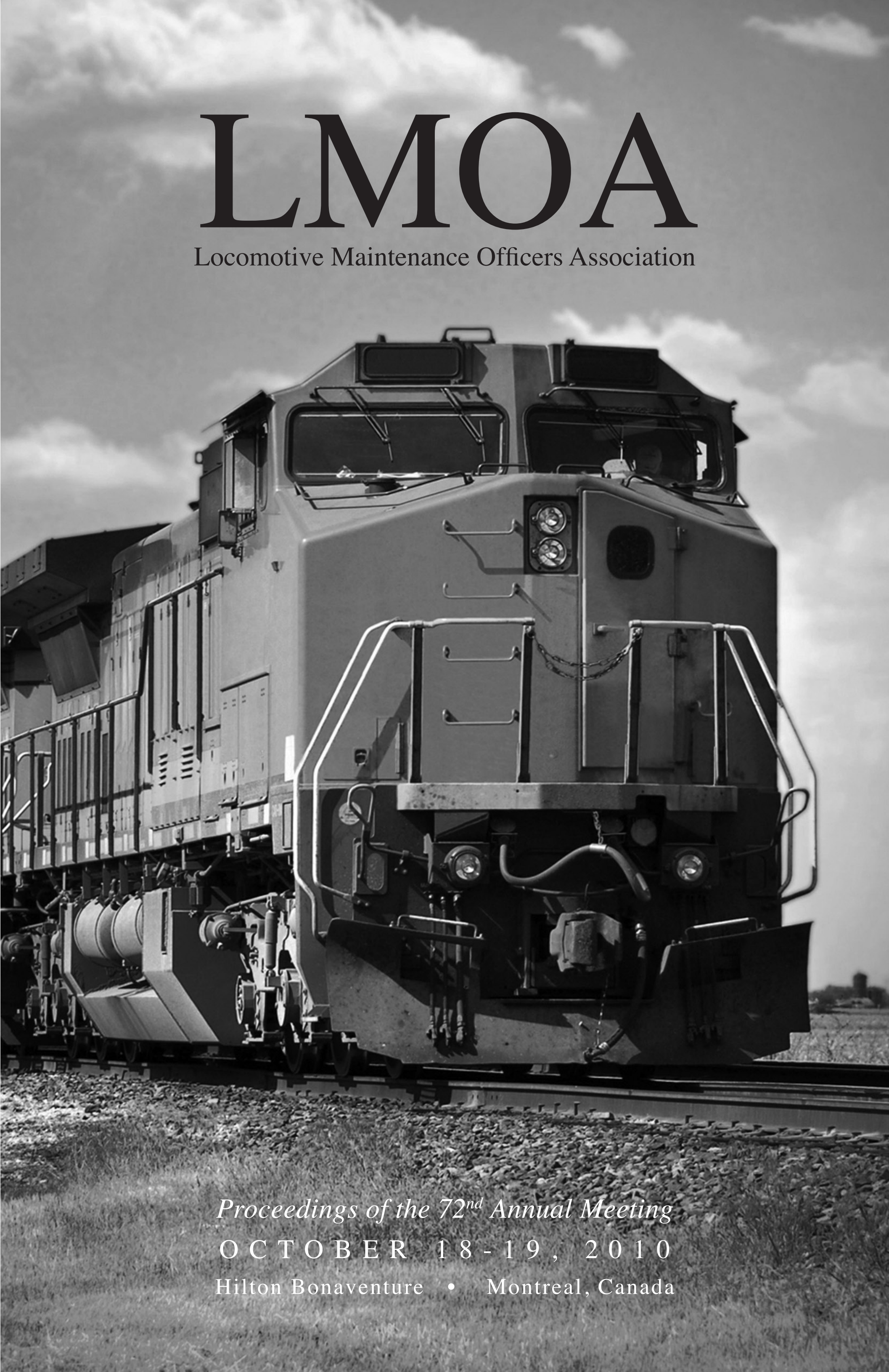
LMOA

Locomotive Maintenance Officers Association



Proceedings of the 72nd Annual Meeting

OCTOBER 18-19, 2010

Hilton Bonaventure • Montreal, Canada

2010 Advertisers Index

Locomotive Maintenance Officers Appreciate these 2010 Supporting Advertisers

Amglo Kemlite Labotatories

Amsted Rail Group

Bach Simpson

Clark Filter

Dapco

Delta Manufacturing

Electro Motive Diesels Inc

Graham White

Industrial Specialty Chemicals, Inc

Hotstart

LPI Lift Systems

Magnus, LLC

Miba Bearings, U.S.

Morgan AM&T (National Electrical Carbon Products)

National Railway Equipment Co

Peaker Services

Penn Locomotive Gear

Power Rail Distribution

Rail Products International Inc

Railroad Friction Products Corp

Safety Kleen Systems, Inc

Simmons Machine Tool Corp

Snyder Equipment, Inc

Tame, Inc

Transportation Equipment Supply

Wabtec Global Services

ZTR Control Systems

2010 TOC and Index

2009 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 2009.

NAME	COMMITTEE
Keith Mellin	Diesel Electrical Maintenance
Jim Christoff	New Technologies
Denise Louder	Shop Equipment and Processes
George King II	Diesel Mechanical Maintenance
Don Mattey	Fuel, Lubricants and Environmental
Jim Fronckoski	Diesel Material Control

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

LMOA Executive Board would like to thank the Norfolk Southern Corporation for hosting their joint Technical Committee at Roanoke Shops on April 26 and 27, 2010

Special thanks to Tim Heilig, VP Mechanical, Don Graab, AVP-Mechanical and Shop Manager, Chuck Sloan, for the tours of Roanoke Shops and for sponsoring the luncheon on Monday, April 26th.

The LMOA Board also wishes to extend their sincere appreciation to Dan Hughes who gave a tour of Graham White Salem on Tuesday, April 27th and to Jim Franz and Graham White for sponsoring the luncheon on Tuesday.

The LMOA Board also thanks Bev Webster for conducting a tour of Vista Corporation in Roanoke on April 27th.

LMOA Executive Board wishes to express their sincere appreciation and gratitude to Dwight Beebe of Temple Engineering for hosting and sponsoring the annual LMOA Family Luncheon held at the Chicago Hilton and Towers, Chicago, Illinois on Friday, September 18, 2009.

Thank you for your continued support of our organization, Dwight.

PAST PRESIDENTS

1939 & 1949	F.B. DOWLEY (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) Vice-Pres.- Equipment, Seabord 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, Seabord 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, Southen 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) General 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, Burlinton Northern Rail-road
1975	L.H. BOOTH (Deceased) Retired Assistant C.M.O.-Locomotive, Chessie System
1976	J.D. SCHROEDER, Retired Assistant C.M.O.-Locomotive, Burlinton 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 (Deceased) Manager-Locomotive Department, Chessie Systems
1981	R.G.CLEVENGER, Retired, General Electrical Foreman, Atchison, Topeka & Santa Fe Rwy

1982	N.A. BUSKEY (Deceased), Asst. General manager-Locomotive, Chessie Systems
1983	F.D. BRUNER (Deceased), Asst. Chief Mechanical Officer, R&D, Union Pacific RR
1984	R.R.HOLMES, Retired Director Chemical Labs & Environment, 600 Brookestone Meadows Place, Omaha, NE 68022
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, 8913 West 161st St, Overland Park, KS 66085
1987	D.L.WARD (Deceased), Coordinated-Quality Safety & Tech Trng, Burlington Northern RR
1988	D.G. GOEHRING, Retired, Supt. Locomotive Maintenance, National RR Passenger Corp, 1408 Monroe, Lewisburg, PA 17837
1989	W.A.BROWN, Retired, I&M Rail Link, 9047 NE 109th St. Kansas City, MO 64157
1990	P.F.HOERATH, Retired, Sr. Mech. Engr. Shop, Conrail 1534 Frankstown Rd, Hollidaysburg, PA 16648
1991	D.D.HUDGENS, Retired, Sr Mgr R&D, Union Pacific, 16711 Pine St., Omaha, NE 68130
1992	K.A.KELLER, Retired, Supt. Locomotive Maint, Reading RR, 241 E. Chestnut, Cleona, PA 17042
1993	W.R.DOYLE, Project Manager, Sound Transit, Seattle, WA 98104
1994	M.A.COLES, Sr. Mgr-Loco. Engineering & Quality, Union Pacific RR, Omaha, NE 68179
1995	C.A.MILLER, Retired Mgr-Loco. Engineering & Quality, Union Pacific RR, 1728 S 167 Circle, Omaha, NE 68130
1996	G.J.BRUNO, Retired, Supt.-Mechanical, Amtrak 14142 S.E. 154th Pl, Renton, WA
1997	D.M.WETMORE, Retired-Genl Supt.-Fuel Opns, NJT Rail Opns, 2005 Acadia Greens Drive, Sun City Center, FL 33573
1998	H.H.PENNELL, Retired-Ellcon National, 1016 Williamsburg, Lanne, Keller, TX 76248
1999	JAKE VASQUEZ, Retired, Asst. Supt.-Terminal Services, Amtrak 1130 Walnut Ave, Osawatomie, KS 66067
2000	RON LODOWSKI, Production Mgr, CSX Transportation, Selkirk, NY 12158
2001	LOU CALA, Retired, Duncansville, PA 16635
2002	BOB RUNYON, Engineering Consultant, Roanoke, VA 24019
2003	BRIAN HATHAWAY, Consultant, Port Orange, FL 32129
2004	BILL LECHNER, Retired, Sr Genl Foreman-Insourcing-Air Brakes, Governors & Injectors, Norfolk Southern Corp, Altoona, PA 16601
2005	TAD VOLKMANN, Director-Mech. Engrg., Union Pacific RR, Omaha, NE 68179
2006	BRUCE KEHE, Retired, Sr. Mech. Supvr-CN Rwy, Westville, IN 46391
2007	LES WHITE, Applications Specialist, Bach-Simpson, London, Ontario N6A 4L6
2008	MIKE SCARINGE, Director-Locomotives, Amtrak, Beech Grove, IN 46109
2009	DENNIS NOTT, Northwestern Consulting, Boise, ID 83703

Our Officers

Our President

MR. BOB REYNOLDS

Sales Manager

Amglo Kemlite Laboratories

Calgary, Alberta T2Y 2V8

Our Chairman of the Nominating Committee

MR. DENNIS NOTT

Northwestern Consulting, LLC

Boise, ID 83703

Our Officers

1st Vice President

MR. JACK KUHNS

Senior Director Business Development and Sales

Graham White Manufacturing
Jacksonville, FL 32259

2nd Vice President

MR. GLENN BOWEN

Director - Laboratory & Testing Svcs.

BNSF Railway
Topeka, KS

3rd Vice President

MR. RON BARTELS

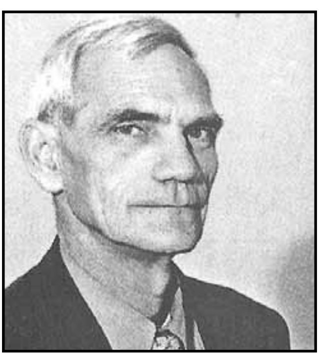
Director Electrical Systems

Via Rail-Canada
Montreal, Quebec

Our Past Presidents

MR. MARK COLES
Senior Manger
Engineering & Quality
Union Pacific Railroad
Omaha, NE 68179

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



MR. BRIAN HATHAWAY
Consultant
Port Orange, FL 32129

MR. BRUCE KEHE
Retired
Canadian National Rwy.
Westville, IN 46391

Our Past Presidents

MR. RONALD R. LODOWSKI
Production Manger
CSX Transportation
Selkirk, NY 12158

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

MR. MIKE SCARINGE
Director -Locomotives
Amtrak
Beech Grove, IN 46107

Our Past Presidents

MR. LES WHITE
Application Specialist
Bach Simpson
London, Ontario
N6A 4L6

MR. TAD VOLKMANN
Director -Mechanical Engineering
Union Pacific Railroad
Omaha, NE 68179

Our Regional Executives

STUART OLSON
Regional Sales Manger
Wabtec Corporation
Alpharetta, GA

MR. BOB HARVILLA
Asst. VP - Regional Sales
Power Rail Distribution
Medina, OH

MR. TOM PYZIAK
Senior Account Executive
Safety-Kleen Systems
Palatine, IL

R. BRAD QUEEN
Mgr-Mech Svc Excellence
BNSF Railway
Barstow, CA

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

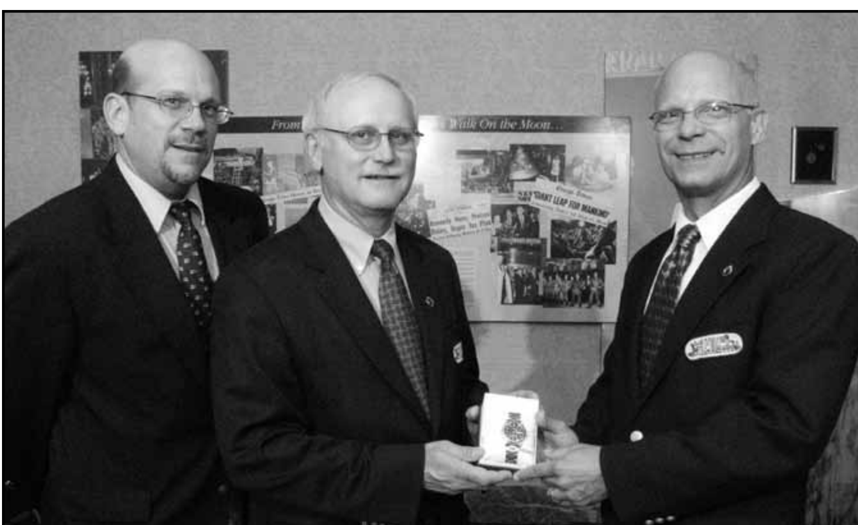
Picture of 2009 Past President's Pin which was given to outgoing President Dennis Nott

Picture of Past President's Watch

LMOA Executive Board – Seated left to right – Past President Bruce Kehe, retired CN, Past President Tad Volkmann, Union Pacific, outgoing President Dennis Nott, Northwestern Consulting – standing left to right – Secretary Treasurer Ron Pondel, Past President Les White, Bach Simpson, newly elected President Bob Reynolds, Amglo Kemlite, newly elected 2nd VP Glenn Bowen, BNSF

Outgoing President Dennis Nott presenting gavel to newly elected President Bob Reynolds – ceremony witnessed by Past President Tad Volkmann

Newly elected President Bob Reynolds (center) presenting Past President's Pin to outgoing President Dennis Nott – newly elected 2nd VP Glenn Bowen looks on



Past President Tad Volkmann (right) presents Past President's Watch to outgoing President Dennis Nott – Past President Bruce Kehe attended the ceremony

Past President Les White (right) puts LMOA blazer on newly elected 3rd VP Ron Bartels, Via Rail – newly elected President Bob Reynolds observes

2009 State of the Union Address

Dennis Nott

Ladies and gentlemen, fellow LMOA Committee Members: Thank you for attending the 2009 Locomotive Maintenance Officers Association Technical Sessions.

This past year has been a roller coaster ride. We had a good turnout for the 2008 Technical Sessions and then the bottom seemed to drop out of the economy. Despite the drop in the economy participation by the Committees remained strong with good attendance at Committee meetings and there was more use of conference calls and Emails to conduct Committee business. Despite the recession and drop in railroad business all six of the LMOA Committees appear to be weathering the storm well.

In April of 2009 the LMOA again participated in the American Short Line Regional Railroad Association National (ASLRRA) Convention. The ASLRRA Convention was held in Las Vegas and all six of the LMOA Committees presented papers at that Convention. The LMOA would like to thank all of the ASLRRA for letting the LMOA to make these presentations. I would like to also thank all of the LMOA members that made presentations at the ASLRRA for their effort to participate in this event. One presentation, on alignment control couplers, was made at the request of the ASLRRA.

I would also like to note that the ASLRRA published a LMOA paper in their monthly Newsletter this past year. The paper was on the new FRA Horn testing requirements and was originally presented by Mr. Jeff Cutright of Norfolk Southern at the 2008 Technical Sessions.

The LMOA recognizes the short line and regional railroads as an important and growing segment of the railroad industry and will continue to develop the relationship with the ASLRRA. In addition, the LMOA will continue to develop technical papers that reflect the needs of the short line and regional railroads. I would also like to note that there are several LMOA Committee members who have roots in the short line and regional railroads; their commitment and participation at the Committee level is greatly appreciated.

In May of 2009 the LMOA held its annual Joint Committee Sessions in Altoona, PA. A big thanks goes out to the Norfolk and Southern for hosting the event and providing the meeting rooms and a great tour of their Juniata Locomotive Facility. Another thank you goes out to Metro East Industries and Helm Financial Corporation for hosting the lunches for the Joint Sessions. My final thank you goes out to 1st VP Bob Reynolds for doing an excellent job of organizing this year's Joint Session.

Despite the economy the attendance at the Joint Session was good with about 50 Committee Members in attendance. The meetings were very productive and all the preliminary presentations made were excellent.

The Joint Session was also an opportunity and a pleasure for me to do something I had not done before; present an MVP award to one of our esteemed Committee Members. Typically the MVP awards are forwarded to the supervisor of the honored MVP for presentation in the work place; hoever, in this case Mr. Bill Peterman of the Shops Committee is a "one man show" and we could hardly let him present it to himself. I made the award to Bill with the appropriate amount of teasing, but as always, Bill got the last laugh when he thanked me for providing the box the MVP award came in so he could "re-gift" it.

There was another high point for the LMOA in late July of this year. As you are aware, the current recession has resulted in many locomotives going into storage until business levels return. Many of these locomotives were put into storage without any preparation. Recognizing this, the Class 1 Chief Mechanical officers requested that the LMOA investigate the storage of locomotives and develop recommendations as to what should be done to store locomotives and what needs to be done to return them to service. The response to the LMOA was immediate. Three Committees of the LMOA have prepared presentations in less than two months to be presented during these technical Sessions. Obviously two months is probably not enough time to do a complete analysis of the storage issue and the LMOA plans to formalize a complete response to the Class 1's at the beginning of 2010 with formal presentation and publication of the LMOA response to everyone at next year's Technical Sessions.

Speaking of next year's Technical Sessions, the Railway Supply Institute has recently informed the Four Coordinated Committees that next year's session in Chicago have been cancelled because of the economy. The LMOA has formed an internal Committee to address the issue and this Committee is currently working with the other three Coordinated Committees to develop an alternate site and venue for next year. Please stay tuned as it is the goal of LMOA to see to it that Technical Session will be held in 2010.

As far as 2011 is concerned the RSI is still planning to support the four Coordinated Committees at the 2011 show in Minneapolis, MN. As previously reported, this event will be conducted in conjunction with REMSA and AREMA.

As we go into 2010 the LMOA is still a strong organization but, as you can see, faces challenges regarding next year's technical sessions.

I would like to thank all the employers who sponsor our committee members. Allowing your employees to work on our committees is the ultimate contribution to the success of the LMOA. I also would like to thank all the vendors and railroads that support out organization with meeting rooms, lunches and the opportunities to tour their facilities.

Last I would like to thank everyone in the LMOA for the support I have received this year. A big thank you goes out to my executives: Mr. Bob Reynolds, 1st VP; Mr. Jack Kuhns, 2nd VP; Mr. Glen Bowen, 3rd VP; and the glue that keeps this whole thing together, Mr. Ron Pondel, Secretary-Treasurer.

Thank you.

Acceptance speech

Bob Reynolds

Good morning ladies and gentlemen, LMOA executive committee and fellow members.

I am very proud to accept the position of president of the Locomotive Maintenance Officers Association for 2009-2010. I would like to thank Dennis Nott for his leadership of the LMOA in the past year. Thank you to the LMOA executive committee for their continued support of the LMOA.

The LMOA is an important organization for the railway industry. It is all about railroad people helping railroad people. The education of railroad personnel, presentation skills and networking are three areas that will help members throughout their careers in the industry. The industry benefits greatly through their LMOA members.

I recently retired from the Canadian Pacific Railway and I am thankful for their support of my activities, in the LMOA. I have now joined the supply industry and I would like to thank the Amglo Kemlite Company for supporting my involvement in the LMOA.

The railroad industry is extremely complex. The railway mechanical departments can be comprised of large numbers of peoples, shops, and equipment. To further complicate things, shops can be spread out over wide areas. The technical complexity of locomotives and hence equipment and shop facilities increases more and more as time goes on. A new mechanical employee who begins his or her career has to continually learn a constant stream of new information. Learning from others, results in the opportunity to save time, effort, and money.

Each year the various committees prepare presentations to this audience. The presentation skills that are learned are then used in their work environment to their benefit and that of their companies. The presentations on various subjects are recorded in the annual LMOA book, which is a very useful and valuable reference. The publishing cost of the annual book is paid for by the advertisers. I would like to thank them for making this book possible. I encourage members to patronize them. There is a list of advertisers in the front of the book.

The meetings each committee has during the year are an excellent way to network. We all know that networking is the best way to communicate between people on railways, suppliers, and other organizations. As an example, my old friend Les White, and a past president of LMOA, worked for an arch rival railway company. Les

worked for CN and I worked for CP. They are two major competitors. But through the LMOA we kept in touch to share technical information, discuss problems, issues, etc. In fact, it was Les who suggested that I join the LMOA electrical committee over fifteen years ago. Thanks Les!

Railways are always looking to do things better, safer, more efficiently, and less costly. There are always new methods developed and new improved materials coming out on the market. LMOA members join committees to find out what's going on.

I would like to thank all committee members for their hard work and dedication to equipment that keeps railways moving day and night. I know a lot of work goes into creating presentations that are provided each year. The work is often done, not during regular day jobs, but after hours and on weekends. Keep up the good work; it is most appreciated. Your industry is better for it.

I would like to thank the Chief Mechanical officers for their support of the LMOA. As Dennis Nott mentioned yesterday, you requested a joint document concerning storage of locomotives. LMOA members were quick to address this important matter.

In addition, I'd like to thank suppliers for supporting their employees who are members of the LMOA.

We have a lot of challenges facing us in the industry. The economy seems to be slowly improving and hopefully rail traffic will return to levels we experienced a few years ago. The storage of locomotives is indeed unfortunate, but we know it will end. When it does end, we will be ready to put the power back in service as demanded by our transportation colleagues.

The site of the 2010 convention is questionable at the moment. It may not be in this hotel. It could be in another city. Unfortunately, the RSI has decided to cancel their involvement in next year's convention. We are working with other Coordinate Mechanical Associations to have a convention next year. We believe it is imperative to have continuity in the important technical work of all our committees.

I would like to thank all of the suppliers and railways that host meetings during the year and support all of the various committees.

In closing, I would like to thank my wonderful wife Mary and my fine son Andrew, who are here this morning, for all of their support over the years.

I would like to thank Ron Pondel, our secretary treasurer, for all of his dedication to the LMOA.

I am looking forward to an exciting year ahead. Thank you and best of luck in the future.

Report on the Committee on New Technologies

Monday, October 18, 2010

9:00 A.M.

Chairman

Jim Christoff
Traction Business Manager
Morgan AM&T/National
Cicero, NY

Vice Chairman
Vacant

Commitee Members

D Brabb	Director-Business Development	Sharma Associates	Countryside, IL
D Brooks	Engineering Manager	ZTR Control Systems	London, Ontario
J Clapper	Asst. Supt-Motive Power	Wheeling & Lake Erie RR	Brewster, OH
W. Durham	Program Dir-Capital Equipment	Amtrak	Philadelphia, PA
B Kehe	Retired	CN Rail	Gary, IN
T. Mack	VP-Sales & Business Development	Motive Power & Equipment Solutions	Greenville, SC
A. Miller	President	Vehicle Products LLC	Golden, CO
C. Nordhues	National Sales Exec	JR Corman-Railpower	Erie, PA
C. Prudian	Senior Systems Engineer	Electro Motive Diesels Inc	LaGrange, IL
C. Riley	Marketing Director	Cummins, Inc	Columbus, OH
D. Sweatt	Director-Telecommunications-PTC	CSX Transportation	Jacksonville, FL
T. Volkmann	Dir-Mech-Engrg	Union Pacific RR	Omaha, NE
J. Whitmer	Loco. Rel. Specialist	CN Rail	Homewood, IL
B. Wolff	Sales Engineer-Rail	MTU Detroit Diesel	Detroit, MI

Note: Tad Volkmann and Bruce Kehe are Past Presidents of LOMA
David Brooks, Jeff Clapper and William Durham are recent additions to the committee
Randy Nelson will be replacing Mr. Riley as the Cummins' representative on this committtee

PERSONAL HISTORY

Jim Christoff

Traction Business Manager
Morgan AM&T/National
Cicero, NY

Jim who was raised in Western Pennsylvania now finds himself in Cicero, NY. His 25 plus years in the carbon business have given him a broad knowledge of DC rotating equipment and an understanding of the operating conditions and environments that are present in railroad freight and passenger service.

Jim has worked for Morgan Crucible plc (parent company or Morgan AM&T/National) for 20 years. From 1989 thru 2001 he handled the East Coast Transit, Industrial, and Consumer Business. In 2002 he started working exclusively on Transit, Traction business and in 2005 he was promoted to Traction Business Manager.

Jim and his wife Diane have 2 children and 2 grandchildren. When work is done they enjoy boating, golfing, and visiting their children.

The New Technologies Committee would like to thank Electro Motive Diesels for hosting their committee meeting at LaGrange, IL on Thursday, November 19, 2009, and for providing the Coffee break and luncheon; and to Morgan AM&T/National for hosting the dinner on Wednesday, November 18th.

The committee held a webcast/conference call on Monday, January 13, 2010.

On March 16, 2010 the committee held a meeting in Golden CO, which was graciously hosted by Vehicle Projects, Inc—dinner on Monday, March 15th was also provided by Vehicle Projects and fellow Committee member, Dr. Arnold Miller. We truly appreciate their hospitality.

Tier 4 Diesel Emission Reduction Strategies

Prepared by
Bruce Wolff
MTU Detroit Diesel, Inc.

Introduction

This presentation is intended to provide an overview of technologies that contribute to reducing diesel exhaust emissions to the levels mandated in the EPA Tier 4 locomotive emission regulations. It also begins with a description of the composition of diesel exhaust, and a brief summary of the EPA locomotive emission regulations.

Composition of Diesel Exhaust

Diesel exhaust is the result of burning diesel fuel and air under the high pressures and temperatures present inside the cylinder of a diesel engine. For a typical pre-regulatory engine, the principal components of diesel exhaust (by volume) are:

- N_2 - 74.1%
- O_2 - 8.8%
- H_2O - 8.6%
- CO_2 - 7.5%
- Ar - 0.87%
- Pollutants - approx. 0.13%

Aside from the pollutants - and CO^2, to be discussed below - these gases are completely harmless. In fact, they are naturally occurring in Earth's atmosphere in more-or-less similar proportions:

- N_2 - 78%
- O_2 - 21%
- H_2O - varies (typically ~ 1%)
- Ar - 0.93%
- CO_2 - 0.04%

The decreased oxygen (O_2) in diesel exhaust - and the increased water (H_2O) and carbon dioxide (CO_2) - are due to the oxygen in the air reacting with hydrogen and carbon in diesel fuel during combustion in the engine cylinder.

A quick note on carbon dioxide: It is considered a greenhouse gas, and is believed by some to be a significant contributor to possible global warming. However, it is not among the pollutants regulated by the EPA locomotive emission regulations. In fact, some technologies to meet these emission regulations actually cause increased carbon dioxide emissions, through increased fuel consumption. Because carbon dioxide is not a pollutant regulated by the EPA locomotive emission regulations, any further discussion is outside the scope of this presentation.

The pollutants governed by the EPA regulations fall within the 0.13% of the typical diesel emissions mentioned above. These pollutants contribute to localized air quality problems. Their proportions, by volume, in typical pre-regulatory diesel emissions, are:

- NO_x - 0.1%

TreadGuard® Brake Shoes cover a lot of ground.

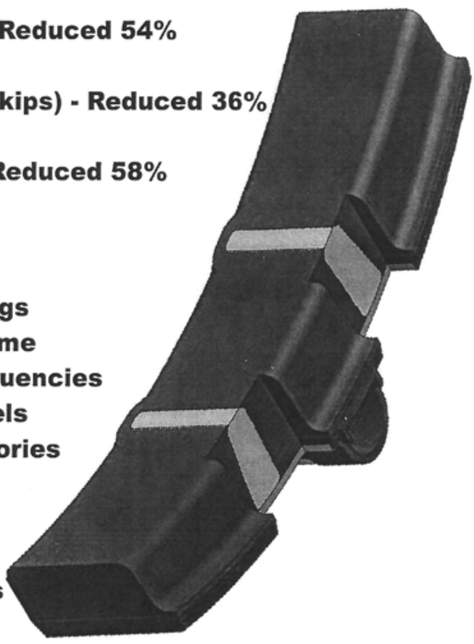
LOCOMOTIVE TREADGUARD® BRAKE SHOES

16 Month Field Test Results

Out of Service Time—Reduced 54%

High Impact Frequency (>90 kips) - Reduced 36%

Wheelset Turnings—Reduced 58%



BENEFITS:

- Reduces Wheel Set Turnings
- Reduces Out of Service Time
- Reduces High Impact Frequencies
- Prolong Life Cycle of Wheels
- Reduces Wheel Set Inventories
- Increased Shoe Life
- Direct Replacement for Standard High Friction Locomotive Brake Shoes

Railroad Friction Products Corporation
PO Box 1349
Laurinburg, NC 28353
910-844-9700
cobrabrakeshoes@rfpc.com
www.rfpc.com

Registered Firm: ISO 9001-2008
AAR M-1003

- CO - 0.02%
- HC - 0.01%
- PM - 0.001%

NOx - or nitrogen oxides - result from nitrogen (N_2) reacting with oxygen (O_2). While nitrogen is normally quite stable, the high temperatures inside a diesel engine cylinder cause it to react with oxygen. The simplest way to reduce NO_x formation is to reduce in-cylinder temperatures. However, this can also decrease the efficiency of the engine, resulting in reduced power and increased fuel consumption.

Carbon monoxide (CO), unburned hydrocarbons (HC) and diesel particulate matter (PM) result from incomplete combustion of the fuel. CO is formed when insufficient oxygen is present at a specific molecule for it to form the more preferable carbon dioxide. HC is leftover portions of diesel fuel molecules that do not burn, typically due to localized low-temperature regions in the cylinder. Finally, PM consists of microscopic particles of soot, or carbon, from diesel fuel that does not fully react with oxygen to form carbon dioxide. PM also includes ash from the small amount of lubricating oil that slips past the piston rings, and sulfur compounds from sulfur in the diesel fuel (more on this later).

EPA Locomotive Emission Regulations

To reduce the effects of the above-mentioned pollutants, the Environmental Protection Agency has implemented regulations to limit the emission of these pollutants from diesel engines in many applications, including locomotives. The locomotive emission regulations vary with the date of original manufacture of the locomotive (applying retroactively to locomotives built as far back as 1973), and whether the locomotive is a “line haul” or a “switch” locomotive. The EPA distinguishes between “line haul” and “switch” locomotives based on whether or not the total power from all engines aboard the locomotive exceeds 2300 hp. Initial regulations were adopted in 1997, establishing Tier 0, Tier 1 and Tier 2 standards based on the date of original manufacture of the locomotive. Further regulations were adopted in 2008, further tightening the Tier 0, 1 and 2 limits for existing locomotives (applicable when the locomotive is remanufactured) and introducing new Tier 3 and 4 limits for locomotives to be built starting in 2011 / 2012 (Tier 3) and 2015 (Tier 4). A brief summary of the locomotive emission standards is given in Tables 1 and 2. More detail is available in the presentation “EPA Emission Requirements for Locomotives” by Chuck Moulis, John C. Hedrick and Ted E. Stewart P.E., presented at the 70th Annual Meeting of the LMOA in 2008. The full regulations themselves are available on the EPA website at http://www.epa.gov/otaq/locomotives.htm. (Nothing in this paper is to be construed as supplanting or replacing the EPA regulations. In the case of a conflict, the regulations govern.)

Engine-Based Emission Reduction

Up to and including the current Tier 2 standards, engine manufacturers have met emission limits by implementing changes within the engine itself. The following sections describe a sample of such engine-based technologies.

High-Pressure Common Rail Fuel Injection

Combustion in a diesel engine takes place when fuel is injected at high pressure into the hot, dense air that has been compressed by the piston in the cylinder. Traditionally, the fuel has been pressurized for injection by individual cam-driven pumps for each cylinder. This results in the injection pressure gradually building up and falling off during the injection event. Lower fuel pressures at the beginning and end of injection can cause incomplete atomization of the fuel spray, forming large droplets that lead to oxygen-poor regions in combustion. This increases PM, CO and HC emissions.

A technology that has been successfully implemented in several engines is high-pressure common rail injection. In this system, a single high pressure pump pressurizes fuel to maintain the optimum injection pressure for all cylinders. This fuel is then delivered to the cylinders by a common pipe, or "common rail", that connects all the injector nozzles to the high pressure fuel pump. This system ensures that full fuel pressure is available from the beginning of injection right through to the end, resulting in improved atomization and more complete combustion. In addition, electronic control of the injector nozzles allows the possibility of injecting a small amount of fuel before the main injection, to reduce noise, as well as post-injection of fuel to help further reduce emissions. The latter can be used in conjunction with possible aftertreatment devices (to be discussed later).

