

LMOA

Locomotive Maintenance Officers Association

Proceedings of the 68th Annual Meeting

September 18 - 19, 2006

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2005 LMOA MVP RECIPIENTS

The executive board of LMOA wishes to congratulate the following individuals who were selected as the Most Valuable People of their respective committees in 2005.

<u>Name</u>	<u>Company</u>	<u>Committee</u>
Tom Aspinwall	Alstom	Diesel Material Control
Ron Begier	Portec Rail Products	Shop Equipment & Processes
Jim Christoff	National Electrical Carbon	New Technologies
David Miller	Union Pacific	Diesel Mechanical Maintenance
Stuart Olson	Wabtec Corporation	Diesel Electrical Maintenance
Tom Pyziak	Safety Kleen Systems, Inc.	Fuel, Lubricant and Environmental

This honor is bestowed on an annual basis to those individuals who perform meritorious service and make significant contributions to their respective technical committees.

LMOA EXECUTIVE COMMITTEE

**THE LMOA EXECUTIVE COMMITTEE WOULD
LIKE TO EXPRESS THEIR SINCERE
APPRECIATION TO THE FOLLOWING COMPANIES
FOR GRACIOUSLY HOSTING
THE 9TH ANNUAL LMOA JOINT
TECHNICAL COMMITTEE MEETINGS
IN LONDON, ONTARIO, CANADA
ON MAY 1ST AND MAY 2ND, 2006**

- BACH SIMPSON**
- ZTR CONTROL SYSTEMS**
- EMD OF CANADA**
- INTERNATIONAL TECHNICAL SERVICES (ITS)**

**WE WOULD ALSO LIKE TO THANK THESE
COMPANIES FOR PLANT TOURS MADE AT
EACH OF THEIR FACILITIES
SPECIAL THANKS TO LES WHITE AND
PAUL WEBER, PRESIDENT OF BACH SIMPSON,
TOM NUDDS OF ZTR AND BILL GRAVES, PRESI-
DENT OF ITS, FOR COORDINATING THE DETAILS
OF THE MEETINGS.**

**WE THANK YOU FOR YOUR SUPPORT
OF OUR ORGANIZATION,
LMOA GENERAL EXECUTIVE COMMITTEE**



**THE EXECUTIVE COMMITTEE OF THE
LOCOMOTIVE MAINTENANCE OFFICERS
ASSOCIATION WISH TO EXTEND THEIR
SINCERE APPRECIATION TO
DWIGHT BEEBE, TEMPLE ENGINEERING,
FOR HIS SUPPORT OF OUR ORGANIZATION
THROUGH THE YEARS**

**WE ALSO WANT TO WISH DWIGHT GOOD LUCK
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**THANK YOU DWIGHT,
FROM THE LMOA EXECUTIVE COMMITTEE**

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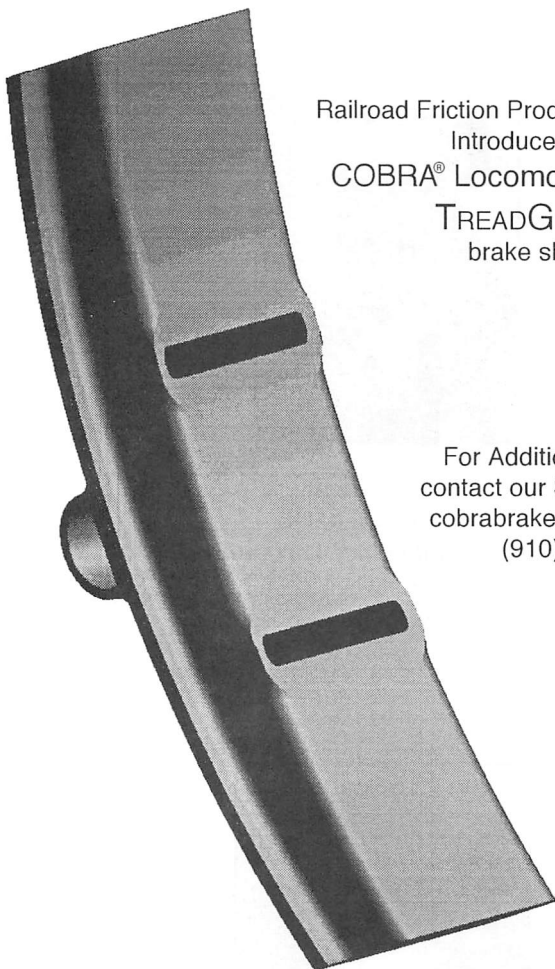
- 1939 & 1949 -** F. B. DOWNEY (Deceased) Shop Supt., C & O Ry.
1941 - J. C. MILLER (Deceased), MM, N.Y.C. & St. L.R.R.
1942-1946, Inc. - J. E. GOODWINN (Deceased) Exec. Vice President, C. & N.W. Ry.
1947 - S. O. RENTSCHILLER (Deceased) Chief Mechanical Officer, Bessemer and Lake Erie R.R.
1948 - C. D. ALLEN (Deceased) Asst. C.M.O. - Locomotive, C. & O. Ry. & B. & O. R.R.
1949 - J. W. HAWTHORNE (Deceased) Asst. Vice-Pres.- Equipment, Seaboard Coast Line R.R.
1950 - G. E. BENNET (Deceased) Vice-Pres.-Gen. Purchasing Agent, C. & E. I. Ry.
1951 - P. H. VERD (Deceased) Vice-Pres.-Personnel, E. J. & E. Ry.
1952 - H. H. MAGILL (Deceased) Master Mechanic, C. & N. W. Ry.
1953 - S. M. HOUSTON (Deceased) Gen. Supt. Mech. Dept. Southern Pacific Co.
1954 & 1955 - F. D. SINEATH, Retired Chief of Motive Power, Seaboard Coast Line R.R.
1956 - T. T. BLICKLE (Deceased) General Manager - Mechanical, A .T. & S. F. Ry.
1957 - J. T. DAILEY (Deceased) Asst. to Pres.-Mech., Alton & Southern R.R.
1958 - F. E. MOLLOR (Deceased) Supt. Motive Power, Southern Pacific Co.
1958 - F. R. Denny (Deceased) Mechanical Supt., New Orleans Union Passenger Terminal
1959 - E. V. MYERS (Deceased) Supt. Mechanical Dept., St. Louis-Southwestern Ry.
1960 - W. E. LEHR (Deceased) Chief Mechanical Officer, Pennsylvania R.R.
1961 - O. L. HOPE, (Deceased) Asst. Chief Mechanical Officer, Missouri Pacific R.R.,
1962 - R. E. HARRISON (Deceased) Manager-Maintenance Planning & Control, Southern Pacific Co.
1963 - C. A. LOVE, (Deceased) Chief Mechanical Officer, Louisville & Nashville R.R.
1964 - H. N. CHASTAIN, (Deceased) Gen. Manager-Mechanical, A. T. & S. F. Ry.
1965 - J. J. EKIN, JR. (Deceased) Supt. Marine & Pier Maintenance, B. & O. R.R.
1966 - F. A. UPTON II (Deceased) Asst. Vice-President-Mechanical, C. M. St. P. & P. R.R.
1967 - G. M. BEISCHER, Retired Chief Mechanical Officer, National Railroad Passenger Corp. Washington, D.C. 20024
1968 - G. F. BACHMAN, (Deceased) Chief Mechanical Officer, Elgin Joliet & Eastern Ry.
1968 - T. W. BELLHOUSE (Deceased) Supt. Mechanical Dept., S. P. Co., - St. L. S.W. Ry.
1970 - G. R. WEAVER (Deceased) Director Equipment Engineering, Penn Central Co.,
1971 - G. W. NEIMEYER (Deceased) Mechanical Superintendent, Texas & Pacific Railway
1972 - K. Y. PRUCHNICKI (Deceased) General Supervisor Locomotive Maintenance, Southern Pacific Transportation Company
1973 - W. F. DADD, (Deceased) Chief Mechanical Officer, Chessie System
1974 - C. P. STENDAHL, Retired General manager M.P.-Electrical, Burlington Northern Railroad
1975 - L. H. BOOTH, (Deceased) Retired Assistant C.M.O.-Locomotive, Chessie System,
1976 - J. D. SCHROEDER, Retired Assistant C.M.O.-Locomotive Burlington Northern Railroad, 244 Carrie Drive, Grass Valley, CA 95942
1977 - T. A. TENNYSON (Deceased) Asst. Manager Engineering-Technical, Southern Pacific Transportation Co.
1978 - E. E. DENT, (Deceased) Superintendent Motive Power, Missouri Pacific Railroad,
1979 - E. T. HARLEY, Retired Senior Vice President Equipment, Trailer Train Company, 289 Belmont Road, King of Prussia, PA 19406

- 1980 - J. H. LONG, Retired Manager Locomotive Dept., Chessie System
5454 Cleander Drive, Cincinnati, OH 45238
- 1981 - R. G. CLEVENGER, Retired General Electrical Foreman, Atchison, Topeka &
Sante Fe Rwy.
- 1982 - N.A. BUSKEY (Deceased) Asst. General Manager-Locomotive, Chessie System
- 1983 - F. D. BRUNER (Deceased) Asst. Chief Mechanical Officer-R. & D. Union
Pacific Railroad
- 1984 - R. R. HOLMES, Retired, Director Chemical Labs and Environment, Union Pacific
- 1985 - D. M. WALKER, Retired, Asst. Shop Manager, Norfolk Southern Corp.,
793 Windsor St., Atlanta, GA 30315
- 1986 - D. H. PROPP, Retired Burlington Northern RR & Vice President, Ontrack,
8913 West 161st St., Overland Park, KS 66085
- 1987 - D. L. WARD, (Deceased) Coord.-Quality Safety & Tech. Trng. Burlington
Northern R.R.
- 1988 - D.G. GOEHRING, Retired, Supt. Loco. Maint., National RR Passenger Corp.,
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- 1996 - G.J. BRUNO, Retired, Supt. - Mechanical,
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- 1997- D.M. WETMORE, General Supt. - Fuel Opns., NJT Rail Opns.
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- 2000- RON LODOWSKI, Asst. Shift Supt., CSX Transportation
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- 2001- LOU CALA, Consultant, LJC Rail, Duncansville, PA 16635
- 2002- BOB RUNYON, Engineering Consultant, Roanoke, VA 24019
- 2003- BRIAN HATHAWAY, Manager-Maint. Operations, Maryland Midland RR,
Port Orange, FL 32139
- 2004- BILL LECHNER, Senior General Foreman-Insourcing-Air Brakes, Governors &
Injectors, Norfolk Southern Corp., Altoona, PA 16601
- 2005- TAD VOLKMANN, Director-Mechanical Engineering, Union Pacific RR,
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- B. A. CUMBEA,** Retired Mgr. Loco. Maint.-Engr., Chessie System, 310 Cherokee
Trail, Huntington, WV 25705

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- J. F. McDONOUGH**, Retired Asst. V. P.-Mechanical, Union Pacific RR, 12225 Farnum St., Omaha, NE 68154
- R. G. RAY BURN**, Retired Executive V.P.-Operations, Chessie System, Baltimore, MD
- H.P. RODES**, Pres., General Motors Institute, Flint, MI 48502
- F. R. RUSSELL**, Retired Chief Mech. Off., Southern Pacific Co., San Francisco, CA
- L. G. SALTS**, Retired, Asst. Manager-Locomotives AT&SF Rwy., Topeka, KS
- H. L. SCOTT, JR.**, Retired Sr. V.P. and Chief Mech. Off. Norfolk Southern, Corp.
- C. M. SMITH**, Retired Mgr-Mech. Engr.-Passenger and Loco. Consolidated Rail Corp., 3 Princeton Rd., Strafford-Wayne, PA 19087
- R. D. SPENCE**, Retired Executive V.P.-Operations, Seaboard System RR
- J. TAGGART**, Retired System Mechanical Officer-Motive Power, CN Rail, 655 Richmond Road, Unit 45, Ottawa, Ontario K2A 3Y3
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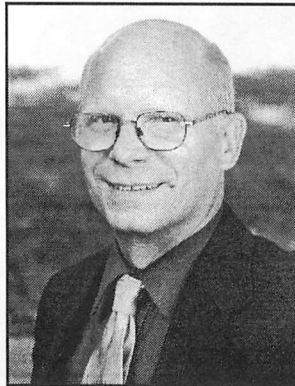
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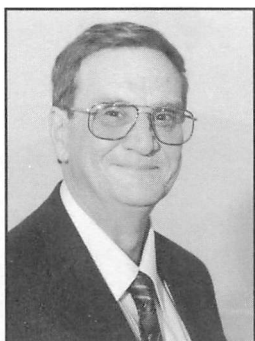


Our President
MR. BRUCE KEHE
Manager-Maintenance Locomotives
EJ&E Railway Co.
Gary, IN 46402



Our Chairman of the Nominating Committee
MR. TAD VOLKMANN
Director-Mechanical Engineering
Union Pacific Railroad
Omaha, NE 68179

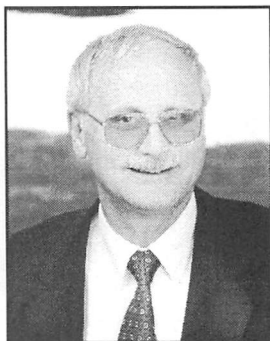
OUR OFFICERS



1st Vice President
MR. LES WHITE
Technical Sales Representative
Bach Simpson
London, Ontario N4W 2C2



2nd Vice President
MR. MIKE SCARINGE
Director-Warranty Enforcement
Amtrak
Beech Grove, IN 46107

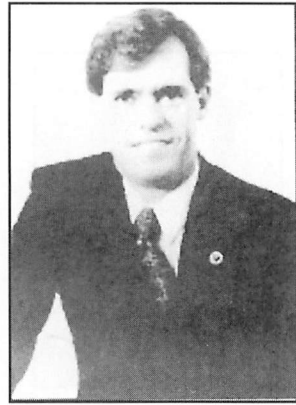


3rd Vice President
MR. DENNIS NOTT
Northwestern Consulting, LLC
Boise, ID 83704

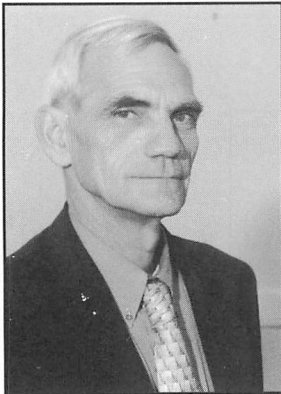
OUR PAST PRESIDENTS



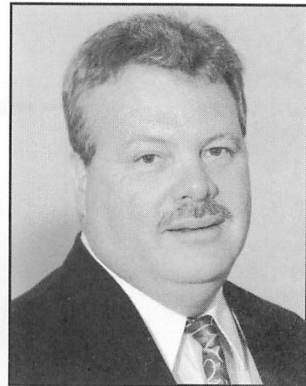
MR. MARK COLES
 Senior Manager - Loco.
 Engineering & Quality
 Union Pacific Railroad
 Omaha, NE 68179



MR. WEYLIN R. DOYLE
 Project Manager
 Sound Transit
 Seattle, WA 98104



MR. BRIAN HATHAWAY
 Mgr. Maintenance Operations
 Maryland Midland Railroad
 Port Orange, FL 32129



MR. BILL LECHNER
 Sr. General Foreman
 Insourcing-Air Brakes, Governors &
 Injectors
 Norfolk Southern Corp.
 Altoona, PA 16601
 Bill also doubles as Regional Executive of the
 Diesel Material Control Committee

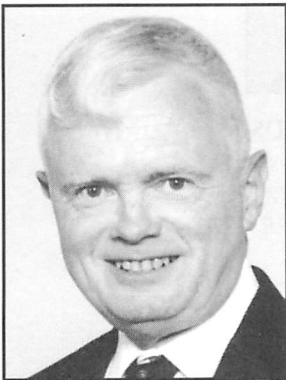
OUR PAST PRESIDENTS



MR. RONALD R. LODOWSKI
Asst. Shift Superintendent
CSX Transportation
Selkirk, NY 12158



MR. H.H (MIKE) PENNELL
Ellcon National
Keller, TX 76248

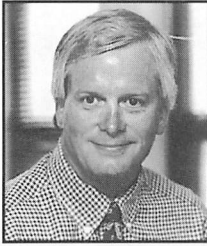


MR. ROBERT RUNYON
(Retired Norfolk Southern Corp.)
Engineering Consultant
Roanoke, VA 24042

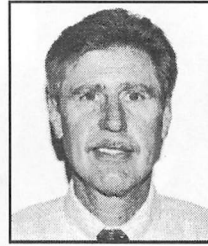


MR. DAVID M. WETMORE
General Supt. - Fuel Operations
NJT Rail Opns
Kearny, NJ 07032

OUR REGIONAL EXECUTIVES



MR. GLENN BOWEN
Director - Lab Services
BNSF Rwy
Topeka, KS 66616

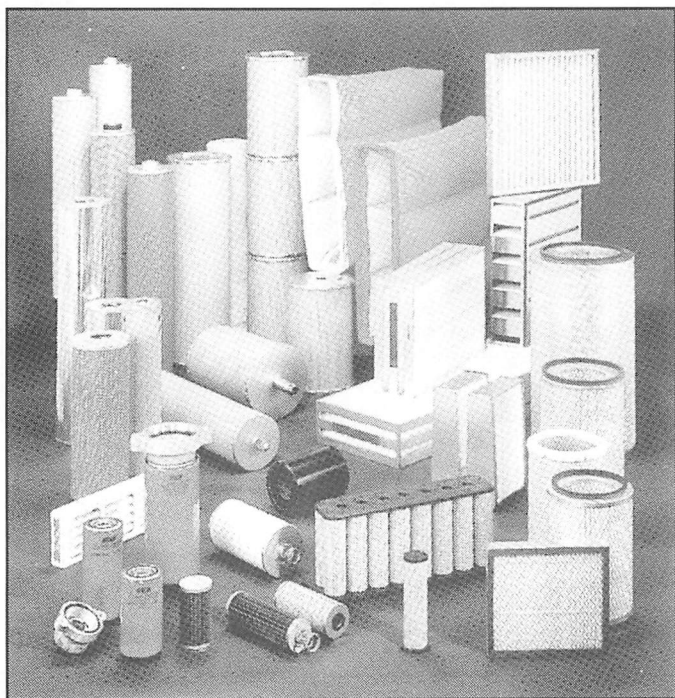


MR. JACK KUHNS
Vice President - Sales
JMA Railway Supply
Ponte Verdra Beach, FL



BOB REYNOLDS
Manager-Loco. Systems
Canadian Pacific Railway
Calgary, Alberta T2P 4Z4

*John Brawley, Regional Executive for the
Diesel Material Control Committee passed away this year.
Our thoughts and prayers go out
to John and his family.*



Total Railroad Filtration

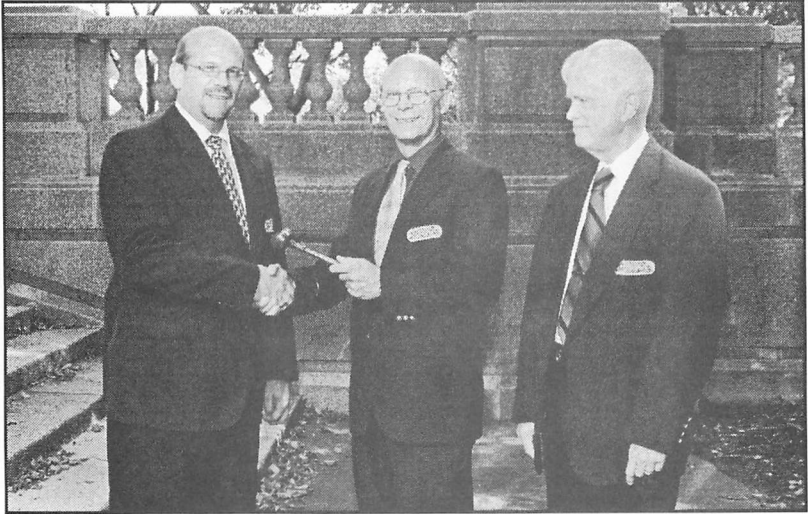
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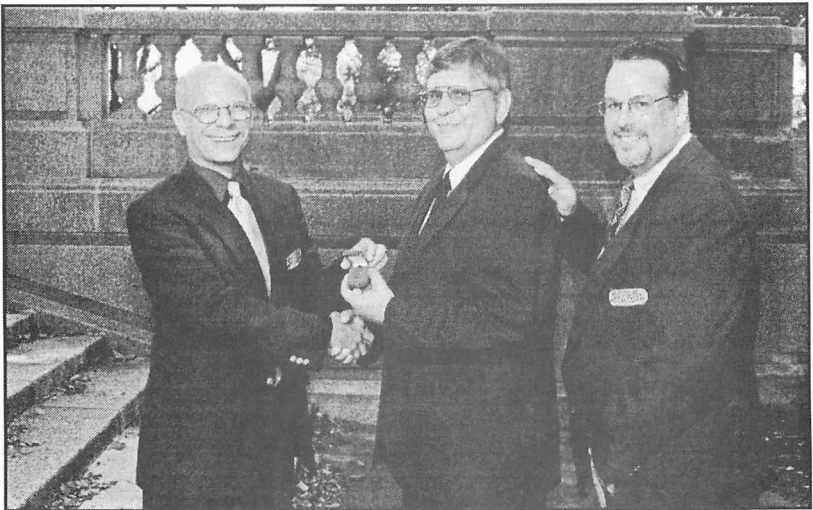
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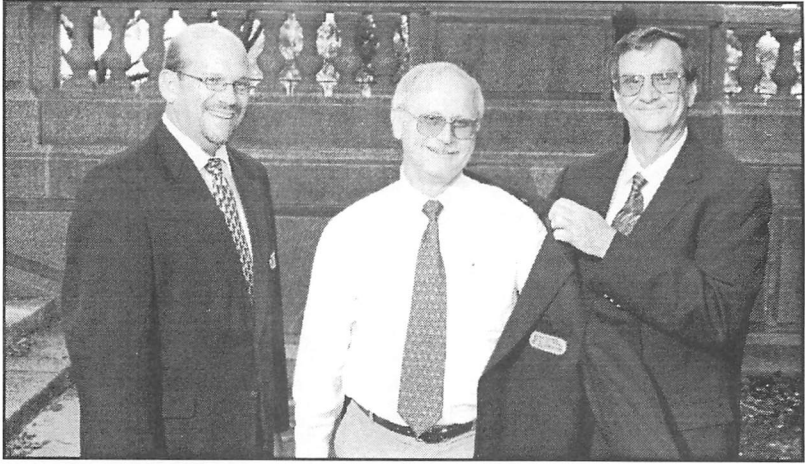
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Outgoing President Tad Volkmann, Union Pacific RR, passing gavel to newly elected President, Bruce Kehe, EJ&E. Past President Bob Runyon witnessed the ceremony.



Past President Ron Lodowski, CSX Transportation, presents Past President's Pin to outgoing President Tad Volkmann, Union Pacific RR with newly elected 2nd Vice President Mike Scaringe, Amtrak, in attendance.



Newly elected 1st Vice President Les White, Bach-Simpson, putting LMOA blazer on newly elected 3rd Vice President Dennis Nott, Northwestern Consulting, LLC, while newly elected President Bruce Kehe, EJ&E, looks on.



Outgoing President Tad Volkmann, Union Pacific, presents LMOA attache bag to newly appointed Chairman of the Diesel Material Control Committee, Bob Harvilla, Standard Car Locomotive Group. Newly elected president Bruce Kehe, EJ&E, was present for the ceremony.



LMOA executive officers - picture taken in Grant Park, Chicago, Illinois during lunch break at the 2005 Coordinated Associations Convention.

First row (left to right) - newly elected 2nd Vice President, Mike Scaringe, Amtrak; Past President Ron Lodowski, CSX Transportation; Past President Bob Runyon, Consultant (former NS); newly elected 1st Vice President Les White, Bach-Simpson; Secretary-Treasurer Ron Pondel

Second row: Newly elected President Bruce Kehe, EJ&E and outgoing President Tad Volkmann, Union Pacific. Back Row: Newly elected 3rd Vice President Dennis Nott, Northwestern Consulting, LLC.

STATE OF THE UNION SPEECH
President Tad Volkmann
September 19, 2005

Mr. Chairman, members of the Executive Committee, Mr. Secretary-Treasurer, fellow members, and honored guests:

As I close my term as the 67th President of the Locomotive Maintenance Officer's Association, my sincere wish is to be remembered as a strong leader in a time of unprecedented change for this venerable, yet still vibrant and relevant organization.

In May 2005, we held our joint technical committee meetings in Overland Park, Kansas; adjacent to the facilities of a member railroad. I wish to extend the gratitude of LMOA to the BNSF Railway, and specifically to Glenn Bowen and Brad Queen, for sponsoring our well-attended joint technical committee meetings, and extending the opportunity to all LMOA attendees to learn and benchmark from tours of the BNSF Technical Training Center and Argentine Locomotive Facility.

We have faced the challenge of the withdrawal of sponsorship by the Railway Supply Institute in non-exhibit years with both tactical and strategic approaches. LMOA agreed to meet with the other technical associations this year in Chicago.

I wish to extend LMOA's gratitude to all of our supplier partners who are providing table top displays of locomotive maintenance products designed to maintain or enhance equipment reliability while reducing our maintenance budgets. Our sup-

plier partners are not only showing us new, innovative products and services to help achieve our member railroads' maintenance goals, but are also helping to defray the expense of this technical conference. For that I say "thank you" and urge all of you to visit our suppliers' table top displays.

LMOA has developed strategic contingencies, including the possibility of holding an LMOA-only technical conference during non-exhibit years at major member railroad facilities on a rotating basis. The Executive Committee will meet on Wednesday morning to evaluate the success of these 2005 technical meetings and chart LMOA's course in future non-exhibit years.

I have full faith in the commitment and leadership ability of the LMOA leadership team, and am greatly encouraged by the talents of the Vice Presidents, Regional Executives, and Technical Committee Chairmen who will lead this proud organization well into the 21st century.

On a personal note, I wish to thank Ron Pondel and Bruce Kehe, without whose outstanding commitment and contributions this year would not have been possible.

I thank my employer, Union Pacific, for allowing me to contribute to LMOA. UP's Mechanical leaders, Barry Kanuch and John Estes, consistently demonstrate the vision and commitment to support LMOA's mission of benchmarking, networking, and learning among member roads. I also owe a debt of gratitude to the First Lady, Mary Volkmann, who has been unwaveringly tolerant

and supportive of my work in LMOA.

Tomorrow I will pass the baton to our new President, Bruce Kehe, and with the support of my employer, will revert to representing Union Pacific on one of LMOA's technical committees as a working member. President Kehe and the leadership team will strive to continuously improve LMOA's relevance and value to our customers; our member railroads.

I believe that they will succeed.

Thanks to all of you for your support and encouragement during this challenging year.

ACCEPTANCE SPEECH
President Bruce Kehe
September 20, 2005

Ladies and Gentlemen-

It is indeed an honor for me to serve as the new President of the LMOA for the 2005-2006 year. I'm in a rather unique position in that I'm the third person from the EJ&E Railway, a relatively small regional railroad, to serve as the president of this distinguished group. On one hand, it's rather unheard of that a 200-mile long railroad has been able to maintain its independence for over 117 years. Even more unique and gratifying is the fact that a railroad like the EJ&E has maintained a presence and has supported LMOA for nearly all of this group's existence. I want to thank my company and management team for that dedication.

I became involved with LMOA in the early 1990's, thanks to some encouragement from Ron Lodowski (CSX) and Chuck Kunkel (Union Pacific) - whom I worked with on several other industry technical committees. I must admit I felt a bit intimidated at my first Fuel, Lubricant and Environmental committee meeting - as topics discussed seemed far removed from my job as a General Foreman in the EJ&E diesel shop. But it wasn't long before terms like "viscosity improver" and "thermal stability" became second nature to me. I went on to become the FL&E committee vice chairman and chairman in ensuing years. In 2000, I was asked by the Executive Board if I would consider filling a vacancy on

the New Technologies Committee as their Regional Executive - which I agreed to do. At my first New Technologies committee meeting, I heard terms like "thyristors" and IGBT's", and I thought - "man I'm way over my head again." But low and behold, after the next couple meetings, I had established a new comfort level with this talented group and was able to contribute regularly in the development of future papers. The reason I have just reviewed my own experiences within LMOA is to encourage all of you to become involved in one of our (6) technical committees. As my past experiences illustrate, no specific prior knowledge in any particular field is required - just a willingness to learn from others and then contribute as you are able. I encourage all railroad executives, managers, shop personnel, as well as our valued railroad suppliers to be supportive and encourage their company's active participation in LMOA. As most of you are aware, several years ago our by-laws were changed to permit our supply partners to serve in any capacity, on any committee, as well as have the opportunity to ascend through the executive ranks.

So now that I've convinced you to become an active LMOA committee member, you might ask "what's in it for my company and me"? Participation in one of our technical committees will help hone your skills as a technical writer, speaker, and as a team player. LMOA prides itself on presenting timely and forward thinking topics to the general railroad audience. During this conference,

you've been able to learn about such topics as locomotive fuel cell technology, the successful hybrid locomotive programs, as well as our continuing series covering mechanical and electrical "best maintenance practices." The opportunities in LMOA to visit railroad and vendor shop facilities and to network with other industry experts is unparalleled. I can't begin to count the times I've relied on my contacts within LMOA for insight and problem-solving help. The benefits are clearly there; please consider taking advantage of them.

As Tad Volkmann mentioned in his "state of the union" address, LMOA will continue to face many new challenges in the very near future. This is the first conference held without the benefit of direct financial support from the RSI. The resulting numbers from this convention (both attendance and monetary) will no doubt have a huge bearing on the direction LMOA takes in the future. Tad has already highlighted some of our options, for example - having LMOA conduct its conference at a member railroad facility in non-exhibit years. It is important to remember that the Executive Committee has been elected to serve you - our members and supporters. We are eager to hear your thoughts, goals, and desires for charting LMOA's future. Please make an effort to contact or speak with any of our Executive Committee members during the remainder of this conference, or in the very near future.

At this time, I want to add my thanks to all the individual suppliers

who purchased table top space in the exhibit halls - which will help defray LMOA's portion of the cost of this convention. I would also like to personally thank the BNSF Railway for hosting our joint meeting this past May, and especially to Glenn Bowen and Brad Queen for working out all the logistics. Lastly, thanks to all the railroad and supply companies that have graciously hosted individual committee meetings throughout the year, and continue to support our organization by allowing their employees to participate on our technical committees.

Thank you again for the privilege to serve as your new president.

REPORT OF THE COMMITTEE
ON SHOP EQUIPMENT AND PROCESSES

MONDAY, SEPTEMBER 18, 2006
10:15 A.M.



Chairman

BILL PETERMAN

President

Peterman Railway Technologies, Inc.
Baie D'Urfe, Quebec

Vice Chairman

TOM STEFANSKI

Tom's Locomotives and Cars
Plainfield, IL

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**THE LMOA SHOP EQUIPMENT AND
PROCESSES COMMITTEE
WOULD LIKE TO EXPRESS THEIR
SINCERE APPRECIATION TO THE
FOLLOWING COMPANIES FOR
HOSTING OUR TECHNICAL
MEETINGS IN
2005/2006**

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INSTITUTE IN SAN ANTONIO, TX
NOVEMBER 7TH & 8TH, 2006**

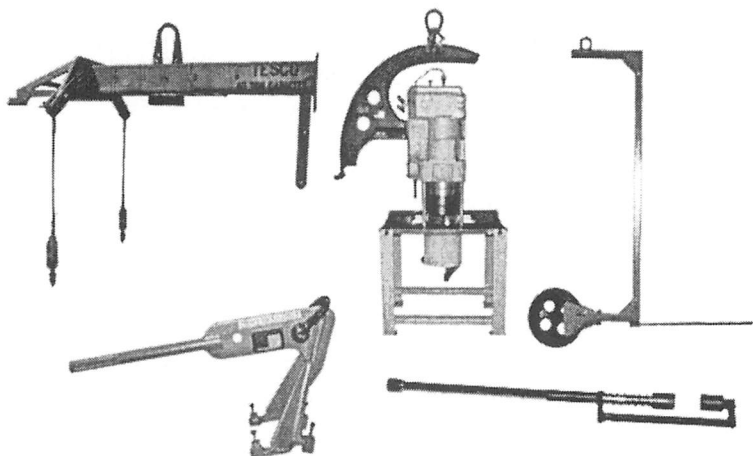
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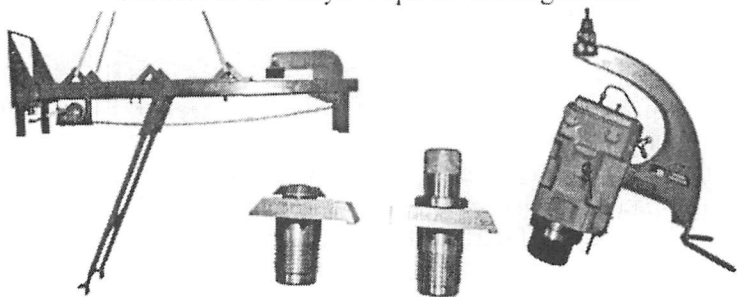
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I. WHEEL GAUGE TECHNOLOGY

*Prepared by
Tom Stefanski,
Tom's Locomotives & Cars*

The code of Federal Regulations 229.75 requires that locomotive wheels do not deviate from established guidelines published there in. Therefore a device capable of measuring wheels to assure adherence to that criteria was designed. We know this device as an AAR finger gauge, as shown in Figure 1. This manual gauge allows us to measure rim thickness and flange height. Additionally, the gauge also provides the capability to measure wheel diameter for matching purposes that is required by CFR 229.73. This utilizes the witness groove that is applied to most wheels at a diameter of 36 inches for a 40 inch wheel and 38 inches for a 42 inch wheel.

As the measurements are taken with the finger gauge the readings must be recorded by hand onto the wheel report. Then someone, most likely the immediate supervisor needs to interpret the data to determine if the wheels are OK for service, require truing or are condemnable and will need replacement. A mismatch of wheel diameters that exceed CFR 229.73 requirements can also dictate the need for wheel truing or replacement to correct the mismatch condition. All of this plays a critical part in your overall strategy to get the most life out of your wheels.

How many times have you been

in a situation where a wheel has been measured using the finger gauge and the measurement is on the ragged edge? So you send out another of your trusted troops to re-measure the wheel only to find out that his measurement is worse than the first measurement. What's happening here? Well, there can be many reasons for unreliable measurements, such as; 1) holding the gauge against wheel at the wrong angle, 2) tilting the gauge to get a better look at the reading, 3) reasonable men can disagree, rounding off of the reading can go up or down, 4) dirty, greasy wheels are hard to read, 5) transcription errors in reading smudged wheel reports sheets, 6) improper training in using or reading the gauge. Figure 2 represents several of these reasons. we need to do something different in order to get more reliable, consistent readings.

Well the time has come to develop the second generation wheel gauge. Well, how do we do this? Of course we are in the electronic age. Let's develop a gauge using electronic proximity technology. So an electronic wheel measurement gauge, or the "EWG" as show in Figure 3, was developed. The electronic gauge would allow the operator to input the operator ID, railroad name, unit number, wheel position, and other selective data into a data logger unit, and then it would record the rim thickness, flange height and flange thickness. It also has the capability of measuring the distance from the witness groove for wheel match-

ing. But there is more. You can now interface the data acquired with the electronic wheel gauge to a personal computer or a printer. This allows you the ability to develop a data base that can be used to predict wheel replacement requirements. A forecasting tool to determine when wheel replacement would be required.

The latest-version of the electronic wheel gauge, shown in Figure 4, has now been miniaturized, is cable-less and wireless, and has the ability to transfer the readings to your laptop, desktop PC, shop workstation, or mainframe. This is accomplished through the use of infra-red communication or radio-frequency, such as "blue-tooth." This makes the downloading of the wheel measurement data effortless and instantaneous, as shown in Figure 5.

But there is still more. You can even interface with the wheel truing machine. With this capability I am told you can get the optimal cut on your wheel while reducing wear and tear on the truing machine. The data is downloaded to the truing machine and then it automatically and optically determines the number of cuts and depth of each cut based on preset limits.

Well the time has come for the latest technology, the third generation, "LASER." In today's world the laser is used for practically everything; we cut with it, we perform surgery with it, we measure with it. Measure with it? Hey, let's measure locomotive wheels with it. Well

that time has come. Some of the latest devices out there today use laser technology. There are hand-held gauges (profilometers) currently available that can measure wheels using laser technology and of course these interface with computers that store the data and decipher it, see Figure 6. The hand held laser at this time is not approved by the AAR or OSHA because of safety concerns and reliability issues in the rugged environment. But, who knows what the future will bring. The capabilities appear to be endless.

We have gone yet a step further and now have the capability of taking wayside wheel measurements with rail-based equipment based on laser-camera systems. These automatic wayside systems can include optional features such as tread crack detection and flat spot detection, as shown in Figure 7. As a train passes a particular point, the locomotive is identified and wheel measurements are taken via laser. The wheel measurements are input into a computer located at the wayside location; they are then relayed to the maintenance facility computer. Based on this real time information, time can be allotted for wheel maintenance as required. This system also has the capability of interfacing with the wheel truing machine through its computer based system.

But, from what we understand there is still more to come. The current technologies that are available today include IRDA (infra-red) and RF (radio-frequency). We can

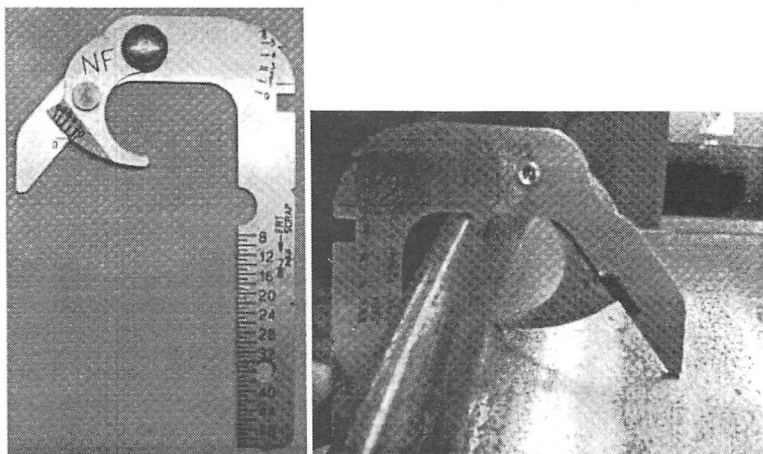
expect to see some of these technologies move to the forefront in the future.

In conclusion we are in the midst of constant change. Some of the newer technologies that are out there today carry a hefty price tag. The cost of moving up to these new technologies for some of the end users is prohibitive at this time. For the smaller railroads the cost does not justify the end. So, we will continue to use the handheld AAR finger gauge and portable electronic wheel gauges on into the future.

LMOA - Wheel Gauge Technology

LMOA Meeting - 2006

AAR Steel Wheel "Finger" Gage



Specifications subject to change without notice.

Figure 1

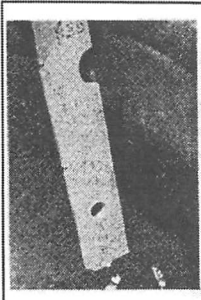
LMOA - Wheel Gauge Technology

LMOA Meeting - 2006

UNRELIABLE WHEEL MEASUREMENTS

Three (3) typical reasons are:

- 1) It's All In The Wrist
Mechanical manual gages are difficult to read even when placed properly on the wheel.



This steel wheel gauge is properly positioned on a 33 1/16" rim. But who can read it? Not me. Not you. Not the inspector.

That's better. It's 35 on the nose. You tilt the gauge to read it clearly. Clearly wrong! 2/16" of metal is really not there! This type of wheel may go back into service when it should be condemned. And this happens all the time.



- 2) Reasonable Men Can Disagree – Rounding errors produce reliably unreliable results.
- 3) Dirt & Grease – Dirty, greasy wheels are hard to inspect & measure.

Specifications subject to change without notice.

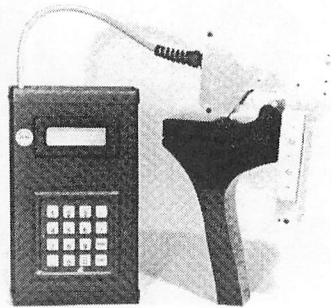
Figure 2

LMOA - Wheel Gauge Technology LMOA Meeting - 2006

Electronic Wheel Gauge



- Introduced in 1987
- Approved AAR alternative to the SWG in 1990.

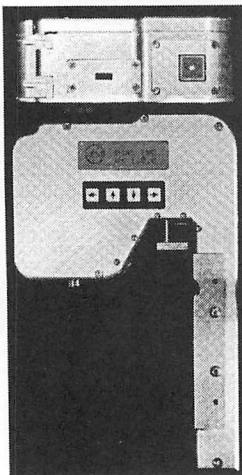


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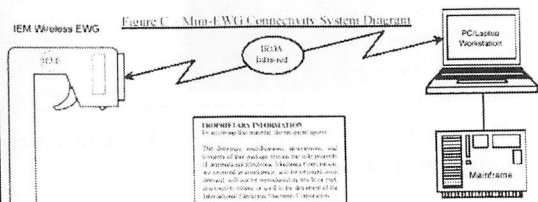
Figure 3

LMOA - Wheel Gauge Technology LMOA Meeting - 2006

Miniature Electronic Wheel Gauge



- Introduction 2005
- Cableless
- Wireless (IrDA or RF)
- Connectorless
- Smaller
- Thinner
- Lighter
- Self-Contained



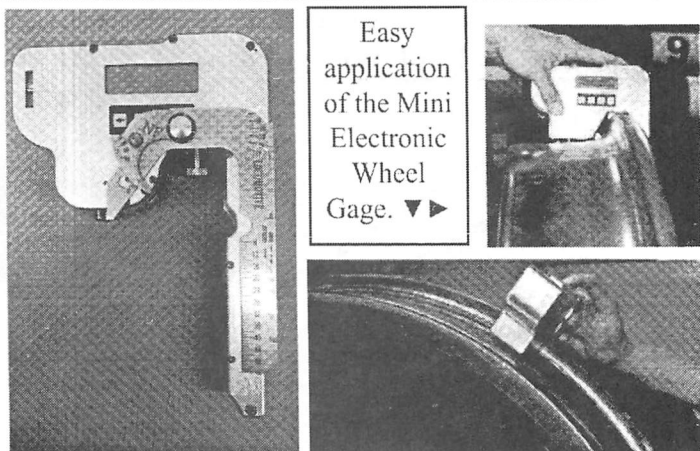
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Figure 4

LMOA - Wheel Gauge Technology

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Miniature EWG comparison to SWG



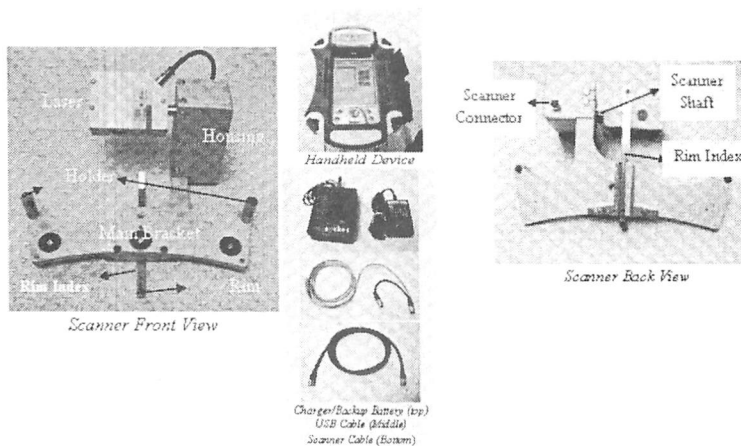
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Figure 5

LMOA - Wheel Gauge Technology

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Laser Scanner Wheel Gauge



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Figure 6

LMOA - Wheel Gauge Technology
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Wayside Wheel Measurement Systems

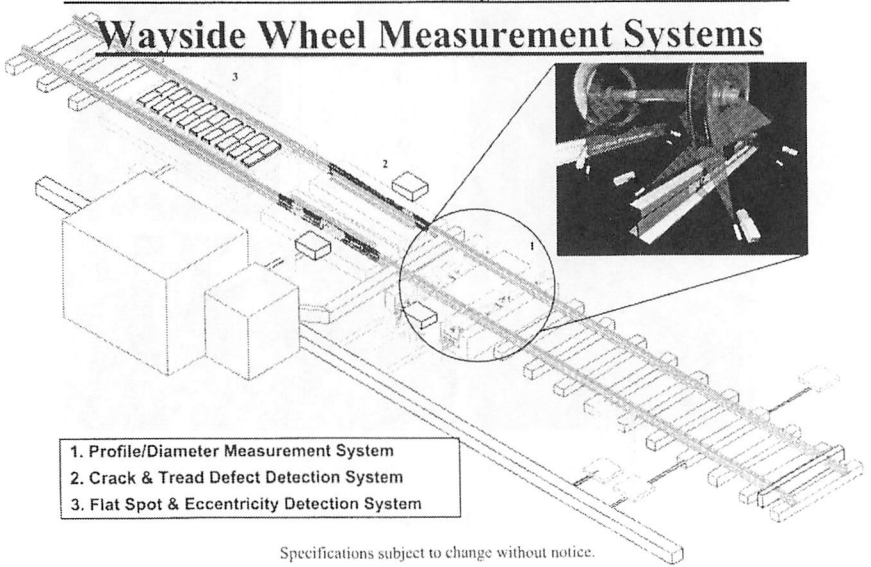
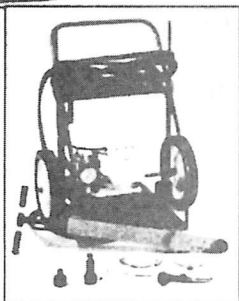
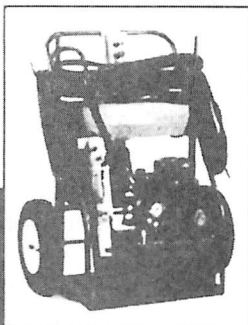
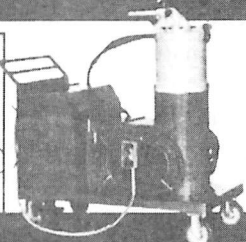
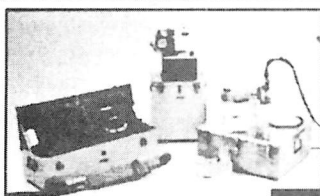


Figure 7

T TIME-SAVING Tools and Machines for Locomotive Maintenance, Parts Reclamation, and Testing



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**REDUCE
LOCOMOTIVE DOWNTIME**

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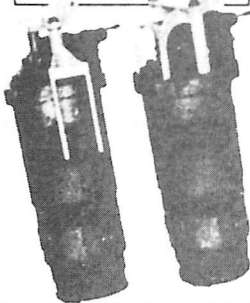
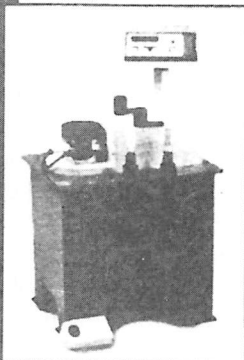
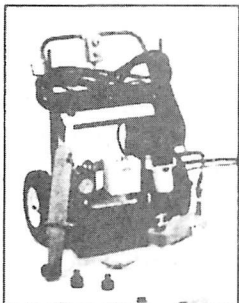
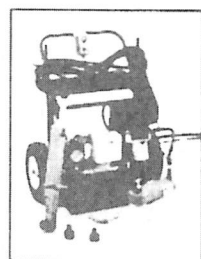
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2. TRAIN WASHING

*Prepared by
Jack Morin
NEU, Inc.*

(A) Train washing introduction

- Background-Train Washing is part of a good maintenance practice.
- All of today's modern maintenance facilities have train wash areas.
- Cleaning means a regular exterior water wash.

Railways are made up of complex mechanical and electrical systems and there are hundreds of thousands of moving parts, generating a dirty environment. If a railway service is to be reliable and project a good image, the equipment must be kept in good working order and regular maintenance is the essential ingredient to achieve this. Train washing is part of good maintenance. Knowing that, rolling stock is the most maintenance intensive part of the railway system and is the most vulnerable if maintenance is neglected. In a few words: A DIRTY TRAIN DOES NOT LOOK WELL MAINTAINED.

Trains require special facilities for storage and maintenance. The basic design of these facilities has changed little in the last 100 or more years and in many cases, the original sites and buildings are still in daily use. Sometimes, these old layouts have made adapting to modern maintenance systems very difficult. This is especially true for

train washers and water reclaim systems that go with them. Lack of room is a common problem and it can affect performance.

Trains are stabled in depots or sidings. They need to be cleaned and serviced. Cleaning means a regular exterior water wash and if passenger cars are involved, interior sweeping and dusting or vacuuming. Exterior washing usually means a drive through washing machine which will wash the sides and maybe the roof.

(B) Train washing

- Generalities
 - Same principle as car wash
 - Minimum of straight track
 - Proper drainage facilities
 - Weather sensitive
 - Dwell time necessary for chemical wash

Train washing facilities work on the same principle as a car wash, except that, usually, the train is driven through the wash and the washer stays in one place. Some designs of a train washer work like a very long car wash, where the train stands still and the washer moves during the cleaning. Normally, water is used for a daily wash, while a chemical wash is used at less frequent intervals - could be several weeks - many daily washes have a detergent added to assist the process. But in general a lot of this will depend on local practice and degree of pollution and dirt collection.

Washing machines require that the track on either side is straight for at least one car's length. This is

to ensure that the car goes into the wash straight.

There is also a need for proper drainage facilities complete with waste water monument and, for the chemical wash, waste retrieval using a clarifier or separator. It is also common to use re-circulating systems nowadays.

Washing machines may need a roof under certain conditions and they must be protected from adverse weather, particularly cold conditions. Freezing temperatures will play havoc (chaos) with the pipes of a poorly protected machine. Most railroad operators do not wash under freezing weather conditions.

Chemical washes are used for heavy cleaning and the chemicals used will often require the train to stand for some time while the chemical reacts with the dirt on the car body. Certain parts of car body must be protected against drips and the waste collected. In places where there is space, it is advisable to do the chemical wash where it is protected from the weather. Some form of ventilation is likely to be required. In some facilities, the chemical and water washes are contained in the same washing machine.

There are three types of machines:

- Manual
- Mobile gantry
- Drive through systems

(C) Equipment and processes

In the case of mobile gantry, the train is standing still while the

washer will move over or next to the cars. The opposite is true for the drive through system where the train will pass through the washer. Some drive-through-systems are bi-directional. Figures 1-14 are examples of the various train washer systems.

Pump choices are plentiful. Pumps can come packaged ready to be used or by the unit to be assembled by system integrators. Figure 15 depicts pictures of various vendors' pumps.

Spraying nozzle designs are plentiful along with the number of vendors who offer this equipment (Figure 16). There are also various spraying arches available (Figure 17) as well as various brushes (Figure 18).

There are many detergent manufacturers available who sell many types of products. There are two main categories available:

- Alkaline base
- Acid base

Each railroad and transit authority has their own supplier and brand.

(D) Water reclamation systems

Switching to water recycling doesn't have to be a draining experience! Reclamation isn't what most railroads have been getting for the last 20 years. They have been getting circulation systems that circulate the water and allow for a lot of germ growth. As we move forward, Railroads face many challenges regarding efficient, safe, environmentally friendly wash operation. One such challenge is

the reclaim and reuse of wash water. As state and local regulations become more and more stringent regarding water discharge, customers continue to search for simple, cost effective ways to meet these requirements.

The thought of adding a water reclaim system is a nightmare for some customers. They have heard horror stories about pit odors, endless hours of maintenance work and reclaim systems that just don't work properly. These customers would rather wait until laws require them to install reclamation systems than take the initiative themselves. Their fears are justified, unfortunately. Customers have been hit by systems that don't always do what brochures promise. But new technology has addressed these issues and with the right system, operators can avoid pitfalls.

Not only can railroads reduce water usage with reclaim, but they can enjoy lower water and sewer cost and take comfort in knowing that when the laws do require them to recycle water, they will be ready. Technologies have come a long way and there are systems on the market that can give you clean, odorless, hassle-free recycled water.

The general definition of reclaim is the process of treating water previously used in the wash and/or rinse cycles, for use in the wash process again. At a minimum, this process requires the separation of grit, oils, and greases in the water prior to reuse in the train wash. Additional treatment processes

include filtration, flocculation, oxidation, deodorization and de-ionization.

Customers need to ask themselves four questions before choosing a particular reclaim system:

- What are the contaminants?
- How much contamination is there?
- How much & how fast do I want to process the water?
- What do I intend to do with the treated water?

With the various water reclaim systems available, many companies have chosen to use a combination of methods for treating wastewater. Some systems are based on ozone recirculation and filtration process. Concerns: Ozone could be corrosive to the wash equipment and need to be applied properly. The system needs to keep the water moving at all times, sensitive to good maintenance.

Most reclaims facilities have traditional mechanical and chemical separation systems such as oil/water separators, filters, sedimentation and flocculation basins. Concerns: These mechanical systems are subject to high failure rates because a large percentage of oil, grease (emulsified by the wash soaps) and dirt can pass through an oil/water separator and/or pre-filter. The oil and dirt particles build up and eventually foul filter mechanisms, spray nozzles, pump impellers and other mechanical parts.

Chemical flocculation systems use specific chemicals to coagulate

and flocculate the organic particles, effectively removing them from the waste stream. Concerns: These chemical systems are extremely sensitive to pH levels, which are often subject to severe pH swings due to fluctuating soap and chemical concentrations and wash water volumes. Because of this, chemical flocculation systems are very difficult to maintain and control, requiring a high degree of operational and maintenance oversight without significant benefit.

Biological Treatment is a process of using bacteria and other biological enhancements under controlled conditions to convert organic compounds (in this case, oils, grease, solvents) to carbon dioxide, water and energy for cell production - with absolutely no harmful byproducts or residuals. The main requirements critical to any successful bio-treatment process include an active, healthy compound-specific biological population, oxygen, nutrients, and a balanced pH environment. Properly implemented, biological and enzymes remove oils, greases, nitrates and phosphates from the wash-water stream. This eliminates not only petroleum and surfactant compounds, but also "bad" bacteria, fungi and molds that can cause strong odors in washes.

