BALL WEAR mm	----									
SCAR DIA 1 KG	----	0.21	0.16	0.27	0.14	0.18	0.27	0.18	0.31	0.16
10 KG	----	0.45	0.25	0.52	0.21	0.26	0.39	0.21	0.39	0.23
40 KG	----	0.52	0.41	0.80	0.31	0.43	0.58	0.32	0.55	0.32
LOAD WEAR INDEX KG	----	27	39	27	46	39	33	46	27	39
WELD POINT KG	----	126	200	126	250	200	160	250	126	200

* Reference

Table 14

LABORATORY ANALYSIS SUPPORT BEARING OILS

MANUFACTURER	OIL A	OIL B	OIL C	OIL D	OIL E	REFERENCE	AAR M-963	GE
ASTM COLOR	CLEAR 2.5	CLEAR 2.0	CLEAR 3.0	CLEAR 2.0	DARK >8.0	DARK .8.0		
VISCOSITY SUS 100 F	341	279	252	276	266	311	-	260-340
VISCOSITY SUS 210 F	56.5	55.7	55.2	54.2	57.2	55.8	53-58	8-9.4 cSt 100 C
VISCOSITY INDEX	108	127	135	121	137	115	100 Min.	100
WATER	None	None	None	None	None	None	0.1% Max	
pH	7.5	8.3	9.8	8.2	8.4	7.9	6.5-9	
ASH	0.05%	0.09%	0.24%	0.04%	0.06%	0.003%	0.1% Max	0.1% Max
CALCIUM ppm.	228	320	883	1301	28	2		
ZINC ppm.	73	12	0	481	23	0		
WATER COMPATIBILITY REFERENCE								
OIL ml.	79	91	87	102	102	100		
CREAM ml.	22	12	20	0	0	0		
WATER ml.	9	7	3	8	8	10		
WATER COMPATIBILITY OIL E								
OIL ml.	87	89	92	101	102	101		
CREAM ml.	17	15	13	0	0	0		
WATER ml.	6	6	5	9	8	9		
FALEX EP TEST LOAD AT FAILURE LBS	1450	800	800	500	3250	1900		

IV. RECYCLING AND RE-REFINING USED LUBRICATING OILS

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Introduction

Across the United States and Canada a major emphasis is being placed on proper disposal of hazardous and non-hazardous wastes. From curbside collection of paper, cans, and glass to the careful monitoring of the disposal of industrial waste streams, people of all ages and occupations are becoming involved in recycling, reuse, and responsible disposal methods.

Disposal techniques considered proper and withing the law as recently as a decade or two ago, such as drum burial of liquid wastes, no longer have that status. These disposal techniques are creating severe pollution problems today. The federal Environmental Protection Agency, and state and municipal agencies, are now reviewing these past practices to account for and, in many instances, clean up these disposal sites because of improper management at the time of disposal.

Thus, generators today have been forced to become more involved with their disposer/recycler and ask questions such as:

· where their waste is going

· what other wastes are at the treatment, storage and disposal (TSD) facility,

· the status of the TDS's permits,

· the testing capabilities at the TSD,

· whether there are outstanding violations,

· the current status of the TSD's grounds (physical appearance), and

· whether any mandated clean up has been initiated.

Unless the collector/recycler can demonstrate thorough understanding of current and future environmental regulations, the generator must also take on that burden. Selection of recycling/disposal options may depend less on which is the least expensive pathway, but more on which offers the most comprehensive program. In other words, it may be more economical to choose the option that has the least long-term potential liability.

This paper will attempt to point out the advantages and disadvantages of oil and oily water disposal techniques in operation today. The emphasis will be on the environmental (long- and short-term) ramifications which may be encountered by each disposal technique.

Historical Background

North American railroads generate large quantities of oily waste. These streams are generated from the locomotive crankcase (of which approximately five million gallons are being re-refined annually), maintenance of way equipment, fueling systems water treatment collection, parts cleaning systems, associated trucking operations, and assorted other generated oils and waters. Railroad companies have actually led the way in several aspects of oil recycling (Blatz & Pedall, Lubr. Engr., ASLE Preprint 79-AM-6E-1, 1979).

Disposal techniques of the past, such as road oiling, track-side foliage control, and indiscriminate dumping are severely restricted (if not outlawed) by current state and federal environmental regulations.

Contaminates found in most streams (Table 15), if improperly disposed of,

have been found to be *carcinogenic* (e.g., benzene's found in fuels and halogens (chlorine) found in solvents and lubricants), *flammable* in the case of dissolved fuels, *toxic* by way of heavy metals, acids and increased levels of polynuclear aromatics, and/or *corrosive* because of oxidation products and cleaners. These characteristics, along with the effects of pollution from oil entering the water table and contaminating drinking water supplies, have intensified the discussion concerning proper oil recycling.

Some state environmental regulations have followed up on these pollution characteristics and in several states have designated these effluent and disposal streams to be classified as hazardous (i.e., used oil is a listed hazardous waste). Thirteen states now support and enforce regulations which track the disposal of these wastes by way of manifesting. Federal and state agencies have also restricted the methods for treatment and disposal of these streams (Federal Register, Vol. 57, No. 98, May 20, 1992, p. 21524).

The federal government continues to issue guidelines under which disposal techniques must be carried out. The newest proposed regulations to restrict the most common disposal technique (burning) are coming out of the revised Clean Air Act. Others are being proposed as part of the reauthorization of the Resource Conservation and Recovery Act now working its way through Congress. It is likely that proposals put forward by Congressmen Skelton, Torres, and Collins will be incorporated into this RCRA bill, again putting a spotlight on used oil recycling.

In coming years, recycling for fuel may be restricted to larger burners which meet air quality standards. On the other hand, recycling to reuse lubricants as lubricants seems to have growing support. Just as communities and businesses are recycling paper, plastic, metal, and yard materials, the conservation of natural resources such as oil is also becoming an issue.

Disposal and Recycling Techniques

The waste disposition techniques we will attempt to cover range from the improper to the highest form of recycling (re-refining). They are as follows:

(1) - Indiscriminate dumping
(2) - Landfilling
(3) - Road oiling and foliage control
(4) - Burning for energy recovery
(5) - Reclaiming
(6) - Re-refining.

We will also attempt to show you how we see future environmental regulations evolving as they pertain to those streams mentioned previously. We will try to point out the concerns a generator may need to have in mind when selecting an appropriate type of disposal.

(1) Indiscriminant Dumping.

By current statistics (EPA, Fed. Reg., Vol. 56, No. 184, p. 48003, Sept. 23, 1991) up to 43% of all used oil generated in the United States is disposed of improperly and ends up as pollution. That is approximately 560 million gallons, of which approximately 180 million gallons are estimated to come from do-it-yourselfers who change their own oil. While household wastes are exempt from regulations, illegal disposal by industrial generators can lead to large fines and potential criminal prosecution.

If someone within your company does not have the direct responsibility for monitoring how all generated wastes are being managed, it should become a high priority to establish controls. If you cannot trace the disposition of your oil, it is reasonable to assume it is not being handled responsibly.

It cannot be emphasized too strongly that not knowing the process which a disposer/recycler is employing can lead to severe penalties. Criminal charges can be focused at any level of an organization, from executive to dock workers, whether or not they know the details of the illegal activities.

(2) Landfilling.

Disposing of oily waste by way of landfilling is currently restricted by Federal Regulation 40 CFR 268, as well as by limitations on the placement of liquids in the solid waste meets current toxicity characteristics leaching procedure (TCLP) standards. Even for disposal in permitted hazardous waste landfills, streams must meet certain land disposal regulations.

Generators currently using landfills for oily wastes need to document all tests and permits which allow this disposal. Even if not currently being used, those who have employed this method in the past should make sure that all past shipments are documented and reviewed in light of current regulations (especially CERCLA, which is known as Superfund and is retroactive).

If the destination was an unlined landfill, it may pay to take action now to determine what legal ramifications may apply to you as a generator and take all appropriate steps necessary to prevent future pollution. You may find yourselves involved in the cleanup or monitoring of these facilities as part of a Superfund action, which applies retroactively to waste transactions occurring before the law was in place.

(3) Road Oiling and Foliage Control

The use of waste oils and solvents for road oiling and foliage control are severely restricted if not banned in most states. Again, the key is to know what is happening at your selected TSD facility. A small used-oil collector in Times Beach, Mo. sold a dust suppressant which turned out to contain dioxin mixed into a waste oil stream. Its use had been so widespread that EPA ended up buying the entire community and moving all residents.

(4) Burning for Energy Recovery

Energy recovery is the most common form of oily waste disposal. Over two-thirds of all oil collected is used as a fuel. There are many advantages and some controversies to this form of "recycling". It is not certain which line of approach the EPA will take on this issue as it continues to publish regulations.

According to the Code of Federal Regulations (40 CFR Part 266), all collectors of waste oil for the purpose of resale as fuel must demonstrate that the waste meets standards as outlined in Table 16. This fuel is referred to as "on specification", and can be handled as any other fuel oil. If it does not meet the specifications (i.e., if it is "off specification"), the used oil can only be accepted by burners who have notified their state environmental agencies that they will be burning such materials and have a permit to do so. Alternatively, these oils can be forwarded to a reprocessor, re-refiner, or hazardous waste facility which holds the appropriate permits to store and process this waste.

Cement kilns and incinerators which operate at very high temperatures are options chosen for those streams that are too severely contaminated to recover economically. Kilns sometimes restrict water content, so well-maintained water separator units at the generating facility may be needed.

Based on current regulatory standards, the kiln/incinerator option involves the lowest risk for burners of waste, because of technologies they utilize provide total destruction and visits by regulatory agencies are frequent. This ensures the generators liabilities are kept to a minimum.

This form of disposal only allows the oil to have two lives - the actual use life (lubrication) and final energy recovery. Thus, energy recovery does not qualify as recycling under some regulations.

One difficulty with the burning option is that most collectors, processors and marketers associated with used oil fuel operations are small. They may handle a collection radius of 100 to 200 hundred miles to keep transportation costs low and to allow them to compete in the local fuel market profitably. Gross profits are minimal because of the limited geographic area served. The EPA requires that testing and records of each load be kept from receipt to final disposition. However, in many instances, a quality control laboratory with necessary equipment at the facility is not maintained, which creates the potential for hazardous waste being mixed with non-hazardous waste, creating a new hazardous waste where all generators involved are ultimately responsible for disposal.

These facilities are also often expected by their customers to treat the waste in some form (decanting, drying or distillation) to remove contaminant's that may be contained in the waste before sale. This can be expensive. Thus, the waste generated and picked up at your facility may go directly to a burner without testing or treatment. Again, it is the generators responsibility to know not only how his waste is being handled, but also how other wastes sent to this TSD are handled, by checking records at the site. The generator is ultimately responsible for the operating techniques that are applied to his wastes and other materials blended with these wastes.

The best situation would be that all fuels sold are "on specification" as defined within 40CFR266 Subpart E. The primary parameters are shown in Table 16. A further restriction applies if the fuel contains between 2 and 50 ppm PCBs, again requiring notification (see 40CFR761.20) by the end user.

(5) Reclaiming

The use of waste lubricant for alternate, less strenuous lubricant applications is common practice. Some used oils have minimal contamination and can be cleaned up with simple process steps. Both of these types of recycling are referred to as reclaiming. For example, heating waste oils to evaporate moisture and running the dry oil through simple filtration equipment remains common for products such as hydraulic fluids that are relatively clean.

Commercial reclamation is generally performed by small compounder/blenders, who inject additive to the partially-spent, filtered waste oil before use as a cutting oil or API/SA motor oil. These uses do not require adherence to the highest standards of performance from the lubricant.

A waste locomotive crankcase reclamation system currently used on several rail systems involves dehydration, coagulant addition, and/or filtration prior to reuse in locomotive engines. If kept as a very small percentage of engine charge these rail systems have yielded a cost savings with no detriment to engine function. The acid scavenger (measured as total base number) remaining in the used oil is oftentimes

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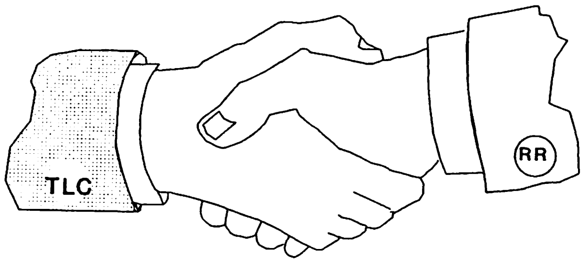

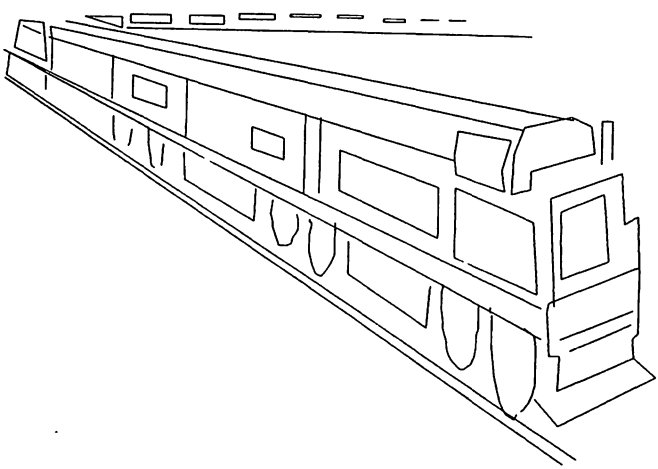

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not completely depleted and remains effective.

The major manufacturers of locomotive engines do not recommend this practice for obvious reasons. The remaining fuel and cranked hydrocarbon molecules (from combustion) offer limited (if not detrimental) lubricating factors. Acids and metals created from combustion and wear, if not completely removed, may act as a catalyst and further degrade or limit the life of the charge of new, fully-compounded lubricant.

From an environmental point of view, this process does reduce the lubricant required for disposal. However, when evaluating this option for in-house installations, one must consider the additional cost and long-term liability of the water, fuel, acid sludge, and residues generated by the drying and filtering process. These new wastes may need to be further treated, either in-house by one's separator system in the case of water and fuels, or landfilled or incinerated in the case of sludge and filter media. As discussed earlier, the use of landfill is not a preferred method of disposal. It is important to underline the need to review all applicable federal, state, and local regulations before undertaking any treatment of wastes.

(6) Re-Refining

The last form of recycling covered in this paper is usually the most expensive, but offers solutions to all of the environment requirements applied to disposal eliminating long-term liability, meeting the requirements of the Resource Conservation and Recovery Act, and providing re-refined lubricant or other petroleum products equivalent to those manufactured from crude oil.

Several types of re-refining employed in the United States will be discussed:

a. - introduction of waste oil into the crude refining process,

b. - acid/clay process,

c. - thin film evaporation/clay contact finishing, and

d. - thin film evaporation/hydrotreating process.

a. Introduction of waste oil into refining streams.

This form of re-refining involves injecting an additional feed stream at some point in the process, including possible use as a "crude" mixed at the front end of the refinery with those already purchased from foreign or domestic sources. The waste oil stream usually is introduced in small amounts into the existing stream to minimize process change requirements. This approach reduces "cradle to grave" liability substantially, but may pose some environmental problems for refiners used to handling only crude oil.

For example, when handling wastes, especially those from other generators, these facilities must meet federal and state EPA standards. For locations where used oil is a listed hazardous waste, the facility must be permitted to store both hazardous and non-hazardous waste. In addition, those facilities must file a waste analysis plan to cover testing for hazardous constituents and to establish the suitability of a waste stream for introduction into the refinery. The additional liabilities and regulations can interfere with refinery efficiency, such that most have elected to avoid this type of processing.

When added to the front end crude feedstream, the process distills the waste as it does virgin crude into fuels, lubricants and asphaltic bottoms. Because the contaminant's which are found in waste oil are generally not found in crude, some of the refineries which have attempted to refine this waste stream have encountered problems with their fuel streams showing high amounts of halogens and solvents and their asphalt (distillation bottoms) showing higher than normal metal contents.

In addition, they have found that the catalysts used in some cranking processes are being contaminated at increasing rates, necessitating earlier than expected maintenance and changeout. Thus, for processing as well as regulatory reasons, refineries feeding waste at the front end have elected to eliminate this waste stream from the process and return to processing strictly virgin crude.

Others have chosen to inject the used oil at a different point in the process to avoid system and product degradation. For example, at least one refiner is injecting the used oil directly into a thermal cracking unit called a delayed coker. Essentially all components of the used oil are thermally checked to yield coker gas oils.

All coker overhead products are subsequently hydrotreated to remove sulfur, nitrogen, and unsaturated hyrocarbons, as well as any non-hazardous halides. The process also produces a small amount of petroleum coke, a solid material similar to coal. The hydrotreated heavy gas oil is then sent to a catalytic cracking unit to produce conventional fuels such as gasoline, diesel fuel, and petrochemical feed stocks, with about 98% recovery of overhead products.

Refinery processing does eliminate or reduce the "cradle to grave" liability and creates high quality fuels and lubricants.

b. Acid/clay process.

The acid/clay process employed for many years as the premier type of refining has lost its edge due to newer technology and environmental concerns.

The process introduces concentrated sulfuric acid into the waste oil stream, creating an acidic sludge containing spent additives, combustion products (carbon), and wear metals. This acidic sludge is then removed and disposed. The metal-free base oil is heated and treated with activated clay, which attracts most of the organic acids, color bodies, and odors remaining in the base oil. The clay also acts as a filtering agent to remove remnants of the acidic sludge.

What remains after filtering is essentially a clean, although still odorous base oil. The lubricant after compounding with new additives usually is of diminished quality to virgin base stocks, or those oils produced by newer re-refining methods. Typically, these oils are restricted to lower quality applications.

Environmentally, the by-products produced, the acidic sludge and oily clay, create a disposal problem for the facility and for the generator. The acid sludge is a characteristic hazardous waste due to low pH. This sludge must be handled as a hazardous waste or neutralized and tested to see if it can be handled as non-hazardous. It must conform to TCLP standards if put into a landfill. The waste generated in the clay-contacting process, although not generally hazardous, is most likely destined for landfill and must meet TCLP standards.

Because of the continuation of "cradle to grave" liability and EPA regulations concerning by-products of processing, including odorous, acidic air emissions, most facilities which employed this process have changed to newer technology or gone out of business. The expense of disposal and the need to meet EPA standards were too great. This disposal/re-refining method carries the burden of potential long-term liability.

Generators must be aware that for the time period before EPA regulations took effect, much of the by-product material was placed in pits and piles on-site. Many generators are discovering that they are now responsible for their portion of any cleanup necessary if the facility falls on hard financial times and it becomes a Superfund site.

c. Thin film evaporation/clay contact finishing

An alternative to acid treatment is to use vacuum distillation to separate the useful hydrocarbons from the high molecular weight contaminants. The process begins with a dehydration process which removes water, solvents, and light fuel fractions from the waste stream. The water is sent to a treatment facility and the light hydrocarbons are burned in the process for heat recovery. Excess fuels recovered may also be sold as "on" or "off" specification fuel (as described earlier).

The dry, defueled oil stream is then fed through a thin-film evaporator which distills and recovers the selected hydrocarbon friction under vacuum and removes the residual asphalt cut for sale as an asphalt extender.

The base oil cut removed is further treated by the addition of clay which removed some combustion acids, color bodies and some odor. The slurry runs through a filter press procedure and is tested and evaluated for sale. Some clay may pass through the initial filter process and require additional filtering prior to shipment.

The EPA considers the by-products of base oil asphalt to be chemically-changed finished products. Thus, the waste has been treated, and "cradle to grave" liability has terminated.

The generator must still be concerned about by-products generated in the dehydration process and that they are handled in accordance with the law. A further concern is disposal of the oily clay, which is similarly to the material generated in the acid/clay process.

Although not the state of the art form of re-refining, this process eliminates much of the liability and produces a less odorous, higher quality re-refined base oil which can be blended and compounded to meet most manufacturers' specification.

One possible concern is that the distillation/clay contacting process does not effectively remove the *polynuclear aromatics* (PNA's) which are created by combustion and have been shown to be potentially *carcinogenic.* Assuming they pass quality control testing, the base oils and finished lubricants produced from this process are often an economic source of lubricants as well as an environmentally safe disposal method.

d. Thin film evaporation/hydrotreat finishing

This disposal/manufacturing process is the next step beyond the thin film/clay contacting form of re-refining. The larger re-refiners in Canada and the United States use this form of processing. A flow chart for one of the installations is shown as Fig. 7.

Not all waste oil streams available which find their way to these facilities are selected to proceed through the re-refining process. The better feedstocks include automotive and railroad crankcase, hydraulic, transmission, UHTF, and other high quality waste streams. Waste streams with high water, excessive contamination, or animal fats are processed as fuel. This leaves a feed or "crude" of sufficiently high quality that it will not effect the efficiency of the plant operation. Quality control at the front end of the system means higher quality product exiting the system.

The selected streams are commingled in a large holding tank which is agitated to form a consistent feed. This eliminates any chance of the system seeing any truck-to-truck variations. The feed is sent on a continuous basis to a dehydration unit to remove water, solvents and light fuel fractions. The water is treated to meet permit limits and discharged into the metropolitan sanitary system. The solvents and light fuel fractions are recovered and burned within the facility to supplement the energy produced in the boilers for operation.

The dehydrated oil is then sent through another defueling distillation column at higher temperature and a moderate vacuum to remove heavier cuts of fuel and cracked molecules. This produces a high quality saleable industrial fuel.

The topped feed is then sent through a series of thin-film evaporators, which are held at different distillation temperatures to produce multiple fractions or viscosities of hydrocarbon base oils. The unfinished base oils produced are tested against manufacturing specification guidelines and sent for a final finishing step.

The finishing process used by this technology is similar to that used by most "virgin crude" lube oil manufacturing facilities. Catalytic hydrogenation removes most sulfur, oxygen, and nitrogen from the base oil, while saturating some of the aromatics. This addition of hydrogen eliminates most of the compounds causing color, odor, or autoxidation. Finished product is again tested to manufacturing guidelines and sold to industry as base oils or blended with additives and sold as fully-compounded lubricants.

Oils which have gone through this processing have passed all bench and engine sequence testing required by government and industry standards. The Lubricants Review Institute found no performance difference between oils produced by this manufacturing method and high quality virgin oils.

Railroad engine bench tests and long-term field tests are being performed to confirm the oxidative stability and lubrication characteristics of these base oils produced. Engine sequence tests and hydraulic pump tests have already been performed on gasoline and diesel as well as hydraulic oils. All have shown these to be equivalent to virgin oils.

From an environmental point of view, re-refining offers to the generator the least long-term liability and the highest form of resource conservation. All by-products except for the water have uses within the plant or can be sold as products. The asphalt bottoms which contain the metals, dirt, and additives are non-leachable, non-hazardous by-product saleable as an asphalt extender and used in the paving and roof shingle industries.

Thus, essentially all constituents found in the initial waste stream have been converted into fuel, lubricant, or an asphalt component.

Conclusion

Current and proposed land disposal and air quality standards are restricting how used oils can be handled. Heavy metals, chlorinated solvents, and fused-ring combustion by-products have caused some states to list used oil as a hazardous waste. Environmental regulations are creating extreme economic hardships on large and small collectors, forcing many to close their doors.

Unfortunately, the costs of generators for the clean up of these facilities are not always proportional to the amount of waste submitted. The generators with the deepest pockets usually pay for the errors of others.

When selecting a facility to remove and process waste such as used oil, it is important that the generator consider more than current costs. In the long run, it may be less expensive to select the facility which is financially stable (with capital for improvements and insurance for long-term viability), environmentally sound (regulatory standards maintained), and operationally clean.

Disclaimer

This paper does not purport to cover all regulatory issues. The reader is responsible for all interpretations of federal, state, and local regulations as applied to his waste streams.

Table 15
Typical Contaminants In Used Oils

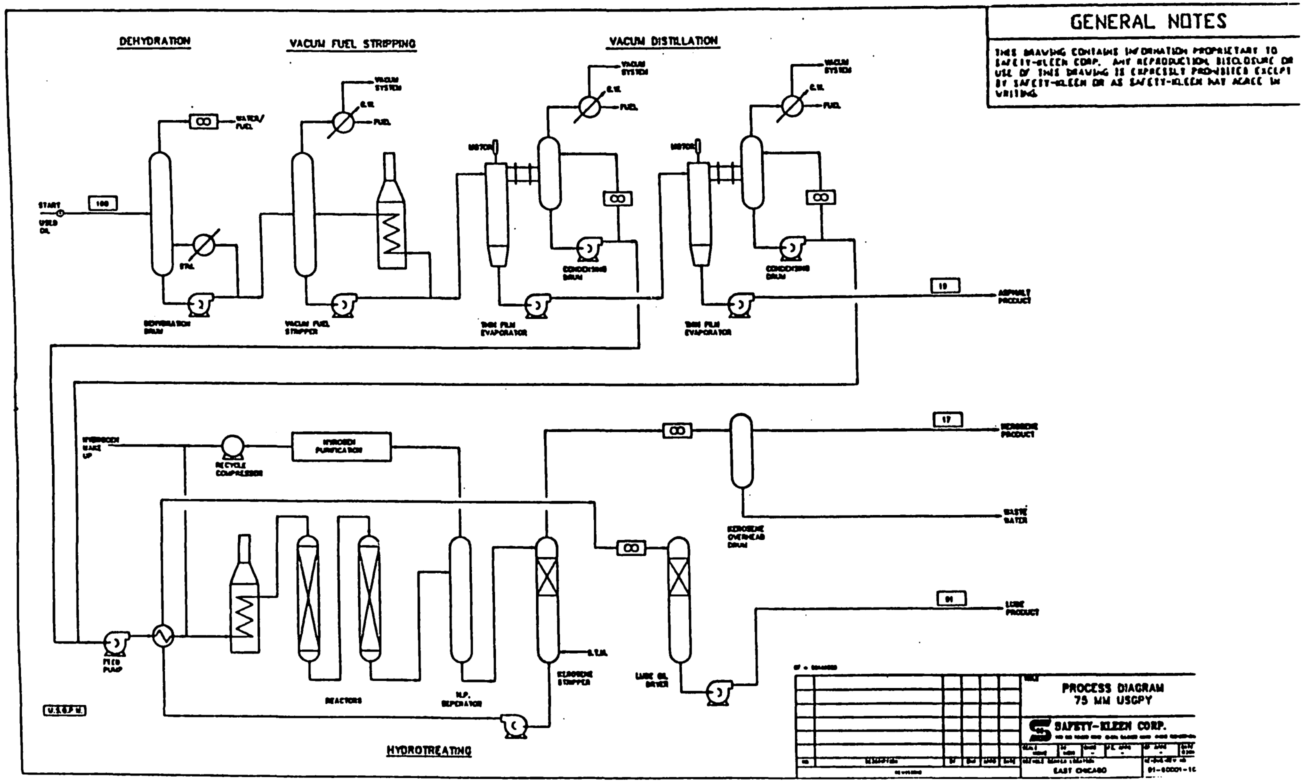
Lead
Chromium
Zinc
Halogenated Solvents
Benzene
Polynuclear Aromatics
Coolants
Fuel Dilution

Table 16
Used Oil Fuel Specifications

AS	< 5 ppm
Cd	< 2
Cr	<10
Pb	<100
Halogens	<4000 ppm*
Flash Point	100°F max.
PCBs	< 50 ppm (TSCA)

* Total Halogens levels above 1000 ppm are presumed to indicate mixture with listed hazardous wastes unless analyses indicate otherwise.

Fig. 7 - Process Diagram For Vacuum Distillation/Hydrotreating Re-Refinery



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

Our Diesel Electrical 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.

REPORT OF THE COMMITTEE ON DIESEL ELECTRICAL MAINTENANCE

MONDAY, SEPTEMBER 21, 1992
3:00 p.m.

Pre-Convention
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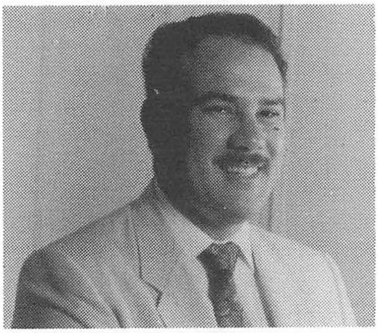

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B.E. Hathaway	Shop Supt.	FL. East Coast	New Smyrna Bch. FL
T. Johnson	Supvr.-Loco. Maint.	DM&IR	Proctor, MN
T.C. Leary	Mgr-Loco. Plng., Svcs & Prog.	Union Pacific	Omaha, NE
D. Gezon	Asst. CMO-Motive Power	Grand Trunk Western	Battle Creek, MI
G.R. Parsons	Mgr-Mech. Training	BN RR	Overland Park, KS
M. Pasini	Sr. Spec. Elect.-MP	Via Rail	Montreal, PQ
A.J. Payne	Loco. Elect. Engr.	CSX Transp.	Jacksonville, FL
J.W. Popp	Mgr-Quality Control	Amtrak	Wilmington, DE
D.T. Smith	Mechanical Foreman	Montana Rail Link	Livingston, MT
J.R. Spiegel	Senior Tech. Engr.	Electro Motive Divn.	LaGrange, IL
D. Thomas	Shop Manager	C&NW Transp. Co.	Council Bluffs, IA
L. White	Special Elect. Asst.	Canadian National	Montreal, PQ
C.S. Wilkerson, Jr.	Asst. Mgr-Mech.	Norfolk Southern	Roanoke, VA

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 of the AAR/Transportation Test Center in Pueblo, Colorado.

He is married with two children.

I. NICKEL-CADMIUM BATTERIES AS AN ALTERNATIVE

Presented by Mauro Pasini, Via Rail

1. Background

It was in February 1901 that the Thomas Edison patent for the alkaline nickel-iron battery was presented. This request had been preceded just a month earlier by a similar one from the Swedish professor Waldemar Jungner. Both inventors claimed priority and rights, but the following court dispute turned in the American's favor.

However, the alkaline battery continued to be developed in both the U.S. and Sweden; and while the Edison battery used nickel and iron as active materials, the Swedish Jungner-Estelle company replaced iron with cadmium as the other major active material. They were soon to be followed by other companies in Germany, Great Britain and France. Although the new battery presented many advantages over the generally used lead-acid type, in particular its longer durability and mechanical sturdiness, its popularity has always been constrained by its higher price. So while we are seeing rapid expansion in the use of the sealed Ni-Cad battery in applications such as lap top computers, video cameras, toys etc., the vented Ni-Cad battery has seen its market shrink year by year. This is probably the reason why in recent years important mergers of manufacturers have taken place. This process has reduced considerably the number of companies, to the point where the benefits of competition are greatly reduced. The price of vented NI-Cad batteries has consequently increased much faster than the lead-acid counterpart. The recent introduction of new Ni-Cad batteries (such as those with plastic bounded plates and the fiber-structured electrodes) is generating renewed and justified interest in the application of Ni-Cad batteries to diesel electric locomotives starting. For this reason, the following text will refer principally to these new battery types, even though the maintenance requirements and practices are generally valid for any type of vented Ni-Cad battery.

2. Battery Design and Types

The Ni-Cad battery uses nickel as active material for the positive plate and cadmium for the negative plate. The electrolyte is a solution of potassium hydroxide with a specific gravity 1.160 and 1.250 at 77 deg F, depending on the type of cell and the ambient operating conditions. The reaction consists of the transfer of oxygen ions from one set of plates to the other. The electrolyte takes no part in the chemical reaction; its density remains practically constant from the charged to the discharged state.

While in the traditional pocket plate battery construction some additional metals (graphite and iron) were added to the active materials to improve conductivity and stability, in the new battery plates the active materials are used in their pure state.

This process has allowed these new batteries to provide superior performance, longer life and reduced maintenance. Ni-Cad batteries come with either steel cells or plastic cells. The former are assembled in wooden crates, while the latter are provided in a stainless steel container. Steel cells offer the strongest construction and resistance to shock and vibration. They are also used were fire-resistance is required. Plastic cells have the advantage of lightness,

case insulation and see-through electrolyte level. The individual cell construction of these batteries allows for a wide choice of assemblies particularly useful in cases of limited space or weight restrictions. Capacities range from 70 Ah to 350 Ah.

3. Battery Characteristics

The main characteristics of the modern vented Ni-Cad batteries are:

- very good discharge performance at high rate;
- high performance at low temperatures;
- important weight and volume reduction compared with other batteries (30 to 50%);
- life expectancy from 2 to 3 times that of other batteries;
- low maintenance requirements (addition of water 2 to 3 times a year);
- no electrolyte freezing even at very low temperatures;
- no toxic or corrosive fumes and gas;
- very long storage whatever the state of charge;
- about 85% of maximum breakaway performance with battery half discharged;
- no memory effect.

4. Maintenance

The Ni-Cad battery requires very simple but attentive maintenance. Precautions must be taken to avoid electrolyte contamination, particular from sulfuric acid. Even minute amounts of sulfuric acid will destroy the battery cells. Care must be taken not to use filling or electrolyte measuring tools previously used with lead-acid batteries.

a) Running Maintenance

The following are the main running maintenance requirements:

- Battery containers and cells:

Battery boxes, cells and crates must be kept clean and dry. Periodic cleaning is necessary to remove dust and the normal slight salt deposits which are often found over the tops of the cells. This is easily carried out by blowing the cells with compressed air.