Combustion Development

As well as increased fuel injection pressure, engine manufacturers have made great improvements in the combustion process inside the cylinder to reduce emissions, increase power and reduce fuel consumption. These improvements have included:

- Optimizing the combustion chamber size and shape through piston crown shaping and designing the optimum compression ratio, to improve interaction between air and fuel during combustion,
- Electronic fuel injection control to optimize injection timing and pressure based on engine speed and load, and
- Valve and head design to minimize restriction to intake air (on a four-cycle engine) and exhaust flow.

Unfortunately, some of these changes can lead to reduction of NO_x emissions at the cost of increasing PM, or vice versa.

Turbocharging and Aftercooling

Turbocharging increases the amount of air entering the cylinder. This leads to increased power by increasing the amount of fuel that can be burned in each combustion cycle. However, the air heats up as it is compressed by the turbocharger, leading to increased NO_x emissions.

The increased air temperature can be mitigated by cooling the intake air after it leaves the turbocharger, and before it enters the cylinder. Charge air coolers have been incorporated which use the engine coolant, a separate low-temperature coolant circuit, or air-to-air cooling using ambient air drawn from outside the locomotive, to cool the compressed air. Cooling the intake air combines the benefits of high-pressure air for increased power, with lower intake air temperature for reduced NO_x emissions.

Another development is multiple-stage turbocharging, with charge air cooling after each stage of turbocharging. Used in, for example, MTU's next generation of engines for surface mining, this system could also be applied to locomotive engines.

Miller Cycle

The Miller Cycle is a modification of valve timing on a four-cycle engine to reduce peak cylinder temperatures. This leads in turn to a reduction of NO_x emissions.

In the Miller Cycle, the intake valve is left open until partway through the intake stroke, expelling some of the intake air and reducing the temperature rise during compression. Effective supercharging is required to maintain the ability to produce torque at low engine speeds.

Examples of locomotive engines using variations on the Miller Cycle include EMD's two-cycle engines, including the current 710ECO, and MTU's Series 4000 R43. In the two-cycle engine, the intake ports in the cylinder wall remain uncovered until partway through the compression stroke. In MTU's Series 4000 R43, the intake valve is closed early, rather than being left open partway through the compression stroke.

Exhaust Gas Recirculation

Exhaust gas recirculation (EGR) is another technique used to reduce NO_x emissions by reducing peak cylinder temperatures. With EGR, a controlled amount of exhaust gas from one or more "donor" cylinders are diverted from the exhaust stream, cooled in an EGR cooler, and mixed with the intake air before entering the cylinders. The higher specific heat capacity of the water and carbon dioxide in the exhaust gas limits the temperature rise during combustion.

There are a few drawbacks to EGR. Presence of exhaust gas in the cylinder leads to increased PM emissions, often requiring a diesel particulate filter (see below). An EGR-equipped engine can have less power and lower fuel efficiency than an equivalent non-EGR engine. And finally, the presence of sulfur in diesel fuel causes sulfuric acid to form when the exhaust is cooled, leading to corrosion and premature failure of the EGR cooler. This last problem has largely been prevented through the requirement for only ULSD (Ultra-Low Sulfur Diesel, with no more than 15 parts per million sulfur content) to be used for locomotives by the time the Tier 4 standards come into effect in 2015.

Homogeneous Charge Compression Ignition

Homogeneous Charge Compression Ignition consists of injecting fuel into the cylinder early in the compression stroke, so that the fuel and air become well mixed as the piston approaches top dead center. Once the temperature and pressure are high enough, combustion ignites spontaneously throughout the fuel-air mixture. The lack of localized high-temperature zones and oxygen-poor regions during combustion leads to greatly reduced NO_x and PM formation. However, it is extremely challenging to control the fuel injection amount for engine speed, load and temperature to achieve the desired ignition timing and to control the engine operation. Although this technology is under development and testing, it is not yet available commercially.

Aftertreatment-Based Emission Reduction

The Tier 4 standards are intended to reduce locomotive engine emissions below what can be achieved strictly by engine-based emission reduction technologies. In order to meet these standards, some form of aftertreatment is likely to be required. The term aftertreatment describes any device in the exhaust stream after the engine, whose purpose is to remove or neutralize pollutants in the exhaust stream.

In general, the cleaner the exhaust leaving the engine, the less aftertreatment is required. This can reduce the volume needed to house the aftertreatment in the tight confines of a locomotive. However, effective aftertreatment can allow the engine to operate in a more fuel efficient—but more polluting—configuration. Choosing the right balance between on-engine exhaust reduction and exhaust aftertreatment is a challenge for engine and locomotive manufacturers.

Diesel Oxidation Catalyst

A diesel oxidation catalyst (DOC) is a passive catalyst chamber inserted into the exhaust stream. It can be used downstream of the turbocharger, or in some engines, in the exhaust manifold between the cylinder heads and the turbocharger. As exhaust passes over the catalyst, CO and HC react with remaining oxygen to form CO_2 and H_2O. DOC can be very effective at reducing CO and HC. It also has a small effect at reducing PM, but is generally not effective at reducing NO_x.

DOC can be used to condition the exhaust to enhance the function of further downstream aftertreatment. Because the oxidation reactions increase the exhaust temperature, controlled amounts of fuel can be injected into the exhaust upstream of the DOC (or added through post-injection in an electronically-controlled common-rail fuel system) for the specific purpose of raising the exhaust temperature to a level that maximizes the reaction rate in other aftertreatment devices further along the exhaust system.

Diesel Particulate Filter

As its name implies, a diesel particulate filter (DPF) acts as a filter to remove particulate matter from the exhaust stream. Based on its design, a DPF can remove anywhere from 50% to 85% or more of the PM from the exhaust. However, the higher PM removal comes with an increased backpressure, leading to increased fuel consumption in the engine.

As the PM builds up in the DPF, the backpressure increases. If allowed to accumulate, the backpressure would soon reach a level where the engine could no longer operate. In order to keep the backpressure within limits, the DPF must be "regenerated" by burning off the PM and turning it into CO_2.

To regenerate, the DPF must reach a relatively high temperature and remain there for several minutes (depending on the amount of PM to be burned off). The use of a catalyst "washcoat" on the filter medium can reduce the temperature needed for regeneration. If the engine's load profile is high enough — for example, a locomotive in line-haul service—the engine's exhaust temperature is often high enough to cause DPF regeneration. On the other hand, an engine whose exhaust temperature is mostly too cold for regeneration—for example, a switcher—must use other means to raise the exhaust temperature. This could involve injecting diesel fuel upstream of a DOC. However, if the exhaust is too cold, even this will not be effective, as the liquid fuel would pass through the DOC without reacting. In this case, a fuel-fired burner upstream of the DPF, or an electric heating element within the DPF, may be required.

Generally, a DPF that can regenerate strictly from the high temperature of the exhaust is called a "passive DPF", while a DPF with a burner or electric heater is an "active DPF". The choice of the type and size of DPF depends not only on the emission characteristics of the engine, but also on a good understanding of how the engine will be used and what exhaust temperature can be expected.

A DPF can be plugged not only by PM, but also by ash coming from engine lubricating oil burned in the cylinder. Minimizing oil consumption and selecting a low-ash oil can help prolong the filter element life. Even so, periodic removal and cleaning of the filter element will be required. Depending on many factors, this cleaning interval may be semi-annual, annual or biennial.

Selective Catalytic Reduction

While HC, CO and ultimately PM are removed through an <u>oxidation</u> reaction, a <u>reduction</u> reaction is needed to convert NO_x back to harmless nitrogen (N_2) gas. In the oxygen-poor exhaust from a spark-ignition engine, this can be accomplished by a passive "three-way" catalyst. However, in the relatively oxygen-rich exhaust of a diesel engine, another strategy is used: Selective catalytic reduction (SCR).

In SCR, an additional fluid is added to the exhaust as a "reductant". This reductant is then mixed with the exhaust, before entering the SCR's catalyst chamber. There, the reductant reacts with the NO_x to convert it to N_2. In existing mobile diesel engine applications, an aqueous solution of urea (commonly known as diesel emission fluid, or DEF, or in Europe as "Ad-

Blue") is used as the reductant. While mixing with the hot exhaust, the DEF breaks down into ammonia, which in turn reacts in the SCR chamber to reduce the NO_x. The amount of DEF injected must be carefully controlled based on the engine's operation (load, speed, temperature, etc.) to maximize the reduction of NO_x, and to minimize the release of unreacted ammonia from the SCR. This "ammonia slip" is also prevented by using a "slip catalyst" to convert any remaining ammonia into harmless N_2 and H_2O.

The use of DEF in SCR requires procuring, storing, dispensing and carrying onboard the locomotive another fluid besides those already used. Typically, an SCR-equipped locomotive can expect to use between 5% and 10% as much DEF as it does diesel fuel. An alternative being developed uses hydrocarbons such as diesel fuel as the reductant, rather than DEF. This avoids the infrastructure needed to support a separate fluid, though it increases the consumption of diesel fuel aboard the locomotive.

As with some other catalyst-based systems, SCR can be "poisoned" by sulfur in the fuel. This means that sulfur compounds in the exhaust attach permanently to the catalyst, eliminating its ability to reduce NO_x. This is another reason why only ULSD (Ultra-Low Sulfur Diesel) can be used in most if not all locomotives designed to meet the Tier 4 emission standards.

Conclusion

Engine and locomotive manufacturers have a wide variety of technologies available to meet the EPA's upcoming Tier 4 locomotive emission standards. When selecting which products are best suited to your railroad, be sure to speak with your locomotive, engine and aftertreatment suppliers. It is critical to gain a solid understanding of their emission-reduction strategies, and their impact on your operating and maintenance practices.

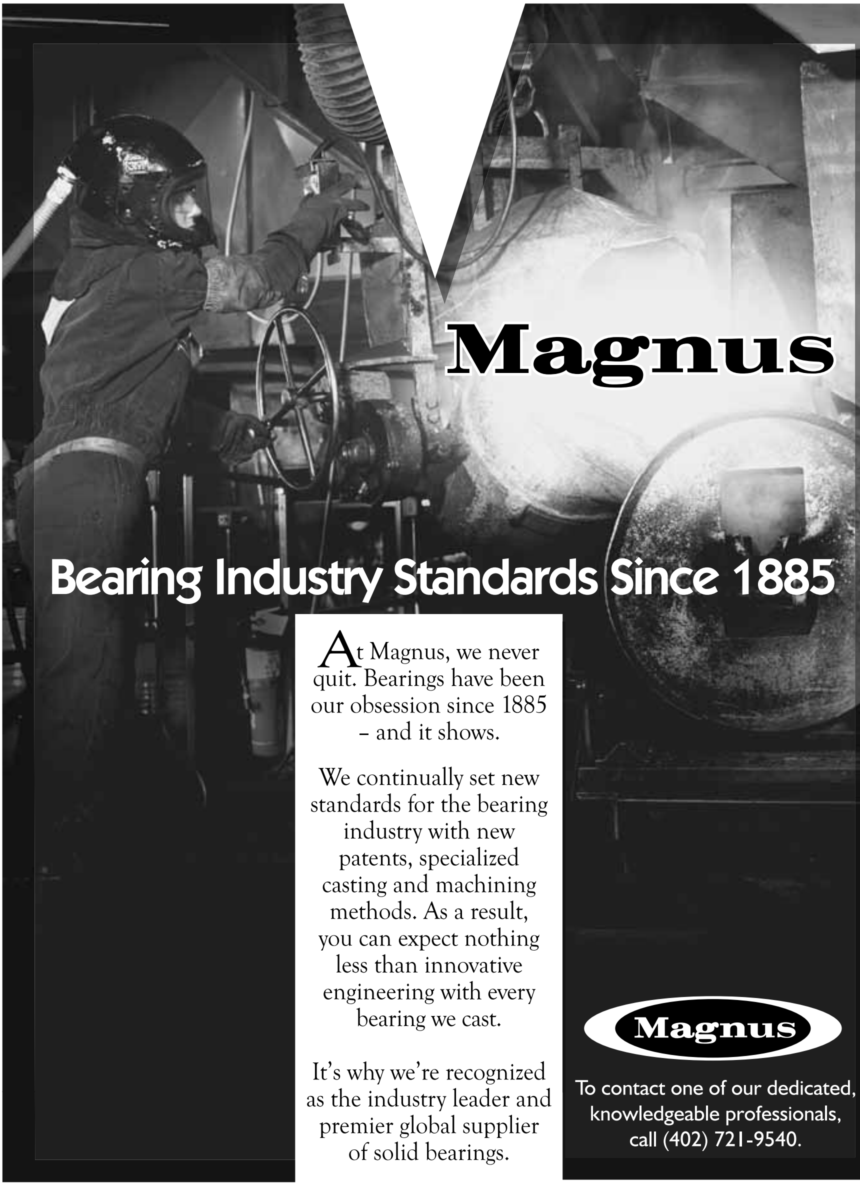
Tables

Table 1: Line-Haul Locomotive Emission Standards					
Year of original manufacture	Tier of standards	Standards (g/bhp-hr)			
		NOx	PM	HC	CO
1973 - 1992a	Tier 0b	8.0	0.22	1.00	5.0
1993a - 2004	Tier 1b	7.4	0.22	0.55	2.2
2005 - 2011	Tier 2b	5.5	e0.10	0.30	1.5
2012 - 2014	Tier 3c	5.5	0.10	0.30	1.5
2015 or later	Tier 4d	1.3	0.03	0.14	1.5

a *Locomotive models that were originally manufactured in model years 1993 through 2001, but that were not originally equipped with a separate coolant system for intake air are subject to the Tier 0 rather than the Tier 1 standards.*
b *Line-haul locomotives subject to the Tier 0 through Tier 2 emission standards must also meet switch standards of the same tier.*
c *Tier 3 line-haul locomotives must also meet Tier 2 switch standards.*
d *Manufacturers may elect to meet a combined NOX+HC standard of 1.4 g/bhp-hr instead of the otherwise applicable Tier 4 NOX and HC standards, as described in paragraph (j) of this section.*
e *The PM standard for newly remanufactured Tier 2 line-haul locomotives is 0.20 g/bhp-hr until January 1, 2013, except as specified in 40 CFR 1033.150(a)*

Table 2: Switch Locomotive Emission Standards					
Year of original manufacture	Tier of standards	Standards (g/bhp-hr)			
		NOx	PM	HC	CO
1973 - 2001	Tier 0	11.8	0.26	2.10	8.0
2002 - 2004	Tier 1a	11.0	0.26	1.20	2.5
2005 - 2010	Tier 2a	8.1	b0.13	0.60	2.4
2011 - 2014	Tier 3	5.0	0.10	0.60	2.4
2015 or later	Tier 4	c1.3	0.03	c0.14	2.4

a *Switch locomotives subject to the Tier 1 through Tier 2 emission standards must also meet line-haul standards of the same tier.*
b *The PM standard for new Tier 2 switch locomotives is 0.24 g/bhp-hr until January 1, 2013, except as specified in 40 CFR 1033.150(a).*
c *Manufacturers may elect to meet a combined NOX+HC standard of 1.3 g/bhp-hr instead of the otherwise applicable Tier 4 NOX and HC standards, as described in 40 CFR 1033.101(j).*


Magnus
Bearing Industry Standards Since 1885
At Magnus, we never quit. Bearings have been our obsession since 1885 – and it shows.
We continually set new standards for the bearing industry with new patents, specialized casting and machining methods. As a result, you can expect nothing less than innovative engineering with every bearing we cast.
It's why we're recognized as the industry leader and premier global supplier of solid bearings.
Magnus
To contact one of our dedicated, knowledgeable professionals, call (402) 721-9540.

Testing of the BNSF Fuel-Cell Switch Locomotive: Part 2

Prepared by Arnold R. Miller,[1,2] Kris S. Hess,[2] Timothy L. Erickson,[2] and James L. Dippo,[2] and Tom, Lambrecht[3]

[2] *Vehicle Projects Inc, Golden, CO*
[3] *BNSF Railway Company, Ft. Worth, TX*

ABSTRACT

A collaboration of BNSF Railway Company, the US Army Corps of Engineers, and Vehicle Projects Inc has developed and demonstrated a prototype hydrogen-fueled fuel-cell-battery hybrid switch locomotive. The locomotive has successfully completed switching operations at the Commerce and Hobart yards in Los Angeles and vehicle-to-grid operations at a United States military base. At 130 t weight and maximum power of 1.5 MW, the hybrid locomotive is the heaviest and most powerful fuel-cell land vehicle. Prime-mover power is provided by a 300 kW (gross) proton-exchange membrane (PEM) fuel-cell. Its carbon-fiber composite storage tanks, located at the roofline, store 68 kg of compressed-hydrogen at 350 bar. Depending on the duty cycle of the railyard, onboard storage is sufficient for an 8-16 h operational shift. The observed mean thermodynamic efficiency of the powerplant is 51 %. This paper focuses on impact testing, hydrogen fueling, and operational demonstration testing in the switching application in Los Angeles.

INTRODUCTION

Urban air-quality and energy-security issues are related by the fact that about 97 % of the energy for the transport sector in the US is based on oil, and more than 60 % is imported. Because the sector's primary energy derives so predominantly from combustion of fossil fuels, it is one of the largest sources of air pollution, including greenhouse gases. Although rail transportation accounts for a very small percentage of the overall transport sector emissions, a fuel-cell locomotive would exhibit zero emissions from the vehicle. A large fuel-cell vehicle that is environmentally friendly becomes practical to serve as a mobile backup power source, termed "power-to-grid,"

1. Address all inquiries to: Arnold R. Miller: arnold.miller@vehicleprojects.com

For Part 1, See A.R.Miller, K.S. Hess, T.L. Erickson, and J.T. Dippo, "Testing of the BNSF fuelcell switch locomotive: Part 1." In: Proceedings of the Locomotive Maintenance Officers Asociation (LMOA) Annual Meeeting, Chicago, IL 16-18 Septmeber 2009.

Fig. 1. Fuel-cell switch locomotive: This is the largest fuel-cell land vehicle, photographed at a press conference in completed form on 29 June 2009.

for critical infrastructure. Power-to-grid applications include military bases and civilian disaster-relief operations.

A public-private project partnership comprised of Vehicle Projects Inc, BNSF Railway Company, and the U.S. Army Corps of Engineers (through the Engineer Research and Development Center Construction Engineering Research Laboratory, ERDC-CERL) has developed a prototype fuel-cell-powered switch locomotive (see Fig. 1) for urban rail applications. This prototype is intended to evaluate the feasibility of this technology to determine if it can, in certain applications (a) reduce air and noise pollution in urban railyards, (b) increase energy security of the rail transport system by using a fuel, hydrogen, whose supply is independent of imported oil, (c) reduce atmospheric greenhouse-gas emissions, and (d) serve as a mobile backup power source for critical infrastructure on military bases and for civilian disaster relief efforts.

At 130 t weight and maximum power of 1.5 MW, the hybrid locomotive is the heaviest and most powerful fuel-cell land vehicle yet built. Prime-mover power is provided by a 300 kW (gross) proton-exchange membrane (PEM) fuel cell. Lead acid batteries provide energy storage and peak power shaving. Hydrogen storage employs fourteen lightweight carbon-fiber composite tanks located at the roofline. Fig. 2 shows the fuel-cell prime mover installed in the locomotive. Previous papers have discussed the theory [1-3] and engineering design [4-6] of the hybrid locomotive. While the fuel-cell locomotive is the largest and possibly the most sophisticated fuel-cell land vehicle to-date, it is not the first fuel-cell locomotive. The first fuel-cell-powered locomotive was an underground mine locomotive successfully completed and demonstrated in a working gold mine by Vehicle Projects Inc in 2002 [7, 8].

Fig. 2. Locomotive under construction: Right-rear view of the locomotive with installed fuel-cell prime mover shown in the foreground (31 July 2008)

The fuel-cell-hybrid switch locomotive project was initiated to demonstrate that a fuel-cell locomotive is a technically feasible solution to reducing chemical and noise emissions in communities with unique air issues such as Los Angeles. Because of the high population density, and consequent reliance on the automobile for transportation, LA has historically had air-quality problems. It is also the site of the adjacent ports of Long Beach and Los Angeles, the largest seaports in the United States, which contribute to air pollution from ships, trucks, and trains. While switch locomotives account for only about five percent of all rail emissions, they are used in close proximity to some communities surrounding large urban railyards. This demonstration has been completed with successful results.

The locomotive has also completed its power-to-grid demonstration at the US Army Defense Generator and Rail Center located on Hill Air Force Base, Utah. In the demonstration, it was the sole source of power to the heavy-rail repair and rebuild shop. This shop serves as the only shop for the Army's fleet of about 100 switch locomotives, which are located at bases throughout the United States. The rail shop executes all major repairs, including diesel-engine rebuilding, rewinding of traction motors and traction alternators, chassis repair of wrecked locomotives, and body painting.

This paper focuses on operation of traction fuel cells in a low-power, heavy rail switch yard environment. We report results on impact testing, hydrogen fueling in the railyard, and operational testing. Operational data from the Los Angeles railyard show that a fuel-cell locomotive is a technically feasible solution, and by virtue of being a zero-emissions vehicle, has the potential to reduce urban emissions of diesel particulates, nitrogen oxides, and noise.

IMPACT TESTING

Extensive impact testing validated shock isolation design of the fuel cell powerplant, power electronics, cooling module, and hydrogen storage system. The tests were conducted by the Transportation Technology Center in Pueblo, CO. The isolation systems were designed with low natural frequencies, in the range of 3-7 Hz, which minimizes the potential of resonance with on-board equipment and track input frequencies. Relatively soft mounts provide dynamic deflections up to 25 mm and maximizes energy dissipation.

Rail-car coupling typically occurs at 1-3 mph; however, occasionally harder couplings occur and result in extreme forces. Impact tests up to 5 mph, the speed limit in the railyard, were performed repeatedly to measure shock loads at critical equipment. The maximum allowable acceleration in longitudinal, lateral, and vertical directions for the fuel-cell hardware is 3 G. At the maximum impact speed of 5 mph into a braked railcar consist weighing approximately 360 t, the maximum measured acceleration of any of the isolated fuel-cell equipment was 2.5 G. The corresponding structures that were directly mounted to the locomotive frame exceeded 7 G. The actual measured coupler force was 270 t, or 2.1 G at the coupler input.

HYDROGEN FUELING

Hydrogen fuel is stored on board the locomotive as compressed gas. Using fourteen carbon-fiber wrapped aluminum tanks, the complete hydrogen system holds 68 kg of hydrogen gas at a pressure of 350 bar (5100 psi) when the tanks are full. The energy content of one kilogram of hydrogen gas is approximately equal to the energy content of one gallon of diesel fuel.

Figure 3 shows a block diagram of the demonstration project hydrogen fueling station, as well as additional equipment that may be used in a typical installation. The system includes several redundant mechanical and electronic fail safes and pressure reliefs. To fuel the locomotive, the quick connect dispensing nozzle is attached to a fueling panel on either side of the locomotive. For flow to occur, the dispenser fuel supply pressure must exceed the locomotive storage tank gas pressure. When the fuel source pressure is below the locomotive fuel storage pressure, a hydrogen compressor is used to boost the supply pressure. Compressors of various capacities can be used, depending on the required fill rate. Additionally, a buffer tank could be used to store hydrogen gas at higher pressure to decrease compressor flow requirements and/or speed the fill process. A cooling loop is used to cool the gas exiting the compressor before it is supplied to the tanks. Without cooling, the hot gas would cause a final tank pressure above the nominal value of 350 bar, and the

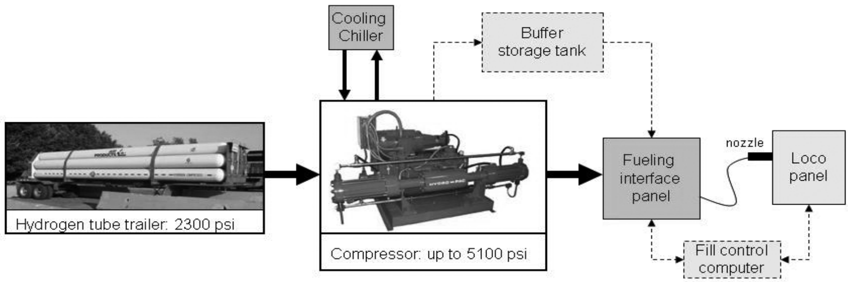


Fig 3: Diagram of fueling system. Features not implemented in the demonstration project are shown in dashed lines (buffer storage and fill control computer).

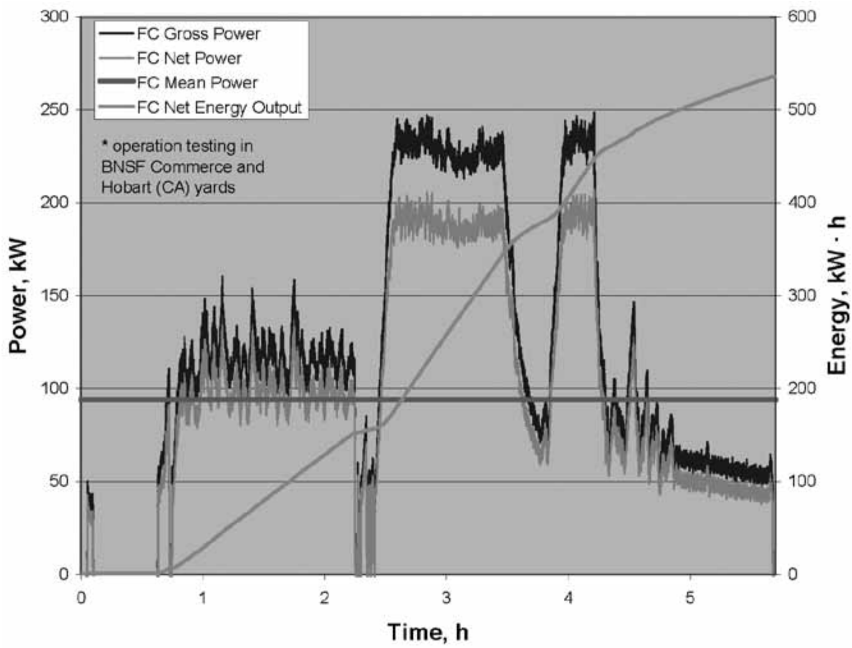


Fig. 4: Empirical duty-cycle segment: Sample of the fuel-cell powerplant power and energy during a 5.7 h shift of work in the Commerce, California, railyard. The vehicle mean power for this specific work was 94 kW. Energy for this work was provided entirely by the fuel-cell prime mover.

extra work to achieve this higher compression would represent an energy-efficiency loss. With a sufficiently large hydrogen pump and active fill control, refueling of the 68 kg system can take place in 15-20 minutes. Although active fill control was not implemented on this project, vehicle tank temperature and pressure can be monitored by a fill station computer to minimize fill time. Computer controlled fueling is common practice in similar automotive and bus applications. A commercial fuel-cell locomotive fueling station would use automated controls and make fueling a hydrogen locomotive no more difficult than fueling a diesel locomotive.

OPERATIONAL TESTING

The fuel-cell locomotive completed several weeks of operational testing at the BNSF Commerce and Hobart yards in the Los Angeles, California, metro area. The locomotive work involved the movement and assembly of flat cars, tank cars, and hoppers within the Commerce yard, as well as a three-mile movement of short consists of 10-30 cars between the Commerce and Hobart yards. The fuel-cell locomotive performed all operational testing as a single-unit locomotive; thus, all work was provided solely by the fuel-cell prime mover. Trains pushed and pulled by the locomotive ranged in weight from 180 to 1600 t, plus additional resistance due to partially-applied air brakes on the entire consist.

Operation of the fuel-cell powerplant is closely monitored, and data for key parameters are logged at one-second intervals. Of particular interest is the mean operating gross and net power levels, associated fuel consumption, and the resulting overall fuel-cell powerplant thermodynamic efficiency. Fig. 4 shows the detail of a typical duty-cycle segment for the fuel-cell powerplant operating under heavy load in the railyard. The fuel-cell operating power level is determined by the hybrid system controller, which determines the power set-point based on throttle position and battery state of charge. Although the fuel-cell modules are capable of 240 kW continuous net power, an unplanned thermal limitation of the DC-to-DC power converter limits continuous net power to 200 kW.

Table 1: Fuel-cell Powerplant Performance

Gross power operating range of fuel-cell stacks	0 – 300 kW
Mean observed net power	87 kW
Mean fuel usage	5.6 kg/h
Useable onboard hydrogen storage @ 20C	63.5 kg
Mean required refueling interval	11.3 h
Balance of plant parasitic losses	17 %
Mean powerplant thermodynamic efficiency	50-51 %

Thermodynamic efficiency is defined as EFC/_GH, where EFC is the net electrical energy produced by the fuel cells during a 1 h time interval, and _GH is the Gibbs free energy of oxidation to gaseous water of the hydrogen fuel consumed during the same time interval. The overall thermodynamic efficiency of the fuel-cell powerplant is calculated as 51 %. This computation is based on the free energy of forming gaseous water output of the fuel cells, the actual chemical output. Though not feasible in our PEM fuel cells, the thermodynamic efficiency would be 50 % if the chemical energy is taken as the free energy of hydrogen oxidation to liquid water.

Table 1 summarizes overall performance data based on preliminary operating data. The observed mean net power requirement of the locomotive is 87 kW. Data was collected during 16 operating days, totaling 56 hours of operation. To maintain this power, actual mean fuel consumption was measured at 5.6 kg/hr. Total usable tank capacity is 63.5 kg at 20 °C, which yields an average mean shift duration of 11.3 hours. Therefore, for this application, daily refueling would likely be required.

The locomotive performed the work well in all respects. The fuel-cell powerplant and associated cooling and fuel systems performed without issue during the repeated couplings to other rail equipment. During all work shifts, the fuel cell-battery hybrid powertrain was successful in providing adequate power to the traction motors. Interface between the train engineer and the locomotive is nearly identical to a conventional locomotive. Training of new operators took only a few minutes, which included an overview of unique circuit breakers, information screens, explanation of safety systems, and discussion of appropriate reaction to possible events. More than five train engineers have operated the fuel-cell locomotive, and all reported an overall positive impression and expressed a consensus that it was pleasant to operate due to the lack of diesel emissions, lack of vibration, and low acoustic noise. The fuel-cell powerplant is virtually silent in the operator's cab, most of the noise being the noise of the steel wheels rolling on the tracks. Several engineers commented favorably on the quick throttle response compared to the turbo-diesel engines they normally operate.

SUMMARY AND CONCLUSIONS

Fuel-cells have never been used in heavy rail applications before this project. Switch locomotives create one of the most severe operational environments due to repeated impacts during coupling. Once the safety and robustness of the locomotive was validated it was then put into a controlled daily service test performing switcher locomotive duties in the BNSF Commerce yard. A temporary hydrogen fueling station was installed at the demonstration location to fuel the locomotive. The following sections expand on impact testing, fueling, and operational testing.

By demonstration of a fuel-cell hybrid switch locomotive in a Los Angeles railyard, we have shown that use of hydrogen fuel cells in a low-power, heavy rail environment is technically practical. The locomotive performed well in all respects and garnered good worker acceptance. The fuel-cell powerplant is virtually silent in the operator's cab, most of the noise being the noise of the steel wheels rolling on the tracks. Locomotive operators commented favorably on the quick throttle response compared to turbo-diesel locomotives. The locomotive routinely pulled trains weighing up to 1600 t.

Fuel-cell rail technology has a potentially significant role in the future of the rail industry. The operational data collected during the demonstration in Los Angeles will be invaluable in the development of future fuel-cell hybrid locomotives. It will assist in modeling their performance to optimize their hybridization and maximize fuel economy and will be useful in modeling subsequent fuel-cell powerplants for use in line-haul and commuter locomotives.

ACKNOWLEDGMENTS

We thank the following funders for their generous support of the work, both mining and rail, mentioned in this paper: US Department of Energy (contracts DE-FC36-99GO10458 and DE-FG36-05GO85049); Natural Resources Canada (Emerging Technologies Program contracts 23440-991022-001); US Department of Defense, Defense Logistics Agency (contracts DAAB07-03-D-B006-0073 [ARINC], W9132T-08-C-0045 [CERL], F42620-00-D0036 and F42620-00-D0028); BNSF Railway Company; the Fuelcell Propulsion Institute; and subcontractors to Vehicle Projects Inc who contributed project cost-share. Disclaimer: Funding support from the US Department of Energy, US Department of Defense, Natural Resources Canada, Government of Canada, or BNSF Railway Company does not constitute an endorsement by same of the views expressed in this paper.

REFERENCES

[1] A. R. Miller, J. Peters, B. E. Smith, and O. A. Velev, Analysis of fuel-cell hybrid locomotives, Journal of Power Sources, 157 (2006), 855-861.

[2] A. R. Miller and J. Peters, Fuel-cell hybrid locomotives: Applications and benefits. Proceedings of the Joint Rail Conference, Atlanta, 6 April 2006.

[3] A. R. Miller, Variable hybridity fuel-cell-battery switcher. Proceedings of Locomotive Maintenance Officers Association conference, Chicago, 19 September 2006.