Biological treatment even if it does not answer all reclaim problems, has distinct advantages over mechanical and chemical removal systems including:

- Complete degradation of both free and dissolved-phase

oil and grease components withing the wash water.

- Removal of regulated nutrient compounds (nitrogen, phosphorus) from within process water by utilizing it in the oil/grease degradation process.
- Effective odor control within wash systems through destruction of odor-causing organisms and contaminants.
- Minimal day-to-day maintenance, providing low cost, consistent oil wash-water treatment.

The success of a water reclaim system depends on the selection of the correct technology to deal with the variables at a particular site. These variables can cause a project to fail if they are not considered at the outset. The critical factors are:

- Concentration of contaminants.
- Procedures and chemicals used in the wash rinse process.
- Process temperature
- Volumes generated (gal day).
- Process flow rates required (gal. min).
- Availability of sewer or other method of discharge.
- Desired quality of reclaimed water and its intended use.

Railroads should expect increased maintenance time and possibly additional maintenance expenses after installing a reclaim system. The equipment requires sufficient space and plumbing. Railroads who choose to do the

least amount of treatment may have water color and odor concerns. Railroads need to understand how the system works and which chemicals are compatible with their system. Railroads who purchase soaps that are incompatible with their treatment systems will experience problems. In situations where labor comes in contact with the water, color and odor problems this will not be acceptable, and greater treatment levels are a must.

Before buying a reclaim system, Railroads need to do their homework and shop for a system that will perform as intended. Look for a system that makes sense to you and stay away from smoke-and-mirror sales tactics. If it sounds too good to be true, it probably is. There is no one product or technology that will deal with every wastewater issue. Some technologies will work at odds with others in an improperly designed system. The need to thoroughly understand the process and all of its aspects are essential to the successful design and operation of a water reclaim system.

Wastewater treatment is not about a thing that works or doesn't, it is much more about developing one or more treatment options into a process. This is especially true in the railroad industry where nothing is constant.

Examples of water reclamation systems are depicted in Figures 19-22.

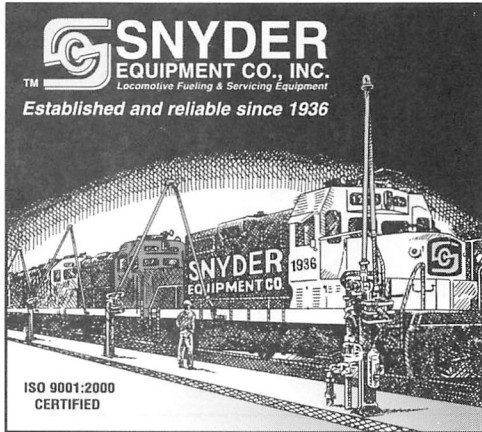
(E) Closing

- A properly designed train

wash system for railroads will remedy many bad current situations and improve system reliability.

- Technical solutions exist to give railroads acceptable overall results in terms of cleanliness.
- Best train wash for a Class I Railroad is still yet to be seen.

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EMD STYLE EXHAUST FLEX JOINTS

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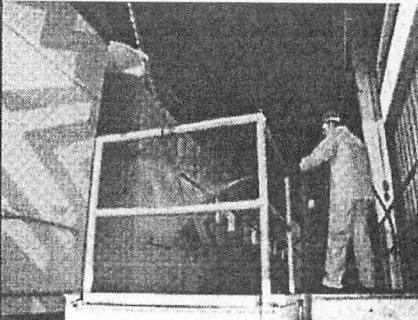
CUSTOM FABRICATION

1375 W. SNYDER BOULEVARD • NIXA, MO 65714 USA

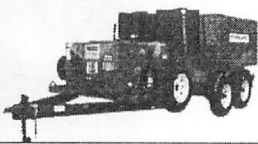
PH: 800-641-4512 • FX: 417-725-4846

www.snyderequip.com • E Mail: info@snyderequip.com

Manual Wash



- Manual Wash or rail car.

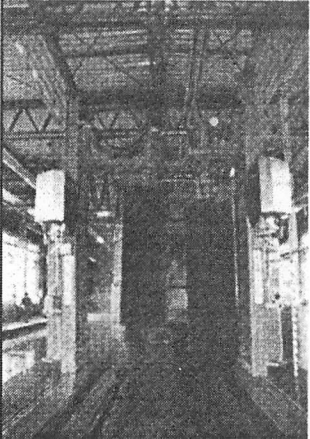


With Trailer Mounted Wash/Recovery System for UPRR

LMOA 2006 7

Figure 1

Mobile gantry



- LRV / Germany

LMOA 2006 8

Figure 2

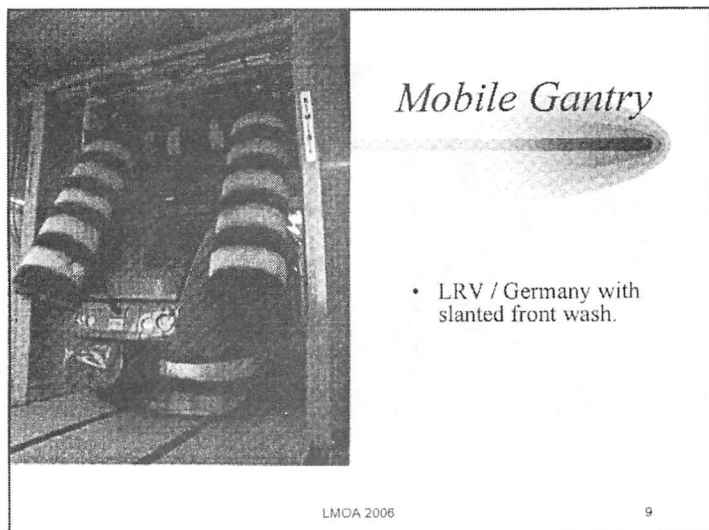


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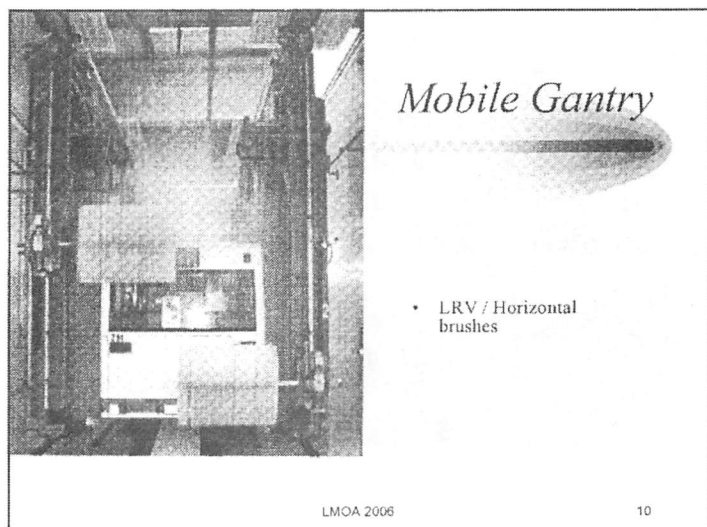


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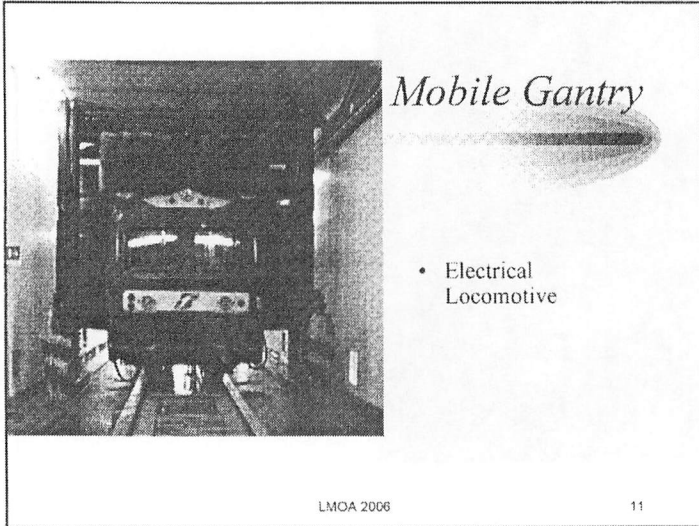


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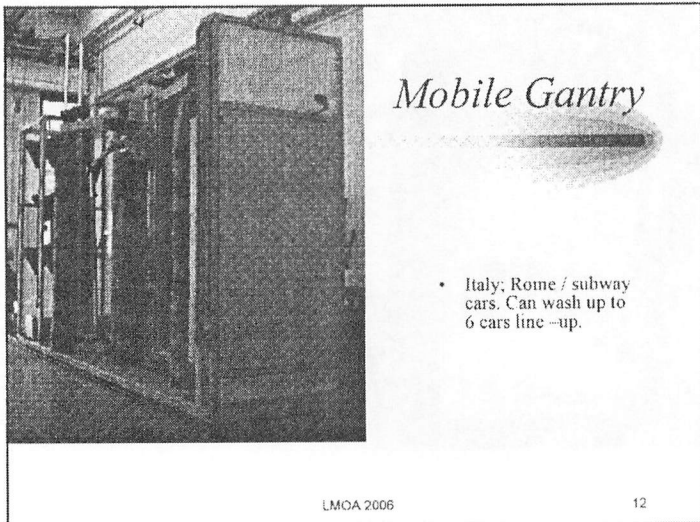


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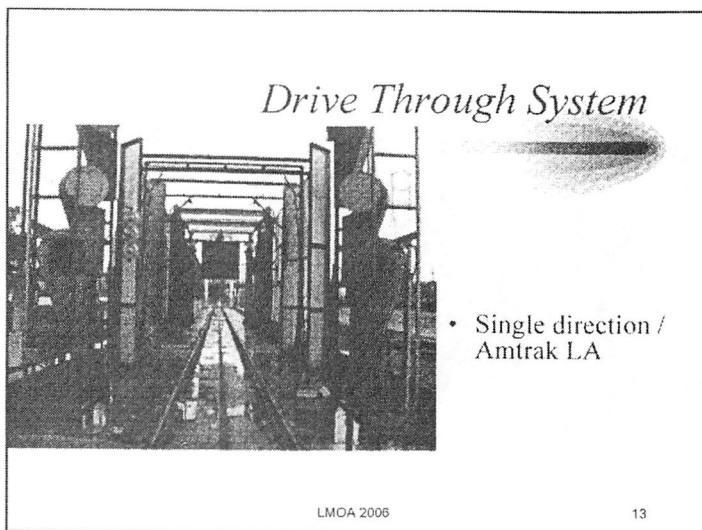


Figure 7

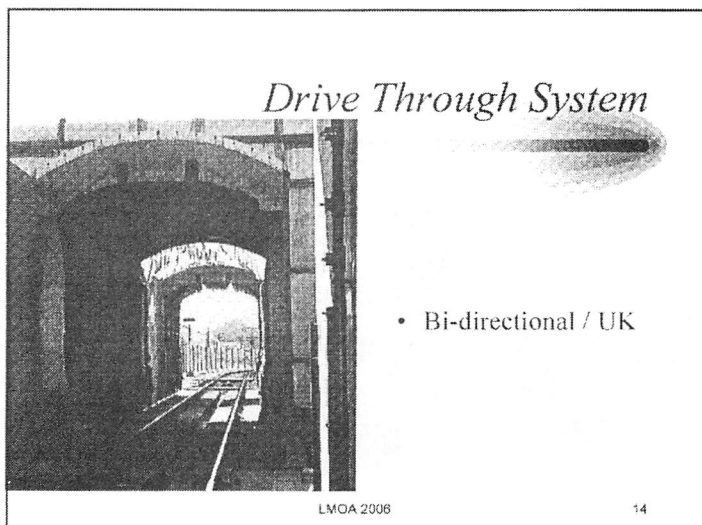


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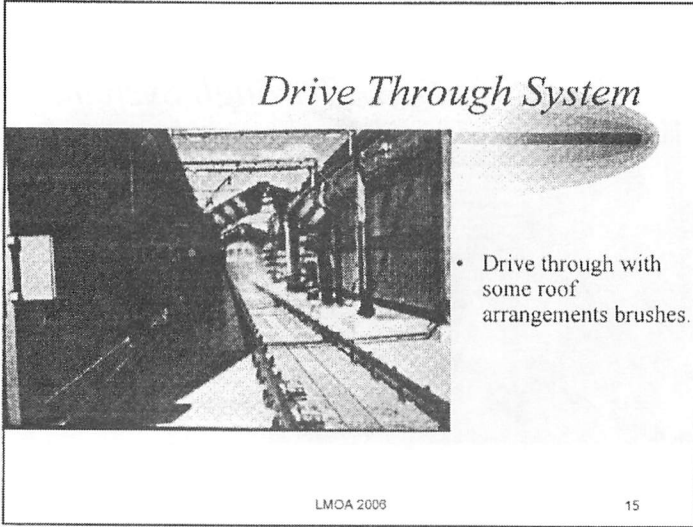


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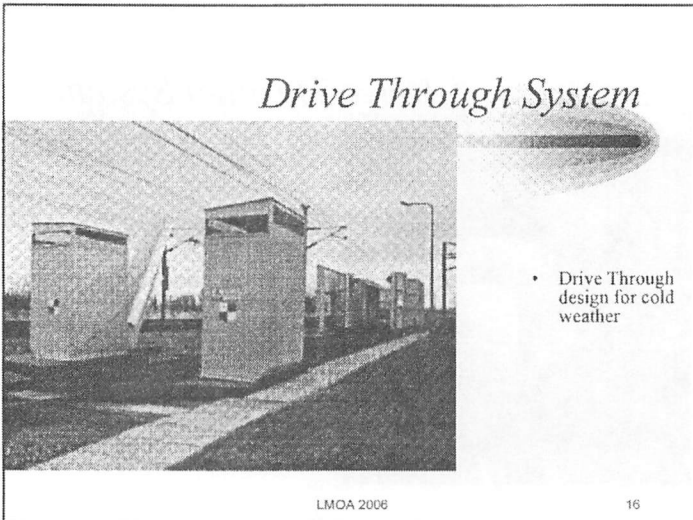


Figure 10

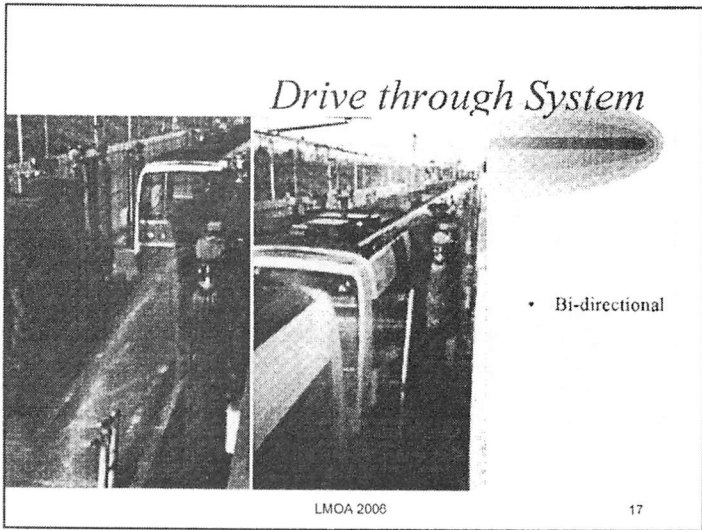


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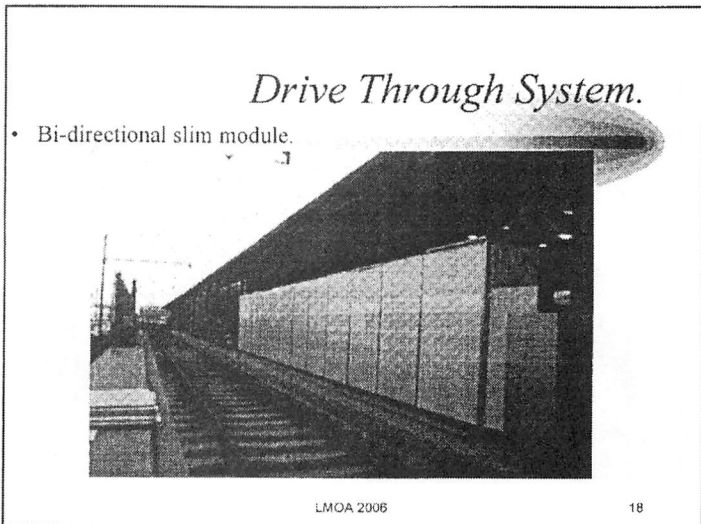


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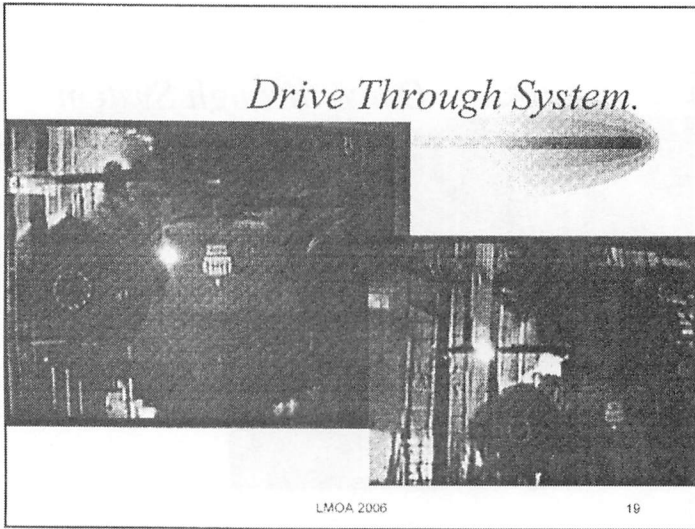


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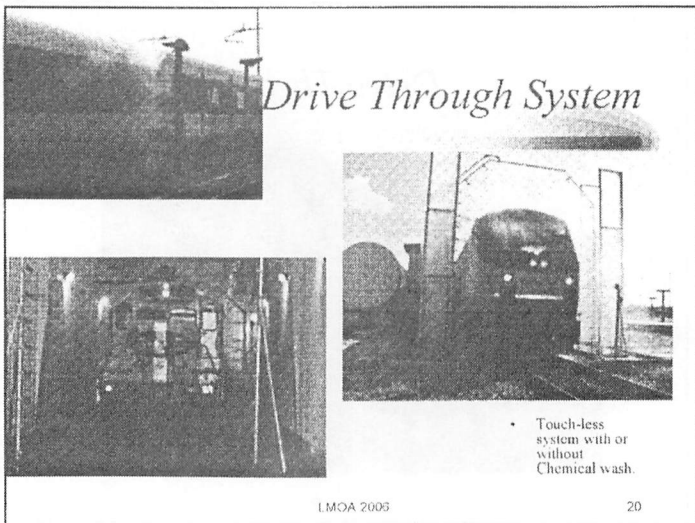


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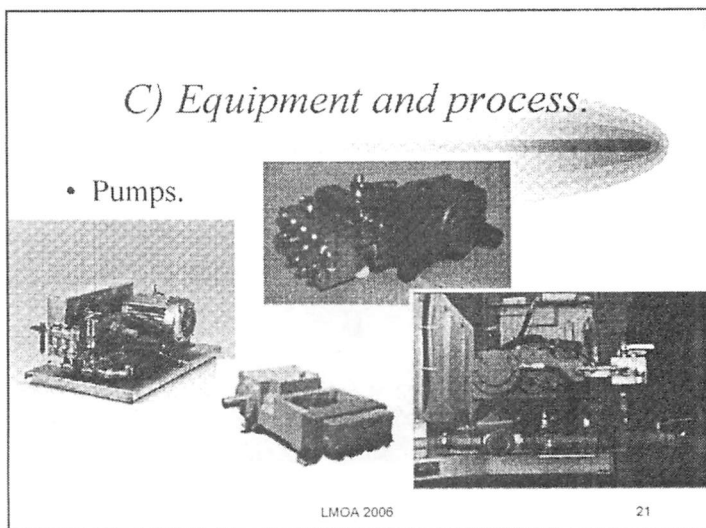


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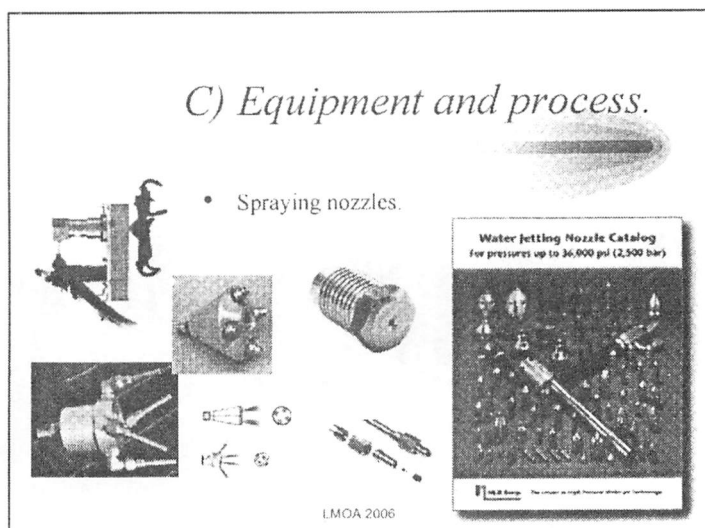
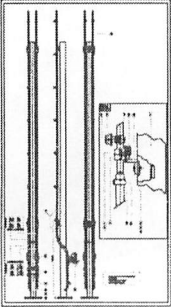
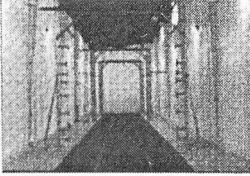
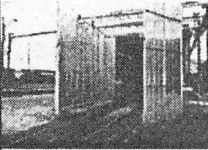


Figure 16

C) Equipment and process.

- Spraying arches:
 - Multiple design exist from Low to high pressure.
 - Shape will be custom to match rail car envelop.

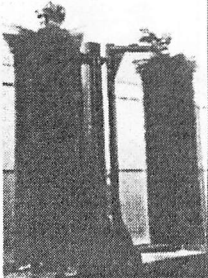
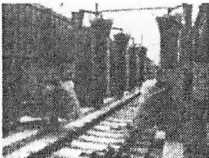
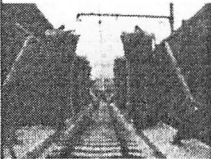


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Figure 17

C) Equipment and process.

- Brushes.



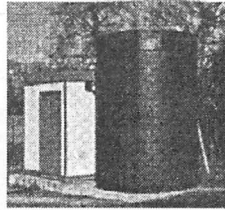
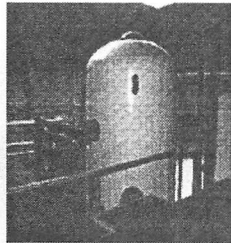
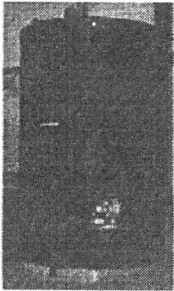
Double Set with lower drive Double Set with upper drive

LMOA 2006 24

Figure 18

D) Water Reclamation systems.

- Examples.



Bio reactors & sand filtration

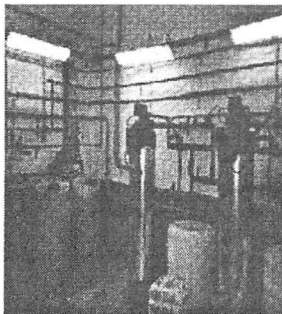
LMOA 2006

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Figure 19

D) Water Reclamation systems.

- Examples.



Water softener

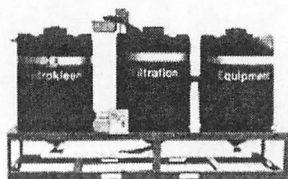
LMOA 2006

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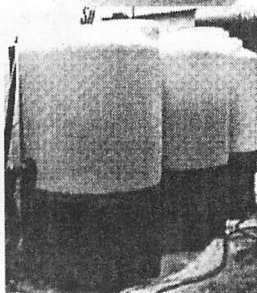
Figure 20

D) Water Reclamation systems.

- Examples.



Oil/water separator.



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Figure 21

D) Water Reclamation systems.

- Examples.

Soap mixing tank.



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Figure 22

3. ENVIRONMENTAL RAILROAD CONTAINMENT PRODUCTS

Prepared by

Ron Begier,

Portec Rail Products, Inc.

(Note:) This paper was presented at the 2005 convention

Introduction

The purpose of this presentation is to introduce new products that have been developed to assist the railroads in complying with the new STORMWATER MANAGEMENT REGULATIONS with its accompanying concern "SPILL CONTAINMENT."

Most storm sewer systems flow directly to the river. Some storm sewer systems flow directly to the ocean.

The basis of stormwater management

REGULATIONS: Stormwater management regulations are a key component of EPA's Clean Water Act.

OVERRIDING GOAL: Protect the quality of U.S. waterways by reducing the discharge of sediment, oil and chemicals into storm drains, surface water and groundwater..

WHO IS REGULATED: Three (3) main categories are now required by comply with these regulations:

A. Industrial (including railroads)
- a total of 450 Standard Industrial Classification Codes (SIC)

B. Municipalities

C. Construction Activities

DID YOU KNOW? Approximately 70% of all storm drains lead direct-

ly to open waterways, without treatment. 46% of all impaired rivers and lakes in the US are polluted due to uncontrolled stormwater runoff. A one quart oil spill causes a two acre oil slick.

In San Francisco, you can be fined \$25,000 for dumping oil into a storm drain. In 2004, Wal-Mart was fined \$3.2 million by the EPA for stormwater violations.

Key Stormwater Acronyms and Phrases

SWPPP - A "Stormwater Pollution Prevention Plan" is an erosion, sediment and waster chemical control plan. All regulated entities must file a SWPPP with the EPA to be granted a stormwater permit.

SWPPP's include

- Site description with a map
- A description of the sediment, erosion and polluted water controls used on-site, including stabilization and structural practices, such as seeding and catch basin devices, i.e. drain guards, track pans, etc.
- Descriptions of BMP's to control stormwater runoff.

BMP - "Best Management Practices" - include operating procedures and products to control site runoff, spills, leaks and drainage from raw material storage. When filing a SWPPP, a detailed description of BMP's planned for use at the site is required.

MEP - "Maximum Extent Practicable" - stormwater permits require that the discharge of pol-

lutants into storm drains be reduced to the “maximum extent practicable.”

NPDES - “National Pollutant Discharge Elimination System” - this is the technical name for EPA’s stormwater management regulations. Regulated entities must comply with NPDES, 40 CFR 122.26 (1999).

Non-Point Source Pollution - This term is synonymous with “stormwater runoff” . . . Unlike stormwater pollution, “point source pollution” can be easily attributed to a single source, such as a catastrophic leak from a storage tank.

Structural BMP’s - “things or products”

- Catch basin inserts
- Track pans
- Baffle boxes
- Filter Media
- Spill Containment Products
- Spill Response Products
- Spill Prevention Products

Non-structural BMP’s - “things that you do”

SPCC Regulations

SPCC

(Spill Prevention Control and Countermeasure Regulations). Regulate Petroleum: Focus is to prevent petroleum spills from reaching navigable waters.

WHO IS REGULATED? Owners of aboveground oil and gasoline storage tanks, which includes railroads

A. Facilities with a total of 1320 gallons of total aboveground petroleum storage capacity.

B. Facilities that drill, produce, gather, store, use, process, refine, transfer, distribute or refine oil products.

There are many products on the market which will enable the railroads to comply with the Stormwater Pollution Prevention Plan (SPPP).

One of these products is track pan - they are modular and are 53.5” in length - they can be ordered in any length in 53.5” increments. These pans are easily connected “end to end” with flow-through, bulkhead fittings (Figures 1-5).

Another manufacturer offers pans in HDPE enviropan, concrete or steel - the drain must be positioned between the two pans (two pans per set). Enviropan is available in 30’ lengths and the concrete and steel versions are available in 15’ lengths (Figures 6-8)

A third manufacturer offers track pans in fiberglass which are available in 20’ or 40’ lengths (Figures 9 & 10).

Other products that comply with the Stormwater Pollution Prevention Plan (SPPP) are as follows:

- GTPlus Absorbent Track Mat which absorbs hydrocarbons but allows water to pass through (Figure 11)
- Catch-All Track Mat which collects grease but allows water to pass through (Figure 12)
- MatMate BarTender Grease Collection Pan - makes easy collection disposal of waste

grease around applicators - fits standard and extended length applicator bars and is disposable (Figure 13)

- DrainGuard Oil & Sediment Plus (Figure 14)
- CutterGuard (Figure 15)
- Spill Deck Bladder System (Figure 16)
- Funnels (Figure 17)
- Drum Truck (Figure 18)
- Ultra Drain Seals (Figure 19)
 - Stop spills from going down the drain
 - Urethane construction allows the pad to deform and seal off most drains - temporarily “seals” to any smooth surface
 - Re-inforced mesh is “sandwiched” between layers of polyurethane - increases durability and resistance to tearing
- Spill Berms (Figure 20)
 - Seals off spills from the environment
 - Unique urethane material “weeps” into small cracks and crevices to seal off liquid flow

bers, and UltraTeck, one of our EnvironFORCE partners. Thanks to Portec Rail Products for allowing me the time to prepare this paper.

Summary

This paper’s objective was to identify the containment products available to alleviate environmental concerns caused by stormwater runoff and other types of spillage.

Acknowledge

I would like to acknowledge the cooperation and contributions I received from committee mem-



Figure 1

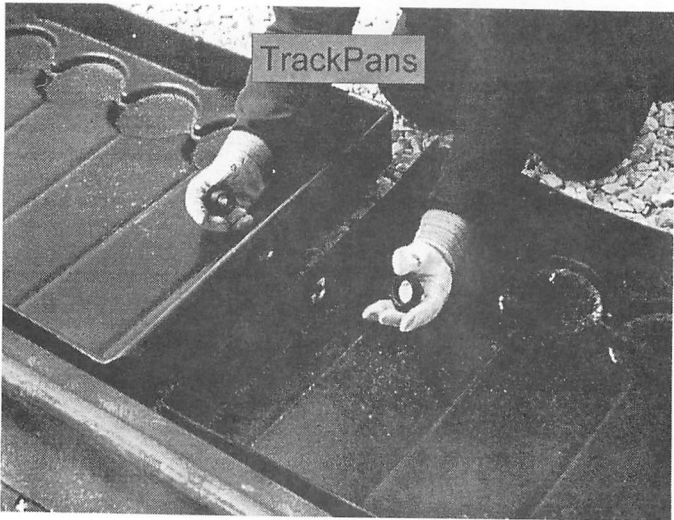


Figure 2

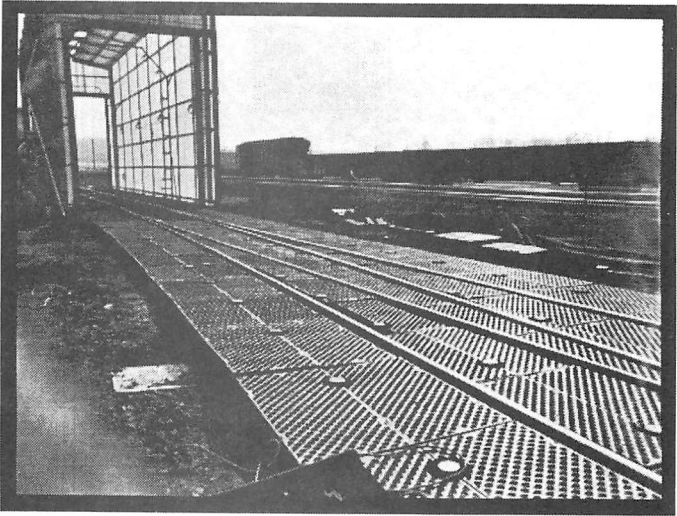


Figure 3

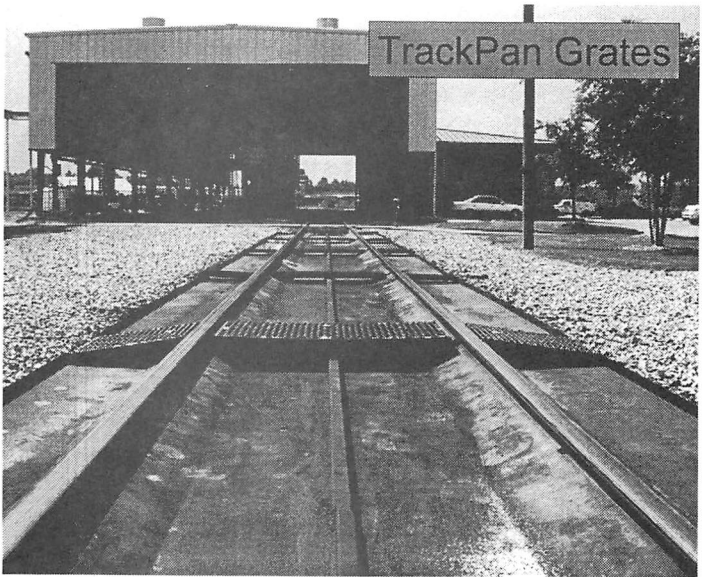


Figure 4



Figure 5

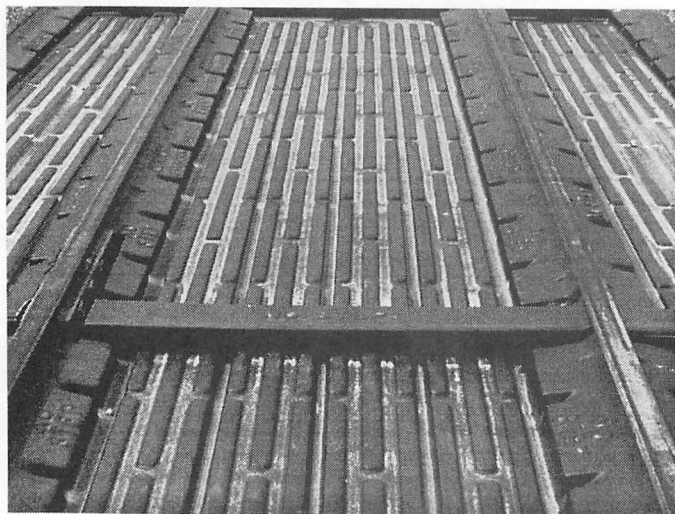


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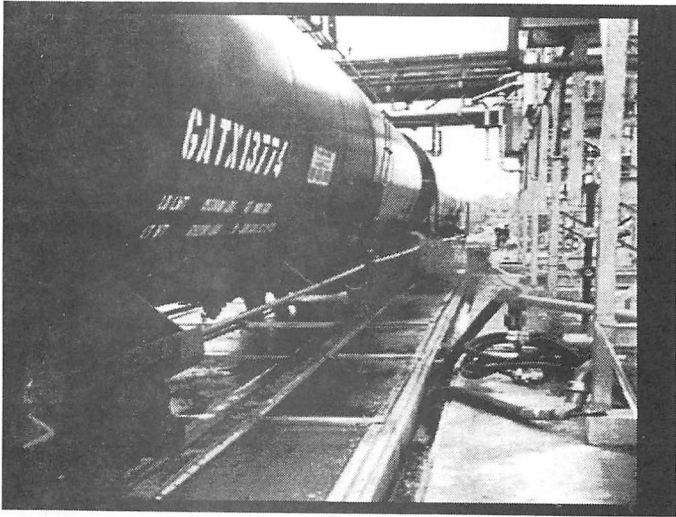


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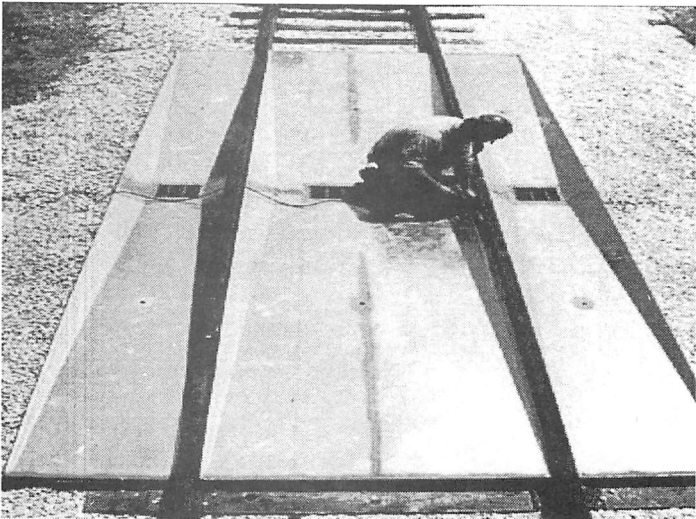


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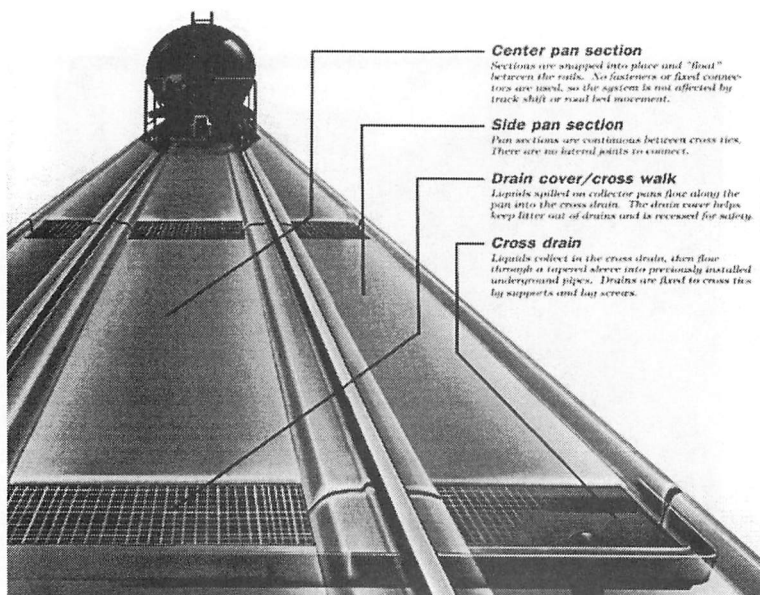


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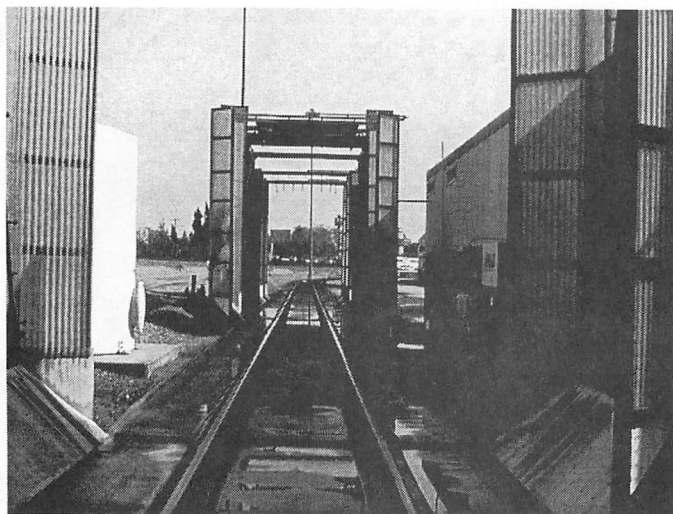
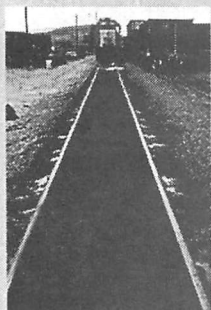


Figure 10

GTPlus™ Absorbent Track Mat

Locomotive Ready Site Soil and Ballast Protection



- Absorbs Hydrocarbons, allows water to pass through

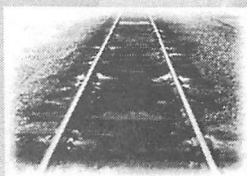
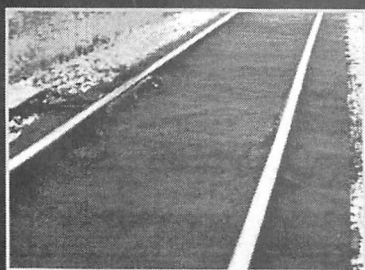


Figure 11

Catch-All™ Track Mat- Soil and Ballast Protector

Trackside Lubrication Site



- Collects grease, allows water to pass through

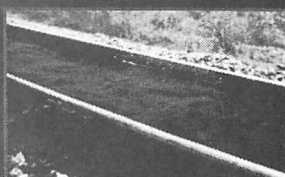


Figure 12



Figure 13



Figure 14

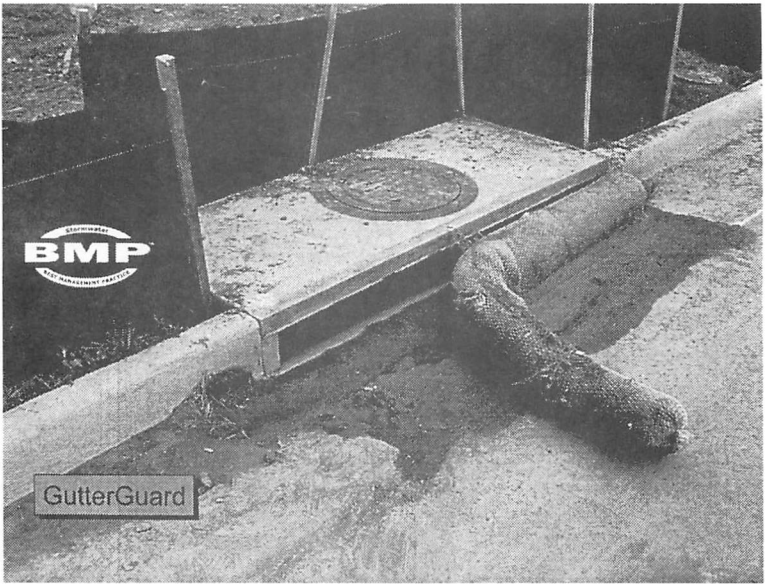


Figure 15



Figure 16

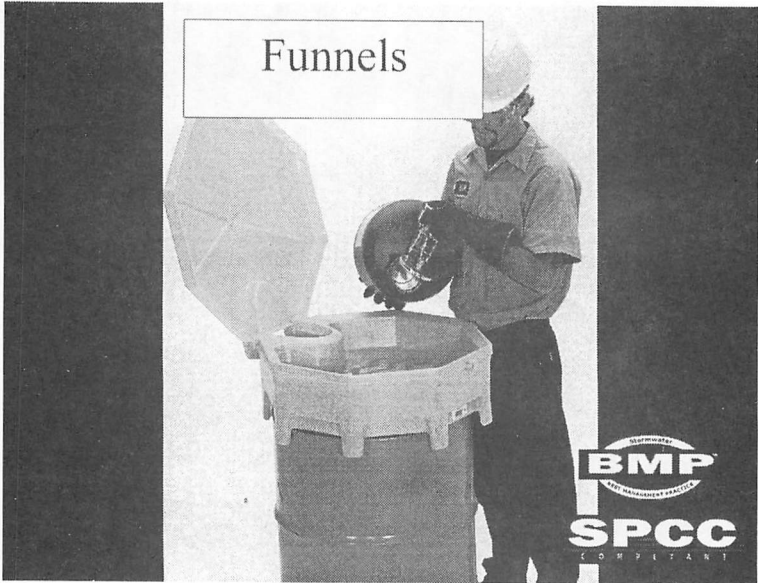


Figure 17



Figure 18



Figure 19

Spill Containment

Spill Berms Spill Response

- Temporary Berm Seals Off Spills From The Environment, Nearby Drains And Doorways
- Unique, urethane material "weeps" into small cracks and crevices to seal off liquid flow



SPCC
COMPLIANT



Figure 20



MOBITURN®
WHEEL TRUING SERVICES

Innovative Mobile Technology



Simmons Machine Tool Corporation (SMTC) is excited to announce its latest technological development in the North American market; "Mobiturn® Wheel Truing Services".

The Mobiturn® is a CNC mobile wheel lathe that maintains a variety of profiles ranging from light rail vehicles to locomotives. The Mobiturn provides customers with cost effective wheel truing as an alternative to their present wheel maintenance processes.

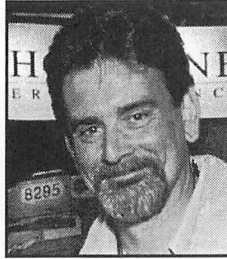
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jreynoso@smtgroup.com

**REPORT OF THE COMMITTEE
ON DIESEL MECHANICAL MAINTENANCE
MONDAY, SEPTEMBER 18, 2006
2:00 P.M.**



Chairman
DAVE RUTKOWSKI
Chief Mechanical Officer
Providence & Worcester RR
Worcester, MA

Vice Chairman
JEFF CUTRIGHT
Senior General Foreman
Norfolk Southern
Roanoke, VA

COMMITTEE MEMBERS

D. Agler	Dir.-Maint. Planning	KCS Railway	Shreveport, LA
I. Bradbury	President	Peaker Services	Brighton, MI
E. Burrier	Consultant	Ed Burrier & Assoc.	Roanoke, VA
T. Frederick	Mech. Engineer	CSX Transportation	Jacksonville, FL
R. Higuera	Field Engr.-Loco-W.	Amtrak	Los Angeles, CA
G. King II	Chief Mech. Officer	NYS&W RR	Binghamton, NY
R. Marchese	Operations Mgr.	Electro Motive Diesels	LaGrange, IL
T. Stewart	V.P. Engineering	Advanced Global Eng.	Atlantic Bch. FL
R. Svoboda	Mech. Compl. Off	METROLINK	Los Angeles, CA

Note: Please welcome the following new members:
Jim Hurst of Omnitrax, Don Freestone of Alaska RR
and Tom Kennedy of Union Pacific

PERSONAL HISTORY

Dave Rutkowski

In 1976, following enlistment in the United States Naval Reserve as an Aviation Machinist Mate, David began his railroad career. He started at the famous Reading Railroad Company in Reading, Pennsylvania, which was later transformed into one of the six conglomerated railroads known as Conrail. David started as a laborer and quickly accelerated into the apprenticeship program to become a Locomotive Machinist. In 1979, David accepted a Locomotive Machinist Leader position in King of Prussia, Pennsylvania. David moved back to Reading, Pennsylvania in the beginning of 1981, and later that year he was furloughed. After applying at numerous railroads, the Alaska Railroad offered him a position in early 1982. David drove his pickup truck loaded with tools from Reading, Pennsylvania to Anchorage, Alaska with a fellow machinist. David worked at the Alaska Railroad for 17 years where he held the following positions: Machinist Leader, Foreman of the General Repair Shop, Wheel Shop Supervisor, and Diesel Shop Supervisor. While with the Alaska Railroad, David was the General Chairman of the IAM Local

General 1735, where he negotiated with management on union contracts and also became the Assistant Terminal Superintendent for the Anchorage Yard which helped him gain transportation experience.

David wanted to return to his roots on the East Coast and became Chief Mechanical Officer for the St. Lawrence and Atlantic Railroad in Auburn, Maine in 1999. In 2001 the Providence and Worcester Railroad, headquartered in Worcester, Massachusetts, made an offer for David to become their Chief Mechanical Officer. He accepted and has been with Providence and Worcester ever since. David is active in both regional as well as national railroading - David has participated in the LMOA since 1999 and is the current President of the New England Railroad Club in Boston, Massachusetts. David also gives his time to local charities through his participation in the Central Massachusetts United Way Loan Executive program.

David and his wife, Katarina, have a seventeen year old son and reside in Pomfret, Connecticut.

**THE DIESEL MECHANICAL
MAINTENANCE COMMITTEE**

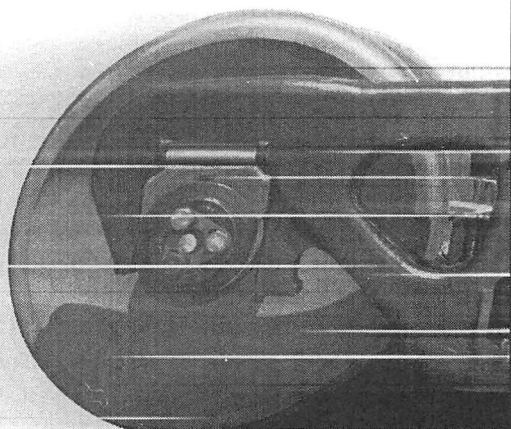
**WISHES TO EXPRESS THEIR
SINCERE APPRECIATION
TO NATIONAL RAILWAYS VMV
FOR HOSTING
THE COMMITTEE'S MEETING IN
PADUCAH, KY ON MARCH 13, 2006**

**SPECIAL THANKS TO JIM GOSA,
REGIONAL SALES MANAGER**

**THANKS FROM THE
MECHANICAL COMMITTEE**

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- Side frames
- Bolsters
- Constant contact side bearings
- Couplers
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- Center plates
- Draft gears
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- Cushioning units
 - End-of-car
 - Center-of-car
- Wheels, curved-plate, heat-treated
- Roller bearings



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I. LOST OPPORTUNITIES OF REBUILDING TRUCKS

*Prepared by
George W. King
Chief Mechanical Officer
New York Susquehanna &
Western RR*

Introduction

This topic discusses opportunities to avoid locomotive truck conditions that lead to non compliance with regulatory standards, safety concerns and operating conditions.

Most carriers have established criteria for rebuild/overhaul/refurbishment of locomotive truck assemblies. With a finite supply of capital funds the dollars typically are spent by train assignment.

- Road
- Branch/local
- Yard

Outside of the major carriers, that breakdown often becomes meaningless as the same unit will operate in a variety of assignments throughout its existence.

In the real world, money is not always available for the traditional scheduled overhaul of truck assemblies.

The locomotive truck assembly receives tremendous stress and punishment in the course of duty. Not only does it support the weight of the unit, it also provides the mechanism for translating electrical power into acceleration, movement and braking.

Locomotive trucks are composed of bolsters, frames, spring rigging and a variety of pins/bushings and mechanical arrangements for brak-

ing.

The type of assignment will determine how much impact and wear the truck components receive. Locomotives involved in long haul road operations do not see the same type of wear to the brake rigging that local switchers and yard units do.

With higher duty cycles on rigging, pins and bushing, wear plates and friction devices, the units not dedicated solely to road service can and do experience higher rates of wear.

This wear will manifest over time into the following conditions:

- Misalignment of brake shoes
- Excessive lateral movement
- Brake strap wear
- Reduced wheel flange life
- Abnormal brake shoe/brake wear

The above conditions occur in all types of service albeit at different frequencies.

49CFR 232.10

General Rules: Locomotives

Provides the criteria that must be met as a minimum standard. In section (i) (1) it states in part, "Brake shoes must be properly applied and kept approximately in line with tread of wheels or other braking surfaces." This statement in itself is relatively straight forward as to the intent of the law. The advent of recessed tread shoes helps in meeting this requirement. However, all too often we are faced with severely worn pins/bushing in the brake head, lever or hangers which precludes compliance. This is where regulatory and

safety concerns come into play. This defect will cause the unit to be unavailable for service. By not correcting the condition before it reaches a critical state, we have missed an opportunity to be proactive. Another cause of misaligned brake shoes is levers and hangers damaged by derailments.

On clasp brakes there should be zero wear on the strap if mechanical conditions are correct. When wear is visible it should serve as an alarm that something is amiss. Excessive lateral motion is the primary source of brake strap wear. Other factors are bent hangers and levers not allowing for proper truck geometry. When this is observed we have another missed opportunity.

Excessive lateral motion also promotes a very expensive problem. That is accelerated flange thickness wear. This condition exhibits itself at various levels dependent upon speed, curvature and dedicated switching service. The price of wheel sets is in itself a motivating factor in keeping lateral within proper margins.

49CFR 229.63 Lateral Motion

States "The maximum allowed uncontrolled lateral motion between the hubs of the wheels and boxes, between boxes and pedestals or both. The limits are clearly defined as 3/4" except for the center axle of a three axle truck which is 1 1/4".

Excessive lateral motion is destructive to pedestal liners and jaws, brake straps, journal boxes and box adaptor, and rail and adversely affects ride quality. Routine maintenance

and scheduled inspection of lateral motion will prevent out of service time due to wear and tear issues. Trainmen are the first to experience lateral conditions that are excessive due to the fact that they occupy the unit while working or observe it in a trailing position. When lateral motion is not controlled it leads to severe truck hunting and oscillations that can be a major factor in derailments. This is especially true at higher track speeds. Motion that is in play at a track speed of 25mph will manifest itself in a violent fashion at 40mph. This missed opportunity can be quite time consuming to validate and correct. Thus out of service time for the unit increases while decreasing the ability to move customer cars. While on the subject of lateral motion, is it imperative that lateral is checked and adjusted if need be on Hyatt equipped TM combos? This is a good question when the center combo is replaced on a three axle truck. That position needs to travel farther when traversing a curve to keep truck dynamics proper. While I was assigned at a major shop for a Class 1 carrier some years back, I observed the drop pit lead man not checking lateral and merely writing in the dimension of 1/2" on all DP records. Food for thought.

Truck Springs

Truck springs are designed to support the weight of the locomotive on the bolster and thence by the coil springs located above the journal boxes. When spring effectiveness deteriorates due to age or breakage

the following areas are greatly affected.

- Ride quality
- Adhesion
- Truck component failure

49CFR229.65 Spring Rigging

Prescribes the minimum requirements for elliptical and coil springs to allow the locomotive to remain in service. Weak or defective spring rigging often leads to costlier repair issues at a later date. One of the most expensive and destructive consequences of non compliant springs are derailment due to improper loading, tracking and overall truck performance.

So what does the lost opportunities mean in the real world of railroading? Quite simply it is the lack of proactive action that leads to crew safety concerns, accelerated component wear, derailments and rail wear.

All too often mechanical forces are stretched to capacity while supplying motive power to move trains. Demand has risen dramatically in the past few years and the railroads are hard pressed to keep up with transportation of goods. Thus, in many instances we lose the opportunity to correct a short term item that becomes a long term defect. The missed opportunities involve detailed daily inspections and correcting matters when found. Mandated Federal 92 day inspection dates are an ideal time to perform the required maintenance that keep one from having a missed opportunity evolve into a major issue. Shop redlines, personnel issues, total count and the drive to increase avail-

ability can produce a negative side effect. Missed opportunities. Are you proactive or reactive in your approach to truck issues?