Plastic cased cells can be washed with warm water to which a mild detergent can be added. After washing, batteries should be dried by blowing with compressed air.

- Addition of distilled water:

Distilled or demineralized water must be added at regular intervals, normally every six months. Care must be taken to insure that the electrolyte level is not raised over its maximum level. Overfilling of the cells will result in electrolyte spillover and, due to its high conductivity, consequent current leakage. Special tools are available from the battery manufacturers that will facilitate the water addition, such as filling guns with light indicators for correct electrolyte level.

- Battery connections:

Battery connections must be carefully examined; if insulation is found defective they must be replaced or repaired. Connections must be tight and show no signs of overheating. Occasionally a light coating of anti-rust protecting grease should be applied to all cell connections for corrosion protection.

b) Periodic overhaul

This maintenance can be carried out concurrently with the locomotive major overhaul.

The battery should be removed from the locomotive and thoroughly cleaned, preferably by washing it with warm water to which a mild detergent has been added. The electrolyte specific gravity should be measured to insure that its density is within the acceptable limits. A capacity test should be performed to verify that all cells have adequate remaining capacity. The test is carried out in the following manner:

- Discharge the battery at a current between 0.2 and 0.5 C5A. The discharge is taken down to 0 V/cell.
- Normal charge of 7 hours at 0.2 C5A.
- Discharge to 0 V/cell at a current between 0.2 and 0.5 C5A.
- Charge 15 hours at 0.2 C5A.

Perform the capacity test by discharging the battery at 0.2 C5A and:

- Measure at regular intervals (every 15 minutes) the terminal voltage of each cell.
- The discharge is continued until terminal voltages are about 0.8 V.

Cells which exhibit low capacity should be replaced. The minimum acceptable capacity is generally chosen at 70%. However since the Ni-Cad battery does not fail of sudden death, a lower value can be selected if starting performance is still acceptable.

5. Lifetime

The longevity of any battery has always been a matter of argument. Although references are often made to applications in which batteries have lived up to several decades, it is very unlikely that the life expectancy claimed by the battery manufacturer will actually be obtained on a regular basis. This is particularly true for locomotive batteries, which generally operate in very harsh environments, receive poor maintenance and are subjected to all kinds of abuse. As a rule of thumb, though, it has always been accepted that the traditional Ni-Cad battery used in locomotive starting will provide from two to three times the years of service of a lead-acid battery.

The new generation Ni-Cad batteries have only been in the market for a few years. For this reason their longevity can only be estimated from laboratory tests, such as the "life test" specified by the International Union of Railways (leaflet 854 R). From this cycling test the new batteries can provide up to 2000 cycles, at 40% discharge. This is about four times the number of cycles provided by the traditional pocket plate Ni-Cad battery or the lead-acid battery. On this basis we should expect from this battery a life of about 20 years.

Indeed, there are other factors that greatly influence the reliability and longevity of a battery, regardless of the type or make of the battery itself. In many cases these are the factors that finally determine the overall performance and user costs for a specific battery. The following factors are the most significant:

a) Battery Size

The choice of the right battery size is the first important step towards insuring a good performance over the entire battery life. Unlike lead-acid batteries, which have been standardized to two major sizes (285 Ah for engines of 1500 HP or less and 420 Ah for larger engines), Ni-Cad batteries can be selected from a large number of sizes. Comparative tests have shown that a 150Ah Ni-Cad battery has an equivalent starting performance to a 420 Ah lead-acid battery. On the other hand, the use of a 150 Ah battery would provide limited energy reserve for supplying locomotive auxiliary loads. For this reason, it is much safer to chose a higher capacity batter (about 200 Ah is considered sufficient) and insure both higher energy reserve and additional starting power. The additional cost will be repaid by a superior starting performance and longer life.

b) Battery Box

The battery box and its location are also very important aspects which must be closely scrutinized to insure lone battery life at low maintenance costs. The battery should be installed in a clean and dry location. Heat is also very detrimental to battery durability, that's why installing batteries in engine rooms should be avoided. Battery boxes should be designed to protect the battery against road dust, water, snow etc. This is very important for steel-cased Ni-Cad batteries because they are very prone to grounds when exposed to dirt and high humidity.

In one recent locomotive acquisition, the original battery box did not provide adequate environmental protection. After some unsuccessful modifications, it was decided to pressurize it. The modified box is practically sealed and the required air exchange is assured by admission of pressurized air from the traction motor ventilation system. This simple change has provided an ideal environment for the battery, which being kept clean and dry requires minimal maintenance. Indeed this is one case where a low cost modification directed at improving and reducing maintenance has also proven very cost effective.

c) Maintenance Practices

The locomotive battery is probably the piece of equipment that is most affected by the everyday practices of maintenance personnel. Indeed it is a known fact that most locomotives are left with their lighting on (engine and electrical cabinets) during shop regular maintenance. The discharge and cycling resulting from this practice are the very reason for short battery life. The best way to solve this problem, is to use a shop battery charger when a locomotive is pulled in the shop where lighting is to be used during maintenance. All locomotives are equipped with battery charging receptacles for this purpose. The use of battery chargers provides energy for the lighting and for maintenance of battery charge, resulting in the optimum conditioning of the battery itself.

6. Economics

As previously stated, Ni-Cad batteries are quite expensive. Their price is about four times that of lead-acid batteries of equivalent performance. But when maintenance, reliability and logistic costs are added to the acquisition price, the yearly expense of using a Ni-Cad battery or a lead-acid is about the same.

However, the superior reliability of the Ni-Cad battery could present a clear advantage, particularly for those railroads whose equipment is exposed to extreme ambient temperatures.

In conclusion, although the new Ni-Cad batteries represent a valid alternative to the lead-acid battery, each interested potential user is strongly advised to first experiment through a field test and in the actual environment before engaging in a fleet-wide use of Ni-Cad batteries. Extended tests will insure that all the expected advantages are indeed achieved and will help avoid possible negative results that are often experienced with a new product.

II. OVERVIEW OF LOCOMOTIVE MICROPROCESSOR BASED CONTROLS

Presented by Jim Popp, Amtrak

Microprocessors are commonly used in today's high-tech transportation systems and the locomotive is no exception. The availability of a wide variety of microcomputer components has created revolutionary changes. These changes have been incorporated into microcomputers based in present-day locomotive control systems.

The microprocessor has already had an extraordinary impact on technology and society since its introduction in 1975. Microprocessors are capable of making millions of decisions a second and are the operational heart of the microcomputer, a machine used by millions of people world wide every day. In addition to the microcomputer, microprocessors control many other familiar machines from home appliance to satellites and virtually every modern weapon system.

In microcomputers, the surrounding components include keyboards, disc drives, and mice. In modern locomotives, the surrounding components can include support systems such as cooling, braking, governor, and safety features. Essentially the microprocessor is used for implementing computer networks, software and hardware development, and specific applications such as instrument control, word processors, heating, inventory, and locomotive diagnostics.

Physically, the microprocessor is generally no larger than one square inch in size and weighs less than one ounce. Microprocessors commonly called "chips," are made of silicon, encapsulated in plastics or ceramics and are able to withstand and operate reliably in adverse heat, moisture and dirt environments.

The microprocessor's silicon is "etched" with up to one million transistors. This collection of miniature transistors works to perform mathematical and logical operations in response to inputs provided by surrounding support components.

The computer is also partitioned into integrated-circuit chip sets. The combination of the control function with the arithmetic and logic functions is called a microprocessor. When a microprocessor chip is mounted on a printed circuit board with other memory and interface chips it forms a microcomputer. When this board is combined with printers and display terminals it forms a microcomputer system.

The memory unit available to the microcomputer is an important determination of its power. Memory is available in several forms which include "RAM", random access memory, and "ROM", read only memory, chips. There is also a clock or crystal which provides a continuous pulse that triggers and synchronizes events for the computing device.

Microprocessors were first used in new locomotives in the 1980's when GE introduced the DASH-8 and EMD the 60-Series. These new locomotives marked the beginning of microprocessor technology incorporated as a basic element of their control system, making them much more efficient and reliable than their predecessors.

The overwhelming success of microcomputer based control systems spawned projects to retrofit these systems into older locomotives. However, the existing locomotive fleet was performing to expectations, and the conservative thinking of most railroads did nothing to speed development of microprocessor technology.

Rebuild programs incorporating this technology have been done by rebuilders such as VMV with off-the-shelf components, while Generation II and Republic performed similar but slightly customized retrofits using PLC's (programmable logic controllers). In addition Woodward/Helm began marketing the CLC (complete locomotive control) system for retrofit programs.

Retrofitting older locomotives is expensive; the high cost is attributed to research and development of the microcomputer based control system to be installed. In addition, these control systems require new electrical cabinets and as a result were only considered if the locomotives were going through major rebuild or upgrade. When most microcomputer control systems became available, candidates for rebuild had disappeared from class 1 railroads. That meant new locomotives would be the area where microprocessor control could have the greatest impact. The OEM's have this very much captive for now. Remanufacturers like Morrison Knudsen are developing new microprocessor locomotives.

The General Motors Electromotive Group has developed an advanced microprocessor based control system. The "EM-2000" will be the basic control system for the SD70 locomotive. The EM-2000 system features a fast 32 bit, 16Mhz microprocessor coupled with a memory system and math coprocessor which reduces the number of support components and modules and improves reliability and efficiency. A six-line text display is included and provides instantaneous operational information and help for the operator. Self test procedures can identify problems to a detailed component-specific level. Among these are individual component tests for contactors, relays and fans which further enhance maintainability.

The General Electric Company DASH-8 locomotive incorporates the latest in digital microprocessor-based technology. The GE system is composed of three sub-systems addressing all locomotive functions. These subsystems are orchestrated and monitored by a cab controller which, like the EMD EM-2000 system, provides an understandable human interface indicating the locomotive's current operational status and fault history.

The OEM's have not forgotten the rebuild market.

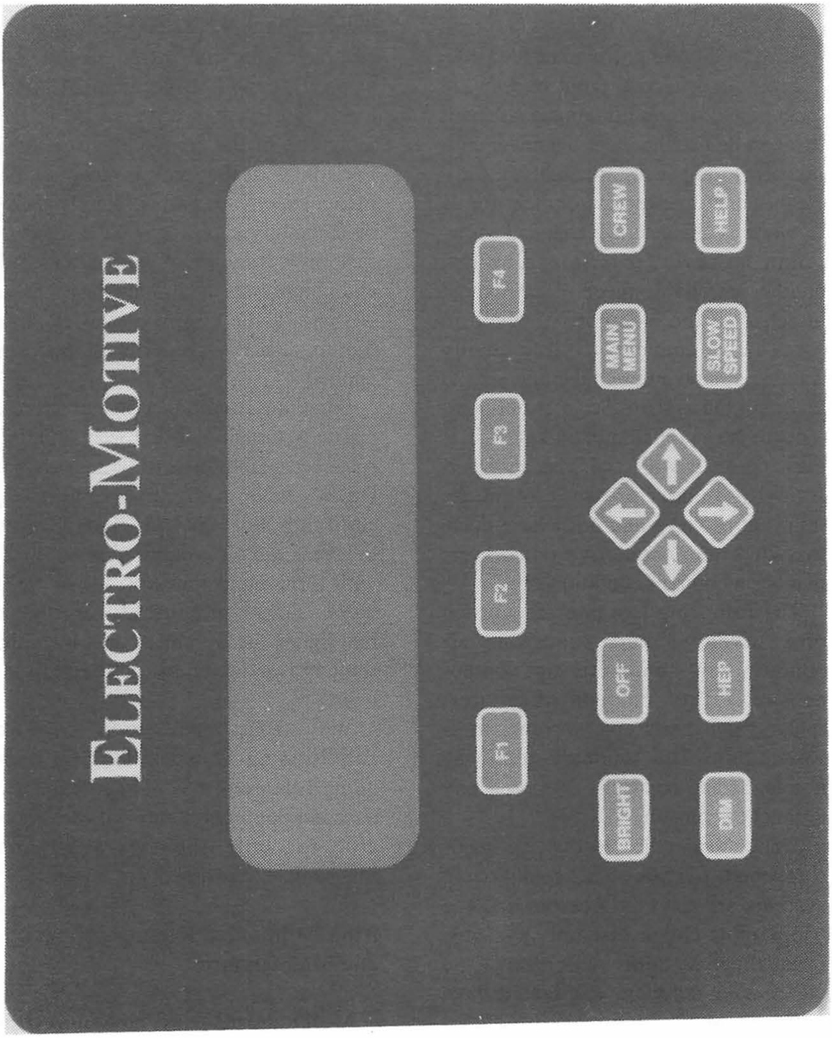
The Electro Motive EM-2000 will also be offered to retrofit other EMD locomotive models in the aftermarket. This will enable railroads to upgrade and simplify the electrical control system on older EMD locomotives.

General Electric in a joint venture with TSM has designed a system to improve reliability and reduce costs associated with maintaining older locomotives. The electronic engine protection system for use on GE Dash-7 locomotives uses much of the technology proven on the Dash-8.

These retrofits are the first affordable for older locomotives, and as the technology of these control systems improves the cost of the retrofit older systems will continue to drop.

Locomotives equipped with microprocessor-based controls have the capability of providing the railroad industry with a wealth of important information. Performance data, fault information and periodic maintenance information can be obtained from the units and used by railroads to improve operation and service while reducing overall costs. Self diagnostics are a major area where the microprocessor

can and must help the railroad. In a time when most railroads have decreased the number of trained maintenance personnel, the use of microprocessor-based controls to help improve locomotive performance and reduce the problems associated with locomotive operations is imperative. Modern microprocessor based control systems make this both technically and economically feasible.


ELECTRO-MOTIVE
F1
F2
F3
F4
BRIGHT
OFF
MAIN MENU
CREW
DIM
HEP
SLOW SPEED
HELP

III. AIR CONDITIONING

Presented by Jake Vasquez, AAR/TTC

Air Conditioning: friend or foe?

From an operating point of view, in most cases, air conditioning is a benefit that can be used to meet the never ending demands put on our industry for a cleaner and quieter environment for us to work in. From a Mechanical viewpoint, however, it is felt to be just another unreliable piece of equipment attached to the locomotive, which in most cases, comes with little quality training and no additional employees to maintain the system. So, it is not common to hear a statement like "if it is blowing air it will cool," because personnel are under pressure to get the train out of town and not take a delay to switch the locomotive out for one that has a good air conditioner.

The following is a brief conclusion of a survey we made concerning air conditioning manufacturing, component reliability, component failures, replacement parts and warranty turnaround time. This summary in no way is intended to condemn or glorify any product or company.

The survey indicated that the major component failures on air conditioning systems are the compressors and the couplers or clutch assembly systems. Even those systems which have the clutches or couplers eliminated have compressor problems or associated component failures.

It is obvious that the reliability of the air conditioning systems is dependent on eliminating compressor leaks, other compressor problems and clutch/coupler components problems. This must be accomplished if the air conditioning system is to remain an economically justifiable part of the locomotive.

Some air conditioner manufacturers are trying to meet the demand by redesigning the system to eliminate the clutch/coupler components, using a direct drive system. This redesign has eliminated the clutch/coupler problem as well as the belt problem. Another modification has been made to the mounting of the compressor assembly horizontal to the track because of the forces experienced when coupling cars or locomotives. Along with this modification was the redesign of fan motors and compressor and motor bearings to withstand the coupling forces. Fan motors also have redesigned bearings applied.

Some air conditioner manufacturers warranty turnaround time was found to be unacceptable (one to three months). Other's have made improvements by certifying local air conditioning firms to repair the air conditioning systems, with turnaround times of one to three days. Other manufacturers have redesigned the a/c unit so that it can be removed or installed in less than an hour.

With smaller modifications to the air conditioning systems along with on going research, it is conceivable that air conditioning systems will be workable for both the Operating and Mechanical departments.

Air Conditioning Repair and Maintenance

Most railroads' air conditioning policy is one of run to destruction. This guarantees high on-line failure rates and many crew complaints. In order to reduce crew complaints and give management a bargaining tool in negotiating crew reduction agreements, one railroad decided to place emphasis on annual servicing inspections and quality repairs.

A study was conducted to determine whether the servicing and repair of air conditioners should be done in-house or outsourced. The study concluded it was more cost effective to do it in-house if high quality standards could be maintained. It was decided to do it in-house, so an air conditioner shop was organized. Both labor and management were involved in every facet of the operation. This was a team approach; labor has ownership in the entire process. The air conditioner shop has been in operation less than a year but the results have been very positive.

The process begins with an inbound inspection looking for physical damage. All defects are noted so the proper repairs can be made.

All covers are removed and the air conditioner is thoroughly cleaned. This is vital to the operation of the air conditioner. Dirty coils means high head pressure and poor performance.

The fins of the various coils are then combed by the worker. This is a very time consuming task but it is extremely important to the air conditioner's performance.

The air conditioner is then inspected for leaks. The worker first checks the pressure to ensure that freon is present and the pressure is a constant. Constant pressure indicates the system is relatively free of leaks.

The worker then uses an electronic leak detector. The most probable places for leaks are around the dryer, the compressor, or at the joints around the condenser coils.

If leaks are found, the freon is removed, using the Robinair refrigerant recovery/recharging system, and repairs are made.

All air conditioners are evacuated. This is to ensure that there are no leaks and that all the air is out of the system. Routine servicing on the 92 day schedule requires the freon to be checked and added if required. Air is often injected to the system during the filling process. Therefore the evacuation process is very important is required 100% of the time.

After the system is evacuated, freon is removed and the filter/dryer is changed.

The system is then recharged per the manufacturer's specifications. The freon is weighed back into the system.

Bad order compressors and damaged coils are replaced. The process has been defined in accordance with the manufacturer's instructions and the workers are required to adhere to those instructions.

Another common problem area is the condensate drain line connector. This leaks and is the source of many crew complaints. The workers have designed a connector that reinforces the area to prevent future failures of this kind.

The bottom cover has also been redesigned with the help of a local contractor. The new cover is made of composite material that is much stronger than the present material. That means all structural problems with this cover have been eliminated.

The air filters are renewed. The covers are reapplied, and the air conditioner is processed to the test area.

The air conditioner is hooked up to the power source, three phase AC and 74 volts DC. The brushes are changed in the DC motors. Fans are changed if they are found defective.

A number of failures were due to loose screws. Therefore the workman decided that all screws are to be checked for proper tightness. This task may be eliminated the second time the air conditioners are processed through the facility.

The covers are reapplied and the

units are run continuously for at least one hour. All three phases are checked to ensure that the motors are operating properly. The motors are also checked to make sure the bearings are good and the alignment is proper.

This process has been very beneficial to us. Several design flaws have been identified and corrected as a result of this process.

For example, the 150 deg ambient sensor was located in line with the exhaust port of the Delco motor. After about three hours of operation, the temperature of the exhaust of the motor was high enough to trip the sensor and shut the air conditioner down. The sensor was relocated and the air conditioner then performed as it was designed to.

After the test has been completed and all repairs made, the air conditioner is placed in a shipment rack. The air conditioner is then sent to the field for application.

It is felt this process will dramatically improve the performance of the air conditioners and satisfy the needs of our customers, who are the train crews.

IV.
TESTING TRACTION ALTERNATOR FIELDS ON EMD LOCOMOTIVES

Presented by Tom Leary, UP

One of the most difficult decisions to make in maintaining locomotives is to determine if the changeout of the traction alternator is necessary when there is no visible evidence of a failure. The expense of an alternator change makes it worthwhile to thoroughly test the locomotive for other problems that may cause light load or dropping of load before finally condeming the alternator.

Often a game of "cat and mouse" is played as shops chase the problem by fixing other suspected systems or changing various less expensive components in the hope that the alternator replacement can be avoided. What is needed is a simple, definitive test for weak alternators and in particular, for shorted field windings on operating locomotives. Associated with this must also be more definitive testing of the alternator field rotor at the generator repair shop, confirming the condition of field windings before performing a normal basic repair and re-insulation when a rewinding of the rotor fields is necessary to assure a return to long service life.

Union Pacific's main generator repair shop at North Little Rock has been testing the rotors removed from EMD traction alternators with an improved short circuit testing device that measures wattage input to each individual field coil testing device that measures wattage input to each individual field coil while A.C. current is applied. This testing method has been much more successful in identifying shorted field coils than the previous method of testing coil resistance with a Wheatstone Bridge. The instructions for the wattage test are contained in an accompanying document.

Problems Associated With Shorted Alternator Fields:

Results of this tesing have indicated that the incidence of weak traction alternator fields due to shorted rotor coils is more common than previously realized. It is evident that several locomotive faults that are difficult to successfully troubleshoot can be caused by weak or completely shorted field coils.

Among these faults are:

1. Ground relay action, but no evidence of propulsion circuit grounds, rectifier diode or fuse failures, or problems with the ground relay circuit. Two or more shorted rotor coils can cause severe unbalance in the alternator output.

2. Light load/drops load problems can result from fields that short and become weaker as alternator heat increases during long periods of operation. Such locomotives often load test good for the short time duration of a typical shop load test.

3. Some mechanical problems can be associated with a weak alternator field that results in prolonged light engine load. These can be diverse as turborcharger clutch failure and unnecessary engine component changes or adjustments made in an attempt to correct the low power condition.

Cause of shorted alternator fields:

Data gathered on traction alternators found to have shorted fields has indicated four factors associated with the probability of this fault.

1. Total mileage over 1,000,000.

2. Total age over 10 years.

3. Application to a four motor locomotive for a significant portion of the alternator's service life.

4. Application to a locomotive with a history of central air compartment and/or filter problems.

NOTE: On the SD60, the AR-11 alternator is connected parallel at low speed. The ground relay does not respond to shorted fields yet above transition speed and in load test the series connection provides normal ground relay response.

Most railroads have a computer function that will provide a component history of the alternator; it does not matter if the alternator has been given a basic overhaul, (disassembly, cleaning, varnish impregnation, and re-assembly). Total mileage and age from the initial application or last rotor rewinding are important. If all field coils have been changed, a correctly applied service code should be indicated. However, if the past practice was that only failed coils were changed then old, high mileage coils may still be applied, and the alternator may have trouble at any time. The repair history for the locomotive can provide information on past problems that can be associated with the component history to provide a profile of the alternator that will be useful in determining if a shorted field is probable.

The association of this problem with age and application to four axle, GP type locomotives is the most dominant factor. Sectioning of both good and failed field poles by a rewinding supplier shows that age and prolonged heating combined with centrifugal and mechanical forces acting on the field winding cause a breakdown of the internal insulation, particularly near the iron core of the pole piece. This breakdown causes significant movement of the conductors against each other or through insulating material to the pole piece. Varnish impregnation cannot reach these areas. Rewinding of the field piece is the only solution.

Higher field current produces higher heating of both the field and the stator of the alternator as well as more mechanical stress of the field windings. When a field winding shorts even a small amount, the field excitation must be increased for the weakened pole, heat is increased and the breakdown is accelerated. Without the benefit of motor transition, four axle EMD locomotives require higher field current than six axle locomotives to produce enough output to low track speed, causing more rapid breakdown.

Long Term Solution:

Since the problem of shorted fields is the result of normal operation of the alternator rather than a catastrophic failure, a long term solution is needed. Rewinding the field poles using the original manufacturer's methods employing round wire conductors and an epoxy to seal the voids between the conductors will restore the original service life.

Several railroads have worked with their rewinding vendors to produce alternator fields employing rectangular wire. Such field windings produce a more compact pole piece that is less susceptible to the effects of centrifugal force while providing improved heat transfer to the outer surfaces for better dissipation.

Each rewind vendor that supplies rectangular wire fields has developed manufacturing techniques particular to its product that assures OEM performance standards for the alternator. However, some technical assistance is required.

EMD cautions that re-winding field poles with rectangular wire can create infant mortality failures. The realtively sharp corner of the wire can produce wire-to-wire shorts during the winding process. If not found during manufacturing, the shorts will surface in the first few months of operations.

Field Current Control on EMD Locomotives:

All EMD locomotives equipped with a traction alternator have a method of field current limit regulation, GX, and excitation current limit protection in case of GX failure or an uncontrolled surge of field current. Dash 2 locomotives are equipped with separate GX and EL modules, while 50 series locomotives have both functions within the EL module; 60 series locomotives have the GX regulating limit and the generator field over-excitation limits programmed into the micro-processor.

	GX Regulation	EL (Overexcitation) Fault
SD40-2 SD 50 -	108 A.	114 A.
SD60 (Varies with throttle)	TM7 = 108A TM8 - 115A	121 A.
GP38-2, GP40-2 GP50 (Above 25 mph)	108 A.	114 A.
GP38-2, GP40-2, GP50 (Below 25 mph)	114 A.	115 A.

NOTE: Self load test and EM99 load box steps, 4, 5, and 6 simulate operation above 25 mph.

The GX function is a regulated operating limit, not a fault. When field current reaches the GX value it will override normal excitation control to prevent field current from exceeding its set limit. GX regulation normally occurs at locomotive speeds below 12 mph in higher throttle positions to limit the traction alternator output current to protect the alternator and traction motors from excessive heating in this operating condition. During normal operation at track speeds above 12 mph, the traction alternator does not require maximum field current to convert the engine power and the field current is controlled at less than the GX limit value through normal excitation control. Alternator field current is adjusted as necessary to produce the required power output for speed and throttle position. It should be noted that several factors determine the exact field current necessary for a given condition and there is no fixed value even during load test where the operating condition is fixed by the load resistance, although a range of 70 to 95 amperes is common for locomotives on self load or an EM99 load box in resistance steps, 4, 5, or 6.

Of all variable factors that affect the alternator field current, heat is the most significant. As alternator temperatures increases, the performance of the alternator degrades and the excitation system must increase the field current to compensate. This increases alternator heat and results in an increase of field current, etc. The other dominant variable is the magnetic strength of the field. Shorted windings in the rotor field coils weaken the field magnetism and require an increase in field current. The increased heating of the field coils will cause insulation damage and more shorting of the windings. Once the GX limit is reached the field can no longer compensate and output power will reduce as heat continues to increase without an increase in field strength. An alternator with partially shorted field coils may produce acceptable power during a short duration load test, but have light load problems during road operation when fully heated.

A good supply of cooling air is also necessary for alternator performance. The alternator depends on air from the central air compartment through the primary filter system. Problems with the filtering system will directly affect alternator performance, increase the damaging effects of heat, and decrease its service life. During testing all carbody doors should be closed to control the alternator air flow the same as during road operation and provide enough heating to allow an accurate test.

Test of EMD Locomotives for Shorted Traction Alternator Rotor Fields

1. Set the locomotive up for self load test or load box test using the appropriate instructions and safety precautions for load testing the locomotive according to railroad and shop rules.

   A. This test can be performed as part of the load test procedure following engine repairs, periodic inspection, or specifically for troubleshooting a suspected shorted field condition.

2. Correct all known defects in the central air supply system and close all carbody doors.

3. Operate the locomotive in throttle 8 load test for at least 30 minutes.

   A. Longer load test time assures that the alternator will be at normal operating temperatures.

   B. If performing load test for engine break-in, measure alternator field current at least each hour of the load test and one last time just before the test is ended.

4. Measure the value of DC current in the field supply cable between the SCR panel output and the traction alternator.

   A. The best method is to use a "clamp-on" DC scaled ammeter around the field lead at the FCT transductor (GCT on SD60) in the electrical cabinet.

   B. An alternative method is to shut the engine down and apply a correctly rated current shunt to the field lead and connect a millivolt meter to indicate the field current during load test.

   C. Field current in excess of 100 amps indicates a shorted field.

5. The generator excitation limit function can be monitored to indicate if field current is being regulated by the GX limit function.

   A. On Dash 2 model locomotives measure the voltage drop across the GX module test points 4 to 8.

      1. If field current is below the GX limit only a few tenths of a volt will be measured.

      2. If field current is at the GX limit a significant voltage drop will be evident.

   B. On 50 series (GP40X) models, measure the voltage between the EL module test point 22 and 25.

      1. +15 VDC indicates that the field current is below the GX limit.

      2. Any voltage less that +15VDC indicates that the field current is being regulated at the GX limit.

   C. On 60 series locomotives

select the "regstat" (41) value from the programmable meter function of the display screen.

1. Normal regstat for load test should be 'KW'.

2. If field current is at the GX limit, regstat will be 'GX'.

3. The generator field current monitored by the computer is also available as selection 25 - 'Gen Fld A'.

Testing Traction Alternator Fields On Union Pacific

For several years, Union Pacific, like many other railroads, had tested the fields of the AR type traction alternators for shorted windings using a Wheatstone bridge tester. Yet a significant number of alternators would fail from shorted fields before the next scheduled overhaul interval for the alternator. Sometimes fields would fail during load testing of a locomotive immediately out of the shop. Obviously, the Wheatstone bridge tester was not capable of finding fields that were only partially shorted or close to failure. It was also clear that a basic repair of the alternator where the field rotor was cleaned and reimpregnated was not getting to the cause of shorted fields.

Union Pacific needed a more definitive method of testing the alternator field windings for shorted conductors. The Electro-Motive Division of General Motors was asked for help. In 1989, EMD design and maintenance engineers demonstrated a testing device that has been in use at their Halethorpe Md. remanufacturing facility for some years.

This relatively simple tester applies 120 volts AC power to each field winding of the rotor and measures the watts of power consumed as current flows through the coil. The test compares the readings of each coil for indication of balanced wattage for determining a partially shorted coil, and for a high limit indicating a badly shorted coil.

The test device is simple, consisting of a 30 amp circuit breaker, a test switch that is pushed to energize the test leads, an indicator light, and a wattmeter.

The following test procedure is easy to perform and the results are virtually foolproof. This test has been so successful for Union Pacific alternators that a significant increase in AR type rotor re-winding has taken place over the last 2 years. Though our expenses for rotor re-winding have increased, the end result is alternators that stay in service for a much longer time with a very low incidence of shorted fields of operating locomotives.

Traction Alternator Field Coil Short Circuit Tester (Developed by EMD Electrical Engineering Dept.)

Instructions and diagrams for building this test instrument are contained in engineering diagrams available from Locomotive Maintenance Operations.

This instrument tests EMD traction alternator, using AC test voltage to the coil and indicating the watt input to the coil. Each coil must be tested individually after being electrically isolated by disconnecting the straps between the rotor coils. A megohm meter test of each individual coil should be made prior to the RT circuit test to eliminate grounded coils.

Safety Precautions

This test is considered a high voltage test and must be conducted using the safety precautions prescribed in accordance with electrical safety rules.

Test Instructions

1. Disconnect the rotor coil connecting straps to isolate each field coil.
2. Test each coil for grounds using a megohmeter at 500 volts.
   A. Coils with less than 1 meghom indication are grounded and must be replaced.
3. With the tester circuit breaker in the off position, connect the line cord of the tester to 110 volts AC, 30 amp supply.
4. Connect the test leads to the terminals of the first coil to be tested.
   A. Polarity need not be observed, test voltage is AC.
5. Place tester circuit breaker in the on position.
   A.. Do not touch test leads or rotor assembly during this test.
6. Press the tester test button to energize the field coil.
   A. Observe that the red test light is illuminated.
   B. The wattmeter should indicate an increasing value.
7. The wattmeter reading indicates the condition of the coil.
   A. 110 to 120 watts is normal.
   B. More than 200 watts indicates a partly shorted coil.
   C. A solidly shorted coil will cause the tester circuit breaker to trip.
8. After the test is complete, release the test button and place the tester circuit breaker in the off position.
9. Disconnect the test leads being careful not to touch the bare clip or coil terminals.
10. Connect the test leads to the next coil to be tested and repeat the test procedure for each coil on the rotor.
    A. It is not necessary to test coils that have failed the preliminary ground test.

V. FLANGE LUBRICATORS

Presented by John Nixon - AT&SF Rwy

Flange lubricators are the most cussed and discussed systems in the railroad industry. The systems are very messy, dirty, and labor intensive. Craftsmen hate working on these systems. Leaks, spills, and other defects cause us to expend additional labor to support the system at a time when labor is at a premium. The FRA has issued exceptions due to dirty conditions caused by these defects.

On the other hand, flange lubrication reduces wheel wear, rail wear, conserves fuel, and reduces truck hunting in high speed operation.

One Western railroad estimates flange lubrication saves it $14 million a year. Operable flange lubricators can be a tremendous asset to the railroad industry which justifies the added labor and material investment.

Initially, there were a lot of suppliers in the market. The function was the same but each had a little different approach. The maintenance approach used in this paper can be modified with very little trouble to apply to any system currently being used.

A. Maintenance Requirements

1. Servicing Type Inspections

Complete visual inspection is to be made. All defects found are to be either repaired or reported so repairs can be made at a later date.

The inspection includes the proper alignment of the nozzle to the flange of the wheel. The lube must be directed into the throat of the flange. If it is hitting the tread area, it will adversely affect traction. If it hits too high on the flange or misses it entirely, it will be totally ineffective.