[4] A. R. Miller, K. S. Hess, D. L. Barnes, and T. L. Erickson, System design of a large fuel-cell hybrid locomotive, Journal of Power Sources, 173 (2007), 935-942.

[5] A. R. Miller, Fuelcell hybrid switcher locomotive: Engineering design. Proceedings of Locomotive Maintenance Officers Association conference, Chicago, 14 September 2007.

[6] K. S. Hess, T. L. Erickson, and A. R. Miller, Maintenance of the BNSF fuelcell-hybrid switch locomotive. Proceedings of Locomotive Maintenance Officers Association conference, Chicago, 22 September 2008.

[7] A. R. Miller, Tunneling and mining applications of fuelcell vehicles. Fuelcells Bulletin, May 2000.

[8] A. R. Miller and D. L. Barnes, Fuelcell locomotives. Proceedings of Fuelcell World, Lucerne, Switzerland, 1-5 July 2002.

Report on the Committee on Shop Equipment and Processes

Monday, October 18, 2010

10:45 A.M.

Chairman

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

Vice Chairman

Tom Stefanski
President
Tom's Locomotive and Cars
Plainfield, IL

Commitee Members

R. Begier	Consultant	Portec Rail Products	Broomfield, CO
R. Collen	Project Mgr.	Simmons Mach. Tool Corp.	Albany, NY
C. Fette	President	TESCO	Erie, PA
D. Louder	Product Manager	Macton Corp.	Mount Airy, MD
J. Morin	Director-Sales	Socofer	Tours Codex, France
M. Scaringe	Dir. Locomotives	Amtrak	Beech Grove, IN
S.G. Smith	Engr. Lean Prod. Systems	Norfolk Southern	Chattanooga, TN

Note: Mike Scaringe is a Past President of LMOA.

PERSONAL HISTORY

Bill Peterman

Bill was born and raised in Galt, Ontario Canada and has worked and lived in various parts of Canada during his railroad career including major stints in Calgary and Montreal where he presently resides. His business career included 25 years with Canadian Pacific Railway and several years with Dominion Bridge in Canada in numerous industrial and facilities engineering positions including various positions in the maintenance facilities and head office. Gained a world of rail experience working in all aspects of service facilities. His railway career began as a Time and Motion Analyst completing his time with the railway as Manager Facilities Engineer.

Currently Bill is President of Peterman Railway Technologies a company specializing in assisting with Rail Maintenance designs, equipment and processes, providing specialized rail maintenance serves and acting as a liaison between railway and non railway entities.

He has been Chairman of the Shop Equipment & Process Committee for several years. Bill lives in Montreal and is married with 5 children and finally has 2 grandchildren.

New Tooling Development -Level Loading, Extended Reach"C" Frame Lifting Device and Manipulator - Under the Hook Load Limiter Alarm

Prepared by,
Eric Watts
Tesco

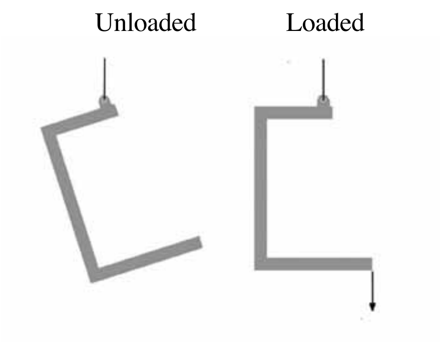
Level Loading "C" Frame Lifting Device and Manipulator

BACKGROUND

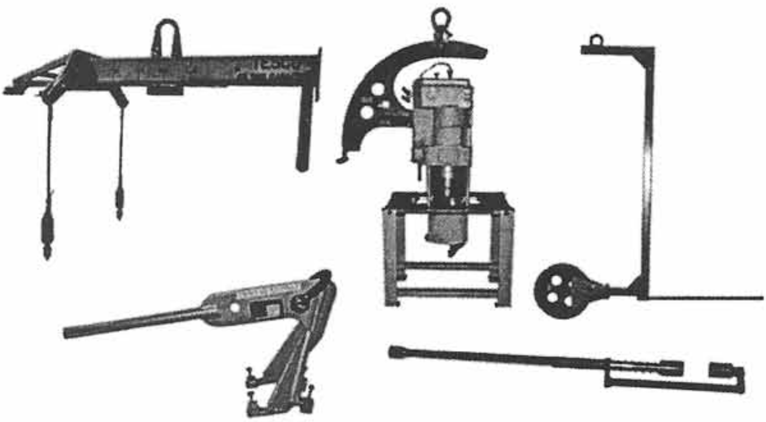
- Removing and installing ancillary components and equipment from within the locomotive carbody can be a challenging prospect due to the close proximity of the equipment, wiring and piping obstacles, and the restricted space of the carbody itself.
- Extended reaches inside the locomotive carbody are often required to reach each piece of equipment
- Smaller pieces of equipment may be lifted and removed using a cantilever style arm, attached to an overhead crane and counterbalanced by hand.
- Larger pieces of equipment have required the use of "C" shaped lifters that extend into the cab and are lifted using overhead cranes.

Current Limitations to Certain "C" Frame Lifting Devices

- In order to remain level when loaded, the design of some "C" shaped lifting devices require the lifting device to be oriented at an angle when entered into the locomotive carbody unloaded. When load is applied, the lifter is level.



- This concept works well for shorter reaches into the locomotive and for removing smaller, lighter components.
- Longer reaches into the locomotive body are often made difficult due to the angle of the unloaded lifter.



- Once the load is removed from this type of lifter, the lifter will then return back to its angled, unloaded position, requiring caution by operators.

Current Limitations to Certain "C" Lifting Devices

- Other "C" style lifting devices utilize two pickup points on the lifter, one for when the lifter is loaded, one for when it is unloaded.
- This type of lifter requires that one pickup point be used to pick up the unloaded lifter and position it so it can be attached to the load. The crane hook is then lowered and repositioned on the second lift point for lifting the load.
- These lifters can only be used in applications where the crane hook can be safely lowered once the lifter is attached to or positioned under the load.

Development of a Level "C" Frame Lifting Device and Manipulator

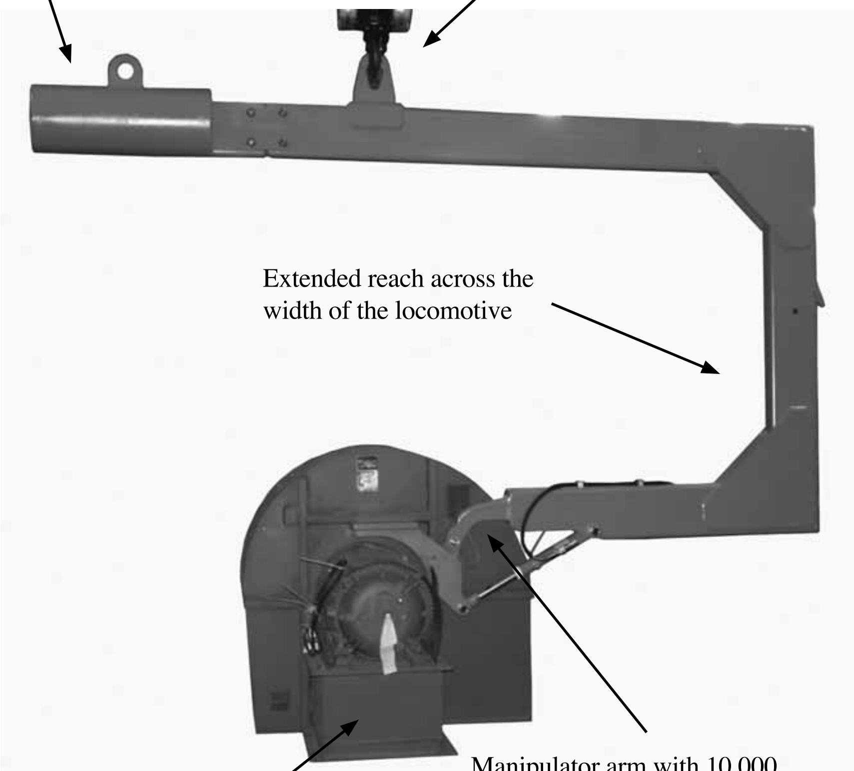
Application

- Removal of traction motor blower from locomotive.
- Space constraints required that the lifting device reach across the entire width of the locomotive carbody to reach the blower motor.
- Additional constraints required the lifting arm to remain level during this reach through the locomotive when accessing the blower motor.
- Once the blower was accessed by the lifter arm, there was limited height in which to lift the blower for removal.

Solution – Extended Reach "C" Frame Manipulator
- Remains Level In Both Loaded and Unloaded State

Counterweight allows lifter to remain level during unloaded state

Single lift point

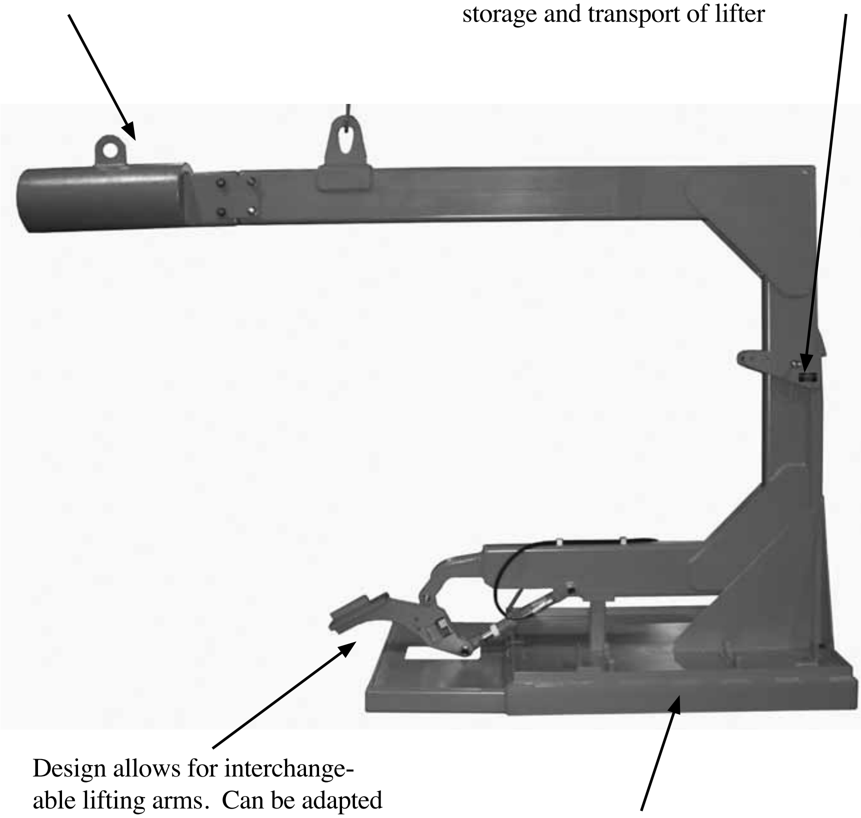


Extended reach across the width of the locomotive

Manipulator arm with 10,000 PSI cylinder and manual pump facilitates lifting of the blower in the tight space requirements

Center of mass of the blower motor is directly below the lift point. No moment is induced on the lifter when the load is lifted

Other Lifter Features

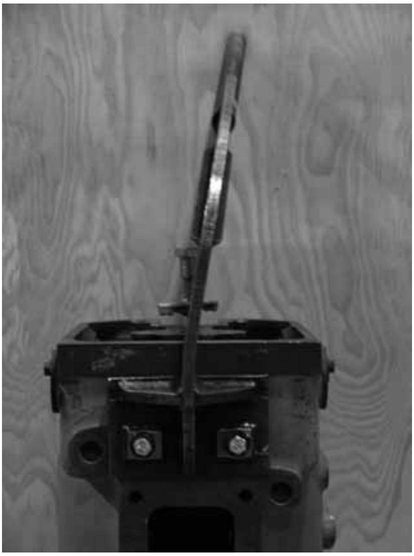


Under the Hook Load Limiter Alarm

Background

- Over the years, there have been instances where lifting devices are damaged while being used due to excessive loading.
- Factors such as failure to remove bolts, components still connected to item being lifted, improper lifting angle combined with large crane sizes can lead to damage as shown below as well as creating serious safety hazards.

Power assembly lifter
Rated Load of 1250 lbs
Proof Tested at 2500 lbs
Load Applied - Unknown



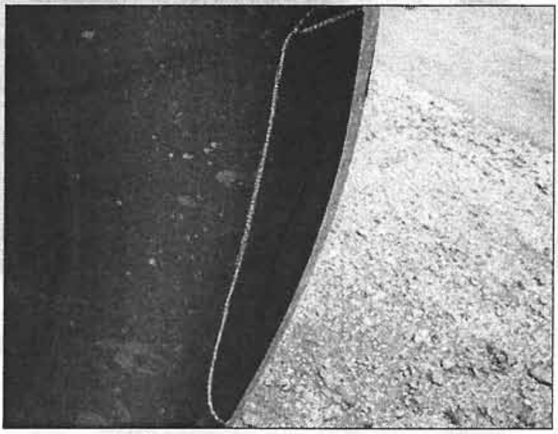
Power assembly lifter
Rated Load of 1050 lbs
Proof Tested at 2100 lbs
Load Applied - Unknown

Under the Hook Load Limiter Alarm

Solution

- The development of a lightweight, compact visual load alarm that can be placed between the crane hook and the lifting device.
- Highly visible flashing LED panels illuminate when pre-set load has been reached.
- Load limit is pre-set based on customer specification.
- This alarm will provide a visual warning to the crane operator prior to lifter damage and potential safety issues occurring during a lift.

Ultrasonic Wheel Inspection



Defect Detected by Dapco

ULTRASONIC WHEEL INSPECTION

- Integrated into existing Wheel Truing Machine or Wheel Lathe

- Inspects wheel sets that are installed on the bogie and/or individual wheel sets.

- Inspect the wheel either before or after the profiling operation (or both).

Meets and Exceeds AAR & Company Specifications

Ultrasonic Inspection of Railway Wheels

Prepared by:
Bob Coakley, Manager, Nordco Inspection Technologies

The Case for Ultrasonic Wheel Inspection (Figure 1)

Broken wheels due to internal cracks are of major concern to railways from both a safety and economic perspective. A broken wheel (missing section) can lead to a derailment or damage up to several miles of track before it is noticed and remedial action taken.

The primary problem for broken wheel failures is caused by internal shattered rim cracks. These are small lamination type defects that run parallel to the running surface of the wheel. They generally initiate at a depth of approximately 1/2" to 3/4", from the running surface.

Traditional means of inspection (Figure 2)

Traditionally, railways relied primarily on manual nondestructive inspection techniques, where wheels (wheel sets) are removed and inspected individually as no technique was yet available to the railroad industry to perform wayside inspections of wheels on a moving train or to inspect wheels without having to remove the wheel (wheel sets) from the train.

The Evolution of Wayside Wheel Inspection

In 1999 the American Association of Railroads (AAR) initiated a research program to detect cracks in railroad freight car wheels using ultrasonic testing methods. Under the direction of the AAR Railway Technology Working Committee, the Transportation Technology Center (TTCI) in Pueblo, Colorado began research and development for this project.

In the spring of 2006, the first Automated Cracked Wheel Detection (ACWD) was commissioned at TTCI. This system ultrasonically inspects railway wheels for possible subsurface cracks and defects on railroad wheels. The Wayside Cracked Wheel Detector is capable of detecting defects in wheels passing over the system at speeds of 5 mph.

In 2008, the Union Pacific Railroad installed an Ultrasonic Cracked Wheel Detector at the Bailey Yard in North Platte, NE (As seen in Figure 3). The ***Union Pacific Cracked Wheel Detector*** represents the latest evolution of the in Wheel System Inspection Technology. In July 2009, this system was featured in *Fast Company* Magazine.

Automated Shop Wheel Inspection

The Automated Shop Wheel Inspection Systems were adapted from the wayside wheel inspection technology deployed at TTCI and at the Union Pacific Railroad.

The Stationary Wheel Inspection system is an off-line application for inspecting rail wheels/wheel sets for possible sub-surface cracks. The system is typically located in a maintenance/wheel shop facility and is capable of inspecting wheels/wheel sets with the wheels installed on the car/bogie or individual wheels/wheel sets.

The automated shop wheel inspection systems can be used as standalone equipment or may be integrated into a wheel truing/profiling machine like the Simmons Stanray underfloor wheel profiling machines (As seen in figure 4).

By directly integrating the ultrasonic wheel inspection system into wheel truing operations, you ultimately save time and reduce operating costs. This type of configuration allows the end user to inspect the wheel either before or after the profiling operation. Having this added feature provides the flexibility needed to find the type of defects that cause broken wheel derailments.

Defect Detection (Figure 5)

The inspection probes are engaged from the tread/running surface of the wheel and the system is capable of detecting shattered rim defects of 0.5" diameter or larger, and Vertical Split Rim defects greater than 1" long and 0.125" deep and tread thermal fatigue cracks of 0.75 " in length and 0.125" deep or larger. For example, the Wayside Wheel System detected approximately a 9 inch shattered rim defect (figure 5).

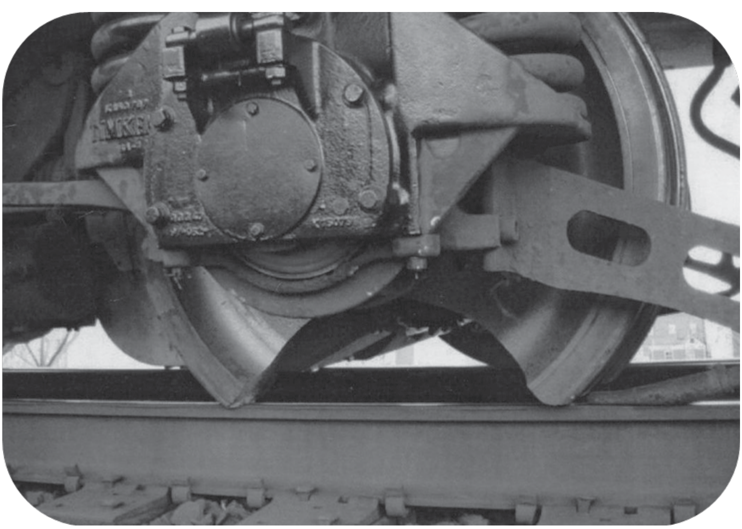


Figure 1

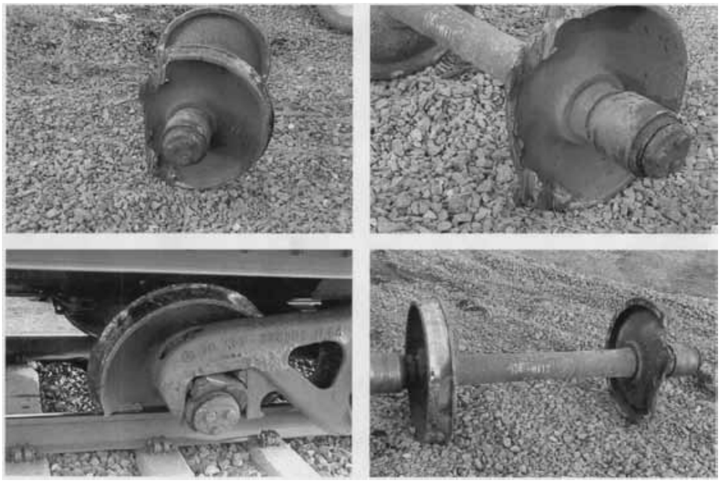


Figure 2

Figure 3

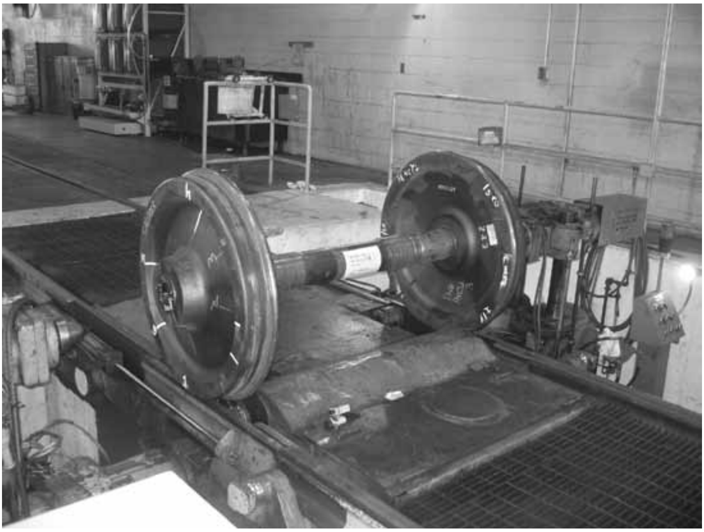


Figure 4

Figure 5

Introducing a Portable yet Affordable Solution for Truing your Locomotive Wheels "Without the need to remove the wheels"

Presented by:
Delta Manufacturing

There are many advantages that our CNC truing system provides; these advantages provide a direct cost savings to your company.

One of the beneficial aspects of this machine is that it is totally portable and can be used in the workshop or "right out in the field." If there is a need to true the wheels at any time or at any place, it can be done! There is NO need to remove the wheel set.

This also eliminates the cost associated with shipping the wheel set to a reconditioning facility, or sending the entire locomotive to an in ground truing system. The down time is drastically reduced and is controlled by you.

The process is easy to set up and operate with minimal training. There is no need to know how to run a CNC machine or computer, as the controls are preset to function in a controlled order and no programming or changes are necessary to the program. All you need to do is control the depth of cut, the RPM of the wheel, and the feed rate of the machine.

The initial set up requires the following steps:

1. Removal of some of the brake rigging components, if necessary.
2. Lifting of the axle which is best done by jacking up the journal boxes.
3. Leveling and clamping of the machine to the track.
4. Hooking up the power leads to the traction motor and control cabinet.
5. Selecting the X and Y axis Home position.
6. Touching off the cutting tool insert on the inside of wheel, top of flange, on the tread and outside face of the wheel - this communicates to the controls where the wheel is in conjunction of the Home position. Now you are ready to run!

The requirements needed for operation are: Power for the DC traction motor utilizing a 400- 600 amp CC/CV 100% duty cycle welder, two 35 ton heavy duty jacks, 208-230 volt single phase power for the control cabinet , basic hand tools, brake shoe keys or wedges, and last, but not least, the proper safety equipment.

There is no need for the operator to be under or right next to the wheel during the truing process, keeping the operator a safe distance away from the hot, razor sharp shavings. The CNC feature provides an accurate, superior profile, and finish. It also produces a faster truing cycle time, thus reducing labor and cost associated to truing wheels with a manual system. It is im-

portant to note that the downtime of the locomotive is minimal because there is no need to remove the wheel set. The truing process is done directly on the locomotive.

The bottom line is the cost saving the portable wheel truing system can provide to your company. On an average, a set of wheels can take as little as 4–6 hours to complete. This approximate estimate provides you a relatively short time to recondition an entire 4 or 6 axle locomotive. This gives you the opportunity to schedule your wheel maintenance more often, and, in turn, lengthens the life of your wheels. Add to that the cost savings to your track and switches with the elimination of flat spots, thin and high flanges. It also helps prevent receiving expensive FRA violations, by keeping the wheel profile within their tolerances. Once you multiply that by your entire fleet, you can definitely see the quick payback of the initial investment and long term savings this machine can provide your company.

Automatic Wheel Inspection Systems

Prepared by
Roger Collen
Simmons Machine Tool Corporation

An Automatic Wheel Measuring System is an electro-mechanical-computer device for measurement of wheel condition either in place on a moving rail vehicle or an individual wheel set. Typical parameters that can be measured in an Automatic Wheel Inspection System are;

- Tread Profile
- Wheel Diameter
- Tread Defects
    - Thin Flange
    - High Flange
    - Slid Spot
    - Shelled Tread
    - Built-up Tread
- Thin Rim
- Out of Round
- Cracks

An Automatic Wheel Inspection System utilizes primarily non-contact systems for identification of the vehicle and wheel set as well as performance of wheel measurement. Typical applications of automatic wheel inspection systems are;

- In-rail System for inspection of wheels on moving vehicles
- Wheel set System for inspection of individual wheel sets on entry to wheel shop and for quality assurance on exit from wheel shop

In-rail System -

An In-rail Wheel Inspection System (Fig 1) can be located in any straight line track section. Performance and accuracy of the In-rail Inspection System is relative to vehicle speed so optimal location is typically on a feeder line into a rail yard or service facility. The In-rail System can be placed outdoors while the supporting computer hardware must be enclosed in an environmentally controlled building near the measuring location. Equipment for performing the measurements is typically at or below rail head height with the exception of the vehicle identification system (Fig 2). While there are multiple vehicle identification systems available, RFID (Radio Frequency Identification) is becoming the system of choice due to reduced cost and technology improvement. The RFID reader identifies each rail vehicle as it passes over the In-Rail System so that measurement parameters can be collated to a specific vehicle. Typical vehicle speed over the In-Rail Systems is 10 MPH for high accuracy measurements. Higher crossing speeds can be accomplished with measurements of less restrictive tolerance.

An In-Rail System typically contains multiple modules for measurement of specific wheel parameters (Fig 3). Modules can be added or removed as needed to customize the measuring system to the rail operator's needs. Typical modules include; wheel defects (out of round, slid flats, shelling, and built up tread) wheel diameter, wheel profile, and crack detection. Each module utilizes technology specific to the parameter to be measured. For example the wheel profile module illuminates the surface of the wheel tread while an optical camera captures the laser image and digitizes it (Fig 4). Once the profile image is digitized it can be compared to an optimum or standard profile and the deviation can be determined and the profile qualified.

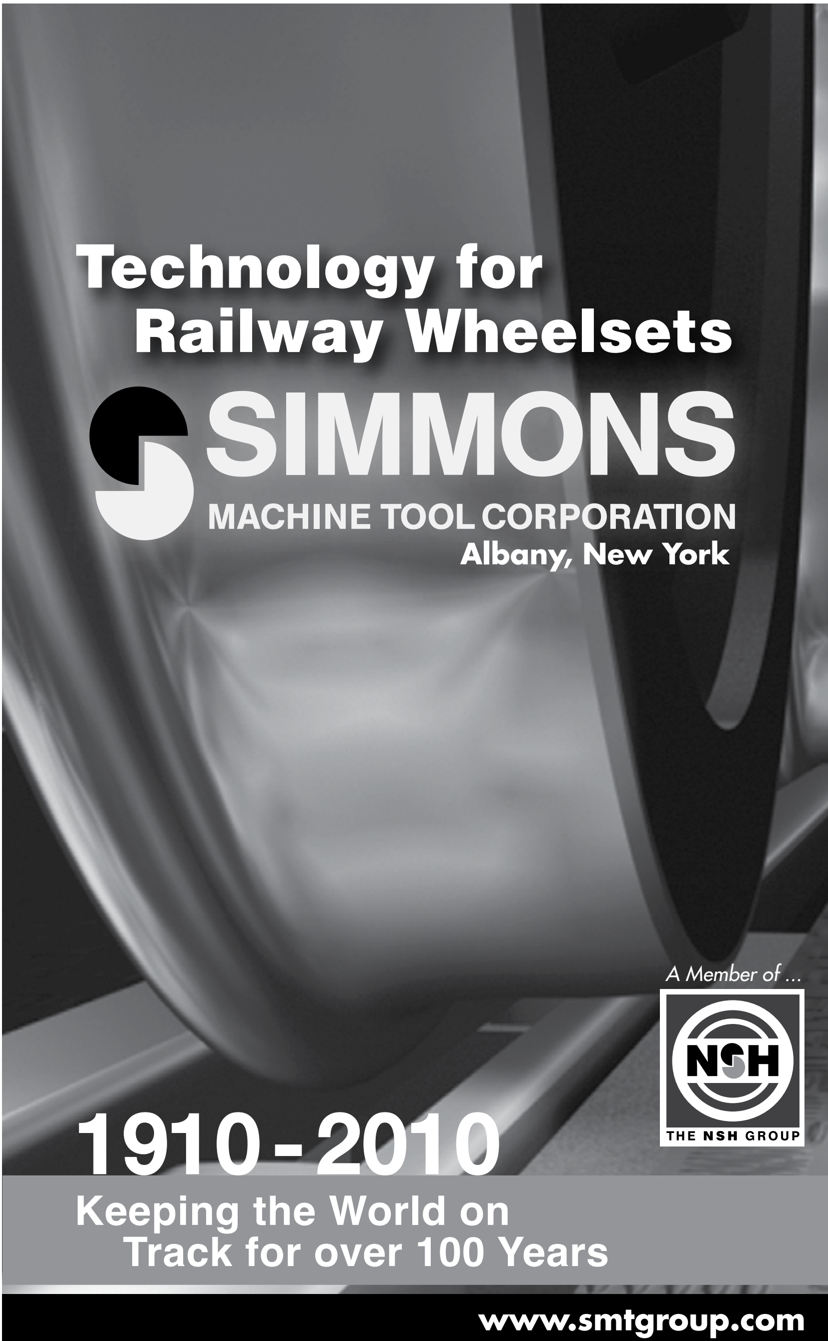
Each module of the In-Rail System communicates directly with a basic module (Fig 5) which is a high speed data processing computer. This module performs the analysis to determine if the data collected indicates a fault condition. The basic module also communicates with an onsite computer that displays the wheel inspection data for any observer (Fig 6). Additionally the basic module transfers measurement data and fault reports to a centralized database making the inspection information available to personnel system wide.

Like most automated inspection systems, the In-rail Wheel Inspection System requires routine calibration to confirm measurement accuracy. This calibration process involves the movement of a known calibrated wheel set over the measuring system (Fig 7) at routine intervals. An automatic calibration mode takes measurements of the known standard and then adjusts measurement offsets in the basic module if necessary to maintain accuracy.

The In-rail Wheel Inspection System can be combined with optional modules for inspection of other rail vehicle equipment such as brake shoe thickness (Fig 8). Optical systems capture the image of the brake shoes as the vehicle passes and digitizes the image to determine the thickness of the brake lining. This system can also be used to determine if there are missing brake operating components such as linkages as well as other vehicle safety equipment. The In-Rail System can also work in conjunction with bearing condition inspection equipment utilizing acoustical or thermal measuring equipment.

Wheel Set Inspection -

Equipment is now available for the automated inspection of individual wheel sets (Fig 9). The inspection of wheel sets is accomplished in a standalone machine located at the entrance of a wheel shop for determination of rebuilding processes, or at the exit of the wheel shop to confirm the wheel set complies with the quality standards. The Wheel Set Inspection System can examine the wheel treads for; rim thickness, wheel defects, wheel run out, and profile over the entire circumference of each wheel (Fig 10). In addition to inspection of mounted wheels, the Wheel Set Inspection System can measure the back-to-back distance of the mounted wheels. Further it has the capability to inspect features of the axle including; axle straightness, bearing journal


Technology for
Railway Wheelsets
SIMMONS
MACHINE TOOL CORPORATION
Albany, New York
A Member of ...
NSH
THE NSH GROUP
1910-2010
Keeping the World on
Track for over 100 Years
www.smtgroup.com

diameter, and bearing journal taper. In addition vision systems are available that can inspect the axle body for nicks and gouges per AAR G-II Rule 1.1.11. All of the measurement data can be transferred to a centralized database for access and work stations in the wheel shop.

There are multiple reasons for implementing a Wheel Inspection System. Access to the wheel tread whether in place on a rail vehicle or on an individual wheel set may require placing hands or measuring instruments in a dangerous location. An automated system eliminates this hazard. Automated Wheel Inspection is extremely efficient operating at a high speed taking thousands of measurements in the normal period a measurement can be taken manually. Measurement by instrumentation is much more accurate over an extended period by eliminating the variability of measurements between different operators or even the same operator attempting to use the measuring instrument in the same manner repeatedly. In addition the automatic transfer of measurement data eliminates the potential for errors that can occur when data is transferred manually. Finally, as data is collected over an extended period, the data can be reviewed and analyzed for trends that can indicate potential equipment or track issues that when rectified, reduce wheel wear and defects adding to the overall operating efficiency of a particular rail system.