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2. GP/SD38-2S LOCOMOTIVE A NEW CLASS OF POWER

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Introduction

CSX Transportation has a new locomotive model running around the system. CSXT has recently converted several GP/SD40-2 locomotives to GP/SD38-2S locomotives, utilizing a different engine classification. These GP/SD38-2S locomotives are used primarily in local/branch line service, switching service, and hump service. As new higher horsepower locomotives are being acquired, older mainline locomotives are being cascaded down into switching service.

Discussion

The GP/SD38-2S locomotive has a unique engine design. The engine is a 16-645E2, 16 cylinder turbocharged/supercharged diesel engine with no aftercoolers. The turbocharger/supercharger is a modified EMD Part #9525597, utilizing a pinned or locked clutch design. In this type of service the engine output does not produce enough heat energy to spin a conventional turbine rotor assembly fast enough to come off the clutch, but uses the gear train to turn the rotor for a significantly higher air output of the impeller to increase the cylinders' air fuel ratio. This large increase in the air fuel ratio greatly improves the Brake Specific Fuel Consumption, BSFC of the engine.

The aftercoolers are not needed because the air is not being compressed as much as with the conventional turbocharger, therefore, does not heat up as much. Also changed on the engine are the governor and fuel injectors. The governor EMD Part #40010013 has a modified speed schedule much like that of a 567 series engine, which operates at 804 +/- 4 RPM in notch 8. The rack balances at only 1.08" in notch 8. The idle speed is 282 +/- 15 RMP and low idle speed is 235 +/- 4 RPM. The injector EMD Part #5229330 is a modified EMD Part #5229250 utilizing a 7-hole nozzle tip with openings of 0.011" in diameter for good atomization.

Background

Now, a little history about the turbocharger/supercharger. The early designs of the pinned clutch utilized six 1/2" x 1/2" keys, locking a mock camplate to the clutch support (see Figure 1). In order to keep costs low, the existing clutch support was annealed to approximately 48-52 Rc for the ease of machining the key ways. The mock camplate was machined from a piece of axle steel and then oil-hardened for added strength. Later designs from Engine Systems and Transpar, Inc. which eliminated the mock camplate had an integrated adapter support hub and high capacity sun gear (see Figure 2). In the GE/Engine Systems' latest design the standard sun gear mounts to a spacer hub that bolts to the turbine bearing support (see Figure 3).

Body

Currently, testing is underway of a new design, which eliminates the turbine blades, nozzle ring, and shroud, in an effort to lessen the cost of the rebuild. The pinned turbochargers/superchargers can be obtained from General Electric in Latham, NY and Transpar Inc. in Fort Edwards, NY. Consideration is underway for the removal of the exhaust screen to reduce back pressure and help scavenge the engine.

The primary criteria for consideration of the locomotive class conversion is that the turbocharger must be in a failed condition and needs to be replaced. This approach best utilizes a serviceable asset since turbochargers often fail. The work to be performed for the conversion is as follows: Remove the turbocharger Part # 9525597. Remove the injectors Part # 5229250. Remove the governor Part # 8483536. Remove the PF21 and TH14 modules. Remove the inlet and outlet aftercooler piping and both the left side and right side aftercoolers. Apply the pinned clutch turbocharger Part # 11T-01259. Apply the injectors Part # 5229330. Apply the governor Part # 40010013. Apply the PF11 module Part # 8461530 and the TH13 module Part #8460537. Apply the Hadady Part # 16509 aftercooler blanking plates and the gaskets to the aftercooler ducts (see Photo 1). Apply the Hadady Part # 16511 aftercooler piping blanking plates and gaskets (see Photo 2). Set the injectors rack length to the governor. Set the injector timing to 0 degrees Top Dead Center (TDC). Restencil

the class of power in the cab interior and on each side of the cab exterior. Self load the locomotive to assure performance.

Notch	RPM	MGV	MGA	Hp.
N-1	270RPM	120V	280A	75HP
N-2	348RPM	267V	625A	280HP
N-3	408RPM	360V	835A	450HP
N-4	495RPM	460V	1062A	700HP
N-5	565RPM	562V	1289A	1040HP
N-6	648RPM	668V	1519A	1450HP
N-7	720RPM	728V	1652A	1720HP
N-8	800RPM	800V	1812A	2100HP

The cascading down of 3000 horsepower locomotives to the 2200 horsepower category provides an alternative medium duty switcher locomotive. The pinned clutch arrangement provides a more fuel-efficient locomotive than the conventional roots-blown version. The material costs to perform the conversion are approximately \$20,000. The resultant locomotive is approximately 14% more fuel efficient and produces less smoke than the GP38-2. In switcher service, the increased horsepower of the GP40-2 provides no advantage over the GP38-2S as the real issue is adhesion to the rails at the lower speeds. A comparison of the GP40-2, GP38-2, and the GP38-2S locomotives for horsepower and fuel rates are shown in Figure 4. The GP40-2 consumes approximately 1180lbs/hr in Notch 8, the GP38-2 consumes approximately 910lbs/hr in Notch 8, and GP38-2S only consumes approximately 780lbs/hr in Notch 8.

The modified locomotive configuration will easily go 12 years between overhaul, compared with the current six or seven year interval

of GP/SD 40-2 overhaul. The intervals can be extended because of the significant reduction in cylinder firing pressure from 1500 PSI nominal to 1200 PSI nominal and the reduction in maximum speed from 900 RPM to 804 RPM. The 300 PSI lower firing pressure greatly reduces the wear on the piston rings and liner bore power assembly components. The lower maximum RPM reduces the wear on valve stems and valve guides and wear at the valve seats and thrust washers.

For CSXT the GP/SD 38-2S locomotives are Tier 0 Emission Certified in two engine family categories. The first category, 6CSXK0645E20 utilizes the 16:1 compression ratio piston. The second category 6CSXK0645E2X utilizes the 14.5:1 compression ratio piston. Performance testing for EPA Emission Certification was performed at Motive Power Industries in Boise, Idaho and at Southwest Research Institute in San Antonio, Texas. The locomotive's exhaust emissions were measured per the Federal Test Procedure, FTP, as specified in Section 92, Subpart B- Test Procedures, which explicitly define the acceptable methods and test equipment approved by the EPA, see Attachment.

Under these certifications the injectors are timed to 3 degrees After Top Dead Center (ATDC) see Figures 5 and 6. With this amount of retarded timing the peak cylinder firing pressures are even lower at approximately 900 PSI. This equates to even lower wear rates for the engine.

Future

At this writing we are evaluating the conversion of 16-645E3B and 16-645E3C engines to the pinned clutch design for additional GP38-2S locomotives.

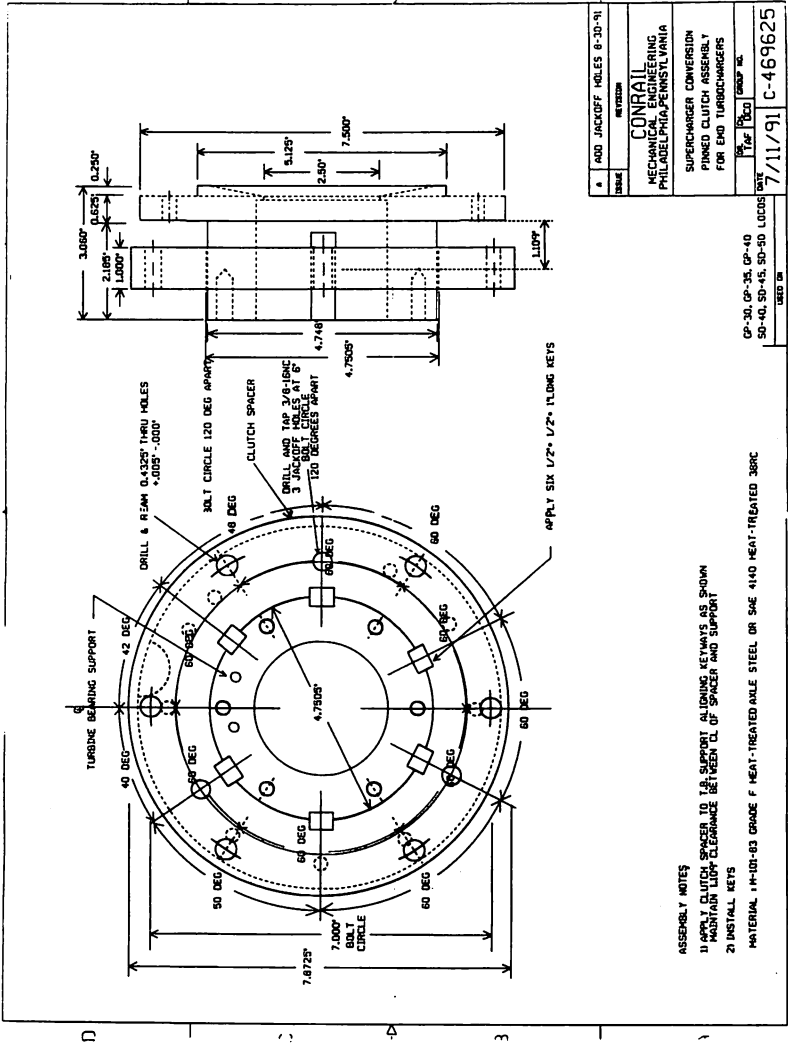
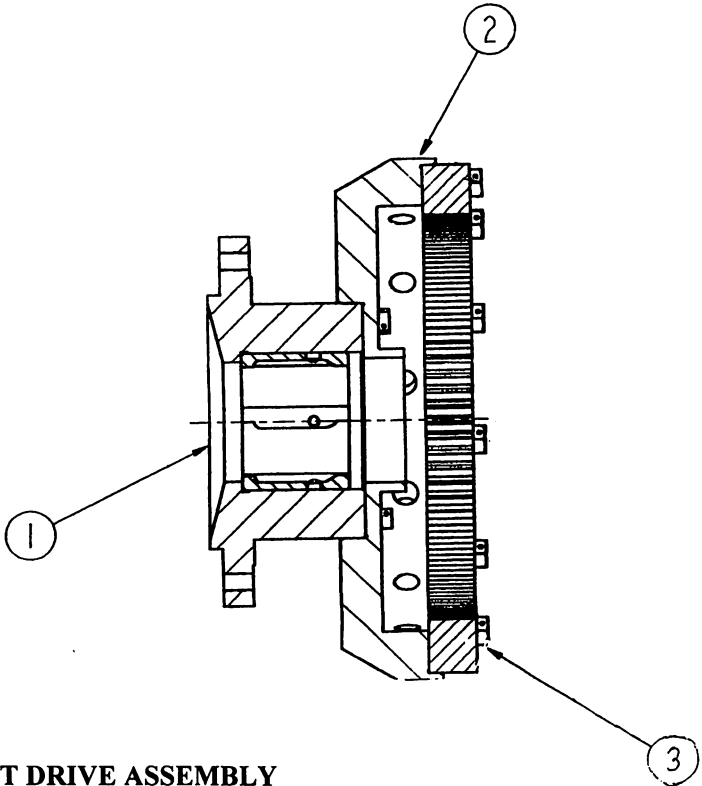


Figure 1



DIRECT DRIVE ASSEMBLY

1. CLUTCH SUPPORT
2. ADAPTER
3. RING GEAR

Figure 2

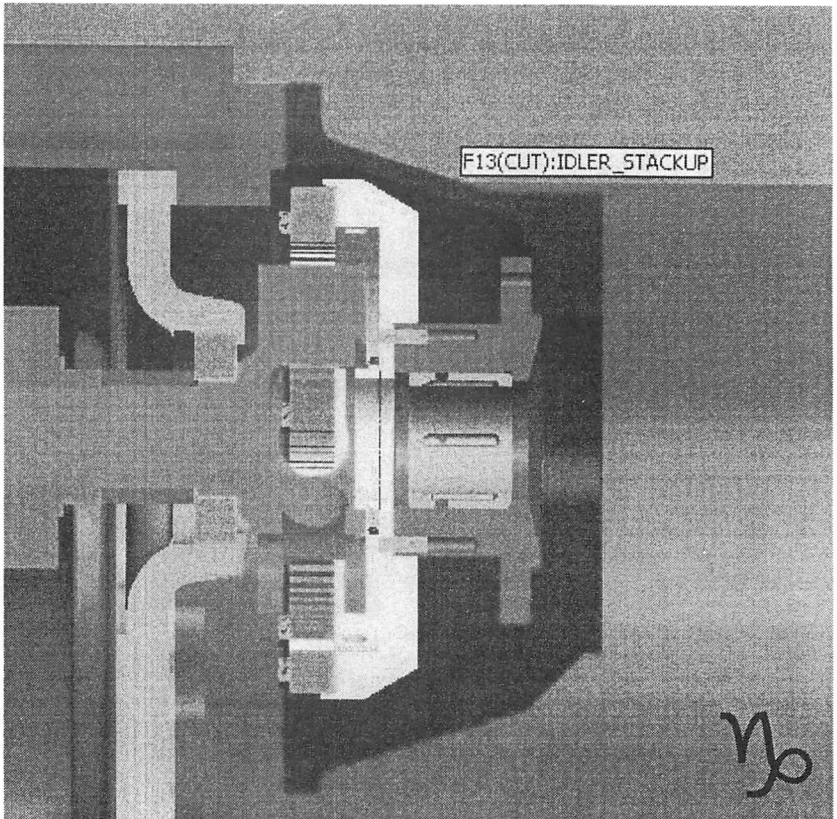
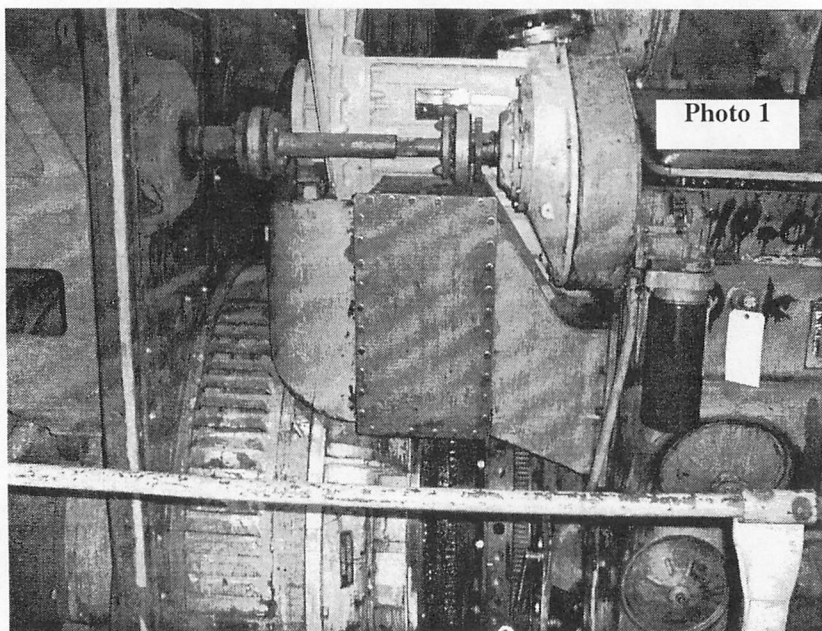
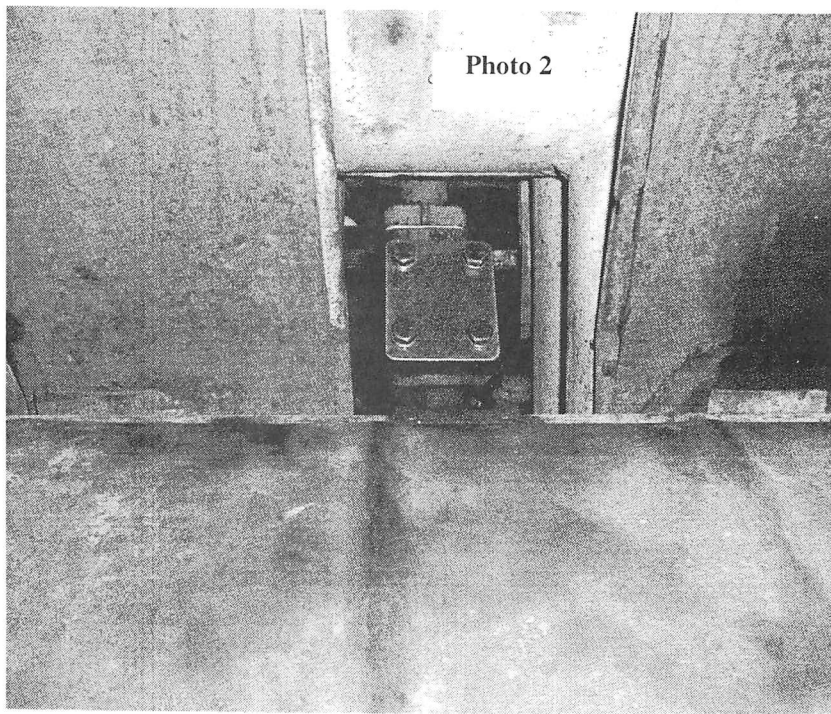


Figure 3





Performance Comparison
GP40-2 / GP38-2S / GP38-2

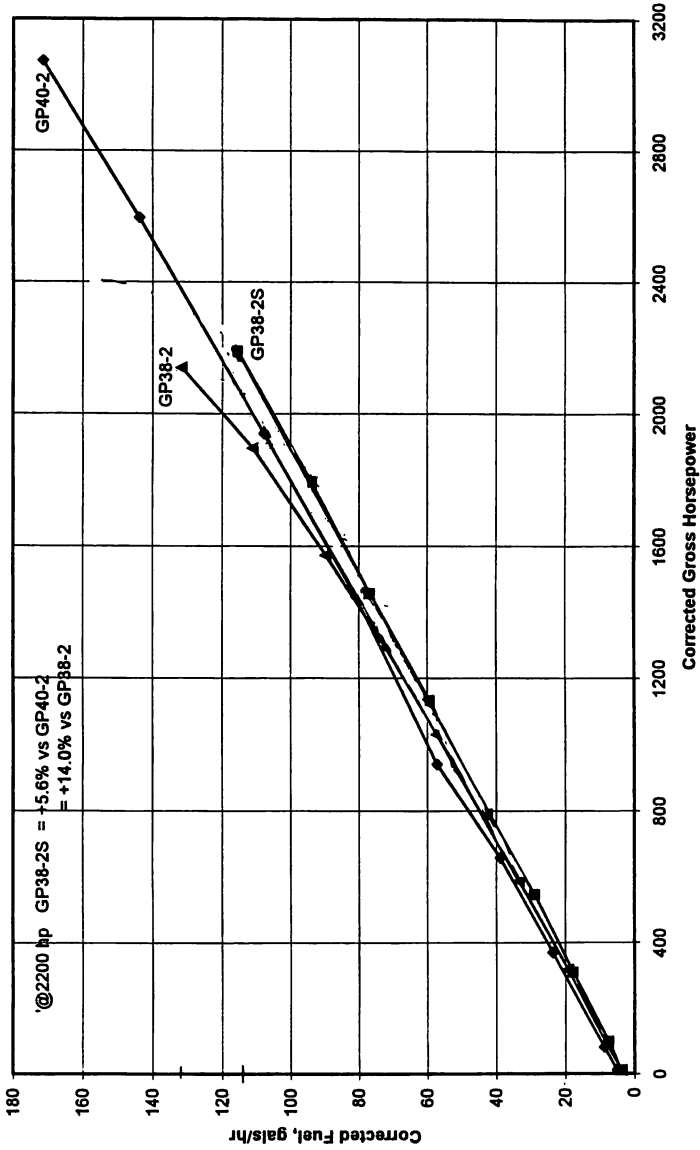


Figure 4

CSXT 6085 GP38-2S

9330 Injectors

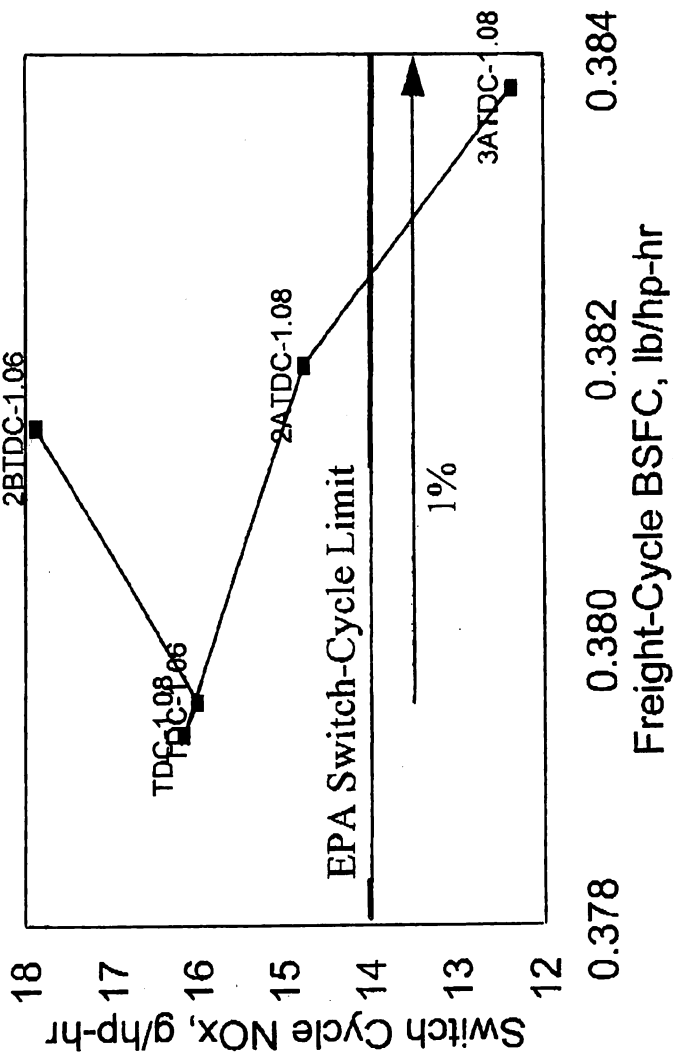


Figure 5

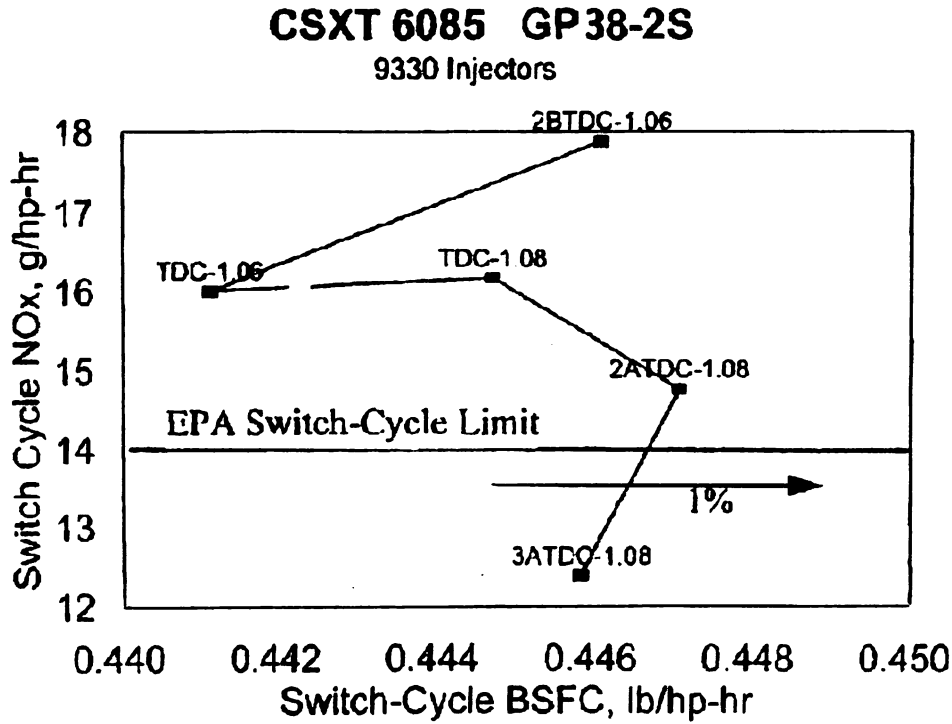


Figure 6

NOTCH 8

CSX 6355 GP38-2S (Test 1)

Date: 9/21/2005

		Average	Min	Max	Stdev	
<u>Ambient Conditions</u>						
AMB_1	Temp (F)	78.8	78.6	79.1	0.2	
PAMB	Barometric Pressure (inHG)	27.4	27.4	27.4	0.0	
RH	Relative Humidity (%)	26.0	25.6	26.4	0.2	
<u>Engine RPM/Power</u>						
ES	Engine RPM	806.3	806.2	806.4	0.1	
TS	Turbo RPM	NA	NA	NA	NA	
RACK	Rack Position	NA	NA	NA	NA	
INERTIAL_HP	Inertial Blower HP	8.5	8.5	8.5	0.0	
AUXG_HP	AUX GEN HP	4.0	4.0	4.0	0.0	
TRAC_B_HP	Traction Blower HP	57.5	57.4	57.5	0.0	
COMP_HP	Compressor HP	13.4	13.4	13.4	0.0	
FAN_HP	Fan HP	26.3	26.2	26.3	0.0	
MGAMP	Main Gen (AMPS)	1799.0	1782.6	1811.1	7.5	
MGV	Main Gen (Volts)	806.2	799.1	811.7	3.4	
MG_HP	Main Gen HP	2071.9	2034.9	2100.2	17.5	
BRHP	Brake HP (for Emissions Calculations)	2181.6	2144.5	2209.8	17.5	
CORR_HP	Corrected HP	2257.5	2219.3	2286.6	18.0	
<u>Fuel Consumption/Temps</u>						
TFin	Fuel Temp In (F)	86.6	86.3	86.7	0.1	
TFout	Fuel Temp Out (F)	90.0	89.8	90.2	0.1	
LOADCELL	Fuel Mass Burned (weight) lbs					
	Fuel Burned (Tank) (lbs/min)	13.249				
T1_TRK2	Compressor Inlet Temp (F)	76.7	76.6	76.7	0.0	
TEWIN_TRK2	Temp Water Into Engine - Right (F)	186.0	182.5	189.9	2.7	
TOIN_TRK2	Temp Oil Into Engine (F)	197.4	196.3	198.5	0.7	
		Average	Min	Max	Stdev	
<u>Emission Data</u>						
NOX	NOX (NO + NO2)	PPM	1106.7	1099.9	1115.2	3.4
CO	CARBON MONOXIDE	PPM	173.2	165.5	183.6	3.9
CO2	CARBON DIOXIDE:	%	5.65	5.61	5.70	0.02
O2	OXYGEN:	%	13.0	12.9	13.1	0.0
HC	HYDROCARBONS:	PPM	108.1	106.7	109.4	0.6

NOTCH 7

CSX 6355 GP38-2S (Test 1)

Date:

9/21/2005

		Average	Min	Max	Stdev	
<u>Ambient Conditions</u>						
AMB_1	Temp (F)	79.1	78.8	79.2	0.1	
PAMB	Barometric Pressure (inHG)	27.4	27.4	27.4	0.0	
RH	Relative Humidity (%)	26.0	24.6	27.5	0.6	
<u>Engine RPM/Power</u>						
ES	Engine RPM	715.6	715.0	715.8	0.1	
TS	Turbo RPM	NA	NA	NA	NA	
RACK	Rack Position	NA	NA	NA	NA	
INERTIAL_HP	Inertial Blower HP	6.0	5.9	6.0	0.0	
AUXG_HP	AUX GEN HP	4.0	4.0	4.0	0.0	
TRAC_B_HP	Traction Blower HP	40.2	40.1	40.2	0.0	
COMP_HP	Compressor HP	11.9	11.9	11.9	0.0	
FAN_HP	Fan HP	19.6	18.3	36.7	4.6	
MGAMP	Main Gen (AMPS)	1637.6	1634.9	1639.0	0.9	
MGV	Main Gen (Volts)	731.0	729.9	731.6	0.4	
MG_HP	Main Gen HP	1710.0	1704.8	1712.8	1.7	
BRHP	Brake HP (for Emissions Calculations)	1791.6	1785.2	1810.2	4.8	
CORR_HP	Corrected HP	1853.4	1846.4	1872.1	4.9	
<u>Fuel Consumption/Temps</u>						
TFin	Fuel Temp In (F)	85.7	85.3	86.0	0.2	
TFout	Fuel Temp Out (F)	89.6	89.5	89.7	0.1	
LOADCELL	Fuel Mass Burned (weight) lbs Fuel Burned (Tank) (lbs/min)	10.680				
T1_TRK2	Compressor Inlet Temp (F)	76.8	76.5	76.9	0.1	
TEWIN_TRK2	Temp Water Into Engine - Right (F)	185.2	183.8	187.0	1.0	
TOIN_TRK2	Temp Oil Into Engine (F)	193.6	192.2	195.0	0.8	
<u>Emission Data</u>						
NOX	NOX (NO + NO2)	PPM	1075.0	1067.7	1091.7	4.9
CO	CARBON MONOXIDE	PPM	123.0	116.9	146.2	5.1
CO2	CARBON DIOXIDE:	%	5.32	5.30	5.34	0.01
O2	OXYGEN:	%	13.5	13.4	13.6	0.0
HC	HYDROCARBONS:	PPM	92.7	90.9	96.6	1.0

NOTCH 6

CSX 6355 GP38-2S (Test 1)

Date:

9/21/2005

			Average	Min	Max	Stdev
<u>Ambient Conditions</u>						
AMB_1	Temp (F)		79.1	78.8	79.2	0.1
PAMB	Barometric Pressure (inHG)		27.4	27.4	27.4	0.0
RH	Relative Humidity (%)		26.3	26.0	26.5	0.1
<u>Engine RPM/Power</u>						
ES	Engine RPM		649.4	649.4	649.4	0.0
TS	Turbo RPM		NA	NA	NA	NA
RACK	Rack Position		NA	NA	NA	NA
INERTIAL_HP	Inertial Blower HP		4.4	4.4	4.4	0.0
AUXG_HP	AUX GEN HP		4.0	4.0	4.0	0.0
TRAC_B_HP	Traction Blower HP		30.0	30.0	30.0	0.0
COMP_HP	Compressor HP		10.8	10.8	10.8	0.0
FAN_HP	Fan HP		27.4	27.4	27.4	0.0
MGAMP	Main Gen (AMPS)		1501.3	1498.3	1504.7	1.3
MGV	Main Gen (Volts)		668.4	667.2	669.8	0.6
MG_HP	Main Gen HP		1433.5	1428.1	1439.9	2.5
BRHP	Brake HP (for Emissions Calculations)		1510.2	1504.7	1516.6	2.5
CORR_HP	Corrected HP		1562.6	1557.2	1569.4	2.6
<u>Fuel Consumption/Temps</u>						
TFin	Fuel Temp In (F)		86.5	86.3	86.7	0.1
TFout	Fuel Temp Out (F)		89.7	89.5	89.8	0.1
LOADCELL	Fuel Mass Burned (weight) lbs					
	Fuel Burned (Tank) (lbs/min)		9.069			
T1_TRK2	Compressor Inlet Temp (F)		76.5	76.3	76.8	0.1
TEWIN_TRK2	Temp Water Into Engine - Right (F)		176.9	174.7	179.9	1.6
TOIN_TRK2	Temp Oil Into Engine (F)		189.7	188.0	191.3	1.0
			Average	Min	Max	Stdev
<u>Emission Data</u>						
NOX	NOX (NO + NO2)	PPM	1034.8	1027.0	1040.9	2.6
CO	CARBON MONOXIDE	PPM	73.3	67.0	80.1	3.0
CO2	CARBON DIOXIDE:	%	4.95	4.94	4.97	0.01
O2	OXYGEN:	%	14.0	13.9	14.0	0.0
HC	HYDROCARBONS:	PPM	83.4	82.2	84.0	0.4

NOTCH 5

CSX 6355 GP38-2S (Test 1)

Date:

9/21/2005

		Average	Min	Max	Stdev	
<u>Ambient Conditions</u>						
AMB_1	Temp (F)	79.1	78.8	79.6	0.2	
PAMB	Barometric Pressure (InHG)	27.4	27.4	27.4	0.0	
RH	Relative Humidity (%)	26.6	26.1	26.9	0.3	
<u>Engine RPM/Power</u>						
ES	Engine RPM	565.5	565.4	565.7	0.1	
TS	Turbo RPM	NA	NA	NA	NA	
RACK	Rack Position	NA	NA	NA	NA	
INERTIAL_HP	Inertial Blower HP	2.9	2.9	2.9	0.0	
AUXG_HP	AUX GEN HP	4.0	4.0	4.0	0.0	
TRAC_B_HP	Traction Blower HP	19.8	19.8	19.8	0.0	
COMP_HP	Compressor HP	9.4	9.4	9.4	0.0	
FAN_HP	Fan HP	9.1	9.1	9.1	0.0	
MGAMP	Main Gen (AMPS)	1276.7	1274.8	1278.3	0.8	
MGV	Main Gen (Volts)	566.0	565.1	566.7	0.4	
MG_HP	Main Gen HP	1032.2	1029.2	1034.8	1.4	
BRHP	Brake HP (for Emissions Calculations)	1077.4	1074.4	1080.0	1.4	
CORR_HP	Corrected HP	1116.4	1113.2	1119.1	1.4	
<u>Fuel Consumption/Temps</u>						
TFin	Fuel Temp In (F)	89.1	89.0	89.1	0.0	
TFOut	Fuel Temp Out (F)	89.5	89.4	89.5	0.0	
LOADCELL	Fuel Mass Burned (weight) lbs					
	Fuel Burned (Tank) (lbs/min)	6.481				
T1_TRK2	Compressor Inlet Temp (F)	76.7	76.7	76.7	0.0	
TEWIN_TRK2	Temp Water Into Engine - Right (F)	179.0	178.3	179.4	0.4	
TOIN_TRK2	Temp Oil Into Engine (F)	185.5	185.3	186.1	0.2	
<u>Emission Data</u>						
NOX	NOX (NO + NO2)	PPM	870.1	862.7	877.7	3.5
CO	CARBON MONOXIDE	PPM	23.0	21.9	24.4	0.7
CO2	CARBON DIOXIDE:	%	4.07	4.05	4.09	0.01
O2	OXYGEN:	%	15.2	15.1	15.2	0.0
HC	HYDROCARBONS:	PPM	68.2	67.6	69.0	0.4

NOTCH 4

CSX 6355 GP38-2S (Test 1)

Date:

9/21/2005

		Average	Min	Max	Stdev	
<u>Ambient Conditions</u>						
AMB_1	Temp (F)	79.2	78.9	79.3	0.1	
PAMB	Barometric Pressure (inHG)	27.4	27.4	27.4	0.0	
RH	Relative Humidity (%)	26.4	25.8	26.8	0.3	
<u>Engine RPM/Power</u>						
ES	Engine RPM	497.3	493.3	499.3	2.0	
TS	Turbo RPM	NA	NA	NA	NA	
RACK	Rack Position	NA	NA	NA	NA	
INERTIAL_HP	Inertial Blower HP	2.0	2.0	2.0	0.0	
AUXG_HP	AUX GEN HP	4.0	4.0	4.0	0.0	
TRAC_B_HP	Traction Blower HP	13.5	13.2	13.6	0.2	
COMP_HP	Compressor HP	8.3	8.2	8.3	0.0	
FAN_HP	Fan HP	0.0	0.0	0.0	0.0	
MGAMP	Main Gen (AMPS)	1046.7	1046.3	1047.4	0.3	
MGV	Main Gen (Volts)	462.2	462.0	462.4	0.1	
MG_HP	Main Gen HP	691.1	690.6	691.8	0.3	
BRHP	Brake HP (for Emissions Calculations)	718.8	718.2	719.5	0.3	
CORR_HP	Corrected HP	744.7	744.0	745.4	0.4	
<u>Fuel Consumption/Temps</u>						
TFin	Fuel Temp In (F)	88.9	88.8	88.9	0.0	
TFout	Fuel Temp Out (F)	89.0	88.9	89.2	0.1	
LOADCELL	Fuel Mass Burned (weight) lbs					
	Fuel Burned (Tank) (lbs/min)	4.564				
T1_TRK2	Compressor Inlet Temp (F)	76.6	76.5	76.7	0.0	
TEWIN_TRK2	Temp Water Into Engine - Right (F)	170.9	170.3	171.3	0.3	
TOIN_TRK2	Temp Oil Into Engine (F)	177.3	177.2	177.3	0.0	
		Average	Min	Max	Stdev	
<u>Emission Data</u>						
NOX	NOX (NO + NO2)	PPM	668.5	661.7	673.8	2.4
CO	CARBON MONOXIDE	PPM	13.3	13.2	14.6	0.3
CO2	CARBON DIOXIDE:	%	3.11	3.09	3.13	0.01
O2	OXYGEN:	%	16.5	16.4	16.5	0.0
HC	HYDROCARBONS:	PPM	55.2	54.6	55.7	0.3

NOTCH 3

CSX 6355 GP38-2S (Test 1)

Date:

9/21/2005

		Average	Min	Max	Stdev	
<u>Ambient Conditions</u>						
AMB_1	Temp (F)	78.5	78.5	78.6	0.0	
PAMB	Barometric Pressure (inHG)	27.4	27.4	27.4	0.0	
RH	Relative Humidity (%)	26.9	26.7	27.1	0.1	
<u>Engine RPM/Power</u>						
ES	Engine RPM	409.4	409.1	409.6	0.1	
TS	Turbo RPM	NA	NA	NA	NA	
RACK	Rack Position	NA	NA	NA	NA	
INERTIAL_HP	Inertial Blower HP	1.1	1.1	1.1	0.0	
AUXG_HP	AUX GEN HP	4.0	4.0	4.0	0.0	
TRAC_B_HP	Traction Blower HP	7.5	7.5	7.5	0.0	
COMP_HP	Compressor HP	6.8	6.8	6.8	0.0	
FAN_HP	Fan HP	0.0	0.0	0.0	0.0	
MGAMP	Main Gen (AMPS)	829.3	828.7	829.9	0.3	
MGV	Main Gen (Volts)	364.8	364.6	365.0	0.0	
MG_HP	Main Gen HP	432.2	431.8	432.7	0.1	
BRHP	Brake HP (for Emissions Calculations)	451.6	451.2	452.1	0.1	
CORR_HP	Corrected HP	468.1	467.7	468.6	0.1	
<u>Fuel Consumption/Temps</u>						
TFin	Fuel Temp In (F)	88.8	88.7	88.9	0.0	
TFout	Fuel Temp Out (F)	88.9	88.8	89.0	0.0	
LOADCELL	Fuel Mass Burned (weight) lbs					
	Fuel Burned (Tank) (lbs/min)	2.990				
T1_TRK2	Compressor Inlet Temp (F)	77.5	77.5	77.5	0.0	
TEWIN_TRK2	Temp Water Into Engine - Right (F)	171.9	170.6	172.7	0.5	
TOIN_TRK2	Temp Oil Into Engine (F)	177.2	176.9	178.0	0.3	
<u>Emission Data</u>						
NOX	NOX (NO + NO2)	PPM	525.9	519.3	529.5	2.2
CO	CARBON MONOXIDE	PPM	14.7	13.5	15.8	0.2
CO2	CARBON DIOXIDE:	%	2.47	2.46	2.49	0.01
O2	OXYGEN:	%	17.3	17.3	17.4	0.0
HC	HYDROCARBONS:	PPM	51.2	50.5	51.8	0.3

NOTCH 2

CSX 6355 GP38-2S (Test 1)

Date:

9/21/2005

			Average	Min	Max	Stdev
<u>Ambient Conditions</u>						
AMB_1	Temp (F)		78.0	77.9	78.1	0.0
PAMB	Barometric Pressure (inHG)		27.4	27.4	27.4	0.0
RH	Relative Humidity (%)		28.2	28.0	28.4	0.1
<u>Engine RPM/Power</u>						
ES	Engine RPM		348.9	348.9	349.0	0.0
TS	Turbo RPM		NA	NA	NA	NA
RACK	Rack Position		NA	NA	NA	NA
INERTIAL_HP	Inertial Blower HP		0.7	0.7	0.7	0.0
AUXG_HP	AUX GEN HP		4.0	4.0	4.0	0.0
TRAC_B_HP	Traction Blower HP		4.7	4.7	4.7	0.0
COMP_HP	Compressor HP		5.8	5.8	5.8	0.0
FAN_HP	Fan HP		0.0	0.0	0.0	0.0
MGAMP	Main Gen (AMPS)		615.8	615.5	616.1	0.2
MGV	Main Gen (Volts)		269.6	269.6	269.7	0.1
MG_HP	Main Gen HP		237.2	237.0	237.3	0.1
BRHP	Brake HP (for Emissions Calculations)		252.3	252.2	252.5	0.1
CORR_HP	Corrected HP		261.4	261.2	261.5	0.1
<u>Fuel Consumption/Temps</u>						
TFin	Fuel Temp In (F)		88.7	88.7	88.8	0.0
TFout	Fuel Temp Out (F)		88.7	88.6	88.8	0.1
LOADCELL	Fuel Mass Burned (weight) lbs					
	Fuel Burned (Tank) (lbs/min)		1.849			
T1_TRK2	Compressor Inlet Temp (F)		76.3	76.1	76.6	0.1
TEWIN_TRK2	Temp Water Into Engine - Right (F)		163.7	163.4	164.5	0.5
TOIN_TRK2	Temp Oil Into Engine (F)		169.7	169.3	170.1	0.3
			Average	Min	Max	Stdev
<u>Emission Data</u>						
NOX	NOX (NO + NO2)	PPM	350.2	345.5	354.1	2.0
CO	CARBON MONOXIDE	PPM	16.6	16.1	17.6	0.4
CO2	CARBON DIOXIDE:	%	1.74	1.72	1.75	0.01
O2	OXYGEN:	%	18.3	18.3	18.4	0.0
HC	HYDROCARBONS:	PPM	45.2	44.6	45.8	0.3

NOTCH 1

CSX 6355 GP38-2S (Test 1)

Date:

9/21/2005

		Average	Min	Max	Stdev	
<u>Ambient Conditions</u>						
AMB_1	Temp (F)	76.6	76.5	76.6	0.1	
PAMB	Barometric Pressure (inHG)	27.4	27.4	27.4	0.0	
RH	Relative Humidity (%)	28.4	28.1	28.9	0.2	
<u>Engine RPM/Power</u>						
ES	Engine RPM	271.0	271.0	271.1	0.0	
TS	Turbo RPM	NA	NA	NA	NA	
RACK	Rack Position	NA	NA	NA	NA	
INERTIAL_HP	Inertial Blower HP	0.3	0.3	0.3	0.0	
AUXG_HP	AUX GEN HP	4.0	4.0	4.0	0.0	
TRAC_B_HP	Traction Blower HP	2.2	2.2	2.2	0.0	
COMP_HP	Compressor HP	4.5	4.5	4.5	0.0	
FAN_HP	Fan HP	0.0	0.0	0.0	0.0	
MGAMP	Main Gen (AMPS)	278.4	278.0	278.7	0.2	
MGV	Main Gen (Volts)	121.4	121.3	121.5	0.1	
MG_HP	Main Gen HP	48.3	48.2	48.4	0.0	
BRHP	Brake HP (for Emissions Calculations)	59.3	59.2	59.4	0.0	
CORR_HP	Corrected HP	61.4	61.2	61.4	0.0	
<u>Fuel Consumption/Temps</u>						
TFin	Fuel Temp In (F)	88.2	88.2	88.3	0.0	
TfOut	Fuel Temp Out (F)	88.9	88.8	89.0	0.1	
LOADCELL	Fuel Mass Burned (weight) lbs					
	Fuel Burned (Tank) (lbs/min)	0.780				
T1_TRK2	Compressor Inlet Temp (F)	75.7	75.7	75.7	0.0	
TEWIN_TRK2	Temp Water Into Engine - Right (F)	175.1	174.5	175.2	0.2	
TOIN_TRK2	Temp Oil Into Engine (F)	176.9	176.9	177.3	0.1	
<u>Emission Data</u>						
NOX	NOX (NO + NO2)	PPM	189.2	184.0	191.9	1.8
CO	CARBON MONOXIDE	PPM	19.4	19.0	20.5	0.4
CO2	CARBON DIOXIDE:	%	0.80	0.78	0.81	0.01
O2	OXYGEN:	%	19.7	19.7	19.7	0.0
HC	HYDROCARBONS:	PPM	41.5	41.2	42.1	0.2

DB

CSX 6355 GP38-2S (Test 1)

Date: 9/21/2005

		Average	Min	Max	Stdev	
<u>Ambient Conditions</u>						
AMB_1	Temp (F)	79.4	79.2	79.5	0.1	
PAMB	Barometric Pressure (inHG)	27.4	27.4	27.4	0.0	
RH	Relative Humidity (%)	25.6	25.5	25.9	0.1	
<u>Engine RPM/Power</u>						
ES	Engine RPM	493.2	493.0	493.4	0.1	
TS	Turbo RPM	NA	NA	NA	NA	
RACK	Rack Position	NA	NA	NA	NA	
INERTIAL_HP	Inertial Blower HP	1.9	1.9	2.0	0.0	
AUXG_HP	AUX GEN HP	4.0	4.0	4.0	0.0	
TRAC_B_HP	Traclion Blower HP	13.2	13.1	13.2	0.0	
COMP_HP	Compressor HP	8.2	8.2	8.2	0.0	
FAN_HP	Fan HP	6.0	6.0	6.0	0.0	
MGAMP	Main Gen (AMPS)	333.5	332.9	334.0	0.3	
MGV	Main Gen (Volts)	145.8	145.6	146.0	0.1	
MG_HP	Main Gen HP	69.5	69.3	69.6	0.1	
BRHP	Brake HP (for Emissions Calculations)	102.8	102.6	102.9	0.1	
CORR_HP	Corrected HP	106.5	106.3	106.7	0.1	
<u>Fuel Consumption/Temps</u>						
TFIn	Fuel Temp In (F)	88.9	88.8	88.9	0.0	
TFout	Fuel Temp Out (F)	89.7	89.6	89.8	0.0	
LOADCELL	Fuel Mass Burned (weight) lbs					
	Fuel Burned (Tank) (lbs/min)	1.541				
T1_TRK2	Compressor Inlet Temp (F)	77.3	77.2	77.3	0.0	
TEWIN_TRK2	Temp Water Into Engine - Right (F)	173.3	172.5	174.6	0.7	
TOIN_TRK2	Temp Oil Into Engine (F)	176.6	175.8	177.4	0.6	
		Average	Min	Max	Stdev	
<u>Emission Data</u>						
NOX	NOX (NO + NO2)	PPM	162.9	157.8	166.1	1.8
CO	CARBON MONOXIDE	PPM	23.4	22.2	23.8	0.2
CO2	CARBON DIOXIDE:	%	0.90	0.87	0.91	0.01
O2	OXYGEN:	%	19.5	19.5	19.6	0.0
HC	HYDROCARBONS:	PPM	40.0	39.5	40.6	0.3

Idle

CSX 6355 GP38-2S (Test 1)

Date:

9/21/2005

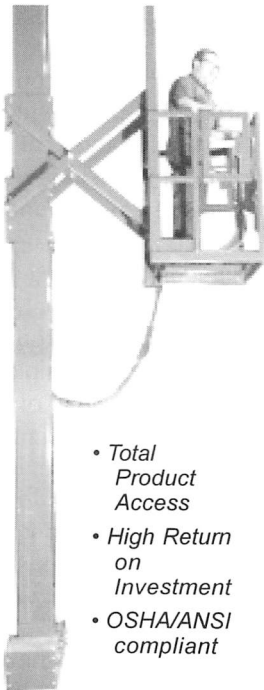
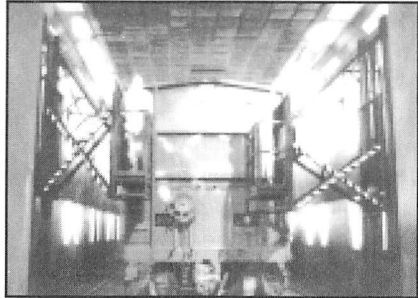
		Average	Min	Max	Stdev	
<u>Ambient Conditions</u>						
AMB_1	Temp (F)	74.3	74.2	74.5	0.1	
PAMB	Barometric Pressure (inHG)	27.4	27.4	27.4	0.0	
RH	Relative Humidity (%)	29.8	29.6	30.0	0.1	
<u>Engine RPM/Power</u>						
ES	Engine RPM	222.6	222.5	222.7	0.0	
TS	Turbo RPM	NA	NA	NA	NA	
RACK	Rack Position	NA	NA	NA	NA	
INERTIAL_HP	Inertial Blower HP	0.2	0.2	0.2	0.0	
AUXG_HP	AUX GEN HP	4.0	4.0	4.0	0.0	
TRAC_B_HP	Traction Blower HP	1.3	1.2	1.3	0.0	
COMP_HP	Compressor HP	3.9	3.8	3.9	0.0	
FAN_HP	Fan HP	1.5	1.4	1.6	0.0	
MGAMP	Main Gen (AMPS)	6.3	6.1	6.3	0.1	
MGV	Main Gen (Volts)	5.3	5.1	5.3	0.1	
MG_HP	Main Gen HP	0.0	0.0	0.0	0.0	
BRHP	Brake HP (for Emissions Calculations)	10.7	10.7	10.7	0.0	
CORR_HP	Corrected HP	11.1	11.1	11.1	0.0	
<u>Fuel Consumption/Temps</u>						
TFIn	Fuel Temp In (F)	88.4	88.3	88.4	0.0	
TFout	Fuel Temp Out (F)	87.5	87.5	87.6	0.0	
LOADCELL	Fuel Mass Burned (weight) lbs					
	Fuel Burned (Tank) (lbs/min)	0.363				
T1_TRK2	Compressor Inlet Temp (F)	74.1	74.0	74.3	0.1	
TEWIN_TRK2	Temp Water Into Engine - Right (F)	164.1	164.0	164.6	0.1	
TOIN_TRK2	Temp Oil Into Engine (F)	167.2	166.8	167.4	0.2	
		Average	Min	Max	Stdev	
<u>Emission Data</u>						
NOX	NOX (NO + NO2)	PPM	108.3	105.3	110.6	1.1
CO	CARBON MONOXIDE	PPM	38.7	35.1	38.0	0.9
CO2	CARBON DIOXIDE:	%	0.47	0.46	0.48	0.00
O2	OXYGEN:	%	20.2	20.2	20.2	0.0
HC	HYDROCARBONS:	PPM	44.5	44.0	45.0	0.3

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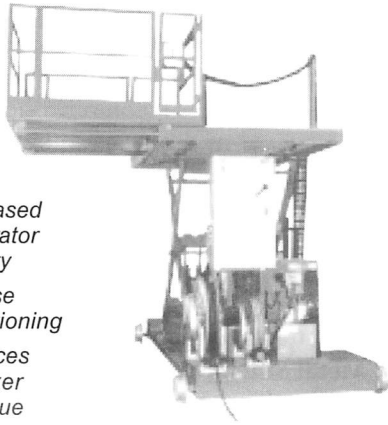
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3. HEAVY DIESEL ENGINE FIELD REPAIR

Presented by

Ian Bradbury

President

Peaker Services, Inc.

Introduction

This paper seeks to provide an overview of some methods available today for performing repairs on EMD and GE engines in the field. Some of the material is a recap of broadly known methods which will hopefully serve as a convenient reference. Additionally, it is hoped that some of the methods described will be new to the reader or will prompt new ideas of repairs which may be performed more cost effectively in place. In some cases, the repairs can be performed without removal of the engine from the locomotive. In others, removal of the prime mover is required, but the repair work can be performed locally (i.e. without sending the prime mover off railroad property).

Cast Iron Repair Metal Stitching or Locking

Metal stitching or metal locking is a method for performing repair of cast iron assemblies that have been cracked or had pieces broken out of them. In the case of crack repair, the general steps involved are illustrated in Figure 1 as follows:

1. A drilling fixture is attached at right angles to and above the crack. The fixture hole pattern is drilled and then repeated at intervals of 3/4" to 1 1/4" along the length of the crack.
2. The metal between each drilled

hole is removed by ripping it away with pneumatic tools to form a slot. The stock removed is narrower than the drilled hole, thus forming a serrated opening.

3. Preformed locks of high tensile alloy are inserted into each slot. These locks are peened into the slots, one on top of the other, to a depth limited by the casting thickness and determined by the strength required.

4. After the locks are installed, holes are drilled, tapped and threaded fasteners are applied. These are spotted along the entire length of the crack, overlapping one another. Their purpose, in part, is to fill the fracture with new metal and provide a pressure seal.

5. The entire repair area is then peened flush and finish ground.

A number of repairs effected by this method are illustrated at the end of this article. They include repairs of cracks in engine case mounting feet (Figures 2 and 3), the water jacket (Figure 4) and in the casting adjacent to the cylinders and valve seats (Figure 5). Whereas such repairs may be familiar, it is also possible to use similar methods for repair of castings which have had significantly large pieces broken out of them. In such a repair, the casting is cut to accommodate a steel fabrication which is stitched into place. This is illustrated by the replacement of an inspection window in Figures 6 and 7.

Such repair methods have been reliably employed to repair GE engine blocks which would otherwise have had to be replaced or scrapped.

In-place machining of crankshaft journals

A number of companies are able to provide in-place machining of crankshaft journals without disassembly of the crankcase. These methods were developed primarily for marine and large stationary engines. One method is illustrated in Figure 8. A turning basket is assembled and adjusted once onto a crank journal and then used as a tool holder for all measurement and turning operations. A frequency controlled motor is chain linked to the turning basket and turns the entire basket and enclosed tool. The pictured design is adjustable to pins from 175 to 370 mm (6.9 to 14.5 inches). This turning basket design allows installation and dismantling in very tight spots without the need for lifting equipment or other supports.

