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SEPTEMBER 22, 23, 24, 1986

Official Discussion Record of 47th Annual Meeting

LMOA

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MONDAY MORNING SESSION
September 16, 1985

DARRELL M. WALKER
PRESIDENT
Diesel Superintendent
Norfolk Southern Corp.
Atlanta, GA

MONDAY MORNING SESSION

September 16, 1985

The 47th Annual Meeting of the Locomotive Maintenance Officers' Association, held at the Palmer House, Chicago, Illinois on September 16-18, 1985, convened at 9 a.m., Mr. Darrell M. Walker, President of the Association, presiding.

PRESIDENT WALKER: I would like to call the 1985 joint session of the Coordinated Associations to order.

We will start with Father Charles R. Kullman, CSD, Old St. Mary's Catholic Church, Chicago, who will give the invocation.

FATHER CHARLES R. KULLMAN: God of steam and diesel, Mover of galaxies and Hauler of worlds, Power beyond our comprehension and Mystery beyond our reach: We begin this convention by raising our minds and hearts to You; for what we do here is important. It does have meaning, as we work to move the resources that build up nations, provide livelihoods for many, and contribute to the well-being and prosperity of our neighbors and countrymen.

Therefore, we humbly petition You, Almighty God, to grant us minds full of wisdom, ears open to listen, and hearts full of respect for each other. May our meetings be productive, and after they are over grant us all a safe journey home. Amen.

PRESIDENT WALKER: Thank you, Father.

At this time I would like to recognize the presidents of the other organizations.

Mr. A. H. Fiedler, General Superintendent Air Brake System and Road Foreman, Burlington Northern, and president of the Air Brake Association.

Mr. H. P. Zakaib, Mechanical Superintendent, CGTX, Inc., Montreal, Quebec, and president of the Car Department Officers Association.

Mr. R. Mauney, System General Road Foreman, Southern Railway, Atlanta, Georgia, and president of the Railway Fuel and Operating Officers' Association.

A very important part of our organization of the Coordinated Association is Mr. Jack Carney, Jr. Jack is with the New York Air Brake Company and is president of the Railway Supply Association. [Applause]

I am Darrell Walker, Diesel Superintendent, Norfolk Southern Corporation, Atlanta, Georgia, president of the Locomotive Maintenance Officers' Association. [Applause]

We are very fortunate today to have as our keynote speaker Mr. Hobart L. Scott, Jr. Mr. Scott was born on October 30, 1927 in Fincastle, Virginia. He was married on June 20, 1948 to Evelyn Seay, and they are the parents of a son, David, and a daughter, Amy.

Mr. Scott's education was with the University of Virginia, where he holds a Bachelor of Electrical Engineering, graduating in 1950. He entered the University of Virginia Graduate School of Business, taking an advanced management course in 1960. He is a graduate of Harvard University Graduate School of Business Administration, Advanced Management Program, in 1972.

His career with the railroads began in November, 1950 as a special apprentice to the Norfolk Northwest Railway in Roanoke, Virginia. Various positions he has held are:

1950 - Special Apprentice, NW Railway, Roanoke, Virginia

1952 - Shop Inspector, Roanoke, Virginia

1953 - Gang Foreman, Roanoke, Virginia

1955 - Mechanical Inspector, Roanoke, Virginia

1956 - Assistant Master Mechanic, Crewe, Virginia

1956 - Master Mechanic, Norfolk Division, Crewe, Virginia

1958 - Assistant Superintendent, Norfolk Terminal, Norfolk, Virginia

1960 - Superintendent, Norfolk Division, Crewe, Virginia

1960 - Superintendent, New River Division, Princeton, West Virginia

1961 - Superintendent, Pocahontas Division, Bluefield, West Virginia

1964 - Superintendent, Scioto Division, Portsmouth, Ohio

1965 - Manager Transportation, Roanoke, Virginia

1966 - Assistant General Manager, Atlantic Region, Roanoke, Virginia

1967 - Assistant Chief Engineer, Johnson Carper Furniture, Roanoke, Virginia

1968 - Assistant to Executive Vice President, Johnson Carper Furniture, Roanoke, Virginia

1970 - Vice President-Manufacturing, Singer Company, Roanoke, Virginia

1971 - Assistant General Manager, NW Railway, Roanoke, Virginia

1971 - Assistant General Manager, Lake Region, Cleveland, Ohio

1972 - Assistant General Manager Motive Power and Equipment, Roanoke, Virginia

1973 - General Manager Motive Power and Equipment, Roanoke, Virginia

1980 - Vice President - Operations, Roanoke, Virginia

1983 - Vice President and Chief Mechanical Officer, Norfolk Southern Corporation, Norfolk, Virginia

Mr. Scott is a member of the Air Brake Association; LMOA; National Defense Executive Reserve; Director, Trailer Train Board; Director, Roanoke Transportation Museum; and Director, Otisca Industries, Ltd.

He was in military service with the U. S. Army Signal Corps in

1946-1947. He is also a Registered Professional Engineer.

Ladies and gentlemen, I give you Mr. Hobart L. Scott, Jr. [Applause]

MR. HOBART L. SCOTT, JR.: Gentlemen, it is a real pleasure to be with you this morning, to participate in the opening of the 1985 Technical Conference of the Coordinated Mechanical Associations and the 24th Annual Convention of the Railway Supply Association.

Those who have worked so hard to make this conference a reality are to be congratulated for setting the theme of "Managing Maintenance for Quality Performance," and for arranging for the presentation of the many timely topics that are the subjects of the papers and discussions to be offered to you during the next three days. I urge you to attend the sessions of your choice and to actively participate in every phase of your conference.

Quality performance is absolutely necessary for long-term profitability and survival in the fiercely competitive environment in which we find ourselves. Not only are we competing with other transportation companies in this country but, because our major mining, processing, and manufacturing customers are competing with foreign counterparts, we are also indirectly in competition with foreign transportation systems, many of which are government owned and blessed with labor rates substantially lower than our own.

Now, there is no question but that we are in a predicament; but if you share my faith in our free enterprise system and in the spirit and resourcefulness of the people of this country, I think you will find that when we fully focus on our problems we will find viable solutions.

We are at our best with adversity. On the other hand you might say, along with the trade protectionists, that we are being required to take on unfair foreign competition. However, what is fair is often, like beauty, in the eye of the beholder — and, as has been so often said, life is not fair. But I dare say that every one of your counterparts in every foreign land would gladly trade his working conditions and living standards for yours.

The reason that our working conditions and standard of living are higher than the foreign competitors is that we, in this country, have been more productive than our foreign competition, and as a result we were the low-cost producer of quality products. I emphasize "have been" because our edge in productivity (the total cost to produce a unit of goods) has been eroding since shortly after World War II, and in some industries our edge has completely disappeared.

The productivity edge that we had was the result of being blessed with an abundance of readily accessible natural resources, a population of healthy, God-fearing, energetic people with a strong work ethic, and a government that encouraged the accumulation of capital and the reinvestment of that capital in power plants, steel mills, manufacturing plants, farm machinery, railroads, and any other undertaking that could lead to reducing the total cost of producing goods.

By reducing the number of manhours and the cost of material for that unit of goods, we could raise our standard of living without working any more hours or maintain our standard of living, and work less hours. In the first case we would be increasing our real gross national product per capita, and in the latter case we would be maintaining our per capita GNP.

In any case, our forefathers built the most productive giant industrial and food producing nation in the world. It was during this period that our foreign competitors were no doubt saying that it was not "fair" for them to have to compete with this industrial giant which had such a substantial edge in productivity, but they learned their lesson well. As they rebuilt after World War II, using the most modern and productive techniques and technology available, we were going through a period of tearing down our work ethic by paying people not to produce, of government price supports for goods the market would not accommodate, and of government disincentives toward the accumulation of capital and the reinvestment of that capital in areas that would keep us among the low-cost producers (and I speak specifically of the tax laws that permit and encourage tax shelters that do nothing to increase the productivity of this country).