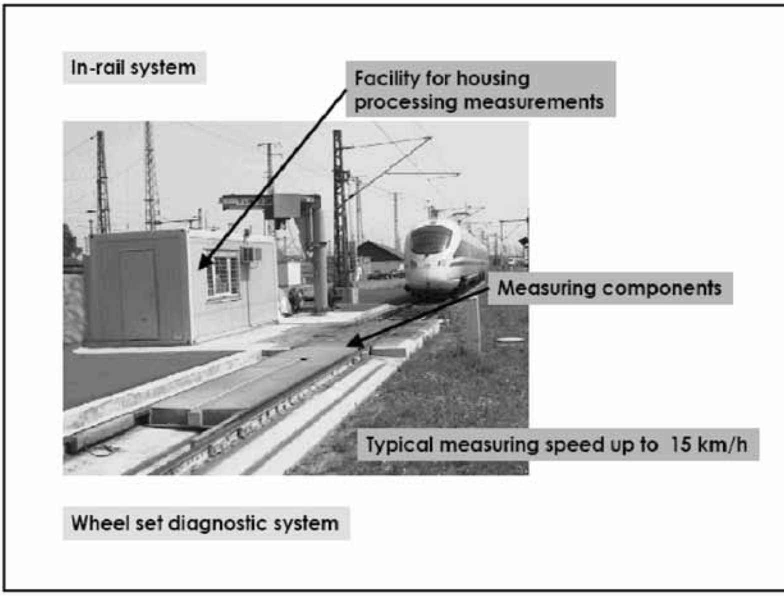


Figure 1

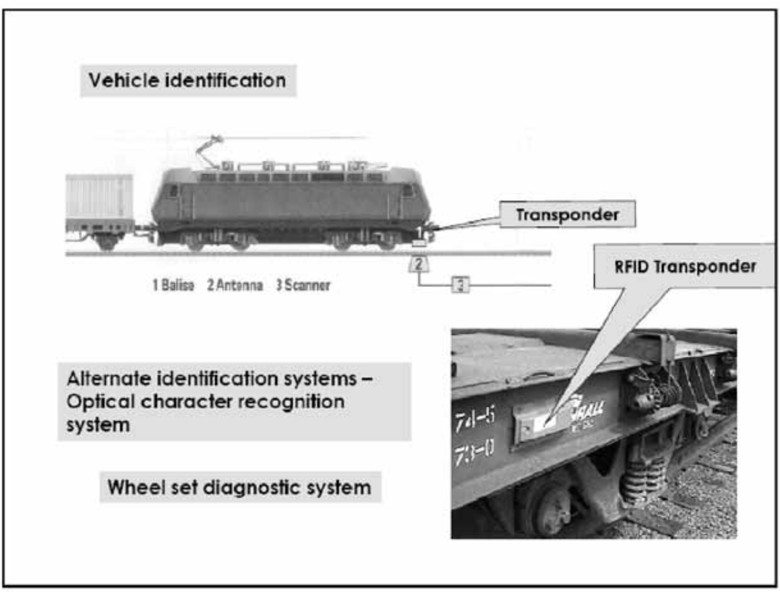


Figure 2

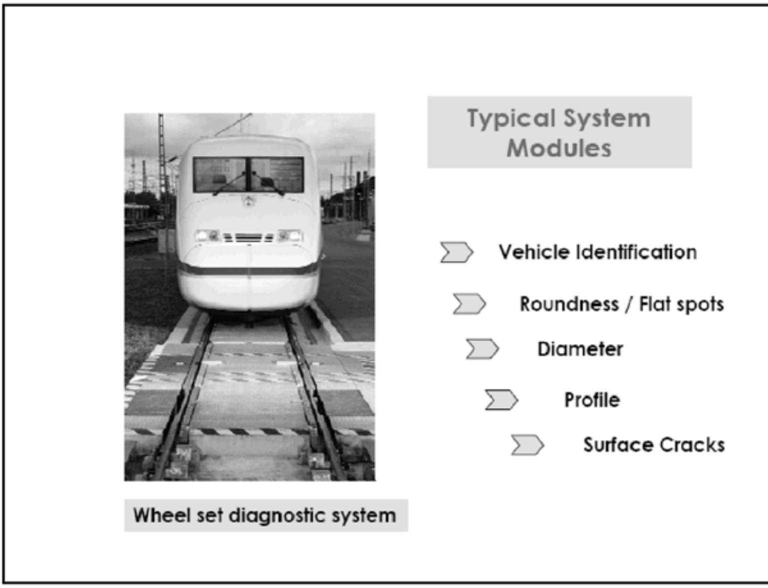


Figure 3

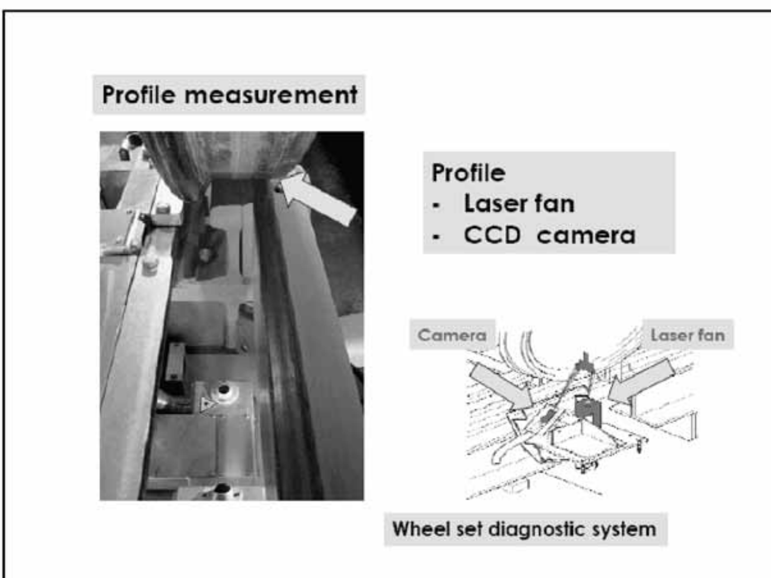


Figure 4

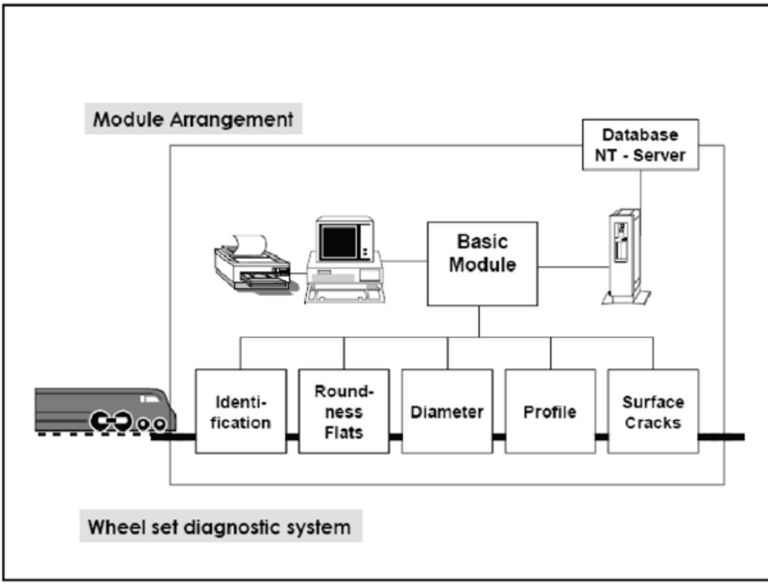


Figure 5

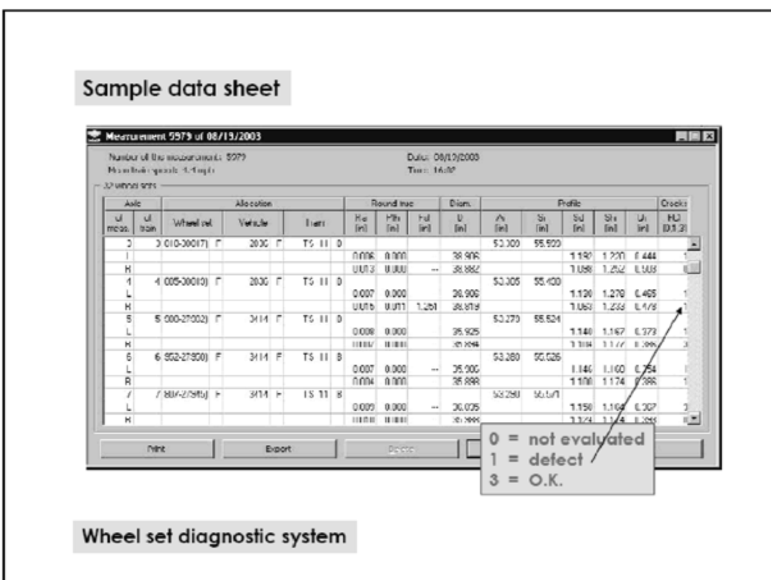


Figure 6

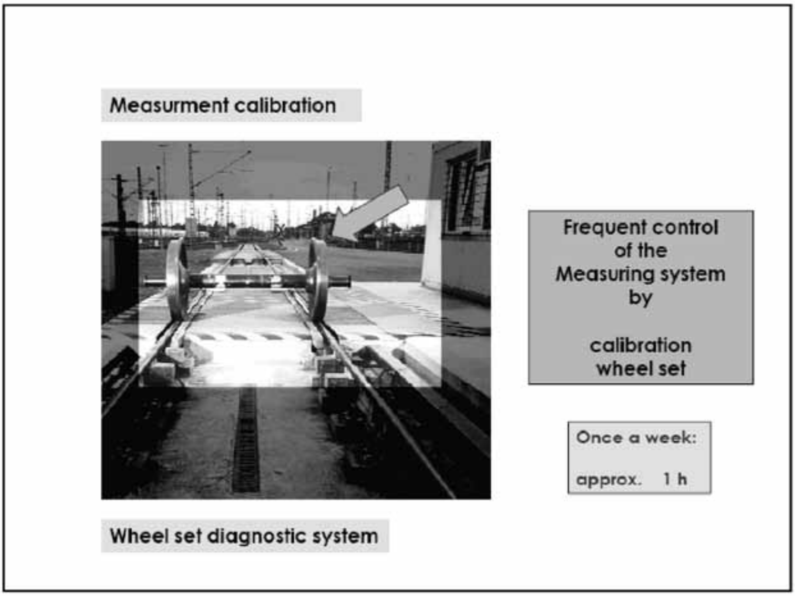


Figure 7

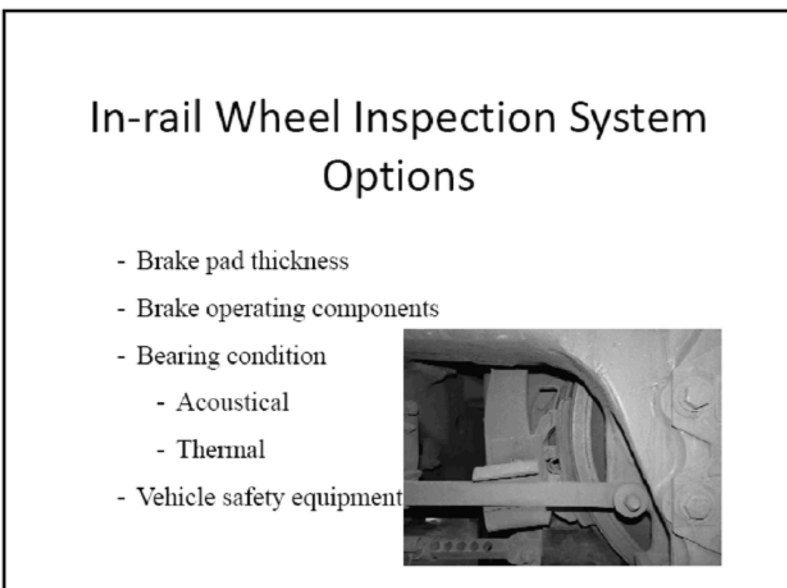


Figure 8

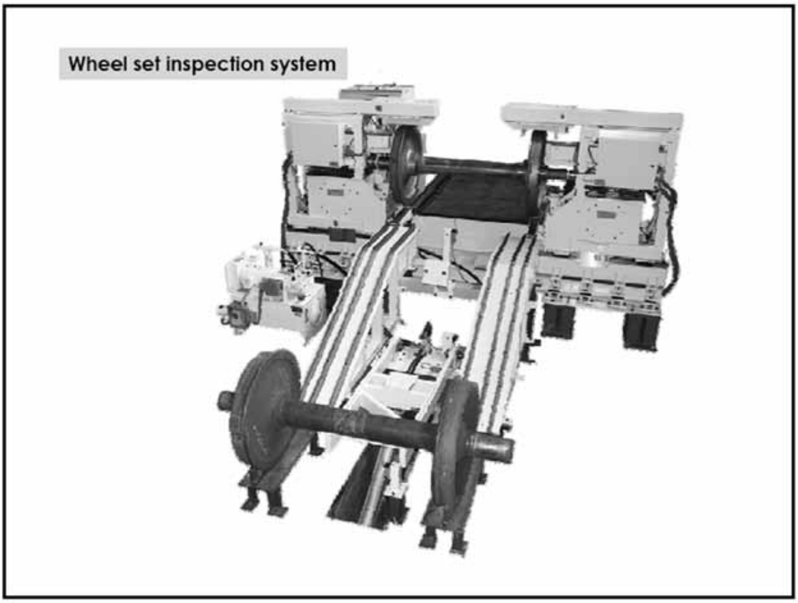


Figure 9

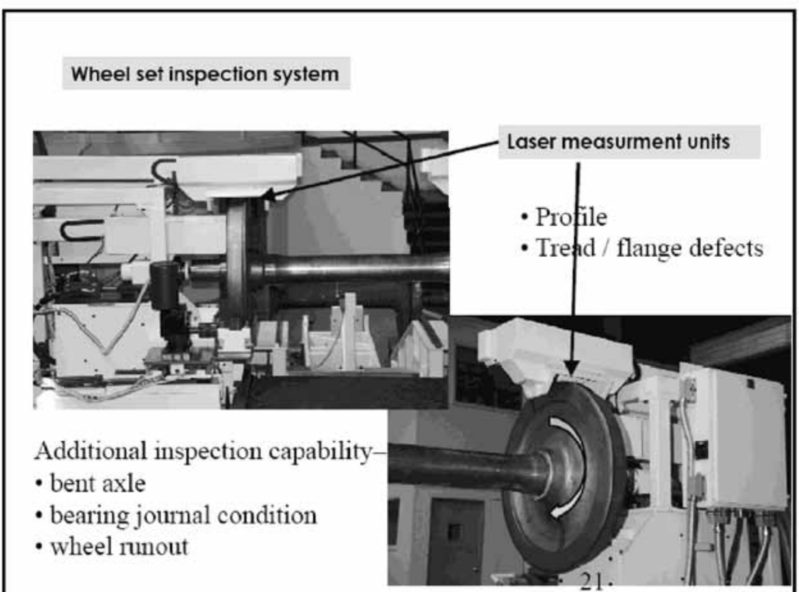


Figure 10


TIME-SAVING Tools and Machines
for Locomotive Maintenance,
Parts Reclamation, and Testing
INCREASE
SHOP PRODUCTIVITY
REDUCE
LOCOMOTIVE DOWNTIME
IMPROVE
YOUR QUALITY ASSURANCE
PROGRAM
MAIN BEARING WRENCHES
EMD & GE Engines
CRAB NUT TORQUE WRENCHES
EMD Engines
TRACTION MOTOR SUPPORT
BEARING CAP WRENCHES
EMD & GE Traction Motors
LOWER LINER INSERT
PULLER/INSTALLER
EMD Engines
CYLINDER HEAD AND LINER
WATER TEST MACHINES
EMD Engines
EXHAUST VALVE SPRING
DEAD WEIGHT TESTER
EMD Engines
and other
SPECIAL TOOLS & MACHINES
designed to
SAVE YOU MONEY
TAME, INC.
Tools and Maintenance Equipment Co., Inc.
2523 Chattanooga Valley Drive • P.O. Box 250
Flintstone, Georgia 30725 • U.S.A.
Telephone: (706) 820-0397
Fax: (706) 820-9802
TAME INC

Report on the Committee on Diesel Material Control

Monday, October 18, 2010

1:45 P.M.

Chairman

Ron Sulewski

Sales & Marketing Manager
Business Development
Rail Products International Inc
St. Louis, MO

Vice Chairman
Vacant

Commitee Members

C. Aday	Inventory Control Manager	SCRRA/Metrolink	Los Angeles, CA
D. Behrens	Managing Director	Alstom Transport	Naperville, IL
J. Brix	Sr. Mgr-Strategic Sourcing	Union Pacific	Omaha, NE
R. Delevan	Mgr-Transp. Products	Morgan AMT/National	Dallas, PA
E. Fonville	Supt. Loco. Material	Norfolk Southern	Atlanta, GA
P. Foster	President	Power Rail Dist. Inc.	Duryea, GA
J. Fronckoski	Senior Procuerment Manager	CSX Transportation	Jacksonville, FL
M. Gast	Senior Materials Manager	CSX Transportation	Waycross, GA
F. Miller	VP-Sales	Relco Locomotive	Warrenville, IL
P. Pinson	Purchasing Manager	Rail America	Jacksonville, FL
M. Zerafa	Purchasing Manager	National Rwy Equipment	Dixmoor, IL

PERSONAL HISTORY

Ron Sulewski

Ron Sulewski was born in Erie, Pennsylvania and earned his BSME from Rensselaer Polytechnic Institute in 1970. He joined GE upon graduation and worked in Erie Locomotive and the GE St. Louis Apparatus Service Shop for over eighteen years with various positions in Sales Management. Ron joined Gardner Denver for seven years as a distributor Regional Manager and rejoined GE Transportation for a Parts Aftermarket Sales Management Position in Denver.

Ron has been in his current position as National Sales Manager for Rail Products International since 2005. Ron and his wife Marje have five grown children and currently reside in St. Louis. He has been active in LMOA activities for over thirty years.

The Diesel Materials Control Committee would like to express their sincere appreciation to Norfolk Southern for hosting their committee meeting on March 22, 2010 at the NS Mechanical Department Headquarters in Atlanta, GA, and for allowing the committee to tour the Chattanooga Diesel Shop on March 23.

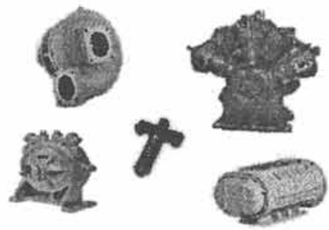
Special thanks to fellow committee member, Eric Fonville, for making all of the necessary arrangements.

"What Ever It Takes"

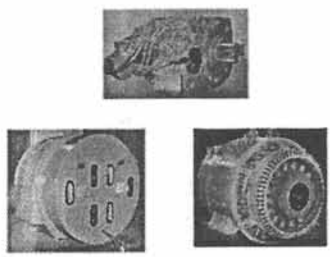
WWW.ePowerRail.Com™

"What Ever It Takes"

Cooper Bearings



PowerRail Mfg.



PowerRail Independent Electric

PowerRail Distribution Inc. offers a complete line of *New* and *Re-Manufactured* products to support both EMD & GE Locomotives.

Our full service repair facilities provides a True *Re-Manufactured* product that meets any Quality Budget with On-Time Proven Performance.

PowerRail Distribution Inc.
205 Clark Road Duryea, Pa. 18642
Phone: 570-883-7005 Fax: 570-883-7006

Green Initiatives

Prepared by Jim Brix
Union Pacific RR

This paper focuses on some of the industry-wide Green Initiatives currently in use. Many of these initiatives not only are beneficial to the environment, but also make financial sense as well. The ideas presented here are from various railroads and railway equipment suppliers, and are meant to be a sampling of potential initiatives currently in use. This collection of ideas in no way should be considered all-inclusive.

One of the largest areas of opportunity for green initiatives is fuel. Next to the military, the railroad industry is the largest consumer of diesel fuel in the US. Some of the initiatives in place to maximize the tons/mile/gallon include the following: Fuel Masters (gas card incentives to locomotive engineers for efficient train handling), increased utilization of distributed power (usage has expanded beyond unit train service), and increased locomotive shutdown time (reduced idling through Automatic Engine Start Stop and/or operating rule changes). Some emerging technologies that are in the test phase include wheel/rail friction modifiers (applied to either locomotives or railcars) and aerodynamic enhancements (ex. Tarps for the gaps between doublestacked containers).

All green initiatives come down to the three "R's":

- *Good*: Recycle products & use recycled material
- *Better*: Reuse containers & products
- *Best*: Reduce the amount of trash discarded

Green Initiatives not only support environmental stewardship, but sound financial strategies as well.

The office environment presents some easily implementable opportunities that include:

Climate Control

- Variable Speed Fans
- Computer Controlled Temperature
- System Adjusts % of Outside Air For # of People in the Building
- Hydraulic Economized Cooling Tower

Lighting

- Energy Efficient Fixtures
- Computer Controlled Lighting, On at 7AM, off at 5:20PM.
- ~85% of the Exterior is Glass, Providing Significant Natural Lighting

In addition to the office building, there are green initiative opportunities for office consumables as well:

- Reduce Paper Consumption- Manage what you print and copy - only what you need, 2-sided (by default), black & white.

- Reduce Disposable Cups Used - Provided only for visitors, HQ Employees bring their own reusable mug/cup (for some floors).
- Reduce Energy - Turn off lights, monitors, and other electric devices when you leave the room.
- Reuse - coffee mugs, water bottles, food ware

In the warehouse environment, there are ample opportunities to conserve packaging resources:

- Reduce
  - Automated inventory management that updates reorder points & quantities weekly based on usage & delivery history
  - Proactive inventory management based on fleet management
- Reuse
  - Repair & return components are shipped in reused packaging
  - Reusable containers for air brake valves, radiators, power assemblies, air compressors, electrical cases, etc.
  - General reuse of boxes, bubble wrap, pallets, etc. for outgoing shipments

Power Assembly Rack

Intercooler Rack

- Recycle
  - Scrap Metal
  - Cardboard (on site balers at high-volume locations)

Cardboard Baler

Additional rail yard green initiatives include updating large energy consuming devices with new efficient replacements, or adding automated controls to existing devices to increase down time. Examples include:

- NS Bellevue & N. Kansas City Yards
  - A wind turbine has been erected at both facilities to power the waste-water treatment plant.
  - Annual electricity production = 100,000 kW hours.
- UP Englewood Yard
  - 450 hp constant run air compressor replaced with 175 hp unit that runs as needed.
  - Utility consumption dropped 75%.
- UP Moffat Tunnel
  - Exhaust Blower control system was reprogrammed to reduce run time.
  - Utility consumption dropped 20%.

Norfolk Southern Wind Turbine

It takes a program champion in order to implement a sustainable green initiative change in an organization. The following tips will help any recycling champion be most effective:

- Focused enthusiasm is contagious
- Know biases – seek the best approach
- Don't be discouraged by resistance
- Seek cooperation – make it convenient to help
- Set realistic timelines
- Value input from those closest to what's thrown out
- Don't sort through peoples' trash without permission – don't be a trash cop!

In conclusion, environmental stewardship has a positive impact on not only the corporation, but also individual employees. The areas of positive impact include:

- Environmental: Long-term impact
- Safety: A Clean Railroad is a Safe Railroad
- Legal: Regulatory compliance
- Security: Risk management
- Financial: Conservation saves money
- Morale: A personal investment goes a long way

Bar Coding, Material Tagging and Identification for Recycle and HAZMAT Controls

Prepared by Ron Delevan
Morgan AM&T

GREEN IS THE NEW INITIATIVE

- Controlling waste
- Recycling
- Accountability

YES THERE IS MORE TO BE DONE!

Many States and the Federal Government are in the process of creating new environmental regulations governing "**GREEN**" issues. Some of these issues involved recycling, cradle to grave legislation and fuel savings (Figure 1)

These issues are in part the focus of the US Navy's initiative using … YOU GUESSED IT…. Bar Coding.

Laser Bar Coding Equipment for marking components (Figure 2)

Features:
- Permanent
- Chemically resistant to solvents, acids and bases
- Abrasion resistant
- Will withstand temperatures above 1800 deg F
- Withstands prolonged UV and moisture exposure
- High resolution
- Easily create barcodes, logos and fine text
- High contrast
- Black marks improve contrast for improved machine readability
- Maintains substrate integrity
- Bonds to the product surface with minimal thermal energy
- Can be successfully applied to plated materials without penetrating the surface
- Flexibility – Laser process facilitates variable data such as barcodes, serialization and personalization
- Ability to mark metal with an inexpensive CO^2 laser
- Color – A variety of colors can be applied to glass and ceramics (Figure 3)

Lasers permit us to indelibly mark parts or assemblies for:

1. Warranty
2. Traceability
3. Ownership
4. Life Expectancy
5. Rebuild History
6. Modifications or Upgrades
7. Control Numbers

The markings are not easily moved and do not get knocked or pried off! (Figure 4)

Radio Frequency Identification (RFID)

- Smart label applications
- Supply chain management
- Inventory control
- Package and cargo tracking
- Reusable container tracking
- Work-in-process
- Access control and security systems
- Capital asset labeling/tracking
- Healthcare—patient ID, blood bags, test tubes
- Airline baggage tags
- Garment and uniform rental
- Document/file tracking
- Hazardous waste drums
- Amusement part and concert wristbands
- Authentication

Smart chips can be placed in or on about any object! (Figure 5)

When scanned, the smart chip sends a signal back to the scanner. The reader device does not have to be close to the object. Smart chips can be placed inside containment packaging for future security verification.

It can be inserted into container design for HAZMAT, sensitive or high cost items to allow protection, security, traceability and compliance with reporting requirements.

It can also be used to follow those same items to their destination and allow for verification through piggybacking with GPS.

- POC/T.BLEDSOE/-/SUP 04XE/FISC NORFOLK/TEL:757 443-1268 /TEL:DSN 646-1268//
RMKS/
1. THE PURPOSE OF THIS MESSAGE IS TO PREPARE FOR FLEETWIDE
IMPLEMENTATION OF THE HICSWIN SOFTWARE AND TO REITERATE HICS HARDWARE
AND
SOFTWARE REQUIREMENTS PRIOR TO IMPLEMENTATION AS DISCUSSED IN REFS A
THRU
D.
2. THE NEW HICSWIN IS A WINDOWS BASED, Y2K COMPLIANT, RELATIONAL DATABASE
MANAGEMENT SYSTEM (RDBMS) TO BE USED TO TRACK HAZARDOUS MATERIALS
(HM?S)
FROM CRADLE TO GRAVE ON U.S. NAVY SHIPS. HICSWIN INVENTORY MANAGEMENT
SYSTEM SOFTWARE IS DESIGNED TO BE COMPATIBLE WITH OTHER SHIPBOARD
SYSTEMS.
IT WILL INTERFACE WITH PREVENTIVE MAINTENANCE SYSTEMS SCHEDULES
(PMS(SKED)), THE HAZARDOUS MATERIAL INFORMATION SYSTEMS (HMIS), AND THE
SHIP?S HAZARDOUS MATERIAL LIST (SHML). HICSWIN ALSO INCORPORATES NESHAP
REPORTING REQUIREMENTS AND AUTOMATED SHML FEEDBACK REPORT (SFR)
CAPABILITY.
HICSWIN ALLOWS NAVY SHIPS TO MONITOR THE PROCUREMENT, USE, AND DISPOSAL
OF
ALL HAZARDOUS SUBSTANCES, REDUCE HM INVENTORIES, PREVENT POLLUTION, AND
INTEGRATE SMART BUSINESS PRACTICES INTO HAZARDOUS MATERIAL CONTROL AND
MANAGEMENT (HMC&M).

Figure 1

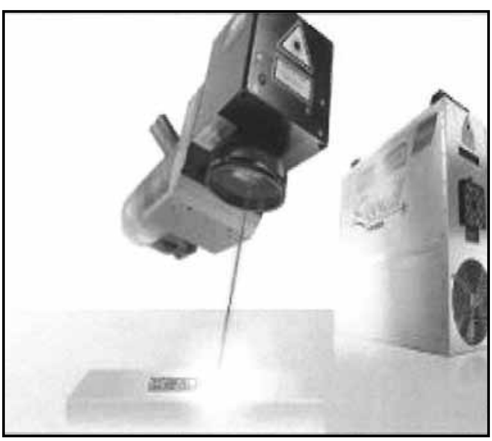


Figure 2

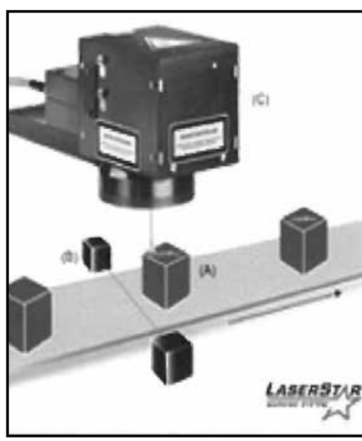
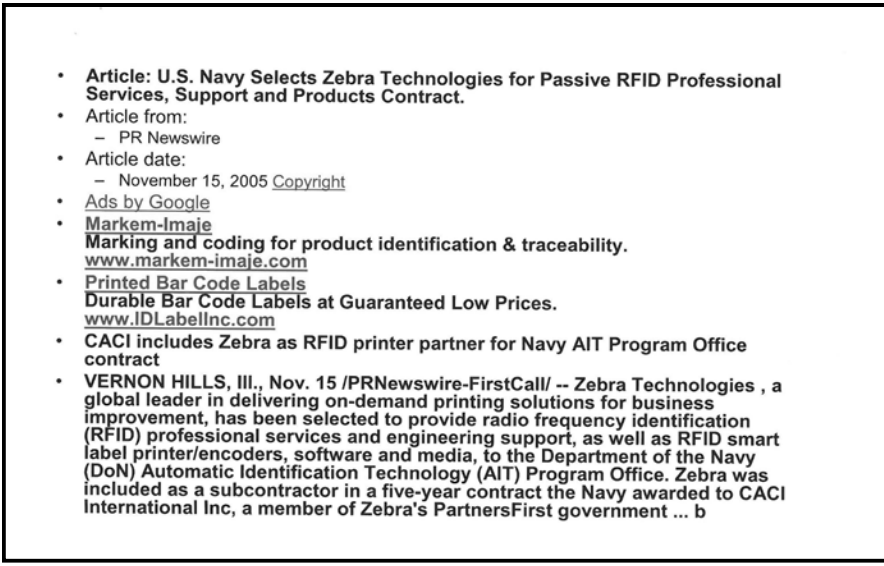


Figure 3



- **Article: U.S. Navy Selects Zebra Technologies for Passive RFID Professional Services, Support and Products Contract.**
- Article from:
  - PR Newswire
- Article date:
  - November 15, 2005 Copyright
- Ads by Google
- Markem-Imaje
  Marking and coding for product identification & traceability.
  www.markem-imaje.com
- Printed Bar Code Labels
  Durable Bar Code Labels at Guaranteed Low Prices.
  www.IDLabelInc.com
- **CACI includes Zebra as RFID printer partner for Navy AIT Program Office contract**
- **VERNON HILLS, Ill., Nov. 15 /PRNewswire-FirstCall/ -- Zebra Technologies , a global leader in delivering on-demand printing solutions for business improvement, has been selected to provide radio frequency identification (RFID) professional services and engineering support, as well as RFID smart label printer/encoders, software and media, to the Department of the Navy (DoN) Automatic Identification Technology (AIT) Program Office. Zebra was included as a subcontractor in a five-year contract the Navy awarded to CACI International Inc, a member of Zebra's PartnersFirst government ... b**

Figure 4

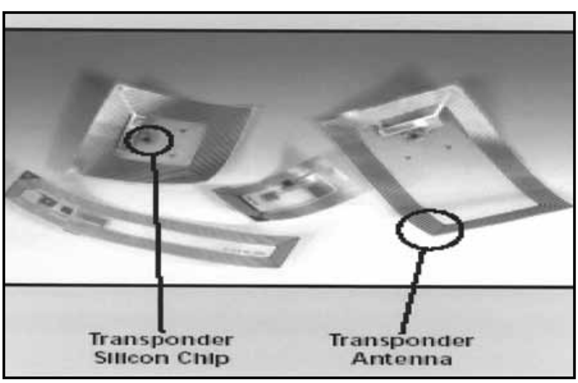


Figure 5

CN & Sustainable Procurement

Prepared by Normand Pellerin
CN Rwys

THE AGENDA –

- Sustainable Procurement Basics
- Who is Practicing Sustainable Procurement
- Looking at Procurement through the "Sustainable" Lens
- Questions

What is "Sustainable Procurement"?

- **Meeting needs** for goods, services, works and utilities **economically** but also **generating social and environmental benefits**
- **Integration** of environmental/social performance considerations **into the procurement process** including planning, acquisition, use and **disposal**
- **Value for money includes** many factors such as cost, performance, availability, quality and **environmental performance**
- Have **a lesser or reduced impact on the environment** over the life cycle of the good or service

What is a "Sustainable" Product?

1. Fit for purpose and provides value for money
2. Energy efficient and resource efficient
3. Made with minimum use of virgin materials
4. Non (or reduced) polluting
5. Durable, easily upgraded, and repairable
6. Re-usable and recyclable
7. Ethically sources

Why do this?

- Reliable supply
- Corporate reputation
- Cost savings

Ensures that the social, environmental and economic factors are all internalized in the decision-making process so that acquisitions deliver the optimum all-around benefit to stakeholders.

Reliable Supply

- Sustainable Procurement helps an organization understand **where and how its goods and services are being produced**
- Products may be manufactured at locations that can be extremely remote from the point of use/consumption
- This allows companies to make better choices and **ensure a reliable supply**

Corporate Reputation

- **Core piece** of risk and reputation management
- **Stakeholders** increasingly expect sustainable procurement process to ensure due diligence
- **Credibility** increases with those an organization seeks to influence

Cost Savings

- **Unsustainable procurement** is not good stewardship of shareholder investments—Create false choice between "value for money" and sustainability
- **SP means more efficient** use of resources
- **Fosters innovation &** cost effectiveness
- **Buy-in** from stakeholder (i.e. customer) increases

Traditional Challenges

1. Cost
2. Competing priorities
3. Lack of understanding & awareness
4. Purchasing habits
5. Inaccurate perceptions
6. No acceptable alternative
7. Absence of/or incomplete data

Commonly Focused on Areas

- Office Supply Products and Furnishings
- Paper
- Energy Procurement
- Technology
- Packaging
- Shipping and Delivery
- Buildings (LEED)
- Break room Supplies

THE STAKEHOLDERS

- Shareholders/Investors/Finance
- Suppliers
- NGO's
- Customers
- Employees
- Communities where we operate
- Government/Regulators
- Procurement Professionals
- Research and Design
- Others?