The tools are mounted on the tool holders of the turning basket. Left and right facing tools are available in order to enable machining close to the walls and supports of the turning basket. Sideways movement of the tool (along the surface of the crank pin) is mechanized, requiring no manual intervention. For polishing and superfinishing of the radius fillet and the crank pin surface, pneumatic tools are mounted on the turning basket. Polishing and superfinishing of lubricating holes is also included in the process. Figure 9 shows an alternative design for in-place machining of crank journals of diameters 6-14 inches. In place machining of crankshaft main journals is also possible. This is performed by removal of the main bearing cap and

main bearings. The machine is then mounted to the underside of the A-frame. The machining fixture cannot rotate around the main bearing journal as with the machining of connecting rod journals. In this case, rotation of the crankshaft is required. In a number of such cases, it is necessary to fit oversize bearings after machining is complete. Custom designs can be poured on-site. Whereas it is sometimes possible to perform journal machining repairs on GE induction hardened cranks, it is never advisable with GE nitrided crankshafts due to the shallowness of the surface hardening. Other related in-place machining possibilities are facing of crankshaft flanges and flywheel fit refacing. It is also possible to cold straighten a crankshaft within the engine.

Integral Stubshaft Replacement

If the integral stubshaft on an EMD crankshaft is damaged, but the crank is otherwise serviceable, this repair can be performed without removal of the crankshaft from the engine.

Figure 10 shows an exploded view of the accessory drive gear assembly for an EMD engine that has an integral stub crankshaft. To perform the repair, this assembly is removed and the hub is discarded. The damaged integral stub is then sawn off the end of the crankshaft, leaving 7/16" or less of the stub shaft as a pilot for the inner disc, as shown in Figure 11. It is not necessary for the cut to be machine finished, but it should be clean enough to avoid interference with the bolt on stub assembly. Figure 12 shows a schematic of the

replacement bolt on stubshaft. The bolt on stubshaft locates on the dowels that pass through the inner disc and is held in place by the four through-bolts of the accessory drive assembly. The bolt on stub assembly generally has about 0.060" clearance from the vestigial stub. It is necessary to center the new assembly. This can be achieved by a variety of methods, including application of a custom fit sleeve to the vestigial stub.

EMD Crankcase Field Weld Repairs

For convenience of reference, a condensed version of general weld instructions for the field repair of EMD engine crankcase follows:

1. The EMD crankcase & oil pan is a welded steel assembly of rolled stock and various forgings and is therefore weld repairable at room temperature (>60°F) - no special pre or post heat treatment is normally required.

2. The crankcase is furnace stress relieved and machined to close tolerances, so welding should be kept to the minimum possible to help minimize distortion and residual stresses. All welds should be kept cool with wet rags or forced air.

3. Fire extinguishers should be available in the repair area and it is recommended that a person be on hand at all times to act as a fire watch. Appropriate PPE should be worn by personnel in the work area. A ground cable in the repair area is required for the welding machine if it's used as a power source for magnetic particle inspection.

4. A thorough initial inspection via

Magnaflux should be performed to identify and mark the extent of cracks and defects.

5. Vulnerable parts should be safely protected from grinding dust, dirt, chips, weld splatter etc. (by welding blankets, for example)

6. Drill small holes at the end of each crack to help prevent further crack propagation.

7. Completely remove the crack, chamfer appropriately and clean thoroughly. Residue from the crack removal can result in inclusions or porosity leading to further cracks. Verify complete crack removal by Magnaflux. Apply back up plate as needed.

8. Ground the welder as close to the work as possible; never through rotating parts.

9. 100% penetration Root pass with AWS-E-6010 or E-6011; no peening (due to the high likelihood of re-cracking); Magnaflux to verify no cracks from weld joint restraint or beyond the drill holes remain.

10. Finish passes with AWS-E-7016 or E-7018; 2"-3" at a time (overlapping); needle peen immediately except final pass, which should be peened $\leq 300^{\circ}\text{F}$. Allow each pass to cool to $\leq 150^{\circ}\text{F}$ and thoroughly clean before next pass. Needle peening at higher temperatures provides stress relief for distortion control, peening below 150°F imparts beneficial compressive stresses to the surface of the weld to help reduce the likelihood of re-cracking.

11. Grind off any sharp corners and undercuts $>1/32"$ as these can provide stress risers, and repeen

(grinding removes beneficial compressive residual stresses of $\leq 300^{\circ}\text{F}$ peening). Mangnaflux for final verification of all crack removal

Numerous weld repairs can be performed in the field, many of which are identified in the EMD M.I. The following describes some of the most common field repairs

A common occurrence following an EMD power assembly failure is for the connecting rod to damage the adjacent piston (oil) cooling manifold. An example of such damage is illustrated in Figure 13. The picture was taken with the pan removed, but repair of such damage can occur with the oil pan in place through the pan window. Fire prevention and protection of critical areas is especially important for performing this repair. Cleanliness is also critical in the areas being welded, and difficult to maintain in this environment. The damaged section of manifold is removed and 3/8" and 3/16"-1/4" sections of pipe are ground out of adjacent undamaged brackets to accommodate the replacement tube span. A locating bar must be used to line up the new brackets and tube being installed relative to the undamaged hole pairs. Failure to do this can result in stress on the p-pipe leading to a fatigue failure of cooling oil supply to the power assembly and power assembly failure. Once properly located, the new bracket and tube sections are tacked together to the old brackets and the locating bar is removed. The pieces are then all finish welded with AWS-E-7016 or E-7018 and

4mm wire peened. It is critical to thoroughly clean the I.D. of the reworked manifold section.

Figure 14 shows a field repair which didn't follow these recommended practices. Excess weld was applied in connecting the new manifold section into the old bracket. There was no evidence of peening and slag inside the pipe indicated that post cleaning was inadequate. The manifold section was misaligned, ultimately causing a power assembly failure from inadequate oil cooling.

An alternative temporary repair method exists whereby a new manifold section is held in place by compression fittings on residual sections of cooling pipe adjacent to the damaged section. Such a repair method has the benefits of avoiding the need for welding in the field.

Another common field repairable failure is cracking where the cylinder head retainer is welded into the airbox. Original failures typically begin at the 6 o'clock position and propagate around the retainer then across the airbox into the adjacent crab stud holes. An example of such a failure is illustrated in Figure 15, where pot cracks cross the airbox from each side of a crab stud hole. Repair should start with measurement of the location of the pot top as reference. If appropriate care is taken to control stress and distortion, the pot top should not be pulled down by more than 0.030 inch. The pot top should be built up with AWS-E-6012 and cut following repair. In many cases, the crack will have passed through the retainer and be visible

above the upper pilot bore. Weld repair should be performed from both sides in such cases. Airbox cracks are typically only able to be repaired from above in the field with 95% crack removal. Such a repair is less permanent than one performed from both sides of the crack (best shop practice). The field repair, if properly performed, should have sufficient integrity for the engine to run to its next scheduled overhaul. It is good practice to cut the test cock free from the cylinder head retainer for the repair so it is not subject to stresses from any pull down caused by the weld repair.

Test cock tube failures like that in Figure 16 are field repairable. It often looks as if the crack exists only in the weld metal against the cylinder head retainer, but commonly it has propagated into the parent metal of the test tube.

EMD recommended practice is to flame or plasma cut 12" x 4" window approximately 1 1/4" below where the end of the test tube exits the top deck to provide access for making such field repairs. An example of this is illustrated in Figure 17. If the crack has propagated into the parent metal of the test tube, it will be necessary to insert an 18 gage or less back up tube of 1-1/8" outer diameter. Care needs to be taken to avoid breaking through this back up tube during crack removal. Following weld repair, the back up tube is drilled and reamed out to return the test tube to 1-1/8" inner diameter. Once the repair is complete, the piece side sheet removed for access should be beveled at 45°

and re-welded from both sides, peening and cooling each pass to minimize distortion. Figure 17 shows a window where this practice was not followed. It was only welded from the outside and appears to have occurred without adequate control of temperature and peening to control distortion. The re-cracking of the test cock due to residual stresses from the repair was fairly severe, as can be seen in Figure 18. Additionally, the weld was sufficiently porous as to allow oil leakage from the top deck side sheet.

In Figure 19, we see damage to an oil pan window from a power assembly failure. It is possible to perform field repair of damage to oil pan cover sidesheet (windows) and crankcase lower airbox cover sidesheet (windows). It is widely known that thermal or mechanical straightening for damage that is not "too severe" is acceptable, since neither sheet is a structural component. Verification of sufficient flatness can be performed with a flashlight from within the case and handhole cover-held against the opening. It has also become fairly common for damage as severe as that of Figure 19 to be repaired in the field by welding in a section of fabricated sidesheet or one cut from a scrap oil pan. An example of this can be seen in Figure 20. Although the sidesheets are not structural components, care should nonetheless be taken to minimize distortion when welding. If excess heat is allowed, or the welds are not properly stress relieved, the pan rail will generally be pulled down. This can create a problem of oil and vac-

uum leaks between the case and oil pan. Additionally, when it is time to split the case and pan for overhaul, the oil pan end sheets will suck in as they have been held out under tension. In the case of the window replacement shown in Figure 20, this was severe enough that the window had to be cut back out and pan rail cut to straighten the end sheets. Weld repair then required welding the end sheets and remachining for alignment with the case in addition to the window and rail repair.

It is infrequently the case that the liner pilots need to be field machined for wear as this would generally indicate that the case and pan are overdue for remanufacture. Some power assembly failures do result in damage to the lower liner pilot bore and, in such cases, the damage can typically be field weld repaired, the pilot can be built up with AWS-E-6012 and machined to size. Figure 21 demonstrates the EMD service tool in use. Such tools have historically been available for rent or purchase from the OEM. Aftermarket tools have also been developed for this purpose.

Similarly, if the surface where the cylinder head retainer (pot top) mates with the underside of the cylinder head flange has worn excessively (as indicated by low lead wire readings), it may be repaired in place. This repair is also typically required following pot crack repair to true the pot top. The top surface is built back up with AWS-E-6012 and recut with a portable machining tool. If sufficient material remains, the same tool can be used to true

and remove the wear step from the mating surface without welding as shown in Figure 22.

Finally, we consider field repair of the crankshaft line bore. Portable methods have been developed for measurement and machining of the line bore in-place. Figure 23 shows the cutting head of such a tool machining a welded bore back to original specifications. This tool is designed to fixture off bores that are adjacent to those requiring work. As such, it allows repair of only those bores in need of adjustment for size or location (to ensure required vertical and horizontal step changes). This repair method is commonly employed in marine applications, where removal of the crankcase may be extraordinarily expensive. It has been applied a number of times in rail applications where the cost of returning a case to a rebuild facility is high or where the line bore repair is a specialist outsourced function and repair work is otherwise performed by internal staff.

The method illustrated allows for machining of only those bores requiring adjustment and is thus particularly well suited to repairing localized damage, from a crank failure, for instance. This type of repair does require the case and pan to be split, but can be performed with power assemblies and top end jewelry left in place. This approach can be used to perform a limited scope repair of an engine part way through its overhaul cycle, avoiding the costs of pulling ahead a complete overhaul of the engine.

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In Place Memory Company
www.inplace.com

Metal Locking Services
www.castironrepair.com

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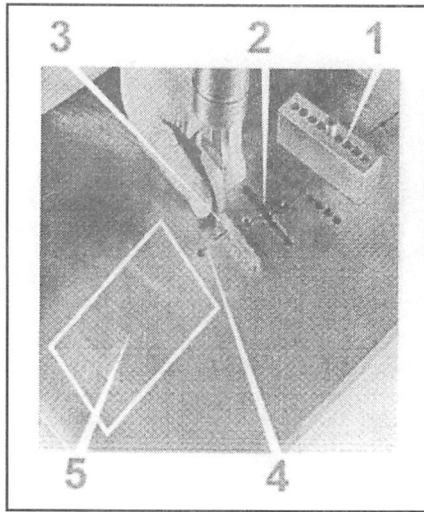


Figure 1

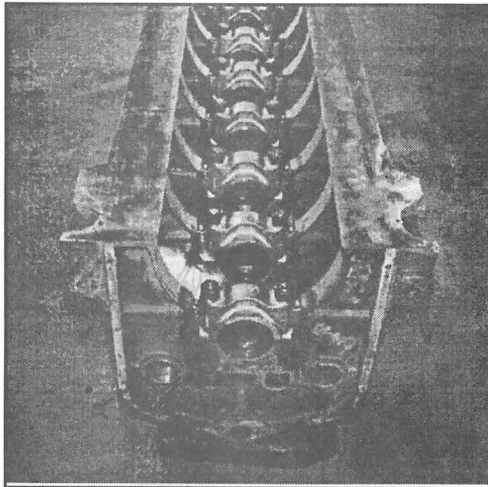


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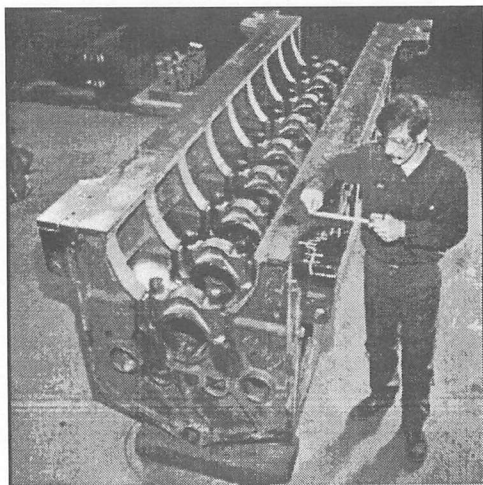


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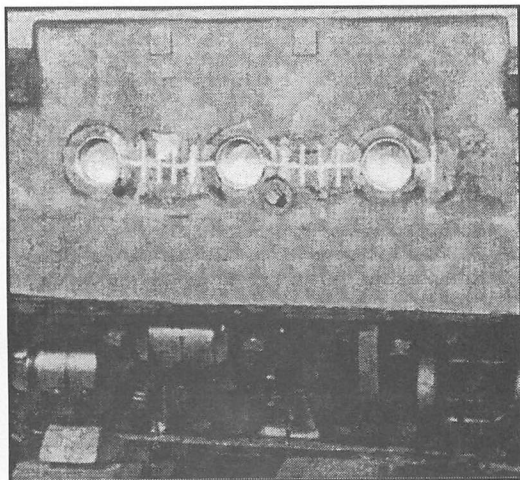


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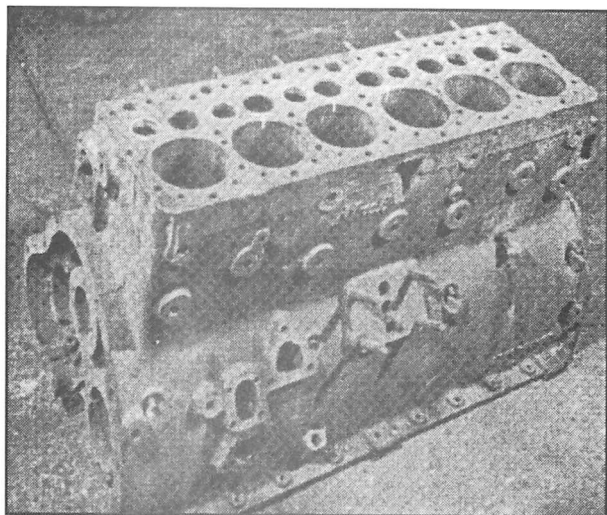


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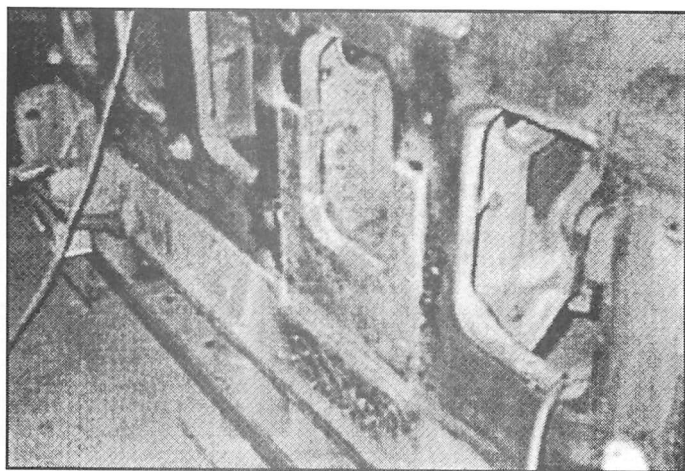


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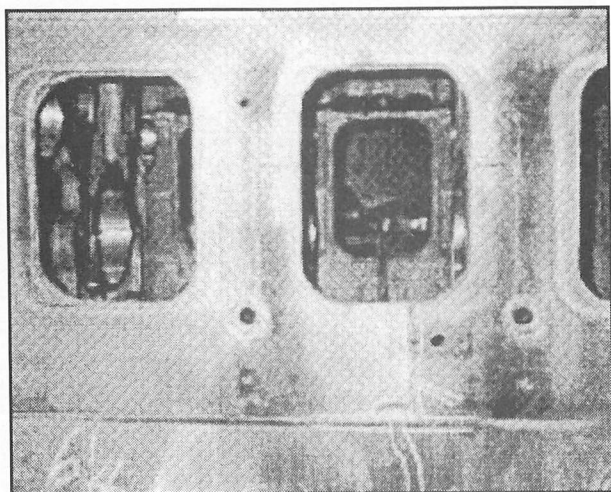


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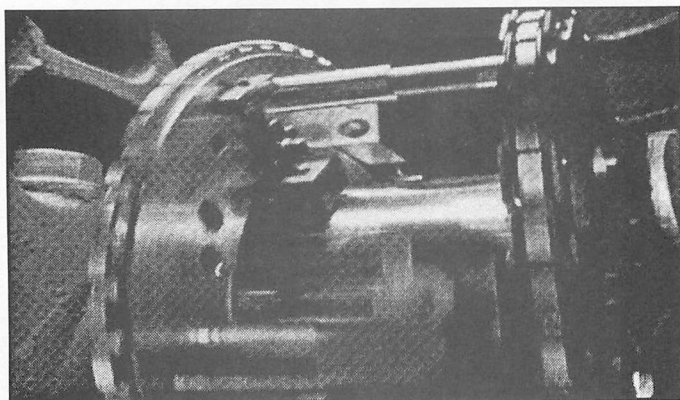


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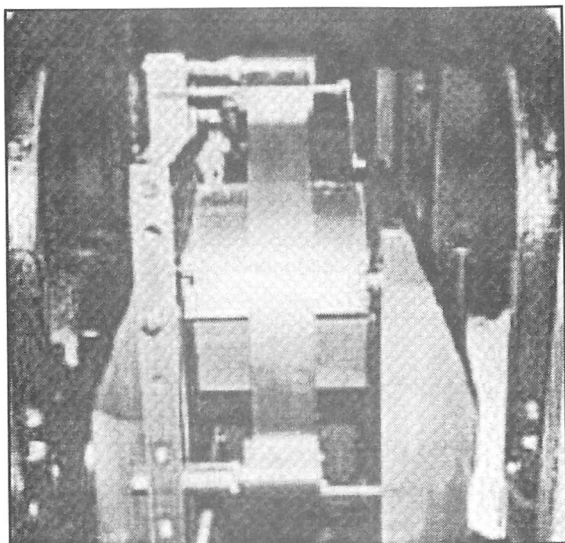


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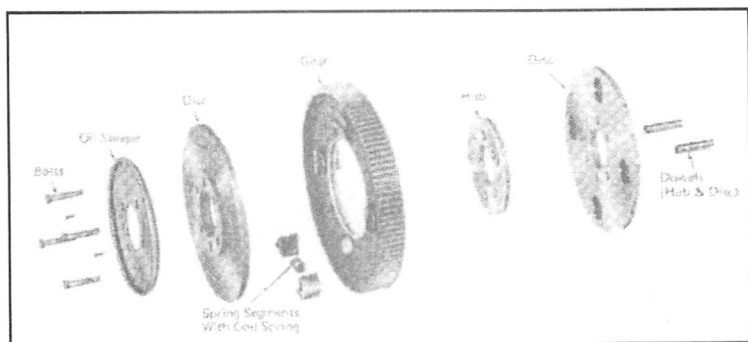


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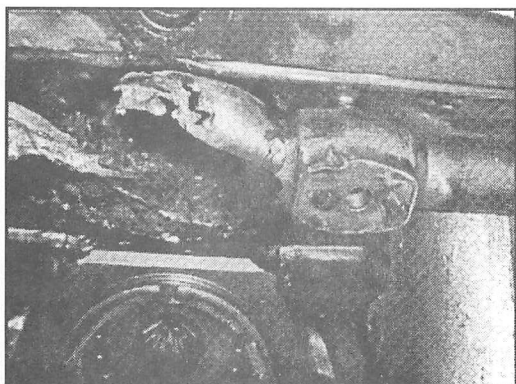


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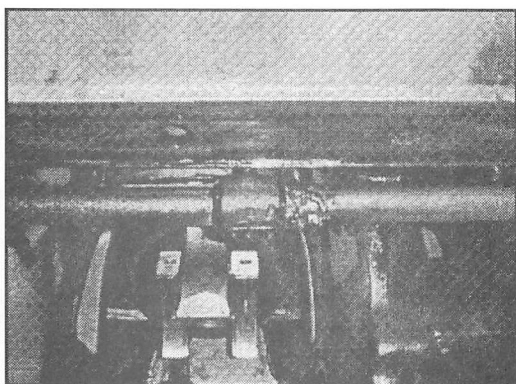


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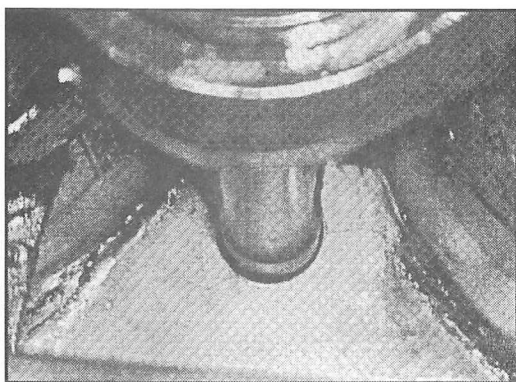


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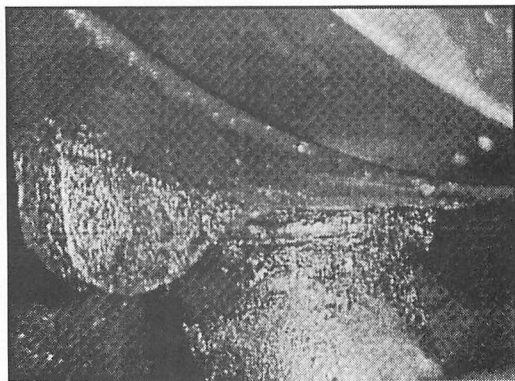


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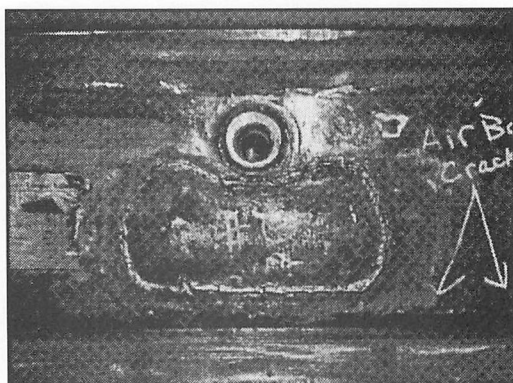


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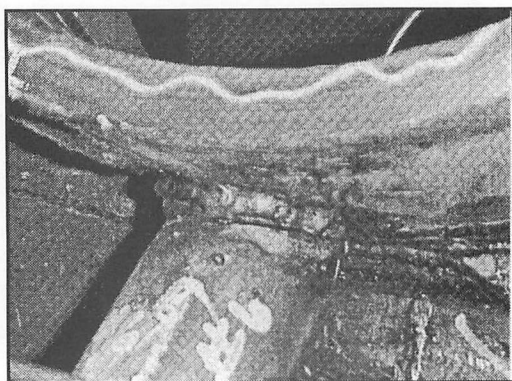


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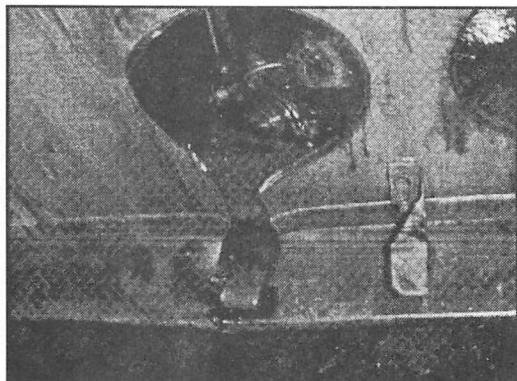


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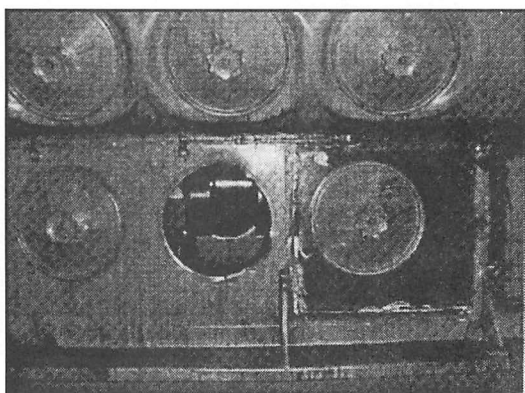


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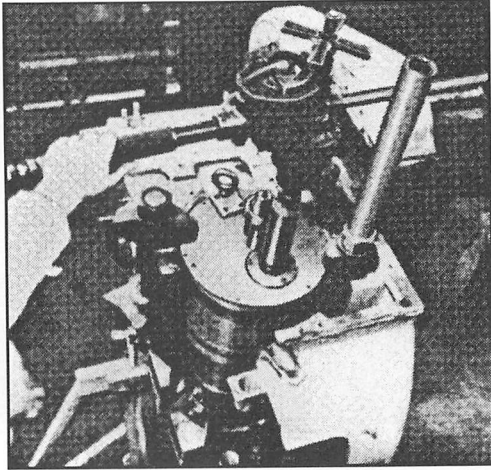


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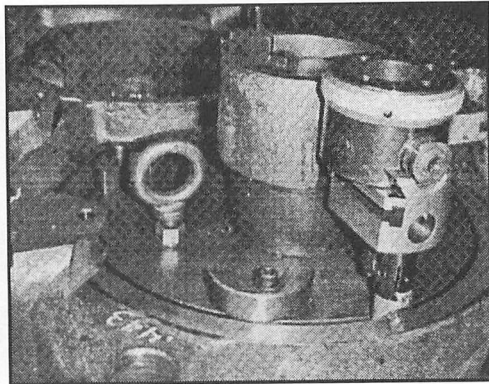


Figure 22

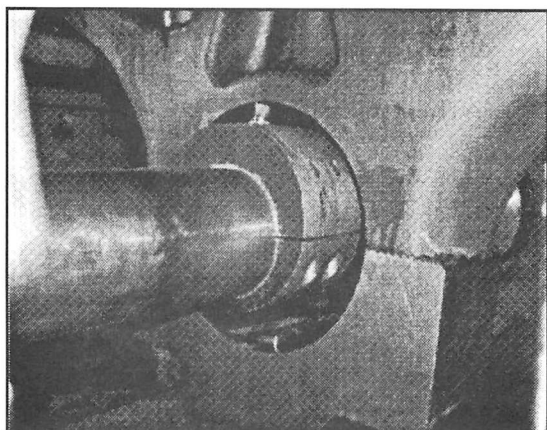


Figure 23

4. BENEFITS OF MOBILE MAINTENANCE

*Prepared by
Dan Agler,
Director-Maint. Planning
KCS Railway*

With the continued increase in locomotive demand and increased cost of maintenance, using Mobile Maintenance is an alternative means of expediting services that normally create congestion and delay due to limited access to fixed facilities. The mobility of these services allows operating plans to remain flexible or change because services are brought to the locomotives, wherever located. Mobile servicing increases the availability, which in turn, increases utilization and reduces dwell time. In some cases it can reduce the number of locomotives assigned to a service pool.

Mobile servicing benefits

- Increases the availability
Reduced out of service time account locomotive not having to return to fixed facility for repair.
- Increases utilization
Increased availability increases utilization of fleet.
- Reduces dwell time
Dwell time saved not having to return locomotives to fixed facilities for scheduled maintenance or unscheduled repair.
- In some cases, it can reduce the number of locomotives assigned to a service pool.
Depending on fleet size, you may be able to reduce the num-

ber of locomotives required for swap set pool.

The following types of units can benefit from Mobile locomotive maintenance

- Low HP Locomotives in captive service.
Switcher locomotives used at outlying points in yard or industry service.
- Medium HP Locomotives in captive service.
GP Locomotives used at outlying points in yard, industry, or drag service.
- Repairs to road power on an occasional basis.
High HP locomotives in main line service that has a line of road failure, i.e. Not Loading, Air Trouble, Distributive Power trouble etc.

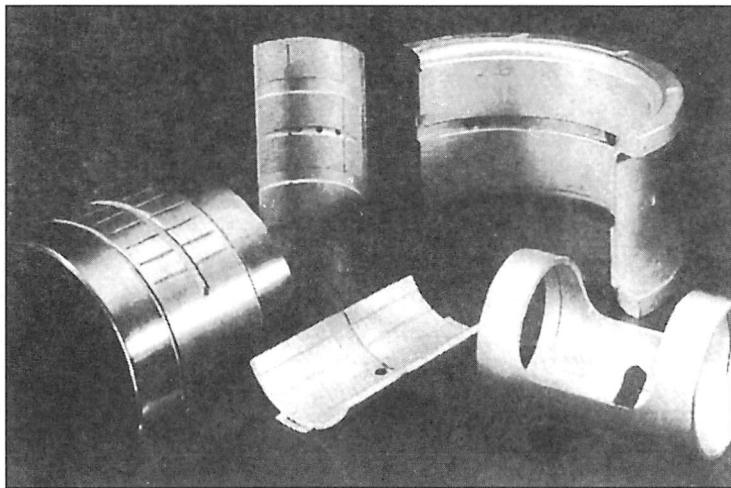
Mobile maintenance events

- Daily Inspections
FRA 229.21 daily inspection, fueling, sanding, and servicing.
- Scheduled Inspections
M92 and M06 inspections
Note: suggest bringing M12 and M36 inspections should be performed at fixed facility.
- Unscheduled maintenance at location of failures.
- Wheel Truing
Can use mobile wheel truing machine or flange cutting brake shoes.
- Major components i.e., Main Generators, AR10's, Turbos, Air Compressors, Power Assemblies, etc.
Mobile maintenance vehicle with crane can change compo-

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nents in the field.

Mobile maintenance vehicle

Below are items to equip Mobile Maintenance Vehicle with:

- Sand
- Lube Oil
- Treated and Untreated Water
- Waste Oil and Waste Sewage Evacuation
- Fuel
- Tool and Inventory Storage
- Air Compressor
- Welder
- Crane

Note: can equip vehicle to fit your needs: Cost can vary: small Pick Up (\$15,000), to a Full Road Truck (\$250,000).

Utilizing fuel trucks to perform direct Truck to Locomotive (DTL) fueling, and performing locomotive maintenance and servicing using a Locomotive Service Truck (LST), is unique in that it offers railroads requiring locomotive fueling and servicing at multiple locations, using specialized equipment. As a result, railroads are able to reduce fuel costs, increase locomotive utilization and realize other cost savings created from not having to return locomotives to fixed facilities.

Fuel and service technicians can inspect locomotives once per week with an eye for identifying mechanical problems that often go unreported by locomotive engineers. This improvement in preventive maintenance contributes to increased power availability and reliability.

It is most efficient to divide the locomotive maintenance servicing areas into several service pods. Each

service pod encompasses a portion of the service area but allows for the maximum utilization of both equipment and labor given resource origins and mileage between service sites.

The operations can be headquartered at several service pod locations and the equipment can swap locations to accomplish the required services. The design is based upon a preset schedule; the driver will provide the corresponding service to the truck being operated. At the end of each cycle, the driver from the first Pod (DTL) will meet the driver from the second Pod (LST) and swap trucks.

For the operation design to be effective, it will be necessary to erect a sand tower at a designated location to load the mobile truck. Additionally, fuel tank cars or main fuel facilities serve as the fuel source for the trucks.

Site specific operating considerations

- Sand tower location.
- Acceptable fueling locations
- One spot maintenance facility with pit.
- Truck turnaround room.
- Designated track space needed for receiving and unloading fuel tank cars.
- Weight limitations on road and bridges requiring use of a tank truck.

Recordkeeping

All locomotive servicing and fueling activities are required to be recorded on either a Fuel Activity

Register, Service Activity Register, or entered into the locomotive service database to generate productivity reports.

Environmental

It is imperative that each worksite is reviewed to identify all possible sources of contamination, surface and storm waters to be protected and outline specific Spill Emergency Plans (SEP) that are compatible with the current environmental laws.

Quality assurance

To insure that all service expectations are met, employees will need to be trained in the proper methods of DTL fueling utilizing a company-wide standard operating procedure. Employees need to be taught proper work processes and emphasize that these processes must be followed precisely.

Fueling technicians must participate in on-going general safety and hazardous materials training and testing.

In closing, using Mobile Maintenance is an alternative means of expediting services. The mobility of these services allows operating plans to remain flexible or change because services are brought to the locomotives, wherever located.

Mobile maintenance benefits

- Improved availability
- Improved utilization
- Reduced dwell time
- In some cases, it can reduce the number of locomotives assigned to a service pool.
- Reduced cost

Examples: Locomotive Lease at \$100.00 per day x 365 days = \$36,500.00

Locomotive Maint. Cost at \$100.00 per day x 365 days = \$36,500.00.

SW1500 Annual Fuel Consumption Based on 75% Duty Cycle.

Utilization = 183,291 Gal/YR. (Rack Rate versus Jobber rate savings 183, 291 gal x \$0..50 = \$91,645.50).

GP38-2 Annual Fuel Consumption Based on 75% Duty Cycle.

Utilization = 247,047 Gal/Yr. (Rack Rate versus Jobber rate savings 247,047 gal x \$0.50 = \$123,523,50).

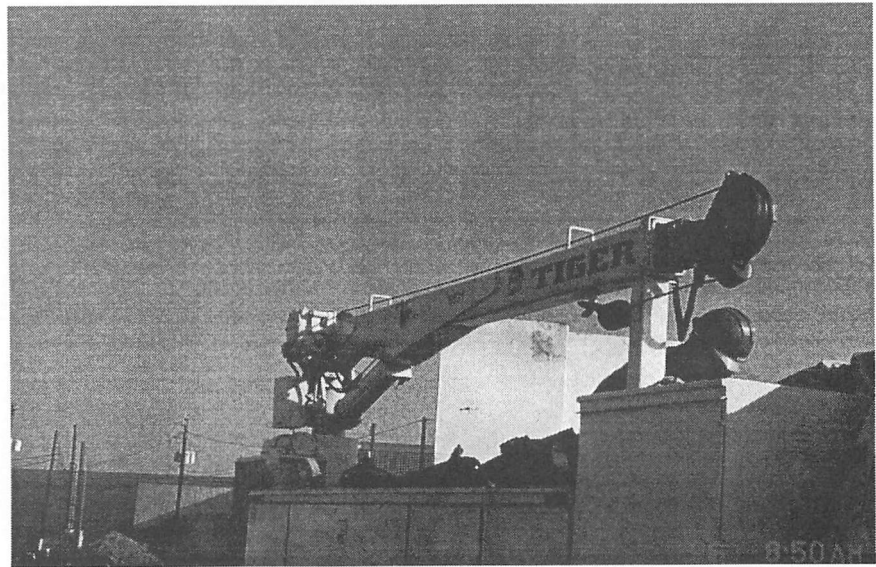
Revenue Moves: \$1,200.00

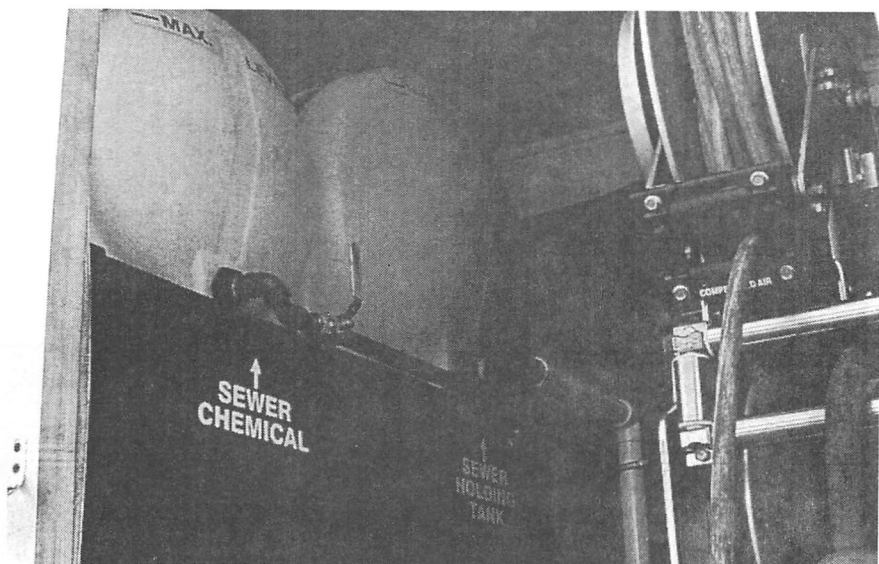
Switching Fees: \$250.00

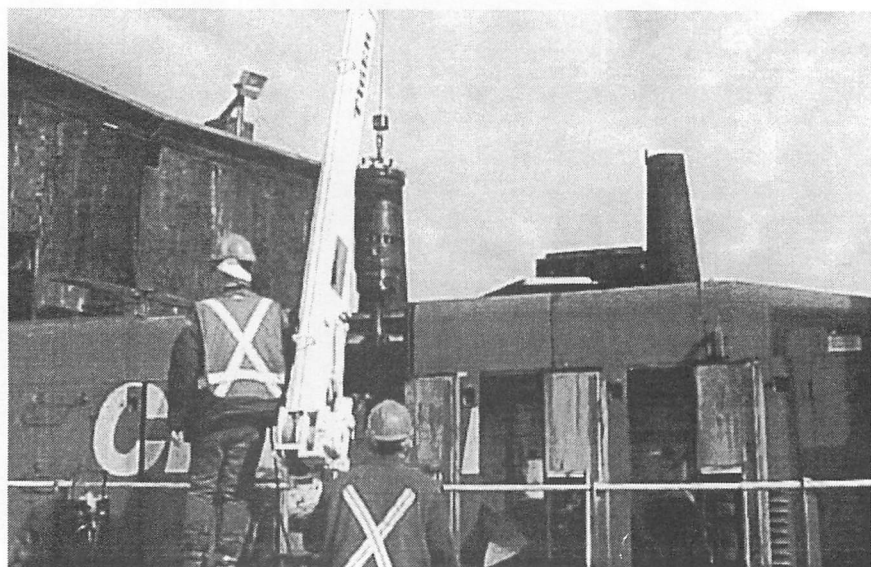
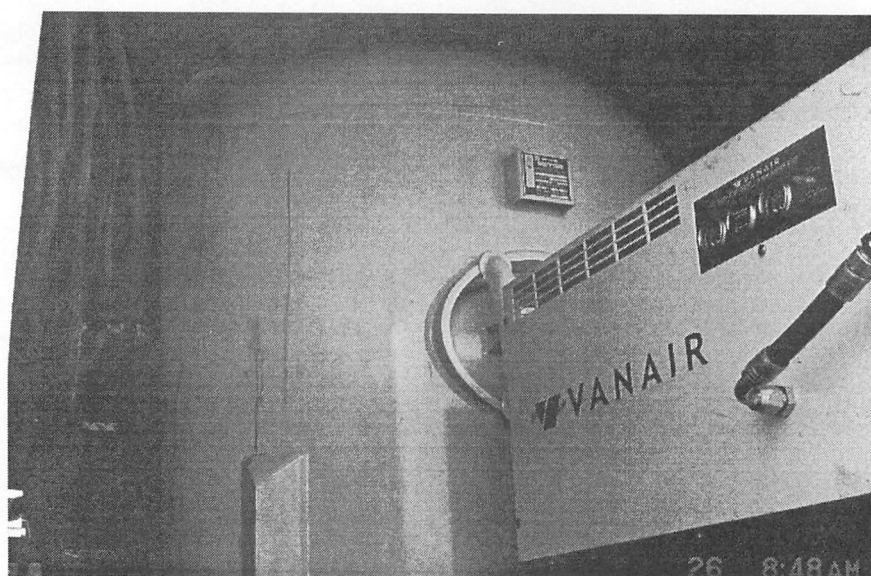
- Increased Capacity May increase capacity at Fixed Facilities.
- Increased Comprehensive Service

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- QRS/KCS Paper
- Providence & Warcester RR CO Truck Picture









REPORT OF THE COMMITTEE
ON DIESEL MATERIAL CONTROL

MONDAY, SEPTEMBER 18, 2006
3:45 P.M.



Chairman

BOB HARVILLA

Sales Manager

Standard Car Locomotive Group
Stongsville, OH

Vice Chairman

JOHN MINNIE

Materials Manager

BNSF Railway
Burlington, IA

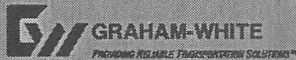
COMMITTEE MEMBERS

B. Ames	Sls. & Mktg. Mgr.	Progress Rail	Chicago, IL
T. Aspinwall	Managing Director	ALSTOM	Naperville, IL
R. Delevan	Mgr.-Transp. Prod.	Nat'l Electrical Carbon	Wilkes Barre, PA
P. Foster	President	Power Rail Dist. Inc.	Wilkes Barre, PA
M. Gast	Sr. Procurement Mgr.	CSX Transp.	Jacksonville, FL
P. Johnson	Supt.-Loco Matl.	Norfolk Southern	Atlanta, GA
C. Mainz	Sales Manager	HKEC	Seattle, WA
A. Pettigrew	Purchasing Mgr.	Rail America	Boca Raton, FL
K. Smith	Sales Mgr.	General Electric	Jacksonville, FL
R. Sulewski	Nat'l Sales Mgr.	Rail Prod. Int'l Inc.	St. Louis, MO

Note: Please welcome Doug Morey of the Union Pacific
who is a new committee member.

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PERSONAL HISTORY

Bob Harvilla

Regional Sales Manager

Standard Car Truck Co., Standard Locomotive Group

Bob Harvilla began his career in 1973 at the General Electric Co. Cleveland Apparatus Service Center, and had a total of 22 years of service with GE. He is currently responsible for sales of the Standard Locomotive Group Companies - Durox, Triangle Engineered Products and Railway

Equipment Associates. He resides in Medina, Ohio, and works out of the Durox offices in Strongsville, Ohio.

Bob and his wife Barb have been married 30 years and have two sons: Rob, 28 and Ryan, 23.

**THE DIESEL MATERIAL CONTROL
COMMITTEE
WISHES TO EXPRESS THEIR
SINCERE APPRECIATION
TO NATIONAL ELECTRICAL
CARBON PRODUCTS
IN GREENVILLE, SOUTH CAROLINA
FOR GRACIOUSLY HOSTING THEIR
COMMITTEE MEETING
IN 2006**

**THANK YOU,
DIESEL MATERIAL CONTROL**

PDA'S FOR INVENTORY CONTROL

*Prepared by
Ronald M. Delevan
National Electrical Carbon
Products*

Finding an appropriate place to place or store an item and recalling the "place" and the "item" has been a problem for the ages. We often are amazed at a squirrel's efforts to hide their winter stores. Even more amazing is their ability to locate the stores for consumption. Our efforts go well beyond simple actions to multilevel tasking of what, where, how many, type, color and so forth. Putting those complex storage and retrieval tasks to the side, ask yourself, "How many times have I misplaced my wallet or car keys?"

Enter now into our much more complex world of many parts, numbers, and inventories: Imagine ten thousand automobiles in your inventory. Some important considerations will be: Builder, model, color, accessories, interior, number of doors, type of wheels and so on. What methods might be used for inventory control, storage and retrieval.

We might consider:

- Clay tablets
- Reams of paper notes
- White boards and markers
- Computer programs
- Others

All of these methods are usable but are subject to being cumbersome and subject to many errors.

As such, we might consider the

computer as the best alternative. Yet, even the computer is subject to input errors. Those errors tend to spoil our efforts:

So how can we collect data on automobiles being unloaded from auto racks, stored, retrieved from their storage location and then ship the automobiles; let alone find the exact vehicle, among the eight thousand, to fill the requested manifest for each truck to be loaded. (Figure 1)

We certainly could manually transcribe or record the necessary data to inventory control forms. The data would then be manually entered into an inventory control program. This information needed could include:

- VIN number (an alpha numeric sequence of 15 to 25 characters)
- The railcar number that the vehicle was off loaded
- Chronological Data

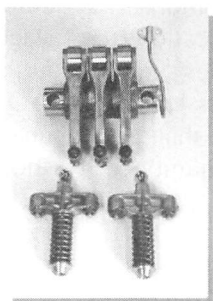
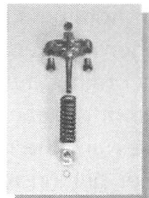
Multiple data recordings, transcriptions and inputs are subject to errors. Those errors complicate and increase our inventory control energies by adding layers of unnecessary and wasteful steps. Remember losing your automobile keys? Do you remember retracing your steps and wasting valuable time in the search? Multiply that by thousands!

The Texas Central Business Lines in Midlothian, Texas has developed a method to reduce and nearly eliminate errors that plague manual inventory. That method centers on the use of PDA's (Personal Digital Assistant) such as Palm

ROCKER ASSEMBLIES & VALVE BRIDGES



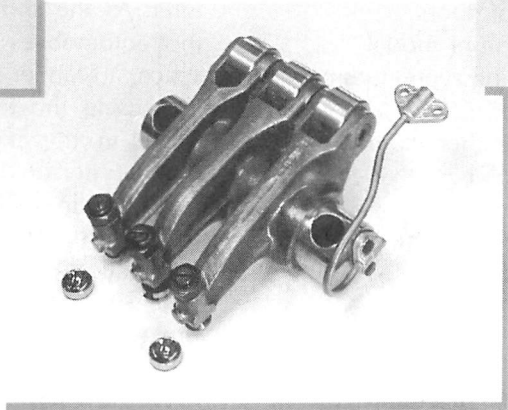
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Pilots.

The PDA is programmed with inventory and BAR Code capabilities. The PDA is then used to read and record the VIN number:

That VIN or "Vehicle Identification Number" contains data used to select the automobile for shipment or modifications including accessory upgrades such as stereo systems or keyless entry. Some of the information that is contained in the VIN number includes:

- Manufacture
- Color
- Style or model (coupe, hard-top, hatchback, etc.)
- Number of doors
- Engine type or model
- Transmission type (automatic, manual)
- Interior (leather, cloth, etc.)
- Interior color

For Toyota Vehicles the VIN numbers are as follows:

Digit Position	Position
#1	Country-J =Japan
#2	Manufacturer-T-Toyota
#3	Type (car, truck...)
#4-#8	Line, Series, Body Engine, Restraint
#9	Check Digit
#10	Year-Designated by Letter
#11	Assembly Plant C=Ontario, Canada O=Supra plants U=Georgetown, KY Z=Fremont, CA
#12-#18	Sequential Production Number

The rail cars arrive at TCBL's Midlothian facility in groups of up to sixty cars from the Union Pacific or the Burlington Northern Santa Fe Railroads. The cars are then spotted for unloading by the TCBL. Upon car placement, the automobiles are unloaded and staged near the unloading area for further handling. (Figure 2)

Once the automobiles are unloaded and staged a team of spotters move the cars to the assigned "Lot". There are eleven lots designated as Lots "H" through "R" for holding. The automobiles are then moved to the assigned lot according to manufacturer. As the spotter team places the automobiles in the lot and space, a scanner person reads the VIN using the PDA. At the first space in the particular lot, the scanner person identifies the lot and space in the PDA. Upon reading the first VIN number, the PDA automatically indexes to the next space and that VIN is read. The process is repeated until the entire lot is completed. (Figure 3)

We now have the VIN number, Lot name, space in the lot, railcar number, date and time and the person performing the scan in that particular PDA. At the end of the scanning operation, the PDA is synchronized with the Inventory Computer located in the office. (Figures 4 & 5)

Once the Inventory information is synchronized with the Inventory Computer we can produce reports showing vehicle location in the form of Lot and Space for pick and

ship operations. That same data base is used to pick the automobiles for accessory upgrades. Pick lists are developed for automobile dealer shipment orders. Those orders are received electronically and the computer program prints a pick list for each truck or outbound railcar to be loaded.

Sample inventory reports are reflected in Figures 6 and 7 showing the VIN, Date, Time, Lot and Space Data runs.

The issues shown to this point have been somewhat simplified. Although we have mentioned 8,000 automobiles and 11 lots, let us take a broader view:

The true scope

- Eleven lots
- 80 car trains
- 8,000 inbound automobiles
- Up to 8,000 outbound automobiles
- Up to 8,000 outbound still on property
- Five separate manufacturers
- 10 models per manufacturer
- 300 plus used automobiles in by truck out by rail

Now the complexity of the system starts to be realized and the magnitude of the evolving inventory can be imagined.

Scanning the inventory as it changes or evolves in real time becomes paramount to timely and correct shipments. In addition, accuracy and error elimination are fundamental to successful customer services in delivery of the correct automobile to the correct truck to the correct dealer.

Automobiles are scanned at receipt, holding lots, modification areas and loading at shipping. Thus we know: what, when, where and to a degree how for each unit is in our stewardship.

How is the PDA's use in automobile inventory control at a rail transload facility become relevant to a Mechanical Department? The controlling, distribution, installation and core returns of major components, certainly comes to the front.

Traction motors, traction generators, wheel sets, auxiliary generators, computers, air compressors and the like are candidates for PDA applications. Bar coded components can be read by PDA's easily and traced from receipt to installation and beyond.

What is the cost? A capable and rugged PDA with Bar Code capability can be placed into service for less than one thousand dollars. Application into most bar coded inventory programs can take a few hours or more. The cost of bar coding can run a few dollars per item depending on the bar code material. Last, the cost of sectioning lay down or storage areas is dependent on needs and size requirements. However, the costs of the PDA are insignificant when compared to the costs of reconstructing the track of a missing major component.