HOBART L. SCOTT, JR.
Vice President & Chief Mechanical Officer
Norfolk Southern Corp.

In addition, during this same time period, as a result of the exorbitant demands of overly powerful labor organizations and lack of incentives for a strong stand by managements, our labor rates skyrocketed. Consequently, in a number of areas we have simply priced ourselves out of the market. And in practically all areas we have lost share in the world market.

In addition to the proper incentives for the accumulation and reinvestment of capital to reduce labor and material costs so as to become the low cost producers, our foreign competitors have done a superb job in marketing. Basically, they did not try to sell us inferior products or even products with quality equal to ours at a lower price, but rather they followed the example of our forefathers and offered us products of superior quality at equal or lower prices.

Being shrewd, quality-conscious consumers, we bought and we bought and we bought — automobiles, television sets, radios, steel bars and shapes and rail, cameras, textiles, shoes, bulldozers, generators, and on and on and on — products of superior quality to our own of similar price. Our foreign competitors have encouraged and rewarded the low cost producers. They have not set up price supports to protect the high cost producers — they have not paid workers not to produce. They have not discouraged the accumulation and reinvestment of capital, and they have not subsidized their high cost operators to protect them from their low cost operators.

Fortunately, we now have an Administration that at least recognizes what our problem is, how we got there, and the measures it will take to restore us as a low cost producer in the world market. Some significant steps have been taken in the deregulation of industry. However, we must not stop short of complete deregulation of all forms of transportation and the institution of user fees that will cover the full cost of the facilities and services provided by government for the transporation industry.

The Staggers Act has been welcome relief and a good first step, but we must educate the public, our customers and our legislators, relative to the fallacy of stopping short of complete deregulation, and the unthinkable damage that would accrue to this nation should the Staggers Act be weakened. We must encourage and reward the low cost producer.

The present Administration, or any other Administration, cannot accomplish what needs to be accomplished to restore our industry and our country to full potential without the support of Congress. It is distressing to continue to read and hear that too many of our congressmen are more concerned with the short term unemployment rate in their state or district than they are with restoring our nation as a low cost producer of quality products in the world market.

Some politicians are inclined to opt for a high cost operator in their area who promises to remain the high cost operator by keeping present employment levels rather than opting for the low cost operator who may reduce employment in the short term but, by having lower costs, will contribute to raising our per capita GNP, facilitating our recapture of world market share and thereby improving our balance of payments, improving our employment rate, reducing our deficit, and raising our standard of living.

Stated more briefly: When you encourage and reward the low cost operator, good things happen for this country. When you discourage and make it difficult for the low cost operator to expand and grow, bad things happen for this country. Again I say, we must encourage and reward the low cost operator.

I believe you can see why I think your theme of "Managing Maintenance for Quality Performance" is so appropriate. Maintenance of equipment expense on this nation's railroads will run between $6 and $7 billion annually and will represent about 23% of combined gross revenues and roughly 25% of total operating expenses. So, we have good leverage on reducing our total costs. A 4% decrease in maintenance of equipment expenses will result in a significant 1% decrease in the total costs of operating America's railroads. The question now is: How do we go about getting a 4% decrease in ME expenses? By increasing our productivity and becoming the low cost producer of quality performance, just as our foreign competitors did.

First of all, we are going to have to have sufficient capital to provide efficient shops, modern locomotives and the cars needed by our customers. Good management is a most important ingredient in increasing productivity. However, a well managed shop or locomotive fleet using the techniques and technology of the '60s will not be as productive as the well managed shop or locomotive fleet using the techniques and technology of the '80s.

Having sufficient capital to keep our shops and equipment up to date so we may be low cost producers requires our industry to be able to generate or otherwise attract capital; and to be successful in this, in the long term, our return on equity must be at least equal to our cost of capital. We must be free to compete, free to make a reasonable return on our investment, and if we mismanage, free to fail.

Secondly, we must have relief from archaic work rules that cause us to be less productive than we can be. The present rule that requires a day's pay for each 100 miles traveled by our train crews is well recognized as a rule that must be changed. The arbitrary payments to train crews above and beyond their daily rate, for initial and final terminal delay, for coupling air hoses, for starting and shutting down locomotives, and for MU-ing units on line-of-road, are matters which have received wide publicity and are now before an emergency board.

In addition, there are archaic work rules in the Mechanical Department domain that are holdovers from reciprocating steam engine days. We must have relief from assignment of work by rigid craft jurisdiction. We simply cannot effectively compete in today's environment when we are required to have three men — a machinist, an electrician and a pipefitter — to remove and/or apply a particular diesel engine component that one man can handle alone. We need a composite mechanic in the locomotive department who has the freedom and versatility to work on any part of a locomotive, just as a carman has the freedom and versatility to work on any part of a freight car. Because of this difference in assigning work, a well managed modern locomotive shop will be about 10% to 15% less labor productive than a comparably managed modern car shop.

Thirdly, we must have a reduction in the hourly rates paid to our work force. We, along with most industries in this country, have paid premium wages when we thought we could afford them. But now that it is obvious we cannot afford them (and in retrospect really never could afford them because of their demonstrated contribution to our loss in world market share), we must have relief. All of us have been partaking too freely of the fruits of past efforts and accomplishments when we should have known there are no free lunches — never have been and never will be.

Too many industries in this country have been depending on the consumer to absorb the increased costs brought on by premium wages and too little capital invested to keep our plants modern. The consumers of the world have now said loudly and effectively, "Enough!"

We no longer enjoy that temporary luxury of the postwar years when demand was so great that there was little or no difficulty in passing increased costs through to the consumer. Gentlemen, those days are gone, and the sooner all the labor organizations realize and acknowledge it, the better. There are too many sources of quality products in the world today for any labor organization in this country to believe their membership is entitled to wages that are not commensurate with their productivity.

Fourth, we need to lower our material costs by more effective purchasing methods and better inventory control, and through improved material reclamation procedures. There are also big dollar savings to be obtained in increasing the useful life of our equipment by well-planned, programmed maintenance rather than running to complaint or failure. In addition, we need to increase the utilization of our equipment during its extended useful life, for by so doing we are lowering our total cost and increasing our overall productivity.

We must impress upon our suppliers that quality performance on their part is an important and necessary component of our own quality performance, and we need to continually re-examine our material acquisitions to ensure that we are acquiring products that result in our being the low cost producer of quality performance.

Finally, we must have truly innovative, dedicated, fair and broadminded management. We must be goal oriented, and insist that our entire organization be goal oriented. If you have an organization that is aiming at nothing, I guarantee you'll hit it every time.

In addition to having challenging but attainable goals in every area of our operations, we will need the wholehearted participation of every employee, not just the managers, to set and meet goals that will enable us to be the low cost producer of quality performance.

Yes, I am an avid believer in goal setting in a participative management environment. We in management do not have a monopoly in connection with the generation of new ideas. We do have the responsibility to solicit and objectively examine ideas from all sources, and to selectively use those ideas that will be of justifiable benefit to our society. We must keep open minds and employ objective approaches in all that we do, and we must be willing to accept change, to embrace and perfect new concepts.

However, we must be careful to see that the realization of Mechanical Department goals will result in lower total costs and not just in lower Mechanical Department costs. For instance, the application of fuel economy kits to older locomotives results in increasing Mechanical Department labor and material costs, with a resulting increase in ME ratio. However, with the resultant fuel savings we obtain a lower transportation ratio and, more importantly, total costs are reduced, making possible a lower operating ratio. This is an example, I think, of managing maintenance for quality performance.

Another example is taking into consideration the total costs when acquiring new locomotives. We must not just consider initial costs and maintenance costs but fuel costs, crew costs, and reliability as well. We must acquire those locomotives that will give us the lowest total lifetime costs. The new high adhesion, high horsepower, microprocessor controlled locomotives provide the low total lifetime costs that we need to be the low cost producers of quality performance today.