2. Underneath Lube Type Inspections

1. All tasks included in the servicing inspection.

2. Function test of the complete flange lubricator system. The extent of the test depends on the manufacturer and the number of options you as a railroad select.

We will go through the test procedures for the TSM and KLS Lubriquip flange lubricators.

A. TSM

1. Set Up

a. 100 psi main reservoir air pressure

b. Main air supply cock open

c. Lube reservoir pressure gauge should indicate 20 psi.

d. Flange lubricator circuit breaker on

2. Test

a. Open access door or panel

b. Push test button, noting if proper sequence of LEDs is present

"gyro on" light

"right" flashing

c. Determine if the lube is being applied to the flange area

d. Hit inhibit button and determine if it is functioning properly

"right" off

e. Swing door to determine if gyro is working properly. "right" stays on slightly longer than before.

f. Resecure doors and panels.

B. KLS Trackmaster 200 Lubriquip

1. Set Up

1. 120 psi main reservoir air pressure

2. Verify grease pressure by pushing manual override button on the middle solenoid valve and observe that the button on the top of the grease filter is up

3. Main breaker is on and power switch in controller is on

2. Test Procedures

1. On the controller, green LED 5 should be lit and green LED 10 should be lit, also. LED 5 indicates that the grease pump has turned on. LED 10 indicates that grease pressure is present. LED 10 may flicker, but should be on most of the time.

2. Apply separately each of the locomotive inhibit signals and release them. Each time a locomotive inhibit signal is applied, the red LED 2 should light.

3. Place the curve sensor into a clockwise curve by holding the magnet provided in the curve sensor enclosure against the area labeled CLOCKWISE TEST POSITION. This will deflect the curve sensor mechanism in a way similar to being in a curve. LED 7 should light indicating a clockwise curve. Leave this magnet in this position.

4. Apply a forward signal from the locomotive. With a speed signal simulator, apply a speed signal that is below the inhibit simulator, apply a speed signal that is below the inhibit speed to the speed signal input terminals. With the red LED off (no locomotive inhibit signal present), the yellow LED 1 should blink with every wheel revolution.

5. Increase the speed to be above the inhibit speed. Yellow LED 1 should be solidly lit (not blinking). Green LEDs 3 and 4 should flash indicating grease shot to the flange. (LED 3 relates to nozzle #`1 while LED 4 relates to nozzle #2.) LEDs 3 and 4 will be flashing at different rates.

LED 4 should fire at the tangent interval rate which is set by the TANGENT rotary switch.

7. LED 3 should fire at the curve interval rate set by the curve rotary switch.

8. Check to see that nozzle #1 is actually applying grease at the curve rate and that nozzle #2 is actually applying grease at the tangent rate.

9. Move the test magnet on the curve sensor to the COUNTER CLOCKWISE TEST POSITION and repeat the process - yellow LED 8 should light. The nozzle #1 and nozzle #2 firing patterns should now reverse. Nozzle #1 and LED 3 should be firing at the tangent rate while nozzle #2 and LED 4 should be firing at the curve rate.

10. Leaving the magnet in the COUNTER CLOCKWISE TEST POSITION put the locomotive into the reverse direction. The nozzle #1 and nozzle #2 patterns should reverse again.

11. Remove the magnet and place it in its storage position.

12. Open the bypass valve on the grease reservoir. Within thirty seconds, the controller should shut down the grease pump. Green LED 5 should go out and red LED 6 should light indicating a large leak or empty reservoir. Close the bypass valve. Depress the "PUMP" button on the controller. The pump should restart, LED 5 will light and LED 10 will light. The red LED 6 should remain off.

That concludes the function test.

3. Periodic Inspection

1. All tasks included in the servicing and underneath lube inspections.

2. Wash nozzles.

3. Fill reservoir with approved lubricant.

4. 1104 Day Inspection

1. All tasks included in the servicing, underneath lube and periodic inspections.
2. Replace magnet valves.
3. Replace air regulator.

5. Locomotive Overhaul

1. All tasks included in the servicing, underneath lube, periodic and 1104 day inspections.
2. Replace gyro/curve sensor.

At the time of wheel truing or traction motor change out, make visual inspection to include alignment of nozzle to the flange of the wheel.

B. Troubleshooting

Before troubleshooting, always make sure the system is set up properly. People spend a lot of time troubleshooting the system only to find an air valve was left off or the circuit breaker was turned off. Do not make the problem harder than it actually is.

After you are sure everything is set up properly, proceed with the manufacturers' troubleshooting guide. The major problem areas that we are familiar with are as follows:

1. Clogged nozzles.
2. Bad order controllers/gyro/curve sensors.
3. Misadjusted nozzles.
4. Leaks.

The systems are really very simple. It does not require a lot of technical training. It does require constant attention in order to keep the systems operable and adjusted properly. Cost reductions can be attained with this system but it takes commitment on the part of both management and labor to realize them.

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 Mechanical Maintenance Committee in Montreal on May 13, 1992.

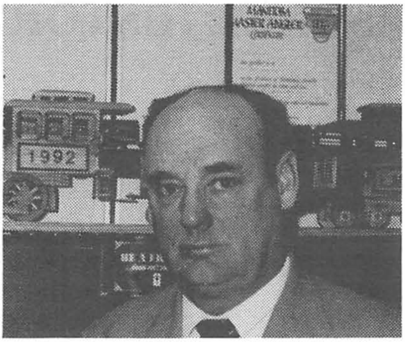
The attendance and interest exhibited was most gratifying.

REPORT OF THE COMMITTEE ON DIESEL MECHANICAL MAINTENANCE

TUESDAY, SEPTEMBER 22, 1992

9:00 a.m.

Pre-Convention
CN/CP



May 13, 1992
Le Chateau Champlain
Montreal, PQ

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Mgr.-Loco. Maint.
DM&IR Rwy.
Proctor, MN

Vice Chairman
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Mgr. Loco. Plng. Stds & Programs
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PERSONAL HISTORY

Eugene L. Oviatt

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

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

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

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

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

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

I. MECHANICAL QUALITY PROGRAMS DEVELOPING ON MAJOR RAILROADS

Presented by John Baranko-Conrail

There is a strong and concerted effort being put forth by all major corporations to improve the quality of their products and, in the railroad industry, their service.

For many years, the railroads have used the word quality in their advertisements and whenever it was appropriate to promote a service, not always in all facets of their operation.

I believe the railroads have now come to the realization that they have to do more than just use the word "quality", but have to provide a quality service that is recognized as such by all their customers.

For many years, the railroad industry has measured quality by several different methods. Many of the departments within the railroad industry gauge the quality of their product or service by utilizing quality control personnel. Although everyone's goal was to have no defects, it became generally acceptable to most supervisors and managers to "achieve a certain percentage of proficiency." In other words, we accepted not doing the job or performing a service properly all the time, as long as we achieved an "acceptable" rating. Other departments were rated on an acceptable limit of missed connections or late arrivals and departures. But an "acceptable" rating, in whatever manner or form that it might be stated, meant that, someone, somewhere, did not get his product repaired or manufactured properly or did not get the service he requested. That someone is the customer.

Many large corporations have invested time and resources to provide a quality product. One such corporation is a well known auto manufacturer. Several years ago, it embarked on a quality program, utilizing an untapped resource to make improvements. that resource was its own employees, who, day in and day out, performed the tasks necessary to manufacture an automobile. The program's success proved beneficial, not only to the corporation, but also to the employees. Another group of individuals that benefitted was the consumer/customer. The phrase used to implement this process is Quality is Job No. 1.

Major railroads are now looking to quality programs for improvements in all aspects of their operation. One carrier has recently embarked on a new quality program because it realized that it needed improvement not only to gain more business, but also to retain what business it now services. The theme used in this program is referred to as Continuous Quality Improvement (CQI).

Unlike a lot of other programs, CQI is not just for certain groups or departments, it is intended for all employees. The program is intended to change the way we do business with all customers, both external and internal.

It is a long range plan; one in which every employee will receive the same training and corporate guidelines. The training starts at the top with the CEO and all upper management. The training that upper management receives will be the same training that all other employees will receive. Each employee will undergo two days of training. It is anticipated that the carrier will take two to three years to complete the training portion. Within each Department and group, a team of employees will be formed to guide their respected areas. These Teams will be referred to as Quality Improvement Teams (QIT). Team members consist of both management and agreement employees. All team members are equal. Various methods of operating the team are being explored. Majority rules and consensus rules are the mostpredominant. These teams are responsible for addressing areas of improvement, insofar as identification and recommendation for resolutions. After an area of improvement is identified, a new team will be formed to address the problem and seek solutions. This team is referred to as a Process Improvement Team (PIT). The members of this team will be made up of the most qualified employees who work with the identified process. These are temporary teams formed solely for the identified project. After the results are forwarded to the QIT, the temporary team is dissolved.

One example of a completed project involves not only a cost saving, but also an environmental saving. At one diesel terminal, it was decided by one team to study the potential of recycling paper products. The practice had been to simply dispose of office paper and cardboard from materials received along with all the trash. Through the team efforts, a project to recycle office paper and cardboard produced a $8,000 a year savings in trash removal. And just as important, if not more so it will keep approximately 40 tons of paper products a year out of our waste stream.

The stated concept of CQI is that all areas of responsibility can be improved, and that all employees involved must be utilized to seek a solution.

There are stated goals, a corporate vision and guidelines in which to conduct business. This quality improvement program requires a change in attitude of how we relate to problems. Look at the process, not the individual. It is equally important for all departments to understand that our ultimate goal is to meet or exceed our customers' requirements. Each department must also realize who its customers are and how to get those customers' needs.

Speaking as an employee of the Mechanical department. I realize that the Transportation (Operating) department is our internal customer. It is our responsibility to provide as many reliable locomotives as the Transportation department requires. When a special need arises, it is our responsibility to address and fulfill that need. Just as the Transportation department is our customer, we in the Mechanical department are the Material and Purchasing department's customer. We expect material and parts to be available when we require them and if not readily available that they be procured in a reasonable period of time at a reasonable cost.

Another key to the success of this program lies in management sharing its ability and talent with labor in the decision making process and labor looking at problems with open minds, so that solutions can be found that are best suited for the customer, not necessarily best suited for labor and management's interests.

Another carrier approaches quality improvement by implementing what it refers to as "Total Quality Management System". There are three major components to this system - #1 planning and control, #2 business processes and #3 employee involvement.

The planning and control component helps senior management set the direction of the company's business efforts by establishing long-term strategic objectives and annual operating plans,

plus budgets that support these objectives.

Business processes are the means by which we do our work so that the company can serve our customer's needs. Some examples of these processes are providing reliable equipment and track, sending accurate bills to our customers and preventing accidents, injuries and derailment.

Employee involvement helps us achieve our business objectives by making full use of employee knowledge and experience in solving problems and improving quality. This carrier began working on TQMS in 1987, starting with the business process component.

Quality system procedures (QSP) focus primarily on key business processes. Basically, a QSP is a document which defines, step-by-step, how a business process should be performed. By business process, we mean how we work together using our resources to provide products and services for our customers, both external and internal. In many cases, these business processes cut across departmental lines, affecting activities in several areas. That is why it is important for the process to be documented. Everybody involved must have a common understanding of what is required and who is responsible.

One example of employee involvement and its benefits are shown with a quality improvement team formed at the Union Pacific Salt Lake Locomotive Shop. Prior to the team being formed, the team members along with other employees were trained in techniques of communication, data collection and problem solving. The team selected as its project to determine and correct the cause of the high unscheduled shopping rate of GE locomotives released from scheduled inspection out of Salt Lake Shop.

These results were made possible by management providing time and data for the team and the employees responded by utilizing their experience and knowledge to solve the problem.

This carrier feels very confident that TQMS will enable it to achieve its quality goal because it properly addresses business objectives, management systems and procedures, and employee involvement.

Another carrier launched its quality process in late 1989. Its approach was and is its commitment to quality, in that "We Are Continually Trying to Improve our Quality." The training consists of quality leadership, quality improvement, and employee involvement. Initially, the problem solving process was saturation training, then a transition from problem solving to improving work processes. The real focus of quality is continuous improvement. Problem solving is a tool to attain customer satisfaction.

This carrier's current approach to quality is as follows:

Focus on process analysis.

No longer saturation train.

Train quality action teams on project basis.

There are currently over 200 quality action teams system-wide.

New teams are identified daily.

The team involve internal/external customers/suppliers. They have a clear and concise mission, a vision and stated values.

This carrier takes extreme pride in its ability to deliver quality customer service.

Another carrier's approach to improve quality in its work environment involves what it refers to as a diesel storm team (DST).

The diesel storm team is one of the tools that this carrier utilizes in the

Quality Process. It is a group of Mechanical personnel that has been brought to headquarters from shops to monitor the movement and repairs of locomotives.

When a locomotive fails out on the line of road, a report is generated to the DST. The team in turn, researches the unit, on the number of incidents and shoppings for the last six months. If a pattern is found; not loading properly, etc., then the team brainstorms the failures and come up with a recommendation for repairs. The team then makes a packet on the unit showing shoppings, incidents and recommendation. The packet is then sent to the shop where the unit is headed.

The team then monitors the shop on the recommended repairs. If the team is not satisfied on the actions or repairs that the shop has made, the team may recommend that other repairs be made. The DST then follows the unit to see that the repairs are successful.

The team also, during its daily evaluation, recommends a "dog of the day". A locomotive is selected that will be at the designated repair point that day. The locomotive has to have a history of failures. The team then makes recommendations and notifies the shop of repairs requested to be made. The locomotive is then tracked to see that the repairs made have corrected the problem. All "dog of the day" locomotives are to be given special attention.

The carrier also monitors all units that are due maintenance in the next five days. Each unit is researched for all failures and shoppings and the DST then makes recommendations. A work report is generated on each locomotive as it is shopped, and every work item on that report must be completed before the unit can be dispatched. All maintenance units are also loadboxed and track tested before given back to transportation.

The following criteria are used as a general guide in determining whether a DST a unit or not. There will be exceptions to these guidelines.

1. Any unit that has two LOR incidents within seven days.

2. Any unit that has three performance related incidents with 45 days.

3. Any unit that has had three unrelated LOR incidents within 30 days.

4. Any unit that has had three water related incidents within seven days.

5. Any unit that has had two unscheduled shoppings with seven days. (Does not include wheel truing.)

6. Any unit that has had four unscheduled shoppings within 60 days. (Does not include wheel truing.)

7. Any unit released from a heavy repair shop that has a LOR incident within 15 days of release (return route to heavy shop.)

8. Any unit released from a heavy shop that has a LOR incident with 15 days of release (return route to heavy shop).

9. Any unit released from a heavy repair shop that has three or more performance related incidents within 90 days.

10. Any unit that has a LOR incident within 10 days of its last Q. (Route back to its last Q location.)

11. Any unit that has three performance incidents, answered "No trouble found" within a 90 day period.

12. Any unit that has had more than two traction motors changed in any position with a 30 day period for reasons other than wheel defects/mileage.

13. Any unit that has had more than one traction motor changed in any one position within six months for reasons other than wheel defects of mileage.

14. Any unit that has more than one turbo applied within 12 months.

15. Any unit due Q in less than five

days that has had more than six unscheduled shoppings or six incidents or a combination of both.

It is apparent that all railroads are committed to improving their product (which is providing safe and reliable transportation service to our customers). Although we have not cited all the member roads and their quality processes the foregoing examples are a good indication of what is being done and what will be done in the future.

II.
COAL FUELLED DIESEL LOCOMOTIVE DEVELOPMENT

Presented by Colin Dathan-Via Rail

This report will summarize more than four years of research into the operation of coal fuelled diesel locomotives. Some 12 learned papers have been given on various aspects of the development, thus you will realize that this is merely an overview to familiarize you with the program and its status.

Our thanks are due to G.E. Transportation Systems who kindly provided background data and slides for this paper.

G.E. Transportation Systems, sponsored by the U.S. Department of Energy, Morgantown Energy Technology Center, with involvement by Norfolk Southern Railway, and assistance from Industry consultants such as Ricardo, Texas A & M University and BKM Inc., has been working for several years on a "proof of concept" program to burn coal as a diesel engine fuel.

The program covered four phases: Technology research & development; Engine development; Locomotive systems tests; and economic analysis (relating the coal fuelled locomotive costs to regular locomotive costs).

1. Technology Research & Development

This phase examined areas of fuel and combustion, emissions and durability. A single cylinder engine was modified to burn a coal powder and water slurry (referred to hereafter as slurry). The goal was to provide the highest combustion efficiency with reasonable fuel consumption using the least amount of pilot fuel, while operating within the existing design limits of engine firing pressure.

The tests included operation on nine fuels of different types and sources, and covered both engine performance and emissions studies.

Achievements are: Combustion efficiency 99.5% (up from an initial 95%); Operation on slurry down to notch 2 with minimum pilot fuel; Duty cycle fuel consumption 80% slurry (up from 66% originally and a target of 75%); Diesel engine cycle efficiency comparable to the fuel oil counterpart.

The selected emissions control is a CuO sorbent with ammonia injection downstream from the turbocharger and an high temperature barrier filter. Expected results are:

Particulate removal 99.5% efficiency
SO2 removal 90% efficiency
NOx removal 90% efficiency.

Durability testing of nozzles, piston rings and liners has been extensive and the present program calls for:

Diamond compact injection nozzles; Tungsten carbide coated piston rings and liners; Nitride and boride coated piston crowns (to reduce ring groove wear); Monolithic exhaust valves.

2. Engine Development

A G.E. FDL series 12 cylinder engine was built with both mechanical pilot fuel injection and mechanical slurry injection hardware, each cylinder having two pumps and two injectors. Both systems are controlled by a mechanical governor.

The engine is started on diesel duel and switched to mostly slurry by means of a manually operated secondary layshaft.

Using mostly slurry fuel it developed 2500 H.P. at 1050 RPM.

After approximately 10 hours of test

bed running it was moved to the first stage locomotive for track testing.

It should be noted that this engine did not have the durable components and emission control previously mentioned, which had only been tested on the single cylinder engine.

A second stage 12 cylinder engine was being built with all electronic controlled pilot fuel and slurry fuel injection. It would have all the durable parts and was planned to be tested this year (1992).

3. Locomotive Testing

The first phase locomotive system test used the first engine in a relatively standard test locomotive. The slurry fuel and its supply system were carried on a flatcar behind the locomotive. As mentioned previously it does not have the durable parts or emissions clean-up. This test was complete when this locomotive developed its rated power and successfully hauled two other locomotives which were operating in dynamic brake.

A second stage locomotive was being designed with an extended frame to accommodate the larger slurry fuel tank under the frame, and the emissions cleanup equipment above deck. It would have been equipped with the second stage engine.

Following initial track testing the plan was to operate it in commercial revenue service.

Unfortunately due to consistently low oil prices and lack of market interest, the federal funds have been cut back and the second stage locomotive will not now be built.

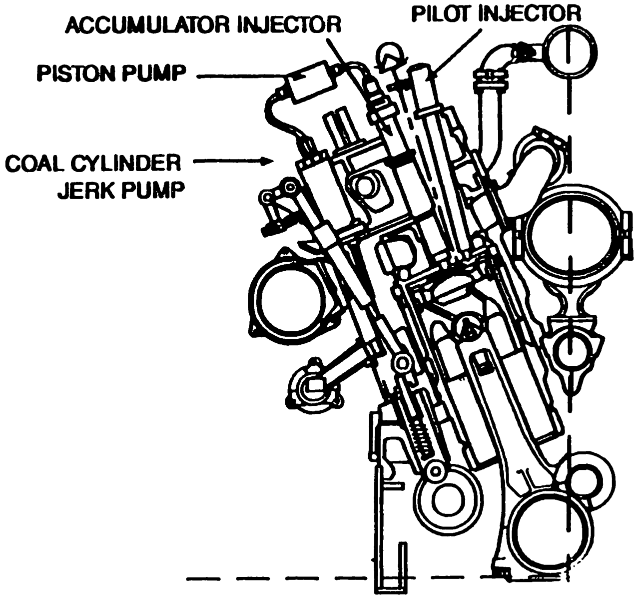
4. Economic Analysis

The incremental cost of a coal slurry fuelled locomotive is estimated at approximately $280,000 U.S. which includes the cost of engine systems ($60,000), emissions control ($160,000) and the locomotive structure ($58,000).

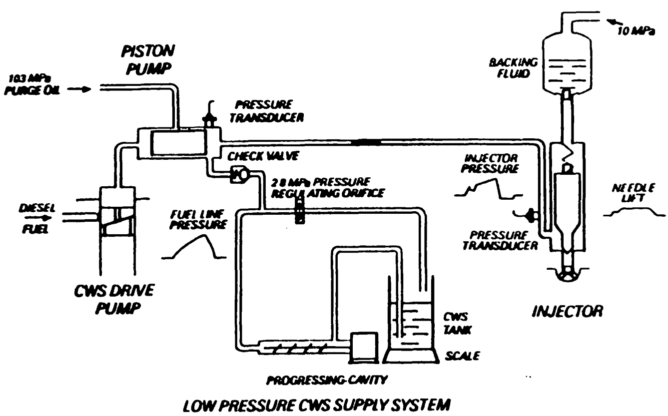
The sources of coal and its transportation cost vary substantially; however under the worst case duty cycle the slurry fuelled locomotive was forecast to provide a 15% return when the price of diesel fuel is 91 cents U.S. per U.S. gallon.

	1988	1989	1990	1991	1992	1993
TECHNOLOGY RES. & DEV.	TEST PLAN MECHANICAL FUEL INJECTION	ELECTRONIC FUEL INJECTION MATERIAL	EMISSIONS CONTROL FUELS	CLEAN COMBUSTION FULL FLOW EMISSIONS		
ENGINE DEVELOPMENT	START BUILD FIRST 12 CYLINDER ENGINE	MECHANICAL FUEL INJECTION HARDWARE	TEST FIRST 12 CYLINDER ENGINE	ELECTRONIC FUEL INJ. HARDWARE DURABLE ENGINE PARTS	ELECTRONIC FUEL INJ. ENGINE WITH EMISSIONS CONTROL	
LOCOMOTIVE SYSTEM TEST	CONCEPT LOCOMOTIVE DESIGN	FUEL SUPPLY SYSTEM	FIRST PHASE LOCOMOTIVE CONVERSION	TRACK TEST 1ST PHASE LOCOMOTIVE	BUILD 2ND PHASE LOCOMOTIVE	RAILROAD TEST OF 2ND PHASE LOCOMOTIVE
ECONOMIC ANALYSIS		CONCEPT LOCOMOTIVE ECONOMICS		(UPDATE)		UPDATE & REPORT

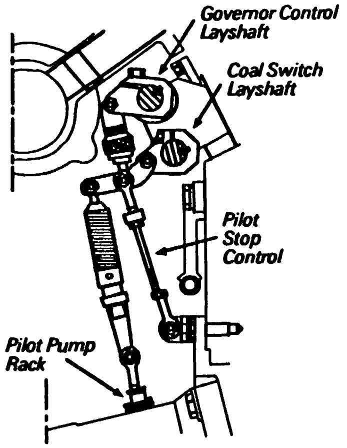
Coal Fueled Diesel Locomotive Project Highlights



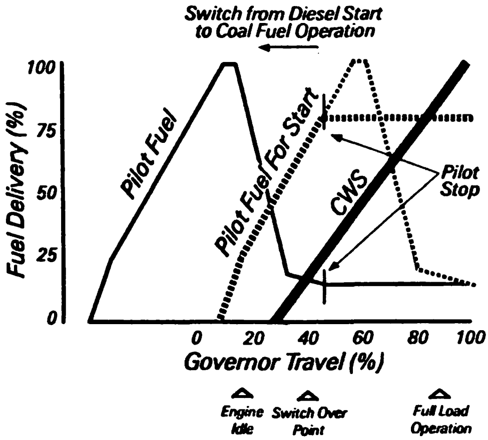
Engine Cross Section Layout of One Cylinder



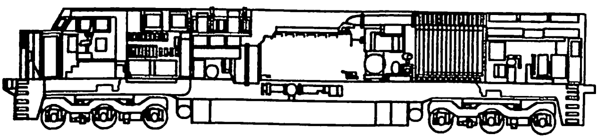
Stage I Coal Fueled Engine CWS Injection System Schematic



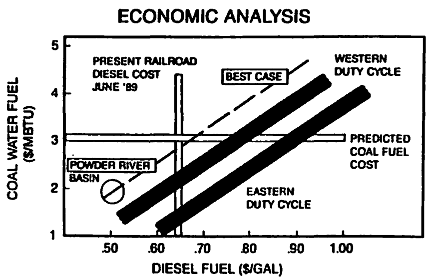
Fuel Control Linkage



Fuel Control Operation



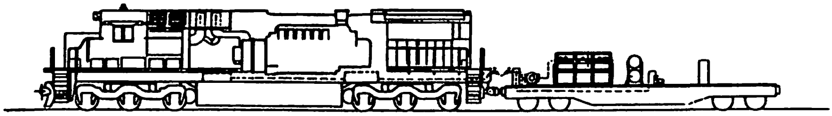
Concept Design of Coal Fueled Diesel Locomotive



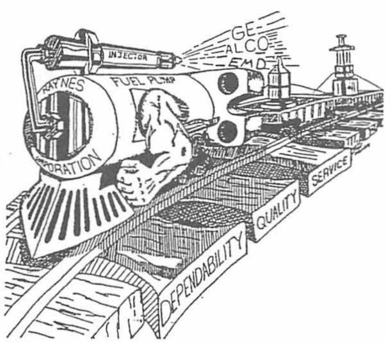
Coal Fueled Diesel Locomotive Economic Analysis

. Incremental Cost Increase of Coal Fueled Diesel Locomotive.

Engine Systems	$60,171
Emissions Control Systems	$160,446
Locomotive Structure	$58,195
Total	$278,812



Stage I Test Locomotive Configuration


INJECTOR
FUEL PUMP
GE
ALCO
EMD
SERVICE
QUALITY
DEPENDABILITY

III.
18:1 UPGRADE FOR THE 645E ENGINE

Presented by Keith Mahalik-EMD

In today's competitive market, railroads are continually searching for ways to reduce costs and improve reliability. Any innovation that can decrease the daily cost of operating a locomotive, increase maintenance intervals, or reduce the number of road failures experienced adds profit to the bottom line of a balance sheet.

A new product is available which offers all of these advantages for the EMD 645E Roots blown engine. Upgrading your engine with the new 18:1 compression ratio piston overhaul package will reduce fuel consumption, enhance engine starting characteristics, and extend the interval required to replace power assemblies. The extension of the overhaul interval is due to the use of EMD's premium power assembly components. Installation of the package can be performed during normal overhaul periods.

The 18:1 upgrade can be applied to any 645E Roots blown engine. Any vintage "E" crankcase can be used, but "D" and earlier crankcases are not recommended due to the increased firing pressure.

The engine overhaul package consists of three major components:

40032429 Partial Power Assembly
8483942 Blower Drive Gear/s
Governor Modification.

Full power assemblies are also available.

Due to the extended power assembly life offered in this overhaul package, the following additional components are recommended:

9319169 Nickel Plated Lower Liner Insert
9581924 Integral Seal Head Seat Ring.

Package Component Detail

Partial Power Assembly 40032429

This power assembly contains a newly designed 18:1 compression ratio piston. The increased compression raises the peak firing pressure by approximately eight percent, which results in improved fuel economy. Durability is not compromised: the 18:1 piston package is composed of premium quality parts and peak firing pressure is still seven percent below a turbocharged E3 engine's peak firing pressure. In addition, the increased compression aids the starting ability of the engine.

The piston is tin plated and features a hardened number one ring groove for improved wear resistance. A premium ring set, consisting of a prestressed stainless steel number one ring and steel number two and three rings, is also included for maximum durability. Due to the higher firing pressures, use of the 8361565 silver insert bearing is required with this piston.

The partial power assembly also utilizes a laser hardened upper bore cylinder liner. Any vintage connecting rod is acceptable for use with this partial power assembly. The assembly is designed for a straight piston pin in order to allow reuse of your engine's existing pin and carrier. The fuel injector is also unchanged.

8483942 30 Tooth Blower Drive Gear

A second component of the 18:1 package is the 30-tooth blower drive gear. The gear reduces parasitic horsepower losses by reducing the blower speed slightly. Instrumented testing has confirmed proper air/fuel ratios with the 18:1/30 tooth blower drive gear worthwhile. Factors to consider are initial cost, service life, reliability, fuel economy, and lost revenues for locomotives out of service time. Each individual operator will experience a different return on investment based on its specific duty cycle, labor costs, and overhaul practices. EMD analysis of these factors demonstrate a clear advantage to the Roots blown engine overhaul kit.

If you are considering the application of the 18:1 upgrade package, it is recommended that you contact your EMD customer service representative for an individual return on investment analysis.

combination. Any engines equipped with 29 tooth gears should be upgraded to the 30 tooth drive gear for the 18:1 application.

Governor Modification

Due to the increased efficiency of the 18:1 piston, the existing governor requires a modification to reduce the fuel rate at full load. The rack length is increased by 0.02 inches and the governor should be re-identified to reflect the modification. The brake horsepower output of the engine will remain the same. Governor modification instructions are available upon request from EMD.

9319169 Nickel Plated Lower Liner Insert

Application of the nickel plated lower liner insert is not required but is recommended. Since the power assembly's life is extended, it is possible that a phosphate lower liner insert will wear out before the power pack. The improved insert provides greater wear resistance and thus increases engine longevity.

9581924 Integral Seal Head Seat Ring

Application of the integral seal head seat ring is also recommended. The integral head seat ring provides significant improvements in "souping" resistance and reduces head seat wear.

Testing

Fuel Economy Testing

Fuel economy testing was performed on a GP38 locomotive in LaGrange. Performance of 16:1 and 18:1 pistons was compared back to back on identical load curves. Very closely controlled parameter testing was conducted in order to assure accurate results.

A fuel economy improvement of 3.5 percent was measured in throttles four through eight. Fuel economy improvement proportionately decreases below throttle four until idle where the 16:1 and 18:1 piston are essentially equivalent.

Reliability Testing

In order to thoroughly evaluate reliability, the 18:1 piston was installed in two marine vessels for a field test. The marine application was selected for durability testing because the duty cycle is much more severe than typical rail engine operation. During the four year test there were no piston failures or failures attributed to the piston application.

Since the recent introduction of this product there have been ten engines upgraded with the new power assembly. No power assembly failures have been reported since installation.

All new 645E engines produced by EMD will now come equipped with the 18:1 piston.

Life Projections

An important consideration when evaluating the overall cost of operating an engine is how long a particular component will last before replacement is required. The 18:1 power assembly is designed for maximum service life. The use of laser hardened upper bore liner, resistance hardened number one piston ring groove, and the premium ring set allow extended intervals between power assembly renewal. EMD states that the 18:1 power assembly will typically last twice as long as a chrome replacement power assembly.

Return On Investment

When evaluating the costs of upgrading an engine at overhaul, a return on investment over the life of the components should be calculated in order to determine if the upgrade is

IV. AUTOMATIC STOP AND START CONTROL SYSTEM

Presented by Fred Pantel, CN Rwys.
Prepared by Barry Savage, Caterpiller

SmartStart was developed by ZTR Control Systems and is a microprocessor controlled system that automatically shuts down and restarts locomotives during their parked idle cycle.

The first applications were made approximately two years ago and have been successfully operating on the GP30C and GP15C units built by Generation II Locomotives for the Soo Line Railroad.

These initial applications of the system were incorporated as part of the complete microprocessor package developed and installed in the locomotives.

The successful performance of this shutdown/auto start system on Caterpillar powered locomotives operating on the Burlington Northern and Soo Line railroads prompted requests for the development of a stand alone system to perform the same function on EMD locomotives.

In response to those requests a stand alone SmartStart System has been developed for retrofit to EMD locomotives.

These applications have been successfully operating on the Soo Line, Burlington Northern and Wisconsin Central Railroads.

Now lets move on to some of the specifics. The control system is enclosed in its own durable metal housing with a footprint size that measures 12 inches (30cm) x 15 inches (38 cm).

The versatility of this compact design provides the end user with several options relative to where the equipment can be mounted on the locomotive.

The control system is installed in the control stand in a switcher locomotive application, whereas on road type locomotives the system is generally mounted under the cab floor.

"Big things come in little packages". The capability of this system certainly lives up to this old adage and here's why.

Along with its capability to constantly monitor and control the operation of the system, the basic system's microprocessor is equipped with its own self diagnostics program and has additional built in capacity that enables it to accommodate the various optional features offered.

Among this ever expanding list of options are features such as fan control, duty cycle logging and event recording.

From an operation stand point, the system's microprocessor carries out is control functions by taking the appropriate action after comparing its preset parameters against the intelligence it collects from a variety of devices. These devices provide input signals that correlate to the various parameters the microprocessor is monitoring. Included is a device to measure the outside ambient air temperature, the temperature of the coolant system, the brake cylinder air pressure and the charging rate of the locomotive batteries.