Looking at Procurement through the "Sustainability" Lens

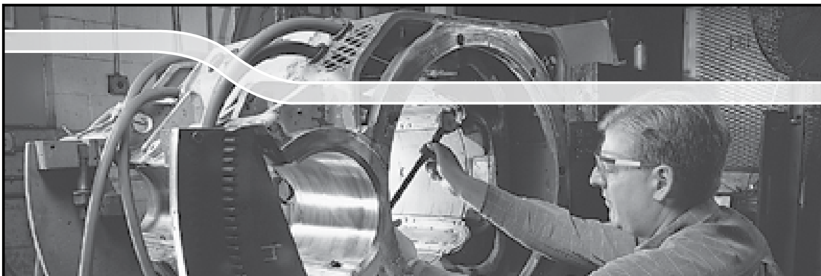
- The business case for Sustainable procurement
- Certification/Labeling programs
- Key Sustainable Procurement decision points
- Raw material sourcing
- Manufacturing
- Transportation
- End-of-Life Management
- Engaging employees

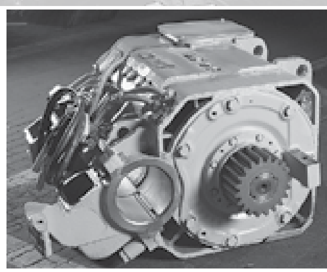
Business Case

- **Economic Benefits:**
    1. **Reduce** suppler generates **wastes and surpluses**
    2. **Decrease** handling expenses and risks associated with **waste disposal**
    3. Supplier **savings** from improved efficiencies may be passed along to buyer, **increasing competitiveness**

- **Competitive Advantage Through Innovation:**
  Efficient production by supplier through use of clean technologies, process innovation, and waste reduction

- **Improved Public Image:**
  Overall reputation and brand will improve image for customers, investors, employees and other stakeholders





The Process

1. Research company procurement policies
2. Define procurement terms
3. Screen suppliers and subcontractors
4. Set clear rules and expectations
5. Select green or socially conscious products
6. Expect slow, incremental change
7. Communicate the benefits

Decision Points

Raw Material Sourcing:

Considerations: Sourcing primary products that are sustainably produced or ethically sourced.

Example: FSC certified wood products

Manufacturing:

Considerations:

- How was the product manufactured?
- Is the processing energy efficient/ resource efficient?
- Minimum virgin materials, maximum recycle content?
- Non or reduced pollution?

Example: ISO 14001 certified products

Transportation:

Considerations: How far has the product or service travelled? Is there a locally sourced alternative?

Example: Paper products from Quebec vs. Sweden

End of Life Management:

Considerations: What will happen to the product after its use? Is it durable, easily upgraded, repairable, reusable, recyclable?

Example: LEED certified office furniture

	SUPPLIER (1st tier/2nd tier/3rd tier etc)			RETAILER			CONSUMER/USER	
Issues to Consider (relating to sustainable development issues)	Material Acquisition from primary source	Manufacture/ Process	Despatch/ Transport	Operations including warehousing	Product design & development	Sales & Market development	Product/ Service in use	End of Life
General								
Changing customer expectations								
Adverse media coverage								
Threat to brand or corporate reputation								
Government procurement requirement								
Losing alignment with corporate/employee								
No appeal to ethical investors								
Specific Issues								
Long-term supply of raw materials:								
Use of chemicals/hazardous substances								
Animal husbandry								
Short term access to supply								
Waste and packaging used								
Labour standards and practices including unsocial hours								
Local supply or overseas								
Water, air or soil pollution/emissions								
Transport; fuel; congestion								
Increase in transport costs								
Energy utilisation								
Increased operating costs, eg. energy, fuel, waste disposal								
Regulatory requirements								

Figure 1

Report on the Committee on Diesel Electrical Maintenance

Monday, October 18, 2010

3:00 P.M.

Chairman

Mike Drylie
Electrical Systems Engineer
CSX Transportation
Jacksonville, FL

Vice Chairman

Victor Trout
Mgr-Mechanical Engrg.
Union Pacific RR
Omaha, NE

Commitee Members

D. Becker	Design Engineer	Electro Motive Diesels, Inc	LaGrange, IL
D. Bruss	Engr. New Cap. Equpt	Amtrak	Philadelphia, PA
B. Hathaway	Consultant		Port Orange, FL
B. Kirdeikis	Sr. Rel Specialist-Elect	CN RR	Edmonton, AB
G. Lozowski	Tech Mgr-RR Products	Morgan AMT/National	Greenville, SC
D. Maryott	Mgr-Locos	BNSF Rwy	Fort Worth, TX
B. McCaffrey	Consultant	Transupply, Inc	Wilmington, DE
K. Mellin	N.E. Sales Mgr.	Peaker Services, Inc.	Brighton, MI
S. Mueting	Field Service Engineer	Siemens Transp.	Aurora, CO
T. Nudds	Training Manager	ZTR Control Systems	London, Ontario
R. Stege	Mgr-Loco. Running Gear	Norfolk Southern	Altoona, PA
C. Taylor	Application Specialist	Bach-Simpson	London, Ontario
L. White	Application Specialist	Bach-Simpson	London, Ontario

Note: Brian Hathaway and Les White are Past Presidents of LMOA
Ron Bartels, 3rd VP of LMOA, and Stuart Olson, Regional Executive are both very active members of this committee
Shane Sledge will be replacing Ryan Stege as the Norfolk Southern representative on this committee

PERSONAL HISTORY

Mike Drylie

Electrical Systems Engineer
CSX Transportation

Mike Drylie was born in Ohio in 1956. He received an Associates of Arts Degree, General Studies from Kent State University in 1978, a Bachelors of Science, Electrical Engineering, from Ohio State University in 1983, and a Masters of Science Degree, Electrical Engineering from The Air Force Institute of Technology in 1986. Mike is a licensed Professional Engineer in the state of Florida.

Mike served in the US Air Force for many years as an aircraft electrical systems maintainer, radar systems design engineer, and guidance systems engineer on space launch vehicles.

Mike has been with CSX since January 1996. He has been on the mechanical departments engineering staff involved with improvements and modifications to locomotive systems. In recent years Mike has worked on the reduction of 92 day maintenance requirements and reducing locomotive Out of Service time through the use of development of reliable systems not requiring service and regular inspections or maintenance.

Mike is married to Debbie Anderson Drylie and they have 4 children, Tara, Michael Jr, Stephen and James. Mike and Debbie also have 3 grandchildren, Christian, Jacob, and Edward with two additional ones expected in 2011.

Mike's hobbies include going to the gym, visiting grandchildren, reading, various computer, number, and logic games.

The Diesel Electrical Maintenance Committee would like to express their sincere gratitude to CSX Transportation for hosting their committee meeting on February 8, 2010 at CSX Headquarters and Jacksonville Service Center in Jacksonville, Florida.

The committee would also like to thank Florida East Coast Railway for allowing them to tour Bowden Yard in Jacksonville on February 9, 2010.

Infrared Thermography in Locomotive Electrical Maintenance

Bill Kirdeikis – Senior Reliability Specialist – Electrical – CN

Infrared Thermography – Just What Is It

First of all prior to going into the uses of Infrared thermography in locomotive Electrical Maintenance we need to understand what thermography is and rather than try and muddle it, I will just give you a portion of the Wikipedia definition which does match most other definitions I have seen.

"Thermography" *—From Wikipedia, the free encyclopedia*

Infrared thermography, thermal imaging, and thermal video, are examples of infrared imaging science. Thermal imaging cameras detect radiation in the infrared range of the electromagnetic spectrum (roughly 900–14,000 nanometers or 0.9–14 μm) and produce images of that radiation, called thermograms. Since infrared radiation is emitted by all objects near room temperature, according to the black body radiation law, thermography makes it possible to see one's environment with or without visible illumination. The amount of radiation emitted by an object increases with temperature; therefore, thermography allows one to see variations in temperature. When viewed through a thermal imaging camera, warm objects stand out well against cooler backgrounds; humans and other warm-blooded animals become easily visible against the environment, day or night. As a result, thermography is particularly useful to the military and to security services.

Thermography has a long history, although its use has increased dramatically with the commercial and industrial applications of the past fifty years. Government and airport personnel used thermography to detect suspected swine flu cases during the 2009 pandemic.[1] Firefighters use thermography to see through smoke, to find persons, and to localize the base of a fire. Maintenance technicians use thermography to locate overheating joints and sections of power lines, which are a tell-tale sign of impending failure. Building construction technicians can see thermal signatures that indicate heat leaks in faulty thermal insulation and can use the results to improve the efficiency of heating and air-conditioning units. Some physiological changes in human beings and other warm-blooded animals can also be monitored with thermal imaging during clinical diagnostics.

The appearance and operation of a modern thermographic camera is often similar to a camcorder. Often the live thermogram reveals temperature variations so clearly that a photograph is not necessary for analysis. A recording module is therefore not always built-in.

The CCD and CMOS sensors used for visible light cameras are sensitive only to the nonthermal part of the infrared spectrum called near-infrared (NIR). Thermal imaging cameras use specialized focal plane arrays (FPAs) that respond to longer wavelengths (mid- and long-wavelength infrared). The most common types are InSb, InGaAs, HgCdTe and QWIP FPA. The newest technologies use low-cost, uncooled microbolometers as FPA sensors. Their resolution is considerably lower than that of optical cameras, mostly 160x120 or 320x240 pixels, up to 640x512 for the most expensive models. Thermal imaging cameras are much more expensive than their visible-spectrum counterparts, and higher-end models are often export-restricted due to the military uses for this technology. "

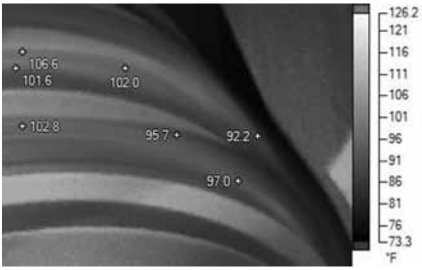
In a nutshell based on the above definition the first thought that comes to mind is that basically a Thermal Imaging Camera is essentially an infrared heat gun on steroids. While there is a lot of truth in this it does so much more than an infrared heat gun could possibly give you.

When we decided to get into thermal imaging we noted that there is a multitude of suppliers with the two major suppliers of this technology in the handheld type of thermal imagers that can be more easily cost justified are FLIR and FLUKE. Which of the two is the better product will not be debated here. We opted at the time to go with FLUKE mainly due to a history of success with other instruments put out by FLUKE so all images and thermographs will be shown from the FLUKE TI-25 Thermal Imager and FLUKE Smartview software.

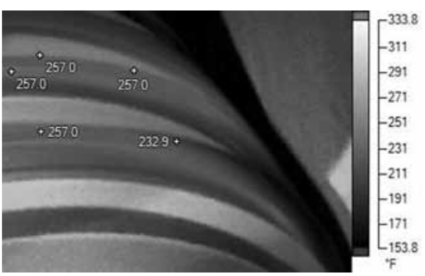
Uses of Infrared Thermography On Locomotives

Electrically on locomotives the following are some of the major uses on locomotives.

1. Examining slip rings for hot spots in the rings. Over time slip rings have shown themselves to be problematic with previous papers from this committee on this exact problem. Unlike an infrared heat gun, a thermograph gives you an overall picture of what is happening exactly overall live and this makes it very easy to spot problems as evidenced by the attached thermograph. This is a capture of the thermograph annotated using the desktop software included with the Thermal Imager.

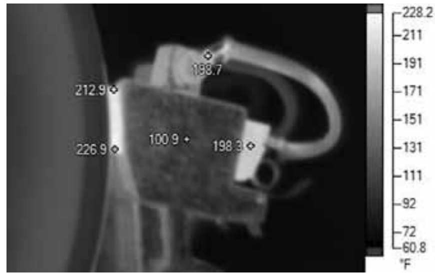


Unfortunately, while I was playing with the Thermograph once again I found out I was not as smart as I thought and still had a lot to learn. Like any thermal device, emissivity needs to be accounted for if you are looking for absolute temperatures of a subject. The initial emissivity setting for the thermal imager is set at 0.95 which does not properly reflect true temperatures of the locomotive slip rings and once emissivity was corrected to 0.10 which would be a truer representation of the heat the following readings were noted.

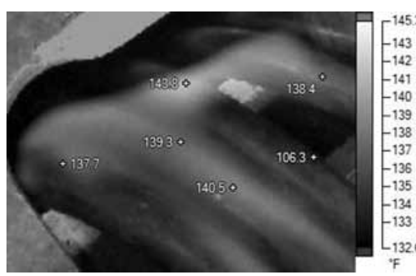


I apologize to our friends the brush manufacturers for thinking what an easy life brushes have at temperatures just over 100 degrees F.

Temperatures noted on a thermograph of a slip ring brush are as follows with carbon being closer to a full emissivity.



2. Checking for bad joints/high resistance connections on high voltage power cables. Over time we have seen with traction motor glad hand connections high resistance develop either at the point where the glad hands join or right in the glad hand itself. Over time as we moved to bolted connectors this problem has abated but using a thermal camera gives you an overall view of the leads and lugs at a glance. In the attached thermograph you can see the general heating in traction motor cables with the unit loading.



3. Contactors and relays high resistance contacts and/or connections. A general look with a thermal imager in any electrical cabinet under loaded conditions on the contactors or relays. To demonstrate this attached is a thermograph of cooling fan contactors on an SD60 unit with fan test engaged.


InteLevel®
Take the Guesswork Out of Locomotive Fuel Levels
• Accurately measure fuel and other liquid levels
• Apply to virtually any type of tank
• Unaffected by mounting angle, foam, rust, scale, or other common conditions
• Patented Design
InteLevel
ESC + ▷ OK
Reliable
Accurate
www.ztr.com/intelevel
1-952-233-4340
railinfo@ztr.com
ZTR™

In this image you can see the general heat increase when the cooling fan test is in progress. This again gives a very quick indication of the relative state of the wiring and contacts, which in this case shows no major problems.

A general shot of an electrical cabinet showed the following.

As can be noted two warmer spots were noted. The first spot under the rubber insulation at 95 deg F showed no problems other than the effect of wrapping wiring in insulating rubber whereas the other point at 94 deg F. did have a suspect fast-on connector.

4. Last but not least at least for us Canucks is the operation of many of the heaters including blow down heaters on the locomotive. While checking blow down heaters on a locomotive can be done with an infrared heat gun, if you already have the thermal imager it will very quickly give you a direct indication of the heater function and heat dissipation into the surrounding components. This can be seen in the attached thermograph.

You can very quickly see proper heater operation and note that heat is properly being conducted into the blow down valve itself.

Limitations Of Thermal Imaging

As noted above in the discussion on slip rings if we are looking for absolute temperatures as with any device that uses infrared to measure temperature we must take into account the emissivity of the material that is being measured.

Most metals have an emissivity much less than 1 and this can vary depending on the condition of the metal or other material being measured.

Attached is a definition of emissivity for clarification.

"Emissivity"—*From Wikipedia, the free encyclopedia*

The **emissivity** of a material (usually written _ or e) is the relative ability of its surface to emit energy by radiation. It is the ratio of energy radiated by a particular material to energy radiated by a black body at the same

temperature. It is a measure of a material's ability to radiate absorbed energy. A true black body would have an emissivity of 1.0, while any real object would have an emissivity of less than 1.0. Emissivity is a dimensionless quantity, so it does not have units.

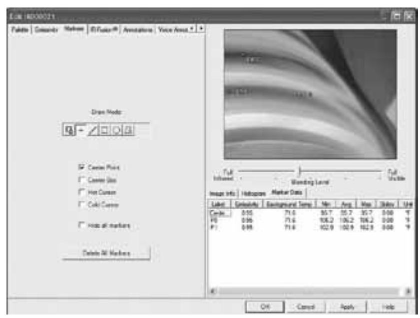
In general, the duller and blacker a material is, the closer its emissivity is to 1. The more reflective a material is, the lower its emissivity. Highly polished silver has an emissivity of about 0.02.

Emissivity depends on factors such as temperature, emission angle, and wavelength. A typical engineering assumption is to assume that a surface's spectral emissivity and absorptivity do not depend on wavelength, so that the emissivity is a constant. This is known as the "grey body assumption".

Although it is common to discuss the "emissivity of a material" (such as the emissivity of highly polished silver), the emissivity of a material does in general depend on its thickness. The emissivities quoted for materials are for samples of infinite thickness (which, in practice, means samples which are optically thick) — thinner samples of material will have reduced emissivity.

When dealing with non-black surfaces, the deviations from ideal black body behavior are determined by both the geometrical structure and the chemical composition, and follow Kirchhoff's law of thermal radiation: emissivity equals absorptivity (for an object in thermal equilibrium), so that an object that does not absorb all incident light will also emit less radiation than an ideal black body."

With a thermal saved thermal image, if there is a need to determine exact temperatures the emissivity can be set on any point in the thermograph using the desktop software included. Further in live view with the thermal imager the emissivity can be set based on the material you are looking at. Emissivity tables are available on many sites on the Internet in varying degrees of detail.



The good news is, while this may critical in some instances, in pretty well all cases where we will use a thermal imager for maintenance purposes this is not an issue. When as maintenance personnel we start looking for problems the absolute value of the temperature is not nearly as critical as changes in a component or wiring relative to surrounding parts of the component or the wiring. In other words, if you are looking at connection points or contacts other like parts will be subject to the same differentials due to emissivity and the differential in temperature is the key.

Conclusions And Final Thoughts

Based on everything I have seen with this device, if used as a differential temperature tool it is invaluable. When used as such minimal training is required. In addition, the power of the desktop software enhances the usefulness of the images immensely and I know of no other piece of test equipment that can do what the thermal imager can do relative to spotting many problems before they become a failure.

Electrical Connectors: Standards & Field Service Challenges

Prepared by:
Charles Taylor, Bach-Simpson Corporation

Introduction

With the life expectancy of a locomotive / transit car being 50+ years; this causes the action to replace, repair and provide maintenance for various on board equipment. With these actions stated above each may affect the systems electrical connector serviceability and maintainability.

Standards

The following are a sampling of standards which should be reviewed and referenced when performing electrical connector replacement and / or repairs.

MIL Standards

There are many MIL standards which directly or indirectly relate to electrical connectors. There are two MIL standards examples that will be briefly described below.

The MIL-DTL-5015 (formerly MIL-C-5015) standard defines the circular multi-pin electrical connectors used in harsh environmental conditions. These connectors are mechanically mated with use of a threaded fastener on the outside of the connector casing.

Some of the parameters specified include crimp / solder type connections, receptacle shell styles.

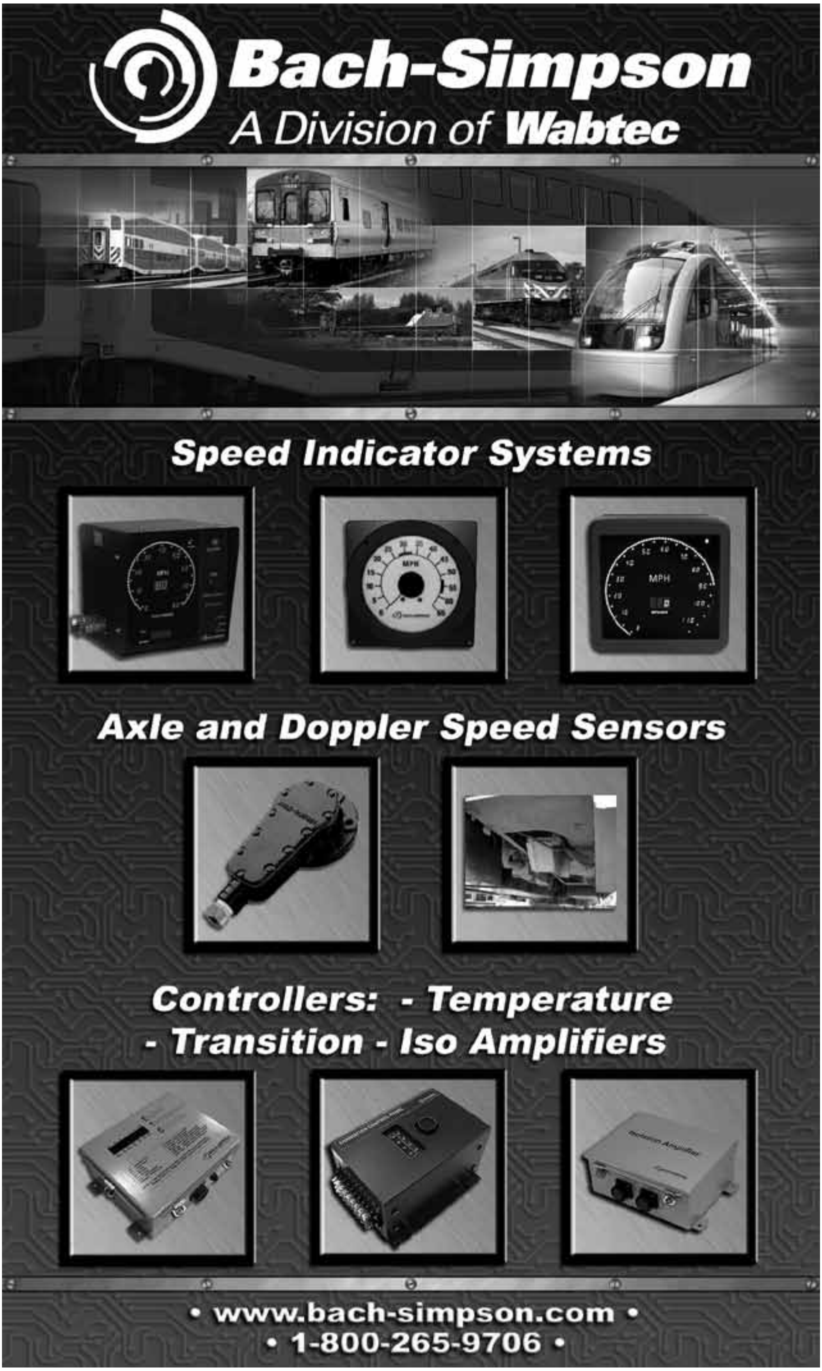
The MIL standard MIL-DTL-26482 (formerly MIL-C-26482) details the requirements of two types of connectors: Series 1 and Series 2. These connectors are designed to protect the electrical contacts from damage during mating and un-mating. These circular multi-pin electrical connectors are also used in harsh environmental conditions and are designed to be sealed against fluids and dust. These connectors are mechanically mated with a bayonet type fastening technique which is part of the outside connector casing. Some of the parameters specified include Class, shell size, insert arrangement, contact, finish of shell, polarization of the connector (keying).

ASSOCIATION OF AMERICAN RAILROADS

AAR-S-512:

When incorporating new on board systems, it is recommended to perform a complete review of the trainline's electrical and mechanical requirements.

The AAR-S-512 standard details the recommended functions for the various trainline contacts on the vehicles and locomotives. The installation requirements are defined to ensure


Bach-Simpson
A Division of Wabtec
Speed Indicator Systems
Axle and Doppler Speed Sensors
Controllers: - Temperature
- Transition - Iso Amplifiers
• www.bach-simpson.com •
• 1-800-265-9706 •

intermixing of various eras of cars and locomotives doesn't cause compatibility issues.

APTA RP-E-019-99

The APTA RP-E-019-99 document contains the details related to hardware and interfacing of the MU control and communication trainlines on the vehicles and locomotives are described within this document. Contact functions and installation requirements on vehicles are also defined to ensure intermixing of cars and locomotives of varying designs doesn't affect the mechanical maintainability and electrical compatibility of the various trainline systems.

National Electrical Manufacturers Association

The NEMA standard contains details on equipment enclosure ratings pertaining to various environmental conditions. This NEMA standard for electrical enclosures should be reviewed as the interfacing to a system's electrical connector may affect the rating of the equipment's enclosure. Commonly the NEMA 4 & NEMA 12 enclosures are installed on rail vehicles and locomotives.

The NEMA 4 specifies "a degree of protection against falling dirt, rain, sleet, snow, windblown dust, splashing water, and hose-directed water; and that will be undamaged by the external formation of ice on the enclosure."

The NEMA 12 specifies "a degree of protection against falling dirt; against circulating dust, lint, fibers, and flyings; and against dripping and light splashing of liquids."

International Electrotechnical Commission
IEC 60529

The IEC 60529 standard details an international classification system that describes the sealing of electrical equipment. It incorporates equipment enclosure ratings pertaining to various environmental conditions. The classification system uses an Ingress Protection (IP) code to define the sealing levels. The IP code uses a system of two numerical digits to define the level of both foreign object and moisture protection. Commonly IP67 / IP68 enclosures are used for equipment installed on rail vehicles and locomotives.

This standard should be reviewed as the interfacing to a system's electrical connector may affect the rating of the equipment's enclosure.

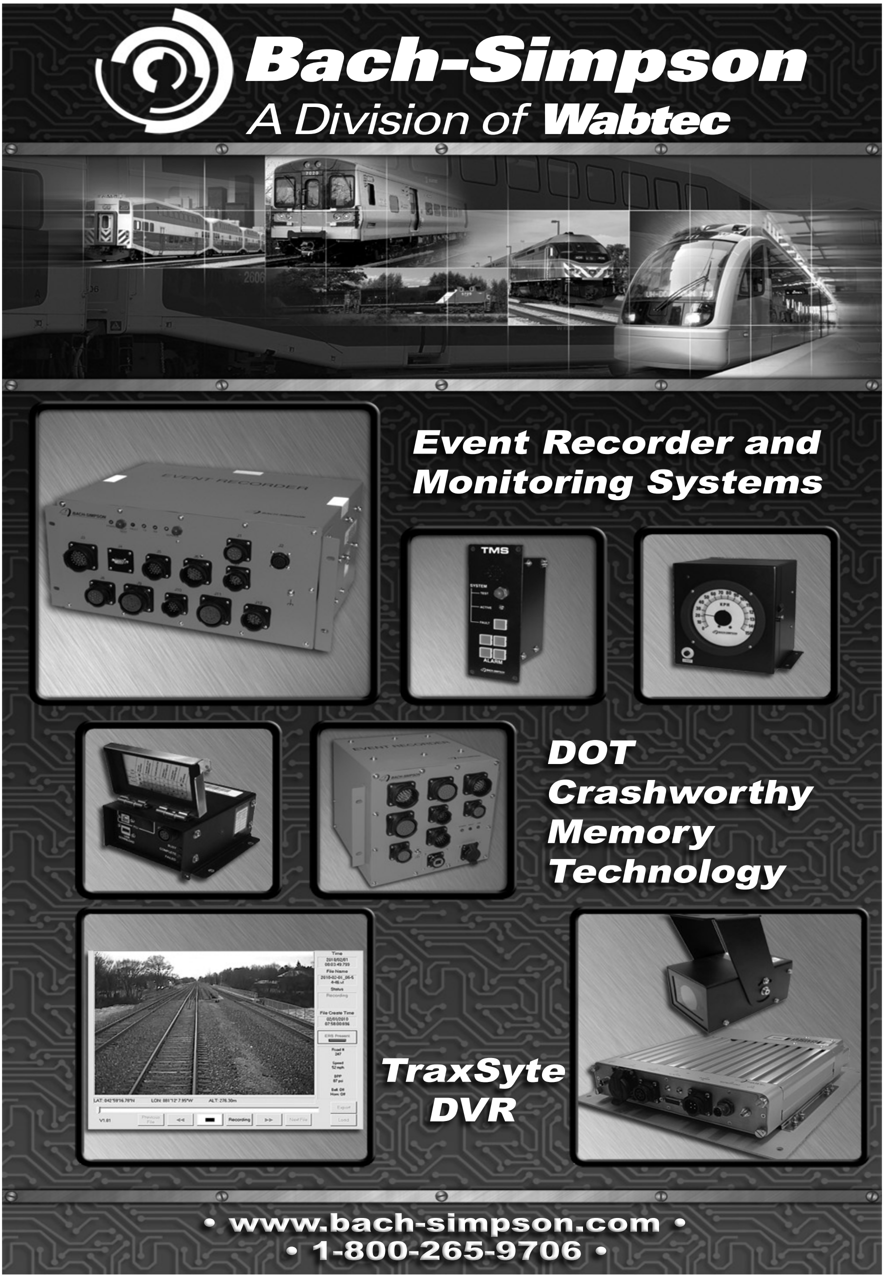

Bach-Simpson
A Division of Wabtec
Event Recorder and Monitoring Systems
TMS
DOT Crashworthy Memory Technology
TraxSyte DVR
• www.bach-simpson.com •
• 1-800-265-9706 •

Figure 1: Train line Connectors (Typical)

CONNECTOR OVERVIEW

Connector Types

Trainline Connectors

The trainline connectors are defined per the previously discussed APTA &AAR documents. There are some wiring differences between HEP systems as well as, control and communication trainlines. Should different era or vehicles from other transit /freight authorities be interfaced; ensure a complete review is done to verify compatibility. Example of trainline differences in configuration is the HEP Amtrak Style HEP versus "Western Canadian" HEP. Also voltage differences between HEP 480V versus 575V.

Circular Threaded Connectors

The circular threaded connectors are available in a variety of configurations from contact type to shell styles. As their description states they are mechanically mated with use of a threaded fastener on the outside of the connector casing. They are used on many system applications both internal and external to the vehicle.

Figure 2: Circular Threaded Connectors

Circular Bayonet Connectors

The circular bayonet connectors are available in a variety of configurations from contact type to shell styles. They are mechanically mated with use of a bayonet type fastening technique which is part of the outside connector casing. These connectors are becoming more widely used and specified than the circular threaded type connectors previously discussed. These connectors are used on many system applications both internal and external to the vehicle.

Figure 3: Circular Bayonet Connectors

Rectangular Locking Connectors

The rectangular locking connectors are used in on-board system applications. The locking mechanism prevents the connector from becoming unseated.

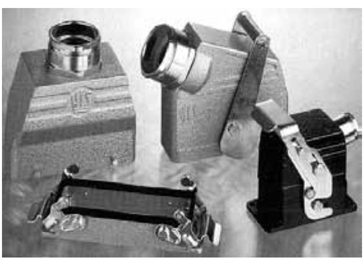


Figure 4: Rectangular Connectors

RF, Coaxial Connectors

There are many types of RF coaxial connectors. They are typically used for communication applications such as GPS (Global Positioning Systems), radio, and wireless monitoring systems.

Figure 5: RF, Coaxial Connectors

Modular Jack (RJ45)

The modular jack (RJ45) has been previously used and still used for Ethernet applications, networks, and PTE (Portable Test Equipment) interfaces. The modular jack (RJ45) connectors are gradually being replaced with the more industrial M12 connectors.

Figure 6: Modular Jack (RJ45) Connector

M12 (D-Coding) Connector

The M12 connector 4-pin version with D-coding is becoming the industrial Ethernet connector of choice. These M12 connectors are now being recommended for nearly all network specifications and also meet the IP67 protection standards. Typically, applications are for Ethernet, car network, video, and PTE interfaces. These connectors were traditionally used to connect sensors and actuators in automation systems. The IEC 61076-2-101 (Amendment 1) details the 4-pole D-coded variation used in Industrial Ethernet applications. It should also be noted the D-coding prevents the other M12 connector variations (A-Coding, B-Coding) from being incorrectly connected to an Ethernet connector port. These M12 connectors meet the EIA/TIA standard of a Category-5 modular jack (RJ45) connector.

Figure 7: M12 Type Connector

Blade Connector

The blade connector is a single conductor connection using a flat blade which is inserted into a blade receptacle. The commonly known blade connector type is the Faston® a trademark of Tyco.

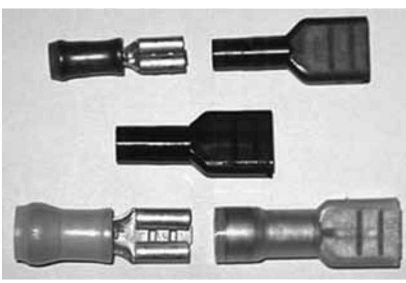


Figure 8: Blade Connectors (Receptacle)

Ring / Spade Terminals

The ring terminal and spade (split ring) terminal are electrical contacts made for inserting a screw or bolt into them. The spade (split ring) terminal design allows the screw or bolt to be left partially screwed in as the spade terminal is removed or attached. The terminal sizes are determined by the size of wire (AWG) and /or the Screw diameter.

Figure 9: Ring Terminals (Typical)

FIELD SERVICE CHALLENGES

Mating Connectors & Contacts

If maintenance /repair activities involve interfacing to or replacing existing connectors; a detailed review of the connectors should be done to ensure connector compatibility and avoid possible problems. The following are other examples of connector details which should be checked: correct contact plating (E.g. gold, silver, tin, phosphorous bronze), galvanic reactions from dissimilar metals, service ratings, proper size for wire gauge being terminated.