For tomorrow, we need to develop innovative and cost justifiable uses of alternate fuels for our motive power. There has been no real effort until just recently to develop a cost-justifiable, coal-burning locomotive in almost 30 years. The last coal-fired gas turbine locomotive effort was in the middle-'50s, and the last coal-fired steam turbine effort was discontinued in the late '50s.

While the diesel locomotive manufacturers have done a creditable job in increasing fuel efficiency to offset rising diesel fuel prices, the fact of the matter is that the diesel locomotive is maturing just as the reciprocating steam locomotive, which it replaced, matured. So, not only do the railroads need a shot in the arm in the way of more cost effective motive power, but the locomotive manufacturers and their suppliers need a new product to replace the oil-buring diesel just as the diesel replaced the reciprocating steam locomotive.

It is interesting to note that, even with the increased escalation in the price of diesel fuel in comparison with coal, because of the significant improvements in efficiency of the diesel-electric locomotive that have been brought about, the ratio of fuel costs between the most efficient middle-'50s coal-burning reciprocating steam locomotive and a new high adhesion microprocessor-controlled diesel-electric locomotive is precisely the same today as the ratio between steam and diesel was 30 years ago — and fuel cost was not the real driver in the conversion from steam to diesel — a real tribute to the locomotive manufacturers. However, they have just about run the string out, and both we and they need a new cost effective coal-burning electric-drive locomotive.

As we manage maintenance for quality performance, we must not only keep our marketing people informed of new materials, concepts and designs — we must also be prompt and innovative in reacting to the needs of our marketing departments. We will need to stay close to our customers, either directly or through our marketing people. We especially need to be sure that we are supporting our free enterprise system by directing our efforts toward cost effectively satisfying a present or future market need, and suppress any possible desire to create a machine or design or system for which there is no need in the market place or which is not totally cost effective. In other words, in addition to "doing things right," we must be sure we are doing the "right things." Just because something can be done doesn't necessarily mean that it should be done; and just because something has never been done doesn't necessarily mean that it shouldn't be done.

If we are to be the low cost producers of quality performance, we must have full and complete facts on which to base managerial decisions. Simply stated, we cannot tolerate inaccurate records, biased reports, juggled figures, or withholding of information. Our objective must be to assure that the most cost effective solution is found for every problem or opportunity, regardless of who appears to get the credit or benefit.

We must never compromise by editing, or withholding, information in order to tell anyone what we think that person or group might want to hear. We must never forget that in our free society, the actions of each individual make a difference and that each of us is solely responsible for our every act; and we must never forget to continually thank God for the privilege of living in this great land and for the good fortune of working in this industry.

Thank you very much.

[Applause]

PRESIDENT WALKER: Thank you, Mr. Scott. In appreciation of your appearance here, and on behalf of the Air Brake Association, this plaque is presented to you. On behalf of the LMOA, which is the host this year (we rotate), this desk set is presented to you, indicating Life Membership in the LMOA. [Applause]

At this time we will break and go into our individual sessions. I hope each of you will attend the meeting of your choice. We do need your support and expect your attendance. The LMOA will meet in the State Ballroom, and the other meetings are listed in your program. Thank you.

[Recess.]

LMOA President Darrell M. Walker presents Hobart L. Scott, Jr. with General desk set, emblematic of Honorary Life Membership in LMOA.

MONDAY AFTERNOON SESSION
September 16, 1985

The meeting reconvened at 2 p.m., Mr. Darrell M. Walker, President, presiding.

PRESIDENT WALKER: Gentlemen, we will start the second session of the 1985 LMOA meeting. As we begin, I would like to announce that we have two foreign members from Australia, one from Singapore and four from India, all foreign members of the LMOA, and some of them may be in attendance. If they are present I would like to have them stand and be recognized. We are very proud to have you with us as members of the LMOA. [Applause]

It appears that at this point the President should give an address. I had a very nice speech written out, but somebody by the name of Scott got hold of it, so I will have to shoot from the hip.

While sitting at the table eating lunch, I was asked how this year has been for me as President of the LMOA. As I look at this question and try to answer it, I can see a changing of an era. Most people who have stood before you as President in the past few years have retired effective as of this meeting. I have a few years yet to serve, and as I look around I see young men in the organization who also have years to serve.

It has been a very exciting year. This year both builders introduced new locomotives. Microprocessor locomotives are a new technology beyond comprehension. I am proud to say that I have had the experience of riding each locomotive, and I believe the technology is so far in advance of anything I have experienced in the last twenty years that I get really excited. I have ridden locomotives for five and six hours at a time, and usually it is pretty boring, but I can tell you that these trips were like five or ten minutes.

That is not to say these locomotives were introduced without problems. We at Norfolk Southern have these locomotives, and we like them enough that we have placed orders for next year with both builders. We are ready to grow with the builders through the growing pains we know are coming.

As mentioned by Mr. Scott, all railroad-related companies must change. We have to take into consideration what mergers will have to do with our organization. We know we are going to reduce in numbers. The Vice Presidents of this organization were assigned the job in the past year to look at our organization and look into the future and find out what our needs might be, and come back with recommendations as to what will be necessary to make this an organization that will continue to be alive and active and strong within the industry.

Some of these changes will be put into effect next year. Some are cost reductions. Others include a way to take the LMOA to the people, knowing that we cannot continue to send the great numbers to one place. I must ask you seated in the audience, whether you are supply people, manufacturers of locomotives or from the railroads, to support the LMOA. Without your support we cannot continue to survive. We need you as members. We need you to solicit new members from your companies. We need new advertisers. We need committee members and people who can progress through the ranks of the LMOA, which is at least a 15-year process. We need people who will grow with the organization.

Often in my 18 to 20 years with the LMOA I have discussed the Association with people, and many times I have heard the comment that we really don't do that much, that we are just one big party group. I would like to respond to that and say that to me the LMOA has meant a heck of a lot. I feel that I have grown as an individual. I also challenge anyone to walk into a hospitality room and really observe what is going on. You will find the women in one corner and the men still railroading over in another corner. These contacts that have been established for me over the years have led to a very strong relationship and friendship. I can pick up the phone and call Bill James, Mike Wall, Jack Kuhns, Dale Propp, and I am calling friends, not necessarily heads of locomotive departments of other railroads. It is easy to talk with friends and get a problem resolved.

So, I encourage you to support this organization. Send people to come through the ranks if you are in a position with your railroad to do that. Give us members on our committees, and I think through this cooperation we will all grow and be a strong organization.

Thank you very much.

[Applause]

Now I would like to ask that you stand in memory of our deceased members whom we lost in the past year, and especially Past Presidents Ky Pruchnicki, George Niemeyer, Nelson Buskey, and a faithful associate member, Mr. Roy Touchstone.

[Silent standing tribute to departed members.]

PRESIDENT WALKER: Now I would like to call on Vice President Jack Kuhns, Manager Planning and Maintenance, Seaboard System Railroad, to serve as officer of the session.

MR. J. L. KUHNS: Welcome to the afternoon session. We have an excellent turnout after a fine luncheon.

I would like to call on our Fourth Vice President, Dave Goehring, for the Membership report.

D. G. GOEHRING
Mgr. Locomotive Heavy Maintenance
National Railroad Passenger Corp.
Washington, DC

B. A. CUMBEA
Mgr. Loco. Maint. - Engr. (Retired)
Chessie System
Huntington, WV

MR. D. G. GOEHRING [Manager Locomotive Heavy Maintenance, National Railroad Passenger Corporation, Washington, D. C.]: The LMOA membership as of the beginning of the meeting yesterday at noon consisted of 773 railroad members, 333 associate members, 30 members from foreign countries outside the United States and Canada, and 90 advertisers, making a total of 1,226. On Wednesday we will announce the total number of attendees at this meeting as well as an update of the membership figures.