Also included in the system is a unique feature that overrides the crankcase pressure/low water protection device (EPD) during the starting sequence on a EMD locomotive.

From a safety aspect, to ensure crews and maintenance personnel are alerted, whenever the system is in the enabled mode an audible warning system is provided and as an added measure a separate circuit breaker is provided, which allows maintenance personnel to disarm the system during normal maintenance procedures.

As indication to crews that the system is in the enabled mode, an indicator light is provided on the locomotive control stand and as a final measure warning labels are posted at various locations on the unit to alert personnel it is equipped with this autostart system.

Not only is intelligence collected, but the microprocessor also shares the intelligence with the end user. For instance, the system is equipped with a integrated diagnostics expert analysis system called IDEAS. It provides installation testing and integrated diagnostics for the entire system.

Another example of this intelligence sharing is the customized reporting system that compiles operational and management types of reports. These reports, namely the detail report and the summary report, not only provide verification of the fuel savings but also can be used as a diagnostic tool. The system also has the additional capacity to generate optional reports which provide duty cycle and event recording information. Downloading this information is easily accomplished through the use of a laptop computer or the rugged optional hand held INFORMER reader.

The operational report that is generated is called a detail report and it provides detailed information regarding the operation of the system and the locomotive (Fig. 1).

To assist in explaining the report, we have broken it down into three sections:

The first section of the report provides information concerning the reporting period covered. It logs in days and hours the in-service and out-of-service times accumulated for the period. It then segments this information and reports the amount of time the engine was running as opposed to shutdown and how much of this running time was spend on loading as opposed to idling and finally whether the idling time was spent in parked or working idle.

Working idle would be those cases where the engineer may move the throttle back to idle while coasting.

The next section of the report indicates what parameters were not met and as such prevented the system from shutting down the locomotive. It reports the specific parameter that was not satisfied and the number of hours the locomotive continued to idle because this unsatisfied parameter prevented shutdown.

In this particular case the information shown next to the Battery Current was useful in diagnosing the fact that the locomotive had a battery charging circuit problem. It should be noted the system continues to log information even though someone may have inadvertently failed to turn on the system's circuit breaker as evidenced by the high numbers shown next to SS Breaker Off.

On the restart side the report provides, in counts, the parameters that caused the locomotive to automatically restart.

The last portion of the report summarizes the number of times the system shut down the locomotive and the total shutdown hours accumulated. Finally it provides verification, in dollars, as to the actual fuel savings along with a calculation of lost savings due to certain parameters not being met.

The management report that is generated is called a summary report and it summarizes the information contained in the detail report (Fig. 2).

For ease of explanation we have broken the Summary Report down into two parts:

The first half of this report summarizes the statistics logged by the system and provides management with a quick overview of how it is performing.

The second half of the report summarizes what the facts are relative to fuel savings achieved.

One of the optional reports the system is capable of generating is a locomotive duty cycle report. Once again this report is broken down into two sections.

The first section provides information similar to that compiled on the detail report and covers locomotive utilization and engine running times. However, in addition it provides data regarding the amount of time the locomotive has spent in specific throttle positions.

Disadvantages of the system are:

Batteries - increased cycling of the batteries will decrease life.

Starter Motors - increased usage will decrease the life of the motors and increase the maintenance costs.

Engine Wear - increased wear due to thermal cycle.

Frozen Engine Blocks - depending on the parameters set this could be very important if the system is active in the ambient temperatures.

Engine Condition - overall engine condition and age could lead to possible hydraulic locks.

An engine dump would be an added feature to this system.

Fig. 1

SMARTSTART (SS) DETAIL REPORT

Unit Number: 252
Date: From 6/18/92 to 10/31/92
Time: 14:10:03 to 09:30:54

REPORTING PERIOD

In Service Hours: 3173.2 (132.2 Days)
Out of Service Hours: 62.4 (2.6 Days)

In Service Hours	Engine Run Hours	Idle Hours
Engine Off: 1202.6	Loading: 404.4	Parked: 717.2
Engine Run: 1970.6	Idle: 1566.2	Working: 849.0

PARAMETER(S) PREVENTING SHUTDOWN (HOURS)

Brake Pressure:	119.9	Water Temp:	0.0
Ambient Temp.:	0.0	Battery Voltage:	3.5
Battery Current:	117.6	SS Breaker Off:	272.8
Rev. Not Centered:	209.6		

REASON(S) FOR SS RESTART (COUNTS)

Brake Pressure:	100	Water Temp:	134
Ambient Temp.:	0	Battery Voltage:	2
Consist:	180		
TOTAL RESTARTS	**416**		

SS SHUTDOWN INFORMATION

SS Shutdown Count:	410	SS Shutdown Time:	1123.4 Hours

SMARTSTART TOTALS

Actual Dollars Saved by SmartStart:	$3594.88
Dollars Lost due to Parameter(s) Preventing Shutdown:	$1714.18

NOTE: All calculations are based on a fuel consumption rate of 4.0 gallons per hour at a cost of $0.80 per gallon.

Fig. 2

SMARTSTART (SS) SUMMARY REPORT

Unit Number: **252**
Date: From **6/18/92** to **10/31/92**
Time: 14:10:03 to 09:30:54

Total Service Time in period was 3173.2 hours. **(132.2 days)**

The unit was pared idling for 717.2 hours.

The unit was shut down by SmartStart for 1123.4 hours.

SmartStart **reduced parked idling time by 61%.**

The time the unit would not shut down because the SmartStart Breakers were off was 272.8 hours.

The time the unit would not shut down because the Reverser was not centered was 209.6 hours.

The time that the unit would not shut down based on all unsatisfied system parameters was 535.7 hours.

FUEL SAVINGS SUMMARY

As a result of SmartStart shutting down your unit for 1123.4 hours over this period:

*** You saved 4493.6 gallons of fuel**

*** You actually saved $3594.88**

As a result of the Parameter(s) Preventing Shutdown:

* You have $1714.10 potential savings.

NOTE: All calculations are based on a fuel consumption rate of 4.0 gallons per hour at a cost of $0.80 per gallon.

V. ACQUIRING LOCOMOTIVES FOR REGIONALS AND SHORTLINES

Prepared by Dave Powell, NYS&W
Presented by Bruce Sweeley, GE

Introduction

One of the key ingredients to any railroad is, of course, its motive power fleet, be it one or three thousand in number. If you ask several people of the same railroad what motive power they would prefer if they had their choice, you would no doubt get several differing opinions. Acquiring locomotives is one of the most interesting aspects of railroading and is perhaps also one of the most complicated. A lot of different things make up that final decision of what and how many locomotives are purchased or leased. This paper deals with some of the unique features of acquiring them for regionals and shortlines.

Methodology of Acquiring Locomotives

As with the purchase of any piece of equipment, there is a method with which to begin. How do I find out what locomotives are available? There are many good sources to choose from. First of all, if you are in the railroad business, word of mouth is your best source. Ask some of your daily contacts, ask a Class I carrier, or get on its mailing list for equipment dispositions. You will find a number of advertisements, magazine publications, and periodic circulars carry regular "for sale" ads that offer a wide variety of motive power. How about the salvage companies and scrap dealers? Many start-up operations have spared an older, cast-aside locomotive from the torch and furthermore, have acquired it for a fraction of the cost had it been sold on the open market. The Pocket List of Railroad Officials will provide you with a long list of equipment brokers, remanufacturers, and even the new locomotive manufacturers. You will normally find these companies eager to work with you and usually they are very helpful. They can be very resourceful and creative. Often a very attractive offer can be constructed through a little negotiation.

Who Does The Acquiring

The person or persons responsible for locomotive acquisitions can be as varied as the types of locomotives they are seeking for purchase. As an example, some railroads buy their locomotives solely on a decision made by their president, others purchase through the advice of the chief mechanical officer, and still other lines buy via the opinion of the locomotive maintenance foreman.

The more common approach is generally a joint decision of the operating staff, finance people, and corporate decision makers. This process often starts as a round-table discussion recognizing that there is a need to pursue acquiring motive power. Once this decision is agreed upon, the next hurdle is what kind and how many. Generally, one person is assigned to begin the long process of gathering facts and technical data. In recent years, even Class I carriers have downsized their staffs to a point where fewer people are involved in the decision-making process of acquisitions. Very often the field personnel and field managers simply hear about the decision made at the top levels of the organization, and eventually the newly acquired

locomotives show up one day at the terminal. For years the fieldemployees have asked to be heard,particularly about specific improvements that could be made to make maintenance easier and save money. Most people today will agree that this finally is being done and they are being heard. Industry-wide there have been huge savings because after all these years it has been proven that listening to the craftsman who works on the equipment everyday provides a unique insight not otherwise available.

What Type of Acquisition Medium To Use?

This question can also be addressed in many different ways. Some of the more conventional methods are to "lease" locomotives, or "outright buy" locomotives, or a blend of both alternatives may be best for a specific road.

One type of commonly used lease is a net lease whereby you pay a set rate per locomotive per day or month, and all maintenance is the responsibility of the lessee. More recent leases are structured with an exception clause relieving the user of responsibility for certain high risk and often costly components, such as turbochargers, main alternators, and even air compressors and traction motors. This type of lease is generally offered at a substantially higher rate to the user due to the increased financial exposure to the lessor in component costs. Either way, the cost is driven by the current prevailing market for lease power plus your ability to negotiate a fair deal for yourself.

Some recent leases, generally reserved for the larger Class I carriers, are so involved with detail that locomotives are used on a "power by the hour" formula which provides for payment only when the locomotive is used. Such things as incentives for availability in excess of preset performance guidelines and penalties for performance below predetermined levels are now quite common. This can be one of the most costly leases taken at face value; however, its potential for favorable return is promising.

In contrast, the net lease which was mentioned previously is a good alternative, but it can place a burden of expensive repair work on the user if there is a high frequency of failure among the leased fleet. It should be remembered that each dollar of labor and material spent on a leased unit essentially becomes the property of the lessor and thus enhances his asset at your expense. In the large carrier's case, this has an impact, but for the small carrier the impact could be devastating. Guarantees for reliability and availability are being demanded more and more in today's strict market.

The railroads are getting more aggressive in their lease negotiations. A new twist has arisen in recent leases which allow the lessee to park leased units not required for service and enjoy rental relief from the lessor for those days not used. This arrangement can prove to be an excellent alternative to buying locomotives and often is the ease of choice.

If you elect to lease motive power, your deal can be structured to include a residual buy-out at the expiration of the lease. The price of the locomotive is prearranged at the time the lease is initially executed or a floating price called "fair market value" is used to determine the value at that point in time when the lease has expired. Fair market price is a barometer of comparable locomotives with consideration of condition, age, special equipment, etc. which can be used to calculate a price the locomotive would be worth on the

open market.

Aside from some form of lease arrangement, acquiring a locomotive can be done through an outright purchase. There are numerous financing vehicles which may be used including banks, trusts, leasing companies, and even individuals in a joint venture. One regional has locomotives that were purchased by its board members and/or its officers. Repayment generally results in some type of monthly repayment system by way of a lease. There have even been reported cases where a road has owned motive power no longer suitable for their own needs, this allowed it to least its unwanted units out and in turn, create enough income to cover nearly all of the lease expenses to obtain the smaller locomotives it needed. Although this appears very attractive, it is the exception rather than the rule.

The Selection Process - How to Select The Right Motive Power

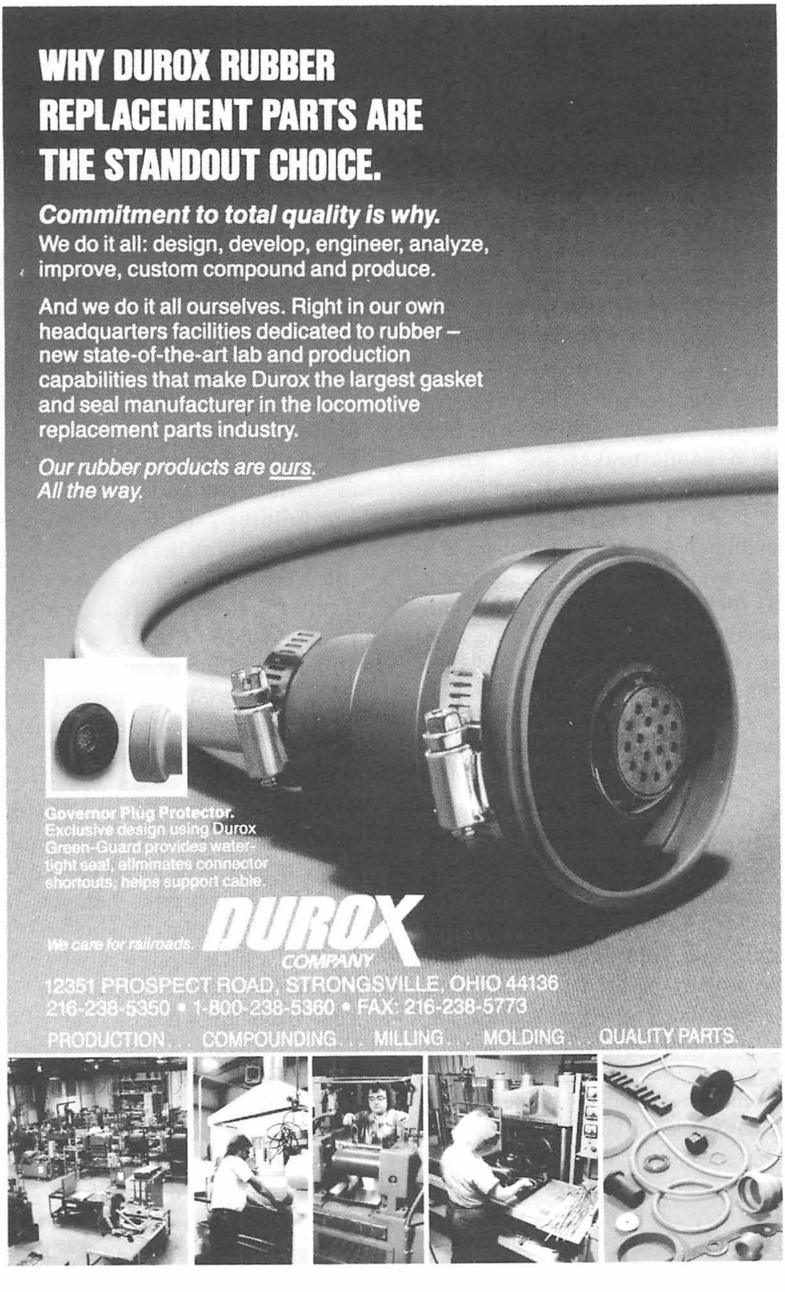
There is evidence that in come cases, especially on smaller railroads, an individual's personal opinion may dictate what type of locomotive is acquired. This may be good or bad; however, in either instance politics of the hierarchy plays a key role in the selection process. As mentioned previously, the best method is to discuss the subject thoroughly with all departments and agree upon such things as the type, manufacturer, size, model, horsepower, and don't forget "cost". If there is any uncertainty or disagreement in arriving at this level of the process, seek advice from those who have the experience in this area--namely, Class I roads, consulting firms, and so on.

When a decision is made to narrow the field to a select few, one should get out and thoroughly inspect the prospects first hand. There is no substitute for experiencing the locomotive at the site, and you will know what you are getting for your money. Once the locomotive is considered a good prospect for acquisition, one must ask two key questions--if we buy this unit when will it be available? How much will it cost to get it to our property?

There are other ways of getting a feel for which unit is right for your railroad. One idea is through the use of a trial locomotive or a demonstrator. What better way to determine if something will perform than to try it in the environment where it must perform? Various other sources can provide computer simulations which will offer a textbook view of probable performance. However, there are some shortcomings in this type of analysis--for example, the computer simulations will often assume perfect rail conditions and can not recognize inclement weather conditions or severe temperatures.

Last, but certainly not least, is the issue of cost. Cost should be a factor, but frequently the limited revenue base of the smaller road will establish a maximum spending level that can not be exceeded. In a case like this, the cash limitations will dictate which motive power is acquired rather than which locomotive is truly the best suited.

Some perameters to help you choose the right locomotive must always include the age-old controversy of which is better--4 axles or 6 axles? Remember that there is a higher maintenance cost associated with maintaining two more traction motors, wheels, and so on, as with a 6 axle. On the other hand, six wheels of tractive effort may work better on your road than a 4 axle will. What about versatility? Can a longer, heavier, 6 axle go on your line


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.
We care for railroads.
DUROX
COMPANY
12351 PROSPECT ROAD, STRONGSVILLE, OHIO 44136
216-238-5350 • 1-800-238-5360 • FAX: 216-238-5773
PRODUCTION . . . COMPOUNDING . . . MILLING . . . MOLDING . . . QUALITY PARTS.

where you need it? Do you have bridges with weight restrictions or light rail in some areas? Do you have track configurations or curves that preclude the use of 6 axle?

How about turbocharged engines? Can we afford to maintain this very costly component if it fails? Take a good look at fuel economy. Once again, in the smaller railroads some of these items may take a back seat to a cheaper priced unit, such as in the case of the 20-cylinder engine. Be careful not to overlook special and sometimes unique requirements you have--for example, do you require large fuel tank, dynamic brakes, cab signals, speed control, duel control capabilities, or even A, B, or F-type carbody configurations? Ask yourself if there is a market available to obtain replacement parts for this model unit. Is this unit compatible with your existing fleet? A large cost saving can be realized simply through standardization of locomotives.

What about the maintenance facilities you have? Will this locomotive even fit in your shops? By this point in the process, you should have been very familiar with all of this information. Therefore, by now you should also be aware of those so-called notorious "bad actors" that are unwanted and cast aside, usually by the Class I's. There are a host of makes and models that are labeled with a bad reputation because of persistent mechanical or electrical problems. These units may be a steal to buy, but you must be willing to accept the higher cost of their maintenance and above all, the possible negative effects they could have on your customers and service levels.

How Many Locomotives To Buy?

Again the question of 4 axle vs. 6 axles. You can perhaps buy fewer locomotives if you acquire 6 axles to pull your trains rather than 4 axles. The level of technology will influence what pulls better--especially in the area of tractive effort. Often when the Class I's offer motive power for sale, some units are in a state of major component fail ure or have even suffered the plight of cannibalism. This can sometimes be a very good source of used parts for the small roads. Buying extra units for parts is smart, especially when volume purchases will drive the collective acquisition price down. Because regionals and shortlines utilize smaller locomotive fleets, a spare locomotive to substitute for periodic maintenance and failures should be considered. What about those heavy bad order units you have? Did you consider selling them off or even trading them in on your purchase of other locomotives? This is being done more often these days. Trade-ins are no longer reserved for the original equipment manufacturers.

Unfortunately, market changes cannot always carry the weight they should in deciding when to buy or lease. If you have the need and it is immediate and urgent, then you must react. It goes without saying that timing in the marketplace is where you save money or lose money. The challenge is to know when.

Length Of Your Financial Commitment

Now that you have chosen exactly what locomotive you wish to buy, you must decide how to obtain it financially. If you lease, the rule of thumb generally is that the longer the lease the cheaper the lease payment. You will find leases ranging from one day to fifteen years and even more. The short-term, renewable lease gives you an "out" to terminate the lease, but you may pay a higher premium for it. The long-term lease is cheaper, but you are locked in with little hope of changing the term even if your need for the locomotive no longer exists. The short-term lease gives you the flexibility to add or return units to react to cyclical peaks and lows in the traffic levels. Each road is unique, and the way you acquire motive power has to be tailored to your needs.

Depending upon a lot of factors, leasing may not work for you, so take a look at purchasing the equipment. There are very definite rules and guidelines for obtaining financing. Among other factors, the value of the asset being purchased, together with current financial market conditions, govern the length of the term. In general terms, new locomotives are financed for 12 to 15 years, used for about 5 years, and remanufactured somewhere in between.

Once You Have Acquired The Locomotive - What Next?

Assuming you have done your homework, you know how you are going to get the unit home. Now look at what parts, consumable items, special tools, if any, you need to obtain. Part of the deal in some cases will be to receive schematic, diagrams, and manuals with the locomotive. If your forces are not entirely familiar with this model locomotive, arrange for instructional training for the maintenance personnel. You may even need to issue policy changes to deal with newly acquired, strange locomotives. Revisit the operating and train handling procedures. Train your engineers and road foreman properly for the changes in equipment. Doing this may avert an accident or even a derailment caused by unfamiliarity. There may be a need to add, remove, or modify something aboard the unit even before it can be placed into service on your railroad--be prepared for it. At the very least, the new owner will have to place his reporting marks on the locomotive as in the case of long-term capital leases or purchase.

Conclusion

In conclusion, it is important that you have made your decisions based upon the best information available to you. Be committed to make it work. Be prepared for some problems and plan for some rough times for a while. Monitor the units closely, not only for their performance, but also for how well they fit in on your road. If you have made a wise decision, it will pay off and eventually be worth all your work acquiring them.

MR. J.R. NUSSRALLAH
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Consolidated Rail Corp.
Philadelphia, PA 19104

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

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

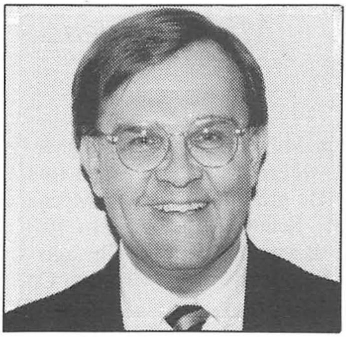
Our thanks to Mr. J.R. Nussrallah and others responsible for and participating in the program.

REPORT OF THE COMMITTEE ON NEW DEVELOPMENTS

TUESDAY, SEPTEMBER 22, 1992
10:15 a.m.

Pre-Convention Presentation Conrail

May 6, 1992 Ramada Hotel Altoona, PA



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PERSONAL HISTORY

Michael Iden

Mr. Iden was born in Milwaukee, WI on June 27, 1950, where he attended public schools. He graduated from the Milwaukee School of Engineering with a Bachelor of Science in 1972. He subsequently attended Northwestern University in Chicago and Evanston, IL, from which he graduated in 1978 with a Master of Management degree in transportation and operations management.

He began his railroad career in 1970 as an Engineering Trainee in the Railway Track Machinery division of Nordberg Manufacturing Co., in Milwaukee. After graduating with his engineering degree in 1972, he joined Southern Railway System as a Management Trainee in the Engineering and Research department, subsequently promoted to Assistant Engineer in 1973.

In 1974, he resigned from Southern Railway, and joined Electro-Motive Division of General Motors in LaGrange, IL as a Mechanical Designer in the Plant Engineering department, subsequently promoted to Mechanical Engineer in 1975.

In 1978, he left EMD and joined Chicago & North Western Transportation Co., in Chicago, as Operations Analyst in the Corporate Industrial Engineering department. He transferred to the Operating department in 1979 as Senior Operations Analyst in the Operations Planning department, subsequently as Manager Operations Planning in 1980. Much of his work involved planning of the western coal operation in Wyoming's southern Powder River basin, including train operations and mainline plant design.

In 1986, he was promoted to Assistant Superintendent Motive Power in the Motive Power department, and in 1989 to Director Motive Power Engineering, his current position.

Mike and his wife, Andrea, have two sons, Jay and Nicholas and reside in Barrington, IL.

I. TALKING TO THE 'SMART' LOCOMOTIVE

Presented by Mike Iden-C&NW

Nine years ago, the keynote presentation of the New Developments Committee was "Microprocessors for Locomotive Control and Diagnosis." The closing comments of that presentation said, in part:

"Through a prudent incorporation of the microprocessor on board the locomotives, this equipment can be made extremely reliable in itself. By minimizing the initial number of ad-on transducers and requiring redundancy in the control design, we will win the confidence of the maintenance personnel who utilize this equipment and assure its success."

The presentation also quoted *Forbes Magazine* (issue of November 22, 1982), describing the microprocessor as having:

". . .an insidious capacity for pervading every aspect of the economy---for filling it, reforming it and reshaping it to its image."

At that time, EMD and General Electric were prototyping their first microprocessor-controlled locomotives, the SD60 and Dash 8. In the intervening nine years, we have indeed seen the microprocessor spread throughout locomotive applications, not only on board the locomotive in control, monitor and recording applications, but off board as well in applications related to locomotive operations and maintenance. Indeed, the portable microprocessor, in the form of laptop computers, has itself become a commonplace tool in locomotive operations and maintenance.

Incidentally, the quote from *Forbes Magazine* used the word "insidious" in describing the microprocessor. *Webster's New World Dictionary* shows that "insidious" is derived from the Latin word for "ambush," and defines it as meaning "characterized by treachery or slyness" and "more dangerous than seems evident."

One year ago, while planning our presentations the New Developments Committee rather quickly came to a consensus that microprocessors have indeed filled, reformed and reshaped locomotive operations and maintenance. But the underlying theme which arose from our discussion as it developed substance was that Malcolm Forbes was right: we've been and we continue to be ambushed by microprocessors, and we've been slow to realize it. The application of microprocessors to locomotive applications has accelerated rapidly and advanced to the point where we must regain control of how we communicate with all of the microprocessors involved. Hence, that's how we shaped the theme and title of this presentation: "Talking to the 'Smart' Locomotive."

Motive power control technology is now in its fourth generation. It required roughly 40 years to advance from relay technology to solid-state electronics. Another 12 or so years were required to bridge the gap to microprocessors. The next generation of locomotive microprocessors is now emerging, only seven years after the SD60 and Dash 8 hit the rails. A decade ago, you could still find applications such as cab signals which used vacuum tubes; the multimeter was perhaps the most important electrical troubleshooting instrument, and railroad managements considered personal computers to be an extravagance.

The pace of change in microprocessor technology will continue. Consider this: If you purchased a personal or laptop computer one year ago, the odds are today that you could acquire a newer device with more processing power, faster operating speed, greater memory for storage of data, weighs less, and probably has a color display instead of monochromatic grey-tones. What really hurts is that the newest device will probably cost no more and possibly even less than last year's purchase! Microprocessor technology is indeed on a geometric curve of development and obsolescence, and that same curve is pushing locomotive technology.

Today's locomotive is filled with microprocessor applications. The on board micro not only tells the locomotive how to operate and respond to operator commands, but also literally defines the locomotive itself. Characterization parameters, for example, are responsible for establishing the horsepower output of the engine, and "telling" the locomotive how many traction motors are underneath. Dr. Strangelove would smile at the multitude of possibilities for creating trouble should the wrong people get access to characterization modules or the toolbox software which can unlock the basics of the locomotive's inner soul. In addition, microprocessors have overwhelmed applications such as event recorders, crew alerters, cab signals, voice and end-of-train radios, cooling fan controllers, on board lubrication systems, adhesion controls and fuel gauging. Visitors to the equipment displays at this year's conference were able to step aboard some of the Burlington Northern equipment and allow Committee member George Hsu to describe the abilities of Advanced Train Control Systems (ATCS) and locomotive health monitoring equipment. Within the next year with electronic fuel injection (EFI), we will see the microprocessor replacing the electrohydraulic governor in controlling the diesel engine.

Control problems on relay-era locomotives could be attacked using a screwdriver, pliers and a multimeter; on today's microprocessor locomotive, you may need a laptop computer, a serial interface cable with the proper connection, and the necessary software. A typical electrician could troubleshoot an SD40-2 or C30-7 given a correct wiring diagram; the electrician tackling today's locomotive has to have some understanding of how to use the on board computer and frequently a laptop computer, as well as how to use the software.

All Cables Are Not Created Equal

A decade ago, there were literally two cables of importance on the typical locomotive: the 27-wire multiple unit jumper and the governor cable, both of which were standardized through many years of evolution. The cable of importance today is the serial interface cable, connecting the laptop computer to the microprocessors on board the locomotive. Most of you have probably heard the name "RS232C" for a serial cable. Walk into an electronics store and ask for an "RS232C" cable, and the sales person will answer, "Which one? Nine - or 25-pin, male-to-male, male-to-female,. . .?" The various microprocessor event recorders, for example, use a variety of cable connections, making a multi-plug cable a practical reality for anyone responsible for downloading recorders owned by multiple railroads. The day of the magnetic tape (one size fits all) is rapidly ending.

Let's consider the 25-pin connector. A standard cable is straight-through cable with a male connector on one end and a female connecter on the other, with the pin "assignment" on both ends being equal. Unfortunately, the end connectors can be any combination of male-to-male (M/M), male-to-female (M/F), etc. This creates the need for two more connectors, called "gender chargers" to enable you to convert a female-end connector into a male. It's also common for some computers to require swapping of the transmit and receive pins between the host computer (such as the on board computer) and the receiving computer (such as a laptop). This arrangement is called a "null modem." In such a situation, failing to use the right cable can and has damaged one or both computers.

There! We've completed the requirements for all cable possibilities, right? Yes, but only for 25-to25 pin-connector cables only. How about 15-to-15 or 9-to-9 pin-connector cables. And, yes, there are frequent needs for unequal-pin cables, such as the 25-to-15, 25-to-9 and 15-to-9 pin-connector style. This gives us a grand total requirement of 3 straight-thru cables, 6 gender chargers, 3 null modems, and 3 converters for unequal pins, just to cover the most commonly-used kinds of "standard" "RS232C" interfaces.

Display Screens

The situation is even more disorganized once the locomotive maintainer establishes communications with the microprocessor. The display screen is the next critical link.

The railroad industry is making a major effort at standardizing operating displays on the locomotive control stand, which is becoming the railroad's equivalent of aviation's "glass cockpit," in which display screens replace multitudes of analog gauges. The AAR's Locomotive System Integration Committee (LSI) is working toward a standard default visual display of locomotive operating information, to improve the man-machine interface. The general guidelines of the LSI effort for control stand displays include:

1) Use the simplest display concept commensurate with the information transfer needs of the operator;

2) Use the least precise display formate matched to the readout accuracy required;

3) Use the most natural or expected display format for the type of information or user response;

4) Use the most effective display technique for user conditions; and,

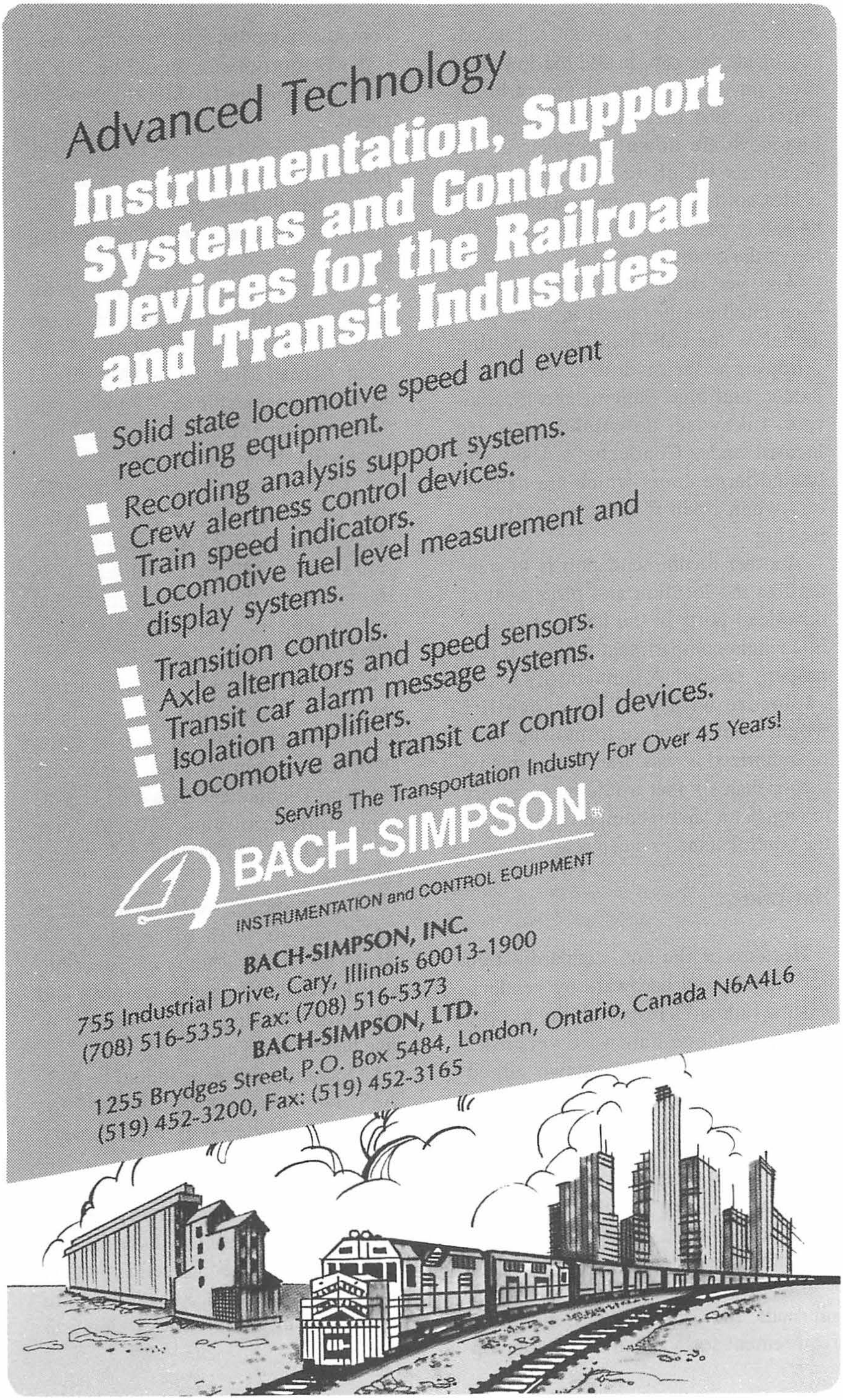
5) Optimize display visibility, conspicuousness, legibility and interpretability.