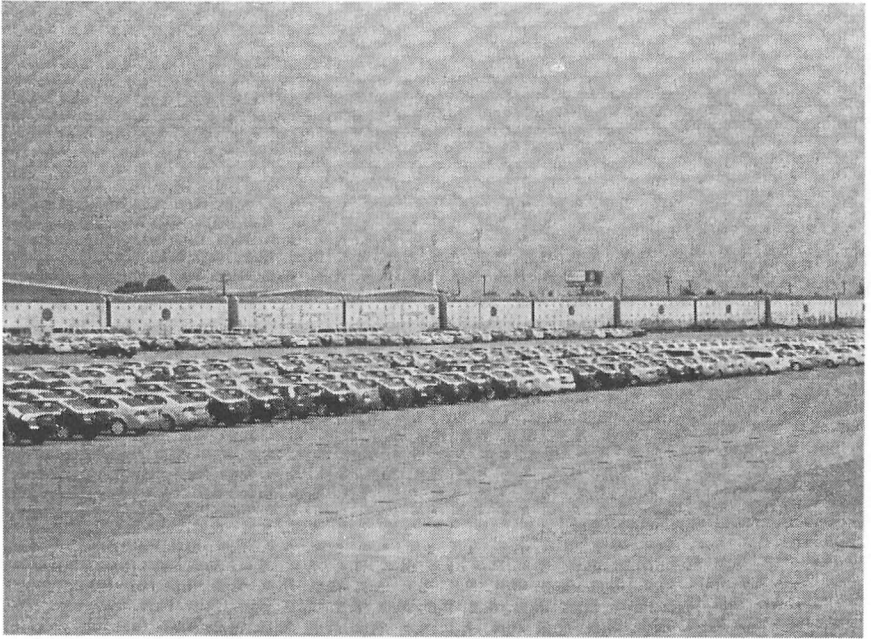


Figure 1
Inventory from Tri-Level auto cars



Figure 2
Railcars spotted for unloading



Figure 3
Automobiles being staged for movement to Lot

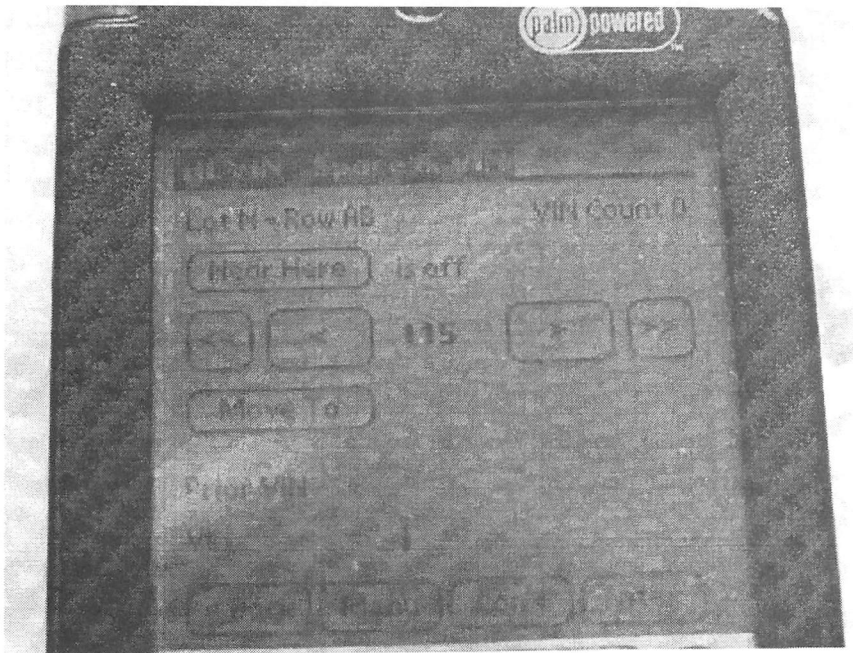


Figure 4
PDA screen showing Lot and Space



Figure 5: PDA screen showing Bar Code and other programs

Scanner Location Transactions by Lot/Scan Order
 For the period 04/28/2006 to 04/28/2006

Page: 1

West of BNSF (grass)				Mazda (North of Center Drive)			
KNDJD733865606729	04/28	06:25:57	D/LN101				
KNDJD733265619637	04/28	06:26:08	D/LN101				
KNDJD733265607777	04/28	06:26:17	D/LN101				
KNDJD733565600452	04/28	06:26:29	D/LN101				
KNAFE161X65264787	04/28	06:26:42	D/LN101				
KNAFE161965264179	04/28	06:26:52	D/LN101				
KNAFE161065253250	04/28	06:27:03	D/LN101				
KNAFE161065282120	04/28	06:27:12	D/LN101				
KNAFE161165303220	04/28	06:27:23	D/LN101				
KNAFE161065282103	04/28	06:27:31	D/LN101				
KNAFE161465264915	04/28	06:27:39	D/LN101				
KNAFE161965284321	04/28	06:27:49	D/LN101				
KNAFE161465281438	04/28	06:27:58	D/LN101				
KNAFE161265246011	04/28	06:28:08	D/LN101				
KNAFE161465305558	04/28	06:28:17	D/LN101				
KNAFE161265284323	04/28	06:28:27	D/LN101				
KNAFE161865282155	04/28	06:28:36	D/LN101				
KNAFE161965284318	04/28	06:28:45	D/LN101				
KNAFE161865269194	04/28	06:28:56	D/LN101				
KNAFE161565264051	04/28	06:29:05	D/LN101				
KNAFE161265265478	04/28	06:29:14	D/LN101				
KNAFE161565253230	04/28	06:29:32	D/LN101				
KNAFE161765284320	04/28	06:29:41	D/LN101				
KNAFE161265280756	04/28	06:29:52	D/LN101				
KNAFE161865268403	04/28	06:30:01	D/LN101				
KNAFE161465269192	04/28	06:30:10	D/LN101				
KNAFE161265269191	04/28	06:30:19	D/LN101				
KNAFE161165268405	04/28	06:30:28	D/LN101				
KNAFE161665281439	04/28	06:30:40	D/LN101				
KNAFE161665281425	04/28	06:30:49	D/LN101				
KNAFE161065280755	04/28	06:30:59	D/LN101				
KNAFE161465282153	04/28	06:31:08	D/LN101				
KNAFE161265281440	04/28	06:31:22	D/LN101				
KNAFE161065253829	04/28	06:31:32	D/LN101				
KNAFE161065253829	04/28	07:51:11	D/LN401				
KNAFE161065282120	04/28	07:51:20	D/LN401				
KNAFE161265281440	04/28	07:58:32	D/LN401				
KNAFE161X65264787	04/28	08:02:18	D/LN401				
KNAFE161965264179	04/28	08:27:28	D/LN401				
KNAFE161065280755	04/28	08:27:36	D/LN401				
KNAFE161465282153	04/28	08:27:47	D/LN401				
KNAFE161065253250	04/28	08:27:56	D/LN401				
KNAFE161465281438	04/28	08:50:15	D/LN401				
Total, this lot		43					

Figure 6: Scan Inventory for Lot "N"

Scanner Location Transactions by Lot/Scan Order
For the period 04/28/2006 to 04/28/2006

Page: 4

KNAGE123066127545	04/28	07:22:30	L/H478	KNAGE124265046993	04/28	07:36:12	L/H364
KNAGE123566127586	04/28	07:22:45	L/H476	KNAGE124065045325	04/28	07:36:29	L/H367
KNAGE123866127596	04/28	07:22:56	L/H474	KNAGE124265047156	04/28	07:36:43	L/H360
KNAGE123566127622	04/28	07:23:13	L/H472	KNAGE123165045079	04/28	07:36:55	L/H358
KNAFE121065307619	04/28	07:23:23	L/H470	KNAGE123165047138	04/28	07:37:15	L/H356
KNAGE123866127601	04/28	07:23:32	L/H468	KNAGE123065046093	04/28	07:37:28	L/H354
KNAGE123366125724	04/28	07:23:55	L/H466	KNAGE124665044566	04/28	07:37:41	L/H352
KNAGE123966127669	04/28	07:24:09	L/H464	KNAGE124965045095	04/28	07:38:46	L/H350
KNAGE123966127669	04/28	07:24:22	L/H462	KNAGE123065047230	04/28	07:38:59	L/H348
KNAGE123266128351	04/28	07:24:32	L/H460	KNAGE123965045623	04/28	07:39:17	L/H346
KNAGE123966128353	04/28	07:24:45	L/H458	KNAGE124665047306	04/28	07:39:40	L/H344
KNAGE123166128346	04/28	07:24:58	L/H456	KNAFE121565306949	04/28	07:39:58	L/H342
KNAGE123966127618	04/28	07:25:12	L/H454	KNAFE121265307086	04/28	07:40:07	L/H340
KNAGE123466128336	04/28	07:25:21	L/H452	KNAGE123365046699	04/28	07:40:21	L/H338
KNAGE123266127612	04/28	07:25:30	L/H450	KNAGE163166127224	04/28	07:40:31	L/H336
KNAGE123266128355	04/28	07:25:41	L/H448	KNAGE123865046733	04/28	07:40:44	L/H334
KNAGE123166128266	04/28	07:25:54	L/H446	KNAGE123165047222	04/28	07:40:55	L/H332
KNAGE123665045627	04/28	07:26:09	L/H444	KNAGE123665046180	04/28	07:41:07	L/H330
KNAGE123465046312	04/28	07:26:37	L/H442	KNAGE123765046704	04/28	07:41:20	L/H328
KNAGE123665046762	04/28	07:26:47	L/H440	KNAGE163266127216	04/28	07:41:31	L/H326
KNAGE1232661047133	04/28	07:27:03	L/H438	KNAGE123765046706	04/28	07:41:50	L/H324
KNAGE124265044466	04/28	07:27:14	L/H436	KNAGE123365046735	04/28	07:42:10	L/H324
KNAGE123065045171	04/28	07:27:29	L/H434	KNADJ133265620660	04/28	07:42:37	L/H322
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KNAGE123365045732	04/28	07:28:24	L/H428	KNAGE123565046042	04/28	07:43:18	L/H318
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KNAGE123665045725	04/28	07:29:03	L/H422	KNADJ133665630347	04/28	07:43:53	L/H312
KNAGE123465046016	04/28	07:29:14	L/H420	KNAGE163866127240	04/28	07:44:05	L/H310
KNAGE123465045593	04/28	07:29:26	L/H418	KNAGE123766127539	04/28	07:44:17	L/H308
KNAGE123566128293	04/28	07:29:37	L/H416	KNAGE124365045321	04/28	07:44:34	L/H306
KNAGE123866128111	04/28	07:29:47	L/H414	KNAGE123766128237	04/28	07:44:46	L/H304
KNAGE123066127611	04/28	07:30:02	L/H412	KNAGE123465047120	04/28	07:45:00	L/H302
KNAGE123566128236	04/28	07:30:13	L/H410	KNAGE123065045087	04/28	07:45:13	L/H300
KNAGE123366128235	04/28	07:30:23	L/H408	KNAGE124665045250	04/28	07:45:26	L/H298
KNAFE121865307058	04/28	07:30:32	L/H406	KNAGE123865047123	04/28	07:45:39	L/H296
KNAGE123166128281	04/28	07:30:42	L/H404	KNAGE123365045181	04/28	07:45:52	L/H294
KNAGE123565045529	04/28	07:31:10	L/H402	KNAGE123665045773	04/28	07:46:06	L/H292
KNAGE123165045700	04/28	07:31:27	L/H400	KNAGE123565045599	04/28	07:46:19	L/H290
KNAGE123565047226	04/28	07:31:39	L/H398	KNAGE123766128271	04/28	07:46:48	L/H290
KNAGE123165047186	04/28	07:31:52	L/H396	KNAGE12306527639	04/28	07:46:58	L/H304
KNAGE123865047122	04/28	07:32:04	L/H394	KNAGE123266128338	04/28	07:47:07	L/H305
KNAGE124865047307	04/28	07:32:16	L/H392	KNAGE123766127637	04/28	07:47:17	L/H307
KNAGE124865046899	04/28	07:32:45	L/H390	KNAGE124165044569	04/28	07:47:28	L/H309
KNAGE123565045232	04/28	07:32:57	L/H388	KNAGE124365047151	04/28	07:47:43	L/H311
KNAGE124865047162	04/28	07:33:08	L/H386	KNAGE124065045695	04/28	07:48:07	L/H315
KNAGE123065045624	04/28	07:33:21	L/H384	KNAGE123665046051	04/28	07:48:25	L/H313
KNAGE123165046651	04/28	07:33:43	L/H382	KNAGE124665047161	04/28	07:48:40	L/H317
KNAGE124965045524	04/28	07:33:57	L/H380	KNAGE123765045703	04/28	07:48:55	L/H319
KNAGE123465046674	04/28	07:34:29	L/H378	KNAGE123965045704	04/28	07:49:11	L/H321
KNAGE124865047158	04/28	07:34:42	L/H376	KNAFE121165306446	04/28	07:49:37	L/H323
KNAGE124765047265	04/28	07:34:56	L/H374	KNAFE1211665106412	04/28	07:49:51	L/H325
KNAGE123865046649	04/28	07:35:09	L/H372	KNAGE124865045833	04/28	07:50:06	L/H327
KNAGE123165046734	04/28	07:35:35	L/H370	KNAGE124865047369	04/28	07:50:31	L/H329
KNAGE123965047199	04/28	07:35:46	L/H368	KNAGE124465047432	04/28	07:50:47	L/H331
KNAFE163366127239	04/28	07:36:00	L/H366	KNAGE123165046703	04/28	07:51:00	L/H333

04/28/06 12:38:34 PM

Figure 7: Additional data from Lot "L"

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(630) 860-5511

INVENTORY MANAGEMENT SYSTEM

*Prepared by
Tommy Aspinwall
Alstom Transport*

Within Alstom we have adopted an inventory management tool that supports our ERP (Enterprise Requirements Planning) system SAP.

SAP has a number of Modules within it that can be turned on, as the business requires; production planning, financial control Materials Management, etc. Within the Material Management module, there is an element of warehouse management. This will give information on material location, sizes and other material details. Figure 1 shows the structure of our systems interface with SAP and some of the modules we use within SAP.

A lot of Inventory management tools calculate inventory by taking customer demand and current inventory and by doing a calculation that tells you what level of inventory you should hold.

Where this model falls short in the total calculation, is that it assumes all vendors will deliver 100% on time all the time. The Inventory tool we use and have developed at Alstom, reviews every delivery by line item from every vendor; it takes this data and captures vendor performance. With this data we are able to add a third calculation to the model. This allows us to optimize our inventory based on the following;

Customer demand + Current Inventory + Vendor Performance = Optimized Inventory

Every night our inventory management tool takes data from SAP, which will include any new demands, any issues from stock, and all deliveries for that day. It then takes this data and produces a new management report that tells us those orders we have to place, and what excess we have in the system for both Inventory and orders placed. It makes us aware of any changes that need to be implemented and what the supplier performance was for the delivered parts. (Figure 2)

Our inventory model reports in many ways and at different levels. The main screen is called the Cockpit. The Cockpit can be shown at many levels; by location, vendor, product or even buyer. (Figure 3).

The Cockpit is split into six main parts:

- Availability
- Excess orders
- Excess inventory
- Potential stockouts
- Expedite orders
- Model inventory

Let me explain these in more detail.

Availability

This reports the availability of material to the customer; typically this needs to be in the 95-98% range. The system looks at the current demand with SAP and then reviews an inventory level to the plan - from this it calculates the

percentage of availability.

If you click on the arrow next to the availability section, a drop table will come down that shows you all the parts that are not available which you will fail to deliver to customer. This will then allow you to investigate why you did not deliver and what action you should take to prevent recurrence.

Excess orders

You may ask why we talk about excess orders before we address excess inventory. It is a natural reaction because inventory is cash and should be reduced if in excess or removed.

Firstly, let me explain what we classify as excess. Inventory may be classed as excess, if there are no forecasts in the system; parts may be repeatedly used, but unless you put a forecast in the system the model assumes no forecast, and no requirement consequently the current stock must be considered excess. This approach forces you to ensure that if there is usage then there needs to be a forecast. This will either come from the customer, or the inventory tool will look at past history and allow you to put a calculated forecast in the system.

The second reason why a part may be classified as excess is the model looks at a 3-year window, so if you have more than 3 years stock, then the subsequent years' inventory are classed as excess. The last reason why a part would be classed as excess is because it is not required, or it is obsolete.

The reason we class excess orders as a higher priority than excess inventory is because once you have purchased inventory there is not a lot you can do with it. You could write it off, find a customer who would be willing to buy it, based on some type of special offer on price, but for the most part once you have inventory there is not a lot you can do. So the priority is not to make this situation any worse by purchasing items classed as excess. This is why excess orders take priority. We need to turn the tap off that is filling our warehouse and business with excess inventory.

Again if you go to the drop down for excess orders, it will list those parts that the systems classifies as excess. This will allow you to find the reason and initiate corrective actions. These actions could include; cancel the PO, delay delivery or ensure the forecast in the system is correct.

Excess inventory

Again the reasons for a part being classed as excess are the same as described above. The actions that you take to remove these parts will be different, but the system logic is the same.

Potential stockouts

The system is monitoring all the parts, all the time, as the delivery date gets nearer; again, via the drop down table it tells you the parts that you may want to check with the vendor and confirm delivery dates and shipping instructions.

By using the system to do this you don't have to expedite all parts, just those that the system sees as a risk. This allows you to put effort into the planning and forecasting, and not expediting/firefighting.

Expedite orders

This section is calculated by the system reviewing all your suppliers' deliveries. As mentioned, it then works out the percentage of delivery performance from each vendor. The system then highlights those parts via the drop down that are due from vendors that are not high performers and may be a risk. These are the orders that have to be expedited and given more focus. If a part is being expedited via this section, and you are getting close to your delivery date then it will move up to a Potential stock-out. You then need to apply added focus to ensure you don't affect availability. Both the expedite orders and the potential stockouts are in effect a safety net. If you address these parts when the system tells you to then you will avoid stockouts and failed delivery to the customer.

Model inventory

The last section of the cockpit, tells you the optimized level of inventory you should see if you follow what the system tells you. Point to note here is the model may tell you that you will have to invest, not always reduce. This is important as normally we approach inventory from a reduction view point, not an investment.

The inventory system can do a lot more than I can explain in this presentation, so I will show you two other key parts to the system. Firstly, lets look at how the system reports the performance of a vendor. It plots every part that is delivered, how many days early, how many days late and how many on time. (Figures 4 & 5)

It also looks at the leadtime in the system and the actual time to deliver. This will then show as a performance issue with the vendor, or bad data in the system, as far as leadtimes are concerned. Now the buyer can take the corrective action. This ensures that all data within the system is topical.

Another tool is the parts inquiry screen. (Figure 6) This shows you the level of detail this inventory management system can show you in one shot.

This screen tells you all you need to know about a part and what action you have to take to ensure you resolve the problem and achieve high levels of availability to customers, as we keep the data in the system topical and more importantly resolve problems.

It's only by using this inventory management tool that allows Alstom TLS to meet high levels of performance to customers, with an optimized inventory and little if any expediting. If you require any further details, do not hesitate to contact me.

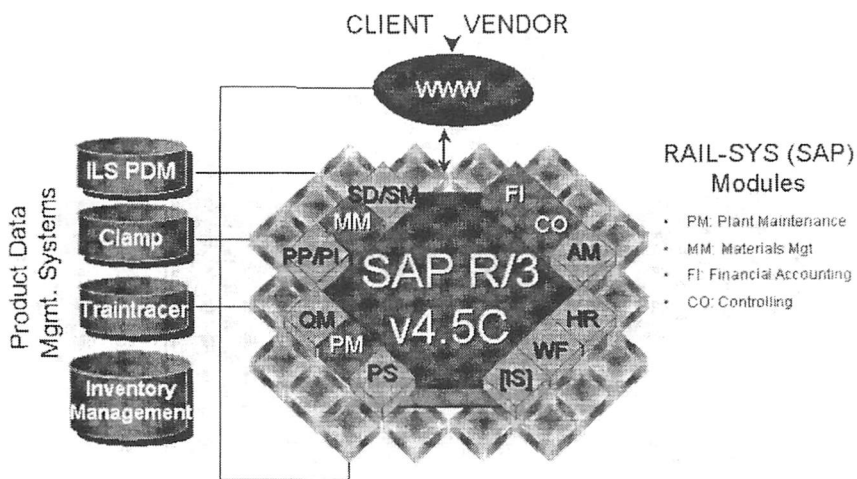
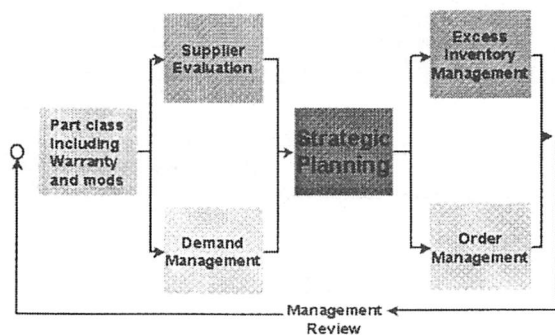


Figure 1



Unique inventory calculation based on Forecast, Present levels and Supplier Performance.

Figure 2

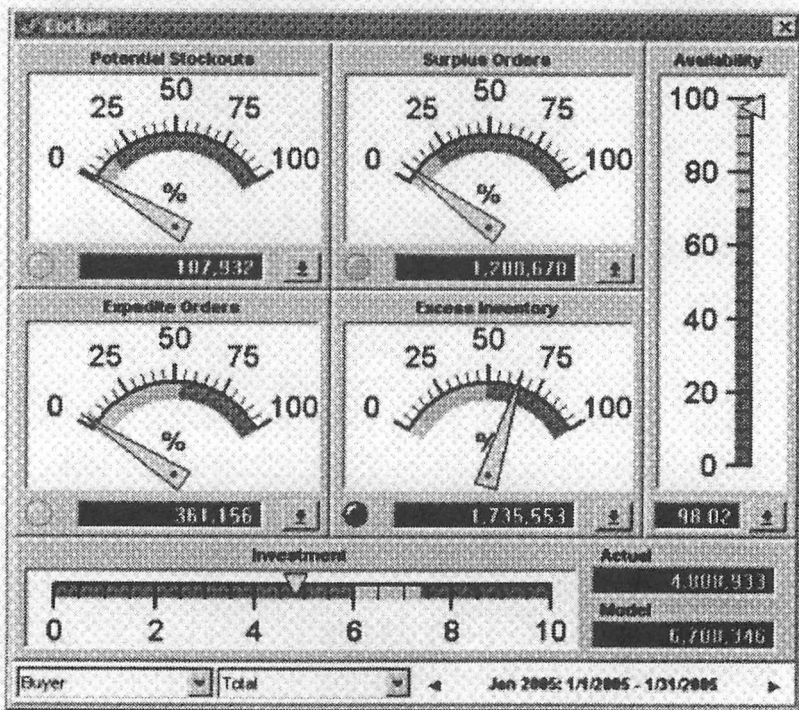


Figure 3

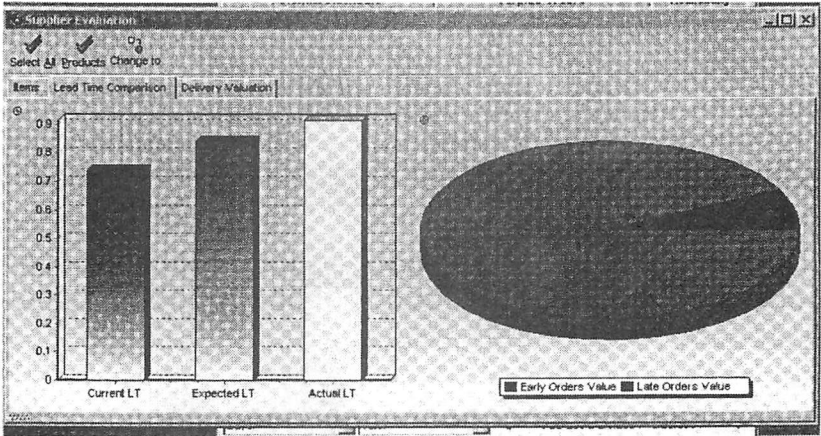


Figure 4

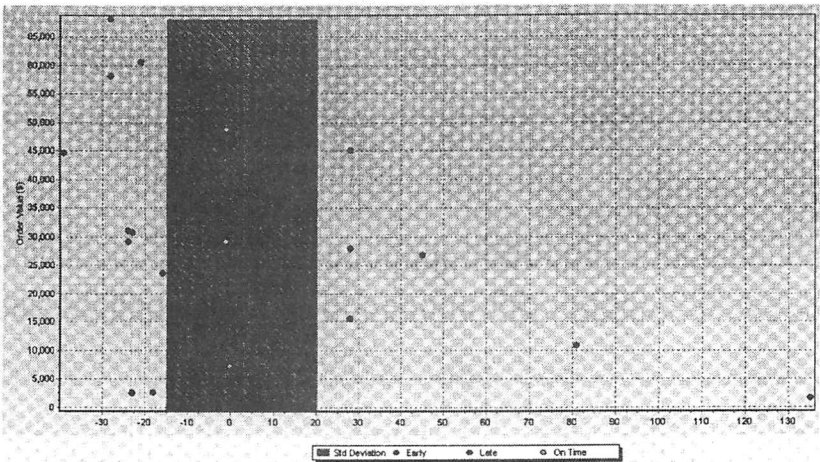
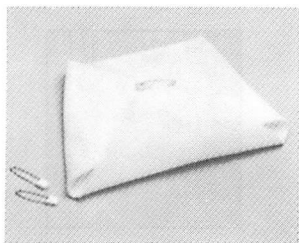


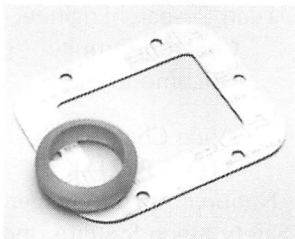
Figure 5

Inventory Enquiry																			
Item	Product Code	DTR0000062199-A-SUP					Product Description												
	CONTROLLER-EMDEC																		
<table border="1"> <tr> <td>Details</td> <td>Issues</td> <td>Purch. Orders</td> <td>Cust. Orders</td> <td>Profile</td> <td>User Fields</td> <td>Report Cat.</td> <td>Stock Build</td> <td colspan="2"></td> </tr> </table>										Details	Issues	Purch. Orders	Cust. Orders	Profile	User Fields	Report Cat.	Stock Build		
Details	Issues	Purch. Orders	Cust. Orders	Profile	User Fields	Report Cat.	Stock Build												
Grouping	Category	0003	ECONOMIC REPAIRABLE							Cost Price	\$2,195.67								
	Buyer	C14	KAREN BRICKMAN							Retail Price	\$0.00								
	Mrp code	007	Mike Douglass							On Order	16								
	Supplier									On Order in LT	16								
	Pareto Cat	M	<input type="radio"/> Stocked	Age	10					Back Orders	0								
	Generic	P	<input type="radio"/> Finished Good	Criticality	3					On Hand	4								
			Discontinuation date		/ /						Periods Cover	0.74							
			Supersession Type Code								None	Lost Issues	0						
	Action	<input checked="" type="radio"/> Surplus Orders																	
		Action Cancel or delay orders																	
Periods On Order										2.50									
Surplus Order Value										\$24,152.37									
Surplus Order Units										11									
Policy		Lead Time/Variance		5.00		20.00%													
		Transit/Alternate LT		0.00		0.00													
	Forecast Error										43.99%								
	Replenishment Cycle		1.00		1.00														
	Review Period										0.04								
	Safety Stock										0.00								
Hist Based Bin Level										8									
Target Service Level										0.00%									
Actual Service Level										62.50%									

Figure 6



STOPS LEAKS.



STOPS LEAKS.

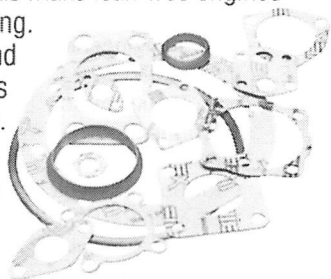
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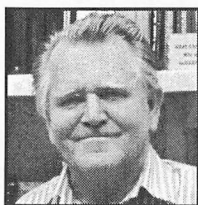


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ON FUEL, LUBRICANTS AND ENVIRONMENTAL
TUESDAY, SEPTEMBER 19, 2006
9:00 A.M.**



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WES MIDDLETON

Lead Research Engineer
Chevron Oronite
Richmond, CA

Vice Chairman

TOM PYZIAK

National Acct. Manager
Safety Kleen Systems, Inc.
Palatine, IL

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PERSONAL HISTORY

Wes Middleton

Wes Middleton, Chairman of the Fuels, Lubricants and Environmental Committee was born in Salt Lake City, Utah. Wes graduated from Berkeley High School, in Berkeley California and immediately joined the Navy. After spending four years as an aviation machinist's mate. He attended Contra Costa College. He studied microbiology and chemistry for three years.

Wes joined Chevron Research Company in 1970 and initially worked as a technician in the Lubricants Performance Testing Laboratory. He then worked for

the Base Oils and Functional Fluids Group and finished his first 10 years in the Tribology Laboratory.

In 1980 Wes joined Chevron Oronite. He is currently a Lead Research Engineer for the Industrial Engine Oils and Specialties Division, where for the past 26 years he had been involved with the product development of railroad engine oil additives.

Wes and his wife Rose will celebrate their 40th anniversary next year. They have two sons Wes Jr. & Larry. They also have three granddaughters.

**THE FUEL, LUBRICANTS AND ENVIRONMENTAL COMMITTEE
WISH TO EXPRESS THEIR SINCERE
APPRECIATION TO THE
FOLLOWING COMPANIES
WHO HOSTED AND SUPPORTED
OUR WINTER TECHNICAL
COMMITTEE MEETING IN
RENO, NEVADA IN
FEBRUARY, 2006**

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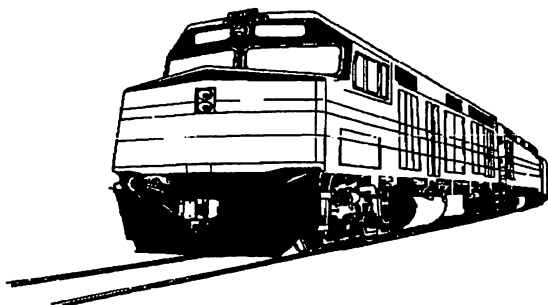
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**I. FUEL ADDITIVES
A POSSIBLE METHOD TO
REDUCE FUEL CONSUMPTION
IN RAILROAD DIESEL
LOCOMOTIVES**

*Prepared by
Chuck Kunkel*

Since Rudolf Diesel developed the diesel engine in 1892, man has searched for ways to increase the performance of this engine by improving the design of the cast iron and the fuels they consume. Unlike Alchemists of old who tried unsuccessfully to convert lead to gold, modern day chemists and engineers have made great strides in improving the combustion characteristics of the engines and the fuels to help meet mandated emissions levels along with reducing fuel consumption.

As the price of No. 2 diesel fuel has reached at times above \$2.00 per gallon, at many locations across the United States, both big and small consumers are looking for ways to stretch their fuel dollars. As the need has been made known, many manufacturers of products have emerged making promises of improved engine performance, lowered emissions, reduced fuel consumption and extended engine life. What information do you need as a railroad manager to help you make a good economical decision on the use of these products? Products intended to reduce fuel consumption and/or exhaust emissions.

Performance enhancing products generally fall under six (6) basic categories. They are:

- Fuel additives

- Crankcase oil additives
- Fuel heaters
- Fuel line magnets
- Water injection systems
- Alternate fuels

Because each of these categories could be a paper all by itself, the following information will address only chemical products, added directly to diesel fuel. No names of products will be mentioned, but an attempt will be made to give a general description of the different types of additives available and what you can do to prove the information the product representative gives you.

Types of fuel additives

Fuel additives generally fall under three basic areas, they are:

- Engine cleaners
- Combustion improvers
- Metal based additives

Engine Cleaners

Engine cleaners are usually petroleum based products that contain solvents and/or detergents. These additives are intended to soften hard carbon deposits on fuel injectors, piston rings and domes, valves and cylinder head intake ports.

Injector

By softening and eliminating carbon from the injector nozzle holes allows better fuel atomization producing better combustion in the engine cylinder. (Figure 1)

Removing built up carbon from the pistons and rings can help provide a better sealing surface of the ring land against the piston groove and a better seating surface for the

piston ring face against the cylinder wall. (Figure 2) This can reduce the escape of atomized unburned fuel during the injection portion of the combustion cycle and the escape of combustion gas during the power stroke of the cycle. Combustion and injection gases that escape past the piston rings is identified as blow-by. Blow-by ends up in the engine crankcase causing the increase of pentane insolubles (mostly carbon) and fuel dilution of the lubricating oil lowering base number, alkalinity and reducing engine oil life.

Removing hard carbon that builds up between the valve and valve seating surface on the cylinder head can help reduce the escape of combustion gases out the exhaust manifold. Reducing or eliminating carbon from the intake ports eliminates the air restrictions that causes reduced engine horsepower. (Figure 3)

Running your locomotive diesel engine at high speed and full load (notch 8), for a long period of time, will help burn out some of these carbon deposits thus accomplishing the same thing as intended by an engine cleaner additive. The problem is, unless you run this diesel engine under heavy load, high throttle service, there is little opportunity to burn out the internal engine carbon. You may be operating this engine at reduced efficiency thus using more fuel than you would with a clean engine. In some cases, carbon builds up into such a large mass in the engine exhaust system that when you open the throttle these large hot carbon masses break away from the steel surfaces in the form of sparks

that escape out the exhaust stack. These escaping sparks, in a large enough mass, can ignite the dead dry wayside vegetation possibly causing large destructive wayside fires.

Cleaner trade off

Improved seating of the power assembly components can result in better combustion and reduction of carbon buildup in the engine air intake and exhaust stacks. But with this added efficiency there is usually an increase in combustion temperature causing an increase in the level of Oxides of Nitrogen, or NOX for short, in the engine exhaust.

Some of the additive companies say their additive helps lower combustion temperatures and therefore lower the NOX. Only extensive testing of the product can determine if the additive will reduce the NOX as well as clean up the engine.

Combustion improvers

Combustion improvers or fuel catalysts are additives that claim to improve the fuel economy by changing the rate of combustion of standard diesel fuel.

Cetane numbers for standard No. 2 diesel fuel, according to the ASTM D975 specifies a minimum of 40. Fuel with cetane above 40 provides good startability, proper combustion, reduces white smoking, engine noise and wear.

Cetane improver additives increase the cetane number of the diesel fuel. The cetane number of diesel fuel is the measure of the ignition quality of a fuel. Here, the high-

er the cetane number, the lower the ignition temperature thereby increasing the duration of the combustion phase of the two (2) or four (4) stroke combustion cycle.

Other combustion improvers claim to expand the combustion phase of the combustion cycle beyond that of a standard diesel fuel providing a more complete combustion of the intake fuel. These additives claim to reduce both white and black smoke emissions and cause some fuel economy gains.

Metal based additives

Some metal based additives claim to improve engine performance by depositing metal ions onto the metal surfaces in the combustion chamber inside the engine. These metal deposits prevent oxygen and carbon from adhering to the metal surfaces thus keeping engines cleaner and preventing the formation of NOX on these surfaces.

The EPA is very sensitive about metallic based additives due to the amount of metal that could be dispersed out the exhaust stack. You have to make sure that if you use these products that they do not increase any regulated emissions.

Analyzing fuel additives

If you are thinking about using a fuel additive the following are recommended steps you can use to analyze the fuel additive.

- Information research
- Review the documentation supplied by the product manufacturer. Also look at any internet web site mentioned in the

information for any additional details not contained in the documents you have reviewed.

- Ask the representative for the users of the product. Contact the users to verify the information that was given to you. This will help you gain insight into how the user justified the use of the product. Most users are happy to share how they tested the product and how they made the decision to use the product.
- In the documentation provided look for any chemical analysis comparing the diesel fuel before and after treatment. Look for changes in Cetane number where we learned earlier the higher the cetane number the lower the ignition temperature.
- Check for changes in API Gravity or the British Thermal Units (BTU) of the fuel. Generally, the lower the gravity the higher the energy content of the fuel, thus giving you more bang for the buck.
- Check acidity levels of the fuel after treatment. Increases in acidity levels could lead to corrosion of expensive diesel engine fuel injection equipment, shortening the life of these components.
- Be skeptical of testimonials of testing performed by trucking companies and bus lines. The engines used in these industries are very different from locomotive engines and this is not an apples to apples comparison.
- Look for testing by reputable

engine laboratories where the product was tested under very controlled conditions.

- Compare the Net Traction Specific Fuel Consumption (NTSFC) of the engine running on standard and treated fuel.
- Check for emissions reductions in particulate matter (PM) and Nitrous Oxides (NOX). As a side bar, know the EPA standard for NOX limits and Opacity Standards to help you understand the emissions results in any test report. (Figures 4 & 5)

Analyzing- Economic review

To determine if the use of a fuel additive can be economically justified you need to ask the representative the amount of additive that is recommended to add to a given volume of diesel fuel. Next find out the cost of a given volume of the fuel additive. Then calculate the cost to treat one (1) gallon of fuel. Divide the cost to treat one gallon of fuel by the cost you are now paying for one (1) gallon of fuel. This calculation produces the percentage of fuel consumption improvement you have to experience just to break even with the additional cost. The equation is as follows:

- Additive treat cost per gallon/current cost per gallon x 100 = break even %

Also keep in mind that you need to include the initial capital investment of additive storage tanks, metering and mixing equipment. This could end up costing an additional \$10,000 to \$20,000 per loca-

tion where fuel additive is injected.

Analyzing- Field testing

Review any in service field testing performed by other companies or railroads. Try to understand the testing methodology that was used to prove the benefit of the product. If the product was tested on a locomotive, it is important to understand the duty cycle the locomotives were working at during the testing. The biggest problems encountered with field tests are the variables that affect locomotive fuel consumption. Those variables include:

- Ambient temperature
- Relative humidity
- Barometric pressure
- Changes in the fuels specific gravity or higher heating value
- Locomotive operator

One of the biggest variables when testing is the locomotive operator. In over the road testing performed many years ago on the Union Pacific, it was found that the difference in fuel consumption between operators could be as high as 20%. So if you are looking to validate a 2% to 5% fuel consumption improvement with an additive, the 20% variance between operators could make the additive improvement hard to find. You want to determine if the locomotives used for the testing were equipped with watt-hour meters. Then you should look for and compare the kilo-watt hours generated by the locomotives and the total fuel consumed during testing of the straight fuel versus the treated fuel.

Analyzing- Product registration

The Clean Air Act requires the registration of motor vehicle fuel and fuel additives. To find out if the additive you are considering is registered visit the website:

<http://www.epa.gov/otaq/regs/fuels/additive/we-dies.htm>.

If the additive is not registered with EPA and if you are operating a registered locomotive with this additive, it could be considered tampering if the additive increases the emissions of a regulated pollutant.

Analyzing- Testing

If you want to consider testing an additive, you should have it tested in accordance with a recognized standardized test; the Original Equipment Manufacturers, private testing companies or you can always perform in house testing.

RP-503

One standardized test is the Association of American Railroads (AAR) Recommended Practice RP-503 "Locomotive Diesel Fuel Additive Evaluation Procedure."

This procedure was adopted in 1980 by the AAR Locomotive Committee in an effort to develop a railroad industry standard for testing fuel additives. It was also an attempt to establish a testing procedure that would best simulate a controlled over the road life service.

The four (4) phases to RP-503 are as follows:

- Phase I - Fuel properties
- Phase II - Single Cylinder Cat

1G2 testing (Figure 6)

- Phase III - EMD 2-567C Engine
- Phase IV - EMD 12-645 or GE 12-7FDL engines

RP-503 has not been updated since 1980 but does allow more modern test procedures to be used in the analysis to test the fuel properties and a substitute for Cat 1G2 single cylinder engine test.

The 'Engine Systems Development Center' in Montreal developed a simplified fuel additive test for Transport Canada that utilizes an Alco/Bombardier 1-251 engine. They claim their testing provides good statistical results and is less expensive than other alternative tests.

You can also perform your own in house testing using a locomotive engine you currently own.

Stationary fuel consumption testing is very difficult and can be expensive to perform. It takes a high level of expertise to equip the locomotive, conduct the testing and decipher the data taking into account the mechanical, electrical and environmental variables.

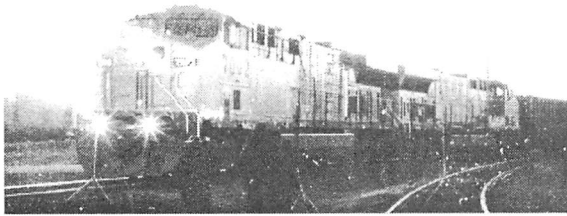
In 1991 the LMOA Mechanical Committee presented a paper where they compared stationary fuel consumption testing to dynamic over the road testing. In summary the paper stated that the test results of the stationary testing was within 1% of the exhaustive over the road testing where you had to take into account many variables, that being wind, air temperature, relative humidity, barometric pressure, differences in fuel, and most importantly, the locomotive operator.

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If you find a fuel additive that was tested by you or a reputable testing laboratory that provides an economic advantage in fuel consumption and an environmental benefit in reduced exhaust emissions, and if you have new locomotives in your fleet you are not thru yet.

Both locomotive manufacturers have not sanctioned fuel additive testing in accordance with RP-503, at Transport Canada's Engine Systems Development Center, any railroads in house testing nor any laboratory. Therefore both have stated they might deny warranty for any engine failure that might point towards a problem with fuel.

Summary

In summary, listen closely to the products representative. Ask questions that will help you understand the information the representative is sharing. Carefully review the documentation that the representative leaves with you. Talk with current users of the product to understand how they justified the extra expense in using the product. You or your company expert should review the chemical analysis of the product to determine if the product has any detrimental effects on the fuel. Understand the testing performed on the product by the current users and determine for yourself if the test results make sense. Make sure the additive is registered with the EPA and ensure that the the use of the product does not constitute tampering and does not increase any regulated emissions. You must then decide to accept or reject the test

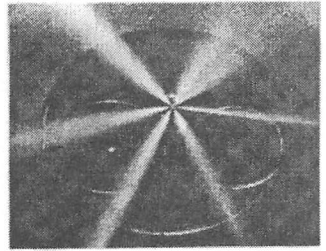
data that was presented to you.

If you are still interested, you must determine how you want to test and economically justify the product for use. Also look at obtaining a guarantee from the manufacturer on what improvements you should expect to see in reduced fuel consumption and lowered emissions.

Fouled Injector



**Fouled Spray
Pattern**



Clean Injector



**Good Spray
Pattern**

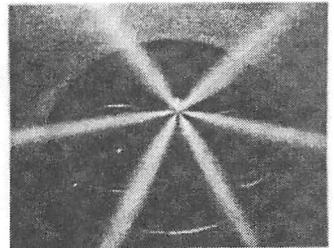
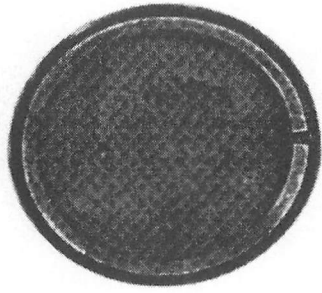


Figure 1

Carbon Coated Piston Dome



Clean Piston Dome

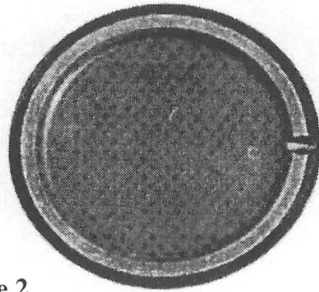
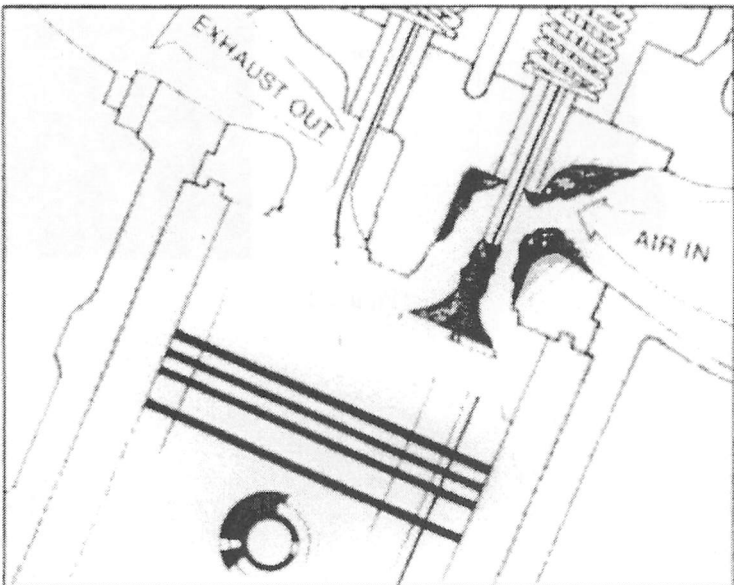


Figure 2



Cleaning out carbon

Figure 3

Exhaust Emission Standards for Locomotives				
Tier & duty-cycle	Gaseous & Particulate Emissions (g/bhp-hr)			
	HC	CO	NO	PM
Tier 0 line-haul duty-cycle	1.00	5.0	9.5	0.6
Tier 0 switch duty-cycle	2.10	8.0	14.	0.7
Tier 1 line-haul duty-cycle	0.55	2.2	7.4	0.4
Tier 1 switch duty-cycle	1.20	2.5	11.	0.5
Tier 2 line-haul duty-cycle	0.30	1.5	5.5	0.2
Tier 2 switch duty-cycle	0.60	2.4	8.1	0.2

Figure 4

Smoke Standards for Locomotives (Percent Opacity – Normalized)			
	Steady	30-sec	3-sec
Tier 0	30	40	50
Tier 1	25	40	50
Tier 2	20	40	50

Figure 5

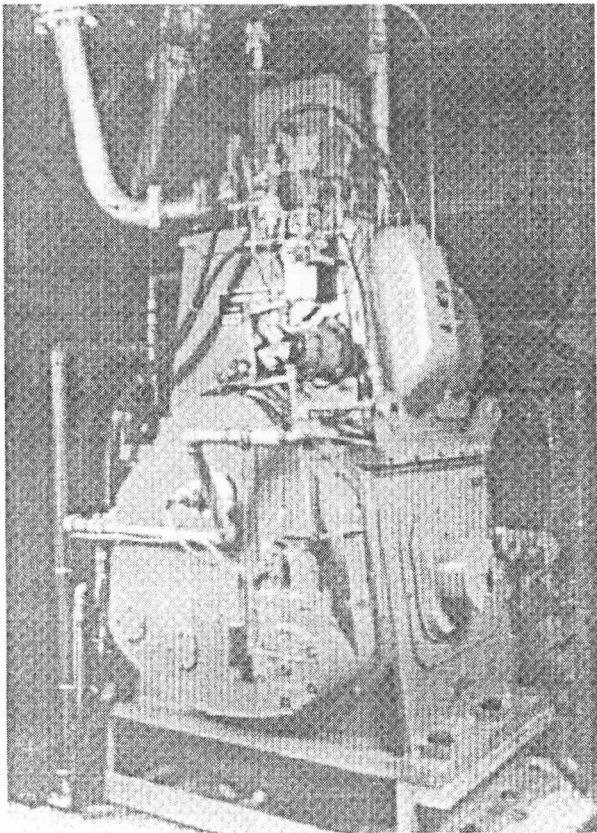
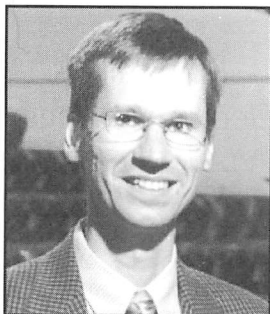


Figure 6

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

**TUESDAY, SEPTEMBER 19, 2006
10:30 A.M.**



Chairman

RON BARTELS

Director Electrical and Engine Systems
Via Rail-Canada
Montreal, Quebec

Vice Chairman

T. STUART OLSON

Regional Sales Manager
WABTEC Corp.
Alpharetta, GA

COMMITTEE MEMBERS

D. Becker	Design Engineer	Electro Motive Divn.	LaGrange, IL
J. Boggess	Sr. Mgr.-Motive Pwr.	Alaska RR	Anchorage, AK
D. Bruss	Project Engineer	Amtrak	Philadelphia, PA
M. Drylie	Electrical Syst. Engr.	CSX Transp.	Jacksonville, FL
F. Fraga	Electrician	FEC Rwy.	New Smyrna Bch. FL
B. Hathaway	Mgr.-Maint. Opns.	Maryland Midland RR	Port Orange, FL
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R. Slomski		RailPower Hybrid	Erie, PA
C. Taylor	Engineering	Bach-Simpson	London, Ontario
V. Trout	Mgr.-Mech. Engrg.	Union Pacific RR	Omaha, NE

PERSONAL HISTORY

*Ron Bartels,
Director Electrical & Engine Systems
VIA Rail Canada*

Ron has always lived in Montreal, Quebec. He was born there in 1965. He attended McGill University and graduated in 1988, receiving a Bachelor of Engineering degree in Electrical Engineering.

He began his career at CN Rail, working for five years in the Motive Power and Car Equipment department. In 1993, he left CN for AMF Technotransport. As Senior/Principal Electrical Eng., and later, manager of testing at AMF, Ron headed the Electrical Engineering and Test Departments, supporting various locomotive and passenger car refurbishment programs.

In January, 1998, Ron took the position of Manager, Electrical

Systems at VIA Rail Canada. Now at VIA, Ron manages the Electrical and Engine Systems Group, which is responsible for the maintenance program and configuration of all electrical and engine systems on VIA's locomotives and passenger cars.

Ron has been a member of the LMOA Diesel Electrical Maintenance Committee since 1998.

A recreational badminton player, Ron also enjoys camping, cycling and cross-country skiing with his wife Karen and daughters Kaitlin and Hannah.

**THE DIESEL ELECTRICAL
MAINTENANCE COMMITTEE**

**WISHES TO EXPRESS THEIR
SINCERE APPRECIATION
TO THE FOLLOWING COMPANIES FOR
HOSTING THEIR 2005/2006 MEETINGS
AND GIVING US TOURS OF
THEIR FACILITIES**

**FLORIDA EAST COAST RWY.
HIALEAH, FL
FEBRUARY 2006**

**SUPER STEEL AND RAIL POWER
TECHNOLOGIES
SCHENECTADY, NY
JULY 2006**

**SPECIAL THANKS FROM THE
COMMITTEE TO THE CSX WHO GAVE
A TOUR OF THEIR SELKIRK, NY SHOP
IN JULY**

I. APPLICATION OF 2,000 HP HYBRID YARD AND ROAD SWITCHER LOCOMOTIVES

*Prepared by
Randall J. Slomski, PMP
Railpower Hybrid
Technologies, Corp.*

In the past few years, railroads have had to begin to review the operation of their older conventional engine locomotives. The very high cost of diesel fuel has forced them to look at lower cost solutions to moving trains.

In the 1980's, many railroads began to rebuild their four axle fleets. Most of these units were thirty years old at the time and needed the electrical systems completely rewired and the engines overhauled. It was a costly program and the goal was to extend the life of these locomotives by twenty years. Some railroads made other improvements to try to reduce fuel consuming idle time. They added engine shutdown systems and electronic governors and control systems to save fuel and improve adhesion. The twenty year life extension served them well, but now, twenty years later, the conventional diesel engine is still a heavy user of fuel. In winter months there is little opportunity to save fuel by shutting down the engine, due to the design of the cooling system. Additionally, the conventional locomotive engine is very costly to overhaul.

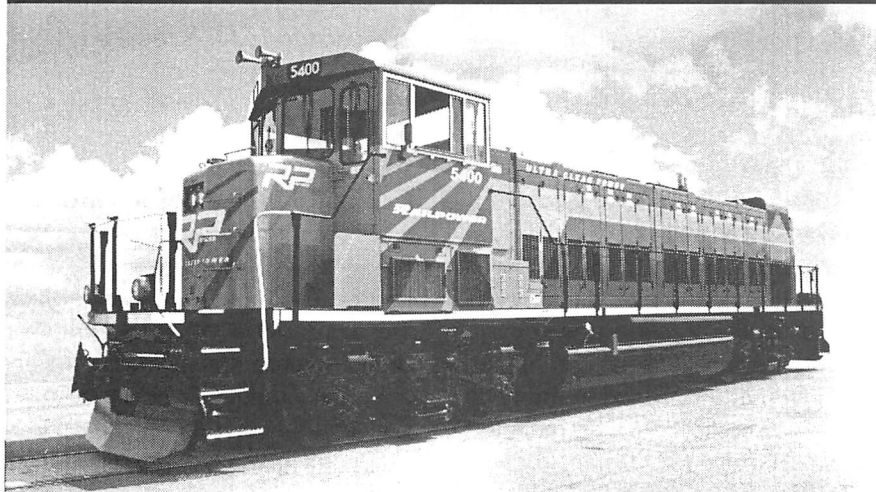
Many railroads have been evaluating the conversion of their now 40+ year old, four axle locomotives to hybrid locomotives. This conversion

replaces the conventional 1,500 to 1,700 horsepower diesel engine with a large bank of batteries that store energy generated by a small (265 to 500 HP) diesel engine/generator set (genset). The conversion replaces all of the old components above the deck with new components including the cab, control electronics and air compressor. The running gear below the deck is overhauled. The frames are inspected and repaired where necessary. The new cabs have windows on all four sides that give excellent visibility. The hybrid locomotive is very useful for yard switching service, as the yard switching duty cycle provides plenty of time to charge the batteries. The small genset provides for quieter operation and reduces fatigue of the operators.

The use of mobile maintenance is now becoming very common in the railroad industry. Instead of bringing locomotives to shop facilities, mobile maintenance equipment provides a very important service by performing repairs on locomotives, on location in the yard. Hybrid locomotives, with smaller gensets compared to conventional engines, make mobile maintenance and repair even easier.

The Railpower GG20B Hybrid Yard Switcher was the first hybrid locomotive to be made commercially available to the railroad industry. This unit has proved itself as being quite, environmentally clean and very fuel efficient in yard service. However, there is also an industry-wide need to upgrade the older, four axle locomotives that are currently

Railpower's RP SERIES Road Switchers Ultra clean power



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ROAD SWITCHER

The RP-series road switcher is available in a three-engine configuration (RP20BD) and in a two-engine battery hybrid configuration (RP20BH). The RP-series design is based on the same patented common architecture used in our GG-series (Green Goat®) locomotives. This design allows for maximum efficiency and the best management of our multiple energy configurations. With our innovative design and power controls system, our locomotives operate more efficiently and cleanly than conventional switchers.

- ▶ 20-35% fuel savings
- ▶ 80-90% reduction in NOx and particulate emissions
- ▶ robust, fuel efficient, diesel engines
- ▶ certified under EPA Part 92 requirements
- ▶ qualified as an Ultra Low Emitting Locomotive (ULEL) by the Air Resources Board of California
- ▶ improved reliability
- ▶ reduced maintenance
- ▶ increased tractive effort
- ▶ better visibility

Better economics, better environment

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being used outside the yard in road switching and transfer services. These types of service are more demanding and require more continuous power to be available.

The GG20B Hybrid Yard Switcher is defined as being a "battery dominant" hybrid, meaning that the storage batteries can provide more instantaneous power than the genset. This hybrid was developed using a modular component philosophy. This means that the parts that make up the traction power system (batteries and gensets) can be easily removed and replaced in the field.

This also allows for the parts to be easily removed and/or replaced on the drawing board. A 500 HP or 670 HP genset occupies about the same space as a 265 HP genset, or another genset could be placed in the same space as one of the storage battery racks. This modular concept was the technology enabler that led to the development of two additional configurations for this locomotive conversion; 1) The RP20BH, a "diesel dominant" hybrid that has two gensets and one storage battery rack; and 2) the RP20BD which has three gensets and no storage battery. These units are able to provide the required higher continuous horse power required by the road switcher and transfer duty cycles, while maintaining many of the advantages of the hybrid yard switcher. These units employ the same common DC buss technology that allows power to be pulled efficiently from either a battery or any number of gensets.

Despite having to use more than one genset, the fuel consumption is

still much less than the conventional locomotive engine. The locomotive control system commands the gensets to turn on and shutdown as demand for power is required. This is called "power on demand." Additionally, the diesel engines on the gensets have a closed cooling system and anti-freeze so they can shut down in freezing weather. This gives them more opportunity to save fuel, eliminate engine noise, and reduce emissions. The use of new Tier 2 or Tier 3 off road compliant diesel engines means that emissions are greatly reduced compared to the conventional diesel engine.

For maintenance, the genset is easier and less costly to maintain. In case of a major failure, the genset skid can be easily and quickly replaced in a few hours.

Technical descriptions and application notes/advantages of each of the three different configurations are as follows:

GG20B

- 2,000 equivalent diesel HP short time rating with 265 HP continuous
- One, Tier 2 diesel engine-generator set, rated at 265 HP
- Two racks of storage batteries

This locomotive is designed for yard classification and light industrial use. The wheel slip control system, with independent axle control, provides superior adhesion which produces high tractive effort. (During one test, one GG20B pulled 9,200 trailing tons up a slight grade.) The storage batteries allow for quick response to throttle inputs. It oper-

ates best on flat grades with cuts of cars not exceeding 30, traveling short distances of two miles or less. It can move longer distances, but at limited speed, around 5 m.p.h., depending upon tonnage. It can be thought of as having 2 engines; one that can sustain about 265 HP, and another that can go higher, but ideally, for only a few minutes. This matches typical yard duty cycles, where the engineer might first call for full power, but then throttle back to a lower notch once the locomotive and cars are moving. The common DC buss architecture of the control system allows the power to be pulled either from the batteries or the genset. This allows the GG20B to achieve minimal emissions and fuel usage, and maximum efficiency (work done per lb. of fuel). Fuel savings of 40-65% have been experienced in the field with this locomotive.