Figure 10: Incompatibility

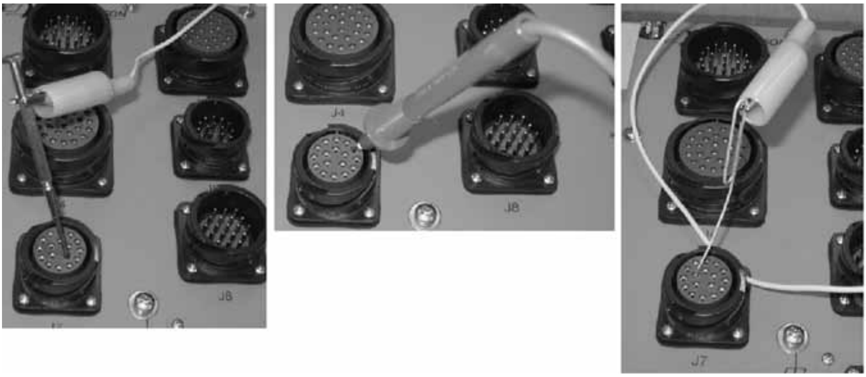


Figure 11: Examples of foreign objects inserted during troubleshooting
Unseated / Worn Locking Mechanisms

The use of incompatible connectors during rebuilds or repair replacements may lead to connector mating issues which in turn can cause intermittent and unreliable terminations.

POSSIBLE CAUSES: INTERMITTENT /POOR CONNECTIONS

Foreign Objects

As electrical connections require good mechanical connections / terminations, any damage, deformation, degrading of the electrical connectors contacts will or may lead to intermittent connections. Proper care should be taken to ensure foreign objects (items not designed specifically for connector) from being used. Although the connector damage may be unintentional and go visually unnoticed, the insertion of foreign objects into connector contacts during troubleshooting, replacement or removal of systems can lead to additional intermittent issues needing future resolutions.

Another common cause for intermittent connections can be caused by unseated, worn connectors when locking mechanisms are not locked in place. When system's electrical connectors are disconnected, connectors should be visually inspected for damaged or worn locking mechanisms. Upon reconnections, the electrical connectors should be checked and verified they are completely locked and seated into the correct positions.

Training / Workmanship

As with all work activities the proper training and guidance of manufacturer instructions, and tool operating procedures should be followed. This will also help in reducing the opportunity for intermittent problems from occurring.

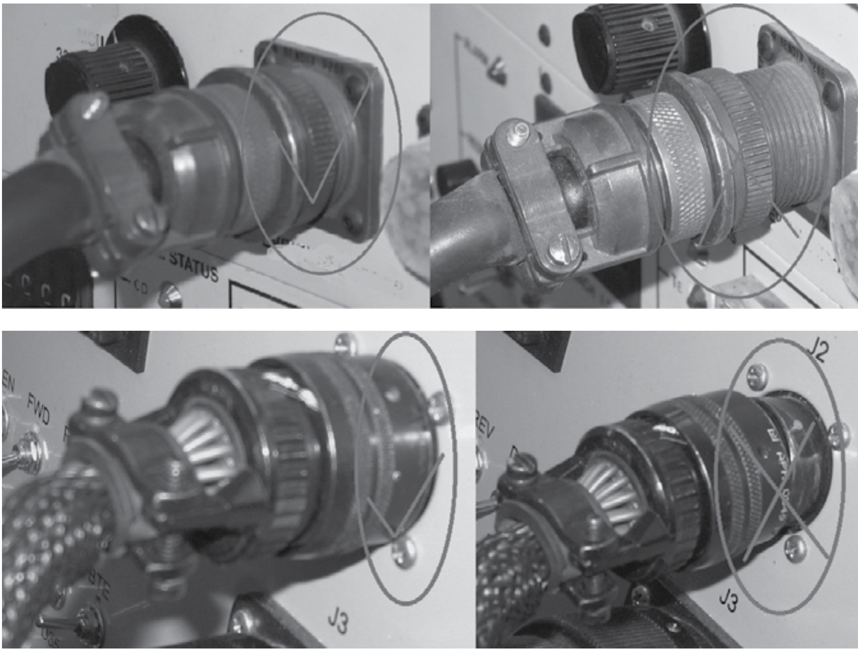


Figure 12: Examples of Seated & Unseated Connectors

Figure 13: Training

Tools

As previously discussed, with use of all tools, proper operation is a must. Follow all manufacturer instructions and tool operating procedures.

Some electrical connectors may require the use of specialty tools (E.g. crimping tools, connector pin insertion tools) in order to terminate, insert or remove connector contacts. An assessment of the tools required should be performed.

Avoid interchanging between various manufacturers' tools; using crimper from manufacturer A to crimp manufacturer B connectors.

Figure 14: Differences

Many connectors look visually similar but may have slightly different


NOW OFFERING...
A Complete Network of Locomotive Support!
Design & Fabrication
Emissions Reduction Packages
Engine & Truck Overhauls
Component Services
Electrical Cabinet Upgrade/Rebuild
Mobile Maintenance
Easy Access
4 USA Shop Locations
Routine Maintenance & Complete Overhauls
For more information:
713.222.0792
wgsinfo@wabtec.com
Wabtec®
GLOBAL SERVICES
Your Locomotive Network

crimping techniques which can jeopardize the crimp termination of the contact.

The use of "general multi-purpose" tools should be also avoided.

Figure 15: "General Multi-purpose"

The best approach should be to use only full cycle ratcheting tools when crimping connector contacts.

Figure 16: Crimping Tools (Typical)

Also avoid use of damaged or worn out tools!

Figure 17:

Safety

As with all work activities the proper guidance of shop safety procedures, manufacturer safety instructions, and tool safety procedures should be followed. This will ensure workmanship / good quality and personal safety are not compromised.

Figure 18:

Procuring Parts

It should be noted that if customized connectors are used in systems they generally are not a stock item at the manufacturer or distributor. Therefore it is recommended for service repairs to have a safety stock of these items as these generally have a longer lead time compared to ordering standard items.

Testing

After completion of the maintenance activities, a system test should be performed to confirm the repaired/ replaced system component has been properly installed and that the system functions correctly.

SUMMARY

As with all aging equipment there will always be the requirement for maintenance, upgrades, rebuilds. With proper planning, reviews and good workmanship a reliable system will be achieved.

Remember: "A good maintained system is a good reliable system"

REFERENCES

MIL-DTL-5015
MIL-DTL-26482
AAR-S-512
APTA RP-E-019-99
Wikipedia.org
National Electrical Manufacturers Association Standards
International Electrotechnical Commission

Locomotive Batteries and Long Term Storage

The Locomotive Maintenance Officers Association was requested by Class 1 CMO's to review long term storage of locomotives and present some recommendations due to the present substantial reduction in traffic. The Electrical Committee has reviewed areas that should be addressed and one area that was identified as needing immediate attention are the locomotive batteries. Lead acid batteries are a substantial investment to the railroad especially when considering the numbers of locomotives stored due to the present economic condition. These batteries if not properly addressed will self- discharge exposing themselves to internal damage caused by sulfation and potential freezing in cold weather conditions.

This paper is taking a realistic approach to the problem being faced with the high number of locomotives in storage and what can be done to limit economical losses of batteries. Under ideal conditions batteries should be removed and placed on trickle charge for protection. The sheer numbers involved make this unrealistic.

There are several key issues that will be addressed in this paper:

1) **Lead acid battery basic facts.**
2) **Minimum requirements when storing batteries on board or removed.**
3) **Importance of reviewing stored fleet.**
4) **Actions that can be implemented to reduce battery losses and costs.**

LEAD ACID BATTERY BASIC FACTS

It is important to understand some basic facts when dealing with the long term storage of lead acid batteries as these facts will establish key time lines and practices.

LEAD ACID BATTERIES WILL SELF DISCHARGE WHEN STORED

Lead Acid batteries will self-discharge even when no load is present. The rate of self-discharge for lead acid batteries depends on the storage, operating temperature and condition of the battery. At a temperature of 80 degrees F, a lead acid battery will self-discharge at a rate of approximately 4% a week and up to 1% per day in higher ambient temperatures. It is important to note that these discharge rates will reduce as ambient temperature decreases but in order to set a timeline for preventative action the 4% per week will be used. For those locomotives stored where ambient temperatures normally exceed

80 degrees F for extended periods, it is recommended to use the 1% per day and judge accordingly.

% CHARGE VS SG

% charge	Specific gravity*
100	1.255 – 1.275
75	1.215 – 1.235
50	1.200 – 1.180
25	1.165 – 1.155
0	1.130 – 1.110

*Corrected at 27°C (80°F). Add/subtract 0.003 for every 5°C (10°F) decrease/increase.

Sulfation: the number one cause of battery failure

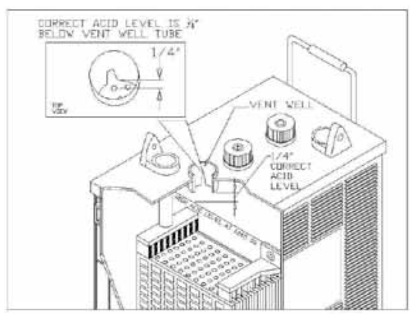
If the battery has not remained discharged for long or has only been discharged slightly, this is a relatively easy process to reverse. However, when the battery has remained discharged for an extended period, the sulfate material can harden into crystals which are more difficult to convert. Until the sulfate is converted, the sulfated portions of the plates are useless, and the battery can accept and hold only a partial charge. Eventually, sulfation can ruin a battery.

GOOD PLATE NO SULFATION

BAD PLATE SULFATED

Electrolyte level

It is most important to make sure that the tops of the plates in a battery never become exposed. They should always be covered by electrolyte or they will quickly sulphate and the battery will fail.



Electrolyte in a lead acid battery may freeze

If your battery is partially discharged, the electrolyte in a lead acid battery may freeze. At a 40% state of charge, electrolyte will freeze if the temperature drops to approximately -16 degrees F. When a battery is fully charged the electrolyte will not freeze until the temperature drops to approximately -92 degrees F.

Freezing Points of Sulfuric Acid Electrolyte

Specific Gravity 25°C/25°C	Specific Gravity at freezing temperature	Freezing Point °C	Freezing Point °F
1	1.003	0	32
1.05	1.06	-3	26
1.1	1.115	-8	18
1.15	1.175	-15	5
1.2	1.235	-27	-17
1.25	1.305	-52	-61
1.3	1.365	-70	-95
1.35	1.405	-49	-56

MINIMUM REQUIREMENTS WHEN STORING BATTERIES ON BOARD OR REMOVED FOR STORAGE

1) Clean batteries with sodium bicarbonate or soda ash to assure no electrical leakage due to dirt or electrolyte residue.

2) Battery electrolyte levels checked and filled, if needed.

3) Batteries should be checked and recharged to a specific gravity of 1.250 to 1.275 a recharge should be performed at least every three months,

4) Disconnect battery leads and tape battery cables.

5) Grease all battery terminals with petroleum jelly.

IMPORTANCE OF REVIEWING STORED FLEET

Due to the unprecedented position that some railroads are facing with the numbers of locomotives stored. It is most likely that battery losses will be incurred simply due to the logistics involved with handling so many batteries. The question becomes what can be done to reduce these losses. It is critical that the stored fleet be reviewed and identified into different categories to minimize losses. The basis for this statement will become evident when we review the actions that can be implemented.

CATEGORIZATION AND REVIEW OF STORED FLEET CATEGORIES

1) Identify portion of stored fleet that could be cycled every 90/92 days back into service.
2) Identify portion of stored fleet that would be returned to service first.
3) Identify portion of stored fleet that would be returned to service last or never.

REVIEW

1) Review stored locomotive and identify where 1-3 year old batteries are installed. This could be performed through physical audit, records tak-

en when stored or through computerized data bases if available.

2) Review geographic areas where locomotives are stored and cross reference with annual average ambient temperatures. This is important to identify as different areas will require different handling as far as risk factors with lead acid batteries are concerned.
3) Review storing locations and evaluate which areas have ready access to shops where batteries can be recharged or charging stations can be set up. These locations will be the prime area to store first to return to service locomotives. Remote areas should only be storing last or never to return to service locomotives.

High ambient temperature areas present a high risk of unrecoverable sulfation damage. In these areas batteries may require recharging as frequently as every two months.

Moderate ambient temperature areas represent the least risk for sulfation and freezing and a minimum recharge every 3 months should ensure good survivability.

Low ambient temperature areas present a high risk of freezing batteries especially areas that experience continuous freezing temperatures for prolonged periods such as 1-2 months

Batteries in these areas should be removed prior to prolonged periods of freezing temperatures. If a battery freezes and cracks the case, there is potential for an EPA issue. In addition a cracked case will reduce the integrity of the case and could represent a safety issue when removing and relocating in the shops.

ACTIONS THAT CAN BE TAKEN TO REDUCE BATTERY LOSSES AND COSTS

1) Cycle as many locomotives as realistically possible in and out of service every 90/92 days. This will protect the batteries and other equipment. It will also retain a portion of the stored fleet that can be easily returned to service should traffic start to increase.
2) Locomotives that have been identified as last to return to service or never should have identified newer batteries removed, qualified and returned to store stock for use on running fleet as per railroad policy, with respect to age, state of charge, etc. This will reduce or eliminate purchasing new batteries for a period of time.
3) Locomotives identified in geographic areas with high risk of freezing should have batteries removed, qualified and returned to store stock for use on running fleet. This will reduce or eliminate purchasing new batteries for a period of time.
4) Select and categorize storing locations based on aforementioned information. This may require moving locomotives around but will reduce battery loses and will reduce return to service problems.
5) Ensure batteries are recharged every 3 months. This should be a priority on locomotives identified as first to return to service. These locomotives will represent the padding that may

be required when the traffic starts to pick up. Battery suppliers may have difficulty supplying sufficient quantities of new batteries for losses that may occur as a result of the unprecedented number of locomotives stored. They will require some lead time.

6) Have your Materials Department deal with battery suppliers to determine if they can store and periodically recharge some battery sets . Preferably at locations near shops. Also have them determine from the battery manufactures the potential lead time that could be expected on new batteries. This could be critical when traffic starts to pick up.

Long Term Storage
Electrical Rotating Equipment

The following is a list of components that fall under electrical rotating equipment:

- Main alternator,
- Generator
- Auxiliary Generator
- Starters
- Turbo
- Lube Oil Pump
- Fuel Pump
- Load Regulator
- Dynamic Braking Blower Motors
- Cab Heater Motors

If locomotive is going to be in storage less than six months, leave the brushes in place – no special preparation is necessary.

If more than six months, remove or lift brushes and leave them hanging on the shunts. Leave spring fingers in the up position.

It is not recommended to spray inside motor or alternators with any liquid rust or corrosion preventative. Place Vapor Corrosion Inhibitor (VCI) emitters in obvious places so removal is easy. Emitters and packets must be changed every six months. Partly seal large openings with tape and plastic, keeping in mind it is not necessary to make it air tight.

On steel slip rings, lift the brushes and slide a strip of VCI paper under the brush holders and ensure that the paper is centered so that all rings are covered. Latch the brushes and springs back in place with the brushes holding the VCI paper against the rings.

A copy of the storage procedure with numbers and locations of all protective material (VCI paper, emitters and packets) should be placed in a conspicuous place on the locomotive to assist in returning the locomotive to service.

Control Stands, Electrical Cabinets and Electronic Equipment

1. Attach VCI emitters or packets inside
2. Manually operate motorized switchgear to midpoint position so contacts are not touching.
3. Place a 4” x 4” piece of VCI paper in each MU receptacle and tape the cover closed.

Displays: Extended exposure to direct sunlight can cause damage to an LCD. Cover with dark paper or plastic or cover all windows from the inside. This will also protect cab upholstery, plastic, etc.

Cab Electronics: Bring all backup batteries up to date before storage - anything that can lose its programming due to backup battery failing. Install new and record date.

Removal from Storage

Main Batteries

- Top up with water
- Recharge
- Do not connect to locomotive circuits
- Leave all breakers off

Undo Preparations

- Remove corrosion inhibitors – paper, film, capsules, coatings
- Replace removed components – brushes, batteries, fuses, radios – ensure brushes move freely
- Remove protective coverings – windows, displays, sensitive components

Inspection and Cleaning – Power Off

- Inspect-exposed, vulnerable – close attention
  1. Electrical cabinets
  2. Control compartments
  3. Rotating machines
  4. DB grids
  5. MU receptacles and jumpers
  6. Traction motor
- Remove foreign matter
- Activate switches and breakers
- Replace missing or blown fuses
- Replace missing parts
- Look for water ingress and corrosion-correct as required
- Corroded slip rings – light corrosion-clean with abrasive pads; heavy corrosion may require machining
- Corroded contacts on switch gear
  1. Light corrosion-clean up
  2. Heavy corrosion-replace contacts
  3. Don't file contacts
- Check memory back-up batteries-may be expired or close to it

Inspection and Tests-Battery Power

- Connect main batteries
- Turn on breakers and switches-check for odors, smoke, blown fuses and tripped breakers
- Ensure ALL software is up to date
- Set clocks on microprocessor-based devices
- Test emergency fuel cut-offs
- Perform self test-tests that must be performed with engine stopped, e.g. relay, contactor tests

Inspection and Tests-Engine Running

- Prepare to start engine
- First ensure that mechanical inspections and tests are done and that protective guards are in place and secured
- Start engine
- Observe noises, odors, smoke, vibration
- Inspect, test and correct as required
  1. Battery charging voltage at idle
  2. Lights
  3. Traction motor cut out
  4. Heated windshields
  5. Refrigerator
  6. HVAC
  7. Radio
  8. Ground relay
  9. Event recorder
  10. Alerter/Vigilance
  11. Layover heating system
  12. AESS
  13. Blowers
  14. Radiator cooling fans
- Perform self-tests – tests that must be performed with engine running, e.g. cooling fan test

Self-Load Test-Low Power

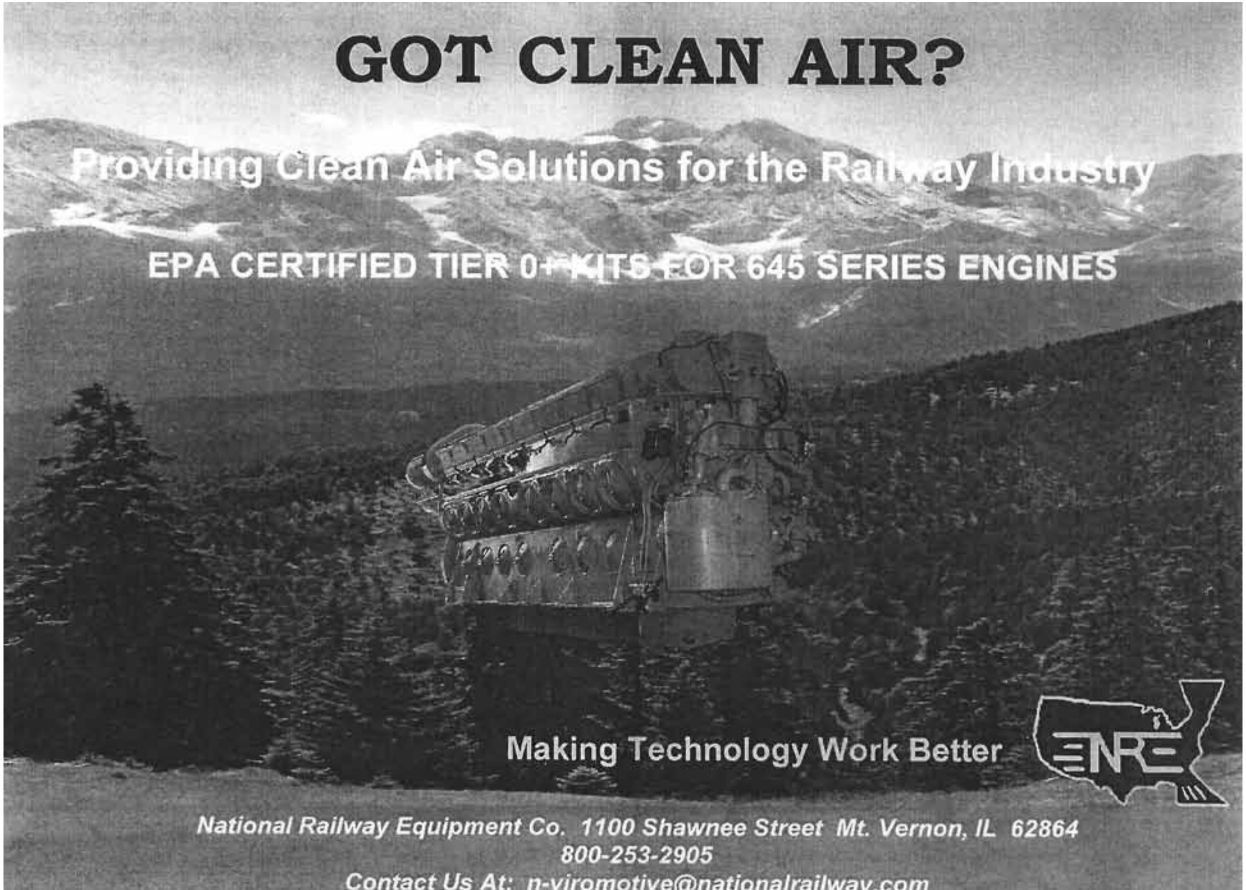
- Perform self load test, low power
  1. Not external load box
  2. DB grids, blowers must operate
  3. Allow components to warm up and dry out
  4. Observe noises, odors, smoke, vibration
  5. Observe DB grids
  6. Stop load test
  7. DB grids? Heat, contamination-bad mix
- Inspect DB grids, rotating machines, switch gear
- Measure insulation resistance (megger)
  1. Pass: next step full power load test
  2. Fail: find and correct the problem, then perform full power load test
- Perform full power self load test
  1. Increase power gradually
  2. Observe noises, odors, smoke, vibration
  3. Observe DB grids
- Head End Power (passenger units)
  1. Power plant (if equipped)
  2. Output voltage
  3. "Train line complete" control circuits

Movement-MU Tests

- Perform single unit movement test
- First ensure – air brake inspections, tests done
- Low speed – both directions
- Observer on the ground to listen for abnormal noises and ensure all wheels rotate properly
- Perform MU operation test
  1. Lead, trail
  2. Both directions
  3. Test all MU functions
- Test cab signal systems

Final Preparations

- Perform inspections that are due – regulatory and non-regulatory
- Download fault logs-correct problems
- Apply seals to switches and breakers
- Keep unit "close to home" for a few trips
- Expect higher than normal failure rates – a smooth return to service


GOT CLEAN AIR?
Providing Clean Air Solutions for the Railway Industry
EPA CERTIFIED TIER 0+ KITS FOR 645 SERIES ENGINES
Making Technology Work Better
NRE
National Railway Equipment Co. 1100 Shawnee Street Mt. Vernon, IL 62864
800-253-2905
Contact Us At: n-viromotive@nationalrailway.com

Long Term Storage Electrical Equipment

This paper covers non-battery related electrical systems. Batteries were covered very well in another paper presented at the same time. The electrical committee investigated all electrical components onboard the locomotives, reviewed OEM and Supplier documentation, and railroads existing policies to determine the best practices when dealing with long term storage.

To begin with a definition of long term is necessary. The time frame for this has been defined as 6 months or longer. Locomotives stored for less than 6 months should be secured from the elements but little extra work needs to be accomplished prior to storage to protect the locomotive. Locomotives stored for short periods of time should be inspected prior to entering and operation. The inspection should begin with a ground level walk around to verify bees, wasps, birds, spiders, violent animals, and insects have not inhabited the locomotive. Inspections should also include visual inspection of any area the operator will place hands and feet to verify no vandalism has occurred that would injure the operator.

Placement into storage

While most railroads are already in the process of removing locomotives from storage some discussion will be made here on what to do prior to placing locomotives in storage. This may be useful when the railroads park a locomotive for an engine failure, waiting to sell it, find they do not need it for a long period of time due to another reduction in rail traffic or some other reason. In any of these cases wanting the locomotive to be useful or sellable is desired.

Again this will deal with long term storage only. First, brushes should be removed or at a minimum lifted off the rotating surface. Spring fingers should be left in the up position. Vapor inhibitors are available to apply to rotating surfaces and inside electrical cabinets.

Many electronic components have internal batteries. Those batteries should be brought up to date. This will prevent loss of programming while in storage. Screens should be covered with dark paper to prevent light damage. A plastic cover or foam over the screen will prevent most vandalism. Applying dark paper over the windows instead of the screens would also provide protection to upholstery and prevent discoloration of plastic and other components.

One of the most important items to accomplish before placing a locomotive into storage would be to make sure the locomotive works well before placing into storage or if this is not practical know and document well what needs to be done prior to use after removal from storage.

Removal from storage

It is easy to say "undo the storage preparations" and it is another thing to actually accomplish this. Ideally when a locomotive comes out of storage the railroad will have some notice of when that will occur. It is recommended that if there is any outstanding work to be accomplished on the locomotives that this work be performed before the locomotive is released. One way to accomplish this is to have any projected material needed for all locomotives in storage routed to the storage location(s) ready to be used. Performing necessary work and delaying a locomotive's return to service by a shift or a day will pay big dividends later when the locomotive fleet has less work to do when all the locomotives are needed.

To begin with the removal process, carefully remove all corrosion inhibitors, screen covers, stack covers, etc, verify all doors, windows operate and install new/reconditioned batteries. As mentioned before give the locomotive a thorough inspection to include grids, rotating equipment, cabinets etc to identify and prevent problems before they occur. After installation of batteries check for low voltage grounds and turn on circuit breakers and switches one at a time until all are on and nothing unusual happens. Slowly turn on all systems one by one until all systems are on.

After the locomotive has been fueled and water added start the locomotive and allow idling for a significant period of time. 30 minutes would not be too long, test the AESS system, if equipped, verify the alerter and any computerized components work and slowly verify there are no issues with the locomotive at idle. Verify during this idle period that water and oil flow is occurring and temperatures are rising as normal. Verify no air, oil, water and fuel leaks exist. A load test of the locomotive should now be performed and again should be performed slowly with several minutes in each notch level. It is recommended that inspections of grids and cabinets be made while being load tested prior to proceeding beyond notch 3.

After the locomotive has been fully checked out it is now ready to pull freight. Here caution should take place also. The locomotive should, if possible, be used in local service as much as possible for a week or so. This will allow unseen issues to be fixed quickly and with little impact instead of while operating as a lead locomotive pulling freight for a valuable customer in the mountains.

Report on the Committee on Diesel Mechanical Maintenance

Tuesday, October 19, 2010

8:45 A.M.

Chairman

Jeff Cutright
Assistant Manager
Norfolk Southern Corp
Roanoke, VA

Vice Chairman

George King II
Chief Mechanical Officer
New York Susquehanna & Western RR
Copperstown, NY

Commitee Members

R. Aranda	Genl Foremann-Locos.	Belt Rwy of Chicago	Bedford Park, IL
I. Bradbury	CEO	Peaker Services	Brighton, MI
S. Bumra	Assistant Manager	Amtrak	Chicago, IL
D. Cannon	Mgr-System Loco Mgr	BNSF Rwy	Ft. Worth, TX
M. Daoust	CMO	Tshiuetin Rail Transp.	Clarke City, PQ
T. Frederick	Mech. Engineer	CSX Transportation	Jacksonville, FL
D. Freestone	Mgr-Loco Opns	Alaska RR	Anchorage, AK
C. Fukala	CMO	Rail America	Sherwood, AB
J. Hedrick	Principal Engineer	SW Research Institute	San Antonio, TX
T. Kennedy	Mgr-Mech Engrg.	Union Pacific RR	Omaha, NE
A. Mallette	Sr. Rolling stock Mgr.	RailPros Inc	Los Angeles, CA
D. Nott	President	Northwestern Consulting	Boise, ID
C. Shepherd	CMO	Arkansas & Missouri RR	Springdale, AR
J. Sherbrook	VP & GM	Loco Docs, Inc	Trussville, AL
T. Standish	Quality Mgr	Electro Motive Diesels, Inc	LaGrange, IL
*R. Svoboda	Mech Compliance	Metrolink	Los Angeles, CA
* G. Winsel	Supervisor	Canadian National	Edmonton, AB
K. Wollschlager	Reliability Technician	Trico Predict	Pewaukee, WI

* Standby

Note: Bob Singleton of TransPar Corp joined the committee at the Monteal Convention In October
Dennis Nott is a Past President of LMOA

PERSONAL HISTORY

Jeff Cutright

Jeff was born in West Virginia and attended WVU earning a BSME in 1979. He joined Norfolk Southern (NS) in 1980 as a management trainee after a year and a half with Weirton Steel. Jeff has held many positions in the NS Mechanical Department, including staff and shop supervision. His work experience includes production monitoring and scheduling, as well as locomotive maintenance, repair, overhaul and emissions compliance. The majority of Jeff's career has been in locomotive back shops that specialized in both GE and EMD engine and component overhaul. Jeff has been active with LMOA since 1994. Jeff earned an MBA from Averett University in 2004. Jeff and his wife Loenita have two daughters, Sarah and Haley, in college who play collegiate sports. Sarah is a catcher and infielder in softball. Haley is a distance runner. Leonita teaches nursing. Jeff enjoys photography, cycling, mountain biking, and being outdoors.

The Diesel Mechanical Maintenance Committee had a conference call on November 11, 2009 to discuss their technical papers for 2010.

The committee would like to thank Southwest Research Institute for hosting their meeting in San Antonio, Texas on March 18, 2010—Special thanks go to fellow committee member, John Hedrick, for arranging the meeting.

EMD Turbocharger Change Out Best Practices

Tim Standish
Electro-Motive Diesel, Inc.

George King
New York Susquehanna and Western Railroad

One of the most complex pieces of mechanical equipment on a locomotive is the turbocharger and due to its high operating temperatures, speeds, tight tolerances, and small oil film thicknesses, it is also one of the more sensitive components. However, with proper troubleshooting, installation, and maintenance, the turbocharger will perform as intended throughout its useful life. There are three main points to keep in mind when working on EMD turbochargers: 1.) Determination of the root cause of the failure is critical before applying a replacement, 2.) Proper installation techniques ensures trouble-free start up, and 3.) Scheduled maintenance is key to turbo longevity, fuel economy, and emissions compliance.

Turbocharger Overview

Before going into these main points, a brief overview of the EMD turbocharger will be covered to help understand its unique design. The turbocharger assembly is primarily used to increase engine horsepower and provide better fuel economy through the utilization of exhaust gases. The turbocharger has a single-stage turbine with a connecting gear train. The gear-drive system takes energy from the engine's crankshaft and transmits it to the turbine wheel through a planetary gear drive system when exhaust gas energy levels are not sufficient to drive the turbine wheel. Under conditions such as engine starting, low speed/light load periods of operation, and rapid acceleration there is insufficient exhaust heat energy to drive the turbine fast enough to supply the necessary air for combustion. During these times, the engine is actually driving the turbocharger through the gear train assisted by exhaust gas energy. Dependency on the gear drive system decreases as exhaust energy levels increase, until eventually no mechanical assist is required. It is the function of the overrunning clutch to "disengage" the gear drive. This is accomplished by allowing the rotating assembly to "overspeed" the driving gear train while the gears remain engaged. When the engine approaches full load, the heat energy in the exhaust, which reaches temperatures approaching 1000°F (538°C), is sufficient to drive the turbocharger without any help from the engine. At this point, an overrunning clutch in the drive train disengages, and the turbocharger drive is mechanically disconnected from the engine gear train. It should be noted that EMD 567/645 turbos have an internal overrunning clutch (part of the turbo) whereas the 710 has an external clutch that is part of the rear end gear train.

Another note is that there is an adapter/screen assembly (see figure 1) that goes between the exhaust manifold and the turbine inlet scroll. This screen functions as a protective device for the turbocharger by minimizing the possibility of foreign material, such as broken piston rings and small exhaust valve pieces, entering the turbine and damaging the turbine vanes. Current screen designs include a small trap box at the base of the adapter assembly to remove foreign material from the exhaust flow, thereby preventing it from continuously hitting the screen and breaking into smaller pieces. Now that the basic description of the turbo design has been covered, the key points mentioned in the first paragraph will be covered.

Troubleshooting/Inspections

The first point to cover is that determining the root cause of a turbo failure is critical before applying a replacement. It is estimated that around 85% of all turbo failures are due to external factors and not a failure originating within the turbo itself; therefore, it is obvious that before applying a replacement turbo its failure mode is determined. It is important to complete all inspections even if a failure mode has been identified since multiple conditions may exist. It is also good practice to inspect turbos that are being removed as part of routine maintenance. Troubleshooting engine performance that may be related to the turbo will not be covered in detail but some items that may point to a turbocharger problem include low turbo RPM, low airbox pressure, oil out the stack, low horsepower, turbo surging/burping, oil leaks, exhaust leaks, and opacity violations. If the turbo is identified as a potential problem from engine troubleshooting the areas that may require inspection include the turbo air inlet, exhaust inlet, exhaust outlet, and the rear end gear train.

Prior to any inspections, observe all shop safety rules including any flagging or lockout procedures and also reference applicable engine maintenance manuals for further instructions or precautions. The order of these inspections should be based on what symptoms that the engine was exhibiting or what can be learned from trouble reports or fault logs.