Thank you.

MR. KUHNS: Now I would like to call on a former Vice President of our Association to give us the Nominating Committee report. Mr. Bud Cumbea, of the Chessie.

Mr. B. A. Cumbea gave the report of the Nominating Committee as follows:

President:
Dale H. Propp, Chief Mechanical Officer, Burlington Northern Railroad, Springfield, MO

1st Vice President:
Donald L. Ward, Coordinator Shop Methods, Burlington Northern Railroad, Springfield, MO

2nd Vice President:
Jack L. Kuhns, Manager Planning & Maintenance, Seaboard System Railroad, Jacksnville, FL

3rd Vice President:
David G. Goehring, Manager Locomotive Heavy Maintenance, Amtrak, Washington, DC

4th Vice President:
Thomas A. Kessenger, Senior Engineer Facility Planning, Seaboard System, Jacksonville, FL

5th Vice President:
William A. Brown, Superinten-

dent Motive Power, Burlington Northern, Overland Park, KS

6th Vice President:

Paul F. Hoerath, Senior Mechanical Engineer - Shops, Conrail, Hollidaysburg, PA

Regional Executives:

Donald R. Hudgens, Manager Field Laboratories, Union Pacific Railroad, Omaha, NE

Joe Kuzela, Jr., Engineer Design, Union Pacific Railroad, Omaha, NE

Francis A. Blundon, Director Material, Burlington Northern Railroad, St. Paul, MN

W. C. "Skip" Hamilton, Asst. Engineer of Tests, Seaboard System Railroad, Waycross, GA

Roger W. Vitek, Superintendent Motive Power, Chicago & North Western Trans. Company, Chicago, IL

Kenneth R. Keller, Asst. to Chief Mechanical Officer, Burlington Northern Railroad, Overland Park, KS

MR. R. W. VITEK [Mechanical Maintenance Superintendent Motive Power, Chicago & Northwestern Transportation Company, Chicago, Illinois]: Mr. President, I move that the slate of officers be accepted.

[The motion was severally seconded, was put to a vote, and was carried unanimously.]

PRESIDENT WALKER: Bud, we would like to recognize you at this time as a member of the LMOA who has served for many

Past Vice President Bud Cumbea, right, is shown accepting the General desk set from President Darrell Walker. The award was in recognition of Bud's outstanding contribution to the association over the years.

J. J. DWYER
Retired Engineer Environmental Control, Chessie System, and long-time LMOA officer.

years and retired before you reached the top. It is a pleasure to give you this lifetime membership in the Association and this desk set. [Applause]

MR. KUHNS: I would now like to ask Jack Dwyer to come up and give us the financial report. Jack has retired from active railroading, but he is still very active with railroads. Jack was on this podium for 12 years as chairman of the What's Your Problem panel. Jack, may we have the financial report, please.

[Mr. Jack Dwyer gave the financial report as follows:]

LOCOMOTIVE MAINTENANCE OFFICERS ASSOCIATION
FINANCIAL REPORT
FOR THE YEAR ENDED DECEMBER 31, 1984

OPENING BALANCE JANUARY 1, 1984			
(Security Bank, NOW Account)			$25,190
RECEIPTS:			
Dues — Active Members	$12,129		
Dues — Associate & Foreign Members	7,433		
Registration Fees	5,110		
Advertising Revenue	22,608		
Interest from Security Bank	1,329		
Miscellaneous	140		
TOTAL RECEIPTS		$48,749	
EXPENDITURES:			
Convention, Publication and Travel Expenses	$26,405		
Office Expenses, Office Assistance, Equipment, Supplies, Postage, Stationery and Taxes	23,536		
TOTAL EXPENDITURES		49,941	
EXCESS OF EXPENDITURES OVER RECEIPTS			— 1,192
CLOSING BALANCE DECEMBER 31, 1984			$23,998

The above presents a summary (rounded to the nearest dollar) of the receipts and the expenditures for 1984 and the year-end cash balance as reflected by the records and the bank statements of the Association.

3/15/85 Edward J. Hannel, Accountant

TUESDAY AFTERNOON SESSION
September 17, 1985

The meeting reconvened at 1:30 p.m., Mr. Darrell M. Walker, President, presiding.

PRESIDENT WALKER: Mr. Propp, will you please step forward? Dale, this gavel represents the Presidency of the LMOA, and it is a great pleasure to present it to you. [Applause]

[Mr. Dale H. Propp assumed the Presidency of the LMOA.]

PRESIDENT PROPP: Thank you, Darrell. Members and friends, I accept this gavel and the Presidency of the LMOA with deep pride, pleasure and humility.

The slogan that you have seen on coat lapels is our motto for next year: $E = MC^2$.

Certainly Mr. Einstein probably would never have believed that the LMOA would use his formula, which is the theory of relativity (all things being relative) in this way. The real meaning is Excellence in Maintenance Culture Committed to the Bottom Line. That's what our LMOA philosophy is all about — excellence in our maintenance; and since culture represents the way we do things, the way we maintain our locomotives,

Outgoing President Darrell Walker presents gavel to newly elected LMOA President Dale Propp, Chief Mechanical Officer, Burlington Northern Railroad, Springfield, MO.

the way we accomplish our business as individual railroads and as an industry.

Our LMOA Constitution identifies the purpose of the LMOA, to improve the interests of its members through information and exchange of knowledge and education resulting in corrective recommendations on locomotive maintenance procedures to the benefit of our industry. Yesterday Mr. Hobart Scott said very ably that we must be the low cost producer of quality. That is what we are saying in our slogan for next year.

Certainly our maintenance programs must exhibit productivity, efficiency and quality. All of us know that we must accept the change required to be the low cost producer; but more importantly, I think each of us has to realize that we are responsible for the design and promotion of the change.

All of us must challenge our locomotive maintenance culture; we must challenge the way we do our business, and we must challenge ourselves. This excellent organization of LMOA has done that for many years, and this is the one organization that provides the format for us to challenge the culture of our locomotive maintenance.

The innovative ideas from the brainstorming sessions we have here in many cases have gone on to promote and generate new technology that we so ably need in the future. Not all is accomplished here. The supply industry and the locomotive builders are always researching the problems daily in support of the railroad industry. They do an excellent job for us.

I personally want to commend Darrell Walker for the excellent leadership he has given in 1985, and we wish him well in the future. I remind you, Darrell, that we will need your continued assistance as Chairman of the Board. I also want to recognize Jim Long and Tom Harley, Past Presidents, who are both here today. Both will be assisting us with presentations. We wish Bud Cumbea our best regards for a long and happy retirement.

Our thanks to each of the Associate members. We cannot operate this organization without you. We need your support, and we encourage you to continue with LMOA. We also give our very special thanks to Marty Hausman and Don Roberts of Power Parts for their continued support to the technical committees.

Finally, our thanks to everyone here, to all our members, because you are the LMOA and you represent the maintenance culture of our industry.

I appreciate this opportunity to become your President, and I look forward to an excellent year. We will do our best to put a little pizzazz and enthusiasm in our meetings. Together I know we will continue the great tradition of the LMOA.

Thank you. [Applause]

Now I will call on Jim Long to make a presentation. Mr. Long.

MR. JAMES H. LONG [Retired Manager Locomotive Department, Chessie System, Cincinnati, Ohio]: Darrell, I would like to present to you the Oscar of the LMOA, a Little General desk set that is emblematic of Life membership. I hope you enjoy it as much as I have enjoyed mine. [Applause]

PRESIDENT PROPP: Now I would like to ask Tom Harley to present the Past President's Pin.

MR. E. T. HARLEY [Vice President Equipment, Trailer Train Company, Chicago, Illinois]: Thank you very much, Dale. I have been kidded a little bit about the Car Department Officers Association badge, but I will have to admit that in the six years I have been with Trailer Train I haven't had one ground relay, I haven't had an engine not loading, I haven't had a water leak. Everything is not all that bad.