RP20BH

- 2,000 equivalent diesel HP rating, 1,340 HP continuous
- Two, Tier 3 off road compliant, diesel engine-generator sets, rated at 670 HP each
- One rack of storage batteries

This locomotive can be thought of as having three engines. For yard applications, one genset and the batteries will work together similarly to the GG20B. When higher sustained power is required (increased speed and/or longer distances and/or grades and/or higher tonnage), the second genset is turned on automatically by the control system. The two gensets can produce 1,340 HP con-

tinuously, which is sufficient for light to moderate tonnages traveling at low to medium speeds (depending on terrain). As a replacement for a GP38 (or similar) traditional road switcher, the RP20BH has improved fuel efficiency, reduced emissions and can do approximately 75% of what a GP38 can. This configuration allows for the optional addition of regenerative dynamic braking. This feature saves some of the power generated during dynamic braking by storing it in the storage batteries, rather than wasting it in the dynamic brake grid resistors. As with the GG20B, the wheel slip control system provides superior adhesion, which produces high tractive effort. Fuel savings of 30-50% can be expected with this locomotive conversion.

RP20BD

- 2,000 HP continuous
- Three, Tier 3 off road compliant, diesel engine-generator sets, 670 HP each
- No storage batteries, standard 74 V locomotive battery system

This configuration uses three diesel engines, controlled individually and/or in combination, through the use of the common DC buss to power the unit continuously and efficiently. For lower notch work, one or two engines are idle at times. Higher power (notches 6, 7 or 8) is obtained by operating all three gensets and can be sustained continuously. It can perform any duties normally assigned to a traditional GP38-type road switcher. Dynamic braking is an available option, but regeneration is

not, as there are no storage batteries in this configuration. As with the GG20B, the wheel slip control system, with independent axle control, provides superior adhesion which produces high tractive effort. Fuel savings of about 35% can be expected with this locomotive conversion.

In conclusion, four axle locomotive power is a necessity for efficient railroad operation. The age of these locomotives causes many service and environmental challenges. However, there exists an economically viable solution to deal with these older, poor performing units. Converting to a hybrid or multiple traction system improves the performance, reduces fuel consumption, reduces environmental emissions, improves safety (by reducing operator fatigue and improving visibility), improves field serviceability, and extends the life of the asset.



Electronic Load Controller

ZTR CONTROL SYSTEMS

Electronic Load Controller (ELC) from ZTR Control Systems eliminates the vane motor, commutator, and rheostat on most EMD Locomotives with DC Main Generators.

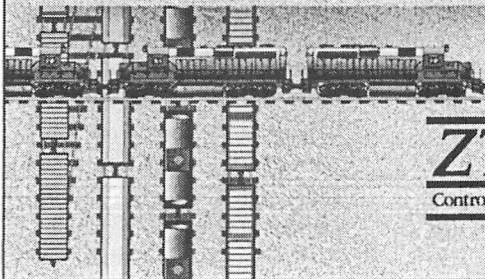
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PORTABLE TROUBLESHOOTING DATA LOGGER

*Prepared by
Tom Nudds,
ZTR Control Systems*

Overview

This product is a result of repeated requests and suggestions from various diesel locomotive maintenance shops to develop a diagnostic tool that helps identify and solve intermittent problems on locomotives without conducting extensive and costly tests. Quite often, reported locomotive problems, and specifically electrical problems, cannot be reproduced and diagnosed in a shop environment. One way to deal with this issue is to temporarily install a recording device which can keep a log of various locomotive conditions. When the issue is next reported by an operator, the recorded data log can be analyzed to diagnose the issue.

As a result of these requests, ZTR Control Systems has developed a Portable Data Logger System. The Portable Data Logger consists of various sensors and cables, a multi channel data recorder, and playback software for data analysis. The system has been designed to allow for quick installation and removal. This can typically be installed by two people in less than an 8 hour shift. The enclosures, sensors, and cables were designed to be rugged enough for railway application and to stand up to repeated installation and removal cycles.

The base system has been configured primarily to help diagnose inter-

mittent electrical issues such as traction motor ground faults, wheel slip system failures or false detection, loading issues, dynamic brake issues, and transition problems. Beyond that, many of the digital and analog inputs can be reconfigured to monitor and record diesel mechanical inputs such as air pressure or oil temperature to diagnose mechanical problems on the locomotive.

In addition to being used as a diagnostic tool, the Portable Data Logger can also be configured for use as either a traditional event recorder or utilized to collect data to be analyzed for locomotive or operator performance data.

Data Logger

The logger itself has many of the features found in a typical event recorder. Data captures are triggered when specific events take place (inputs transition from one value to another). However, the following features expand the Data Logger functionality well beyond that of a typical event recorder:

- monitors and records up to 28 analog and 32 discrete electrically isolated inputs (well above the capacity of a standard event recorder)
- in addition to capturing data triggered by events, it can also capture data at a timed sample rate which can be configured by the user
- 256 Mb of non-volatile memory
- capable of storing up to 3 months of continuous data even at the highest sample rates of 10msec

- battery backed Real Time Clock retains correct time stamp of data even on power down
- GPS antennae input
- data retention for up to 20 years with no external power
- log file downloads and file uploads via standard Ethernet cable
- portable self contained enclosure
- condition-based search engine for data analysis

Monitoring more data points at a higher resolution allows for a more detailed analysis of the conditions leading up to, and following the event (or intermittent failure) in question. The fast sample rate is extremely important when diagnosing intermittent electrical issues which can be caused by short voltage spikes or higher frequency electrical noise. Providing large memory capacity and long storage times allows for much greater flexibility in being able to retrieve data, even on units which may not return to the shop for extended periods of time. In the event that the unit cannot be returned to the shop for data analysis, the log file can be retrieved using a laptop computer loaded with the proper software, and a standard Ethernet cable. In extreme cases, the logger enclosure has been designed such that it could be disconnected and shipped to the appropriate location for retrieval of the log file without concern for damage or data loss. Figure 1 shows the front of the logger mounted in its case with the front cover removed.

Signals

Intermittent electrical failures on locomotives are often impossible to reproduce and diagnose reliably in a repair shop and only reveal themselves while the unit is in service. As such, the inputs to the Portable Data Logger have been tailored to focus on these types of failures. The system monitors and logs 32 digital points and 27 analog points as well as track speed and GPS location of the locomotive under test. The digital inputs include engine cooling fan contactors, series and parallel power contactors, braking contactors, governor valve signals, and the state of various relays in the high voltage cabinet. The analog inputs typically recorded are traction motor armature voltages and currents, main generator field current, ground relay current, alternator phase voltage and current, engine water temperature, engine rpm, and load regulator position.

Sensors

All of the traction motor and main generator voltage and current transducers as well as temperature and frequency (rpm) transducers are all of proven "railway hardened" quality to maintain reliability over repeated install/removal cycles. Figures 2 and 3 show examples of the traction motor voltage and current transducers respectively.

Installation

One of the key industry requirements for a diagnostic tool such as this is that it must be relatively quick and straight forward to install and

remove. It stands to reason that if the installation process is time consuming and cumbersome, then the tool simply will not be utilized often enough, if at all, to realize its full potential. Keeping this in mind, the Portable Data Logger has been designed to be installed by a 2 person crew during a single shift. The most time consuming part of installing a system such as this is the routing of all of the cables to the various desired test points on the locomotive. To simplify this process somewhat, the Portable Data Logger system has been modularized through the use of trunk cables and junction boxes. Figure 4 shows an overview of the system and how it is connected.

The logger itself may be mounted in the generator compartment, under the floor in the cab, or in the short hood. Coming from the Data Logger there are two trunk cables. The first trunk cable is routed from the Data Logger to the junction box which is mounted in or near the high voltage cabinet, and the second trunk is routed from the Data Logger to a junction box mounted near the AC cabinet. Each of the junction boxes act as break out points to the various data test points with a separate cable for each group of points. This provides many advantages over a large harness direct from the logger to the test points both in terms of ease and time to install and in terms of making it very easy to replace damaged or worn cables. A majority of the cables in the system incorporate bayonet style coupling for fast and secure connections.

As illustrated in Figure 5, installation time is also reduced by utilizing traction motor current transducers that are of a split yoke design which allows them to be applied without disconnecting the traction motor cables.

Configuration

The base version of the Portable Data Logger is configured for the inputs described previously in the "Signals" section. It is also configured with the highest possible sample rate. This base configuration has been optimized for capturing and diagnosing intermittent electrical issues. That being said, the design of the logger is very flexible and the system can be configured to monitor a wide variety of inputs and signal types at various sample rates depending on the detail and length of data log required for a given application.

The logger confirmation is controlled through a parameter file. The content of the parameter file defines details such as input signal types, names, and measurement units. The customer can work with a company Technical Service Representative to define and develop the required parameter file for any given application. This new parameter file is then uploaded from a computer to the logger via an Ethernet cable. The end user can then switch between various Data Logger applications by uploading the appropriate parameter file. If, for example, an application requires the monitoring of various air pressures but does not require traction motor voltages to be logged,

then a new parameter file redefining the name and measurement units for the affected analog input signals can be developed and uploaded, and the existing voltage transducers are replaced with air pressure transducers. Any sending unit which provides a 4-20 mA signal may be utilized for an analog input. Care must be taken to ensure the sensors and test points for a given installation correspond to the parameter file loaded into the logger.

Playback Software

Obviously, the real diagnostic power of a tool such as this hinges on the ability to properly and easily analyze the data produced by the logger. The Portable Data Logger incorporates a software play back tool called Winlogs. The Winlogs software allows the user to view up to 6 analog signal channels and all 32 digital signals simultaneously. The data may be displayed in a time based mode or by distance traveled. This feature is very useful when analyzing locomotive performance or reaction at a specific point on the track such as a hill, bridge or tunnel. Distance and speed information can be derived from either an axle generator input or from the GPS data.

Figure 6 shows an example of a typical Winlogs playback view. The top left section of the screen shows the specific locomotive information (only used for permanent recorder applications), file information, cursor location, and detailed analog cursor values. The lower two sections of the screen display either time or distance depending on the setup. In the

analog section, the left and right margins show the name, units and scale for each of the signals. In the lower digital section, the margins display the names of the signals. Up to six analog signals and all of the digital signals can be displayed simultaneously as shown in Figure 6. However, to make the data easier to read we have chosen to display only 11 signals. Depending on the type of analysis being performed the user has the option to choose which and how many signals to display at one time and can also change the ratio of the display screen area used for analog to that of digital. Therefore, if users are more interested in the relay activity and less interested in the analog values, they can shrink in the analog section as shown in Figure 7.

A bar at the top of the right margin indicated what portion of the log is currently displayed on the screen. The user can navigate forward and backward through the log and can zoom in or out at any point. When the cross hair cursor is moved on the screen, the analog values for the cursor location are displayed at the top of the screen.

The data is also searchable by date, time, and specific input conditions. Searches may be performed by using the **Search** command in the **Edit** menu. The user can select one of the predefined searches or create a new one. For example, as shown in Figure 8 the data can be searched for all instances where the Main Generator Voltage goes above 1000V and Traction motor 1 voltage is above 1100V. Various combinations of search algorithms can also

be stored and labeled for use when searching for specific types of problems or events.

As shown in Figure 9 the Winlogs software also allows the user to flag points of interest for easier subsequent analysis or for comparing similar events within the same log or in other logs.

Tabular reports of the data can also be generated into a flat file format for easier storage and/or entry into a database. Winlogs also provides the ability to perform searches on multiple data logs simultaneously which can be useful when trying to discover trends.

Conclusion

This new Portable Data Logger goes well beyond the capabilities of traditional event recorders. Portable hardware design, user configurable sample frequencies and extended data storage capacity combined with condition-based data search engine make this logger system ideally suited for any number of uses including diagnostics, performance monitoring, and event recording in both temporary and long term installation situations.



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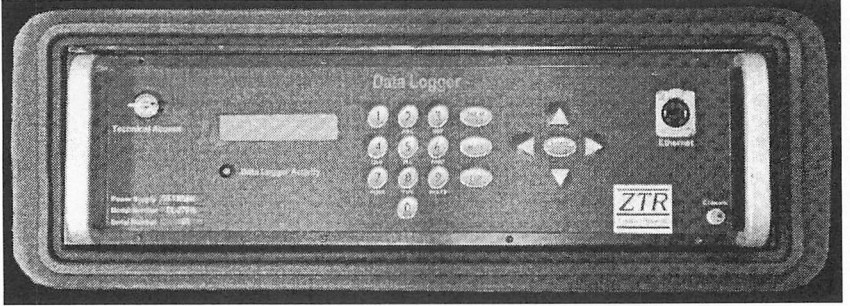


Figure 1

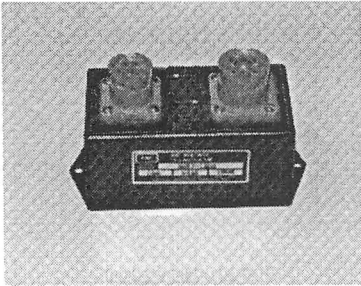


Figure 2

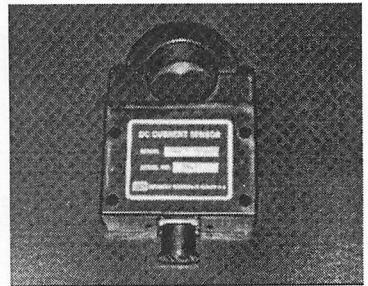


Figure 3

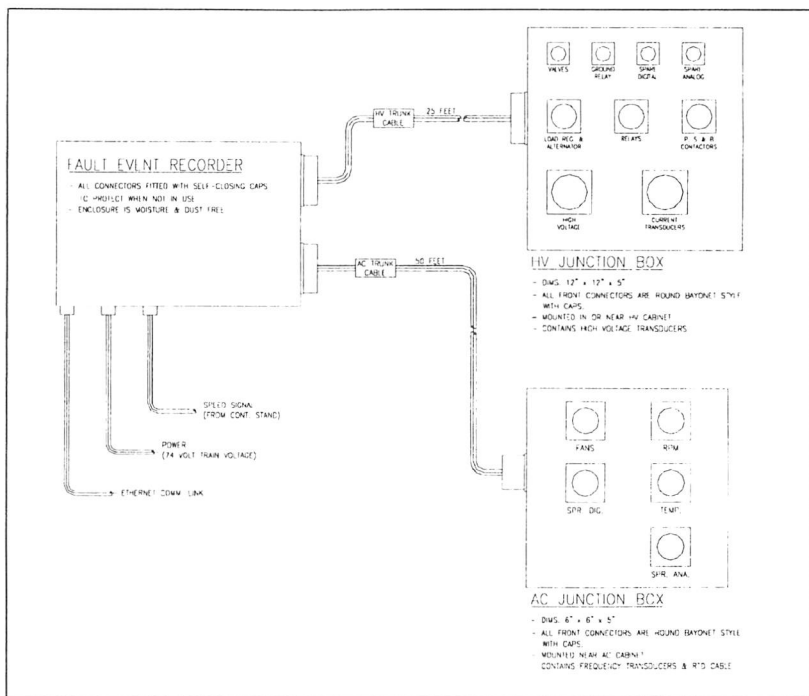


Figure 4

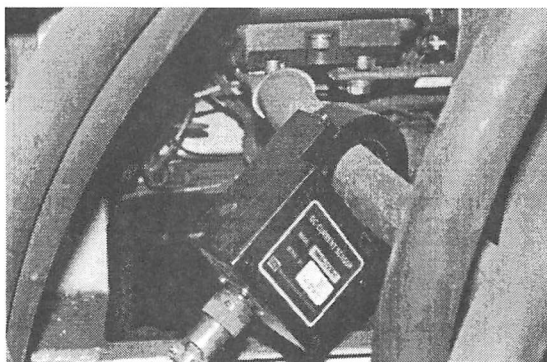


Figure 5

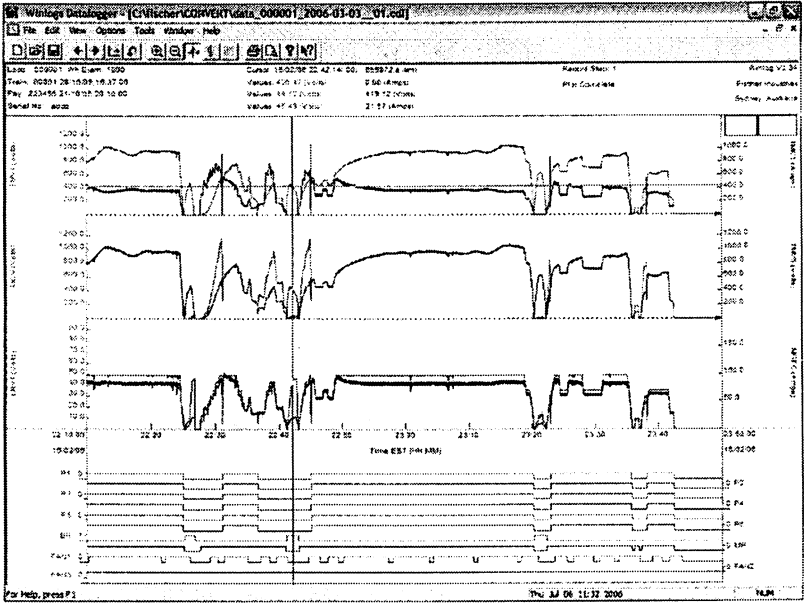


Figure 6

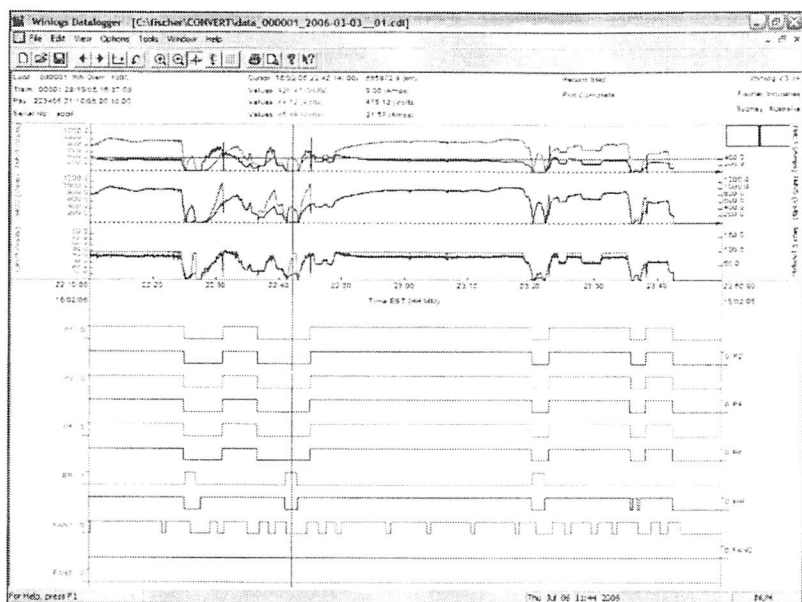


Figure 7

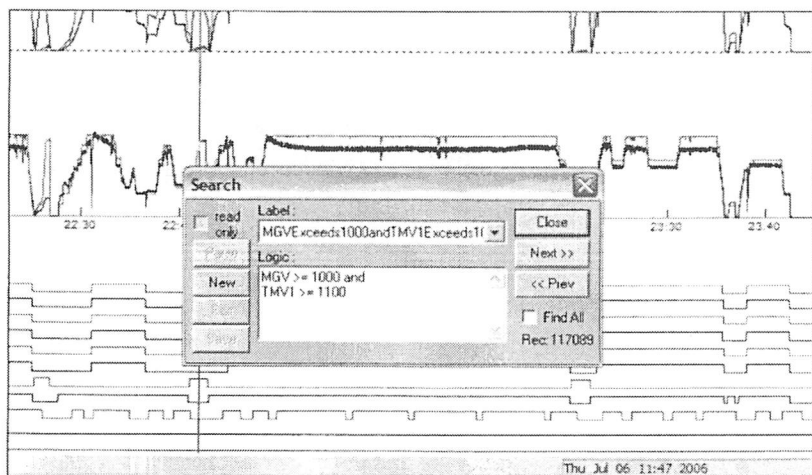


Figure 8

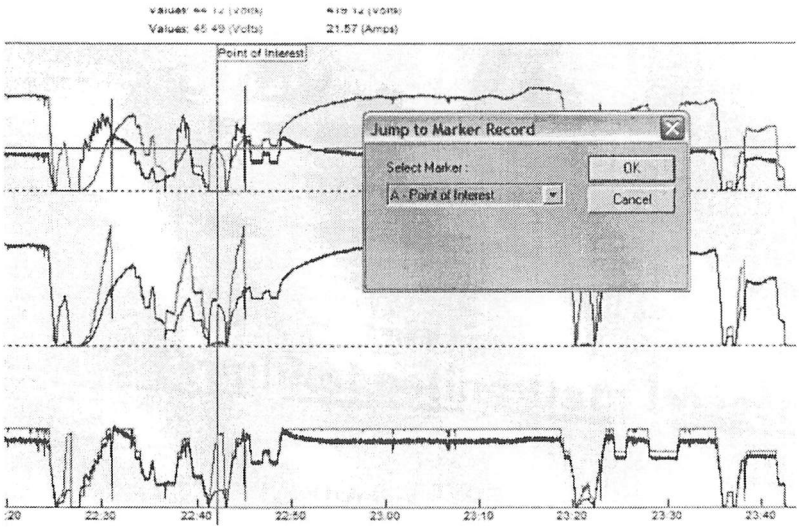


Figure 9



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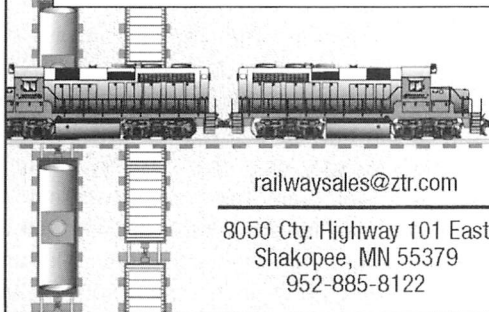
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3. LOCOMOTIVE LIGHTING IMPROVEMENTS

*Prepared by
Ron Bartels,
Via-Rail Canada*

Introduction

Historically, lighting on locomotives has not received much attention in the media or from locomotive operators or builders. It is usually overshadowed by subjects that have a big impact on a railway's operating costs, such as EPA emissions regulations, fuel consumption, or tractive effort.

But lighting performs some important functions. It can:

- Make locomotives visible (or conspicuous) to others.
- Allow operating crews to see ahead in darkness.
- Allow operating crews to read documents (task lighting).
- Allow operating and maintenance personnel to safely navigate their way through the locomotive.
- Allow maintenance personnel to see clearly while performing their work.

This paper describes VIA Rail's efforts to improve lighting performance in most of the above areas. On-board maintenance lighting was not addressed. It is generally used a small percentage of the time and maintenance personnel have access to a wide variety of portable and effective light sources, both battery and AC-powered.

Apart from improving lighting performance in terms of visibility or light output, the other objectives of the

upgrades were reductions in maintenance costs, fuel consumption and environmental impact as well. Can all this be achieved with lighting? Surprisingly enough, it can, and how it can be done is explained throughout this paper.

History/Evolution

The history of evolution of locomotive lighting in North America does not make for a very interesting story. Taking headlights for example, locomotives used to have a simple incandescent bulb mounted in a fixture with a huge reflector, such as in Figure 1. The next evolution for headlights was the parabolic reflector (PAR56) sealed beam, 200 watts, 30 Volts, narrow spot. Locomotive control voltage was typically 74 VDC and 30 VDC was required for the headlights. Using the technology available at the time to reduce voltage, dropping resistors were used. A lot of heat was generated and wasted to provide 30 VDC to the headlights. It takes 6.7 A or 495 watts at 74 VDC to power a 200 watt headlight at 30 volts when using dropping resistors. Even today, dropping resistors are still widely used.

Around the 1980's, railways started installing ditch lights, or auxiliary lights, on locomotives. They were mounted a few feet lower than the headlights and are usually about five feet apart. There were two main reasons for adding the ditch or auxiliary lights. One was to better illuminate the sides of the track and the track itself when travelling in curves. Today, some automobiles have headlights that swivel to point in the

direction of the front steered wheels. This was much the same idea except executed more simply by focusing the ditch lights to cross in front of the locomotive, lighting up a wider area at all times.

The other benefit of having the triangular shaped lighting pattern at the front of the locomotive is that it made the locomotive more visible and it was easier to gauge its distance and the speed at which it approaches. Many railroads used, and still use, a 350-watt, 75 Volts parabolic reflector (PAR56) sealed beam spot in this application for a few reasons. It provides a wider beam than the 200-watt narrow sealed beam, which is useful in illuminating the track ahead when travelling in curves. It also eliminates the need for dropping resistors. It consumes 350 watts versus 495 for the 200 watt sealed beam while providing more total light output. This is a net savings of 290 watts for a pair of headlights.

Railroads soon realized that having two physically interchangeable types of PAR 56 sealed beams on their locomotives and in inventory would lead to problems. Operating either of them at the wrong voltage has undesirable consequences. A 30-volt headlight bulb connected to 74 VDC will burn very brightly but not for very long. On the contrary, a 75-volt bulb powered from 74 VDC through a dropping resistor does not produce as much light. The result was that a number of railroads switched their headlights and ditch lights to 350 watts, 75 VDC sealed beams, eliminating any chance of

confusion and simplifying inventory.

There have been some recent efforts to introduce halogen technology into locomotive headlights. Some railroads have tested them with mostly positive results in terms of lamp life and light output, both new and long term, but they have not yet gained widespread acceptance.

There is not much history behind other lighting besides headlights and ditch lights. The 75-volt rough service medium screw base bulb has been around for decades providing general lighting in locomotives. When new, they provide a yellow glow and, after a period of time, only provide a fraction of their rated output because the globes are black. They are still widely used today in new locomotives, mainly because they are inexpensive to install, but are ineffective at providing much useful light.

Small fluorescent fixtures in locomotive cabs for general lighting have been around for a number of years now. They replaced incandescent bulbs with longer lamp life and reduced power consumption but came with problems of their own: lamp starting and ballast life were initially not very good and improvements in both of these areas were not significant.

There are other small incandescent bulbs used for indicators, as well as for instrument, toilet, and step lighting. These bulbs have also seen very little changes over the years.

Recent Improvements

A number of improvements in lighting technology have been made over the years, but few, if any, made their way into locomotives.

VIA explored how the newer commercially-available technologies could improve performance in terms of safety, reliability, environment-friendliness, and operating maintenance costs.

Improvements were made in the following areas:

- a) Number lights
- b) Indicators
- c) Reading lights
- d) General cab lighting
- e) Headlights

a) **Number Lights:**

To reduce power consumption and virtually eliminate the need to ever change number light bulbs again, VIA installed light-emitting diode (LED) lighting strips with multiple LED's on one of its F40 locomotives, to replace the incandescent bulbs. It is expected that the LED strips will last an average of 20 years. It is still too early to validate the reductions in maintenance, mainly because they were only recently installed as part of a major overhaul, and the locomotive is not back in service yet. The reductions in energy consumption, however, are measurable. Overall, they use about 90 watts less power whenever the locomotive is running compared to the previous configuration with four 25-watt incandescent bulbs. A pair of new LED number light strips, that replace two 25-watt bulbs, is shown in Figure 2.

b) **Indicators:**

On the same locomotive that has the LED number lights, all the "egg-crate" style indicators were eliminated. This was accomplished largely by removing the need for them by adding a microprocessor-based control system with a display screen. The few indicators that are still required have been replaced by LED indicators. The push-to-test feature is no longer required because the indicators have multiple parallel circuits. If one circuit fails, over half of the LED's still function. It will be visibly dimmer, giving an indication that it is no longer working with all LED's. It is expected that these indicators will last the life of the locomotive.

c) **Reading lights:**

Again in the same locomotive, two 12 VDC gooseneck halogen lamps were installed. They use off-the-shelf technology. They provide local lighting exactly where the operating personnel need it: on their desk, without any glare because they are near the desk and not on the ceiling. Unfortunately, no reliable data is available to determine consumption of light bulbs. For longer bulb life, LED versions are also available.

For VIA Rail, the 12 VDC was easily available because VIA's locomotives have an additional radio that works off of a 12 VDC isolated power supply. Even if there is no existing power supply on board, railroad-grade isolated DC-DC converters have become quite affordable lately so it is less of an obstacle. The crews appreciate the reading lights. Initially one was installed on the engineer's side and, during the F40

major overhaul, one is being added on the helper's side as well. A typical gooseneck lamp is shown in Figure 3, although it is not the exact type used on VIA's locomotives.

d) **General Cab Lighting:**

Given the lamp starting and life problems with the ceiling light fixtures normally used in the locomotive cabs, a different type was installed in the F40 locomotive in major overhaul. It operates with two fluorescent tubes and uses a remote-mounted railroad-grade ballast with a simple on/off slide switch. There is no news yet on the long-term performance of the fixture, again, since the locomotive is not in service yet.

e) **Headlights:**

The main motivation for improving headlight performance was not because of any issues regarding possible non-compliance of the 350-watt, 75-volt PAR 56 spot sealed beam with FRA and Transport Canada Regulations. It was to improve long distance visibility in the dark and locomotive conspicuity at all times. At speeds of 100 MPH, obstacles approach a train and trains approach crossings twice as quickly as with a 50 MPH freight train.

A single off-the shelf Xenon "pencil-beam" off-road lamp was installed on the nose of two VIA F40 locomotives, underneath the lower headlight. The "pencil-beam" designation means that its beam is extremely narrow. It uses free-form reflector technology instead of a parabolic reflector. This allows for an optimization of the beam pattern. Figure 4 shows a photo of the lamp. Figure 5 shows it after installation. It provides a light-

ing level of 1 lux at 3/4 mile, consumes about 35 watts at 12 VDC (about 40 watts total including efficiency losses in the DC/DC converter), and has an expected lamp life of 3,000 hours vs. 500 hours for the standard sealed beam. One has been in service for over a year and the other for about 8 months. Neither has needed a lamp replacement yet.

Operating crews unanimously appreciate the safety benefits the Xenon light provides. On the first trip after installation on one of the locomotives, the crew were able to spot an obstacle on the tracks at night long before they would have without it. They minimized damage to the locomotive by applying the brakes sooner than they otherwise would have.

Benefits of Lighting Improvements

The primary benefit and objective of the improvements was to improve safety. With better illumination in the right places, operating crews can see better with less strain, allowing them to be more alert. This reduces chances for error and can also help them avoid a collision or at least minimize its impact.

Reducing maintenance costs was another benefit and objective in the quest for better lighting. There will be much less time spent changing lamps. Fluorescent lamps can easily last 10,000 to 20,000 hours and sometimes more while many LED's are rated for a life of 100,000 hours. In some applications, namely replacing incandescent bulbs with LED's, it is difficult to forecast if material

replacement costs will decrease, since LED's are still quite expensive. However, when figuring that the LED's are expected to last about 100 time longer than the incandescent bulbs, the savings in labor costs, and the overall savings in maintenance costs can be quite appreciable.

Reductions in operating costs, while not a primary objective of improving locomotive lighting, were an additional benefit. They appear as reductions in fuel consumption. Based on the assumptions that a locomotive operates on average in lead position for 8 hours/day and 350 days/year, every reduction of one watt of power consumption equates to an annual reduction in fuel consumption of about 0.18 USG. For example, just take into consideration 75 V, 350 watt headlights compared to 30 V, 200 watt headlights and LED number lights compared to incandescent bulbs. The headlights reduce power consumption by 290 watts and the number lights contribute another 90 watts of savings, for a total savings of 380 watts. This equates to a reduction in fuel consumption of about 70 USG/year. At today's fuel prices, the savings add up quickly.

The reductions in maintenance requirements and fuel consumption also benefit the environment. Since the improved lighting systems all have longer life lamps than the ones they replace or supplement, far less waste will be generated from burned out bulbs. The quantity of EPA regulated emissions produced will also decrease if less fuel is burned.

Opportunities

There are other lighting systems on board locomotives that still have room for improvement. Areas where the light source is not very far from its target, such as walkway, step, and ground lights, can be illuminated by LED's to replace the existing incandescent lamps. There are LED substitutes currently available for these applications but the only ones tested so far by VIA did not have adequate light output. Some additional development will surely solve that problem.

General area lighting, such as in engine rooms and electrical cabinets, can be provided very well by fluorescent or compact fluorescent lamps. Although these technologies are widely used in buildings and passenger rail cars, they haven't gained widespread acceptance in locomotives, except in the driver's cab. There are many choices available that can increase light output with reduced power consumption and much longer life, compared to incandescent lamps. They were, however, not part of the current lighting improvements tested at VIA.

Halogen headlights have been available for a few years now. They have been tested by some Class 1 railroads but have not yet gained widespread acceptance. They provide more light output than the standard 350 watt, 75 V sealed beam and maintain a more constant light output throughout the life of the lamp. They are also expected to last longer than the standard sealed beams. Another advantage of the halogen sealed beam is that the fila-



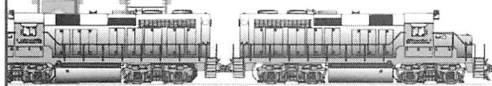
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ments have less tendency to sag under certain conditions, preventing them from losing focus. As can be expected, they also cost more than the standard sealed beams. VIA has not yet used halogen headlights but plans to test some for evaluation purposes.

Conclusion

In general, since the advent of the diesel-electric locomotive, there have been very few widely accepted improvements in locomotive lighting. There are, however, many options available that can improve safety, reduce maintenance and operating costs, and help railroads contribute to a cleaner environment. A number of them have been tested and some of these tests have already produced encouraging results. Others will require longer periods of time to evaluate, due to their very long expected lifetime.

One of the big advantages of most of these potential lighting improvements is that they use proven commercially available technologies that require little or no development to adapt them to a locomotive environment. Therefore, there is little risk in making these improvements. with many potential benefits.

Acknowledgements

I would like to thank Bill Barclay, Andre Milot, Sandip Bhamrah, Peter Imhoff, and Bob Becker of VIA Rail's Technical Services department for their contributions and support in preparing this paper.



Figure 1
Old style locomotive headlight, bulb with reflector

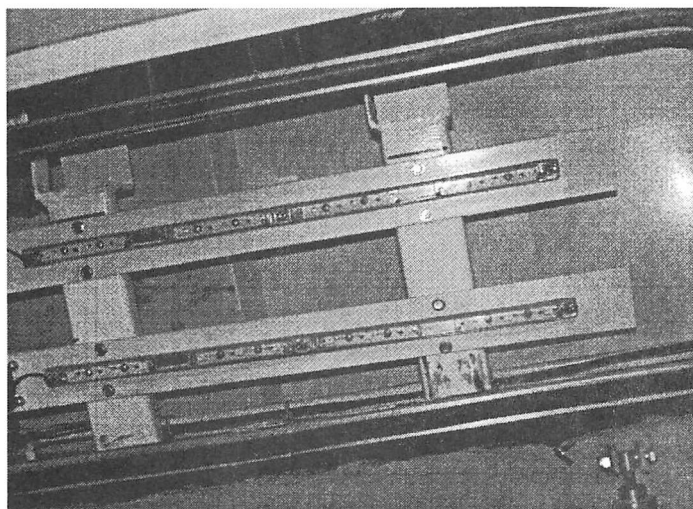


Figure 2
Two LED number light strip assemblies

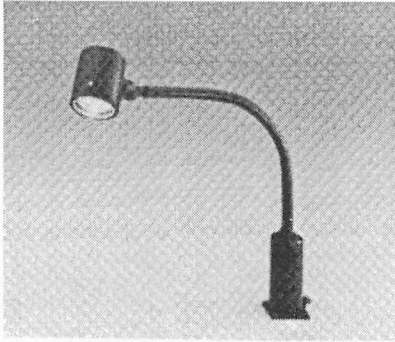


Figure 3
Typical gooseneck lamp



Figure 4
Xenon pencil-beam lamp



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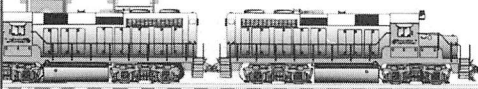
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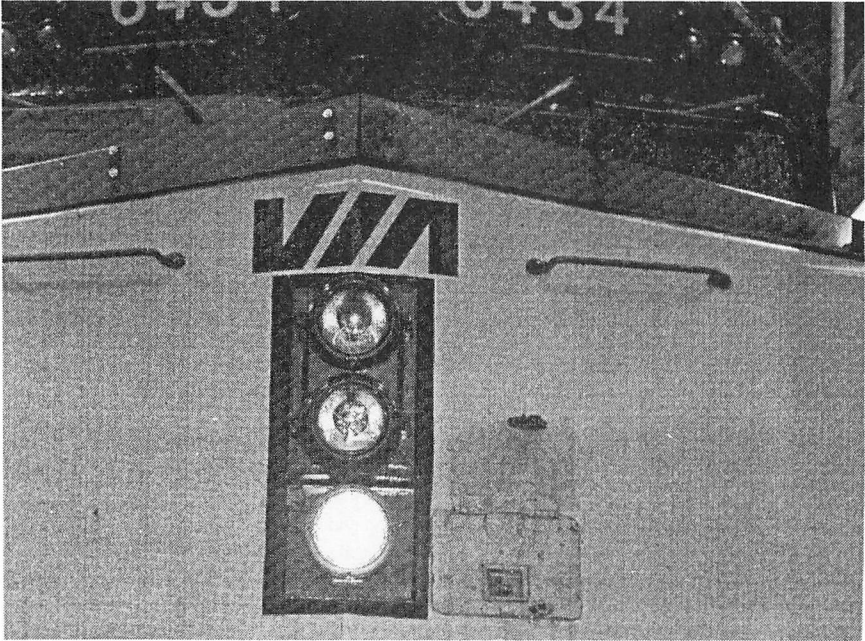


Figure 5
Xenon pencil-beam lamp, installed on a locomotive

3. ADAPTING A FREIGHT LOCO INTO A PASSENGER LOCO

Prepared by

Jay S. Boggess, P.E.

*Alaska Railroad Corporation
formerly with*

*Electro Motive Division of GM
(now called Electro Motive Diesels)*

This paper will describe a clever adaptation of an AC freight locomotive into a dual-service passenger/freight locomotive - the SD70MAC-HEP. It was a project driven (like many projects are) by an aggressive delivery schedule and design requirements. By taking several existing bits of locomotive technology, a unique and useful locomotive was developed and delivered in nearly record time for The Alaska Railroad.

The SD70MAC-HEP has its lineage in four other EMD locomotives: Figure 1 is the first SD70MAC, delivered in 1994 to the Burlington Northern. Alaska Railroad purchased 16 units in a winterized configuration in March 2000, as shown in Figure 2.

Figure 3 is the Long Island Railroad DE/DM30AC locomotive. This locomotive was the first EMD production passenger locomotive with AC traction motors, Siemens GTO inverters and inverter-based Head End Power (the EMD F69PH-AC prototype units of 1989 never went into production, although many concepts initially tried on the F69's ended up on the DE30's).

Figure 4 is the CSX 4300HP SD70MAC. This locomotive, designed and built just before the

SD70MAC-HEP, put the Tier-1 emissions engine and cooling system onto a 70MAC for the first time. During its design, the equipment at the long hood end was extensively rearranged so that space could be allocated for the CSX-requested Eco-Trans Auxiliary Power Unit. The space would later turn out to be key to the success of the SD70MAC-HEP.

These previous designs coalesced into the Alaska Railroad SD70MAC-HEP (Figure 5), a 4300 THP freight/2400 THP-730kW HEP passenger locomotive.

I had an interesting perspective on this project. I was involved in the locomotive's original conceptualization, design and build at EMD. I came to work for the Alaska Railroad soon after they were delivered and then was knee-deep in the post-delivery HEP commissioning. Thus, when I need to complain to someone about who designed this mess, all I have to do is look in the mirror!

The Railroad

The Alaska Railroad connects Anchorage (the state's largest city) with Fairbanks, 356 rail miles north, along with the seaports of Seward and Whittier 114 and 72 miles to the south, respectively. Freight service consists of oil trains from the Flint Hills refinery at North Pole, Alaska to Anchorage, coal trains from the Usibelli mine near Healy to the port of Seward and interchange cars from our barge operation in Whittier. Three trainsets of SD70MAC's and hopper cars move aggregate from quarries in the Palmer-Wasilla area

for construction in Anchorage all summer long. Our passenger season starts in mid May and consists of a mélange of trains:

- The Denali Star - Two trains in daily service from Anchorage to Fairbanks, with stops in Wasilla, Talkeetna and Denali (Mt. McKinley). Eight ARR cars plus 8 to 10 cars owned by the cruise ship companies are pulled every day.
- The Coastal Classic - One train to Seward and back, dovetailing with day cruises to Kenai Fjords National Park.
- The Hurricane Turn, which provides flag-stop service using RDC's from Talkeetna to Hurricane, where a series of cabins are only accessible by rail.
- Trains connecting cruise ship passengers from Whittier and Seward to the airport in Anchorage.

As tourism increased, more cars were added, which is what started this whole project in 2001.

HEP for our passenger trains was first handled by 2 paralleling 150-kW generator sets slung underneath the baggage car (see Figure 6). Later in 2000 and 2001, six GP40's were rebuilt into HEP-equipped units for passenger service. 3009/10/11 were equipped with 300kW Detroit Diesel generator sets and 3013/14/15 with ex-Amtrak 800kW gear-driven generators. Each has their disadvantages:

- The baggage car gen sets have limited capacity and are susceptible to clogging with cot-

tonwood lint.

- The 300kW Geeps are noisy and again have limited capacity.
- The 800kW Geeps (see Figure 7) are VERY noisy, have very small fuel tanks and are not at all fuel-efficient.
- ALL the locomotives (even though recently rebuilt) are getting old.

As an answer to Alaska Railroad's passenger power problem, EMD offered F59PH locos, but Alaska considered them very expensive, especially for a unit that would only be needed in the summer. Robert Stout (ARR CMO at the time) suggested to EMD, "We like what the SD70MAC does for us - what's the possibility of putting HEP on a MAC?" Such a dual-purpose unit would be flexible for both the short passenger season and again useful the rest of the year as a freight locomotive.

When this suggestion wound its way to EMD Engineering, Tim Keck (EMD Manger of Systems Engineering at he time), posed that question to me and others. We all realized that one of the two TCC's of a SD70MAC might be modified to provide HEP, leaving the other TCC and truck to propel the unit (and the other truck just coasting). Consultations with our counterparts at Siemens confirmed that yes, EMD and Siemens could adapt the HEP transformer previously designed for the LIRR DE-DM30AC locomotive with the inverter of the SD70MAC to provide 480V HEP.

As the original SD70MAC had no

room in its carbody for the additional needed HEP equipment, several different ideas were proposed, including using the locomotive roof and running board. The only realistic hope was to dramatically shorten the fuel tank and sling the HEP equipment underneath the underframe. As the LIRR DE3030AC HEP transformer was hung similarly under its structural carbody, this didn't seem too bad of a situation. The challenge would be designing cabinets for the HEP switchgear for the underslung application. Design, cost and manpower estimates were made at EMD. But then, ARR decided not to buy locos for that calendar year - not completely forgetting the idea, just not for that year.

In the fall of 2002, CSX entered into this story. They came looking for new units - more SD70MAC's like they already had - with 3 important differences.

- The engines were hopped up from 4000 to 4300 THP.
- By EPA regulations, they would be required to meet Tier-1 emissions and thus needed a new split cooling system (first applied to UP SD70DC units but never to a SD70MAC).
- CSX requested space be designed in the rear of the unit for an Eco-Trans APU.

By some creative re-arranging of components, a volume of 3'6"x6'x5'9" was created for the APU by:

- Replacing the 4-cylinder WLA electric drive air compressor with a shorter direct-drive-only WLN 3-cylinder compressor.

- Rotating the #2 TCC 180 degrees so that its "blind side" faced aft (the Siemens TCC has one face with no access doors for maintenance). This put the access door for the TCC computer in the same room as the air compressor - less than desirable but acceptable.
- Moving the battery box from the conductor's side to engineer's side of the long hood.

As always, EMD Drafting worked quickly to deliver the necessary production drawings to the shop for a December 2003 start of construction. CSX would eventually acquire 130 4300-THP SD70MAC's.

With the CSX Tier-1 70MAC design complete, EMD realized that the CSX APU space could easily morph into a location for an Alaska HEP system without shortening the fuel tank and without slinging transformers and equipment underneath the loco. This proposal was offered up to Alaska in the spring of 2003.

Now the problem became one of delivery schedule - Alaska needed locomotives by April/May 2004, so as to avoid leasing locomotives for the 2004 summer passenger season. However, the lead time for the Siemens-supplied software and equipment for HEP prevented such a schedule (although they could easily deliver freight-only equipment for an April ship date). Around this impasse, EMD came up with the idea - deliver the locomotives *without* HEP capability for April 2004, then install the HEP equipment *later*. With that compromise, Alaska signed for 8 SD70MAC-HEP loco-

motives (up from the 4 they were originally considering) in June 2003. This was a very ambitious design/build schedule for Electro-Motive.

After settling details with the railroad in July 2003, it was time for EMD to translate wild-hair, back-of-the-envelope ideas into something that could actually be assembled in London (ONT) - and assembled in time. The key problem was this: how to shove ten pounds of...*stuff* into an eight pound bag! The design process for the Alaska HEP was fraught with limited time, false starts and changing concepts. We knew that the transformer could not be delivered until August 2004, but then we realized that the more equipment we *could* mount in the HEP Equipment Room in London, the less work that would be required to do in Alaska and the better for all parties involved.

The system

The final arrangement for the SD70MAC-HEP ended up as follows:

- Siemens GTO TCC cabinet with modified software in Siemens ASG computer.
- Repackaged HEP transformer, based on LIRR transformer design.
- Three delta-connected capacitors for AC harmonic filtering - 550 kVAR (capacitive) total.
- Switchgear to switch modes between HEP and traction and to disconnect the #1 end receptacles.
- HEP blower and filter behind the long-hood headlight.

- Main HEP contactor (ACC) and sundry HEP contactors, relays and equipment.
- HEP switches, pushbuttons and fault lights located in cab on HVC door.

Most of the equipment ended up squeezed into the volume that was created for the CSX APU, which was renamed the HEP Compartment. Figure 8 is the outside of the HEP Compartment, figure 9 is the inside and figure 10 is a one-line diagram of the HEP system.

Siemens TCC

The Siemens TCC (Traction Converter Cabinet) required limited hardware yet extensive software changes to accommodate HEP. The TCC went through a redesign in 1999 and is identical to TCC's that were built since that redesign, except for several Alaska-specific cold-weather modifications first applied on Alaska's previous SD70MAC order and reused again on the SD70MAC-HEP.

Small changes were required to the ASG hardware (ASG: Antreib Steuer Gerat - German for "Propulsion Control Apparatus"). The chassis required a half-dozen wire wrap mods and one PC board needed a capacitor and resistor so that the unit could monitor the 480V HEP output for closed-loop voltage control.

The largest single change was new software for HEP. "New Software" was not the correct phrase - "extensive additions to existing software" is much more appropriate. The ASG processor is nearly unchanged from

1992 and its software written in assembly language. In spite of all the new code, the software version written for the Alaska HEP TCC's is backwardly compatible with every other Siemens TCC.

When in HEP mode, the TCC is programmed to switch the GTO's at about 400 Hz to create a stepped 60 Hz (fundamental) 660V output, which is then fed to the HEP transformer. The TCC can generate the 60 Hz under widely varying DC Link voltages. At lower HEP loads, only 1050V (dc) is required, which the diesel engine/main generator can handle at TH2. Full HEP load can be supported with TH3 and 1250 V(dc). As the engineer changes his throttle, the TCC adapts to the changing DC link voltage and continues to deliver constant HEP voltage and frequency.

HEP transformer

The HEP transformer (Figure 11) serves to isolate the 2600V(dc) world of the DC Link from the 480V(ac) of the passenger cars. It is of 939 kVA capacity wound with a delta primary and wye secondary (nominally 660V I-I in, 480V I-I out). The neutral of the secondary is connected to a ground relay for ground fault detection. It was manufactured by Trafomec of Italy to Siemens specifications and wound with a series inductance to form the "L" of an L-C harmonic filter. The core is practically identical to the LIRR transformer except for better insulation to avoid water issues painfully learned on Long Island.

The original Long Island HEP transformer (known as TAPS) consisted of

a single underslung package that combined transformer core and harmonic filter capacitors. It was set up so that its cooling air came from the traction motor plenum, which was pressurized by air that first cooled the LIRR inverter phase modules, and exhausted out the sides.

For the SD70MAC-HEP, the transformer core was placed in its own package and capacitors mounted separately in the HEP compartment. In Figure 11, you can see the first HEP transformer in London, supported by long forklift blades for installation across the walkway at the left rear of the locomotive. The transformer windings can be seen just above the blades, which is also the warm air exhaust to the transformer. The sheet metal plenum surrounds the top and sides of the core, but is open on the bottom, forming a sheet metal "skirt" around the base. This skirt aligns with 2" x 2" foam held in place by channels on the floor of the compartment, forming a tight air seal for the exhaust air. Four holes in the two forklift tubes mate with threaded holes drilled into steel bars precisely aligned onto the underframe. Guide pins were temporarily threaded into the mounting holes to guide and align the transformer installation. The back pins and hold-down bolts were reached by removable access plates in the transformer plenum and lower battery box.

The first transformer was air-shipped from Italy so that it could be fitted into the last locomotive while still under construction in London. Several minor dimensional problems were discovered in the process, defi-

nately justifying the efforts folks at Siemens and EMD went through to get the transformer delivered in time. The problems found were then corrected on the seven remaining units still in Italy, greatly streamlining their installation in Anchorage.

As bulky and unwieldy as the 3500-pound transformer appears, the Alaska Railroad mechanics, electricians and forklift operator quickly became adept at the transformer installation.

Harmonic filter capacitors

The three HEP harmonic filter capacitors are mounted behind the locomotive handbrake (Figure 12). This handbrake was redesigned so that the entire brake was mounted on a large removable vertical steel channel. This way, the brake chain could be detached and the assembly could be lifted out with a crane on the rare occasions that the capacitors had to be accessed. The three capacitor cans form the "C" of the L-C harmonic filter. Each can consists of three 700-microfarad capacitors connected in delta and all three cans are connected in parallel to the transformer busbars.

As soon as the HEP system starts up, 220 amps circulate between each of 9 capacitor terminals and the HEP transformer. This adds up to 660 amps per phase and 550 kVAR (kilo-Volt-Amperes-Reactive), leading power factor. Under full load (730kW, 878amps at 1.0 power factor), the inverter HEP system delivers 480V with 2.7% total harmonic distortion (THD). The resulting current THD is 3.9%. The worst-case voltage

harmonic is the 7th (420Hz) at 1.7% of the fundamental.

An interesting effect of the capacitor bank shows up when summer-type loads (air conditioner compressors and blowers) are powered by the HEP system. During cooler weather, HEP loads are mostly heaters and cooking equipment and thus nearly unity (1.0) power factor. In that situation, the TCC has to handle the real current of the load plus the 660 amps of capacitive current of the capacitor bank. In the summer, the load is much more inductive at ~80% power factor. The leading capacitor current cancels the lagging inductive current of the compressor and blower motors. This lessens the amperage the TCC has to handle (the TCC being a peak-current limited device) and actually allows for another 110kW of HEP capacity at lagging power factor.

Switchgear

The HEP/TM switchgear (Figure 13) has two functions to perform:

- Switch the output of TCC#2 from either the three rear truck traction motors or the HEP transformer.
- Disconnect the #1 end HEP receptacles so that they are electrically dead when HEP is not required out the lead end of the locomotive (known as TLD for train line disconnect).

In most HEP locomotives, these functions are handled by two separate motor-operated switchgears. Roberto Michelassi of Elcon, Inc. suggested a method where one switch motor could handle both

functions. A five-module switchgear is mounted on mounting plate bolted to aft end of TCC2. Two switch modules switch the TCC output from traction motors to transformer. The other 3 heads handle TLD function. The switch modules are equipped with motor cut out solenoids (just like the switch modules used on an EMD DC locomotive to isolate traction motor fields). When it is desired to disconnect the #1 end HEP receptacles, the solenoids are energized and the switchgear rolled back and forth to center the switch fingers on the TLD switch modules. Figure 14 illustrates the four possibilities that correspond to the four modes of HEP/Traction.

HEP blower and filter

The HEP blower was no exception to the challenge of trying to get all the HEP equipment into the space available. At one point of the design cycle, we even considered dispensing with the blower entirely and using dampers to allow traction motor air to cool the transformer. In the end, EMD found a small 480-V blower that would fit high in the long hood, right behind the headlight (see Figure 15). This blower draws air from a grill high on the engineer's side just aft of the radiator hatch and discharges to two 10" flexible ducts that route to the top of the transformer (Figure 16). The air exhausts out a labyrinth grill just above the walkway, designed to prevent wash water entering the transformer compartment (Figure 17). The blower and motor are mounted to a removable roof hatch bolted to the end of

the long hood.

One interesting, unexpected concern that didn't arise until the locomotives arrived in Alaska was cottonwood. Up and down the Railbelt in June and July, cottonwood lint wafts through the air. The lint can be so bad that during the height of the season, undercar gen sets (the cruise train companies have their own generators) need their filters changed twice from Anchorage to Fairbanks. This problem was pointed out by ARR senior electrician Gary Odens and a solution was quickly found. The HEP blower air intake is nearly the same size as the 25" x 16" x 2" carbody filter used on our MP15's. ARR boilermaker, Jim Blakely quickly came up with an easy-change filter holder that would bolt on to the air intake (Figure 18).

Fortunately, the conservatism in the HEP blower design paid off here. AS EMD was uncertain of the pressure vs volume characteristics of the repackaged HEP transformer, the air flow engineer over-designed the HEP blower. Thus, there was plenty of static pressure for the air filter and still allow for sufficient cooling air thru the transformer.

The blower is controlled by temperature sensors inside the transformer. Three 100-ohm RTD sensors are installed in the windings. These are read by the TCC#2 computer and fed to the EMD computer, which turns on the blower when any sensor is hotter than 115C and then turns off the blower when all sensors are below 75C.