Theoretically, the LSI effort will give the locomotive engineer the best information needed to operate the locomotive and train. Unfortunately, there is no counterpart effort underway on the maintenance side.

The 60 Series and Dash 8 microprocessor displays have been followed by several other displays. Each offers a different packaging of data and information related to locomotive performance and problems. Displays are 2-line versus 4-line. One offers data packs displaying multiple pieces of information on a screen, the other one parameter at a time.

Download Ports

The "download port" is the physical point at which a laptop computer can be connected to the on board computer. The application (or misapplication, depending on your viewpoint) of download ports on today's locomotives substantiates how little standardization of type or location has been accomplished. Currently, download ports are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located all over the locomotive, including inside the cab, inside the low-nose area, on the exterior of the carbody, outside and inside event recorder boxes. Some download ports are in locations which require extra long cables so that the laptop computer can be safely placed on the cab seat or on top of the control stand.

And, yes, some download ports have been intelligently placed in areas such as below the cab floor, necessitating dropping exterior doors, climbing a ladder, and blue flagging the locomotive. Likewise, download ports are located under Conductor's desks and behind large doors which are dangerous when open if the locomotive is moving.

Another recommendation is to standardize the location and placement of download ports in the locomotive cab, in a single compartment with each port properly labeled. A hermetically-sealed enclosure with padlock capability would limit exposure to moisture and unauthorized access. Ideally, a cable no longer than six feet would be necessary to connect a laptop computer placed on the control stand or a cab seat.

Hardware

Because of the non-standardization of software and hardware by vendors, it is the railroad's responsibility to keep its maintenance hardware versatile. Computer hardware is a two edged sword: We sometimes try to minimize our investment, only to find that the equipment is lacking in necessary processing speed or storage capacity; likewise, too often we buy the best equipment, only to have prices fall drastically within a year.

Based on the experience of several railroads, the following is a minimum requirement for acquisition of a laptop computer intended for locomotive use:

* Microprocessor should be 386SX with 20 megahertz (MHz) processor speed.

* Math coprocessor socket should be present (a math coprocessor is necessary to handle most event recorder programs without excessive processing times).

* Data storage should be 60 megabytes (MB) minimum, average access time of 19 milliseconds (MS); Read Access Memory (RAM) should be 2 MB, upgradable to 6. At least one floppy drive for a 3.5 inch diskette (1.44 MB) should be present.

* The video display should be VGA style giving enhanced graphics, particularly necessary for event recorder programs (640 x 480 image pointes), with 16 gray scales for contrast. An external port to support a super-VGA monitor (IBM compatible) is desirable.

* The laptop should have an internal modem to support uploading data to mainframe applications, such as GE's Dash*Star system for Dash 8 fault and run data. The modem should be Hayes-compatible minimum 2400 bits per second (BPS) MNP-class 5 error-checking.

* Laptop should weigh no more than eight pounds with battery, which should sustain two hours of operation, with low-battery charge warning and automatic shutdown when inactive to save battery charge.

* Operating software should be MS-DOS, latest version (currently 5.0). Windows software may be necessary for some programs.

* Anyone using a laptop on board a locomotive should have a carrying case to haul the laptop, cables, diskettes, etc. There's nothing like the feeling you get when you drop a $3,000 laptop onto the underframe deck while walking to the cab!

A printer (and sometimes a graphics plotter) is necessary to complete the system. Unfortunately, specific details can't be given, because printers are often specified by the software packages.

In the shop or office, a stand-alone work station should have:

* 486 microprocessor at 33 MHz clock speed, again with capability for installing a math coprocessor.

* Data storage should be 200 MB hard drive; depending on how much data will be stored and from what source, less space may be acceptable. Some solid-state event recorders, for example, can use one MB with each downloading. RAM should be 4 MB upgradable to 32 MB.

Keyboard Standardization (Not Everyone Can Type)

A key piece of the man-machine interface is the keyboard. Again, the keyboard is found both on board microprocessor-controlled locomotives and on laptop computers. At first glance, most keyboards look alike. It's a well known fact, however, that only the alphabet keys are in standard locations. One of the most common keys found in different locations, sizes or shapes between computers is the <ENTER> key. Computer users frequently become frustrated when switching between computers by inadvertently striking the wrong key. This simple error can "crash" some software programs if they are not robust enough.

As if the differences between keyboards aren't enough of a problem; how about the arrangement of alphabetic keys? Why are they arranged as they are? To accentuate the kind of real world problems encountered on the locomotive shop floor or in the cab, here's an interesting example: One railroad's shop supervisor caught a machinist who failed to enter what work had been performed on a locomotive. The man was asked to remedy his oversight. This employee walked to the computer terminal and reluctantly and clumsily began typing on the keyboard. Suddenly, he blurted out a frustrating comment: "Why can't this #@!*'%^$ keyboard be in alphabetic order?" That is indeed a profound question.

To many people, it is not important why the arrangement of the alphabet keys is the way it is because they are used to typing. But, the people who have never typed or have had little exposure to a typewriter or computer keyboard often face a disaster when trying to find the right keys. It is reasonable, therefore, to assure that a keyboard with alphabetically-ordered keys is probably a better choice for users not familiar. In fact, this is how the key pads are arranged in the cockpits of the Boeing 757 and 767 aircraft (keep in mind that pilots of these craft are typically college graduates!).

Another related problem is frequent lack of understanding of the differences between the letter "O" and the numeral "0;" computer software usually treats the two characters differently, as it should, but we usually "speak" and "think" the letter "O" for both applications.

Nested Menus

It's probably unrealistic to think that the conventional computer keyboard will ever be changed to alphabetic-order. Nor is it entirely realistic to assume that all keyboards can be rigidly standardized. Fortunately, there is another popular method of consolidating various programs sharing the same computer to totally avoid the need to type. This is the "nested menu," which uses a combination of "function keys" (F1, F2,. . .F12), numeric keys and the screen "cursor," to guide even the first-time user to the right place in a program without the need of typing any letters or numbers.

Fig. 1 shows an example of the concept. If there are new programs to be added, they are incorporated into the main menu so that the user doesn't have to memorize all different kinds of commands.

Data Structure

One of the most useful features of modern locomotives is their ability to store operating data on board, either automatically as in the case of fault histories or on request as in trip histories. Unfortunately, it is a challenge to access the data and sometimes a monumental task to make sense of the data, that is, converting the data into useful information. This is because the data are in different formats and structures. A classic example is the differences in how the various solid-state event recorders store data. You need each manufacturer's software program to download, decipher and manipulate the recorded data. No railroad probably has installed every brand of solid-state recorder, so the required software is limited to actual users of the equipment. A big problem arises, however, when locomotives cross corporate boundaries as in run-through type operations, where, for example, locomotives of one railroad are exposed to grade crossing accidents on another railroad in another region of the continent.

Again, as with keyboards, it's unrealistic to assume that data formats can be rigidly standardized. There is a solution, however, by having software constructed to provide the most popular formats; each railroad should be able to access the data, while using its software to convert data into information. Also, data structure should be provided by the vendor as part of the electronic documentation, to permit users to access data as required.

Computer Security

The locomotive manufacturers have taken different paths in making their on board microprocessors secure against unauthorized tampering with the software programming and data files. Security against tampering is critical, because the microprocessor is the critical link between the locomotive engineer or maintainer and the point where the wheel meets the rail. The approaches taken have included access switches and passwords.

Access switches are meant to be accessed. They frequently require installation of conventional doors with locking devices if tampering occurs. Passwords, on the other hand, are transparent to unauthorized users only as long as their distribution remains limited. One railroad learned of the password to enter higher levels of a locomotive manufacturer's on board programming from engineers at another locomotive builder (who, in turn, received the password from locomotive crewman at another railroad).

Limited distribution of "toolbox software" as a special diskette avoids the need for access switches and passwords, but again, care must be taken to avoid unauthorized copying of that software.

The Bottom Line: Get Organized Before It's Too Late!

The microprocessor has obviously wrought great changes in locomotive technology, and will continue to be a technology driver in our industry. but, as we've reviewed here, the uncontrolled and non-standard proliferation of microprocessor applications and equipment has created and will continue to create problems for locomotive maintenance personnel. There will be a definite economic cost associated with those problems, particularly those involving ineffective interface between maintenance personnel (who are not computer experts) and the machines which they are supposed to control.

Our recommendations include:

1) Standardize as much as possible the download cables used to connect on board microprocessors with laptop computers, including the cable-end connections.

2) Create an industry-wide consensus on the content of on board microprocessor display screens, aimed at providing the most effective display of maintenance and performance data for locomotive maintainors, comparable to the Locomotive Systems Integration (LSI) task force effort which is creating a homogenous display for locomotive engineers.

3) Standardize the location of download ports on the locomotive, where laptop computers can be connected to the on board systems; these ports must be located in a common location inside the locomotive cab, with security covers if necessary, to avoid conflicts with blue flag protection.

4) Be selective in acquiring computer hardware (laptops, and the various internal options such as memory size, processor speeds, etc.). Also, be prepared for rapid obsolescence.

5) Standardize keyboards of on board microprocessors. Consider using the alphabetic arrangement found on state-of-the-art aircraft such as the 757 and 767, to make computer usage easier for the non-typist. All computers are extremely unforgiving of spelling errors and mistakes such as confusing the letter "O" with the numeral "zero (0)," for example.

6) Manufacturers should also give serious consideration to the use of "nested menus," which prompt the user to make his selections from the function keys instead of requiring keyboard typing.

7) Data from on board microprocessors should be freely available to authorized users. It is unreasonable to expect locomotive maintainers to carry software for each microprocessor application, specifically to download and access the data from each application. This is rapidly becoming a problem with the spread of solid-state event recorders, each of which requires specifically-written software; this is a problem for many railroads engaged in run-through locomotive operations.

8) Microprocessor security is an important aspect of microprocessor technology. Manufacturers must improve security to prevent unauthorized access to critical on board programs and data files, but must also avoid making the systems too cumbersome for maintenance personnel to use. One thing can be said for certain: Passwords are sure to be written on cab walls, inside notebooks, and passed by word-of-mouth to everyone! The task is to keep unauthorized users away from critical locomotive operating programs and data files, but also make the system accessible to locomotive engineers and maintainers at their appropriate levels of "need-to-know.

AN EXAMPLE OF A NESTED MENU

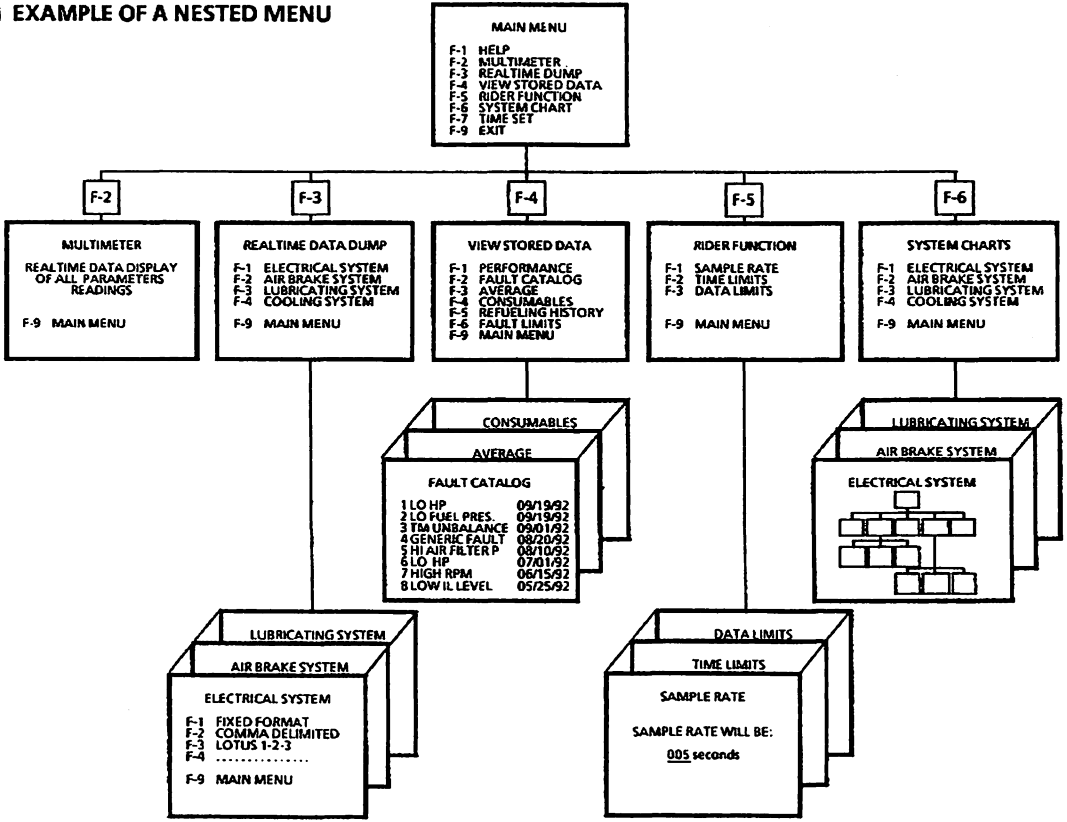


Fig. 1

II. CAB NOISE ABATEMENT

Presented by Rick Mackowiak, Alaska RR

The maximum permissible noise exposure levels established by the Federal Railroad Administration are primarily for the purpose of protecting locomotive occupants from hearing losses due to prolonged exposure to excessive noise levels. This report is accented more toward reducing cab noise levels far below any established limits. The primary objective is to eliminate or reduce all noise to the lowest possible levels and even to reduce or eliminate vibrations transmitted into the cabs from other sources. The logic applied here is that any noise or vibrations that locomotive cab occupants are exposed to can and will affect their performance, fatigue and, of course, their perception of the cab comfort level. Any reduction in vibration levels will also improve the environment for the electronic devices located in the cab. New locomotive construction offers the greatest opportunities to all but totally eliminate the noises and vibrations; however, there are a number of relatively inexpensive modifications that can be applied to existing locomotives.

1. Horn Relocation

The warning horn which has been traditionally located on the cab roof is probably the largest contributor to high cab noise levels. A relatively simple solution is to move the horn toward the rear of the locomotive and off the cab (Fig. 2). However, using the existing horn valve and extending the existing piping to the new location will greatly increase the response time of the horn. If you change to an electric magnet valve you must still consider the length of pipe between the magnet valve and the horn. If the magnet valve is located too close to the horn, the response time of the horn is almost instantaneous, but the horn "feathering" effect is lost. One railroad, after trying numerous combinations, settled on locating the horn either over or between two cooling fans. This location has totally eliminated horn freeze-ups during inclement weather conditions. The horn control is electric with a normally open spring switch located on the control stand, similar to a sander control switch. The magnet valve is located near the AC cabinet, where there is an air supply as well as ambient heat to keep the valve from freezing. This location also gives enough distance between the valve and the horn to maintain the ability to "feather" the horn.

2. Air Brake Exhaust

Another irritating source of cab noise is that which occurs during the operations associated with air brake functions, particularly the exhausting of the air. An inexpensive yet effective modification is to pipe the exhaust air to the area below the cab. This significantly reduces the noise; however, this noise must not be totally eliminated because it is important for the operator to hear the air escaping to ensure proper operation and it also immediately indicates an undesired release of the train brakes. If these noises were to be totally eliminated, which could be done, some other either visual or audible indicator would have to be installed. Piping the exhaust through the cab floor offers the least expensive and rather simple solution to the problem (Fig. 3). It also has another advantage in that it also directs the distasteful odor of the exhaust air outside the cab.

3. Radio/Warning Signals

Radio communications and warning signals such as alerters are another source of noise that contributes to uncomfortably high levels of noise exposures to the cab occupants. These devises' sound levels are typically adjusted to be loud to overcome background sound levels and ensure that they are audible. The obvious solution to this problem is to reduce the background noises to a level where these devices could also have their noise levels reduced without compromising their audibility. One simple and inexpensive solution to the radio set at "blaster" levels on one side of the cab in order to be audible on the opposite side, is to install another speaker with a separate volume control on the opposite side of the cab.

4. Windows

Probably the largest single source of excessive noise exposure would be the commonly seen open cab window (Fig. 4). All the acoustical materials that could be applied, or the relocating of the horn, etc., are of little value if the occupants of the locomotive cab position themselves near an open window, particularly when passing buildings or anything which redirects the noises back to the locomotive. Naturally, operating with an open window then necessitates increased volume levels of the radio and other audible devices to ensure that they will be heard. The only real solution to this problem is to provide the locomotive cab with a good environment control. A heating, ventilating, air conditioning (HVAC) system which can effectively control the cab occupants' environment will, in turn, encourage them to keep the cab windows closed in all weather conditions.

5. Structure Born Noise and Vibration

The sounds heard in locomotive cabs come from numerous places in a wide range of frequencies at different intensity levels. Even the best HVAC system will be a noise source that creates sounds at what is referred to as annoying levels. Soundproofing or acoustical treatment to the interior of the cab is an effective way of reducing particular noise frequencies. There is a wide variety of sound absorbing materials that can be used as acoustical headliners and floor mats; however, they are only effective for treating mid to high range frequencies, those above 500 Hz. Acoustical materials have little to no effect on low frequency noise.

The latest development in low frequency noise and vibration or structure borne noise reduction is the modular cab which is attached to the locomotive frame with isolation pads or pedestals. Slip joints are added in front of and behind the cab module to allow for the relative motions. The collision posts are not affected and therefore the crash worthiness standards are not compromised. Not only does this design reduce the low level noise and vibrations for the cab components, but it also will increase the longevity of the electronic equipment located in the cab. This type of frequency isolation is effective for frequencies below 80 Hz. Along the same lines is the development of tuned panels which reduce structural resonances at normal engine operating speeds.

6. Active Noise Control

Active noise control or active cancellation of undesirable noise is accomplished by electromagnetically generating an anti-noise signal of equal frequency and amplitude, but at 180 degrees out of phase (Fig. 5). The concept itself is nothing new, in fact, there are patents covering this technique that date back more than 50 years (Fig. 6). This cancellation of noise, as a natural phenomenon has been known to concert hall designers for many years; the area where reflected sounds in a room meet with a generated signal of equal frequency but 180 degrees out of phase is known as the node point and the sound is cancelled. Although the cancellation theory has been around for many years, its application has been very difficult until the advent of the microprocessor. The reason is that digital signal processing requires millions of calculations per second, which is not difficult today with microprocessors.

A number of automobile manufacturers are testing noise cancellation technology on cars, both inside as well as outside the car. They have been successful in eliminating the exhaust muffler with as little as 100 watts of power. This active system is most effective in the lower frequency range 50/80 to 200/500 Hz. At this time locomotives with active noise control switches are being tested.

In short, the technology is available to make the locomotive cab as comfortable and quiet to the occupants as their private vehicles. The big questions yet to be answered are: How much value will this have to the railroad industry? How much will this cost? How will the benefits, if any, be measured?

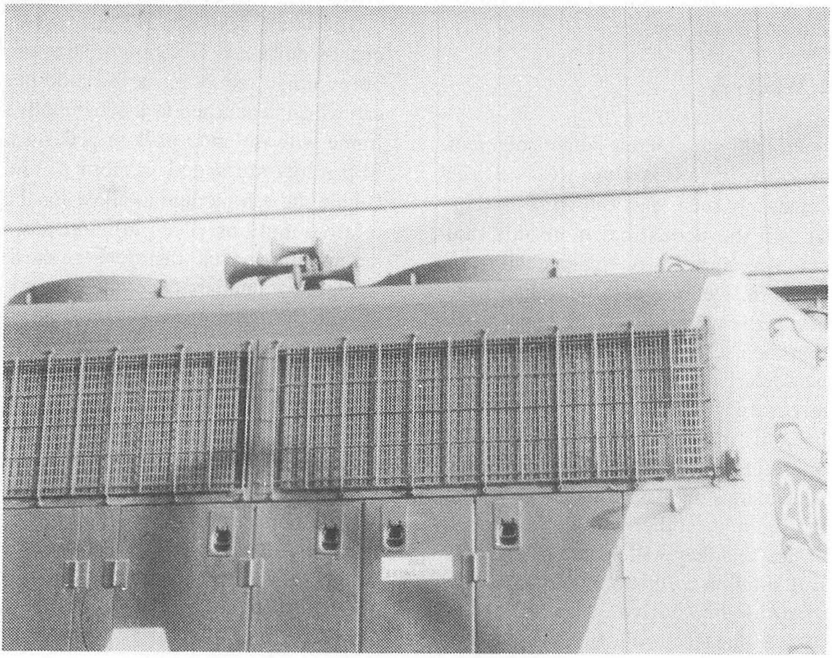


Fig. 2

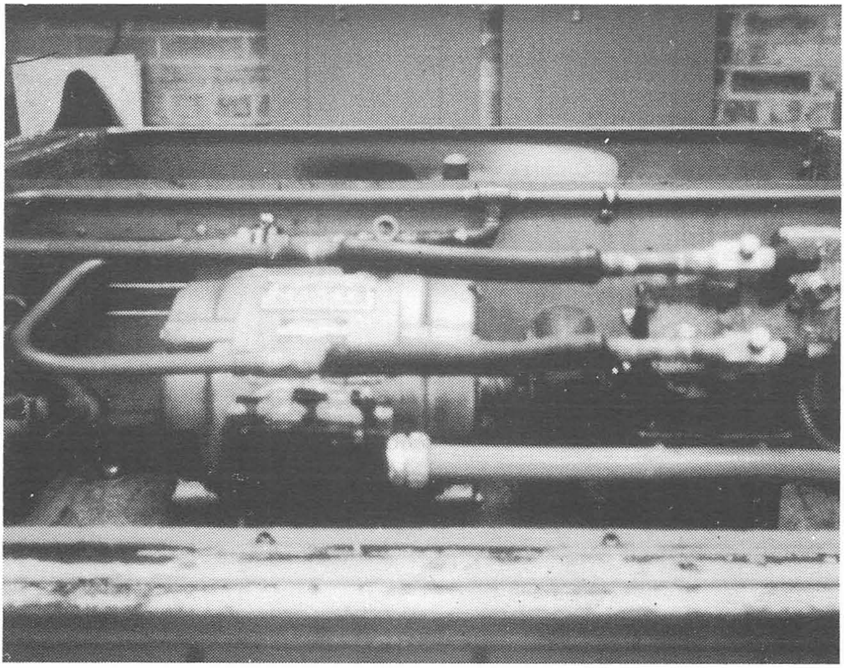


Fig. 3

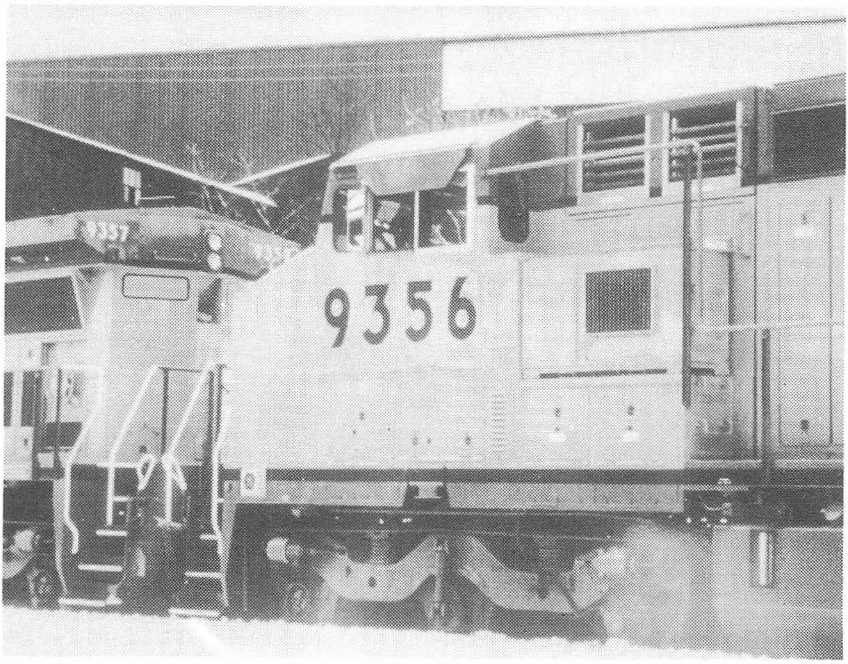


Fig. 4

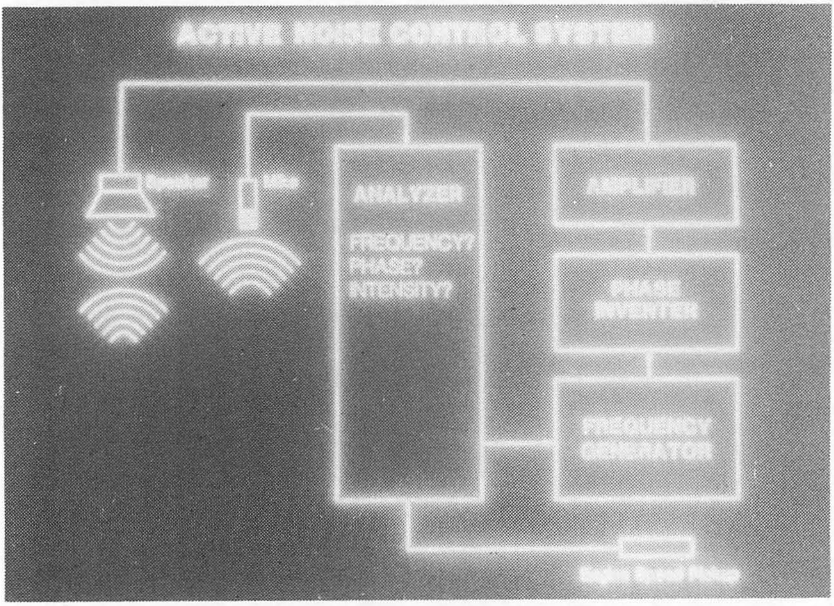

ACTIVE NOISE CONTROL SYSTEM
Speaker
Mic
ANALYZER
FREQUENCY?
PHASE?
INTENSITY?
AMPLIFIER
PHASE INVERTER
FREQUENCY GENERATOR

Fig. 5

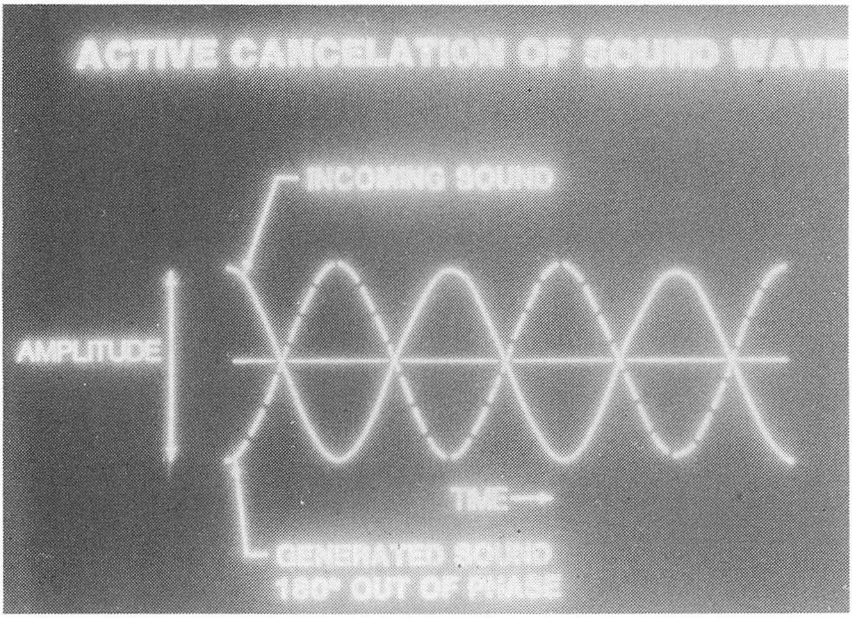

ACTIVE CANCELATION OF SOUND WAVE
INCOMING SOUND
AMPLITUDE
TIME→
GENERATED SOUND
180° OUT OF PHASE

Fig. 6

III. ELECTRONIC MANAGEMENT OF LOCOMOTIVE DRAWINGS

Presented by Bob Runyon, P.E.
Norfolk Southern

Since the early 1970's, the major domestic locomotive builders have used computer-aided design, or CAD, systems for the creation and maintenance of locomotive drawings. Typically, such a system required the services of a dedicated main-frame computer, and was therefore cost-prohibitive to many potential users. By the mid-1980's, personal computers had been developed with enough speed, memory, and sophistication to support individual CAD software, which then became affordable over a much larger base of potential applications. This milestone coincided somewhat with the adoption of personal computers within the rail industry.

The logical next step was to persuade the locomotive builders to furnish their drawings in a form directly usable by the customers' CAD systems. The major obstacle to this effort has been the difference and lack of compatibility among the various systems in use by the locomotive builders and railroads. Most of these have become so firmly entrenched that it would be out of the question to demand that all CAD users convert to an arbitrary standard system.

Fortunately, third-party translators have now become available which will, to a large extent, convert a drawing created on one system to a format usable on another. Some difficulties remain to be worked out, largely due to entities or data structures in the source drawing that have no counterpart in the target CAD system. By overcoming some of the problems and tolerating others, the major builders have demonstrated a capability of supplying drawings that are useable in a railroad-owned CAD system.

Some of the potential benefits of using computer-aided design are as follows:

1. Drawing Precision Not Dependent On Human Talent. Most CAD systems make provision for a user-definable grid, with means to round off point locations to the nearest grid intersection if desired. The computer can calculate and store these points to an accuracy of many decimal places.

2. Minimal Effort Required To Make Changes. Since the entire drawing is maintained as a computer data base, no blemishes are left by extensive and/or repeated erasure, which might require total reconstruction of a conventional drawing. Thus only the items being changed need to be redrawn.

3. Repeated Identical Items From Single Reference Copy. Any arrangement of drawing entities (lines, circles, etc.) can be collected and stored for subsequent treatment as a single entity, typically known as a "block" or "detail." Multiple copies can be drawn simply by reference to the single stored copy giving location, size, and orientation for each instance. This feature is particularly useful as a means to draw schematic symbols.

4. Extract Of One Drawing Transportable To Another Drawing. Any portion of an existing drawing can be extracted and written to a separate file for subsequent use, with or without erasure from the source drawing. This feature can save considerable effort when several drawings are found to have common features.

5. Hard Copy Easily Replaced If Damaged. A paper drawing or transparency obtained from a CAD system is not the original, but a copy derived from the original, and therefore easy to replace if necessary. Since the original drawing is maintained in digital format, it may be duplicated for backup or other purposes without loss of integrity; there is no progressive deterioration between successive generations.

6. Drawing Entities May Be Linked To External Data Base. This feature is relatively new to the personal computer arena, being offered only after recent advances in speed and memory size made it practical. It is of particular value when attempting to integrate graphic and non-graphic data bases into a single coherent system.

A successful drawing management system must, above all else, make accurate, legible, and usable drawings available when needed at each necessary point of use. As will be seen in the following discussion, the implications of this statement go far beyond the data entry process.

The term "point of use" deserves close scrutiny, and will be a large factor in determining the optimum system. For example, a person who only refers to drawings one at a time at a fixed location such as desk in the office or a workbench in the shop, might rely on a screen display and seldom need a permanent copy on paper. The case is somewhat different with an electrician attempting to troubleshoot a defective locomotive, as the electrical schematic will most likely be needed at any of numerous locations on board the locomotive, none of which are close to a computer monitor. To accommodate this kind of environment, the traditional paper format will remain for some time as an essential component of the system.

It is one thing to make a drawing available at a specified point of use, and quite another to make it usable. As an extreme example, if a repairman must lie on his side under the locomotive cab floor to access the components being checked or repaired, and such work requires frequent reference to a drawing, that location is the point of use for the purpose of drawing availability. A 42-inch wide rolled drawing would be of little value in this case.

It was stated above that drawings should be accurate, which demands not only meticulous effort during creation, but also that the correct revision be available for use. With the need for hard copies of drawings at many locations, it is difficult to make sure that all outstanding copies are kept updated or destroyed. The problem is compounded when the supply of copies is insufficient to meet the perceived need, as the superseded copies will be kept on hand in the belief that an incorrect print is better than no print.

However, in apparent contradiction to the preceding paragraph, there can be situations in which the correct version of a drawing might not be the current or latest version. A typical example is found in the drawings for electronic modules, which can be needed simultaneously in two or more versions to support similar modules manufactured over different periods of time. A similar problem of a more temporary nature occurs during the transition period of an extensive modification program, when both modified and unmodified locomotives are included in the fleet.