It is a great pleasure to present Darrell Walker with his Past President's Pin. Darrell, you have done a great job for LMOA, and we give this pin to you in honor of your service to LMOA. [Applause]

I have one more thing to present to Darrell. This is the bound volume of the Annual Proceedings, which is also given to each new Past President. [Applause]

PRESIDENT PROPP: Darrell has been delegating all year to the 1st Vice President. This time I would like to delegate back to him. I would like to call on Darrell Walker to present a blazer to our 5th Vice President.

MR. WALKER: Bill Brown, will you come forward?

[Mr. Brown was presented with his blue blazer.] [Applause]

PRESIDENT PROPP: We have one more presentation before we start the afternoon session. I will call again on Darrell Walker and Jim Long.

MR. WALKER: Marty, will you come forward at this time, please? For those in the audience who may not know, Marty, of Power Parts Corporation, is celebrating his 40th year of service. This guy has been named Man of the Year by the LMOA in the past. Marty, we have had a hard time coming up with something else to show our appreciation and to join with you in this 40th year celebration.

Marty is not quitting. He picks on us youngsters all the time. He especially likes to pick on the ones just coming into the organization without having to shave.

Marty has a goal even at this time in life — to double his business in the next two years, he says. I believe he can do it. Anyway, we couldn't find an appropriate gift, so we reached out to a man who is a Past President of the LMOA and who has a few whiskers on his chin. At this time I will ask Jim Long to make a special presentation to Marty Hausman.

MR. LONG: First of all, when called upon to handle this little task for the LMOA, I wondered what we could give to a fellow who has everything. With a few ideas from Joe and other officers,

Past President Darrell Walker is shown receiving the General desk set and life membership in LMOA in recognition of his service as president and for his years of service in LMOA. Making the presentation is Dale Propp, newly elected president. Looking on in approval is Vice President David Goehring.

First Vice President Don Ward is shown presenting Darrell Walker with the past president's pin. In center is LMOA Vice President Tom Kessenger.

Past President Jim Long is shown presenting Marty Hausman with a special LMOA pin in recognition of the 40th year of Marty's company. A smiling Darrell Walker joins in the celebration.

we came up with this, and I like it so much that I'm not going to give it to him but take it back home with me.

Marty, you have been in business for 40 years. The LMOA was organized from the old Boiler Makers and the Master Mechanics Association, so really you and this Association are tied together hand in hand.

This is a little locomotive with "LMOA" and "Marty" on it. It is dated "1985" and "40." The "40" is for 40 years young. I would like to present this to you on behalf of the Association. I hope you wear it with pride. Congratulations, and we hope you have many, many good years ahead. [Applause]

MR. MARTIN C. HAUSMAN [Power Parts Company, Chicago, Illinois]: Those of you who have received letters from me know there is no way in this world I am going to say what I want within three minutes. Give me five minutes or twenty minutes. (How much time do I have?) [Laughter]

Of course, we start out and say thinks; but I've got a little more than that to say, and if you will forgive some sentiment and honest emotion I will share it with you.

In 1935 I was Employee #13 at Electro-Motive, which is 50 years ago, and little did I dream in 1985 I would receive this kind of honor, which I take with a great deal of pride. I would like to go back a little farther than that.

When I was 4 years old, one of a family of 5 children, in abject poverty, I was brought here as an immigrant from Budapest, Hungary with my family, and all we had was a lot of dreams. Well, when you get something like this it's a fulfillment of a dream. When you hear this expression, an expression of our President uses and justifiably so, "Only in America," or "The American Dream," well, you are looking at him right now. So, how about giving me a hand? [Applause]

That was something like a joke, but I took a little poetic license. Never give me a microphone.

But seriously, somebody asked me not too long ago what I had in mind when I first started this business, and for want of a better answer I said I don't know, but sure as hell it was nothing like this!

I told you that in 1935 I was with Electro-Motive. What I need to tell you is that I was in the Purchasing Department, and there I discovered that Purchasing, and Stores, and Services are all fine, but the power — the real importance of a railroad — is in you fellows, the Mechanical Department.

I remember when I first came out to see you, you pushed me down the steps when I tried to get approval on something. There was just no way to get something like this.

When an outfit with such a prestigious character sees fit to honor

MARTIN C. HAUSMAN
Power Parts Company
Chicago, IL

me, I might use the metaphor that's fashioned after David and Goliath. Just imagine taking on G.E., G.M., Alco and Baldwin at that time, and not only manage to survive, but I think we've done pretty well, wouldn't you agree? Just ask my wife — she's got the money.

At this point I would like to mention Don Roberts. Incidentally, Don, thank you for maneuvering this thing. I want to thank you publicly. I don't know how you did it, but I think it is wonderful. I want to thank Don and all of you here. It's fantastic. I can go home tonight and convince my wife and children that I am really something, and I think I am. If you can survive in an industry of this kind and win the blessings of the Mechanical Department, that's where it's at. If you fellows say we're all right, we have it made; if you say we're not, we're dead. It's that simple. Purchasing can buy exactly nothing except the Mechanical Department. So, we respect and we love you, and we try like the devil to win your confidence.

Those of you who came to the plant this afternoon were given a tour, and I had the opportunity to show you my family and show you my background. We had a man visit from Australia who owns the Comeng Company there, and he walked through our plant and said, "By Jove, fellow, you have a lot of 'blood' around here." I didn't know what the devil he was talking about. He was impressed by our people, by the fact that we were free-wheeling, and everybody seemed to enjoy themselves; and we have no unions, and no one quits, and no one gets fired. I am the oldest guy, but we have a lot of old guys around the place, and we are going to hang around as long as we can.

Again I want to tell you this honor is very, very important to me, and I accept it with a great deal of emotion, and I want you to know that I appreciate it. And if I'm around here for our 50th Anniversary, you'd better come up with a hell of a lot more than this!

Thanks very much. [Laughter and applause]

PRESIDENT PROPP: Thanks again to Marty, and thanks to Tom Harley and Jim Long.

PRESIDENT PROPP: It is a pleasure for me to call Jack Hoffman to the podium at this time. As Mr. Hamilton mentioned, Jack is retiring in the next few days. Jack has represented General Electric very well for many years. He has been with the LMOA for 25 years, and served on the Fuel and Lubricant Committee all that time. All of us know that Jack has answered a lot of questions, not only on behalf of his own company but questions on behalf of other members of the LMOA. His expertise is highly respected by all in our industry.

Jack, it is a pleasure for us to wish you well in your retirement and to thank you for your outstanding performance in LMOA. We would like to present to you this certificate, which reads: "In recognition and appreciation of your 25 years of outstanding contributions to LMOA and particularly to the Fuel and Lubricants Committee, LMOA is honoring you with a special 25-year pin" that will be presented to you upon its completion. [Laughter and Applause] Thank you again, and best wishes for a long and happy retirement.

MR. J. G. HOFFMAN [Manager Combustion Engineering, General Electric Company, Erie, Pennsylvania]: All I can say is that for the first time on this Committee I am speechless. I certainly want to make three comments or observations.

First, I want to thank Dale and the LMOA for this very unexpected honor.

Second, I want to thank all of you for your friendship over these many years.

Third, I would like to thank all of you for all you have taught me to help make my job easier.

I want to congratulate Dale on becoming President of LMOA. Perhaps the major regret I have in severing relationships with the Association is to not be here and observe his presidency and in some way contribute to it.

Thank you very much.

[Applause]

PRESIDENT PROPP: Thank you, Jack. You are going to be missed a lot. Do come back and see us next year, won't you.

LMOA Vice President Jack Kuhns presents Darrell Walker with bound copy of the LMOA Annual Publication covering his year as president.