Remainder of the equipment

The rest of the electrical equipment was wedged into the space available. A small cabinet was set into the long hood aft of the radiator hatch and was dubbed the Small HEP Cabinet (appropriately enough). Figure 19 shows the cabinet. It contains the contactor and circuit breaker for the HEP blower, the HEP Ground Relay, a Train Line Voltage relay (prevents the main contactor from closing or the HeTm switchgear from moving if the external HEP trainlines are energized) and a pilot relay for the big ACC main contactor.

Figure 9 also shows the rest of the ancillary equipment. The Potential Transformers (PT's) are 100:1 transformers that provide voltage feedback of two line-to-line HEP voltages to the Siemens ASG. An "old-fashioned" Under-Over-Voltage relay serves as hardware backup to open the ACC if the voltage control of the TCC fails. The main ACC contactor is partially obscured by the HEP air ducts. This is rated at 1200 amps and is equipped with CT's and a thermal overload element. Both are somewhat redundant as the TCC quickly acts to cease HEP whenever there is an overload or short circuit in the passenger cars.

HEP controls

The HEP controls for the SD70MAC-HEP were, in some ways, a step forward into the past. The LIRR DE/DM30 uses several display screen menus to control its HEP system, but very early in the design process, Dennis Melas (EMD

Software Systems Manager) told me, "you know, I can pay for a lot of switches and pushbuttons before I can justify spending man-hours to write code for more menus - especially for just 8 locomotives."

So instead, we used the old EMD "eggcrate" lights for status and fault information (controlled by the computer), pushbuttons for start, stop and fault reset (read by the computer) and a multi-deck 4-position rotary switch for the HEP/Traction mode select (this also handles the convoluted Train Line Complete logic). Instead of digital or analog meters for voltage and current, a Display default meter screen is just one FIRE screen button press away. Thus, we made a control panel that's a combination of the look and feel of our older GP40-H locos. Moreover, we also duplicated the pushbutton/light sequence of the GP40-H as well. The montage in Figure 20 illustrates the back wall panel and engineer's station display.

Conclusion

The results of this project are eight versatile passenger/freight locomotives - ARR 4317 through 4324. When the HEP system is off, the unit is a 4300-THP locomotive. With HEP on, it is a 2400-THP, 730-kW HEP locomotive. Moreover it can deliver that HEP load in TH3 (490 rpm) and up to 270kW HEP in TH2 (370 rpm). An F40PH or GP40-H in contrast would run at a constant 900 rpm to deliver the same HEP.

The system has turned out to be very reliable. If the 710 engine starts, then HEP is available. There is no

pony engine to service and thus no pony engine cooling system, fuel system or lube system to deal with. The only filter to change is the HEP blower filter and so far, the cottonwood lint at 15 feet of the rail has been very manageable. The only failures have been one HEP blower contactor and one broken switch module.

Presently, we have four 4300's on our Anchorage-Fairbanks daily service. Two units leave Anchorage and two leave Fairbanks every morning at 8:15. One unit in each consist provide HEP and 2400 traction horses; the other provides full 4300 THP.

Last summer, one 4300 handled the Seward Coastal Classic train by itself, but this summer the train gained two cars, putting it outside our comfort zone of a single 4300 making HEP and pulling the 3.0 percent grade approaching Grandview. So, we put our older P30 power car (a 4-axle ex-E9B) and a 4300 making full traction. Our cruise train service from Seward, Anchorage airport and Whittier is handled by another 4300 and our P31 cab/HEP power car.

The MAC's making HEP *do* have a unique sound - the switching of the inverters produces a distinct "EEEEEEEEEE" pitch at about 400 Hz, very noticeable when standing right next to the TCC#2. In terms of sound levels, the whine of the MAC is 82 dBA at 20 paces versus 85 dBA of a GP40 in HEP mode. But a single-tone whine is much less objectionable than the roar of a 900 rpm 645 engine!

The HEP system efficiency turned out to be a bit of a surprise when finally tested. Efficiency was never a

contract requirement, but upon testing we found that full load efficiency was only about 88%, rising to 92% at part loads. This represents nearly 100kW of losses at 700kW load.

Consultations with Siemens revealed that part of the poor efficiency was due to the limitations of the TCC computer. The LIRR computer has a more modern processor so that more efficient switching pulse patterns could be selected. These could not be realized with the SD70MAC TCC computer.

But in many ways, the "poor" efficiency is of little consequence. Seldom will we see large 700kW HEP loads. To improve that efficiency would require more copper and more steel in the transformer. That in turn would cost more money and demand more space in an already crowded locomotive - even if there was money to do a redesign! Thus, the poor efficiency really is just an acceptable result of a logical engineering trade-off.

The SD70MAC-HEP units arrived in Alaska in April and May 2004 and immediately started pulling freight and passenger trains (with HEP provided by other means). HEP transformers were installed in September-December 2004. EMD and Siemens engineers arrived in October, 2004 to test and commission the HEP software. Limited runs with the HEP system running were made on our weekend Aurora trains starting in January, 2005. After correcting one extremely annoying software bug in the spring, the units entered day-in/day-out on May 15th of the same year. I see no reason to expect them

not to be running 20 years from now (Figure 21).

Contributions

All photos and diagrams are by the author, except for Figures 1, 2, 3 & 4, which are courtesy of Electro-Motive.

The Alaska HEP project had many participants; all who deserve recognition and all who without their help this project would not have succeeded.

Ulrich Foesel, Hartmut Wagner and Horst Nowy of Siemens: Ulrich was my counterpart at Siemens, Hartmut was the software engineer on TCC's and Horst was the long-time service engineer in Alliance, NE, who did the ASG hardware mods.

The following Electro-Motive folks:

Dennis Melas (software manager), Curtis Montgomery (software engineer) and Margaret Foltz (software testing). These three had to translate, write and test the code for 70MAC HEP.

Forrest Green (systems engineer): He and I worked together (along with many design/drafters) to get the 10 pounds of stuff into the HEP compartment of the 70MAC.

Todd Lail (systems engineer). He got to pick up the pieces after I left EMD for Alaska.

Tony Bladek (lead engineer for LIRR DE/DM30) and Craig Prudian (systems engineer); both whom I bounced many ideas off of.

Plus dozens of others at EMD in LaGrange and London who pushed pencils, swung wrenches, found

wayward parts and translated barely-dry drawings into a completed locomotive.

Roberto Michalessi and Frank Garrone of Elcon, Inc. (Minooka, IL): We worked together on the 2002 incarnation of Alaska HEP when EMD thought we'd mount HEP equipment would be mounted beneath the underframe. Elcon didn't get to build the cabinets for the final version, but did build some sub-assemblies.

The electricians, machinists and boilmakers at the Alaska Railroad who installed the HEP transformers in Anchorage and helped commission the HEP system.

Finally, Tim Keck and Dave McColl of EMD and Robert Stout, formerly of the Alaska Railroad (now with Colorado Rail Car); the idea of the SD70MAC-HEP first germinated in their minds. I and everyone else just watered the seedling and let it bloom.

Figure 1 – Burlington Northern SD70MAC

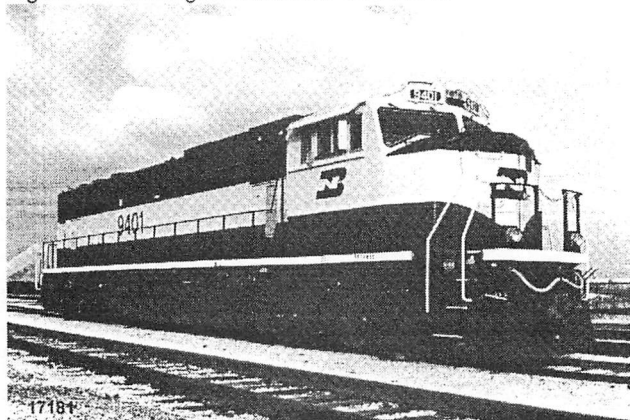


Figure 2 – Alaska SD70MAC

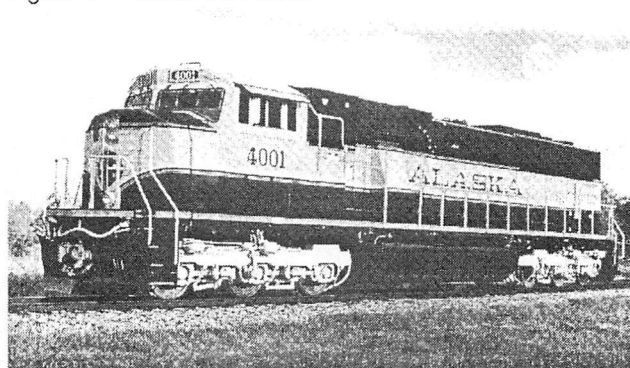


Figure 3 – Long Island DE30AC



Figure 4 – CSX 4300-THP SD70MAC locomotive of 2003



Figure 5 – Alaska SD70MAC-HEP 4300 THP 730kW HEP



Figure 6 – Baggage Car w/ undercar generator sets



Figure 7 – GP40-H with gear-driven HEP



Figure 8 – Outside View of HEP Compartment

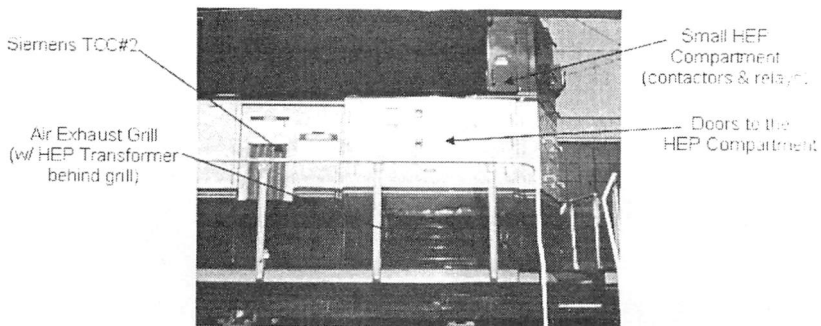


Figure 9 – Inside View of HEP Compartment

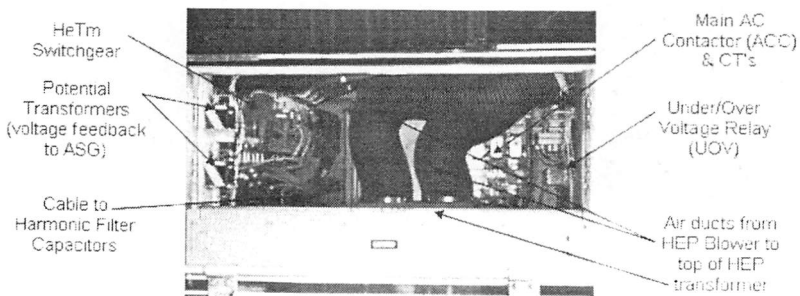


Figure 10 – One-Line Diagram of the HEP System

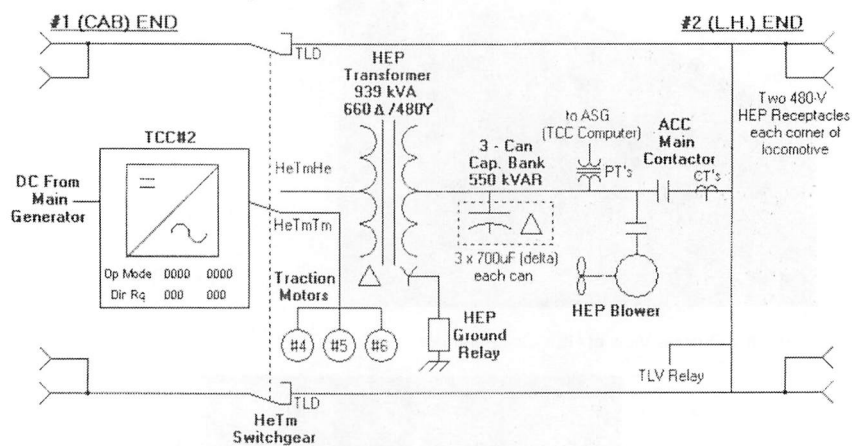


Figure 11 –HEP Transformer on forklift blades

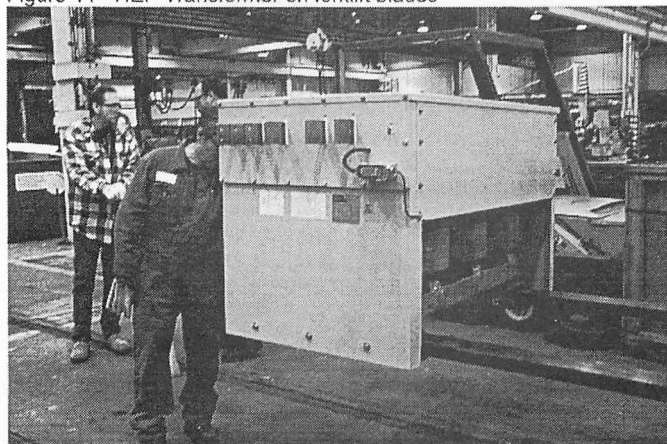


Figure 12 – Harmonic Filter Capacitor



Engineer's Side view of Battery Box/Handbrake Area



700uF (delta)
Harmonic
Filter
Capacitor

View with Handbrake removed

Figure 13 – HeTm Switchgear

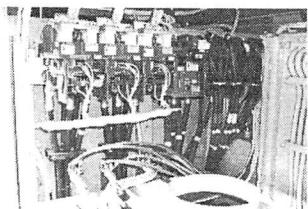


Figure 14 – Four modes of HEP/Traction

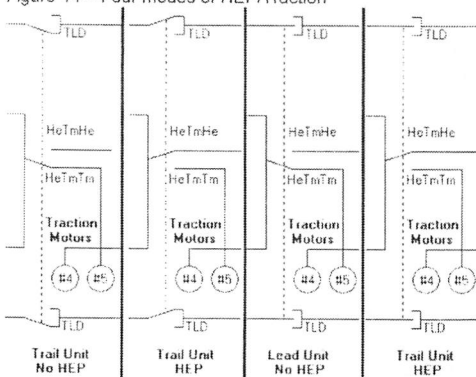


Figure 15 – HEP Blower Air Intake

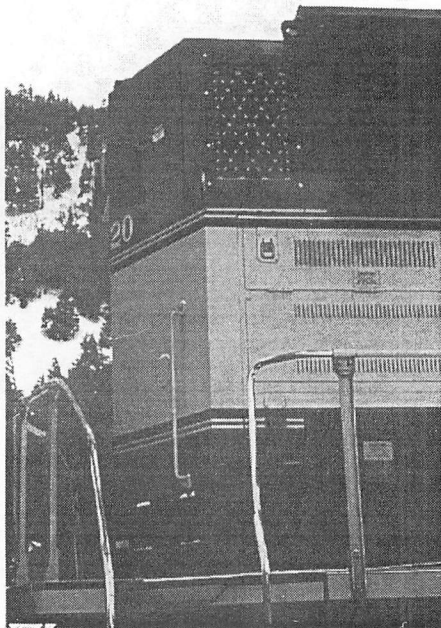


Figure 16 – Flexible Ducts to top of HEP Transformer

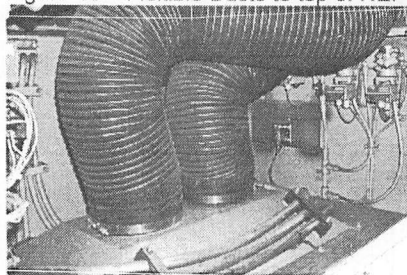
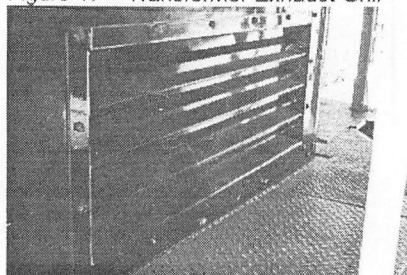


Figure 17 – Transformer Exhaust Grill





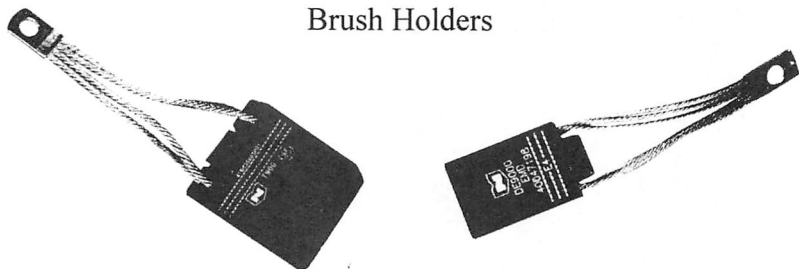
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Figure 18 – HEP Blower Paper Filter Installation

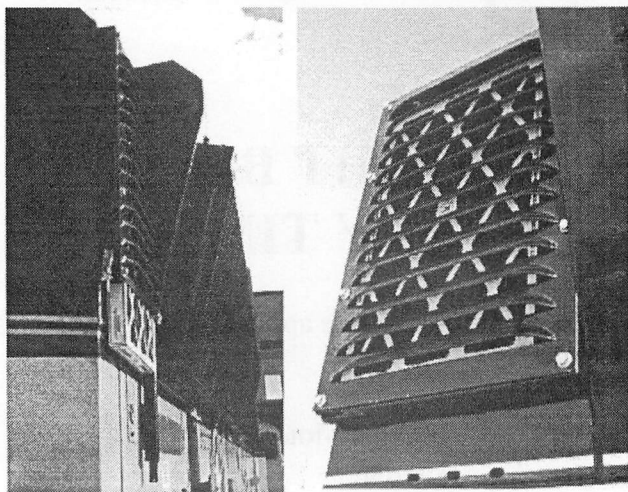


Figure 19 – Small HEP Cabinet

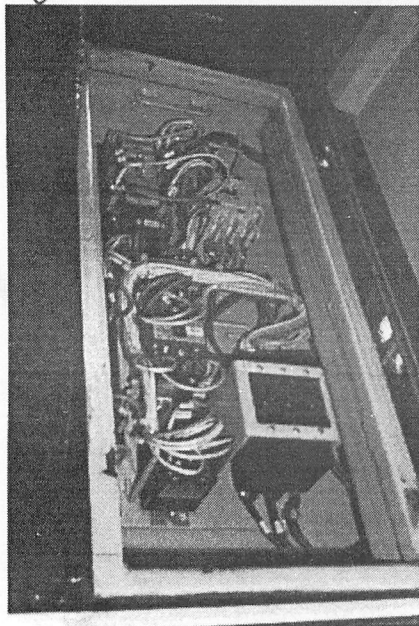


Figure 20 – Montage of HEP cab controls

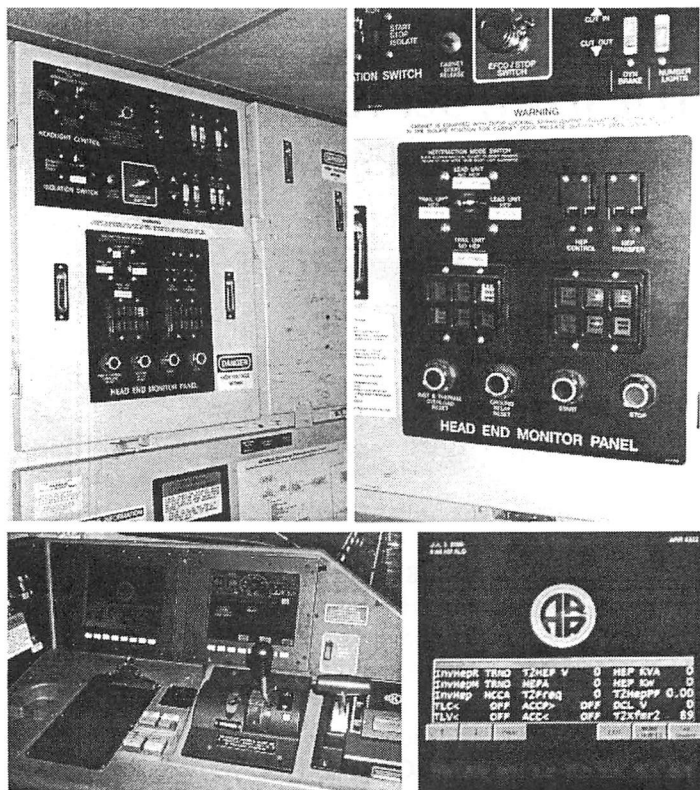
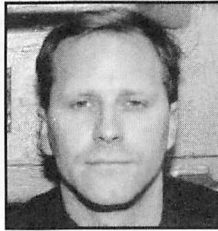


Figure 21 – SD70MAC-HEP on first day of 2005 passenger season



REPORT OF THE COMMITTEE
ON NEW TECHNOLOGIES

TUESDAY, SEPTEMBER 19, 2006
1:45 P.M.



Chairman

R. BRAD QUEEN

General Foreman-Locomotives,
BNSF Railway
Barstow, CA

Vice Chairman

RICH DALTON

Director-Project Management
Motive Power Inc.
Boise, ID

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J. Whitmer	Loco. Rel. Specialist	CN RR	Homewood, IL

PERSONAL HISTORY

*Ralph Brad Queen
General Foreman-Locomotives
BNSF Railway*

Brad, Chairman of the New Technologies Committee, was born in 1965. He graduated from high school in Lansing, MI in 1984. He entered active service in the U.S. Navy in 1984 and served in Pearl Harbor. He also did a stint in the Naval Reserves.

Brad started with the Burlington Northern Railroad as an electrician in 1994 in Lincoln, Nebraska. In

2000, he was promoted to Locomotive Supervisor at the Topeka, Kansas Back Shop.

He was recently promoted to General Foreman-Locomotives at the BNSF Bartow, California LMIT Shop. He recently completed his Associates Degree in General Business.

Brad's wife is Karen and they have been married for 13 years.

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VARIABLE HYBRIDITY FUELCELL-BATTERY ROAD-SWITCHER

*Prepared by
Arnold R. Miller, PhD
Vehicle Projects LLC*

Introduction

Objectives

Commencing in June 2003, an industry-government consortium (see Table 1) began developing a fuelcell-powered 109-tonne road-switcher locomotive [Miller, et al, 2004 A] [Miller, 2005] as a prototype of a new generation of locomotive that will:

- Reduce air pollution in urban rail yards, particularly yards associated with seaports.
- Increase energy security of the rail transportation system by using a fuel independent of imported oil.
- Reduce atmospheric greenhouse-gas emissions.
- Serve as a mobile backup power source for critical infrastructure on military bases and for civilian disaster relief efforts.

These four capabilities address issues or opportunities for the rail transportation sector. As the volume of commodity imports continues to rise, the cities surrounding American seaports are suffering increasing levels of air pollution due to engine emissions from ships, trucks, and trains. Energy security and its effect on cost and supply are critical contemporary issues for the transportation industry. Nearly 100% of the energy for the transportation sector

is based on oil, and more than 60% is imported. World oil reserves are diminishing, demand is increasing, and political instability threatens supply disruptions. A consensus is being reached that the burning of fossil fuels and subsequent atmospheric release of carbon dioxide is a significant factor in global climate change. The greenhouse-gas effect is the likely cause of the melting of the polar ice caps and the increased severity of storms. A need also exists for a vehicle that, in addition to being used for conveyance, serves as a mobile backup power source for critical infrastructure. Applications include military bases and disaster-relief operations. Indeed, following Hurricane Katrina, a makeshift jail in New Orleans was powered by an Amtrak diesel-electric locomotive.

The fuelcell road-switcher under development addresses all of the issues above:

- It will offer zero emissions and low acoustic noise, while meeting the performance of a diesel locomotive.
- Its fuel will be hydrogen (stored safely and compactly as a reversible metal hydride), and hydrogen can be produced from many domestic sources, including coal and nuclear energy.
- Fueled by hydrogen, the vehicle itself will emit zero greenhouse gases. Hydrogen production from nuclear, solar, or wind energy would likewise produce no greenhouse gases. Although hydrogen production from coal would produce carbon dioxide

as a byproduct, the gas can be sequestered and thereby not released into the atmosphere.

- Under self-power on rails, it can deliver itself as at least 1 MW of continuous backup power for critical infrastructure during military or natural disasters. Its low acoustic noise, compared to a diesel, is an essential feature of its practicality in this application.

Variable hybridity concept

A fuelcell hybrid powerplant utilizes a fuelcell prime mover, plus an auxiliary power/storage device to carry the vehicle over power peaks and recover kinetic or potential energy during braking. Figure 1 depicts such a system. As we have shown in previous papers [Miller, et al, 2006; Miller and Peters, 2006], whether a hybrid rail vehicle is worth its extra complexity and generally lower efficiency depends on the application and in particular the duty cycle. For example, freight trains should garner little benefit because they operate at nearly constant power and the kinetic energy is so high that practical auxiliary storage devices can recover only a small fraction of the total available energy during regeneration. On the other hand, we have shown that a hybrid switcher can offer the benefit of reduced capital cost.

The degree to which the powerplant of a vehicle is hybrid is termed its "hybridity." We define hybridity as follows [Miller, 2001]:

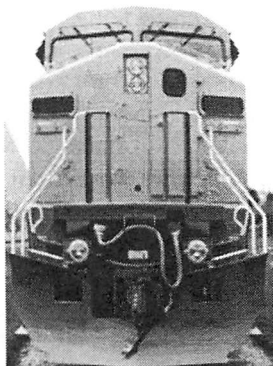
$$h = p_b / (p_b + p_f), \quad P_{\text{mean}} < p_f < P_{\text{max}}$$

where h is the hybridity, p_b is rated power (kW) of the auxiliary power/storage device such as a battery or flywheel, p_f is rated fuelcell power (kW), p_{mean} is the mean power of the duty cycle and p_{max} is the maximum power. By this definition, a pure fuelcell vehicle has a hybridity of zero. With fuelcell power fixed, hybridity increases toward unity as battery or flywheel power increases. (If prime mover power p_f lies below the mean p_{mean} of the duty cycle, in our view, the system is not a bona fide hybrid since it cannot be self-sustaining.)

In previous projects, we have developed both hybrid and non-hybrid powerplants. We have developed a fuelcell-battery hybrid mine loader [Miller, et al, 2004 B] with a hybridity of approximately $h = 0.4$. Although packaging has been challenging (see Figure 2), the "peaky" duty cycle of a loader [Desrivieres and Betournay, 2002] made a development of a hybrid powerplant compelling. Another vehicle was the world's first fuelcell-powered locomotive [Miller and Barnes, 2002], an underground haulage vehicle, that was not hybrid (Figure 3). Our performance analysis [Miller, 2000] for that locomotive showed that wheel adhesion was the limiting factor in performance, not fuelcell power, and hence a non-hybrid ($h = 0$) was appropriate. Excellent performance of the locomotive in a working mine has shown the analysis to be correct.

The concept of a "variable hybridity" vehicle is that its prime mover is

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modular, and the modules can be grouped so as to give a hybridity that maximized the benefit, of the application. The locomotives fuelcell powerplant will be comprised of up to eight identical, standalone 150-kW power modules (PMs), each with complete balance of plant. The modules can be grouped in any combination, like memory cards of a computer, to give a prime-mover power of any multiple of 150 kW up to 1.2 MW. For example, three PMs can be grouped to give 450 kW of prime-mover gross power, and a traction battery or fly wheel would provide peak power of at least 1.2 MW (see Figure 4). In this case, the locomotive is a fuelcell-battery hybrid. At the extreme of using eight PMs to provide 1.2-MW of continuous power, no traction battery would be required, and the locomotive would be a pure fuelcell vehicle with $h = 0$ (see Figure 5).

For rail-yard applications at sea-ports, a hybrid using three PMs, supplemented by a battery, is an appropriate configuration, primarily due to its reduced capital cost and therefore near-term commercialization potential. For line-haul freight operations, which operate at nearly constant power, or as a mobile backup power supply, the 8-module pure fuelcell locomotive ($h = 0$) would be the most appropriate.

Project scope

The overall project consists of seven phases, summarized as follows:

- Feasibility analysis: \$1 million, completed one year from June

2003, funding from the US Department of Defense (DOD)

- Conceptual design: \$1 million, completed one year from June 2004, funding from the DOD.
- Fabrication of Prototype PM and Locomotive-layout design: \$2.9 million to be completed 20 months from June 2005, funding from the US Department of Energy (DOE) and the Government of Japan. Completed prototype PM is shown in Figure 6.
- Development of 3-PM, 450-kW (1.2-MW peak) Hybrid Switcher: \$6 million, to be completed 12 months from March 2007, proposed funding from DOD.
- Demonstration of Switcher in Commercial Applications: Estimated \$2 million, one year duration.
- Development of 8-PM, 1.2MW Road Locomotive. (Remove batteries from 3-PM hybrid and replace with five additional fuel-cell modules.) Estimated \$5 million, one year duration)
- Demonstration of Locomotive in Road Applications and Military Backup-Power Applications. Estimated \$2 million, one year duration

Total project cost: 19.9 million.

Duration: 92 months (7 years and 8 months)

Background

Fuelcells

Fuelcells are electrochemical power devices that directly convert

the chemical energy of a fuel into electric power. From hydrogen fuel and air (oxygen), they produce electricity and water the reverse of water electrolysis. While fuelcells share principles of operation with batteries, they differ in that the electrochemically active materials, hydrogen and oxygen, are stored or are available externally and are continuously supplied to the device rather than being stored in the electrodes. They are periodically refueled, like an engine, rather than recharged electrically. Like batteries, individual cells are grouped together into "stacks" to provide any voltage or power required.

Chosen for their safety, reliability, and high power density, fuelcells have provided electric power and drinking water in manned spacecraft for four decades. Since 1992, commercial stationary fuelcell powerplants of 200 kW rating have provided high-reliability, clean, quiet, and safe electric power to hospitals, commercial facilities, universities, airports, and military bases.

By separating the energy storage and power production functions, fuelcells are more convenient, more efficient, and safer than storage batteries. They are more convenient because the refueling process can be completed in a few minutes rather than the hours required for efficient battery recharging. They are more efficient because electrochemical losses that occur in batteries during recharge, as witnessed by their evolution of heat, do not apply to fuelcells. They are safer because short-circuiting a fuelcell harmlessly

dissipates only the energy associated with the small amount of hydrogen present in the cell - in contrast, short-circuiting a battery dissipates all of its stored energy.

Insight into fuelcells follows an understanding of the special place of hydrogen, their natural fuel, among the chemical elements. Most of the elements of nature are metals, and while most have the familiar metallic properties, not all do. Mercury (Hg), a liquid, lacks hardness. Hydrogen, as a gas, would seem to lack all metallic properties. Nonetheless, the most fundamental characteristic of a metal is its tendency to donate electrons in chemical reactions, and on this basis, hydrogen is classified as an alkali metal in the first column of the periodic table. Moreover, solid hydrogen (at low temperature) has decidedly metallic properties. This construct of hydrogen as a gaseous metal allows us to readily see the fuelcell as a special type of battery: Conventional batteries use a metal such as lead, cadmium, or lithium as the anode material (negative plate), while fuelcells use a gaseous metal as anode material, and this is the basis of their advantages of separate energy storage and being refuelable.

This simple fact of using gaseous electroactive materials has far-reaching implications: (1) The energy-storage component is separated from the power-producing component. Unlike a conventional battery, in which the metal electrodes or plates serve as both the energy-storage and power-production functions, the fuelcell separates these two functions, and power and energy are not

linked. (2) Energy for the vehicle is stored in a fuel tank, analogous to the fuel tank of a conventional engine vehicle, and the vehicle may be rapidly refueled by refilling its fuel tank.

Because fuelcells are electrochemical power devices, essentially "refuelable" batteries, they are not limited in efficiency by the Carnot limit faced by heat engines. Fuelcells do have an analogous limit, namely, the intrinsic maximum efficiency [Larminie and Dicks, 2000].

$$\eta_{\max} = \Delta G / \Delta H$$

Where ΔG is the Gibbs free energy and ΔH is the enthalpy of the chemical reaction of the fuelcell. Depending on the fuelcell type, the intrinsic maximum efficiency is typically in the range of 80-90%. As a rule of thumb, the overall practical efficiency of a fuelcell powerplant is on the order of 50%, compared to 30-40% for an internal combustion engine.

The type of fuelcell used in our projects, and exclusively favored by the auto industry, is the proton-exchange membrane (PEM) type, which uses a solid ion-exchange membrane for its electrolyte.

Hydrogen storage

Storage of hydrogen onboard the vehicle is a greater technical challenge than producing power from a fuelcell. Methods of storage include (1) direct storage of hydrogen as a compressed gas, a liquid, or a reversible metal hydride, (2) onboard chemical transformation of feedstock, such as hydrocarbon or alcohol, to hydrogen, and (3) physical

dissociation of liquid ammonia to hydrogen. Each method has advantages and disadvantages. For some rail applications, reversible metal-hydride storage is appealing, and this is the method we have used in all of our vehicles to date.

Reversible metal hydrides are low-flammability, solid materials that use metal-hydrogen chemical bonds to store hydrogen safely and compactly. Metals, which are crystalline solids, consist of a regular array or *lattice* of spherical atoms. Spheres cannot pack perfectly, and the lattice of atoms also forms a superimposed lattice of holes or *interstices*. The interstices interconnect to form a three-dimensional network of channels. Because hydrogen is the smallest atom, it chemically bonds to the metal atoms while occupying the interstices. Transition metals form hydrides that are readily reversible and constitute a safe, solid storage medium for hydrogen. By removing low-temperature heat from the crystal, hydrogen atoms enter the interstices throughout the crystal and *charge* the metal. Conversely, by providing low-temperature heat (50 - 70 C) to a charged crystal, the process is reversed and the metal is *discharged*. The gas pressure is approximately constant during the process and can be very low, even below atmospheric.

Unlike liquid or gaseous fuels, metal hydrides are of low flammability. This is because hydrogen is trapped in the metal matrix or lattice, and the rate at which hydrogen atoms can file through the channels, recombine into hydrogen molecules

on the surface, and then be released is limited by the rate of heat transfer into the crystal. Rupture of a hydride system is self-limiting: as hydrogen escapes, the bed naturally cools because chemical bonds are being broken, and the colder bed has a lower rate of atom migration. The metal matrix, moreover, forces the hydrogen atoms close together, as close as in liquid hydrogen, and is responsible for the high volumetric energy density. Although metal-hydride storage is heavy, weight is generally not an issue for locomotives.

While reforming of hydrocarbons or alcohols, which involves high-temperature catalyzed reaction of the feed-stock with water, has been strongly pursued by the auto industry, it suffers the disadvantages of high volume, high complexity, and relatively low thermodynamic efficiency. Its large potential advantage is that a hydrocarbon-fuel infrastructure is already in place.

Ammonia, as feedstock for catalytic dissociation to hydrogen, is a non-carbon-based, renewable commodity that is typically transported by rail tank car. Because ammonia dissociation does not involve a chemical reaction with another reactant (water, in the case of reforming), it is easier than reforming hydrocarbons or alcohols and cleanly produces a mixture of 75% hydrogen and 25% nitrogen. The nitrogen is separated and harmlessly exhausted to the atmosphere. For rail applications such as line-haul freight and high-speed passenger trains, we believe an energy-dense liquid fuel such as

ammonia is necessary. Although ammonia has the disadvantage of being a strong tissue irritant, it offers the advantage of being nonflammable under the conditions of intended use. It is classified by regulatory agencies as a nonflammable material.

Results and discussion

As part of the feasibility and conceptual-design analysis of the fuelcell road-switcher project, we have analyzed the potential benefits of a hybrid powerplant in which fuelcells comprise the prime mover and a battery or flywheel comprises the rechargeable auxiliary power device [Miller, et al, 2006][Miller and Peters, 2006]. Potential benefits of a hybrid powerplant are (1) enhancement of transient power and hence tractive effort, (2) regenerative braking, and (3) reduction of capital or recurring costs.

Generally, tractive effort of a locomotive at low speed is limited by wheel adhesion and not by available power. Enhanced transient power would most strongly benefit applications, such as subway trains, with all axles powered and requiring high acceleration; however, packaging of the power equipment under the floor is a challenge. Hybrid commuter rail and long-distance intercity passenger trains are the most likely applications to gain a practical benefit from enhanced tractive effort or regeneration. Because maximum power is required for extended periods and because only a fraction of the large kinetic energy of a train can

be absorbed in today's auxiliary power devices, high-speed rail and heavy freight are less likely to benefit. Due to wheel-adhesion limitations, low available kinetic energy, and low efficiency of their traction motors in generation mode, switcher locomotives are unlikely to significantly benefit from the potential of enhanced tractive effort or regeneration.

In most cases, the benefits of regeneration in locomotives are limited. For low-speed applications such as switchers, the available kinetic energy and the effectiveness of traction motors as generators are low. For high-speed heavy applications such as freight, the ability of the auxiliary power device to absorb a significant portion of the available kinetic energy is low. Moreover, the hybrid powerplant suffers a double efficiency penalty: losses occur in both absorbing and then releasing energy from the auxiliary device, which result in a net storage efficiency of no more than 50% for current battery technology.

Capital cost in some applications may be reduced. Given the current high cost per kilowatt of fuelcells, justification of a hybrid powerplant may be possible on the basis of cost. However, a cost justification cannot be made solely on capital (or first) cost - changes in operating and maintenance costs must also be considered. Accordingly, we have developed a spreadsheet cost model that finds the least-cost of a hybrid system as a function of fuelcell continuous power rating and other variables. To allow combining capital

and recurring costs, the model uses annualized costs. The methodology used in this model is identical to that used in the model developed by Miller [Miller, 2001] to find the least cost for fuelcell-battery hybrid industrial vehicles. Input variables and functions of the cost model include (1) equipment capital cost, (2) equipment maintenance cost, (3) projected equipment life, (4) operating costs (including fuel), and (5) the duty cycle as a discrete function. The input variables were provided by the partners in the locomotive project, and as input variables, they can be revised for other service types.

Results of our preliminary cost analysis of a fuelcell-hybrid switcher locomotive as a replacement for diesel-electric switcher are shown in Table 2. Cost input data include the projected total annual cost, the fuel-cost component of the total, and the fuel-cost penalty resulting from the double efficiency penalty - losses occur in both in and out of the auxiliary power device. The duty cycle was derived from the analysis of time-at-notch event-recorder data for 1500 kW (maximum power) diesel yard switcher [Peters, 2004]. Searching for a minimum of total cost, the model varies fuelcell power from 200 kW through 1200 kW (continuous). The highest power rating of 1200 kW is deemed sufficient for a fuelcell switcher to perform equivalently, without an auxiliary power device, to a 1500 kW diesel: the power rating of the fuelcell is continuous, rather than maximum, and fuelcells do have overload capacity. Thus, the bottom row in

the table, corresponding to 1200 kW, represents a pure fuelcell ($h = 0$) powerplant. Once the fuelcell power is fixed for a row in the table, the battery capacity is determined by (1) the area (energy) between the duty-cycle function and the horizontal line representing the fuelcell continuous power and (2) the requirement for steady-state operation of the vehicle [Miller, 2001].

In the example shown, the model predicts that total annual cost, annualized capital plus recurring cost, for the pure fuelcell switcher is approximately \$370 thousand, including a fuel cost of \$70 thousand. The least-cost hybrid configuration - a 400-kW fuelcell coupled with 752-kWh battery (see row in bold print in Table 2) - is reduced to \$260 thousand, even though the fuel cost increases to \$90 thousand, corresponding to a cost and tank-capacity increase of 29%. Fuel consumption increases because of the decreased thermodynamic efficiency of a hybrid system. Weight and space limitations constrain available hybrid configurations and probably prohibit the use of the cost-optimized solution. Because of increased system complexity, we predict that maintenance costs will also increase. In the future, as fuelcell cost per kilowatt decreases, the least-cost configuration will migrate toward the pure fuelcell case ($h = 0$).

Conclusions

The concept of a variable hybridity fuelcell-battery road-switcher locomotive, presented in this paper, allows using a configuration of a fuelcell-battery relative power that

optimizes the benefits of hybridity for the application. A switcher analyzed in this project would optimally gain its greatest benefit of lowered capital cost with a fuelcell prime-mover power of around 450 kW, with much higher peak power being provided by the auxiliary traction battery. Road applications or other applications benefiting from the largest possible prime mover would correspond to the pure (non-hybrid) fuelcell locomotive.

Yard switchers, and possibly other rail vehicles, may benefit from reduced capital cost (or first cost) of a hybrid powerplant; however, this benefit comes at the price of increased complexity and reduced thermodynamic efficiency. Compared to a pure fuelcell locomotive, a hybrid will require either a 20-40% increase in fuel capacity or a 20-40% reduction in refueling interval for the same duty cycle. Nonetheless, the fuelcell-battery hybrid offers the following benefits: (1) Zero emissions and low acoustic noise, while meeting the performance of a diesel locomotive, and (2) non-dependence on imported oil because its fuel will be hydrogen (stored safely and compactly as a reversible metal hydride), and hydrogen can be produced from many domestic sources, including coal and nuclear energy.

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Acknowledgements

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Disclaimer: Funding support from the US Department of Energy, US Department of Defense, Natural Resources Canada, or Government of Canada does not constitute an endorsement by same of the views expressed in this paper.

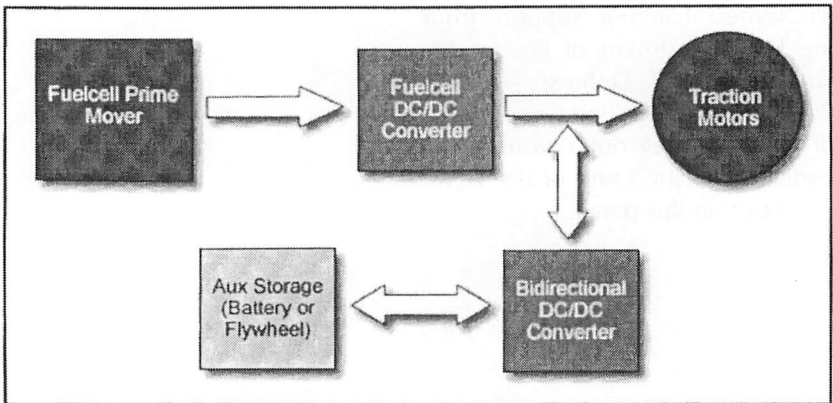


Figure 1 – Main components of a fuelcell hybrid power train. “Aux Storage” represents either battery or flywheel auxiliary energy storage. Arrows point in the direction of power flow. The traction motors are used as generators during braking. A system using AC traction motors would be analogous to the DC system shown.

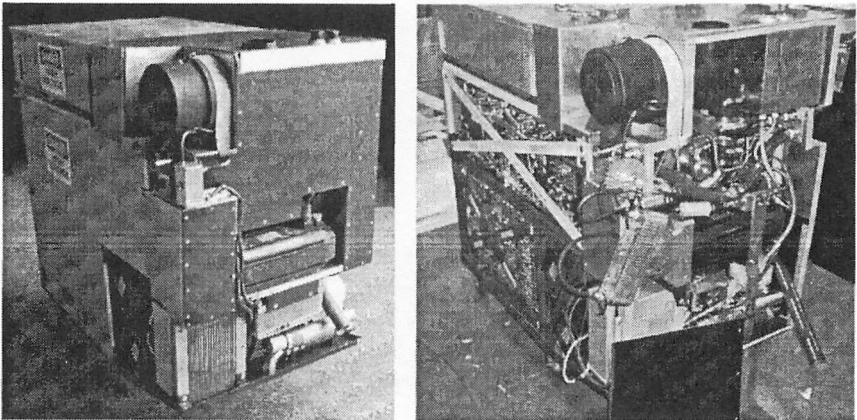


Figure 2 – Fuelcell-battery hybrid powerplant (hp 0.4) developed by Vehicle Projects LLC for a 23-tonne underground mine loader: Left view shows powerplant with covers in place; right shows covers removed. The fuelcell stacks occupy the volume in the center behind the “X” structural member; nickel metal-hydrde traction battery is in the lower rear. Fuelcell and battery together provide 160 kW of peak power. The cylindrical black object is the air filter for the cathodic air, which is pumped by a 150,000 rpm electricly driven centrifugal air compressor.

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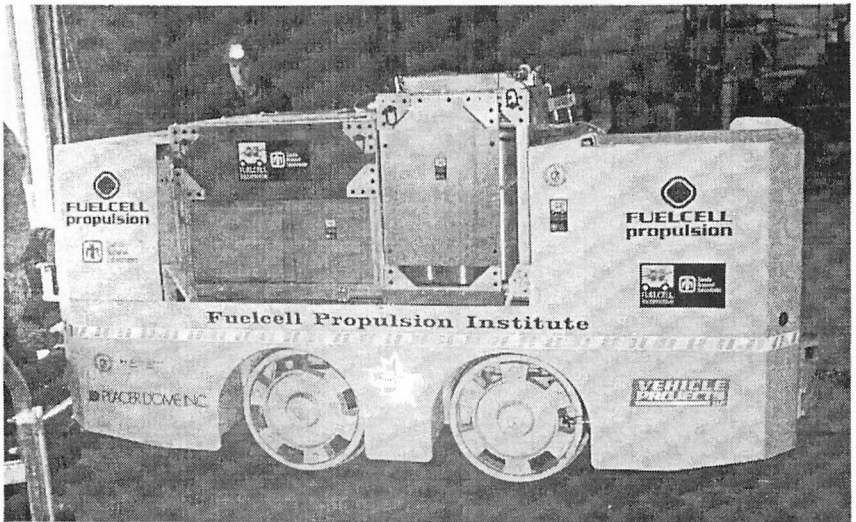


Figure 3 – World's first fuelcell-powered locomotive, an underground haulage vehicle. The 17-kW fuelcell stacks reside behind the dark-gray panel. Hydrogen (3 kg) is stored safely and compactly as a reversible metal hydride. The project commenced in 1999 and was completed in 2002 with the locomotive's successful demonstration in a working gold mine. This is not a hybrid vehicle ($h = 0$).

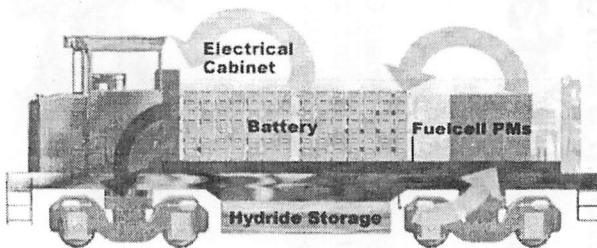


Figure 4 – Locomotive Concept: The illustration depicts a hybrid locomotive using three PMs plus batteries, a configuration appropriate for switcher applications at seaports. With eight PMs and no batteries the vehicle is a non-hybrid 1.2-MW (continuous) locomotive appropriate for road or backup-power applications. (Diagram courtesy of RailPower Technologies)

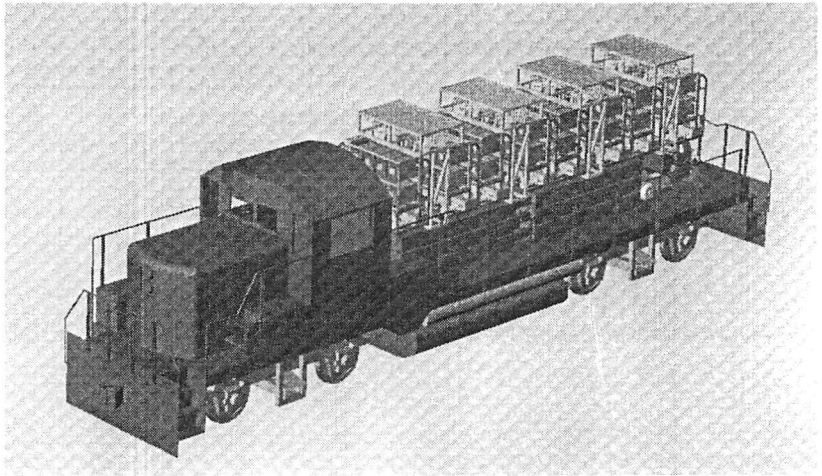


Figure 5 – CAD model of the pure fuelcell ($h = 0$) extreme of the variable-hybridity locomotive: The eight PM's are shown above the metal-hydride storage system to the top-rear of the vehicle, and they share four radiators on the roof of the locomotive.

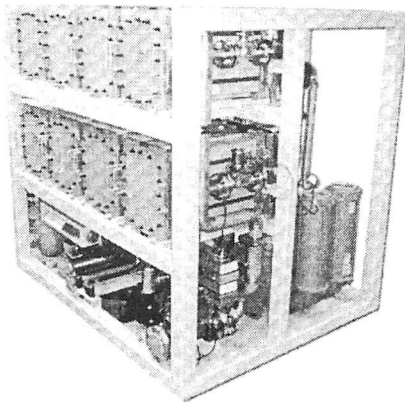


Figure 6 – Prototype Power Module (PM): Various combinations of these 150-kW modules will comprise the powerplant. The completed and tested prototype was sold to an offshore customer in February 2006.

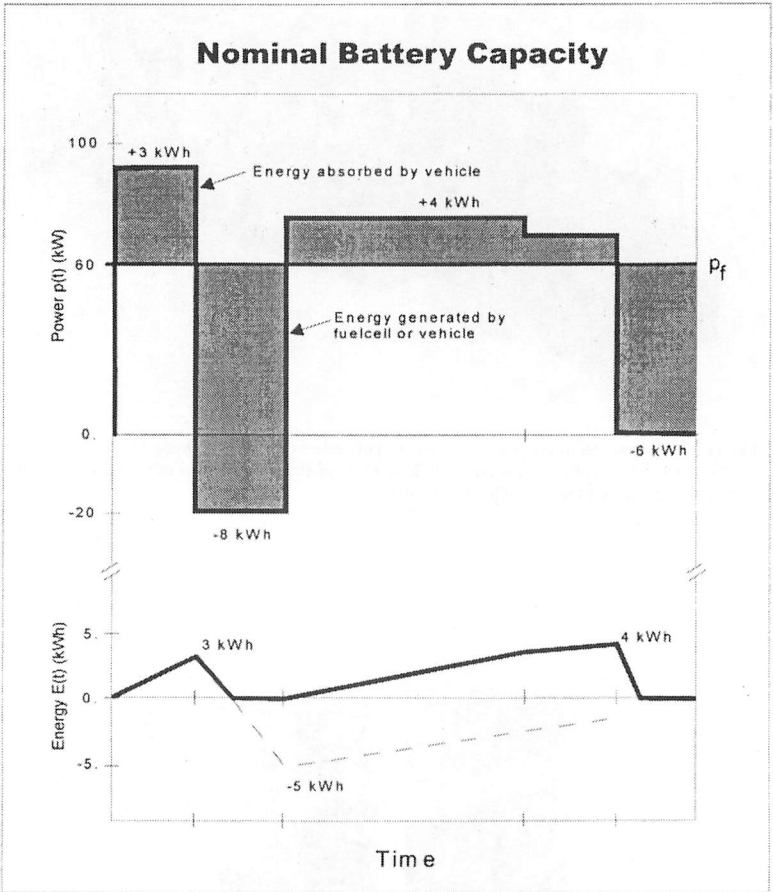
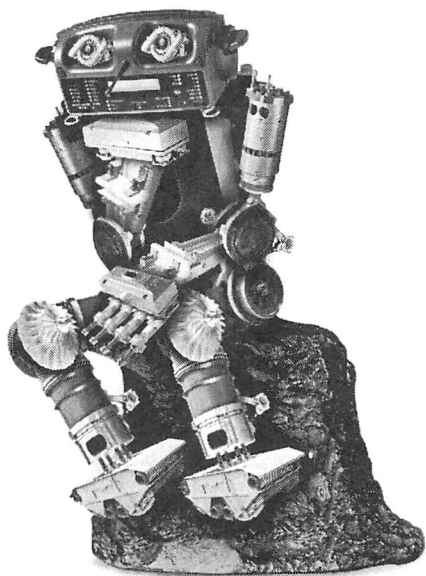


Figure 7 – Diagrammatic representation of the mathematical model that computes nominal battery (or flywheel) capacity to maintain steady state in a hybrid vehicle. When a battery is used as the auxiliary power/energy device, the actual battery capacity must be larger in order to limit depth of discharge and thereby allow an acceptable battery cycle life. The upper part of the diagram is a hypothetical duty cycle, and the shaded areas represent the energy that the battery must provide or can accept from the prime mover. Details are provided in a publication [Miller, 2001].

GE Transportation

At GE - Transportation, we never stop thinking about ways to make your railroad stronger, faster, safer, smarter, and cleaner. Listening and responding to your greatest challenges inspires us to produce new fuel-efficient locomotives. It drives us to create control systems that increase your rail capacity as well as signaling and communication technology that boosts on-time performance and safety. It motivates us to develop aftermarket solutions that reduce fuel consumption and emissions.

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imagination at work

TABLE 1: Fuelcell Locomotive Consortium

BNSF Railway Company, USA	Seaport switcher demonstration
Defense NTG & Rail Equipment Center, USA	Packaging and integration
DOT Volpe Nat'l Transportation Systems Center, USA	Safety and economics
Fuelcell Propulsion Institute, USA	Project advocacy
Ovonic Hydrogen Systems, USA	Metal-hydride storage
Modine Manufacturing Co, USA	Heat exchangers
New York City Transit, USA	Subway transit applications
Nuvera Fuel Cells, USA	Module balance of plant
General Atomics/Power Inverters, USA	Power electronics
Railway Technical Research Institute, Japan	Passenger rail applications
Regional Transportation District – Denver, USA	Light rail applications
Transportation Technology Center Inc, USA	Locomotive performance
Union Pacific Railroad, USA	Freight applications
University of Nevada – Reno, USA	Refueling system
Vehicle Projects LLC, USA	Prime contractor
Washington Safety Management Solutions LLC, USA	Safety analysis

TABLE 2. Cost Model

Hybrid Configuration			Hybrid Cost Data (Annualized)			
Fuelcell Rated Power (kW)	Battery Capacity (kWh)	Battery Weight (Tonne)	Total Cost	Hybrid Fuel Cost	Fuel Cost Penalty	Fuel Capacity Penalty (%)
200	1863	28.7	\$345,001	\$106,829	\$36,904	53
250	1105	17.0	\$276,578	\$102,442	\$32,517	47
300	870	13.4	\$261,006	\$98,091	\$28,166	40
350	824	12.7	\$267,075	\$94,558	\$24,633	35
400	752	11.6	\$260,033	\$90,474	\$20,549	29
450	683	10.5	\$266,299	\$87,753	\$17,828	25
500	624	9.6	\$269,961	\$85,793	\$15,868	23
550	559	8.6	\$281,328	\$83,458	\$13,533	19
600	497	7.6	\$271,644	\$80,826	\$10,901	16
650	372	5.7	\$279,592	\$79,479	\$9,554	14
700	328	5.0	\$286,634	\$78,497	\$8,572	12
750	288	4.4	\$293,836	\$77,246	\$7,321	10
.
.
.
1200	0	0	\$369,925	\$69,925	0	0

2. GE TRANSPORTATION HYBRID FREIGHT LOCOMOTIVE

*Prepared by
Len Baran
GE Rail Transportation*

Agenda

- Transportation Ecomagination®
- Market application
- GE Hybrid Program Overview
- How does it work?
- What will change?
- Challenges
- Questions

You, our customers are facing even more pressure than ever to reduce energy cost and lower emissions. Looking forward, this is only going to get tougher with more stringent regulatory requirements and less secure energy sources. GE's Ecomagination strategy is all about taking on these challenges, using the breadth and depth of leading technologies that only GE can provide.