A typical railroad is widely dispersed geographically, with locomotive maintenance and repair centers at multiple locations. A considerable logistical effort is required just to keep these centers supplied with drawings which, aside from obsolescence, can quickly wear out or become illegible through normal use. Central control of drawing integrity has traditionally required that all copies of a drawing be made from a reproducible master and shipped to the using locations as needed. Recent advances in computer hardware have opened up alternative methods for distribution. For example, a master drawing in digital format can be transmitted to the field electronically as needed to make paper copies on demand, which will greatly reduce the response time and eliminate the need to stockpile copies at each using location.

It can be seen that there is no "best" system arrangement for all situations, and the choice of both hardware and software must be made with full consideration given to the needs of the organization, consistent with making drawings available as needed. Any compromise of drawing availability will lead to a similar compromise in quality of maintenance.

IV. UPDATE ON HIGH PRODUCTIVITY INTEGRAL TRAINS

Presented by Jim Hogan, Caterpillar

In 1983, the Research and Test Department of the Association of American Railroads requested the North American railroad supply industry to develop engineering designs for rail transportation that would contribute significantly in the demand for rail transportation.

Many companies responded to request by proposing intermodal train concepts. However, due to lack of engineering soundness and/or development funds, most of these concepts never got off the drawing board.

However, at least one project spawned by the AAR challenge is being developed in the United States. In addition, a second intermodal train concept being developed in Canada is also in the prototype stage.

This paper will update both projects and give you a status report. The first project consists of two motive power and control cabs separated by a number of 28-foot load carrying units articulated together to form a continuous platform. In the center of the nominal 1000 foot long train is a ramp that allows the train to separate to permit drive-on drive-off loading of trailers at terminals or intermediate stops. Although cranes or lift trucks can be used, a feature of the train is its ability to work from relatively unimproved areas.

Each power and control unit, one at each end of the trainset, consists of two 750 hp diesel engines driving AC alternators. The two engine/alternator pods can be removed for servicing and replaced with backup. Even if one of the four power pods is shut down, the train can make its terminal.

The drive system uses the two engine pods electrically paralled driving five AC motors attached to three-speed transmissions. One transmission is mounted on the first five axles on each end of the train. The train lading is used to load the axles and provide for traction.

One U.S. Class I railroad is working with the manufacturer and the prototype will be tested at the AAR Research and Test Center in Pueblo, Colorado.

The concept of specialized intermodal trains is also alive and well in Canada. A Montreal based firm is using the concept of carless technology, making use of existing truck trailers modified to fit on rail bogies. Recently, a large Canadian railroad decided the concept had merit and promise, and purchased a major stake in the company developing the concept. This infusion of capital is now allowing for continued prototype train development and will likely bring the concept to first production this year.

An artist concept shows truck trailers riding on rail bogies. Train control is provided by a special cab which resembles a cab-over truck.

Standard highway truck trailers are modified with a mounting system which includes a second pin mounted at the rear of the trailer.

When the trailer is pushed into the rail truck bogies, the rear pin locks into a fifth wheel located on the rail truck. Then the trailer and bogies are pushed under a second trailer which locks the standard pin into the second truck-mounted fifth wheel. The whole assembly is lifted with air and locked out, making the transition to rail mode complete.

Control for the train is provided by a cab system located at the front of the train. Although is resembles a highway tractor it is designed for rail service. The rubber tired axle allows the control cab to be moved off the rails.

Power for the system is provided by power modules distributed through out the train. Each power modules uses one diesel engine driving a traction alternator. The engine package output is used to dive one DC traction motor coupled to a single axle. Tractive effort is increased by using the lading of the truck trailer mounted on the fifth wheel on the power module. By using distributed power, modules can be added as the length and load of the train increases. Distributed power also provides heavy draw bar loads on the truck trailers. Like the control cabs, power units can be moved off the rails for servicing or transport to other locations. The prototype train is now in testing in Pueblo.

Both of these trains concepts have left the drawing board and are becoming reality. Although much research and testing and further development will be required, it is highly likely designers such as these will impact on the shape of railroading beginning this decade.

V.
AC TRACTION, A NEW DEVELOPMENT

Presented by Ben Smith, NJT

AC traction is not new. At the turn of the century General Electric, which favored DC technology, battled Westinghouse, which was a proponent of AC technology. The railroad market soon became a field for harvest, when urban areas pushed for reduced smoke emissions.

The basis for most of these early AC traction applications was the use of a single phase universal AC motor. Its construction mimicked the standard DC motor. It had a commutator, brushes, armature and was plagued with the same inherent problems, - insulation grounds, stall burns, flashovers, out of round commutators and dirt-related failures.

For more than 40 years, however, the DC motor has been the favorite for railroad traction because of the ease with which it can be controlled, even though it has inherent weaknesses.

In the 1970's with the advent of the thyristor (especially the Gate Turn Off Thyristor - GTO)., the prospect of using the simple, but robust, three phase induction motor became a reality. Reliability of AC technology was increased through the use of microprocessor controls.

ASEA Brown Boveri (ABB)

ABB has delivered 25 of a 35 car order of light rail vehicles (LRV) to Baltimore, MD and 26 third rail subway cars to SEPTA's Norristown Line.

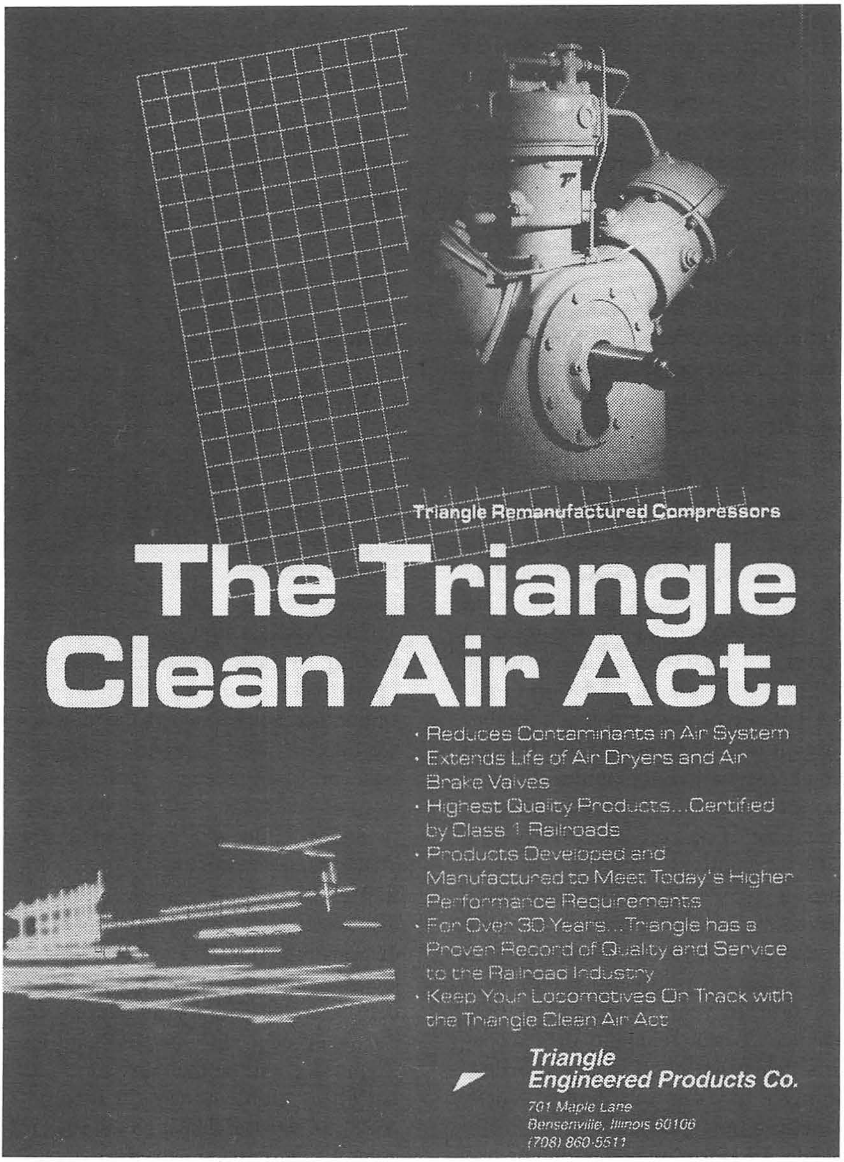
Metro North is operating five AC converted third rail-diesel electric FL-9 locomotives. Two presently are in testing on the Long Island Railroad and the other two are in revenue service on the Croton-Harmon line. ABB is refurbishing an additional five. There are three (3) three phase inverters - two for propulsion and one for Head End Power (HEP), which supplies power to the coaches (480 VAC-3 phase) and one specialized inverter/converter to raise the third rail voltage to maintain a stable 880 Vdc for the propulsion and HEP inverters.

Presently New Jersey Transit has six AC Multiple Unit cars (MU's) that will soon enter into revenue service and ABB- ELMIRA is in production of refurbishing 100 DC MU's into AC Traction cars with blended dynamic brake. The cars have individual air cooled replaceable Modular AC (MAC's) inverters per truck. The cars have regenerative capabilities to support the auxiliary 880 volt DC link and inverter used to provide HVAC and lighting during dead sections in the catenary or through phase breaks. One traction inverter can be substituted when the auxiliary inverter has a non resettable fault to support car amenities.

Bombardier/GE Transportation Vehicle Product Division (GE-TVPD0

Bombardier and GE/TVPD will deliver an 86 car order to Boston's MBTA's RED Line, beginning in September 92. Nine (9) prototype R-110 B cars (motor, trailer, and motor car configuration) will be delivered in September 1992 for a 14 month extensive service test before the NYCTA negotiates a contract. The test period will provide adequate time for the NYCTA to test other new technologies not only in propulsion but support and passenger comfort systems.

Bombardier has just been awarded a


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

contract to manufacture 58 motor/trailer electric multiple units (EMU) AC propulsion cars for the Montreal Deux Montagnes line.

Additionally, GE has orders for 60 AC drives for trolley/coaches, plus 35 light rail vehicles for San Francisco Muni. GE has also just received an order for 298 AC propulsion systems from Washington Metropolitan Transit Authority.

Freight-Update On AC Traction

The AAR Research and Test Department recently formed an Ad Hoc Committee on AC Traction to develop a performance specification for a fleet of AC traction demonstrator locomotives. Roads which are active on that committee include Amtrack, Burlington Northern, Conrail, Chicago & North Western, CSX, Norfolk Southern, Santa Fe, SOO, Canadian Pacific and the Union Pacific. That performance specification was released in July of this year, along with the Committee's recommendation to the AAR Board of Directors that a demonstration fleet of prototype AC traction freight locomotives be built and placed in revenue service. The recommended fleet size to be considered is twenty (20) locomotives, to go into service during early 1994. Revenue service testing by those 20 locomotives would extend through 1996, including two (2) full winters, in order to produce 40 locomotive years worth of service maintenance and reliability data to confirm that AC traction is indeed mature enough to function under North American freight conditions.

The Ad Hoc Committee determined that AC traction can be economically justified in freight service on the basis of making unit reductions, that is, for example, two large AC locomotives replacing three existing high adhesion locomotives. AC traction probably cannot be justified on the basis of simply reducing maintenance expenses associated with DC traction motors. In other words, don't expect to see AC traction motors replace DC motors on a large scale basis in the next ten years. The conversion to AC traction in freight service will be a gradual one, and will most likely occur as larger, more powerful AC motor locomotives assume more and more of the heavy haul unit train operations.

AAR AC Update

The Ad Hoc Committee also met with the four builders which expressed interest in building these AC demonstrators locomotives: GE, GM Locomotive Group (EMD), a consortium of Morrison Knudsen/Caterpillar/ Siemens/Kato and Republic Locomotive.

The AAR is now soliciting non-binding estimates from member railroads for the number of such demonstrator locomotives, which the railroads would consider acquiring from the builders. Upon receiving these expressions of intent, the AAR will then notify the four builders of the potential size of the demonstrator fleet. As of mid-September, four railroads have expressed their intention to acquire AC demonstrator units. The builders and the individual railroads will then negotiate separately. The performance specification produced by the AAR Ad Hoc Committee will be the basis for building all of the demonstrator locomotives, as it would be undesirable to have 20 locomotives built to several radically different specifications. Again, to avoid anti-trust problems, each railroad will negotiate individually and in private with any of the interested builders.

Here's the basic performance specification developed by the Ad Hoc Committee:

1) Preferred diesel horsepower is 5000 for traction

2) Six axles, with the ability to cut-out individual motors so that the full 5000 HP. can be pumped into only four motors, in order to test the AC transmission at 1250 HP per motor. A four axle locomotive could not presently be built at this horsepower level and desired fuel capacity without exceeding axle load limits.

3) Maximum weight would be between 390,000 and 420,000 pounds depending on the railroad.

4) The AC inverter scheme would be either one inverter per truck or one inverter per motor, depending on the builder.

5) Adhesion will be minimum of 45 percent at start and 32 percent under all weather conditions.

If this program proceeds as desired, by this time next year, some or all of the interested builders should be constructing these prototype AC traction motor locomotives for freight service.

General Electric AC Locomotive

GE is developing a freight locomotive with individual axle control and with characteristics comparable to, or exceeding the AAR AC/AC draft product specification (25% more continuous tractive effort, 10% more HP, components sized to 6000 HP). The product features inverters, which use direct air cooling with no intermediate cooling. Substantial increase in both continuous tractive effort and adhesion will be achieved based on technology currently in production for the transit systems developed by General Electric.

Program timing calls for prototype testing in 1993 followed by production in 1994.

Testing of the SD60 MAC model has been ongoing at the TTC in Pueblo since December of 1991. A demonstration run for the AAR board oversight committee was held on May 15th, of this year. At that time, a single SD60 MAC was able to pull a 5700 ton, 37 car train up a 1% grade through a 1½ degree curve.

In mid August, three Burlington Northern SD60 MAC units began runs in coal unit train service on Powder River between Denver and Fort Worth, normally handled by five SD40-2 locomotives. Operational evaluations continue, with some impressive results, owing to the AC technology. Drawbar measurements in excess of 410,000 lbs. are being measured, as the three unit consist has been able to take the hill out of the Caballo Rojo mine, that normally requires TWO helpers to assist.

Amtrak- Mainline Passenger

AMTRAK/EMD F-69 PH prototype AC passenger locomotives have under gone testing since September 4, 1990 and are currently operating in revenue passenger service out of Chicago. Collectively, these locomotives have logged more than 400,000 revenue miles. Significant fuel savings continue to be recorded, relative to the rest of the Amtrak fleet.

The 21st century will be heralded in by this new technology, the prospect of 125 to 150 mph high speed rail passenger service between Boston and Washington by Amtrak's and ABB's X-2000 demonstration program will commence by this years end. These luxury train sets consist of one power locomotive and five passenger coaches, one with an operating cab, radial steering trucks, special suspension, oil cooled inverters and regenerative dynamic braking. Ergonomics studies have produced accommodations that accent passenger comfort for the individual or group environment catering to the business executive or to the vacationing family.

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

REPORT OF THE COMMITTEE ON SHOP EQUIPMENT

WEDNESDAY, SEPTEMBER 23, 1992
8:30 a.m.

Pre-Convention Presentation
Southern & Southwestern Rwy. Club

April 16, 1992
Holiday Inn Center City
Philadelphia, PA

JOHN CLONTZ, Chairman
Supt.-New Technology Implentation
Burlington Northern RR
Overland Park, KS

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

COMMITTEE MEMBERS

D. Anderson	General Foreman	Burlington Northern	West Burlington, IA
R. Collins	Mgr-Wheel Shop	Burlington Northern	Lincoln, NE
S. Fuzail	Dir. Opns Research	C&NW Transportation	Chicago, IL
J. Gamble	Mgr-Loco. Maint.	Electro Motive Div.	N. Kansas City, MO
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J. Hunt	General Foreman	Illinois Central	Homewood, IL
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R. Plaugher	Maint. Planner	Union Pacific	N. Little Rock, AR
R. Lynch	Sr. General Foreman	Norfolk Southern	Roanoke, VA
C. Pope	Senior Industrial Engr.	Amtrak	Philadelphia, PA
C. Stoner	Senior Industrial Engr.	CSX	Jacksonville, FL

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 Mechancial 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.

I.
AUTOMATED EQUIPMENT

Presented by Robert Lynch-NS

Competition in today's railroad industry continues to demand improvements in safety, quality and efficiency. Norfolk Southern's system assembly shop at Chattanooga, Tennessee continues to be a leader in developing automated test and production equipment. Three of the most recent developments are a locomotive temperature switch tester, an EMD cylinder head water leak tester, and a piston pin polisher. All three pieces were designed and fabricated by system assembly shop personnel and local machine shops in Chattanooga.

The first piece of equipment is a locomotive temperature switch test stand. In order to save the cost of applying all new temperature switches at an engine overhaul, a test stand was built which can qualify up to eight temperature switches at a time. With 60 percent of the switches passing the test and being reused, this amounts to a $96,000 annual saving to Norfolk Southern. Further development of a data base is in process to determine the cause and effects of a "hot engine" on power assembly failures and also to evaluate suppliers of switches.

The test stand meets specifications detailed in GEMS Volume IX dated April 30, 1987. After the switches are connected to the mounting plates, a thumbwheel at each switch location is manually set according to the pick-up temperature for each switch. Once this is completed, the cycle start button is pushed. This activates a programmable Chromalox temperature and process controller which starts a pressure pump circulating anti-freeze at - 4 GPM through the pipe system and also initiates the heat cycle. A 3-KW tube type heater heats the liquid from ambient temperature to 130 degrees F under full power, taking approximately 13 minutes. Then, the temperature and process controller limits the rate of increase to 1 deg. per minute. This continues until the temperature reaches 225. The temperature is then allowed to drop through normal thermal losses inherent in the machine at the rate of 1 deg. per minute back to 130 deg. The cycle between 130 deg. and 225 deg. is repeated. The third and last cycle goes to 280 deg. to check the 225 deg. hot oil switch. The Modicon computer monitors all three cycles for correct pick-up and drop-out. The switch must pass all three cycles for a green light to be displayed indicating the switch is OK for reuse.

The next piece of equipment we will look at is a two-station, programmable controlled EMD cylinder head water leak test machine, designed by Chattanooga System Assembly Shop and built by TAME, Inc. of Flintstone, Georgia.

The operator is guided through the test sequence by a Quartech Datamate 8700 display panel interfaced with an Allen Bradley programmable controller. The test station is loaded with a cylinder head by an overhead hoist. The operator is then instructed to press the start button #1. The head is automatically clamped onto the test stand. Water fills the bottom water ports and flows out the top port through a hose for approximately 30 sec, assuring that all air is purged from the system. Water pressure is then raised and held at 250 PSIG using an air-over-water pump manufactured by SLC. While the cylinder head at station #1 is in the process of reaching 250 PSIG, the operator loads station #2 and begins the clamping pressurizing sequence by pressing the start button #2. The operator then gives the cylinder head at station #1 a visual inspection checking for any leaks. Upon completion of the inspection, he presses the release button #1. The water pressure is released and air is blown back through the cylinder head to purge water from the head. The operator next unloads the head, spraying it with a rust inhibitor, and loads it onto a rack for shipment. The operator then reloads station #1 and presses the start button #1. Using this procedure, an operator can alternate testing between Stations 1 and 2, not wasting time for the head to purge and pressurize. Future plans include automated loading and unloading and a differential pressure sensor for automatic qualification of cylinder heads.

The last item is a Rand pin polisher. While the Rand Model LD50 is a standard polisher, this one has been retrofitted with a system to automatically feed a magazine of wrist pins. The piston pins are placed in the inlet rack while still dirty. The rack was designed to hang on an existing monorail which runs through a washer. After washing, the complete rack (which holds 16 pins) can be placed on the polisher. The rack has a slide mechanism which connects to an air cylinder on the polisher. The cylinder, controlled by an Omron timer, operates the slide every 13 sec. This allows a pin to fall onto the feed system of the Rand polisher. The pin is rotated as it feeds under a 3M Scotchbrite 95 EXL polishing wheel. On the outlet side when the piston pin contacts a proximity switch, a "kicker" arm drops the pin into a magazine rack similar to the one used for the infeed. The entire rack can then be transferred to the one used for the infeed. The entire rack can then be transferred to an assembly station for reuse.

These types of improvements are absolutely necessary for competition in the 90's.

II.
SAFETY CORRECTIVE ACTION TEAM

Presented by Ray Plaugher - UP

During the early 1980's, a Western based railroad decided to establish a team designed specifically to tackle safety concerns that seemed to have no apparent solution. The team was called, "SCAT", or Safety Corrective Action Team. In the mid 1980's, as a result of various mergers and departmental changes, the team was abolished. Increased concerns for employ safety and a determination to improve operational safety led to the reinstatement of the Safety Corrective Action Team in 1989.

When the team reorganized in 1989, the first item on the agenda was to establish a charter describing the purpose, responsibilities, and objectives of the team. The purpose of the team is "to examine safety related concerns which have no apparent solution and actively seek permanent solutions to these safety concerns and ensure that the solutions have been adequately communicated to all affected personnel. "In addition: "to implement corrective action and provide follow-up by auditing to ensure that the implemented solutions are uniformly understood, utilized, and kept in place."

The responsibilities of the team include a five-step problem solving process involving the identification of the root cause of the problem, design of the best solution available to eliminate the root cause, customer acceptance and testing, implementation and communication to the field, and finally, follow-up to ensure that the solution has been implemented.

The objectives of the team for the current year are to:

1. Publish and distribute at least four safety newsletters during the year;
2. Complete a minimum of 15 safety related projects and introduce them to the field through new safety equipment release bulletins;
3. Provide a viable solution to accepted safety projects in three months or less; and
4. Publish a minimum of two Safety Corrective Action Team newsletters per year.

The safety newsletters are published quarterly and provide an update as to the team's progress on safety related items. Each newsletter also contains information pertinent to any safety item we feel may be of interest or benefit to forces in the field.

The new safety equipment release bulletins are the method used to introduce the solutions to safety concerns to the field. They contain all of the information pertinent to the product, including a summary of safety and operational benefits, from whom and where it is available, who came up with the idea, costs, and a brief operational summary. If the tool is complicated to use, a video tape is produced describing its operation in detail.

Project requests are received by the Safety Corrective Action Team verbally, by letter, or through the use of a specifically designed form that is accessible by all field forces through a computer program. New requests are currently being received at the rate of about four or five per month. The team meets once a month, usually at a system repair shop location, to review new projects, give progress reports on existing projects, and work on finding solutions to safety concerns. During 1992, the team will attempt to conduct at least two meetings at foreign railroads in a benchmarking effort to share our safety successes and concerns. Once a project has been accepted, it is placed on a docket and assigned an ad hoc

leader. This leader is responsible for seeing the specific project through to completion and implentation.

The team currently consists of nine cross-functional members, each from a difference department and area of expertise. There is a definite reason to acquire members from various departments. Each member contributes a necessary talent or service to the team. The following is a listing of the current members, and the reason for selecting his area of expertise for membership.

Purchasing & Supply department: This member provides a liaison between the team and Purchasing. He assists in determining pricing from vendors, and issues item numbers for purchasing by field employees.

Mechanical & Facilities Engineering: This member makes drawings of tools and fixtures, makes stress analysis calculations to ensure safety of designs, works with vendors to construct final tools for distribution.

Technical Training: This member provides the necessary instructions, support documents, or video tapes pertinent to correct operations.

Locomotive department: Provides support, testing, and maintenance expertise related to locomotive and computer repairs.

Car department: Provides support, testing, and maintenance expertise related to freight cars and component repairs.

Research & Development Laboratory: This member provides methods for testing new tools, fixtures, or other products using sophisticated test methods and machinery at our research laboratory.

Safety & Casualty Management: Having a member from this department provides us with a liaison to field employees, and provides us with the statistics necessary to prioritize and justify the safety projects we pursue.

Since the inception of the new Safety Corrective Action Team in 1989, we have produced eleven safety newsletters, two special edition newsletters describing a number of innovative safety inventions created by the field, and 38 new equipment safety bulletins depicting solutions to safety concerns expressed by field employees. It should be noted that the majority of the solutions to the problems that are presented are conceived and created by field employees. In these cases, the Safety Corrective Action Team simply acts as a clearing house, ensuring that the tools or solutions meet our safety standards. Many of the solutions that have been implemented are related to Car department concerns. Following is a listing of some of the safety solutions related to locomotive and component maintenance.

1. A tool for breaking loose and removing EMD overspeed housing drain plugs.
2. A positive locking bearing & gear puller.
3. A self propelled lift table for transporting heavy materials in the shop or ramp areas.
4. A special tool for removing sand traps from locomotives.
5. A forklift mounted locomotive component and power assembly replacement tool.
6. A tool designed to straighten bent handholds without the use of heat.
7. Custom designed work platforms to access various components and areas of locomotives.
8. Compressors to hold locomotive truck shock absorbers during wheel true or traction motor changes.
9. A tool to raise and lower the hatches on the new Dash 8 style General Electric locomotives.
10. A tool to easily compress the intake valves on General Electric engine heads.

11. A bolt extraction tool that has improved grip and will not break off in the bolt.

12. Vacuum cups for handling windshields on the new"comfort cab" locomotives.

A look at the latest agenda for Safety Corrective Action Team indicates that there are an additional 29 projects in process under various stages of completion. Of these, 15 are locomotive related.

The Safety Corrective Action Team is a definite step in the right direction towards improving safety. We hope that our efforts, combined with the efforts of supervisors and employees in the field, have assisted in preventing injuries. The team is always open to suggestions and ideas from any source. If you have any safety related item you would like to address, or would be interested in hosting one of the team's future meetings at your location to share information and efforts, please let us know. A Safety Corrective Action Team booth was displayed at this year's convention in Chicago, and members were free to visit this booth and share in our safety information.

Finally, we have received suggestions to expand the scope of the Safety Corrective Action Team to include interfacing with other railroads. The exchange of safety information amongst all railroads could assist all of us in preventing injuries to our employees. Please offer your suggestions or comments for initiating this interface to any representative of the Safety Corrective Action Team.

III. AUTOMATED LOCOMOTIVE WHEEL SHOP

Presented by R.L. Collins - BN

In the third quarter of 1986 construction was started on what was to be Burlington Northern's first automated locomotive wheel shop. The decision to close Burlington Northern's aging locomotive wheel shop in Livingston, Montana was made earlier this year.

Several factors contributed to this decision:

· Consolidation of locomotive and freight car wheel activities at Burlington Northern's existing automated freight car wheel shop in Lincoln, Nebraska.

· Need for replacement of manual locomotive shop equipment requiring extensive maintenance and lacking desired production and quality capabilities.

· Improved locomotive wheel distribution to Burlington Northern's repair facilities enhanced by Lincoln's centralized location.

· Improved material control with consolidation of material inventories from two locations to one centralized wheel shop.

Construction was completed in the fourth quarter of 1987. Locomotive wheel production commenced in January, 1988.

The design of the new automated locomotive wheel shop was modeled after the Burlington Northern's proven automated freight car wheel shop. Many of the same technologies and patterns were used in this design. The automation at Havelock Wheel Shop was made possible by the use of programmable logic controls (PLC's), computer numerical controls (CNC's), and computer controlled systems. These control systems, coupled with state of the art machinery provided the catalyst for a highly effective locomotive wheel shop.

The outline which follows will facilitate a better understanding of the flow of components through Havelock Locomotive Wheel Shop:

1. Overhead cranes unload up to three locomotives wheels from specially designed wheel cars or flatbed trailers. Wheels needing repair are then introduced into the wheel shop.

2. An automatic locomotive wheel washer cleans the needing-repair locomotive wheels. The wheel washer removes the build-up of grease and grime that is present on these wheels.

3. Once washed, the wheels, axles, and bull gears are inspected to determine process requirements. Roller bearings and /or inner races and water guards are also removed at this time. Qualified wheels are then staged for the next step in the process.

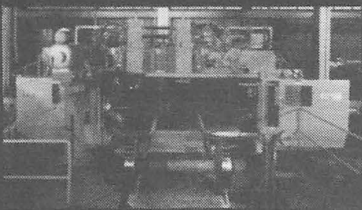
4. Locomotive wheels identified through inspection with nonconforming components are automatically moved to the demount press. An operator oversees the demounting process by the computer controlled demount press. Wheel components are handled by an automated material handling system. Axles are moved to an axle storage rack, gears to a gear staging area, and scrap wheel moved to a scrap gondola, by means of an overhaul monorail.

5. Nonconforming locomotive axles are then moved to an axle preparation lathe where the axle receives final cleaning and qualification.

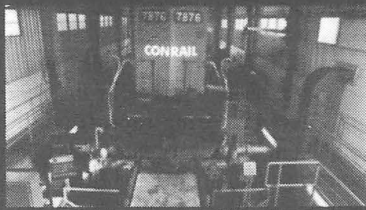
6. Axles are then moved to a CNC axle lathe for final preparation. The CNC axle lathe is capable of machining wheel seats, gear seats, traction motor support journals, and burnishing traction motor support journals. When required, axles can also be downsized using the CNC lathe.

7. Once the axles have been process-

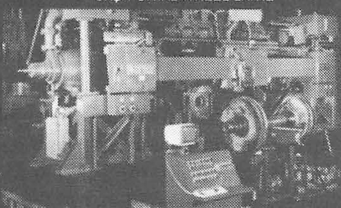
HIGH PRODUCTION SYSTEMS FOR THE RAILWAY WHEELSHOP



SIMMONS-FARREL HIGH PRODUCTION CNC PORTAL WHEEL LATHE

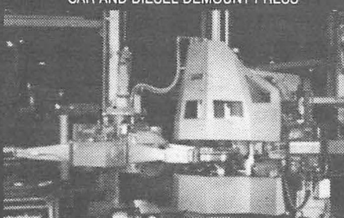


SIMMONS-STANRAY AUTOMATIC UNDERFLOOR WHEEL PROFILING MACHINE

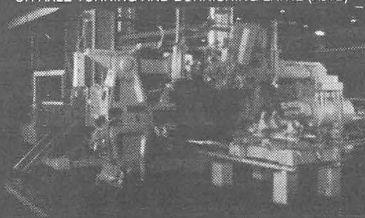


SIMMONS-NILES 600 TON AUTOMATIC CAR AND DIESEL DEMOUNT PRESS

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



SIMMONS-NILES CNC DIESEL WHEEL MACHINING CENTER



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ed through the CNC lathe, they are directed to the magnetic particle testing booth for inspection of surface defects. Traction motor support journals are then qualified with a tally surf indicator to verify wave index, micro-inch finish, and positive and negative asperities. Axles are then moved to axle storage racks to await processing.

8. After the locomotive bull gear is demounted, it is automatically moved to the gear grinding area of the shop. Bull gears requiring reprofiling are grouping in tooth wear categories. Gear tooth reprofiling is accomplished by electrochemical grinding. The charged electrolytic solution flows around the stone providing the required tooth profile. The profile stone never touches the gear teeth. Bull gear hubs and bores are then prepared to OEM specifications. The bull gears are now ready for mounting.

9. New locomotive wheels ready for mounting are introduced into the shop by means of an automatic material handling conveyor system. A CNC locomotive boring mill, computer controlled axle measuring station, and computer material handling work in conjunction with each other to facilitate boring of wheels for an interference fit of the measured axle. The CNC boring mill also finished the wheel hubs to OEM specifications. Bored wheels are then automatically moved to the computer controlled wheel mounting press.