To conduct an air inlet inspection, remove the rubber air intake boot and flange and inspect the impeller for broken or nicked vanes due to foreign material (see figure 2) or any visible signs or rubbing. Foreign material damage to impeller can be due to debris being left in the filter housing from a previous turbocharger failure and being drawn into the new turbo. Damage can also occur if there is a misapplication of the compressor inlet boot in which the boot may travel and a clamp may enter the impeller and destroy it. If there is damage to the impeller the turbo needs to be replaced, the air filter housing cleaned out, and the air intake filters replaced. Inspect the aftercooler ducts and cores for debris as pieces of the impeller may enter the air duct and damage the aftercoolers. Also inspect for impeller rubbing which is often caused by an unbalanced condition within the turbocharger and can be detected visually or by excessive movement of the impeller. Unbalance conditions are often due to a turbine bearing failure which rarely occurs without an external contributing input. Therefore the turbocharger should be inspected for other defects prior to application of a replacement turbo such as damage to turbine blades or a lack of lubrication. If no damage is observed on the turbine blades the lube oil flow needs to be confirmed after installation of the replacement turbo prior to returning the engine to service; this will be covered in the installation section.

If the turbo clutch is suspected, turn the impeller by hand to check for a locked-up condition or a badly damaged clutch. It should turn freely in the counter-clockwise direction, but engage when turned clockwise. It is usual for a malfunctioning clutch to slip only intermittently, therefore only occasionally causing burping and smoking by its failure to engage therefore a roller clutch test should be performed. This test is outlined in the applicable engine maintenance manual troubleshooting section. If no defective conditions are found on the air inlet side of the turbo, reinstall the flange and the boot and inspect the exhaust inlet.

Inspection of the exhaust inlet (turbine inlet scroll) is conducted by removing the expansion joint and adapter/screen assembly and inspecting the leading edges of the blades and nozzle ring for damage through the nozzle between the 1:00 and 2:00 o'clock positions (see figure 3 and 4). Foreign material damage is generally in the form of small pieces of broken piston rings or exhaust valves that make it through the turbine inlet screen. It is recommended that whenever foreign material damage is observed in the turbine section that the turbo be removed prior to running it to destruction thereby increasing its repair cost. The power assemblies need to be inspected for damage such as broken piston rings, dropped valves, and scuffing. The screen must be removed and inspected for damage along with using magnetic particle inspection to check for cracks. The trap in the adapter/screen assembly (if equipped) must be cleaned out. The rest of the exhaust manifold should be inspected to ensure no other foreign material is present. The nozzle ring should also be inspected for deposits forming on the openings which indicate an engine problem such as a cooling water leak. Restriction of gas flow created by dented or plugged nozzles can cause the turbo to surge or "burp" at higher engine speeds therefore, inspect for internal water leaks.

Inspect the turbine blades to see if they are oily as this is an indication of worn power assemblies or excessive idling. Perform an air box inspection and pay particular attention to the condition of the piston, rings, and liners. If ring wear exceeds the recommended limits or if rings are broken, renew or replace power assembly. Also check the piston crown and port area for signs of oil problems in a specific cylinder. Excessively wet crowns and oil sludge throw off from the inlet ports may point out cylinders with oil control problems.

Next inspect the exhaust outlet for a warped diffuser, oil out the stack, or any other obvious failures. Exhaust diffuser vanes will appear to be "wavy" (see figure 5) when viewed from above if the turbo is subjected to an overheat/overspeed condition. Also look for a bulged turbine shroud which may also indicate an overheat/overspeed condition. The rotating assembly will be unable to turn due to elongated turbine blades from the excessive temperature and centrifugal force in which the blades contact the shroud. If the above conditions are found, the turbo will need be replaced, and the engine will have to be inspected for conditions that may create excessive heat such as broken piston rings, worn injector tips, broken exhaust valves, improperly timed injectors, incorrect valve timing, plugged aftercooler cores, and plugged engine air filters.

If there is oil out the exhaust stack (wet stack), check engine air filters for plugging. A lack of air to the turbo's labyrinth seals will cause oil migration across the seals, especially at higher speeds. If the turbine blades are found wet then the oil source is from engine, but if found dry, the turbo may have a true seal problem. Since labyrinth seals are non-wearing components, they have either plugged due to dirt or have become physically damaged from contact with the rotor as a result of a bearing failure. At this point, the turbo must be removed. Inspect the lube oil separator by removing the eductor tube looking for a damaged or missing screen, which would allow oil to be drawn out with crankcase vapors. Oil passage through the separator can occur when the flow rate through the separator exceeds design capacity. This is usually caused by combustion gases, ambient air, or pressurized air box air entering the crankcase. This condition is characterized by a reduction of crankcase vacuum, and can be detected by measurement with a manometer at the oil dipstick tube.

Removal

Once it has been determined that the turbo must be replaced, the steps from hatch removal to draining the cooling system to removing various connections to the turbo can be found in the applicable engine maintenance manual, therefore, only key points will be covered in this section. Point 1: On Tier 2 engines, the aftercoolers (charge air coolers) are to be removed as an assembly as the core is an integral part of the duct. Point 2: If turbo lube filter is extremely heavy and metallic particles are present, the main lube filter housing by-pass valve may be defective and must be verified and replaced if found defective. Point 3: When removing the turbo lube filter, don't drain it into the engine top deck as this is just putting contaminated oil back into the lube system. Point 4: When lifting the turbo, do not let the lifting chains press against the exhaust duct as this may damage to the duct. Point 5: Do not use torque wrenches for bolt removal as this a sure way to wear out, damage, or compromise its calibration; instead use a breaker bar or impact wrenches (depending on shop practices). Point 6: Use the jackscrews to drive the turbocharger away from the engine until the turbocharger pilot bore clears the No. 2 stubshaft. If the turbo does not clear the stubshaft and the turbo is lifted, it is probable that it will be broken which is very costly and time consuming to repair. A good tool for inexperienced employees, or even as an ongoing standard practice, is to use a scale on the lifting device for turbocharger removal. If the scale reads more than the turbo weighs when lifting and all the bolts have been removed, it is most likely that the turbo has not cleared the stubshaft. Point 7: It should be noted that engine timing will not be disturbed during turbocharger removal as long as the camshafts and crankshaft are not moved when gears are disengaged. If timing is suspected as a potential cause for the turbo failure or if the camshafts are moved while the idler gear is off, timing must be checked.

Inspection before Application of Replacement Turbo

There are inspections that need to be performed after the turbo is removed especially if the turbocharger is being replaced because of a failure. The replacement turbocharger should remain in the shipping container until actual application. Start with the exhaust manifold and inspect for foreign material, and completely remove any found. If the manifold condition is in doubt, remove and look for cracked leg baffles and cracked expansion joints which should be replaced. Inspect the screen/adapter assembly for debris and for plugging. A plugged screen must be cleaned as it will impact engine and emissions performance. It is best to Utex the screen assembly, in particular if debris is found in trap or if there is foreign material damage to the turbine wheel. Never grind or drill out holes to unplug the screen as this will impact turbo performance. A plugged screen can be an indication of an internal water leak, excessive oil blow by, excessive idling, or even from usage of ultra low sulfur diesel fuel with a high TBN oil. The engine air intake filters should be checked for foreign material and new ones applied after the filter housing completely cleaned out. Clean the air box to remove all evidence of aluminum dust and chromate or borate water stains. Inspect the cylinder assemblies for broken valves, valve blow, cracked pistons, broken piston rings, scored pistons and liners. Clean all gasket surfaces on the engine and remove any nicks or burrs. Clean the No. 2 idler turbocharger pilot stubshaft, using an oil stone and remove all indications of fretting. Inspect the seal groove for nicks and burrs, and smooth the surface after removal of any nicks or burrs. Check the gear train area and remove any metallic debris that might be found. Visually check the gear train for nicks, burrs, evidence of improper backlash, and uneven or excessive wear. Damage to the gears on the back-side of the

turbo is generally an indication of an engine gear train problem rather than a turbo malfunction. Inspect for metallic debris in oil drainage screen located just below the turbomounted idler gear. If a planetary gear train component is broken, the oil drainage will carry this debris with it, and will deposit the chips against the inside of the screen. Check the spring drive gear or clutch drive assembly. On 645 engines, qualification of the spring drive gear assembly includes verification that all bolts are tight and that the lock wires are in place and not loose or broken. Verify that springs are not broken, or appear to have been damaged in anyway. If the turbocharger has experienced a catastrophic failure, replace the spring drive gear assembly. Some railroads elect to replace the spring drive gear on any turbo replacement. On 710 engines, verify that the clutch drive gear assembly rotates freely in a counter clockwise direction and listen for any clicking noises when rotating clutch gear assembly. Any clicking noise is cause for replacement of the clutch drive gear assembly. Inspect clutch gears for foreign material damage and excessive gear tooth wear.

Installation

As noted before, the turbo is one of the more sensitive pieces of equipment on the engine due to the tight tolerances and correct installation is critical to ensure trouble free start up and to reduce or even eliminate early turbo failures such as gear train or turbo bearing failures. Just like the removal process, the instructions and installation torques are fairly straightforward and well detailed in applicable engine maintenance manuals therefore only key points will be covered. Point 1: The most crucial point to turbo installation, and one that will be covered in most detail, is ensuring that the turbo housing is not distorted upon application to the engine or when the aftercoolers or exhaust silencer is applied. If distorted, the rotating assembly will not be properly aligned within the turbo housing and bearing supports causing clearance issues and will ultimately lead to a bearing failure. To avoid this situation the turbo impeller clearance between the impeller blades and impeller housing must be verified at different stages of the installation process. This clearance is called the impeller "eye" clearance. See Figure 6.

First step is to take the initial eye clearance reading when the turbocharger is in its shipping container or stand prior to application. These clearances should not be taken while the turbo is hoisted in the air with the lifting chains as this may result in improper readings. To determine the impeller eye clearance: 1.) Remove the air inlet collar if applied and mark (chalk or marker) an impeller blade at the 12 o'clock position so that the impeller can be returned to this position when the eye clearance is rechecked after turbocharger installation. 2.) Insert approximately the same feeler gage thickness at the ends of the impeller blades at the 3 and 9 o'clock positions simultaneously to determine the available horizontal clearance. Clearances should be determined with a heavy drag on the feelers. Record the clearance for these positions and remove the gages. 3.) Use the feeler gage at the 12 o'clock position to determine the upper vertical clearance. 4.) Leaving the feeler gage in the 12 o'clock position, use another feeler to determine clearance at the 6 o'clock position. Record the clearances obtained.

There are various practices in the number of eye clearance readings that are taken during the turbo application process, but the main point is to ensure that the initial readings and the final readings match after all components have been applied and torqued. Intermediate readings may be taken to minimize the chances of having to reposition the turbo or other components after the installation is complete thus reducing the overall application time. The minimal time it takes to take multiple readings is easy to justify and is also good for understanding where distortions may occur along with aiding inexperienced mechanics in proper application techniques. If at all possible, the readings should be conducted by the same mechanic as each may have their own "feel" for these readings. One railroad does six eye clearance readings during the installation process (on the stand, after turbo application, after aux gen drive application, after RB air duct, after LB air duct, after screen/adapter is applied, and after exhaust stack is applied).

Continuing on with other key points for turbo application, Point 2: It is recommended (and mandated by some railroads) that impact guns are not used for turbo installation as this causes conditions such as housing distortion, over torqued components, and flange breakage. Point 3: Make sure that all steps for aftercooler duct application are adhered to as improper gaps will result in improper eye clearance readings and/or duct flange cracking. Point 4: When applying the aftercooler ducts, start with the right bank duct because if the left duct were installed first the bolts on the right could not be tightened. Point 5: When applying the expansion joint(s), the tapered end of the interior liner should be facing toward the front of the engine. This taper will not be evident by external viewing of the expansion joint. If expansion joint is installed incorrectly the expansion joint will burn out. Point 6: Use high temperature thread lubricant on exhaust outlet and inlet flanges as this will make for easier removal at next maintenance interval. Point 7: If the turbo is equipped with a temperature probe, make sure that it is not mistakenly put into speed sensor hole as this will cause damage to the impeller blades and the turbo will have to be removed (see figure 7). Point 8: Replace the lube oil check valves in the turbo filter housing. Point 9: The turbo lube oil filter and the soakback need to be changed and filled with clean engine oil prior to application.

Once the turbo has been applied and all components attached, cooling system filled, verify that the soakback system is functioning properly. This is done by applying a 0-100 psi gage in place of the pipe plug to the compressor bearing oil passage on the right bank side of the turbo (see figure 8). With soakback system running, pressure must be 10 to 35 psi, and if lower then 10 troubleshoot soakback piping. Open top deck cover and visually inspect that no oil is flowing from camshaft bearings, if there is the check valve needs to be replaced. The oil pressure at Governor should be zero. Visually inspect that a steady flow of oil is returning from the gear train to the oil pan by inspecting through the #16 crankcase cover. The oil flow should be 3 inches wide with cold oil and about 10 inches wide with hot oil. Once verified, the following steps must be followed to verify that turbocharger is operating properly: Step 1: Move locomotive out of the shop. All safety equipment must be in place and all carbody doors open start the engine. Step 2: Let engine idle until warmed up to at least 150° and verify the reading of oil pressure gauge on turbocharger. It should read the same as oil pressure gage at the engine start station. If the replacement turbo is being installed after a bearing failure, an evaluation of the soakback oil systems should be conducted by doing an oil pressure test as outlined in the applicable engine maintenance manual. Step 3: Shut engine down and wait for soakback pump to time out (approximately 35 minutes). Then remove test pressure gauge, apply pipe plug, and then start the engine. Step 4: Verify that no leaks are present at pipe plug where gage was installed also verify that no oil leaks are present at any location around the turbocharger. Step 5: Load test and check horsepower. Step 6: Check and correct all oil leaks, water leaks, and exhaust leaks. Step 7: Let engine idle and allow engine to cool down before shutting down the engine. Step 8: Verify soakback operation. Soakback pump must operate for at least 30 to 35 minutes after the engine is shut down. If soakback pump does not operate for 30 to 35 minutes corrective action must be taken and repairs made. Then re-qualify the operation of the soakback pump.

Maintenance

Scheduled maintenance is important to overall engine performance and in particular health of the turbocharger. Refer to applicable OEM scheduled maintenance instructions for specific items and intervals. Replace the turbo and soakback filters at the same interval and pre-fill both with oil before applying. It is good practice to do both and keep it consistent as this will avoid doing wrong one. Dating and putting a shop ID on the filter is also a good idea so that the last change is easily identified, and if there are issues with the last change, you can feedback information to that particular shop. Verify turbo soakback and lube system are functioning properly every 6 months. Ensure that the soakback pump is allowed to operate and not shutdown to allow for other maintenance to be performed prior to completing the 30-35 minute cycle as this will result in damage to internal components. Replace engine air filters at required intervals and also clean oil separator element every year. Inspect turbo screen, as it is susceptible to plugging with carbon and water treatment residue. Should screen become plugged, performance of the turbocharger and the engine will be adversely affected. Fuel economy will also be impacted with dirty intake filters and clogged screens. It is important to follow the emissions related maintenance to ensure proper engine emissions which is outlined in specific maintenance instructions. The proper part number turbocharger must be applied per emission critical components as outlined in the applicable emission kit instructions. Applying a turbo that may be "close enough" to the original equipment is not an option as specific turbine wheel and impeller matching is critical to emissions performance and fuel economy.

Summary

Turbochargers are a critical component to engine performance, emissions, and fuel economy. Proper troubleshooting, installation, and maintenance are essential components to turbo longevity. There are no shortcuts when it comes to the turbocharger; when all steps are followed early failures can be avoided.

Acknowledgements

We would like to thank the contributors to this paper which include Bill Hilgenberg, Mark Gronych, and Faria Yousuf from EMD along with Tom Kennedy from Union Pacific. We would also like to thank the LMOA Mechanical Committee for their review and feedback on this subject.

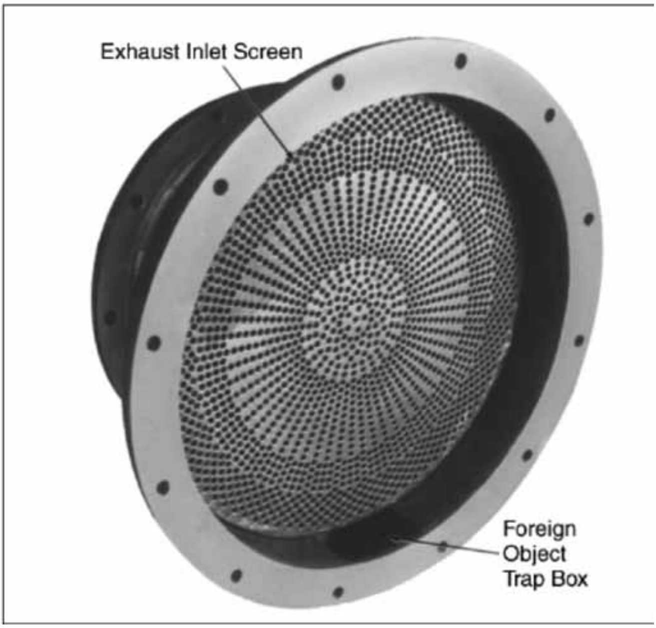


Figure 1: Turbo adapter/screen assembly

Figure 2 Impeller damaged due to foreign material ingestion

Figure 3: Turbine blade inspection through exhaust inlet scroll

Figure 4: Foreign material damage to turbine wheel

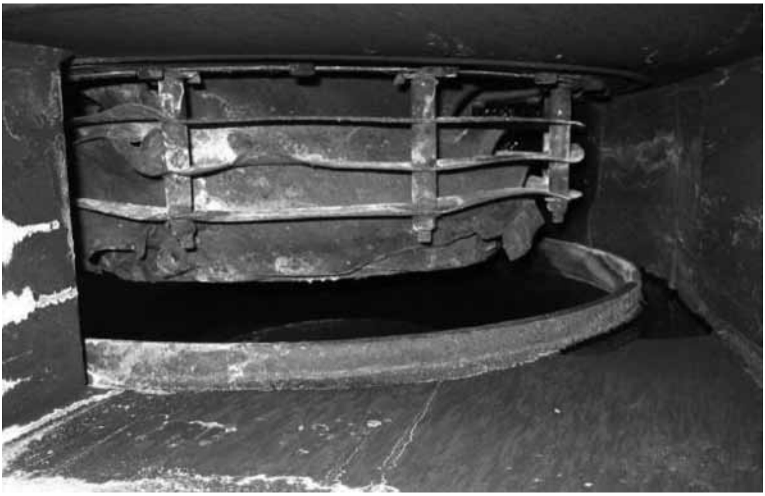


Figure 5: Warped exhaust diffuser

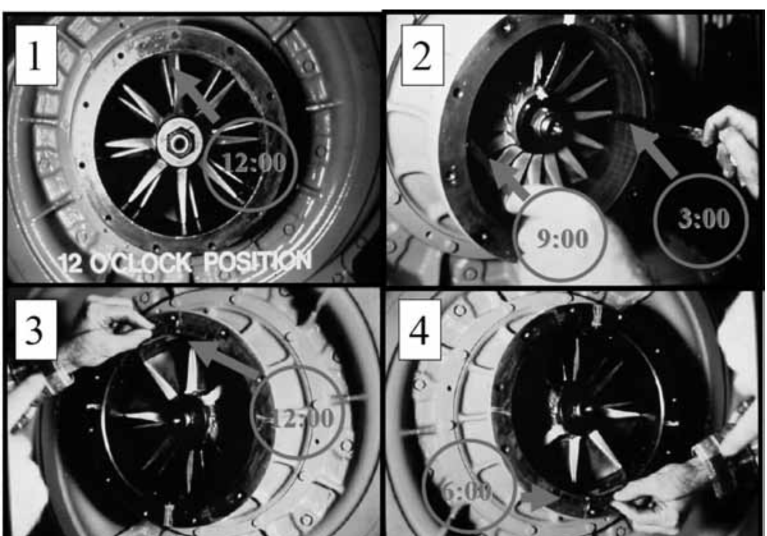


Figure 6: Impeller eye clearance measurements

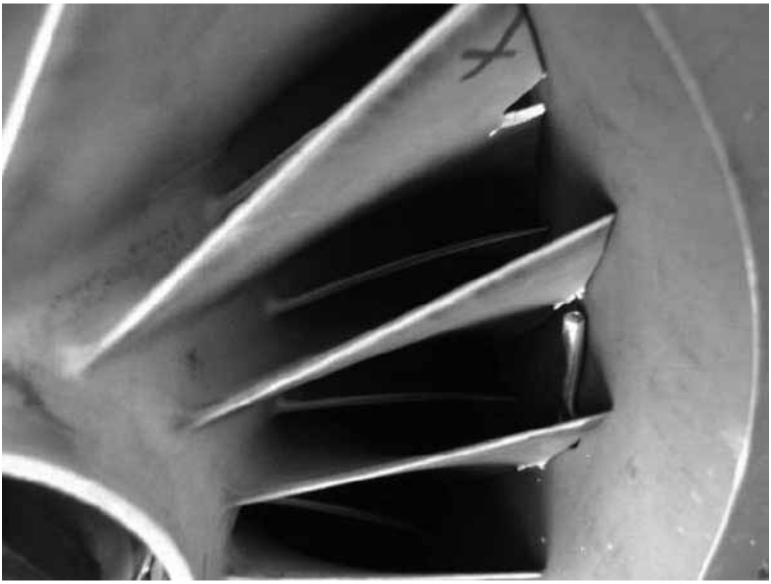


Figure 7: Temperature probe improperly installed in speed pickup hole

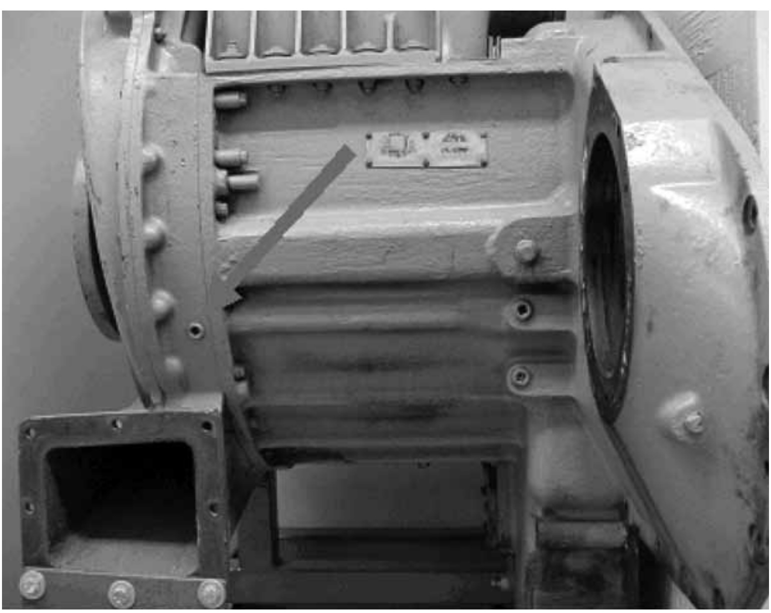


Figure 8: Where to apply pressure gage to verify oil pressure

Effect of Intake Air Filter Restriction on Fuel Consumption and Emissions

John Hedrick
Southwest Research Institute
San Antonio, TX - USA

ABSTRACT

This paper investigates the fuel consumption and emissions changes due to the addition of intake restriction on an Electro- Motive Diesel (EMD), two-cycle, 12-645E3 diesel engine. The intake restriction was introduced by blocking off the engine air filters, simulating increased engine intake air filter and inertial filter restrictions.

The tests show that there is an increase in the fuel consumption, PM emissions, and smoke opacity of the engine with increasing intake restriction.

TEST ENGINE

A 1,715 kW (2,300 HP) EMD 12 cylinder 645E3 engine was used to determine the relationship between the intake restriction and fuel consumption and emissions. This engine was installed in a test platform and is shown in Figure 1. Specifications of the test engine are listed in Table 1. This engine was tested for this project in a pre-Tier 0 configuration.

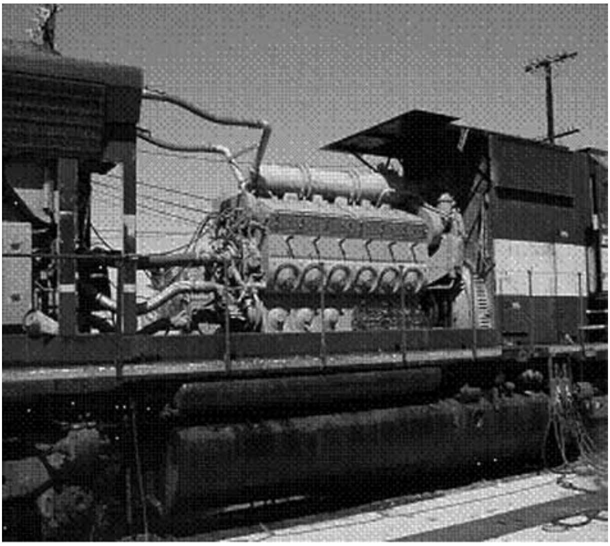


Figure 1. 12-645E3 Engine Installed in EMD SD45 Test Platform

TABLE 1. TEST ENGINE DETAILS

Engine Model	12-645E3
Rated Power	1,715 kW (2,300 HP)
Rated Engine Speed	904 RPM
Operating Cycle	2-Stroke Uniflow Scavenged
Cylinder Arrangement	V-12
Bore	230 mm
Stroke	254 mm
Displacement/Cylinder	10.75 L
Fuel Injection	Direct Mechanical Unit Injection
Boost Air System	Mechanically Driven Turbocharger with Overrunning Clutch

All testing for this project utilized Ultra-Low Sulfur Diesel (ULSD) known as Texas Low Emissions Diesel (TxLED).

EXHAUST EMISSIONS TEST PROCEDURE

Exhaust emissions measurements were performed according 40 CFR Part 92 Federal Test Procedure (FTP) for control of air pollution from locomotives and locomotive engines. [1]

INTAKE FILTER RESTRICTION LIMITS

Inertial and engine air filter restriction limits are typically specified by the locomotive manufacturer, but railroads often have internal limits or air filter change out intervals. Seven different railroads were contacted and asked to provide their railroad's air filter change out criteria and the results of this informal survey are shown in Table 2. The railroad's air filter maintenance interval varied from a specific upper restriction limit for each of the manufacturers to a set period of time for the filter change out. Regional railroads typically had a much longer air filter change out period.

TABLE 2. INFORMAL SURVAY OF CURRENT AIR FILTER CHANGE OUT CRITERIA

Railroad	GE	EMD	Condemnation
A	11" of water column (1)	10" of water column(1)	14" of water column (1)
B	Air Filter Pressure Drop Not Tested (2)		
C	Air Filter Pressure Drop Not Tested (3)		
D	Air Filter Pressure Drop Not Tested (4)		
E	Air Filter Pressure Drop Not Tested (5)		
F	Air Filter Pressure Drop Not Tested (6)		
G	Air Filter Pressure Drop Not Tested (7)		

(1) Inertial & air filter pressure drop
(2) "If anyone sees dirty filters, they just get changed."
(3) "change filters out on 184 schedule or on condition for loading problems."
(4) Filter "changed every 92 days, regardless of their condition, due to the operating environment."
(5) "filters are changed on a 368 day basis only. Filter drops are taken due to HP loss only."
(6) "change them at 368 days."
(7) Filters changed semiannually.

TEST RESULTS

Testing was conducted at Notches 4, 5, 7 and 8, but for this paper only the Notch 8 values will be reported because of the importance of Notch 8. Additionally this is the Notch that air filter restriction is tested by the railroads during routine maintenance and inspections.

Figure 2 shows the tradeoff between the inlet restriction and percent change in AAR Corrected Brake Specific Fuel Consumption rate (BSFC) rate at Notch 8. If one assumes that the typical air filter change out occurs at around 10 inches of water inlet restriction, the fuel consumption penalty at Notch 8 is just over 2% at the time of change out. If one assumes that filters are typically replaced at 5 inches of water restriction, the fuel consumption penalty would still be 0.9%.

An increase in intake restriction also increases smoke opacity and PM emissions at Notch 8. Increase of PM and smoke opacity typically replaced at 5 inches of water restriction, the fuel consumption penalty of 0.9% are typical for a system that increases fuel consumption and reduces NOx emissions. Figure 3 show that a 10 inch water restriction caused the smoke opacity to increase to 10% opacity, which was a 60% increase over the baseline level.

Figure 4 shows that the elevated smoke opacity at Notch 8 trans-

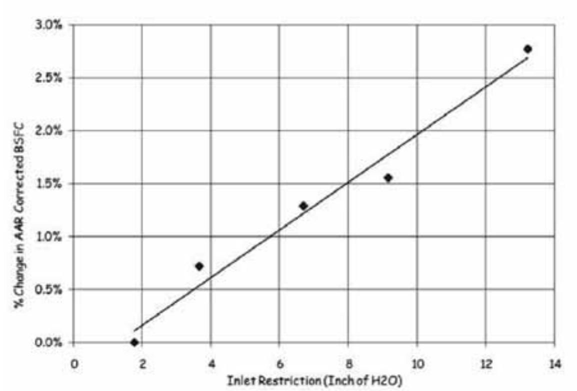


Figure 2. Inlet Restriction vs. Fuel Consumption Rate

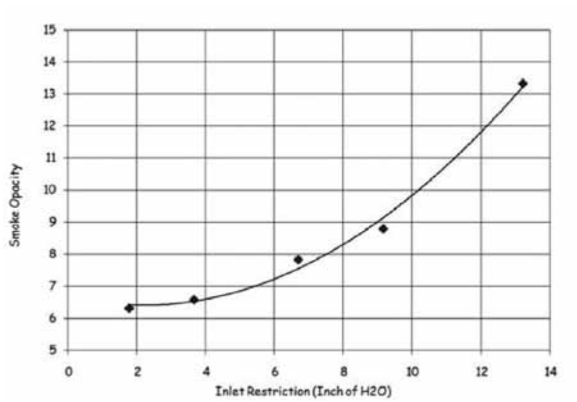


Figure 3. Inlet Restriction vs. Smoke Opacity

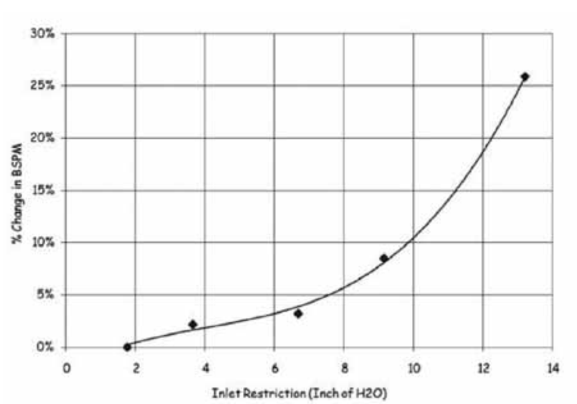


Figure 4. Inlet Restriction vs. PM Emissions

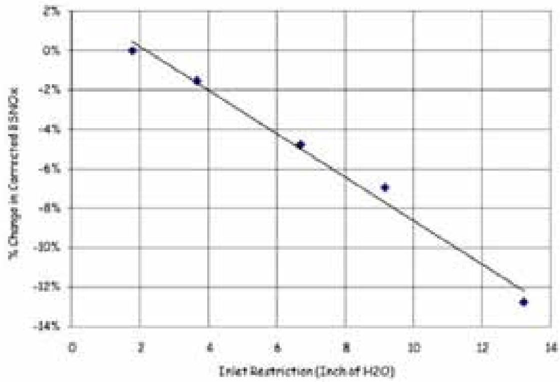


Figure 5. Inlet Restriction vs. NOx Emissions

lates to over a 12% PM increase at 10 inches of water column inlet restriction. This increase in smoke and PM emissions could be a compliance issue, if the engine is close to the upper end of the US-EPA limit for PM emissions or smoke opacity due to other engine related issues (IE: plugged aftercooler, worn injectors, worn rings and liners providing high oil consumption, …).

Generally, most engine maintenance related issues that increase the fuel consumption and increase PM and smoke, also tend to reduce NOx emissions. This is also the case with the inlet restriction test results. Figure 5 shows the engine out 3 NOx emissions drop as the inlet restriction is increased. This will not affect the engines ability to meet the US-EPA's NOx emissions.

CONCLUSIONS

Key points that can be concluded from this research include:

1. Any additional inlet restriction will cause a measureable increase in fuel consumption at Notch 8.
2. The amount of increase in fuel consumption in a real world application will be dependent on the duty cycle of the locomotive and the rate that the air filter loads over the air filter change out interval.
3. PM emissions and smoke opacity increased with increased inlet restriction.
4. NOx emissions are reduced with increased inlet air filter restriction.

FUTURE WORK

Future research should attempt to quantify the fuel consumption penalty associated with the inlet restriction on GE locomotive engines and other engines in the EMD family. Additionally, it would be interesting to see if GE and EMD are taking advantage of these changes to fuel consumption and emissions in their engine control strategies.