For GE Transportation, this includes technology built into our latest products such as the GE Evolution Series® locomotive and Smartburn® as well as our next generation products, like the hybrid locomotive. (Figure 1).

GE Transportation invested more than \$250 million dollars and six years of research and development to create the new GE Evolution Series® diesel locomotives. The result is truly an "evolutionary" locomotive platform - one that incorporates the best of proven diesel locomotive engineering with advanced technologies that have to date yield-

ed 25 United States patents.

The Smart Burn option utilizes several new GE Rail technologies present on the Evolution Series® locomotive, Adaptive control, the GEVO-12 engine and geo-fencing to enhance the railroads emissions compliance options. These new technologies enable the application of a GeoZone around a pre-defined region along with the ability to command the locomotive to operate at a different operating point while operating within the GeoZone. A different operating point can be a different emissions level, performance level or any variety of performance/operational metrics.

This brings me to our next generation product, the hybrid locomotive.

In the railroad industry, is there a market for a hybrid locomotive? The answer is yes but it depends on the application. Because the hybrid locomotive uses dynamic braking to recharge the battery, the profile of the run dictates how much savings can be generated by the use of hybrid locomotive. Typically, the largest savings can be realized in the movement of grain and coal commodities. GE has examined run data provided by the railroads on different commodity movements and has found that on average, a 7-10% improvement in fuel burn can be achieved depending on the hybrid locomotive configuration. (Figure 2).

As I explained on the previous chart, our hybrid locomotive converts previously wasted heat energy into an electrical battery charge. The operator could have the ability to

either use this stored energy to conserve fuel or manually use the energy as a HP boost.

One of the byproducts of the hybrid locomotive is an improved engine overhaul cycle. The locomotive control system will optimize between battery and engine output. In essence the control system will derate the engine and supplement the horsepower reduction with energy from the batteries. We can envision applications in the future where the locomotive could enter "green zones" and utilize both the SmartBurn® option coupled with hybrid technology to minimize emissions. (Figure 3).

How the hybrid works.

(Figure 4)

Today's conventional diesel locomotive wastes a significant amount of energy in the form of heat. The Hybrid will capture previously wasted braking energy, store it in batteries and use this energy to lower fuel consumption. An on-demand 750 horsepower boost capability could increase train speed and allow freight to be delivered faster. The Hybrid locomotive will incorporate advanced technology including Smart Locomotive Power Management (SLPM). SLPM controls the amount of battery energy and diesel energy that a locomotive uses in motoring. The optimization of this balance will allow the locomotive to maximize fuel economy.

How will the hybrid save fuel?

(Figure 5)

The hybrid loco saves fuel by sim-

ply substituting engine MWhr with battery MWhrs. Attached you will find an example of a coal run taken from a Class 1 railroad. In this application, if our hybrid locomotive were used in this operation, a savings of 9.3% in fuel burn would have been realized. Now extrapolate this operation out one year, you could eliminate 333 tons of CO₂, 3.5 tons of NO_x, and 2.4 tons of SO₂ per loco.

How do we change the locomotive?

(Figure 6, 7, & 8)

On the hybrid locomotive, two major configuration issues had to be addressed; the location of the batteries and their additional weight. To address the location, we raised the walkway 6" to accommodate storage of all batteries underneath. Also the locomotive had to increase in length to 34". With the exception of the main cab, all other cabs had to be raised by this amount. The locomotive will still meet plate L. To offset the added weight of the batteries, some of the structures such as the platform will be lighter.

Our commitment to you is to make the most reliable product in the industry. This involves taking a rubber tire application battery and making it robust for the rail vibration and the tough environmental requirements is essential to any successful launch. We plan to spend a number of years making sure the batteries are up to the challenge.

Weight is more of a concern for some railroads than others. We also have future emissions and crashworthiness that will cause additional

concerns. Our goal is to make the system flexible enough to allow us to take advantage of the space/weight available. This is why we mentioned the configuration in the previous charts. For customers with lighter units, we may have more batteries in their system and allow them to achieve greater fuel savings.

Our goal is to not make it any harder to service the current systems on the Evolution Series Locomotive. This is certainly a challenge as we look to put more in the same space.

And finally the battery cost which is crucial in maintaining the value of the hybrid locomotive. We are continuing to work to improve the batteries' efficiency and look for ways to improve production yield to drive cost down.

Given today's fuel prices and battery cost, our plan is start the assembly of a prototype locomotive in 2007. Validation/demonstration units are planned in 2009 with an anticipated production launch of 2010. We will continue to monitor the market and adjust our program as required.

Transportation Ecomagination

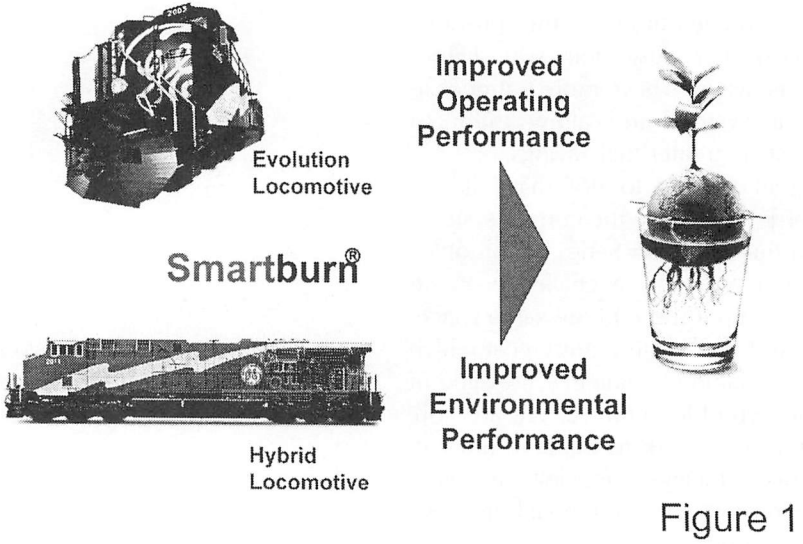
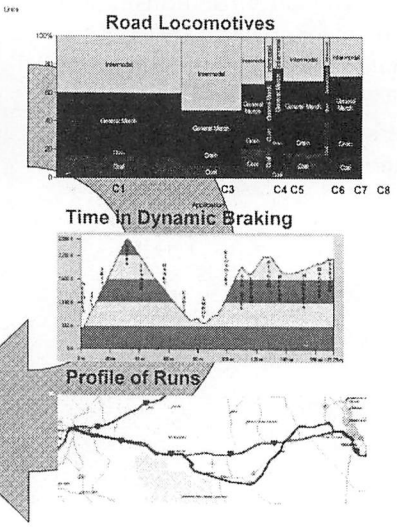


Figure 1

Market Application

**Our Opportunity is
300-400,000 Gallons
of fuel a year**



For each Hybrid Loco
7-10% fuel savings
\$2.00/gallon
—————
\$~200,000 savings

Figure 2

GE Hybrid Locomotive- Overview

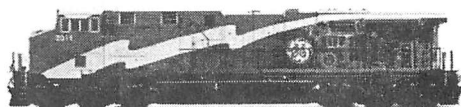
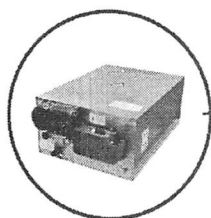
Recover wasted DB Energy
 Store up to 650 kw-hr of Energy
 ✓ Reuse to Save Fuel or Increase Power

Drive flexibility for customers:

- Optimize for fuel
- Optimize for emissions
- Manual boost

Benefits:

- 7-10% fuel savings
- Reduced LCC...ext. O/H cycle
- Bridge to advanced Technology ... fuel cells, etc.
- GEVO + 1750 HP

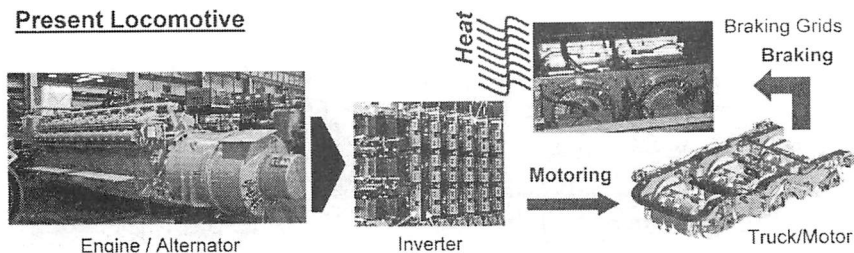


- TE and Adhesion parity w/ GE Evolution Series
- Target: AC Heavy haul Application

Figure 3

How does it Work on the Loco?

Present Locomotive



Hybrid Locomotive

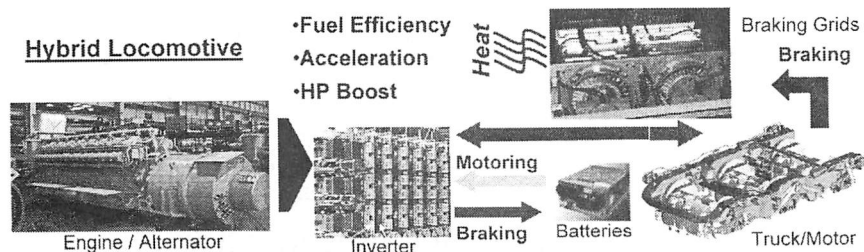
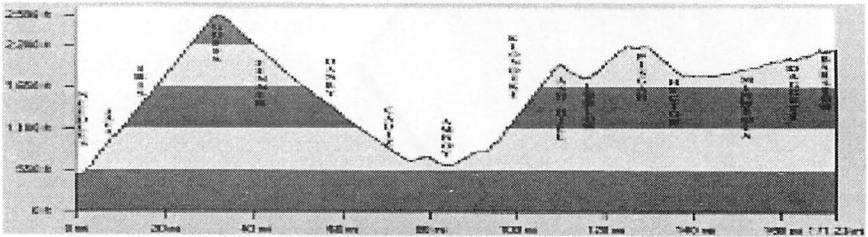


Figure 4

How will hybrid save fuel?

The hybrid loco will save fuel by substituting Engine MWhr by Battery MWhrs!!!

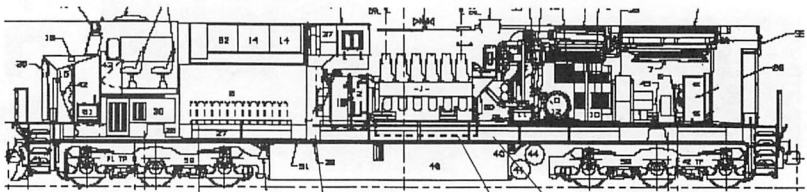


Class 1
Coal Run
Example

Mileage	3,084
Hours	233
Gross Engine HPhr	155,239
DB HPhr Captured	14,455
Energy Savings	9.3%
DB Captured	~30%

Figure 5

How do we change the Locomotive?



Walkway is raised 6"

Piping and cabling inside plenum

Lighter platform which is 34" longer (AC6K length)

Batteries under walkway

Preliminary Configuration

Figure 6



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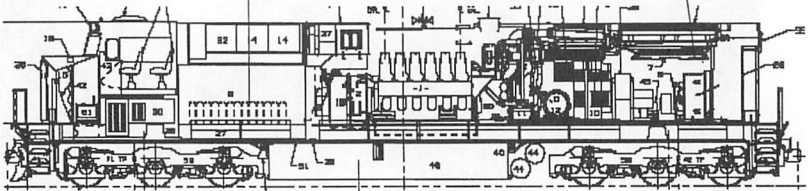
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How do we change the Locomotive?

Aux cab same length with height adjustment for batteries with 2 extra inverters and other electronics

Radiator cab 34" longer and 6" less in height battery blower



4500 gallon fuel tank with new wrapper

Preliminary Configuration

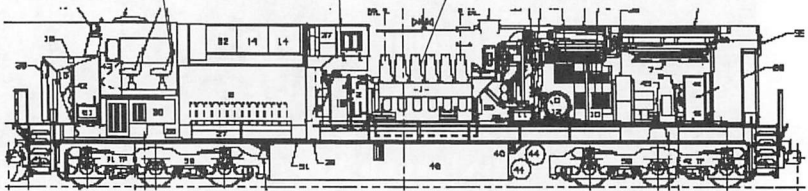
Figure 7

How do we change the Locomotive?

Main cab and CA1 very similar to UP configuration

Blower cab 6" less height

Engine cab 6" less in height with extra ventilation



Preliminary Configuration

Figure 8

DYNAMIC BRAKE STATUS REPORTING

*Prepared by
Craig Prudian,
Electro Motive Diesels*

Introduction

Railroad operations today rely on providing workers with relevant information in order to allow them to do their best work. This is true especially for railroad employees in engine service. Locomotive Dynamic Brake Status Reporting (DBSR) is the latest system now fully coming "on line" for locomotives operating in North America; a feature that is driven by a commitment to safety, but promises to add operational benefits as well. All new locomotives with dynamic brake (DB) are now being manufactured with this system on board, due to FRA mandate.

Just what is this system that will start showing up on new locomotives very soon? This paper will provide a simplified overview of this system, how it works, and what forms it may take, depending upon the type of locomotive in which it is installed.

What is DBSR?

Simply stated, Dynamic Brake Status Reporting is a system that provides a locomotive engineer with real-time information of the dynamic brake condition of his locomotive consist. The new FRA rule requires new locomotives with dynamic brakes to be outfitted with this system. The AAR has subsequently expanded the scope of this system to also include reporting of the real-

time tractive effort of the consist, as well.

When does it become effective?

New locomotives ordered after April 1, 2006 or delivered after October 1, 2007 must be equipped with DBSR, as defined. Technically, this requirement only applies to locomotives with dynamic brakes, so some specialized power may be excluded.

Rebuilt locomotives placed in service as of April 1, 2004 can be equipped with this equipment if the railroad desires, but must at least be equipped with a real-time display of train deceleration (like that already provided with a head-of-train control box and many newer speedometers).

Why is this being implemented?

For as long as trains have been running, stopping them has been an issue. To this day, efforts continue to make stopping trains more safe and sure. One of the continuing problems has been how to control the speed of trains on long downgrades, as friction brakes are not always sufficient to counteract the kinetic energy that trains can gather. The use of dynamic brakes has proven to be valuable in downgrade train speed control. Yet even this is not enough to hold a train back, after critical speeds are exceeded. Recent history is peppered with incidents where trains have outrun the capability of their brakes, often with disastrous results. The final straw came as a result of a train runaway on Cima Hill and subsequent derailment in Kelso,

CA on January 12, 1997. The resulting NTSB investigation of the incident led to NTSB Safety Recommendation R-98-6.

“Require railroads to ensure that all locomotives with dynamic braking be equipped with a device in the cab of the controlling locomotive unit to indicate to the operating engineer the real-time condition of the dynamic brakes on each trailing unit.”

In response to the NTSB, FRA amended 49CFR232 part 109, and added new requirements for locomotives with dynamic brakes. This provided the umbrella, under which more detailed specifications could emerge.

The specifics of how the system would be configured were then developed and detailed by the AAR. AAR Specifications S-5509 offers details of DBSR architecture. The specification also serves to define relevant interfaces, so that proper interoperability between equipment manufacturers and end users can be assured.

How does DBSR work?

This system is designed to be compatible with locomotives already in service, as well as having standardized interfaces, for maximum interoperability. There are two ways to implement the system, dictated by the sophistication level of the cab display electronics of the locomotive.

Figure 1 shows the system in place. The first issue that needed to be addressed was how would the locomotives communicate with each other? During the development of

this standard, the AAR formed a committee, and entertained a number of proposals from the industry, ranging from hardwired solutions to LAN-based wireless communication schemes. After much debate, the final solution was settled on; that of an MU trainline overlay system, where the DBSR signal would be superimposed on an existing trainline. The trainline chosen was sanding trainline #23, with TL #4 used as a negative return.

Now that the locomotives have a pathway to talk to one another, what else is needed? Each locomotive will need to have a central controller to oversee this function. This controller will allow locomotives to speak; to take the parameters monitored within a locomotive and broadcast them out onto the trainline. Also, the controller will be able to listen; to take the information off the trainline and assemble it for transmittal to the operating engineer. Lastly, the controller will have to actually display the information to the locomotive operator, and be able to respond to his requests for consist information.

Integrated or non-integrated?

The question of integrated or non-integrated, determines how a Dynamic Brake Monitor (DBM) system is implemented in a locomotive. Simply, this means that the DBSR function will be either inserted into an existing locomotive controller (integrated), or be applied as an add-on “black box”, apart from the central locomotive control system (non-integrated). For simple, non-integrated applications all the DBM func-

tionality resides in the add-on hardware that can be applied in an after-market fashion. The box is “plugged into” the trainline, wired into the locomotive to capture operating parameters, and a new display is installed. For standardization, the AAR requires that the display replace the existing load ammeter, and physically occupy the same space. Display format will change from the familiar analog needle, to one of text only, as defined in the AAR Standard S-5509.

Integrated DBM is a bit more (or differently) complicated. This arrangement takes advantage of extra “overhead” that is already in the locomotive control system, and adds the DBM functionality to it. New hardware is only needed for the wired interface to the trainline, and for whatever specific input sensors are not already there. The display will be integrated as well; the computer screen that is standard for the locomotive will now take on the additional information for the DBM feature.

One of the functions that requires special attention is DBSR with distributed power remote units in the consist. Obviously, we cannot use the trainlines to pass this information from the DB remote units, so this must be done wirelessly. For non-integrated installations, the DBM controller must have a “listening port” that can interface to the DP equipment, extracting the information of interest from the DB data packet. Integrated versions must also perform this extraction, but no extra port is needed, because the DP

interface is already there. It becomes a collection and data manipulation function exclusively within software.

What information is shared between locomotives?

To implement DBSR, certain information must be collected and managed. The following list outlines the local locomotive data that is monitored by the controller.

- Tractive/brake effort,
- Tractive/Dynamic brake status (to generate condition codes),
- Locomotive isolation switch status,
- Locomotive speed,
- DBM self-test status.

Armed with this information, the DBM is responsible for broadcasting its data out onto the trainline for other locomotives to use. The data packet sent contains:

- Locomotive Manufacturer ID,
- Railroad ID,
- Locomotive Road #,
- Traction/DB Status (with condition codes),
- Traction/DB Effort,
- DBM Health Status

Each locomotive sends this information out onto the trainline at periodic intervals. The DBM has a routine that synchronizes up with the other units on the line, so that transmissions are more-or-less orderly, and every locomotive is able to “take turns” transmitting. The DBM in the lead locomotive becomes responsible for taking all of the consist information and putting it together for display to the engineer.

A “situation” exists with data transmission in DB mode that bears men-

tioning, as it differs from the information available from the locomotives wired on trainline #23. As expected, the communicating DP remote unit is responsible for transmitting the dynamic brake status information for all the locomotives trainlined to it. But rather than sending each locomotive's individual information to the controlling unit, the DP remote can only send a single composite data package for all units on its trainline. This is because the data package has insufficient bandwidth to include each locomotive's individual information.

What information is displayed to the engineer?

The format and content of the display information is specifically outlined in AAR S-5509. The display is all in text format, and the information is formatted in two lines. The first line of text provides individual locomotive information and the second line carries consist data. Briefly, the content of the display includes:

First Line:

- Individual unit ID & Status
- Individual unit TE / BE
- DB status code (for trailing units in consist)

Second Line:

- # Of units reporting (equipped with a DBM),
- # Of units contributing to the total TE or BE,
- Mode (Power/DB),
- Total consist TE or BE in kilolbs.

The display is concise, providing much information in a small area. A button is provided along with the

display, for the engineer to select which locomotive's individual information will be viewed as the first line of data. The display defaults to the local locomotive information, but with a push of the button, the system will scroll through each locomotive in the consist (the ones equipped with this system), one at a time. That means that each time the engineer pushes the button, a different locomotive's data will populate the top line of the display. After each unit has been polled, the display rolls back around to display the local unit data once again.

Conclusions

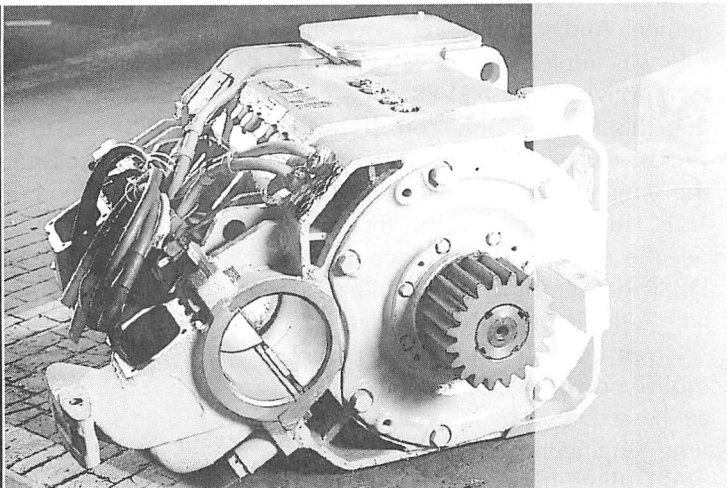
Dynamic Brake Status Reporting offers the engineer new information about his consist that was previously unavailable. At this point however, it is unclear whether this feature, in the near term, will provide the benefits envisioned.

It is important to remember that this rule only applies to NEW locomotives. All NEW locomotives with DB will be equipped with this DBSR system, but existing locomotives DO NOT have to have this new system, ever. What this suggests, is that it will be decades before entire fleets are equipped with this new technology, because it will only happen by attrition, as older power is removed from service.

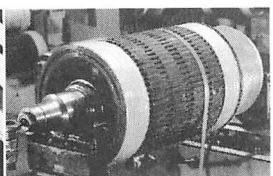
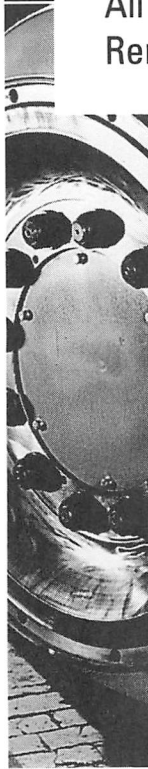
In an informal poll of engineers in the western US, feedback received indicates that if the information is true and reliable, it will be of some help to operations. But if the data displayed does not accurately reflect the consist status, engineers will like-

ISO 9001
2000

AAR M-1003



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ly ignore the DBSR information altogether. And considering how the rule was implemented, with existing locomotives likely NEVER to be getting this feature, only consists with exclusively new power will provide the engineers with useable data. Thus, most consists, for the next decade or so, will yield incomplete DBSR data, prompting engineers to ignore the information provided.

Given enough time, Class 1 road motive power will, by natural course, all have DBSR by default. At that time, engineers will be able to feel good that the information they receive from it will reasonably reflect the status of their consist. But that will be more than ten years away. Until then, however, the system will experience growing pains and will have its detractors. For the next decade, look for the reviews of the usefulness of DBSR to be spotty.

The Kelso, CA accident triggered the birth of this feature, yet had this DBSR been installed, it would have not helped avoid this accident. An arguable case can be made that the information would have contributed to safer operation, due to more complete information of the status of the motive power being available. But that would not have prevented Kelso, as the runaway was caused by the engineer accidentally kicking the MU Engine Stop switch with his foot!

In summary, the efforts to bring about DBSR have been extensive and with good intent. The information provided by this new system to the engineer will work to eliminate some of the factors that have led to runaways in the past. But the true

effectiveness of this system will not be felt for many years. Let us hope that the inevitable time lag that will delay this system's full effectiveness will not give rise to other incidents that will necessitate additional Federal intervention.

How does it work?

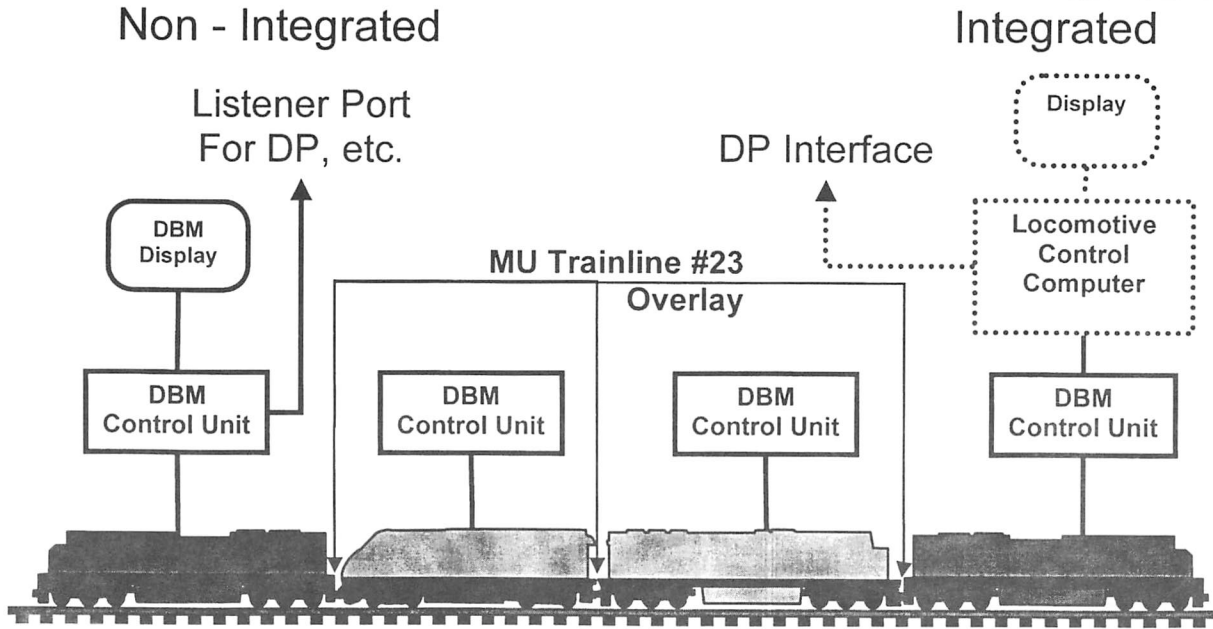


Figure 1

CONSTITUTION AND BY-LAWS LOCOMOTIVE MAINTENANCE OFFICERS ASSOCIATION

Revised September 22, 2003

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 - Railroad Membership shall be composed of persons currently or formerly employed by a railroad company and interested in locomotive maintenance. Membership is subject to approval by the General Executive Committee.

Section 2 - Associate Membership shall be composed of persons currently or formerly employed by a manufacturer of equipment or devices used in con-

nection with the maintenance and repair of motive power, subject to approval of the General Executive Committee.

Associate members shall have equal rights with railroad members in discussing all questions properly brought before the association at the Annual Meeting, and shall have the privilege of voting or holding elective office.

Section 3 - Life membership shall be conferred on all Past Presidents. Life membership may also be conferred on others for meritorious service to the Association, subject to approval by the General Executive Committee.

Section 4 - Membership dues for individual railroad and associate membership shall be set by the General Executive Committee and shall be payable on or before September 30th of each year. The membership year will begin on October 1 and end September 30. 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. Life members will not be required to pay dues, but 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. Each officer will hold office for one year or until successors are elected. In the event an officer leaves active service, he may continue to serve until the end of his term, and, if he chooses, continue to serve as an executive officer and be allowed to elevate through the ranks as naturally occurs, to include the office of President.

Section 2 - There shall be one Regional Executive officer assigned to oversee each technical committee. Regional Executives shall be appointed from the membership by the General Executive Committee for an indefinite term, with preference given to those having served as a Technical Committee Chairperson. A Regional Executive who leaves active service may continue to serve as such, and shall be eligible for nomination and election to higher office.

Section 3 - There shall be a General Executive Committee, composed of the President, Vice Presidents, Regional Executives, Technical Committee Chairpersons, and all Past Presidents remaining active in the Association.

Section 4 - There shall be a Secretary-Treasurer, appointed by, and holding office at the pleasure of the General Executive Committee, who will contract for

his or her services with appropriate compensation.

Section 5 - All elective officers and Regional Executives must be LMOA members in good standing. (See Article III, Section 4.)

Article V - Officer, Nomination and Election of

Section 1 - Elective officers shall be chosen from the active membership. A Nominating Committee, composed of current elective officers and the active Past Presidents, 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 - Vacancies in any elective office may be filled by presidential appointment, subject to approval of the General Executive Committee.

Section 4 - The immediate Past President shall serve as Chairman of the Nominating Committee. In his absence, this duty shall fall to the current President.

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 additionally 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.

The Vice Presidents shall perform such other duties as are assigned them by the President.

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 General Executive Committee.

C. Perform the duties of the Secretary of the 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 Regional Executive officers shall:

A. Participate in the General Executive Committee meetings.

B. Monitor material to be pre-

sented by the technical committees to ensure reports are accurate and pertinent to the goals of the Association.

C. Attend and represent LMOA at meetings of their assigned technical committees.

D. Promote Association activities and monitor membership levels within their assigned areas of responsibility.

E. Promote and solicit support for LMOA by helping to obtain advertisers.

Section 5 - Duties of General Executive Committee:

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 Auditing and Finance Committee.

D. Determine the number and name of the Technical Committees.

E. Exercise general supervision over all Association activities.

F. Monitor technical papers for material considered unworthy or inaccurate for publication.

G. Approve topics for the Annual Proceedings and Annual Meeting program.

H. Approve the schedule for the Annual program.

I. Handle all matters of Association business not specifically herein assigned.

Section 6 - The General Executive Committee is entrusted to handle all public relations deci-

sions 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 General Executive Committee.

Section 2 - A vice chairperson, selected by the chairperson and approved by the President.

Section 3 - Committee members, selected as follows:

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 direction of the General Executive Committee, non-railroad personnel may be allowed to participate in committee activities.

Section 4 - All individuals who are on technical committees must be LMOA members in good standing. (See Article III, Section 4).

Section 5 - Subjects for technical

papers will be selected and approved by the General Executive Committee.

Article VIII - Proceedings

Section 1 - 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.

Section 2 - Those present at any meeting called on not less than thirty days advance written notice shall constitute a quorum.

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 and By-Laws may be amended by a two-thirds vote of the active members present at the Annual Meeting.

**DIESEL MECHANICAL MAINTENANCE COMMITTEE
TWENTY-FIVE YEAR INDEX**

2005

1. Crankcase Overpressure Today - Concentrating on EMD and GE Locomotives
2. Cold Weather Locomotive Operations
3. Importance of Cooling System Health, EPA Compliance Impact
4. Overhaul Extension
3. How to Maintain ALCO Locomotives in the 21st Century
4. Catastrophic Engine Failures: Shortlines & Regionals (Best Practices)
5. Are We Ready for Reliability-Centered Maintenance?

2004

1. GE Evolution Series-Maintenance and Reliability
2. EMD 70ACe and SD70DC-Tier 2 Locomotive Models-Mechanical Maintenance Enhancements
3. Best Practices Series-For Regional and Shortline Railroads-Managing Locomotive Wheel Wear
4. Maintenance Savings - Mother/Daughter Units
1. 2000 Emissions Review - GE Perspective
2. 2000 Emissions Review - EMD Perspective
3. EMD Diesel Engine Crankshaft Main Bearings Edge-Load Condition (Description, Detection and Resolution)
4. 2000 - LMOA Best Practice Series: Locomotive Truck Overhaul Procedures

2003

1. Training 60/30 Impact Now & Beyond
2. Condition Based Maintenance, Practical Approaches and Techniques
1. Training 60/30 Impact Now & Beyond
2. Condition Based Maintenance, Practical Approaches and Techniques
1. Vibration Analysis
2. EMD Power Assemblies Change Out Practices for Regional and Shortline Railroads
3. Improved Access to GE7FDL Engine Intake Manifold for Cylinder Inlet Port Cleaning
4. What's Ahead in Plastics for Locomotive Applications
5. Cast Iron, Composition Brake Shoe Arrangements vs. Type-J Relay

2002

1. Detrimental Effects of Locomotive Engine Idling
2. Emissions Standard Compliance for the GE Dash 8 Locomotives
3. Tier 0 Emissions Compliance for the GE Dash 8 Locomotive
4. Locomotive Inspection Training - A Preview of CFR 229/238
5. Computerized Record Keeping to Improve Performance and Reduce Maintenance Expense for Shortline and Regional Railroads

2001

1. Troubleshooting Electronic Fuel Injection on GE Locomotives
2. Troubleshooting Electronic Fuel Injection-EMDEC Electro Motive Division Two-Stroke Engine
1. LMOA Best Practices Series: GM Engine Crankcase Pressure Troubleshooting
2. Union Pacific's New EMD Diesel Engine Rebuild Line At Downing B. Jenks Locomotive Facility-No. Little Rock, Arkansas
3. GE Turbo Rebuild Procedures
4. Mechanical Impact of Locomotive Emissions Regulations
5. Locomotive Engine Bearing Developments

1997

1. LMOA Best Practices - GE Water Leaks
2. Locomotive Update - MK 1200G LNG Powered Switcher
3. Proper Use of Gaskets and Seals

1996

1. Air Brake Trouble Shooting- Where We Are Now
2. Best Practices - Internal Water Leaks on EMD Locomotives
3. Best Practices - Oil Out Stack

1995

1. General Electric New 7HDL 6000 HP Diesel Engine
2. LMOA Best Practices Series - Low Oil Pressure Trouble-shooting Procedures for EMD Turbocharged Locomotives
3. How Can a Regional or Shortline Justify a Wheel Truing Machine?
4. EMD SD60M Natural Gas Locomotive Development

1994

1. Electronic Fuel Injection.
2. ICAV - The Physical Affects on Instantaneous Crank Shaft Angular Velocity Technology
3. Maintenance Practices Comparison Between Regionals and Class I Railroads
4. Amtrak Document Management.

1993

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

1992

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

1991

1. Recommended Practices for

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

1990

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

1989

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

1988

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

1987

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

1986

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

1985

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

1984

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

1983

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

1982

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

1981

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

**DIESEL MATERIAL CONTROL COMMITTEE
TWENTY-FIVE YEAR INDEX**

2005

1. Centralized Materials Management
2. Centralized Component Core Management-Centralized Warehouse-Locomotive Components - Part A: BNSF Rwy. Centralized Component Core Management-Rotable Warehouse - Part B: Norfolk Southern Corp.

2004

1. Milk Run: Norfolk Southern's Dedicated Locomotive Parts Shipping System

2003

1. Just in Time Delivery - The Juniata - Shop Material Control Program
2. The Continuous Improvement Approach

2002

1. "Mentored Champion Process" - CSX Supply and Service Management

2001

1. RAILMARKETPLACE.COM - The Industry's Market Exchange

2000

1. GE Global eXchange Services
2. My.SAP.Com

1999

1. Composite Floors and Doors for Locomotives
2. Packaging Standards

1998

1. Tighter is Not Better
2. Are Vending Machines the New Wave for Safety Items?

1997

1. Raising Our Standards for Safety
2. The Rail Industry's Electronic Parts Catalog Exchange Standard (EPCES) - A Better Way

1996

1. Technology Transfer-The Hot Process of the 90's-Condition Based Maintenance
2. Warehouse Automation

1995

1. Warranty and Reliability Management
2. Railroad Industry Group (RIG) Exchange Standard for Parts Catalog Information

1994

1. Material Consignment
2. The Next Step in Electronic Information Management - Interactive Technical Manuals.
3. Electronic Catalog Alternatives.

1993

1. Technology Transfer
2. Electronic Cataloging from a Material Perspective
3. Computerized Reordering from the Mechanical Employee's Point of View

4. Electronic Catalogues: OEM /Supplier Point of View

1992

1. Warranty Overview and Issues
2. Recycling - 1992
3. Bar Coding

4. Material Packaging

1991

1. The World of Recycling
2. Problems with Solution
3. Problems with Opportunities

1990

1. Waste Minimization.
2. Hazardous Materials End Cost
3. The Role of the Suppliers

1989

1. Packaging and Containerization for Today's Railroad.
2. Innovations in Material Distribution Resulting from Shop

Consolidations.

3. Outsourcing! Does Anyone Really Understand the Difference Between UTEX and Repair and Return and the Affect on the Budget?
4. "Stuff" Happens! - A Skit About the Necessity of Feedback from Suppliers - Suppliers to the end User

1988

1. Communication - The Vital Link in Materials Acquisition
2. Quality Assurance Through Communications and Feed-back
3. Paperless Requisitions
4. A Practical Application of Bar Coding in the Railroad Industry

1987

1. Suppliers Selection for Component Failure Analysis
2. Vendor Performance or Service Level
3. Bar Codes
4. Bar Coding - Railroads
5. Material Handling Innovations by the Airline Industry

1986

1. The In-House Electronic Requisition System
2. Electronic Data Interchange.
3. RAILING and Electronic Purchasing
4. Quality Evaluation of Material Sourcing Decisions

1985

1. Evaluating Locomotive Maintenance Projects
2. Reconditioning Material: In-House vs. Vendo
3. Identification and Disposition of Surplus Material
4. Cost of Carrying Surplus
5. Evolution and Future Directions

of Material Handling Equipment in Railroad Use

1984

1. Bar Coding of Material
2. Forecasting Material Requirements
3. a. Fuel Security - Are You Getting What You Pay For?
b. Fuel Oil Is Expensive
4. Pros and Cons of Material Purchasing Contracts (Single Source - Just In Time Inventory)

1983

1. Improved Locomotive Productivity Through Computerized Data
2. Inbound Material Inspection
3. Minimize Maintenance Cost Through Material Management Systems
4. New Ideas In Material Storage Containers

1982

1. Use of kits in locomotive maintenance
2. Cost effective methods of shipping material from vendors.
3. Union Pacific's Component Inventory Maintenance System (CIMS).
4. Advantages of using shipping containers

1981

1. Disposal of Unserviceable Component Parts: What is the Most Profitable Method?
2. Innovations in Stores Material Handling, Via Computer Technology
3. Locomotive Held for Material: an Update for the 80's
4. The Best Approach to Procuring Material; New, UTEX, Repair and Return or Shop Repair

SHOP EQUIPMENT AND PROCESSES COMMITTEE TWENTY-FIVE YEAR INDEX

2005

1. Mobiturn Wheel Truing Services

2004

1. Under the Hook Lifting Devices
2. Sanding in the Railroad Industry- Part III - A Gentle Answer for an Abrasive Situation

2003

1. Locomotive Shop Support Systems and Equipment
2. Hand Tools - An Ergonomic Update
3. Locomotive Lifting Systems

2002

1. NOTE: PAPER ON LIFTING SYSTEMS WAS PRESENTED BY RON BEGIER OF PORTEC AT THE 2002 CONVENTION; HOWEVER IT DID NOT APPEAR IN PUBLICATION - WILL APPEAR IN THE 2003 PROCEEDINGS PUBLICATION

2001

1. Standing in Railroad Industries - Part II - How to Specify Reliable and Safe Sanding Systems

2000

1. The Tandem Wheel Truing Machine at Amtrak's Ivy Shop
2. Shop Talk 2000: Fall Protection Technology
3. Sanding in the Railroad Industry

1999

1. Increasing Diesel Shop Capacity
2. Conrail-Cold Asphalt Processing of Environmental Waste Sand and Sludge
3. Dry Ice Cleaning of GE Intake Ports
4. AAR-LFIS No Spill Fueling System

1998

1. Smoke Opacity Testing-Emission Detection Equipment and its Use
2. Hydraulic Tensioning Tools and its Use

3. High Speed Portable Align Boring Series

4. Locomotive Mobile Servicing

1997

1. Wheel Truing as Preventive Maintenance
2. Conrail-Selkirk Diesel Terminal Wastewater Treatment Facility Recent Environmental Improvements

1996

1. Locomotive Painting
2. Drop Table Tooling for New EMD and GE Locomotives

1995

1. Pre-Maintenance Inspection
2. Railroad Turntable Modification
3. Mobile Locomotive Service Vehicle

1994

1. Electronic Fuel/Unit Injection Tooling.
2. Locomotive Roller Support Bearing Tooling.
3. Fall Protection and Man Lifts.
4. Locomotive Washing Systems.

1993

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

1992

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

1991

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

1990

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

1989

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

1988

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

1987

1. Modern Servicing Facility for Improved Reliability and Availability
2. New Developments in GE Tools.
3. Implementation of a Quality Process

4. A Quality Traction Motor Shop.
5. Wheel Truing Machine Technology

1986

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

1985

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

1984

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

1983

1. Locomotive Maintenance Using a Production Line Process
2. Shop Tools to Increase Productivity and Improve Quality.
3. Dynamic On-Line Performance of Locomotives Without On-Board Tele-Metering

4. Management in Action
5. New GE Training Center
6. Welding Qualifications

1982

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

1981

1. Training Aids.
2. Testing Devices Inspired by New FRA Laws
3. Tools and Training for Productivity

ty

4. Changes to Shop Facilities Required by Newly Adopted EPA & OSHA Regulations
5. Tour through Conrail Altoona Shop
6. Supply/Service Facilities
7. GE Assembly Shop

DIESEL ELECTRICAL MAINTENANCE COMMITTEE TWENTY-FIVE YEAR INDEX

2005

- | | |
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| <ol style="list-style-type: none"> 1. Wireless Communication Technology Overview 2. Maintenance Benefits of the Green Goat - Part A
Hybrid Switcher Update - Green Goat - Part B | <ol style="list-style-type: none"> 2. Locomotive Wire Update 3. Integrated Air Brake & Distributed Power Under EMD Fire System 4. Carbon Brushes - A Fresh Look 5. RM&D - What It Is, What It Does 6. An Alternate Adhesion System |
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2004

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| <ol style="list-style-type: none"> 1. Electrical Maintenance Benefits of the SD70ACe 2. Remote Monitoring & Diagnostics: Development and Integration with Maintenance Strategies 3. Carbon Brushes Revisited - an Update for 2004 | <ol style="list-style-type: none"> 1. Transition Panels for Older Locomotives 2. R.S. A.C. Crash Worthy Event Recorder Update 3. Traction Motor Suspension Bearing Temperature Monitoring System 4. EMD SD90MAC 6000 HP Locomotive-An Update 5. IGBT-What's New for GE AC6000 Locomotives |
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2003

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| <ol style="list-style-type: none"> 1. Diesel Driven Heating System 2. Trainline - ES TIBS as Applied to CN/IC Locomotives 3. Head End Power (HEP) Safety Issues 4. Fuel Savings, Using Locomotive Consist Management | <ol style="list-style-type: none"> 1. Locomotive Troubleshooting Assistant 2. Locomotive Electronic Brake Maintenance 3. SD70MAC Capacitor Discharge Procedure 4. Power Savings for Electrical Locomotives 5. Auto Stop/Start and Layover Systems |
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2002

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| <ol style="list-style-type: none"> 1. Commutator Profiling 2. Basics of an Operations Center 3. Diagnostics for Older Locomotives 4. Traction Motor Protection Panel 5. "Locomotive Auxiliary Power Units" - Lessons Learned | <ol style="list-style-type: none"> 1. Review of Battery Maintenance and Available Options 2. Battery Charger/Booster 3. Locomotive System Integration 4. Electronic Governors |
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2001

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| <ol style="list-style-type: none"> 1. Diagnostic and Predictive Maintenance 2. Locomotive Replacement Control System 3. Automatic Shutdown Startup Controls - Fuel Savings through Technology 4. Locomotive Alternative Air Conditioners | <ol style="list-style-type: none"> 1. EMD SD80MAC High Voltage Safety 2. GE AC Locomotive Electrical Safety Features 3. Electromagnetic Interference (EMI on AC Locomotives) 4. QTRAC 1000 Adhesion Control System 5. Locomotive Health Monitoring-The Key to Improved Maintenance |
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2000

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| <ol style="list-style-type: none"> 1. Custom Electronics and their Applications | <ol style="list-style-type: none"> 1. Canadian National Battery Water |
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1999

1. Canadian National Battery Water

1998

1. Canadian National Battery Water

1997

1. Canadian National Battery Water

1996

1. Canadian National Battery Water

1995

1. Canadian National Battery Water

Usage

2. Remote Diagnostics-Radio Download
3. Programmed Preventive Maintenance
4. Commutation Monitoring in Locomotive DC Traction Motors
5. The EMD Diesel Engine Control (EMDEC) System

1994

1. Safety First - Video on Electrical Safety
2. Locomotive Health Monitoring Systems
3. Event Recorder Update
4. SD60 Dynamic Brake Improvements

1993

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

1992

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

1991

1. Locomotive Rebuilding - Something Old - Something New. Standardization of Electrical Equipment
2. Locomotive Batteries
 - a. Storage Handling Procedures
 - b. Recommended Maintenance Procedures
 - c. Recommended Repair Procedures
3. Amtrak's AC Traction Locomotives
4. Modern Tooling for Electricians Recorders
3. Why Can't We Have One Central

Computer?

4. EPA and Regulation Driven Cleaning

1990

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

1989

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

1988

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

1987

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

1986

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

1985

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

1984

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

1983

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

1982

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

1981

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

NEW TECHNOLOGIES COMMITTEE

TWENTY-THREE YEAR INDEX

2005

1. PL42AC Locomotive-Overview
2. Fuel Cell Locomotives
3. Locomotive Electric Hand-brake Systems

2004

1. GE Evolution Locomotive - An Overview
2. EMD SD70Ace Locomotive-Reliability for 2005 and Beyond
3. Get Them into Condition: Condition Based Traction Motor Reliability
4. Making the Switch - An Update on the EMD GP20D/GP15D Switcher Locomotive
5. "Fuel Proof Tank Repairs" - A Best Practice for your Locomotives

2003

1. New MPXPRESS Commuter Locomotive Models MP 36PH-3S & MP36PH-3C
2. The Green Goat Hybrid Locomotive
3. Observation on Auto Engine Start/Stop

2002

1. On Board Rider - A Remote Locomotive Condition Monitoring System
2. Cool Your Jets: A Low Cost High Performance Rooftop Air Conditioner

2001

1. Performance and Economic Aspects of Various Environmentally Friendly Coatings for Rolling Rail Equipment
2. Non-destructive Testing: Crack Detection Technology - EMFaCIS

2000

1. FIRE: EMD Turns up the Heat on Railroad Electronics Integration
2. Put the Chill on Air Conditioning Costs
3. Do Not Get "Steamed" Over Fuel Tank Repairs
4. Industry Responses to Emission Regulations

5. Improved Adhesion Through the Use of Individual Axle Inverters

1999

1. Locomotive Filtration-Where are We Going?
2. EMD Markets a New Line of Switchers

1998

1. Expert Systems
2. EMD SD90MAC 6000 HP Locomotive - Where Are We Today? GE AC6000CW Locomotive - Where Are We Today?

1997

1. An Overview of the Electro-pneumatic Train Brake
2. Locomotive 6724, Where Are You? GPS, Mobile Telemetry and GIS Technologies in a Railroad Environment
3. Runout Measurement Using Non-Contact Sensor Tech-nology
4. Common Rail Fuel Injection

1996

1. Activities Toward New Safety Standards for Passenger Equipment
2. SP-3 Thin Sensor Technology for Variable Force Measurement
3. Top-Of-Rail Lubrication
4. Traction Motor Vibration and its Effects

1995

1. Beltpack Locomotive Control System
2. The MK1200G Switching Locomotive
3. Advanced Traction Motor Testing

1994

1. Electronic Fuel Injection Systems.
2. Status of Distributed Power in Freight Trains.
3. Advances in Distributed Power-

Iron Highway.

1993

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

1992

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

1991

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

1990

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

1989

1. A Rational Approach to Testing Locomotive Components
2. New Developments in Loco-

motive Cab Design

1988

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

1987

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

1986

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

1985

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

1984

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

Locomotive

1983

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

FUEL, LUBRICANTS AND ENVIRONMENTAL COMMITTEE TWENTY-FIVE YEAR INDEX

2005

1. Engine Oil 202 - Refined Base Oils and their Importance in Lubrication
2. Biodiesel - A Potential Fuel Source for Locomotives

2004

1. Discussion of the LMOA Fuels, Lubricants and Environmental Committee Pentane Insolubles Procedures Revision 4
2. Engine Oil 101 - Viscosity and Additives
3. Used Oil Analytical Results, What do they Mean, How to Interpret the Results and How do you Respond?

2003

1. Laboratory Results May Put Your Locomotive at Risk
2. Top of Rail Friction Modification Studies on the BNSF

2002

1. Improved Generation 5 Lubricant Provides Potential for Extended Lube Oil Filter Life
2. Corrosion Protection of Locomotive Cooling Systems

2001

1. On-Board Oil Management System
2. Evaluation of Locomotive Engine Oil Analytical Laboratories
3. Fuel Additives - Friend or Foe

2000

1. Biodegradability and its Relevance to Railroad Lubricants and Fluids
2. Engine Lubricating Oil Evaluation Field Test Procedure
3. Detecting Abnormal Wear of AC Traction Motor, Pinion End, Armature Bearings Through Lubricant Wear Debris Analysis
4. Further Development in Top-of-Rail Lubrication Testing

1999

1. Lube Oil Analysis-Achieving Quality Results

2. Effects of Engine Lubricants on Oil Filtration
3. Recycling and Re-refining of Used Lubricated Oils

1998

1. Safety and Chemical Cleaners
2. Development of a Low Emissions, Dual Fuel Locomotive
3. Fuel Oil Stability Update
4. Ten Questions on EPA's Locomotive Exhaust & Emission Regulations

1997

1. Ferrography-Used Oil Analysis Program
2. 2000 - A New Millennium for Locomotive Maintenance: EPA Exhaust Emissions Regulatory Impacts
3. Standardized Test Procedures - Current Developments
4. Industry Updates and New Developments

1996

1. Standardized Test Procedures-The Annual Subcommittee Update
2. Diesel Fuel Standards and their Applications to Railroad Fuel Quality Issues
3. A Look at Generation 5 Oil Performance and Future Oil Needs
4. LNG as a Railroad Fuel

1995

1. MSDS'S - What do they tell us?
2. Applying Satellite Communications Technology to On-Line Oil Analysis of Crankcase Diesel Engine Lubricants
3. Standardized Test Procedures - Past, Present & Future Developments
4. Locomotive Exhaust Emissions Regulations

1994

1. TBN-A Review of Currently Accepted Methods.
2. GE Multigrade Lubricating Oil Testing and Specification.
3. The Economic Impact of Low-Sulfur Diesel Requirements.

1993

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

1992

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

1991

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

1990

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

1989

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

1988

1. Used Oil Analysis and Condemning Limits
2. Review of A.A.R. Procedure RP - 503, "Locomotive Diesel Fuel

Additive Evaluation Procedure"

3. Update on Improved Oils - Multigrade
4. Wheel Flange Lubrication Update - Lubricants Being Used
5. Survey of Disposable Practices or Locomotive Engine Lube Oil and Lube Oil Filters
6. Speaker on Overview of Environmental Requirements for The Use of Petroleum Products in The Railroad Industry - Peter Conlon - AAR

1987

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

1986

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

1985

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

1984

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

1983

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

1982

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

1981

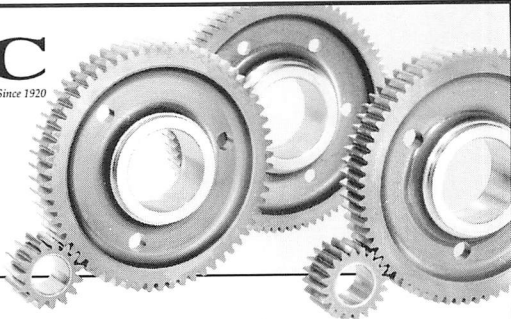
1. Effects of Using Alternate Fuels on Existing Diesel Engines
2. Update on Cold Weather Procedures for Fuels
3. New Techniques in Lube Oil Analysis
4. Traction Motor Gear Lubri-cation.
5. Multi-Viscosity Oils as an Energy Conservation Technique

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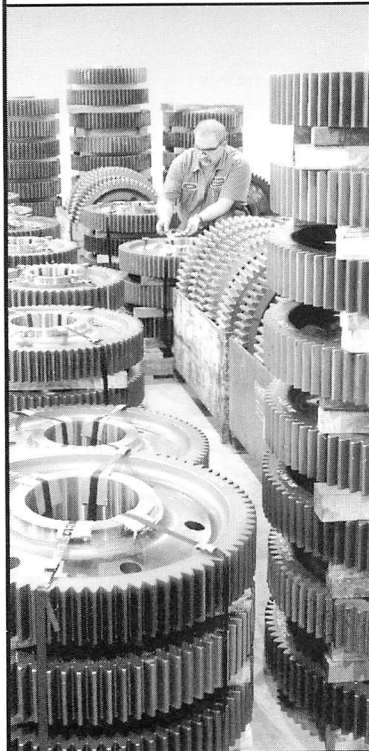
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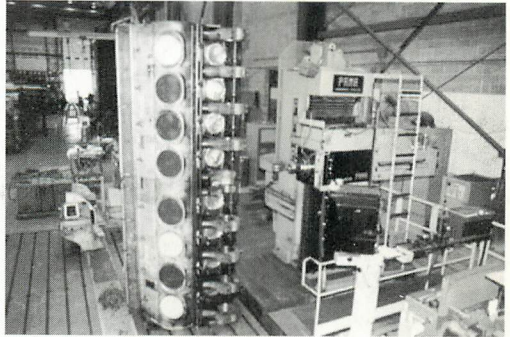
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