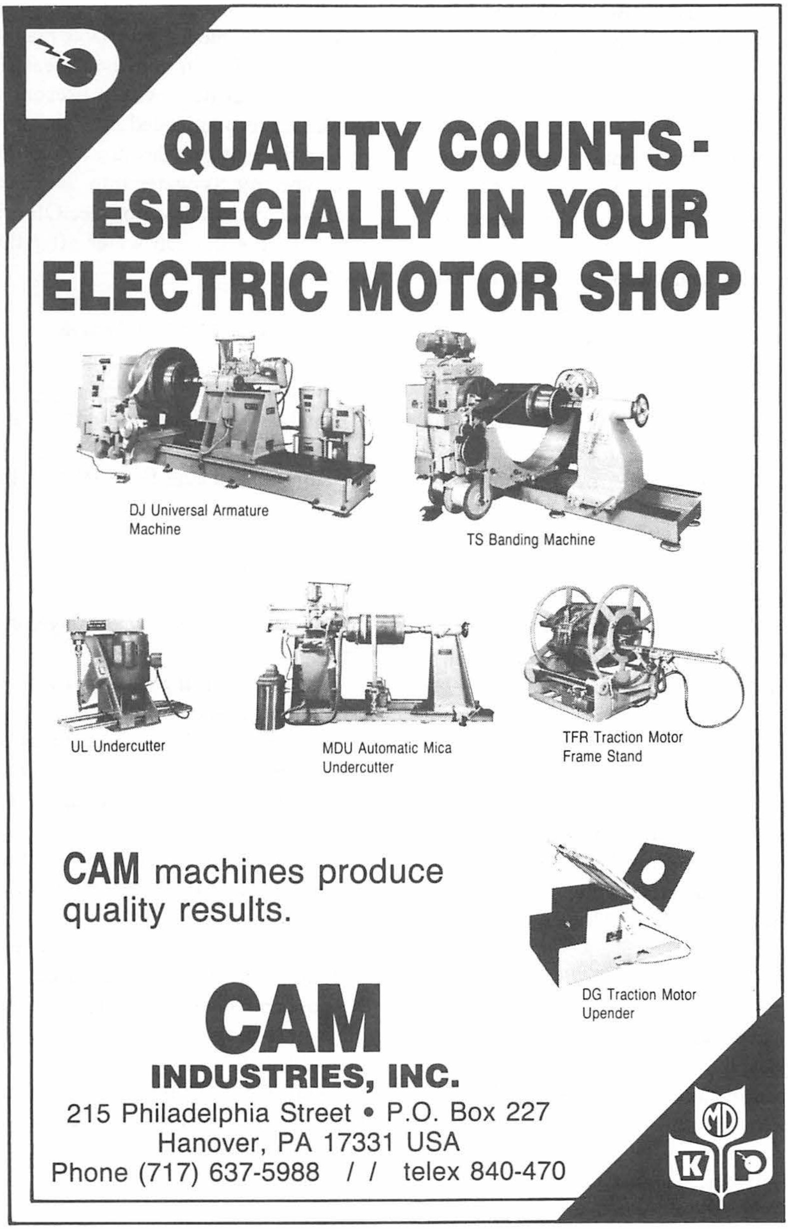
10. Wheel mounting is accomplished in a two step precess. First, the gear is mounted to the axle. The axle gear assembly is then automatically moved to the premount area of the mounting press. The wheel axle assembly is then moved to final mount where the auto matic measuring system controls wheel and bull gear back to back measurement.

A mounting press operator oversees the mounting functions. He enters serial numbers of the wheels, axle, and bull gear into the mounting press data computer. These data are then associated with the wheel mounting pressures and wheel mounting diagrams. If all mounting requirements are met, the mounting press operator verifies wheel and gear back to back measurements and directs the wheel set to the bearing mounting area.

11. In the bearing mounting area, roller bearing assemblies or inner races are applied to the wheels. A control number is then given to each wheel that includes wheel, axle, and bull gear serial numbers. This control number is entered into the material computer system which allows for tracking of locomotive component parts for service and reliability. A rust preventative is then sprayed on all machined surfaces of the wheels. The wheel set is then moved out of the wheel shop, where it is again handled by an overhead crane for distribution.

12. Locomotive wheel sets requiring only traction motor support journal machining are directed to a mounted wheel lathe for process. This lathe eliminates the need to demount wheels requiring only support journal work.

The automation utilized at Burlington Northern's Havelock locomotive wheel shop is an integral part of the efficiency realized in wheel production. Consistency in wheel production rate, wheel quality, and wheel distribution have resulted in lower wheel cost.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IV. CLEANING AND SURFACE PREPARATION WITH SODIUM BICARBONATE BASED ABRASIVE BLASTING

I.. Introduction

Sodium bicarbonate based abrasive blasting (SBBAB) was developed in response to the acute need for an environmentally sensible method of depainting and cleaning, without hand sanding or using chemicals that are harmful to workers and the environment.

The major supplier of these specially formulated media's is Church & Dwight Co., Inc. of Princeton, New Jersey, makers of Arm & Hammer® products.

The process is a low impact blasting, for the removal of paint and other coatings from virtually any substrate.

Blasting may be done wet or dry. Some systems use the media in conjunction with high pressure water.

2. Media

The media is a white, free flowing crystalline powder, specially formulated from a sodium bicarbonate base, whose characteristics are:

· hardness 2.8-3.0 Mohs scale
· ph 8.2
· water soluble
· non-sparking
· crystal size 50-30 and USDA approved.

Some media is FDA and USDA approved.

3. Delivery Systems

Delivery systems vary as to how the media is conveyed and flow regulated.

Some systems use differential pressure (pressure pot) while others rely on a venturi (eductor) to accelerate the crystals. Compressed air and high pressure water systems are available for use with the blast media's.

Because the media is a friable material, wet blasting in confined areas or anywhere that dust would present a problem is recommended.

A variety of nozzles are available. One type injects water into the blast stream ahead of the nozzle. Others introduce the quench water after the nozzle.

4. Features of the Blast Systems

· Portable
· can blast wet or dry
· adjustable blast pressure
· adjustable media flow 3/4 to 5 lbs per min.

5. Advantages

· The ability to remove one layer at a time
· the non-sparking media is safe to use in hazardous environments
· the media will remove corrosion and coatings from soft metal and composite substrates without damage to the substrate
· the media is water soluble which can greatly reduce the amount of waste to be disposed
· increased worker safety over chemicals and other blasting techniques
· poses no threat to the environment
· won't peen or fill cracks making them difficult to find
· masking and preparation required with other methods are not needed
· cleanup is easy.

6. Applications

CSX--Huntington, West Virginia

CSX has used SBBAB for stripping and profiling existing coatings on locomotives prior to repainting.

RFS--United Kingdom

Once part of the government operated British Rail System RFS is now a privately owned and operated engineering and maintenance shop located in Lancaster, England. For the past two years RFS has been using the SBBAB to prepare wheels and axles for magnetic particle testing. Also cleans stainless steel and aluminum car parts.

Government Operated Rail Systems -- New South Wales, Australia

Three of the eight government operated rail systems have used SBBAB to clean stainless steel passenger cars for more than two years.

Bombardier--Montreal, Quebec, Canada

Commissioned the stripping of the aluminum moldings and interior panels of 1.5 to 2 mils of epoxy powder coating from three New York City mass transit cars prior to recoating with epoxy powder coating. Media usage was 100 lbs per hour. A total of nine cars were done during the project. Due to the superior surface provided by the SBBAB, the three cars done with the new technology exceeded the customer's requirements.

Northshore Scenic Railroad--Duluth, Minnesota

Cleaned the outside of five stainless steel passenger cars.

7. Demonstrations

CP Rail--Calgary, Alberta

Cleaned:

- traction motors
- wheel sets
- gear cases
- locomotives
- concrete
- undercarriages

Stripped paint from:

- locomotive
- tank car
- buffer plate
- headlight rings (in place)
- locomotive window frames.

CP Rail--Toronto, Ontario

Cleaned:

- cement cars
- wheel sets
- traction motor
- locomotive.

CSX--Heavy Locomotive Shop--Waycross, Georgia

Cleaning undercarriages and stripping paint from locomotives

Amtrak--Wilmington & Baer, Delaware

Cleaning undercarriages, stainless steel passenger cars and removing decals from stainless steel passenger cars.

Chicago & North Western--Chicago, Illinois

Stripping locomotives.

Burlington Northern--Duluth, Minnesota

Stripping track maintenance equipment fro repainting.

DM & IR--Duluth, Minnesota

Preparing surface of ore car end slope sheet and door surfaces prior to thermally applied powder coatings.

8. Benefits

- Removes only the failed coating
- improves worker safety
- cleaner, safe environment
- reduces preparation and cleanup costs
- reduces disposal cost
- increases equipment life
- reduces likelihood of surface damage
- improves community relations.

9. Summation

I would like to thank the committee for allowing me to present this paper.

The CDS Group does not profess to

totally understand the requirements of or the challenges faced by the railroad industry. We do firmly believe that the technology we offer, holds the key to resolving many cleaning and stripping needs, in a cost effective, environmentaly sensible and safe manner.

We are willing to work with you to develop the proper solution to your toughest challenges.

V. TRAINLINE CONTINUITY TESTER

Presented by Jeff Gamble, EMD

As railroad maintenance officers we share in the responsibility to ensure that locomotives placed in our charge operate with the highest degree of safety, availability and reliability. With rising maintenance costs, it is becoming more and more difficult to maintain a fleet in top condition while attempting to reduce costs.

In today's market place, the phrase "the customer is always right" is more meaningful than ever. When the customer says "I need it delivered by this date," that's what he means. If you can't deliver, he'll find someone who can. Locomotives that fail, cause train delays, and delays cost money, and possibly lost customers.

We all know that good maintenance practices prevent locomotive failures, and we do our best to make sure that locomotives we dispatch are in good condition. However, there is an area that is difficult to test and trouble shoot: train line signals.

The train line wiring and MU (multiple unit) cables make up the central nervous system in a consist of locomotives. This system allows all of the locomotives in a consist to act as one. It also relays important safety and train handling information from trailing units to the lead unit. Severe damage and even derailment may be caused by the loss of signals such as WHEEL SLIP and BRAKE WARNING.

A large stationary train line tester is in use on some railroads. This works quite well for testing the train line; however a unit having train line problems must be switched to this location. This requires a crew to switch the locomotive and normally disrupts the flow of the entire shop.

Fig. 1 is an example of a portable unit commonly in use today. As you know, the easier you make a job the more likely it will be done and done correctly.

The train line tester in Fig. 2 was developed by an Electro-Northern employee and is presently being used in the Kansas City shop.

The tester is housed in a tough polyurethane casing to protect it from shock and provide for portability. There is also a small jumper box constructed of the same material.

The name and number of each train line pin connection is clearly marked on the face of the tester. This allows for easy identification of the connections being tested. To the left of these markings is a row of LED's. The LED's will light either red or green. These lights indicate the polarity of the voltage at the pin. The knob on the right side of the tester is a selection switch. With a simple twist of this switch one can test all 27 pin connections.

First notice the size of the tester. It is considerably smaller and lighter than the previously shown portable units. This is accomplished by making use of the latest in electronic technology. Only one man is needed to use this tester. The tester simply plugs into the MU cable at one end of the locomotive and a small jumper box into the MU cable at the other end. The LED's will light up either green or red showing continuity of the circuits. If an LED does not light the circuit is open.

By rotating the selector switch one can check for shorts between the train line wires. These shorts can cause many different problems. For example a short between a headlight signal and

emergency stop switch can cause an entire consist to shut down every time the headlight is turned on.

One then connects a small jumper wire from the tester to the frame of the locomotive. This tests for grounds in the train line signals. When one attaches the ground wire, the ground fault LED should remain off. If the ground fault indicator lights, the grounded wire can be determined by using the selector switch. Again, as before these grounds can cause many different and difficult problems to troubleshoot.

In conclusion, the attributes of this tester are that it allows one man to test train line and MU cables at any shop or service track location or out on the road. Since it uses the latest electronic technology, it is much more durable and dependable. The tester even has a solid state protective device that will stop a short circuit from damaging the tester. Not only does this tester check continuity, but it can also test for other short circuits and grounded wires. All in all, this tester can provide you with better maintenance of train line signals, and better maintenance means fewer failures and lower costs.

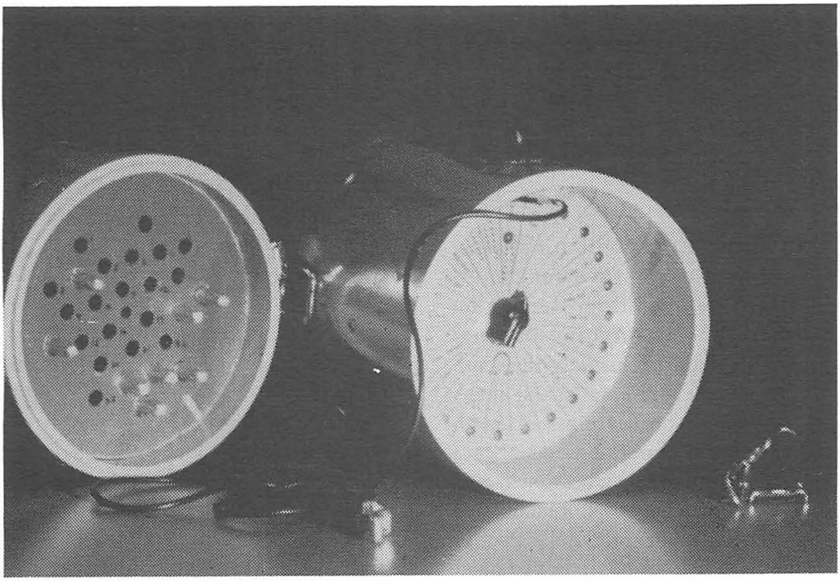


Fig. 1

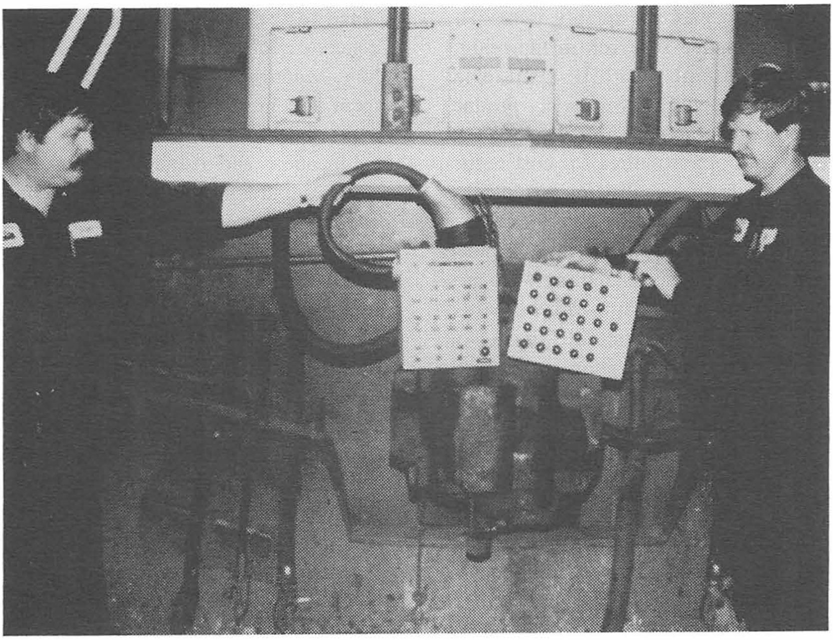


Fig. 2

VI. BURLINGTON NORTHERN RAILROAD POWER ASSEMBLY SHOP OF THE 1990's

Presented by William A. Brown, BN

Background:

To support the continuing quest toward quality improvement in all phases of its operation, Burlington Northern has an ongoing internal process devoted exclusively that end. All operations, both internal and external, are subject to ceaseless research and analysis to search out better ways or means to improve our service to customers and manage costs. Reclamation of power assemblies, for BN's fleet of locomotives, fits adeptly into that quality process.

During 1989 a study of our power assembly process was implemented to address, in part, the quality issue. The study included research in the realms of component reliability, material usage, expected performance, production requirements, shop work operations and opportunities for cost reduction and desired quality improvement.

At about the same time, significant changes affecting field maintenance and system material handling were proposed and were being implemented that would have a notable impact on the power assembly shop's capability effectively to meet future production requirements.

These two issues dictated the necessity to continue and evolve the study into a formal modernization plan. The plan addressed such issues as:

1. Future production requirements.
2. Worker productivity improvement opportunities.
3. Component quality improvements.
4. New process instructions (MEPI's).
5. Ergonomics and safety.
6. New equipment.
7. Budget.

Authority to proceed with the modernization was received and the process of construction planning and equipment was begun in late 1989.

Construction:

Based on equipment and machinery delivery lead times, construction was planned to commence in July of 1990. The system inventory of repaired power assemblies was increased to address the expected one month of lost production time during construction.

The entire bay was emptied of material and equipment, and bases for required jib cranes were constructed (Fig. 1). Utility connections to each machine and work station were fastened to the existing floor and a new concrete cap was poured over the entire bay. Machines and other equipment were then brought into the building on a schedule consistent with their physical locations and installation times.

A computer system was used to plan and track progress of the many phases of the actual construction and equipment location work. Goals or construction milestones were easily achieved, by the several craft workers involved, due to the clearly identified requirements in the program. Computers also played a major role in tracking expenditures and kept the shop drawings current with the several subtle changes that occurred throughout the project. The intense effort in pre-planning was rewarded by the project being completed on schedule and without major incident.

Work Flow, Process:

The power assembly shop, in its original state, was basically several small "job shops" placed within various designated areas within the confines of the main building. Some unpowered conveyors were used to transport certain components; however, the larger part of the material handling was completed by fork trucks. Transporting of materials in containers, via fork truck, forced most operations to be completed on a "batch" basis, with less than desired opportunity for uniform output and worker productivity.

A number of operations were conducted in other areas of the shop building which added to the material logistics problem. In one interesting example of the productivity improvement achieved, we determined during the study that one engine component had been handled by various employees up to 17 times before it was reinstalled in an engine. The incidents of operator handling of this particular component have now been reduced to seven.

Many of the machines used in the shop were either obsolete or would not meet future requirements in terms of productivity and desired quality.

Fig. 2 is a schematic layout of the original shop which depicts the several work stations with the center aisle for material handling traffic. The center aisle also segregated the GE and EMD work operations.

Although the shop was functional and served Burlington Northern well in the past, it was obvious there was a definite opportunity for significant improvements.

Fig. 3 is a schematic of the shop layout as it is today. The upper half, or north part of the shop is devoted to GE and the lower portion EMD. The two areas are divided by a common parts conveyor designed to move baskets of cleaned parts to their respective work station.

Flow of material is basically from east to west, right to left in the photo. Components needing repair are dismantled at the extreme east end, cleaned in three self-loading washers and conveyed to the appropriate work stations. After process and assembly, completed power assemblies are delivered to the user at the west end of the shop.

The central parts conveyor system was designed specifically to reduce the time required to move material from one operation to another. Operators stationed in the dismantling area load components needing repair into specially designed baskets at the east end of the conveyor system. Each basket is equipped with an adjustable signal target and the operator selects the appropriate station to which the basket is to be delivered. The conveyor moves the loaded basket through a washer and a scanner reads the target on the basket as it exits the washer. The conveyor will automatically discharge the basket at one of nine work stations along the line.

Conveyors were also provided to address handling or power assembly shipping containers, more commonly referred to as "caskets". These weather-proof containers were designed to protect and ship both needing-repair and repaired assemblies between West Burlington Shop and our field maintenance facilities.

Shop Overview

Fig. 4 shows the EMD side of the line as viewed from west to east. In the foreground is the EMD assembly area, where power assemblies for the shop and system receive final assembly. New power assemblies are also fitted with top deck components in this area.

Fig. 5 shows the GE side of the line as viewed from west to east. Cylinder heating, assembly and testing are completed in this area.

In Fig. 6 we see the end view of the central parts basket conveyor system. A powered conveyor used to handle the green power assembly containers runs parallel with the parts conveyor.

Fig. 7 is a view of the east end of the EMD side of the shop as viewed from the supervisor's elevated office structure.

A view of the east end of the GE side of the line is shown in Fig. 8. The jacket and parts washers are in the background and the feeder end of the conveyor system is visible.

New Equipment

The following section briefly explains some of the new and innovative machinery installed in the facility that has made a significant contribution toward meeting the quality and productivity goals:

EMD connecting rod
qualification bench.
(Fig. 9)

This machine is used to check blade and fork rods for bend and twist. The process is very quick and accurate; when the rod is clamped in place a transducer provides an instantaneous signal to the various indicating meters.

EMD rocker arm
qualification bench.
(Fig. 10)

This machine is used to make accurate measurements and replace components in the rocker arm assembly.

EMD valve bridge
qualification bench. (Fig. 11)

This machine has electronic gaging equipment, measures energy and time required to install a lash in the tee and completes the leak down timing test. Results of the installation and function test are displayed to the operator.

EMD valve seat cutter.
(Fig. 12)

Valve seats are machined to OEM or better specifications without the necessity of grinding. The machine is set up as an integral part of the conveyor line to reduce material handling time.

Pin Buffer.
(Fig. 13)

This machine works on the same principals as a centerless grinder. Pins from both GE and EMD engines are fed through the machine by two tapered rollers and a polishing wheel contacts the material to perform the actual buffing.

GE jacket carts.
(Fig. 14)

These fixtures were designed to address the problem of moving heavy jackets between work stations and provided an alternative to the considerable expense for the other material handling methods. The carts travel on a rail track constructed of inverted angle iron and are used to hold the jackets for several of the required work processes during reclamation. A bolt-on trunion for lifting the jackets was also designed to work with the carts. Each trunion also provides a water tight seal over the jacket cooling water openings and is equipped with fittings to charge the cooling chamber with compressed air during testing operations.

EMD power assembly carts.
(Fig. 15)

These fixtures were designed to hold the power assembly during assembly operations and are equipped with caster wheels to allow movement in the assembly area. They allow rotation of the assembly from vertical to horizontal position for lifting into shipping containers.

EMD cylinder head
milling machine.
(Fig. 16)

This machine was custom built from a basic vertical lathe design and is used to machine the head's firing face, collar and injector radius. It is also capable of machining the fit on GE piston crowns and skirts. The machine is equipped with a GE Fanuc programmable control system.

Powered washing machines.
(Fig. 17)

Three machines are used in the shop, a conveyor model handles baskets of various component parts and is integral with the parts handling conveyor system. The other two machines are dedicated to washing of EMD heads and GE cylinder jackets. Both machines use a robot to load and unload components and are controlled by a PLC.

Conveyor system.
(Fig. 18)

The computer controlled central conveyor delivers baskets of cleaned parts to one of nine work stations. Empty baskets are returned by an endless return conveyor, which also serves as a storage que for baskets until they are needed. Other powered conveyors were provided to handle power assembly shipping containers and a non-powered conveyor is used for moving EMD heads between various process stations.

Automatic guided vehicle.
(Fig. 19)

This system eliminates fork truck handling of power assembly containers from the shop to the material department shipping area. The electric truck follows a guide wire imbedded in the floor and its on board computer system allows a variety of directional options for the operator to use.

Conclusion:

In summary, the shop has been in operation just under two years and we were very pleased to find that both productivity and production results have exceeded the plan. Recent review of operations has indicated current production at 33% above plan with less than an 8% increase in labor.

These improvements were achieved through a strong commitment and effort by both management and employees throughout the entire project. Burlington Northern has achieved its goals of producing cost effective, top quality GE and EMD power assemblies for both internal use and for the industry.