REFERENCES

1. CFR Title 40: Protection of Environment, CONTROL OF AIR POLUTION FROM LOCOMOTIVES AND LOCOMOTIVE ENGINES; PART 92.
2. CFR Title 40: Protection of Environment, CONTROL OF AIR POLUTION FROM LOCOMOTIVES AND LOCOMOTIVE ENGINES; PART 92, Section 92.132.

ACKNOWLEDGMENTS

Funding for this project was provided by Advanced Global Engineering, Inc. Southwest Research Institute's effort was performed in support of a grant from the Texas Environmental Research Consortium (TERC) and the Houston Advanced Research Center (HARC) under the New Technology Research and Development (NTRD) Program. The project titled as, "Development, Verification and Testing of Technologies to Reduce NOX Emissions from Diesel Engines" was submitted to AGE Engineering in support of NTRD RFGA-13 Grant 35. The author would also like to thank the technical staff of SwRI's Locomotive Technology Center and Allen Fata, Student Engineer from Texas A&M University, for their help to make this a successful project.

Locomotive Diesel Exhaust Aftertreatment Demonstrations

Size, Location and Issues

Presented by:
Sarabpreet Bumra
Amtrak

Acknowledgement:

This presentation is a continuation of the technological information presented by John Hedrick, Principal Engineer in the Medium Speed Diesel Engine Group at Southwest Research Institute's Locomotive Technology Center, San Antonio, TX. Previous presentations were made on behalf of the LMOA Diesel Mechanical Committee – one in 2007 entitled Locomotive Particulate Matter Reduction Through Application of Exhaust Aftertreatment Systems and the other in 2008 entitled Locomotive Exhaust Aftertreatment Systems-Definitions and Maintenance.

The following devices will be addressed

- **Diesel Particulate Filter (DPF)**
- **Diesel Oxidation Catalyst (DOC)**
- **Selective Catalytic Reduction (SCR)**
- **Exhaust Gas Recirculation (EGR)**
- **Crankcase Ventilation (CCV)**

NOTE: The following locomotive and engine demonstrations are strictly "prototype test designs".

Diesel Particulate Filter (DPF)

A Diesel Particulate Filter is a mechanical filtering device, mounted in the exhaust system of the engine, containing passageways or channels that physically capture the particulate matter. Figure 1 is a representation of internal cross-flow passages of the filter.

DPF Issues

Test engines: 12 cylinder, 645E, roots blown, 1500 HP

Operational/Maintenance

- Weight: 2300 lbs (4 ft wide, 6 ft long, 3 ft high)
- Exhaust back pressure – OK for blower engines – not good for turbocharged
- Filter regeneration, schedule and duration
- Inspection of regeneration heat source/burner
- Filter elements will need to be removed and cleaned-intervals not known-being developed

Safety

- Filter elements will have to be handled-safety procedures being developed. In California, Catalyst ash is considered to be hazardous material

Diesel Oxidation Catalyst (DOC)

A Diesel Oxidation Catalyst (figure 2) is a flow-through-catalyst arrangement that oxidizes Hydrocarbons, Particulate Matter and Carbon Monoxide in the exhaust stream.

The catalyst substrate material is coated with a precious metal that induces a chemical reaction with the pollutants that come in contact with these surfaces.

DOC Issues

Test engine: 12 cylinder, 710G3A, 3000 HP

Operational/Maintenance

- High sulfur fuel – "poisoned" elements-suppliers recommend using fuel with 15ppm or less-catalyst may recover with limited exposure to high sulfur fuel
- Exhaust temperature sensitive: >400 deg F for efficient operation
- Plugged elements due to accumulation of residual lube oil ash deposits=back pressure increases
- Catalyst elements will need to be removed and cleaned-intervals not known-being developed
- Catalyst exposure due to locomotive washing
- Catalyst elements will have to be handled-safety procedures being developed
- In California, Ash is considered to be hazardous material
- NO^2 formation in a shop environment is a safety issue-bringing hot engine into the shop-catalysts continue to react forming NO^2

Selective Catalytic Reduction (SCR)

Selective Catalytic Reduction, as shown in figure 3 is a process to reduce NOx emissions by injecting a "reductant" such as urea into the exhaust stream where it chemically reacts with the NOx gases to yield N^2, CO^2 and H^20.

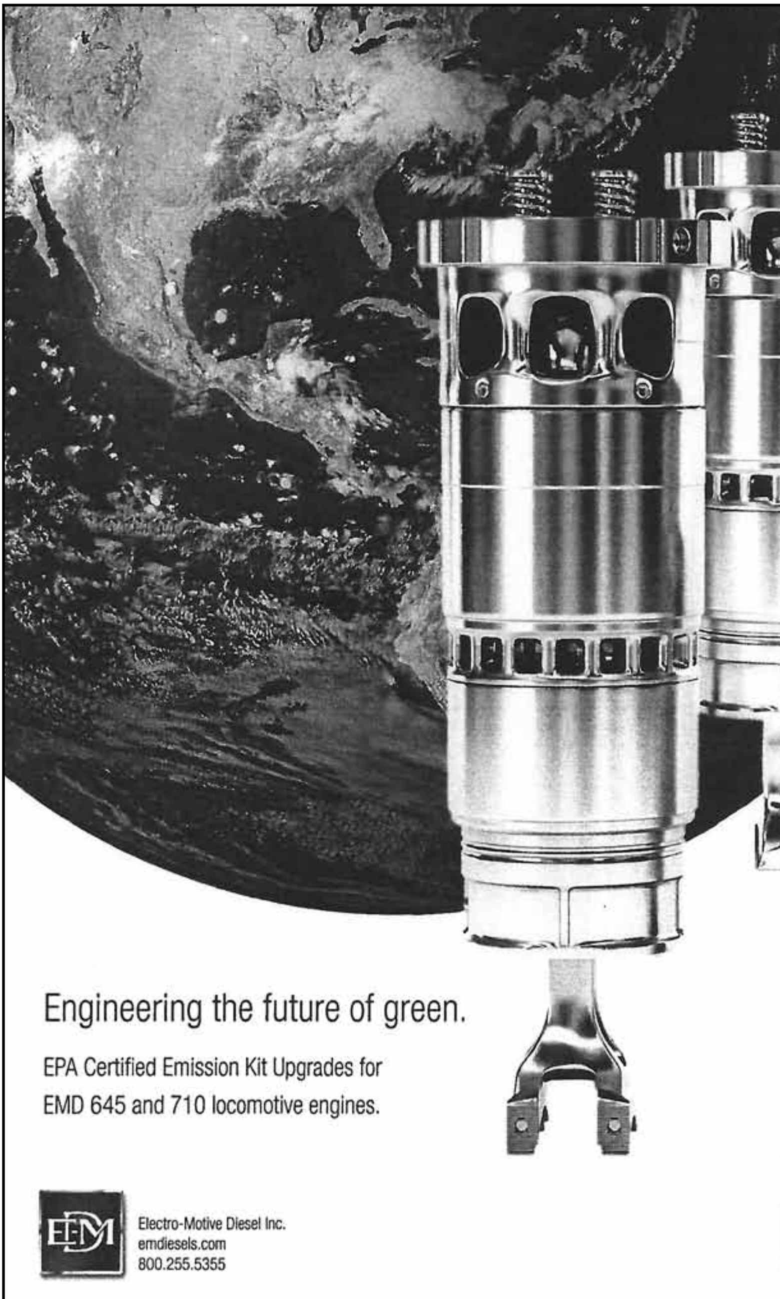
SCR Issues

Operational/Maintenance

- Maintaining infrastructure containing the urea fluid (32% urea and 68% water)
- Can't get too hot (@100 deg F, urea evaporates)
- Can't get too cold (@11 deg F, 32% urea freezes)
- Maintaining on-board storage: 3-5% of locomotive fuel tank capacity which is equivalent to about 250 gallons
- "Out of Urea" policy vs. emissions compliance
- Urea injection control system and nozzles routinely checked to ensure correct ratio of urea-needs exhaust temperatures greater than 40 deg F for efficient reaction.
- Shut-down vs. cold start-up policy to be developed

Safety

Ammonia Slip-raw ammonia being expelled will require DOC added (operating temperatures of both systems directly affect DOC location, efficiency and durability).


Engineering the future of green.
EPA Certified Emission Kit Upgrades for
EMD 645 and 710 locomotive engines.
Electro-Motive Diesel Inc.
emdiesels.com
800.255.5355

Exhaust Gas Recirculation (EGR) – Figure 4

Exhaust Gas Recirculation is a valve that channels or re-circulates a small percentage of exhaust gas back into the air intake to cool the peak combustion temperature which helps to lower the NOx levels.

Cooling this re-circulated exhaust gas with auxiliary heat exchangers helps to lower NOx even more.

EGR Issues

Test engine: 12 cylinder, 710G3A, 3000 HP

Operational/Maintenance

- Prototype On-highway truck system required a mounting platform: 8 ft wide x 20 ft long.
- Valves and piping-plugging with soot and carbon requires periodic cleaning and servicing.
- Prototype system required a DPF to clean the exhaust stream prior to heat exchangers.
- Condensation of exhaust corrosive by-products had effects on valves and piping.
- The cooling water requirements exceed locomotive capacity

Closed Crankcase Ventilation (CCV) – Figure 5

Closed Crankcase Ventilation, although not directly associated with the combustion exhaust gases, will become an important contributor to the overall reduction of PM levels.

CCV is a device or filtering system that captures and cleans the crankcase blowby gases before entering the atmosphere or possibly back to the engine (1/2 gallon lube oil per hour).

CCV Issues

Operational/Maintenance

- Routine cleaning is required to prevent crankcase overpressure.
- If filters are used, then scheduled removal and replacement must be incorporated per the supplier's recommendation.
- Gen-Set engines have CCV filters with scheduled maintenance intervals.
- If the system involves centrifugal spinners, the device should be removed and cleaned once a year.

Conclusions

Exhaust Aftertreament demonstrations of these technology prototypes required on new 2012 locomotives are identifying the potential issues.

The final system may consist of a combination of all the previous technologies in order to comply.

All of these systems will require additional maintenance and service to keep the engine in compliance

There will be safety issues that will require new policies.

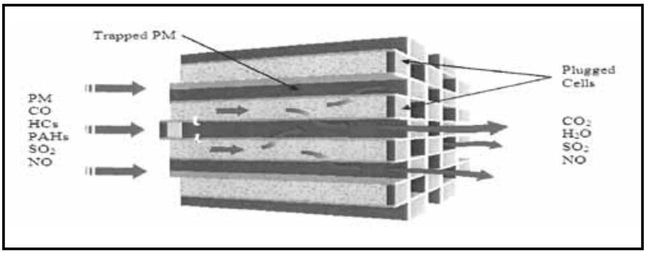


Figure 1

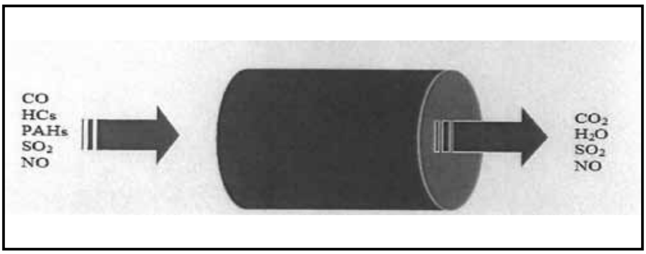


Figure 2

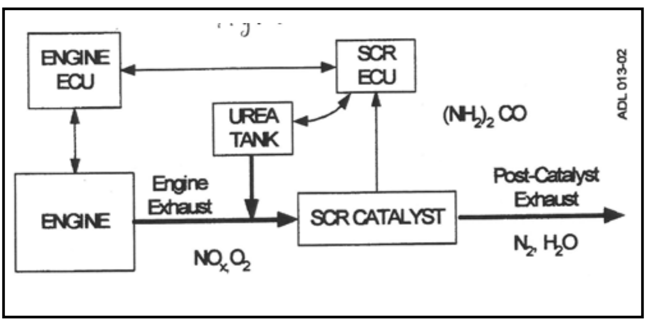


Figure 3

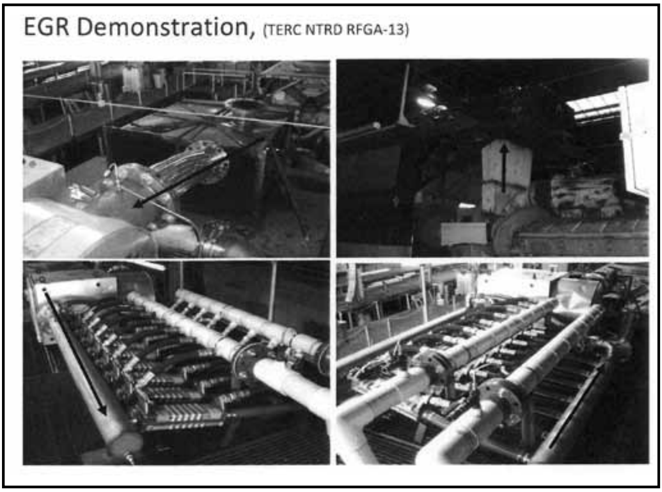


Figure 4

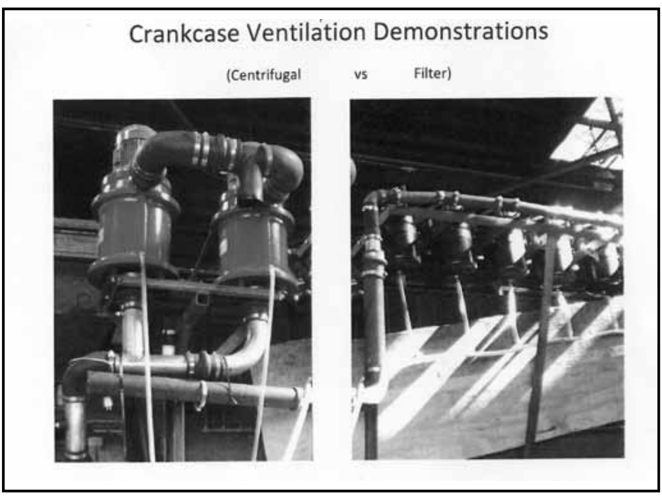


Figure 5

Report on the Committee on Fuel, Lubricants and Environmental

Tuesday, October 19, 2010

11:00 A.M.

Chairman

Bob Dittmeier

Customer Technical Service

Afton Chemical Corp

Richmond, VA

Vice Chairman

Chuck Kunkel

Sr. Mgr.-R&D

Union Pacific RR

Omaha, NE

Commitee Members

D. Beebe	Vice President	Temple Engineering	Liberty, MO
K. Bills	VP-RR Operations	Searle Petroleum Co.	Council Bluffs, IA
R. Dunn	Consultant	CN	Pierrefonds, Que
S. Fritz, P.E.	Mgr. Med. Spd. Dsl. Eng.	Southwest Research Inst.	San Antonio, TX
T. Gallagher	Technical Liaison	Oronite	Commerce, MI
F. Girshick	Sr. Tech Advisor	Infineum USA L.P.	Linden, NJ
L. Haley, Jr	Chief Chemist	Norfolk Southern Corp.	Chattanooga, TN
D. Koehler	SLS Mgr.	Predict USA	Cleveland, OH
G. Lau	Sr. Rel. Specialist	Canadian National	Edmonton, AB
R. Lodowski	Prod. Mgr.	CSX Transportation	Selkirk, NY
M. Maddox	Tech. Support	Industrial Speciality Chem.	Harvey, IL
D. Mattey	Key Acct. Manager	Alfa Laval Inc.	Hermitage, PA
D. McAndrew	Fuel & Lube Spec.	GE Transportation Rail	Erie, PA
J. McDonald	Off. Of Trans. & Air Quality	EPA	Ann Arbor, MI
D. Meyerkord	Sr. Engineer	Electro Motive Diesels	LaGrange, IL
K. Myles	Mech. Engineer	Amtrak	Wilmington, DE
T. Savage	RR Program Mgr.	ALS-Staveley Svcs.	Kansas City, KS
W. Strickland	Mgr. Test & Lab Svcs.	CSX Transportation	Jacksonville, FL
D. Tuttle	Mgr. RR & Marine Sls.	American Refining Group	Roswell, GA
P. Van Slyke	Engineer	Oronite	Richmond, CA
K. Wazney	Chemist/Testing Spc.	Canadian Pacific Rwy.	Winnipeg, MB
P. Whallon	Director Tech. Sales	Clark Filter	Lancaster, PA

Note: Ron Lodowski is a past president of LMOA; 2nd VP Glenn Bowen and Regional Exec Tom Pyziak are very active on the FL&E Committee. Johathan George, Camil Farr, and Tom Reischman, Exxon Mobil, joined the committee during the Montreal Convention; Corey Ruch of BNSF was introduced to the committee as Glenn Bowen's replacement on the committee

PERSONAL HISTORY

Bob Dittmeier

Bob Dittmeier grew up in St. Louis, MO and has been an employee of Afton Chemical Corporation for over 35 years. He received his education from Rockhurst College, the university of Missouri and Washington University.

His career with Afton (then called Ethyl Corporation and located in St. Louis, MO) started in their mechanical research department in 1973. He held various positions within the mechanical research group including managing automatic transmission fluid research testing and the gear lubricant research testing group. This involvement with gear lubricant research also included formulation and testing for gear lubrication oils that were developed and targeted for U.S. military approvals. During this time frame he was also involved with Afton field trial activities for both gear and crankcase technologies. He transferred from mechanical research and into customer technical service for gear oil additive technology. From that position he was promoted into technical coordinator for medium speed diesel (MSD) research. He continues with Afton's MSD group, managing the technical service aspects of this business while also directing the field research for this group.

During his many years with Afton he has been involved in the design, writing and editing of various manuals published by the Coordinating Research Council and in addition to the Locomotive Maintenance Officers Association (LMOA) Fuels, Lubricants and Environmental Committee chair he has also chaired the Society of Automotive Engineers (SAE) Technical Committee Nine which was involved with medium speed diesel and railroad locomotive technical issues.

He has enjoyed riding motorcycles for most of his adult life. He and his wife Barb enjoy motor racing, world travel, and are avid skiers. They currently reside in Richmond, VA.

The Fuel, Lubricants and Environmental Committee would like to extend their sincere appreciation and gratitude to the Southwest Research Institute for hosting their committee meeting on March 17 and 18, 2010 in San Antonio, Texas.

The meeting on March 17th was attended by some of the members of the Diesel Mechanical Maintenance Committee to tackle the topic on long term locomotive storage which is going to be presented at the convention in Montreal Quebec Canada on October 2010.

Locomotive Diesel Fuel Additives and Fuel Savings Devices Evaluation Procedure

Prepared by:
Chuck Kunkel, Union Pacific RR

The LMOA Fuel, Lubrication and Environmental Committee (FL&E) has been working the past two (2) years on updating the AAR Recommended Practice RP503 "Evaluation Procedure For Measuring Changes in Fuel Consumption and Exhaust Emissions in Medium Speed Diesel Engines" a procedure to evaluate diesel fuel additives and add-on fuel saving devices.

The name change along with the revised procedure is intended to provide a more uniform procedure for evaluating the effectiveness of engine performance-enhancing products including diesel fuel additives (fuel-borne or air-borne) and fuel saving devices that purportedly reduce fuel consumption and/or exhaust emissions in medium speed diesel engines.

The test methods and the evaluation techniques, in the revised procedure will provide more consistent results to enable direct comparisons of test results of performance enhancing products when performed at laboratories and stationary test facilities, independent of the test facility.

The procedure provides results that may serve as one indicator to the potential user of the comparative use of an untreated fuel, or engine without fuel savings device versus that of an additive treated fuel or an engine with fuel savings device. Subsequent testing by the potential user under actual operating conditions or additional engine/locomotive models and/or tiers may serve to provide additional information.

The revised practice does not address the evaluation of alternate fuels or blends of alternate fuels such as biodiesel, synthetic fuels or alternate energy resources such as natural gas.

Why the Revision?

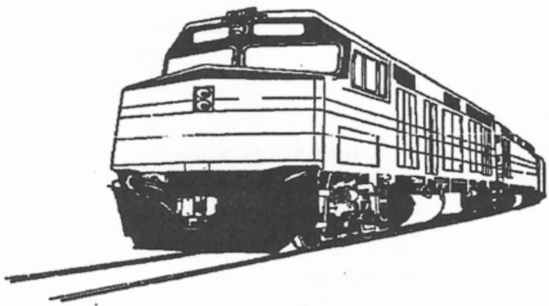
The original RP-503 procedure was adopted in 1980, utilizing the most up to date knowledge and testing equipment of the time. Since then, there have been great improvements in the accuracy and robustness of test equipment. Also, there has been an increase in the number of engine test facilities.

There is now a greater emphasis on exhaust emission including mandatory compliance with the rules and regulations from the EPA.

The new procedure includes the addition of a field testing protocol and the testing of fuel saving add-on devices.

Evaluation Procedure

The evaluation procedure consists of four (4) test phases. These phases



are organized to determine that the additive or device will cause no harmful effects and will verify the claimed beneficial effects.

Phase I is evaluating the fuel properties of the base fuel and the treated fuel in accordance with ANSI/ASTM D 975 standards.

Phase II is testing the baseline and treated fuel, or the add-on device, on a single or dual cylinder research test engine. This phase will determine if there are any immediate or short term benefits to the use of these products. All engine parameters are monitored to determine fuel consumption and emissions trending.

Phase III is full scale locomotive testing either stationary or during field operations. During this phase baseline tests are run on the engine using baseline fuel or with no test device. Next the test fuel with the additive or the test device is installed on the engine and is evaluated. And finally the baseline fuel is again used and/or the device removed to determine the residual effects of these products on the engine.

Phase IV is emissions testing in accordance with the latest edition of Federal Test Procedure, EPA 40 CFR, Part 92, 1065 and 1033. This phase may also be performed during Phase 3.

Please see the procedure for more details on the requirements for each phase of the testing.

Conclusion

The completed revised procedure was submitted to the AAR Locomotive Committee for their review in January 2010.

The FL&E Committee will be available to address comments from the Locomotive Committee and provide professional support to any future necessary revisions to the revised procedure.

Thank You

The FL&E committee would like to thank the AAR Locomotive Committee for the opportunity to revise the RP503 procedure.

We would also like to thank Engine Systems Development Center, South West Research Institute, the locomotive OEM's, various industry consultants and various additive manufacturers for their input and review of the procedure.

The Clean Water Act and How it Affects Railroad Operations

Prepared by:
Mike Maddox
Industrial Speciality Chemicals, Inc.

This paper focuses on updates to Spill Control and Countermeasures (SPCC) plans, the implementation of recent changes, and your involvement. In addition it includes information on Wastewater Treatment, and Storm Water Pollution Prevention Plans (SWPPP).

To begin, SPCC is not new to the railroads but over the past few years has gone through quite a few changes. All railroad employees, in addition to training for Mechanical, Electrical, Buildings & Bridges (B&B), and Maintenance of Way (MOW), receive annual training regarding the SPCC plan. The railroad managers carry the extra responsibility of enforcement of these programs and in general all railroad personnel hold the key to successfully adhering to these federal laws. Failure to do so can lead to civil and/or criminal fines for those responsible, as well as unwanted public relations issues for the railroad.

The background to this legislation is the federal *Clean Water Act of 1972* managed by the Environmental Protection Agency (EPA). This act federally protects surface and ground waters in the U.S. from pollution generated by private industry. Other countries carry similar laws such as *Canada's Clean Water Act and Pollution Prevention and Control Plan* and *Mexico's Ley General de Equilibrio Ecológico y Protección at Ambiente* (LGEEPA), which are not addressed in this paper but similar in content. A 1074 amendment added SPCC to the U.S. law. In 1977 the law was amended to include how spills were to be handled and reported. It further authorized enforcement capabilities to federal and state governments. In 1987 wetlands and storm water run-off were also included as important concerns; important because most of America is now considered as a protected area. In 1990 the *Oil Pollution Act* further regulated the transportation and storage of petroleum products to prevent water pollution. Finally in 2002 the Environmental Protection Agency (EPA) felt rain, farm and airline regulations were too lax so it legislated several more stringent regulations on these petroleum users. Litigation over these changes has pushed the implementation of these laws into the near future as clarification is sough for the proposed changes. Railroad implementation is currently scheduled for November 20, 2009.

The railroads have worked toward adhering to these new standards before the law takes effect and have prepared for the changes necessary.

The first of these Clean Water Act regulations to address is the compliance of waste treatment facilities. These facilities are a demonstration of a railroad's ability to meet the EPA regulations. If a railroad continually demonstrates unacceptable performance against the regulations at facilities with past documented contaminations it does not instill any confidence within the EPA of how well that railroad will respond to an accidental release from either a derailment or punctured fuel tank.

Waste water collection point vary in size and complexity but are critical points focused on by the government. The following are some points to consider based on size.

1. Smaller sites and fueling facilities will normally have an oil-water separator to repove and recover petroleum drippage. Even with their small size, these facilities cannot be ignored. If spillage occurs outside these control systems, storm water can be affected. They have limited holding capacity so should be maintained to prevent filling with sand or fuel. Most states require monitoring and sampling of discharges from these areas quickly after rain events to fulfill environmental reporting requirements. With the thinning of staff at railroad facilities some responsibility has shifted to B&B or MOW departments. Local facility personnel should receive training to understand their responsibilities and roles to address any spill event. In addition the time to preform preventative maintenance needs to be included in daily schedules which allow the facility to recognize their compliance to the government regulations between regulated events.
2. Larger shops offer have full wastewater treatment facilities. These facilities remove contaminates from the wastewater which are typically introduced during the regular maintenance and washing or equipment. These treatment facilities can be costly to operate and generate large amounts of waste oil and sludge mixtures that must be disposed of properly. There are new cleaners and chemicals that have been or can be introduced within the shop to improve treatability of the waste water. Segregation of engine oil drains also limits treatment needs. When these systems have been installed in the shop, training and oversight is needed to ensure employees and contract employees adhere to proper disposal needs and chemical use. Within the treatment plants waste oil demulsifiers have made great strides in maximizing the amount of sellable waste oil, offsetting overall treatment costs, and sometimes becoming a profit center. This also leads to lower total environmental costs and improved environmental impact realization.
3. In locations with over one million gallons of "hydrocarbon" storage capacity even more stringent regulations kick in. Monthly inspections must be conducted and personnel

have to conduct drills on spill response. This is enough for most railroads to limit their capacity below this threshold.

4. One final waste consideration is the proper handling of wastes by 3rd party contractors. Years after a mishandled spill; whether it occurred in a rail yard or on a main rail line a rail road could be found liable because of a previous contractor's mishandling of the railroad waste. Rapid response is important, but tracking and follow-up are also critical to managing the activities of contractors. By utilizing contractors that are actively involved with the railroad's environmental initiatives it can help to limit their level of impact at a localized site. Their training should better prepare them to dispose of the wastes collected at a spill site correctly. In addition their education can greatly facility any future inquires by state or federal governing bodies.

The next point is the (SWPPP). Most of you have probably had some landscaping activity in and around the yard. This is also due to the EPA's new clean water initiatives. Primary isolation is the directing of non-impacted rainwater away from industrial activity and is the best way to handle storm runoff in your yards. If you don't have any rain water contamination, your don't have to handle it. By engineering you facility to divert storm water away, treatment is unnecessary. Adding this strategy to accident and spill sites, further lowers the total cost of cleanup to your railroad.

1. Limiting or minimizing the affected area at any size is the best way to reduce costs. Much engineering work has taken place since the 2002 regulations to direct storm water runoff away from impacted areas and out of required regulatory rules. Landscaping around storage tanks and ditches in the yard provide necessary secondary containment while properly maintaining slopes and ditches on the line offers the most cost effective long term practice to divert storm water away. If a spill was to occur in these areas of the line, quick response will minimize the environmental and legal impact of an incident.
2. In known impact areas such as spill sites or fuel pads, not only best practices need to be followed but also proper collections of water and maintenance of separator equipment is required. Personnel located at these sites are the best candidates for monitoring and reporting the equipment condition. Their assistance to the environmental personnel will help keep a railroad in compliance. Once trained, non-environmental personnel from B&B or MOW can preform simple inspections and sampling. Fixed position collection equipment normally requires storm water sampling within 24 hours of a rain event, which can be a somewhat difficult task if the only railroad environmental representative is located on the other side of the state.
3. Some new requirements of the SWPPP plan that have been updated in this recent legislation which

built on previous requirements already instituted:

1. Permitting of any impacted area. This can be as inane as clearing some trees of filling a ditch. These activities, which previously were largely overlooked can now involve notifying the Army Corps of Engineers (COE), as well as the State and Federal EPA. The COE has stated they will try to not get involved, but without the proper COE permits additional fines could be issued because of alteration of the landscape.
2. Another new development is secondary containment required for any oil or grease storage container of 55 gallons or greater. This can be from something as simple as lube grease, bacon grease, motor oil or radiator treatment brought out to trackside up to large fuel trucks performing direct fueling.
3. But probably the most important change is the reduction of the size of the impact area to be permitted when the location is outside of a recognized rail yard. Previously a project or soil disturbance site under 5 acres did not necessarily need a permit. Now the new limit is one acre so unless there is a paved road trackside, it is vary easy to go over that limit. Several trucks and backhoe working off the pavement just 100 yards has already impacted enough ground to require permitting before the work begins. This can make any work, because of the needed permitting time consuming and the contractor knowledge of the permit needs is important. Space is a premium. Limiting traffic to and from the job site is a narrow corridor should minimize the area impacted by wheel traffic all of which must be included in the acreage calculation.

4. The final point regarding SWPPP is that every State is different. Some States have approved the use of statewide permitting, allowing a quicker response for performing necessary isolation and cleanup activities. Other States require individual site permits. With the movement of railroad personnel to a new locations it is important to insure that this information is not being over looked by incoming personnel. Additionally, the training of all employees and contractor will help build their understanding of what's required to help insure adherence to the plan rules.

A railroads's Spill Prevention Control & countermeasures (SPCC) plan is another important point to cover. Understand the SPCC plans in general are not of cookie cutter variety. The railroads of North America do not all have the same plan. Each facility that requires a plan must have one that is specific to that facility. Further, how each railroad implements and oversees their SPCC plan will, most likely be different than how another railroad implements its plan.

The primary purpose of the SPCC plan is to prevent oil spills into navigational waters hence the reason why the COE could possibly use the Coast Guard to respond on behalf of the responsible parties involved. A navigational waterway can be as small as a depression in the ground that has 3 inches of water in it for one day every hundred years. The Coast Guard could then become involved if a spill is related to a navigable waterway.

The SPCC plan must include these items;

1. Spill history, spills that could occur, control measures, tank descriptions and maps of piping, transfer operations, inspection records, security, lighting, rain water logs, training and must be approved by a Professional Engineer (PE).
2. The facility must have secondary containment for any potentially impacted area, piping, pumps, tanks, and drums. All tanks when not in use must have any potential release point locked out to prevent accidental release. The entire facility is to be lit and fenced for security. Spill response equipment is to be on hand and maintained. Tanks of any size are to be tested and inspected regularly. Records of all activities are to be kept.
3. Other considerations are; petroleum of any kind; hydraulic, vegetable, asphalt or fuel. Fuel truck delivery points or holding fuel cars on a siding for direct fueling. What alternate security measures are in place to avoid the need of fencing the whole yard? MOW activities may need their own plan including security. Work trucks with portable fuel tanks on the back need to be included when in a SPCC covered area.

The final concern about any SPCC plan should be liability. Some railroad facility managers may have more potential liability than the environmental managers. I have been told by the railroads and the EPA (unofficially) that no one will go to jail or have to dig in their own pockets for fines but these measures are written in the law. Why? Proper training and implementation of the SPCC plan will make everyone's life easier.

The final discussion point is that it never happened unless there is adequate documentation to confirm that it did happen.

1. Inspection records for all sites, tanks and former impacted areas should be maintained at the facility. Copies of the PE's credentials and approvals should be kept. State approvals and permits should be kept at the site and certainly afterward. All training records should be kept in detail as well as all disposal documentation.
2. Waste water treatment records and waste disposal records should be maintained as well as all operator certification. Any railroad activity requiring a SWPPP plan and/or permits should be kept.

With a firm understanding of why these procedures are needed and how personnel activities affect them, a railroad can avoid unnecessary costs and possibly reduce spending on environmental requirements. Environmental personnel and the emergency response center will handle most of the training and documentation, but know your part, and do your part because the environment is everyone's responsibility.

Constitution and By-Laws Locomotion 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 1-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 connection 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 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 the 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 on 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 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, he may continue to serve as an executive officer and be allowed to elevate through the ranks as naturally as 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 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 distributed, monitoring membership levels and reporting same at 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 Nominating Committee, and General Executive Committee without vote.

D. Furnishing security bond in amount of $5000 of behalf of his/her assistants directly handling Association funds. Association will beat 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 presented 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 decisions within LMOA and coordinated associations with confidentiality.

Article VII-Technical Committees

The technical committees will consist of:

Section 1-A chairperson, appointed by the President and approved by the General Executive Committee.

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

Section 3-Committee members 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 its attendees for mutual benefits to the railroad industry. It is understood that the expression of opinion, or statements by attendees in the meetings, and the recording of papers containing the same, shall not be considered as representatives 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 proceeding and business transactions of this Association shall be governed by Robert 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.