Newly elected LMOA Vice President William A. Brown, Supt. Motive Power, Burlington Northern, receives his LMOA blazer from President Dale Propp.

WEDNESDAY MORNING SESSION
September 18, 1985

PRESIDENT PROPP: At this time I would like to call on our 3rd Vice President, Mr. Dave Goehring, for a membership report.

MR. GOEHRING: I have some good news. First I would like to give the membership figures as they stand as of 7 o'clock this morning. We have 850 railroad members, 383 Associate members, 30 members from countries outside the United States and Canada, and 90 Advertisers in our book, making a total of 1,353 members.

This year at the convention there are 293 registered in the LMOA. This is a little less than we had last year — but last year, being an exhibit year, was an exception. There is always a higher attendance at that time.

Comparing these 1985 figures with 1983, in 1983 we had 287 members attending and registered, and this year with 293 we have actually exceeded our membership of two years ago. I think that is a great achievement.

I particularly want to mention and thank two railroads that have a good representation this year, the Santa Fe and Conrail. They have really helped to boost the attendance at these meetings, and we appreciate that very much. I hope some of the other major railroads will put this kind of emphasis into attendance in future years.

PRESIDENT PROPP: Thank you, Dave.

Now I would like to recognize three very important people at our meeting: Our Secretaries, Joe and Lou Koerner, and our recorder, Charlotte Emmons. [Applause] We do really appreciate the long and faithful service by all of you.

Now I would like to call on our 1st Vice President, Don Ward, to act as officer of the next session.

MR. WARD: Thank you. We have reached the final session of our LMOA meeting this year, and of course we consider this more or less to be the highlight of our meetings. This is our What's Your Problem session, the time when you, the participants, ask any questions you might have. The people up here on the platform and some in the audience will try to answer them. No questions are off limits. I hope you will all participate as much as possible.

It is now my pleasure to present Joe Kuzela, Engineer of Design, Union Pacific, Omaha, who will be the chairman of the What's Your Problem session.

MR. KUZELA: Thank you, Don. I would like to welcome all of you to our meeting today. I would like to introduce our expert panel along with our vendors out in the audience who are going to help us answer all your questions, I hope.

Ken Keller, chairman of the Electrical Committee, Burlington Northern Railroad.

Roger Vitek, Chicago & Northwestern, chairman of the Diesel Mechanical Maintenance Committee.

Merrill Anderson, Manager Mechanical Services, Duluth, Missabe & Iron Range Railroad, chairman of the Committee on Shop Equipment.

"Skip" Hamilton, Assistant Engineer of Tests, Seaboard System Railroad, Waycross, Georgia, chairman of the Committee on Fuel and Lubricants.

Mike Starr, Senior Locomotive Engineer, Southern Pacific, San Francisco, chairman of the Committee on New Developments.

Fran Blundon, Burlington Northern Railroad, St. Paul, Minnesota, chairman of the Diesel Material Control Committee.

Now I would like to open the floor for questions.

MR. K. A. KELLER: My first question is going to be directed to my long-lost cousin from the Burlington, on traction motor builders and suppliers of traction motor brushes. Anybody and everybody who wants to get into this one, feel free to do so.

Here is my problem. I run diesels between Chicago and Los Angeles over the Santa Fe, also between Chicago and Oakland over the Burlington, the Rio Grande and the Southern Pacific, and I have what I percieve is a big traction motor problem — flashovers on grounded armatures, and other problems.

To give you a little background as to what these locomotives of ours face, we run 90 mph on the Santa Fe mile after mile after mile, and then all at once we hit Raton Pass out of Trinidad, Colorado, and we are down on our knees for about 20 miles at the continuing rate or worse, and then if we make it over that hill we go to dynamic braking for 20 or 30 miles down the other side, and then we go for several hundred miles up and down, up and down, and we get to Needles, California and we do the same thing two more times before we get to Barstow. So, we have the worst of both worlds. We have high speeds, 90 mph mile after mile, and low speeds, high current, in the red maybe if it is up to the maximum car consist and one engine maybe is a little weak, or we get wet rail, or that sort of thing.

That's my problem. My question is this: The builders have always said you can't mix traction motor brushes in the same traction motor. I ask: In this case, why not? It can't be any worse than the problems we have right now. What would happen if I were to mix two different grades of brushes that are, let's say, vastly different in terms of their performance and characteristics?

MR. KEN KELLER: I think your question is pretty lengthy and

there is more than one part to it. I will make a few comments first, and then if I have not answered your question let me know and I will try again.

I think your circumstances are certainly unique. We in the freight business don't see quite the extremes you just mentioned, 90 mph and then at Trinidad you are in minimum continuous speed for quite a long time. Maybe in this type of service you will get some film stripping, and when you reach 90 mph you have extremely high voltages on your traction motor armatures and your brushes begin to trail fire; you ionize the air in the traction motor, and you are bound to see a lot of flashovers. I thing if you haven't done so it would be a good idea to try several grades of test brushes in your motors under these conditions, and get a grade in service that will perform best for your conditions.

To answer your question about mixing brushes: On our railroad we use several grades of brushes and several manufacturers of brushes. Although we try to keep them in areas where they won't get mixed, it does happen, and we do have some classes of power in certain types of service where we do have considerable flashover problems.

The older classes of power with DC generators and transition steps and traction motor field in some cases have a severe problem. We have brush pigtails burning off, some cases where brush holder segments will be blown apart, and brushes consequently sticking, adding to this problem. There again I think you have to look at the type of service and the particular class of power, and you have to watch your brush grades and performance extremely closely.

I am not sure I answered your question.

MR. K. A. KELLER. Would you comment on mixing brush grades in the same traction motor?

MR. KEN KELLER: All I can say is that on our railroad we try not to do it, but it does happen. Many times a locomotive that may be assigned out West somewhere will receive a 92-day inspection, and some brushes will be installed elsewhere on the railroad and we will get some mixing. I do believe there could be cases where this is contributing to some of our flashover problems.

MR. K. A. KELLER: What about doing it deliberately? Do you think it has any merit?

MR. KEN KELLER: Well, I really don't think it is a good idea. There are some people on our staff who feel you are not going to have extreme consequences. However, I think under certain conditions, especially unique conditions that you are talking about, your best bet is to try not to mix them.

MR. KUZELA: Do any vendors have a comment on that?

MR. STARR: On the EMD motors, GE, strangely enough, has come up with a flash ring applica-

tion. I personally think it is very promising, and we have a few out on tests on our railroad.

I think flashovers are a function of high speed and high potential and improper transitions in power. Those conditions are difficult to change, but you can change where the flash will move to. You may want to try a test of some flash rings on EMD motors as well as research the potential dollar in a cost benefit analysis.

MR. WILLIAM PINCH, JR. [Union Carbide Corporation, Electronics Division, Lakewood, Ohio]: Brush operation on DC motors is an extremely complicated mechanism. Addressing the question of mixing brushes on traction motors, parallel circuits are involved. There are two positive brush arms and two negative brush arms. The filming characteristics of different brush grades are different among grades of the same manufacturer, and certainly different among grades of other manufacturers.

The problem in the mixing of brush grades is specifically contact drop. No two grades exhibit the same contact drop, which is the voltage drop between the commutator and the brush right at the interface. With the parallel circuitry some brushes, the ones with the lower contact drop, will tend to hog a larger share of the load current. Current is directly proportional in the laying down and taking off of commutator film. When brush grades of different contact drops are mixed, a dissimilarity in the collection of the current among brushes exists and a change in the film can occur, which can then change the frictional characteristics of the film. This changes the ability of the brush to stay down in intimate contact with the commutator, and sparking may begin to occur.

If it is necessary to mix brushes, do it by polarity. This allows the positive brushes and the negative brushes to maintain a similar contact drop for more equitable current sharing. So, if you agree that you have to mix brushes by polarity, then it is probably just as easy to maintain the same brush grade in a given motor.