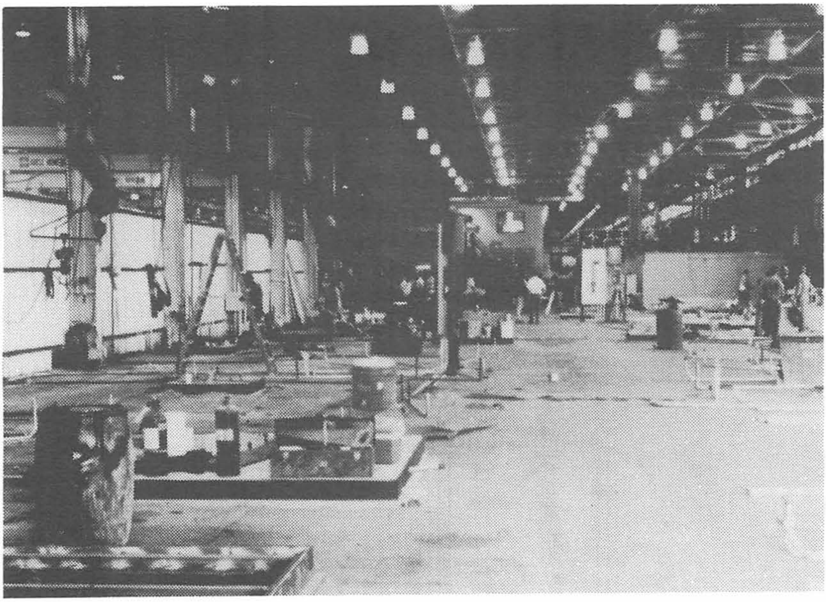


Fig. 1

ORIGINAL CYLINDER LINE LAYOUT

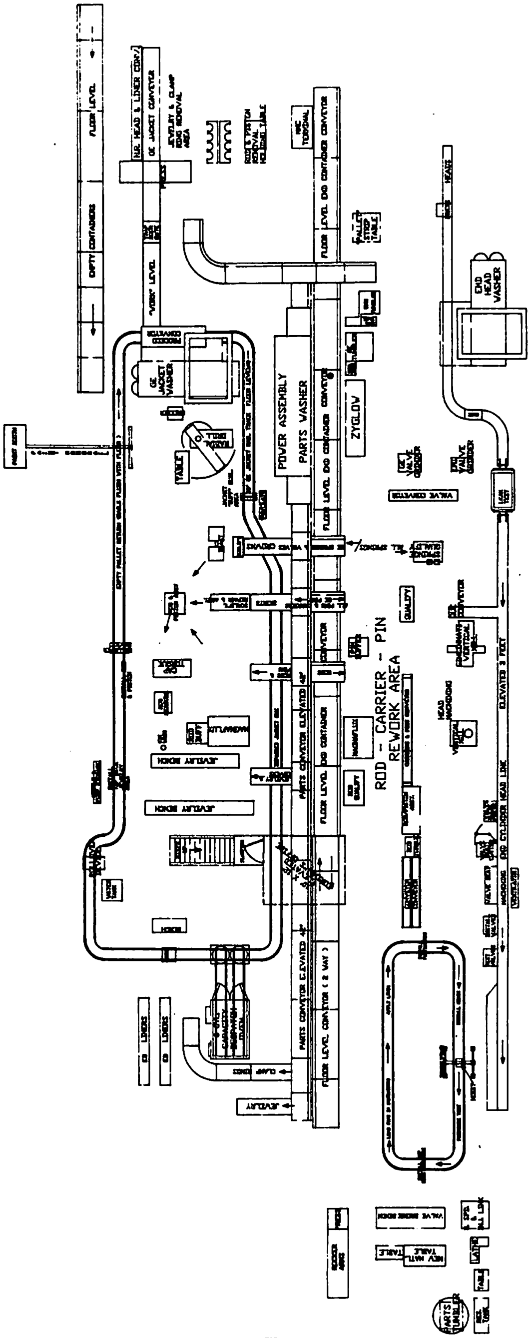


Fig. 2

PRESENT CYLINDER LINE LAYOUT

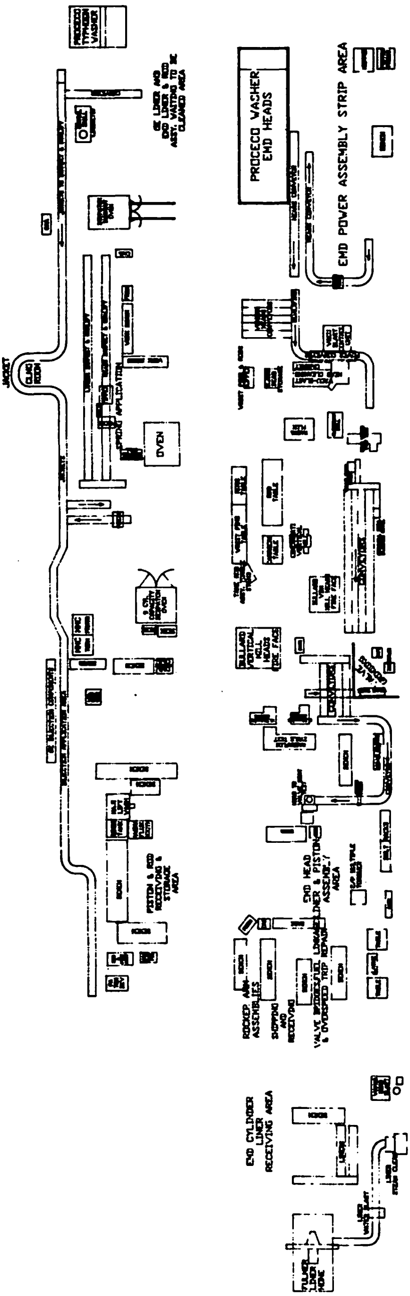


Fig. 3

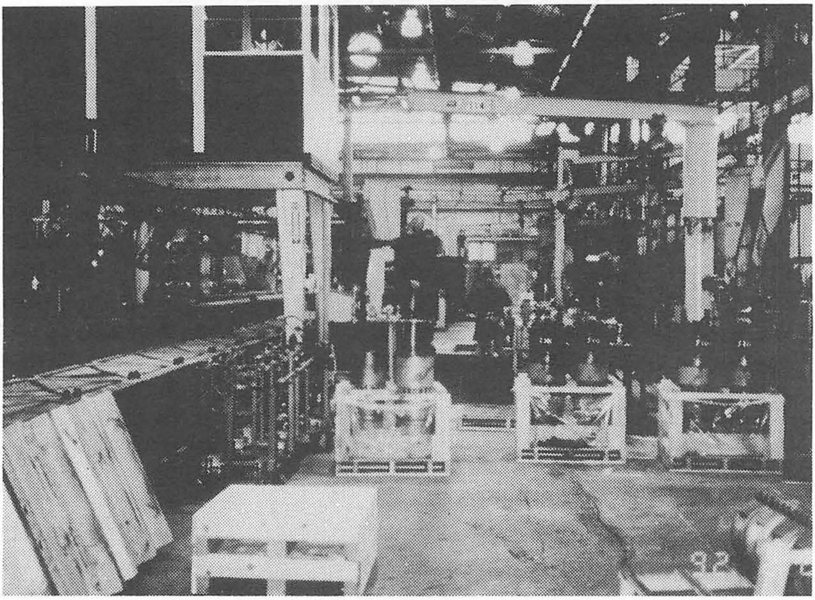


Fig. 4

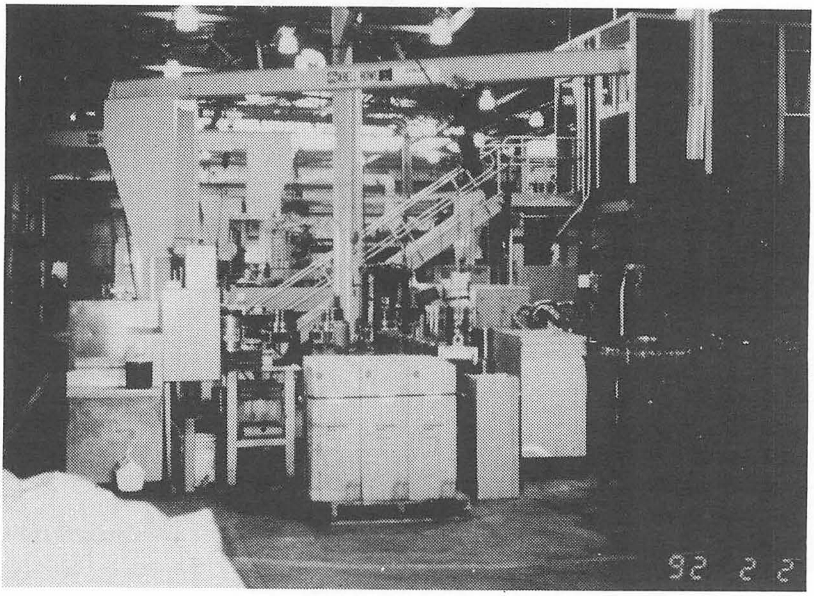


Fig. 5

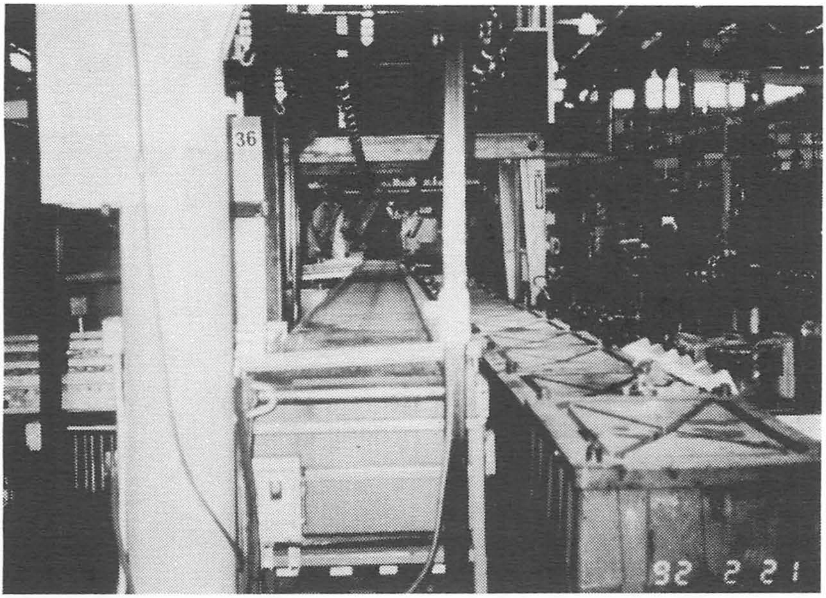


Fig.6

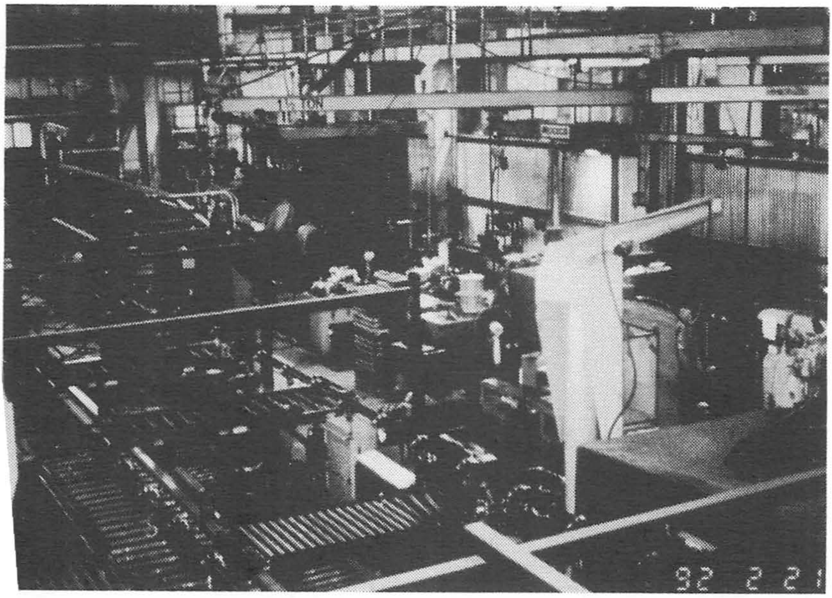


Fig. 7

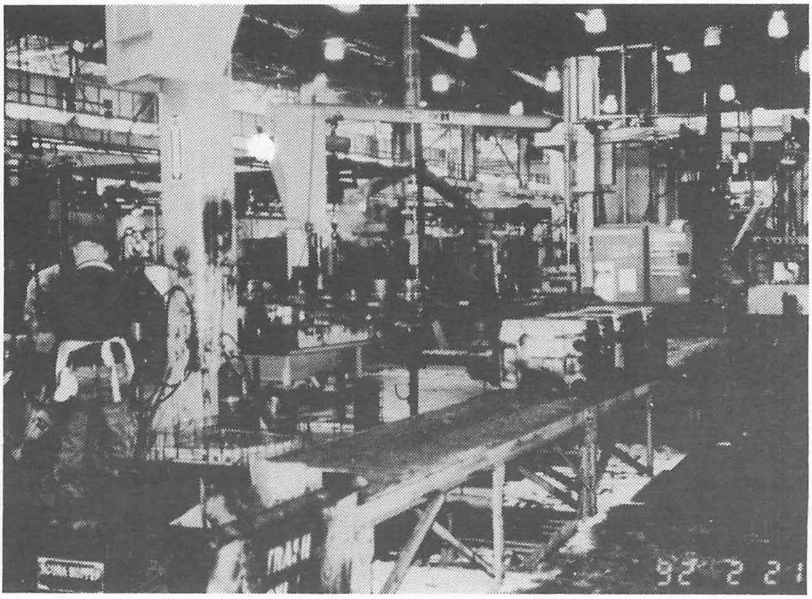


Fig 8

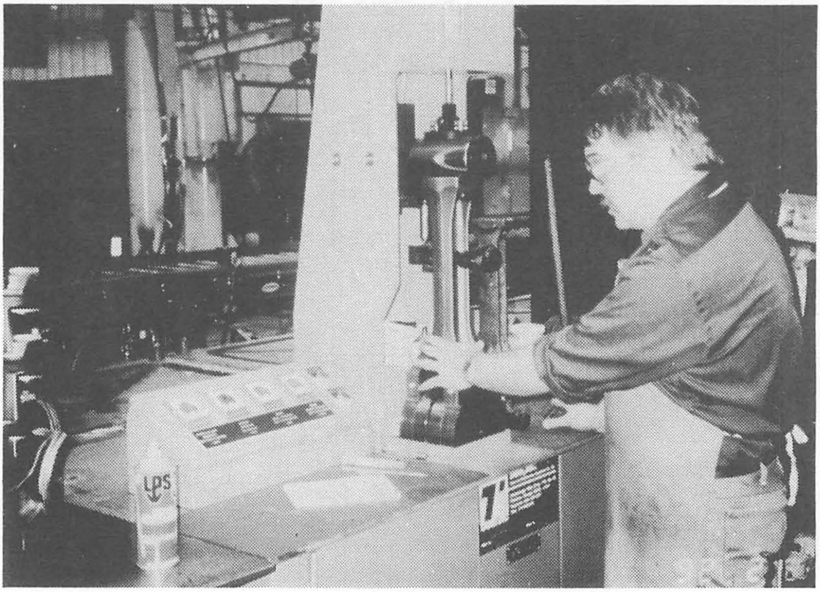
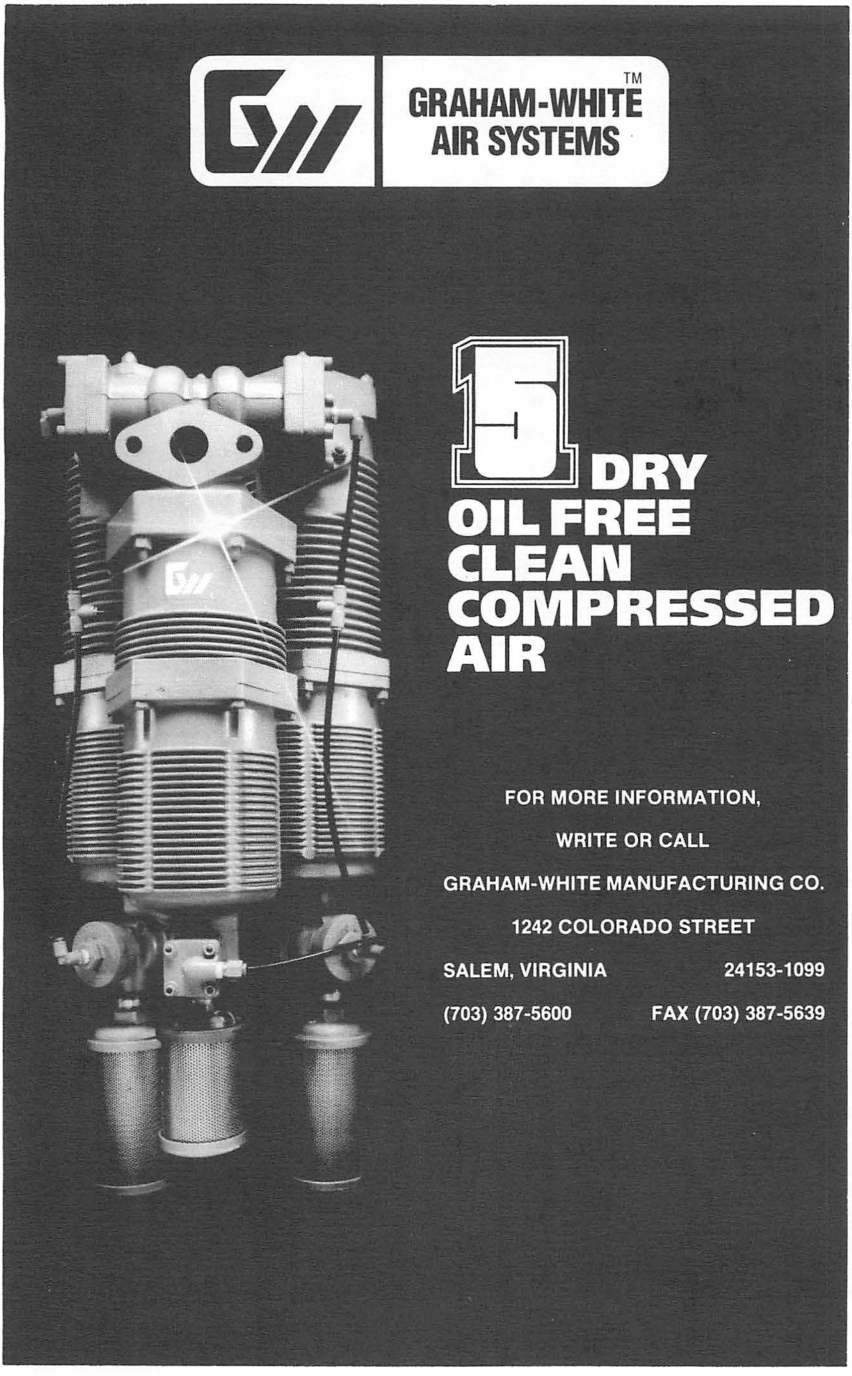


Fig. 9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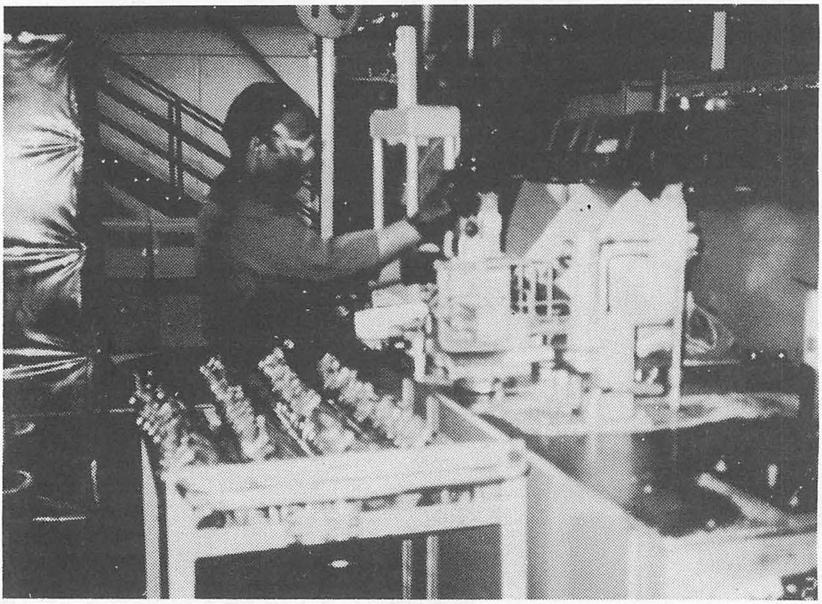

Fig. 10

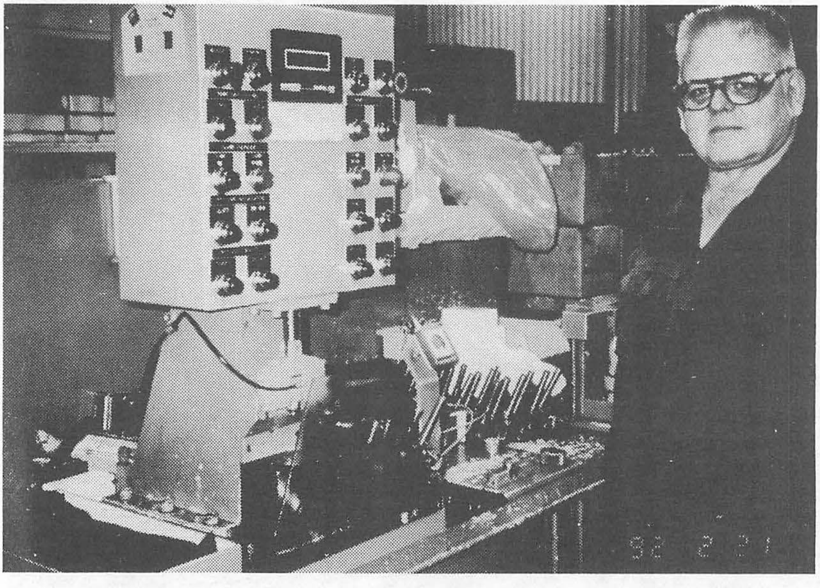

Fig. 11

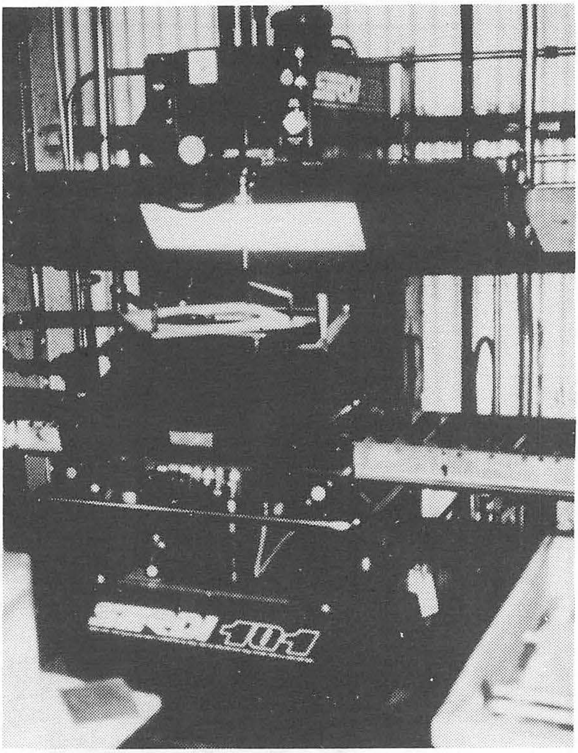

Fig. 12

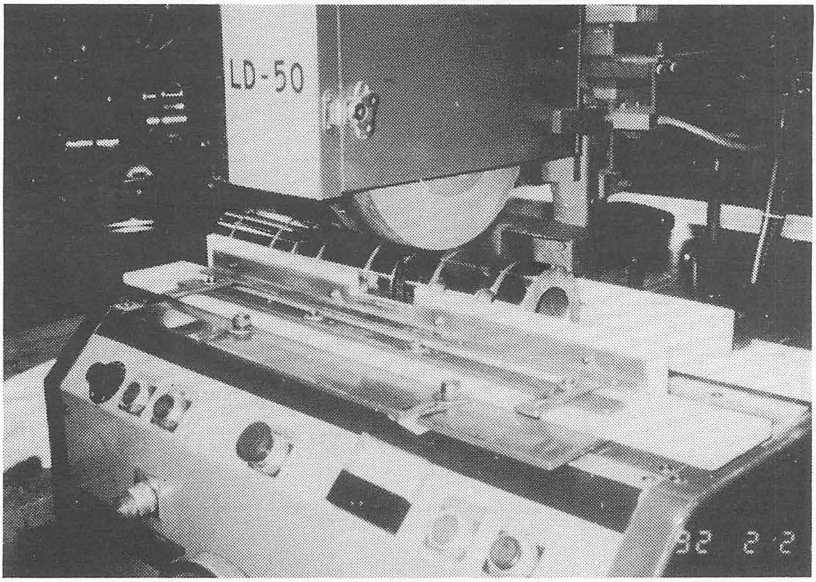

Fig. 13

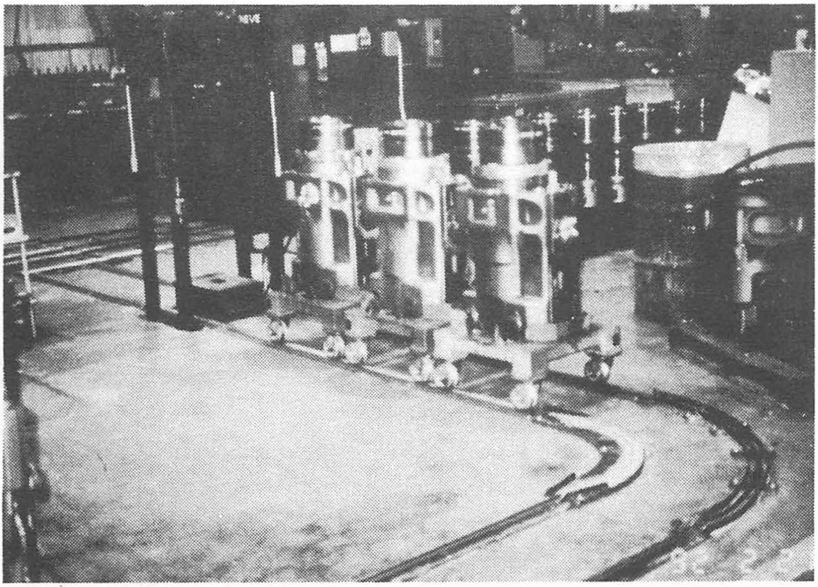

Fig. 14

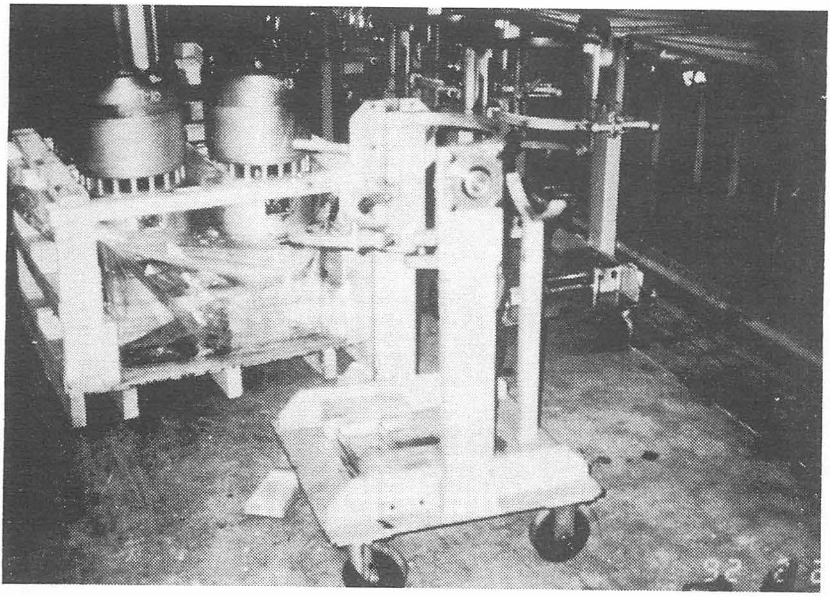

Fig. 15

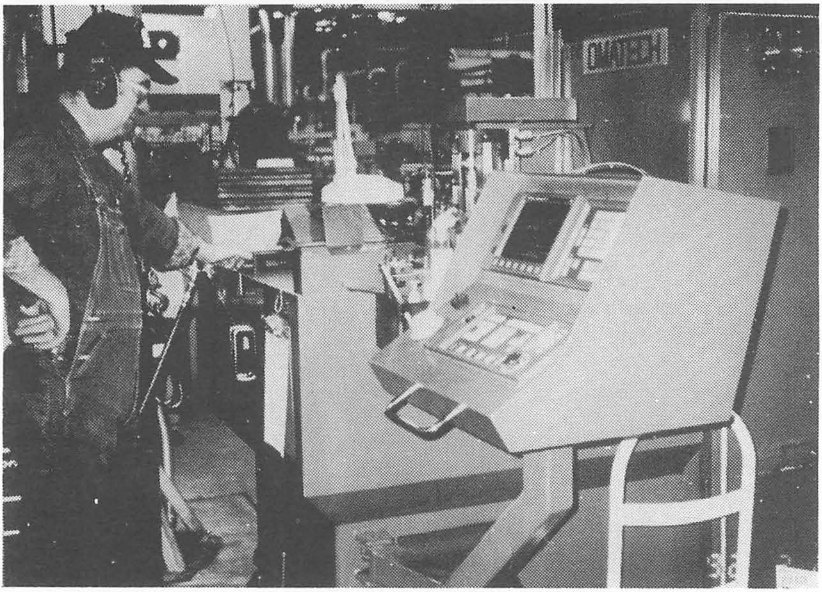

Fig. 16

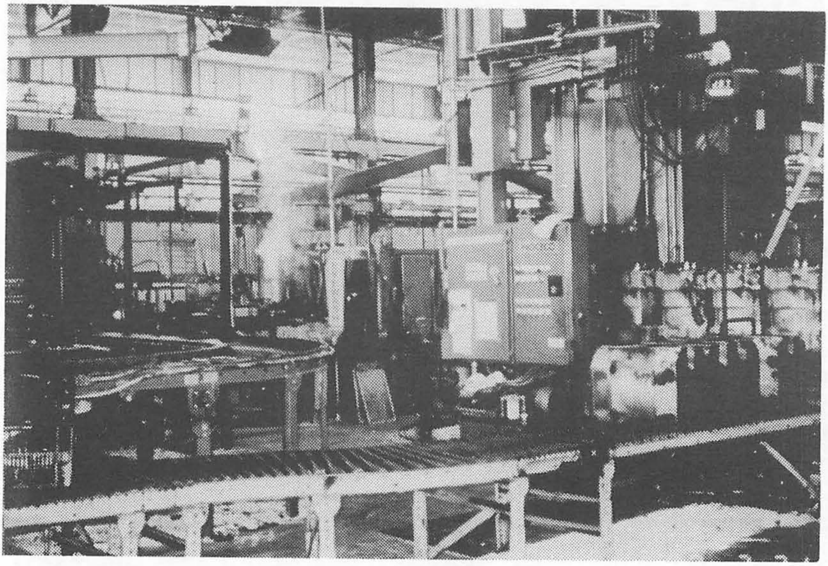

Fig. 17

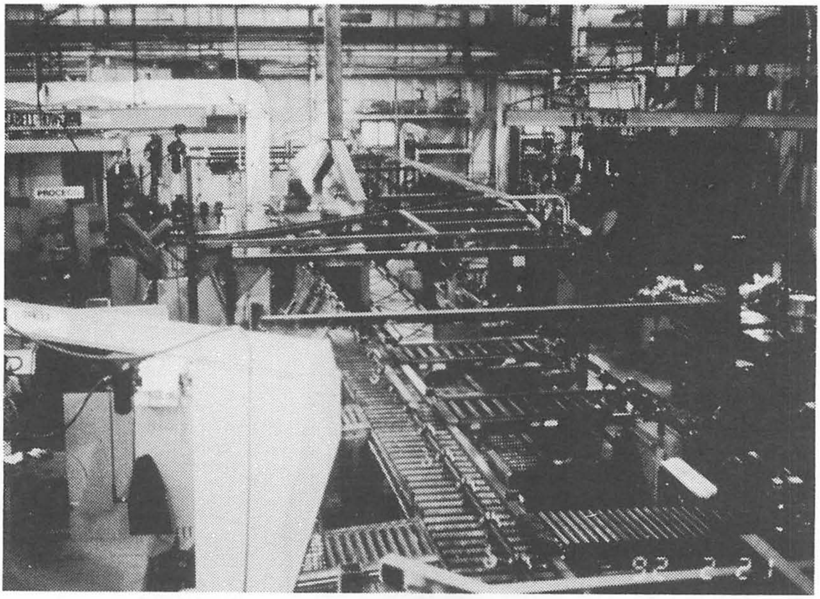

Fig. 18

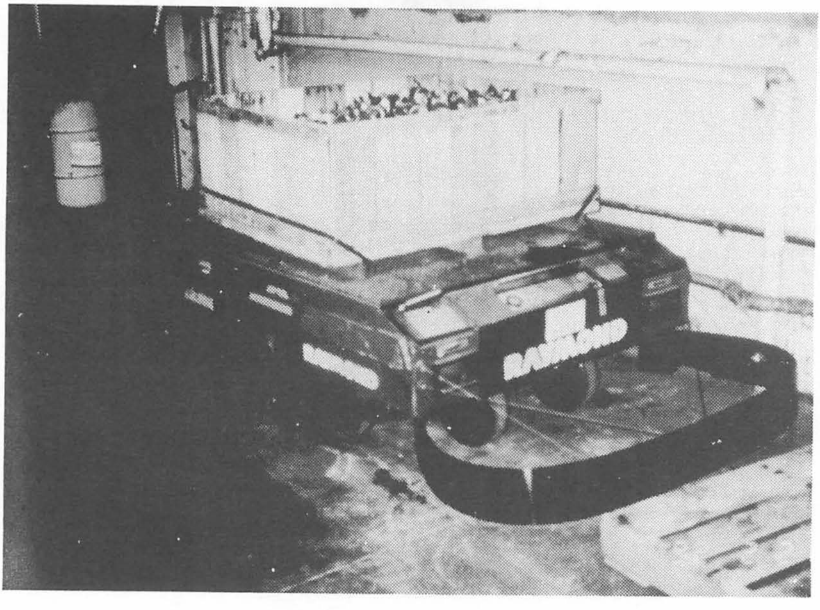

Fig. 19

DIESEL MECHANICAL MAINTENANCE COMMITTEE ELEVEN YEAR INDEX

1983
Cost Control and Extended Service Through Improved Maintenance

1. Leaks: Cooling Water, Lube Oil, Fuel Oil and Air.

1982
Quality Maintenace - The Key To Fuel Conservcation

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

1981
Increased Service Life Through Improved Technology

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

FUEL, LUBRICANTS AND ENVIRONMENTAL COMMITTEE ELEVEN YEAR INDEX

1983
Cnanges in Fuels and Lubricants

1. Field Test Update of Multigrage 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.

DIESEL ELECTRICAL MAINTENANCE COMMITTEE ELEVEN YEAR INDEX

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..

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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
NINE YEAR INDEX

1991

1. Locomotive Lab Integration and Accessory Management
2. Improvements in Locomotive Adhesion Performance.
3. The Role of Duty Cycles in Locmotive 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 Locomtives 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.

DIESEL MATERIAL CONTROL COMMITTEE
ELEVEN YEAR INDEX

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 Contaierization 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 Acquisiton."

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 Perforance 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 Requisiton 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. Forcasting Material Requirements.
3. a. Fuel Security - Are You Getting What You Pay For?
   b. Fuel Oil Is Expensive.
4. Pros and Cons of Material Purchasing Contracts (Single Source - Just In Time Inventory).

1983
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
ELEVEN YEAR INDEX

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 Forkleft 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.

CONSTITUTION AND BY-LAWS LOCOMOTIVE MAINTENANCE OFFICERS ASSOCIATION

Article I - Title:

The name of this Association shall be the Locomotive Maintenance Officers Association (LMOA).

Article II - Purpose of the Association

The purpose of the Association, a non-profit organization, shall be to improve the interests of its members through education, to supply locomotive maintenance information to their employers, to exchange knowledge and information with members of the Association, to make constructive recommendations on locomotive maintenance procedures through the technical committee reports for the benefit of the railroad industry.

Article III - Membership

Section I - Active Railroad Membership shall be composed of persons employed by a railroad company and interested in locomotive maintenance. Membership is subject to approval by the Board of Directors.

Section 2 - Associate Membership shall be comprised of persons employed by a manufacturer of equipment or devices used in connection with the maintenance and repair of motive power, subject to approval of the Board of Directors.

Associate members shall have equal rights with active members in discussing all questions properly brought before the association at the Annual Meeting, but shall not have privilege of voting or holding elective office.

Section 3 - Honorary Membership: Honorary Membership may be issued at the discretion of the President, subject to the approval of the Board of Directors. Honorary Members may not vote or hold elective office; all Honorary Membership shall expire at the end of the current membership year.

Section 4 - Life membership shall be conferred on all Past Presidents. Honorary life memberships shall be conferred on others for meritorious service to the Association, subject to approval by the General Executive Committee.

Section 5 - Dues and Fees: Membership dues for individual active and associate membership shall be set by the Board of Directors and shall be payable on or before September 30th of each year. The membership year will begin on October 1 and end September 30. Life and honorary life members will not be required to pay dues. Members whose dues are not paid on or before the opening date of the annual convention shall not be permitted to attend the annual meeting, shall not be eligible to vote and/or shall not be entitled to receive a copy of the published Pre-Convention Report or the Annual Proceedings of the annual meeting. Failure to comply will result in loss of membership at the end of the current year. A registration fee will be set by the Board of Directors for those attending the annual meeting. Life, life honorary, and honorary members will be entitled to receive a copy of the Pre-Convention Report and Annual Proceedings.

Article IV - Officers

Section 1 - Elective Officers of the Association shall be President, First Vice President, Second Vice President and Third Vice President. There will be one Regional Executive for each technical committee. Each officer will hold office for one year or until successors are elected. In the event an officer leaves active railroad service, he may continue to serve until the end of his term.

Section 2 - Board of Directors: There shall be a Board of Directors composed of the President, Vice Presidents, and all Past Presidents in active official railroad service. In the event a member of the Board of Directors becomes inactive, he may continue to serve until the end of his term of office.

Section 3 - General Executive Committee: There shall be a General Executive Committee, composed of the Board of Directors, the Regional Executives, and the Technical Committee Chairpersons.

Section 4 - Secretary-Treasurer: There shall be a Secretary-Treasurer, appointed by, and holding office at the pleasure of the Board of Directors, who will contract for his or her services with appropriate compensation.

Section 5 - Advisory Board - There shall be an Advisory Board composed of at least nine members, who are Senior Mechanical Officers, Assistant Vice Presidents or Vice Presidents. They will be invited by the Board of Directors and serve as ex-officio members of the General Executive Committee without vote.

Article V - Officer, Nomination and Election of

Section 1 - Elective officers shall be chosen from the active membership. The nominating committee, composed of the Board of Directors, shall submit the slate of candidates for each elective office at the annual convention.

Section 2 - Election of officers shall be determined by a voice vote, or if challenged, it shall require show of hands.

Section 3 - Vacant offices. Vacancies in any elective office may be filled by presidential appointment, subject to approval of the Board of Directors.

Article VI - Officers - Duties of

Section 1 - The President shall exercise general direction and approve expenditures of all affairs of the Association.

Section 2 - The First Vice President, shall in the absence of the President, assume the duties of the President. he shall countersign all expenditures of the Association and be responsible for preparing and submitting the program for the Annual Meeting.

The Second Vice President shall be responsible for selecting advertising. He will coordinate with the Secretary-Treasurer and contact advertisers required to underwrite the cost of the **Annual Proceedings.**

The Third Vice President will be responsible for maintaining a strong membership in the Association. He will ensure that membership applications are properly prepared and distributed, monitoring membership levels and reporting same at appropriate time to the General Executive Committee.

Section 3 - The Secretary-Treasurer shall:

A. Keep all the records of the Association.

B. Be responsible for the finances and accounting thereof under the direction of the Board of Directors.

C. Perform the duties of the Secretary of the Board of Directors, Nominating Committee, and General Executive Committee, without vote.

D. Furnish surety bond in amount of $5000 on behalf of his/her assistants directly handling Association funds. Association will bear the expense of such bond.

Section 4 - The Board of Directors shall be responsible for the following duties:

A. Assist and advise the President in long-range Association planning.
B. Contract for the services and compensation of a Secretary-Treasurer.
C. Serve as the Nominating Committee.
D. Serve as the Auditing and Finance Committee.
E. Determine the number and name of the Technical Committees.
F. Exercise general supervision over all Association activites.
G. Handle all matters of Association business not specifically herein assigned.
H. The Vice President shall perform such other duties as are assigned them by the President.
I. Those present at any meeting called on not less than thirty days advance written notice, shall constitute a quorum.

Section 5 - There will be one Regional Executive officer assigned to each technical committee. Their duties wil consist of:

A. Participate in the General Executive Committee meetings.
B. Monitor material to be presented by the technical committees to ensure reports are accurate and pertinent to the goals of the Association.
C. Represent LMOA in their respective regions.
D. Promote Association activities, especially those held within their assigned region and monitor membership activities on those railroads so assigned.
E. Promote and solicit support for LMOA by helping to obtain advertisers.

Section 6 - Duties of General Executive Committee:

A. Monitoring technical papers for material considered unworthy or inaccurate for publication.
B. Approve topics for the **Annual Proceedings** and Annual Meeting program.
C. Approve the schedule for the Annual program.
D. Administer all Association activities not specifically assigned to the Board of Directors.

Section 7 - The Advisory Board shall act in a consulting capacity. Past Presidents still in official active railroad service shall automatically become members of the Advisory Board.

Section 8 - The Board of Directors are entrusted with all public relation decisions within LMOA and coordinated associations with confidentiality.

Article VII - Technical Committees

The technical committees will consist of:

Section 1 - A chairperson, appointed by the President and approved by the Board of Directors.

Section 2 - A vice chairperson, selected by the chairperson and approved by the President.

Section 3 - Committee members will be made up of:

A. Representatives of operating railroads and regional transit authorities submitted by their Senior Mechanical and Materials Officers and approved by the President of LMOA.
B. Representatives of locomotive builders designing and manufacturing locomotives in North America.
C. The Fuel and Lube Committee will include members from major oil companies or their subsidiaries as

approved by the General Executive Committee.

D. At the discretion of the General Executive Committee, non-railroad personnel may be allowed to participate in committee activities, subject to annual review.

E. All individuals who are on technical committees must be LMOA members in good standing. (See dues and fees, Article 3, Section 5).

Subjects for technical papers will be selected and approved by the General Executive Committee.

Article VIII - Proceedings

The Locomotive Maintenance Officers Association encourages the free interchange of ideas and discussion by all attendees for mutual benefits to the railroad industry. It is understood that the expression of opinion, or statements by attendees in the meeting, and the recording of papers containing the same, shall not be construed as representations or statements ratified by the Association.

Article IX - Rules of Order

The proceedings and business transactions of this Association shall be governed by Roberts Rules of Order, except as otherwise herein provided.

Article X - Amendments

The Constitution may be amended by a two-thirds vote of the active members present at the Annual Meeting.

Article XI - The Constitution and By-Laws have been amended at the Annual Convention on September 19, 1988.