MR. KUZELA: Is there anyone else who has a subject to bring up or who wants to expand on the last subject? If not, I have a challenge here for the locomotive builders:

"I would like to challenge the locomotive builders to build or produce a non-plugging, maintenance-free crankcase eductor tube. The biggest complaint we have from the California and Oregon Forest Departments is that dirty eductor tubes cause fires, and they are actually inspecting locomotives and want to stop trains to do this."

So, maybe by next year they will have a maintenance-free, non-plugging eductor tube. Any comment on that? If not, I have some questions from the Mail Bag that I will bring up. One of them is an unanswered question from a previous session.

This question concerns the fact that we were going to give the battery manufacturers time to give us an answer on a quick, easy way to fill the batteries — the cells that are under the carbody portion in the back of the battery box. Any comments?

MR. V. HERNANDEZ: [General Battery Corporation, Lisle, Illinois]: As far as cell fillers are concerned, there have been a number of them on the market for some time.

I think the biggest problem with regard to railroad operation is the wear and tear that takes place on cell fillers. There have been problems setting up repairs on them, they become expensive to repair, and they are not cheap to begin with.

There is another problem to consider. You can take half a dozen different battery supply people and each of them has a different watering level for their batteries. You buy yourself a cell filler which will be compatible to one type, and if you have three types of batteries each of them might have a different watering level, so when you go to buy a filler you have to compromise. You don't go by the depth of the solution above the plate itself — you go by the amount of distance from the top of the plates to the bottom of the filler hole. There again you might have anywhere from 1½ to 3 inches. You stick a cell filler down in there and have it set for a 3-inch distance. That is no good for a 1 or 1½ inch battery solution level, so you have to make a compromise.

As far as I know, I think you can specify the depth to the bottom of the filler hole as to what you want in the way of solution. It has been pretty much standard for years. You want to fill that cell to about ⅛ to ¼ inch below the bottom of the fill tube. You may have to sacrifice a little bit of solution on some of them, where you set to fill, let's say, ⅛ or ¼ inch below the bottom of the fill tube. On another type that may be too high, so you have to govern yourself by the one that has the longest fill tube. It can be done.

They also used to put collars on cell fillers, which were a problem. The collars got lost, or you didn't have a chart which told you which collar to use for which type of battery, or whose battery, and those collars went by the wayside.

It got to a point where people listened when filling a cell, and as soon as it sounded like the cell was filled they stopped filling. You may be low, and by the same token you think you are all right and you overfill the cell. There was also a lot of breakage in cell fillers. They have gone pretty much to plastic now. I remember I used to take them and have a half set of batteries on one side of the track, and I would fill those batteries on that side, throw the filler through to the other side, walk around and pick it up, and I broke them myself. You can't

handle them that way. It is a piece of equipment that requires careful handling.

These cell fillers come in various lengths, anywhere from 12 or 13 inches up to 48 inches, and intermediate lengths like 30 inches will probably take care of most of your battery boxes. If you have to reach in 30 inches, the 30-inch type cell fillers will reach in there to fill the battery. They have an automatic shutoff on most of them today. They have a quick-disconnect, so you can disconnect and don't have to go back and shut the water off.

Does that answer your question?

MR. KUZELA: Thank you. I guess there is no easy way.

MR. HERNANDEZ: There is no easy way, really, and it is a compromise as to where you have the levels set, unless you want to bother with collars again, which nobody liked.

Another problem was that a lot of people sold them, and it was hard to get them serviced. There are people who will service them today.

MR. KUZELA: We have bottled drinking water now, and maybe we could have bottled battery water and a disposable filler. Maybe somebody will come up with that next year.

MR. GOEHRING: The problem appears to me to be not just filling the battery but getting access to the battery cells so that the water can be applied. What I am about to suggest may not be a solution for the diesel locomotive, but at Amtrak we are currently placing batteries in a rollout drawer under electric locomotives.

The device that Wilmington Shops came up with is like a filing cabinet drawer that slides out from beneath the locomotive, exposing the whole battery tray where everything is accessible. After the batteries are serviced the battery drawer is put back and locked in place.

VOICE: The session is leaning on battery people here, and I think the problem is EMD's. I think it is a lousy installation where those batteries are, and where they are placed on the locomotive. We ought to ask EMD and GE about looking into where they can put the batteries so they are more accessible for servicing.

We average, I would say, anywhere from eight to ten failures a day due to battery problems, and the problems are in the servicing, using a garden hose to fill the battery. You overfill it. This is what they call flushing the batteries. They flush all the electrolyte out of them. I am sure it is not unique to our railroad, the Southern Pacific. The battery boxes themselves rot away because the electrolyte spills over. Basically it is a lousy application of where those batteries are located. I would like to have an EMD representative address that.

MR. KUZELA: Has any builder a comment on that? I guess they

don't want to make a comment on that.

MR. KUHNS: Maybe we can get them to comment on this: I would like to know if we are the only railroad that is having difficulty starting our SD50s with the F3B engine. If not, what are we supposed to do?

MR. WALTER WECK [Electro-Motive Division, LaGrange, Illinois]: Jack and I go back a long way, and Jack has a habit of asking questions he knows the answers to. [Laughter]

Jack, your organization is not the only one that is having that particular problem. Your sister organization on the Chessie had exactly the same problem. As to what we are going to have to do, it ties into an entire research project you are also aware of, with all of the oil carryover and things that will hold valves open that will not allow for enough compression. It is a long, involved development in order to get what you are looking at — 100% start 100% of the time.

MR. KUZELA: Is it that the valves are staying open?

MR. WECK: The assumption at the present time is that after a protracted period of shutdown some of the carbonaceous material in the head seat area is depositing itself on the valve seat and is giving us incomplete closure. That is the only thing we can come up with at the present time. The rings, the liner sizes, the wearing components are excellent, so the only place you would get into this kind of thing is in the area Jack is talking about.

MR. KUHNS: Are we sure that is what it is, Walter? I am not sure we know this yet. We have tried bouncing the valves and it still will not start.

MR. WECK: Jack, you and I are never going to solve this problem standing here on this floor talking about it. We are working with you on this particular problem, and we will work with anyone on the problem.

MR. KUHNS: Let's get away from the EF3B. Let's stay with the E3B. Does anybody have trouble starting that one?

MR. M. M. STARR [Senior Electrical Engineer, Southern Pacific Transportation Company, San Francisco, California]: We had a rash of problems with our SD45s. We recently changed our requirements for our 20-cylinder engines to specify only high capacity batteries, what we like to call John Wayne batteries for our 20-cylinder engines. This has helped us with our problem.

MR. KUHNS: Maybe we should just turn it faster, then.

MR. KUZELA: Put a booster battery on it.

MR. K. A. KELLER: Since I asked the original question a day or two ago, I thought about the problem some more. Dave Goehring mentioned what we are doing with the electrics at Wilmington, and I have this to offer as far as

the rest of the locomotive fleet goes:

I think maybe what we need to do is to design the battery installation so that you can very easily remove the whole battery with a forklift truck. This would get into Mr. Anderson's committee, but build the thing so you can pull it out with a forklift truck, get it disconnected in 30 seconds or a minute or whatever, yank it out with a forklift truck, and then see what you are doing. You can get at everything, and do what you have to do, and put it back in the battery box and hook it back up in two minutes or whatever time it takes you, and go to the other side and do the same thing. It will probably be faster and easier and better than trying to get the last row of batteries the way they are presently.

MR. BLUNDON: Ten or fifteen years ago I had an automobile that had a battery with caps on it. I had to check the water regularly. Today I have an automobile with a maintenance-free battery, and I don't even have to look at it.

Is EMD and the battery industry going to develop a battery like that for locomotives?

MR. STARR: I will make a quick comment. About four or five years ago a major battery manufacturer, which I don't believe is represented here, advertised a low-maintenance battery. They did a lot of research to reduce water consumption and change the calcium alloys, and so on. It was a failure, not lasting more than two years.

I think the railroad application is unique because of the higher temperatures and more cycling. I don't think it is possible to design a maintenance-free battery for locomotives that will last four to six years. You may extend the watering interval a bit, but we looked at it closely and came to the conclusion that "maintenance free" is a misnomer for locomotive applications. There were a lot of advertisements to that effect about four years ago.

MR. HERNANDEZ: There came into the market about 15 years ago, if I remember correctly, a so-called self-watering battery which was on the order of a low-maintenance battery. It was tried. I don't see it around today, although the idea is still there. The one point watering system is now available from several manufacturers.

One of the things we all hear from you people is: "When are we going to get a sealed maintenance-free battery?" There are several things that enter into it. One is the high currents you are dealing with. You hit that battery with a cranking load and you have a breakaway that goes up to 1800 amps, and that battery jumps. It is the same way charging back. You are going to have gassing, you are going to build up pressures within it, and this is probably one of several things that hold up this development.

The battery companies are aware

we are talking about, and the E3Bs still have that problem.

MR. VITEK: Some of the gentlemen on our Diesel Mechanical Committee brought up the fact that at one time in the recent past EMD had a problem with some of the rebuild kits they were supplied, in that the thickness of the diaphragm particularly in the low water portion was somewhat thicker than it should have been. I don't know what the exact dimensions were, but this was causing a problem with false shutdown.

MR. WECK: That was a while back, and that was exactly the case. That surely should have been behind us for several years now. There could be some of the pieces still in existence. That is not an impossibility. We would certainly like to look at those particular devices. That is about the only way we could get to a solution.

MR. FINDER: Are you open for a new subject?

MR. KUZELA: Yes.

MR. FINDER: Let me make a few comments on ceramic components. I feel this subject was somewhat glossed over a little too fast yesterday, and there are some misconceptions that need to be straightened out.

In my 18 years' association with putting on and applying ceramic coatings, I can tell you that if you have the correct application, quali-

heat treatment of metal for surface hardening.

In addition to that, I am going to share a little secret guideline with you, and it is a very simple checklist. It is for people who are skeptical about these coatings:

Whenever you get on an aircraft that has jet engines, simply pose a question to the pilot: Do you have ceramic coatings in your combustion chambers? If he says yes, stay on the plane. If he says no, get off and take as many people off with you as you can, as fast as you can. If he says "I don't know", tell him you are not going to let him move that plane until he finds out.

That sounds a little facetious, but the point I am trying to make is that for the past ten years ceramic coatings have kept those jet engines running long beyond the OEM's design engineering criteria.

Let me make a few more comments about what is going on in your own industry, because I feel there are people who don't know. I am going to praise several organizations. First, the Kansas City Southern Railroad has now running two engines with ceramic coated components on them. One of them has been running two years as of this month, and according to their personnel, whom I will tell you

of the situation and have talked about it, and some of them are coming up with low-maintenance batteries, but I think a true maintenance-free battery is a little way in the future.

MR. T. D. LEMONS [Supervisor Locomotive Equipment, Missouri Pacific Railroad, St. Louis, Missouri]: We are going to start taking delivery of sixty C-36-7 GE locomotives this month. Ten of these locomotives will have batteries with sealed tops on them, and they are predicted to go five years without watering. They are 476 amp/hour batteries. Maybe I will have something to report on that later.

MR. K. A. KELLER: After the five years will you be able to take the tops off the batteries and extend their service life?

MR. LEMONS: Yes.

MR. K. A. KELLER: And get ten years out of them?

MR. LEMONS: Predicted, 14. They are Exide batteries.

MR. KUZELA: Mr. Teghtman, Shop Superintendent on the Union Pacific, asks this question: "Is any other railroad experiencing problems with vibration on the front end of E3B engines causing false engine protector shutdowns?

Does the vendor or builder want to comment on that?

MR. WECK: Our experience with the engine protector on the E3B engine or any of the engines has been excellent. The thing we think is the problem the gentleman is referring to is not vibration within the engine, but literally a worn-out engine protection device itself that is badly in need of overhaul. Properly maintained, properly rebuilt, these will not be set off by "front end vibrations" in the engine.

MR. KUZELA: I was pretty close to this project. We found that our older engines, our E3s, don't do this. They can have more miles on them than the E3B, and you don't have a problem with the shutdown. We have even gone so far as to blank off the shutdown device so that it didn't get any crankcase pressure, and it still tripped. We feel changing out the harmonic balances did not help. We still have four or five of those culprits out there.

MR. WECK: We will be only too pleased to give you four or five shutdown devices that will be qualified, and let's see if we can go through the same drill on a small number of units.

MR. KUZELA: We went so far as to tell the mechanics that they can only change out the shutdown device once, not five times. Our master mechanic, who just retired, said the low water/crankcase pressure device was changed out so many times that it knew its own way on and off. [Laughter] The engine still has problems.

MR. WECK: It is a specific. I don't hear anything from anyone else in the audience, so I hope it is unique to yours. We will be only too pleased to get into those devices with you on a 1:1 basis.

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The same is occurring with their second engine, which has been running in the field for 8 months. The first engine has been running over 200,000 miles now, without a problem and with good results. The gentleman to talk to about that is the man who oversees that, Mr. Bob Jones from Shreveport. I don't know if he is here today, but he has been here during the conference.

The second order of praise goes to the Union Pacific Railroad. They now have two ceramic coated engines in-house and they are now going through the motions of testing them. Mr. Bill Jacobs is overseeing that project. I am not sure whether he is here today, but he is another person to confer with.

Going back into a little history, we talk about the ICG. They have had ceramic coated pistons somewhere in their system for about 3 years, with excellent results. Mr. Mel Dinius can probably fill you in on those details more than I can. So, you see, we are not talking about a dream, but a reality.

The U. S. Maritime Administration is funding a program which will end some time this year on a test boat on the Mississippi River system utilizing an 8-cylinder 645 EMD engine. It is heavily screwed, it is computerized, the data is very accurate, and this information will be made public. It is a very carefully organized program.

I will close with one word of caution. There has been some comment about the test being run at Southwest Research Institute. I myself recommended that they not use the coating systems they were using, but they were so far along in the program that they went ahead with it anyway, on the recommendation of people who did not have any experience in the field. Now they are testing coating systems which are not applicable to your operations. I don't know what the results are going to be, but I understand now some of them are not too good. They have gone beyond the limits of using those materials in their coating system, and I would caution you to be very wary of relying on those results.

Thank you.

MR. VITEK: Carl, have any of these railroads you are talking about made any tests on brake specific fuel consumption?

MR. FINDER: They haven't made it on fuel consumption, but they have made it on horsepower, oil and water cooling temperatures, interaction with the turbos, and some of the oil pressures, and some of the other information that they normally check during their operating procedures.

The U. S. Maritime program has made specific measurements on fuel consumption, and they are very, very accurate. The Union Pacific, I understand, is going into a very extensive program, and I expect their results to be very sig-

nificant because they are covering all the bases that you will be asking about. I really expect their results to be highly significant. I shouldn't speak for Bill Jacobs, but I would expect their results may be available in the next couple of months. I am not sure about that. Only Bill can tell you about that. He knows what the schedule is.

VOICE: What about the fuel cell in the gas battery? Is that safe enough for locomotive power, and will it simplify the locomotive construction and maintenance if they go to a fuel cell operation?

MR. STARR: We will certainly look into that as a possible topic for the New Developments Committee, but to date we haven't done any investigation in that area.

VOICE: I haven't heard anything on it for years, but several years ago Allis Chalmers built a tractor, and it proved out all right in reports I have read, although I have no up-to-date information. It may be you can save carrying a hydrogen tank around. That is one problem I can see. Maybe that can be safe enough; I don't know.

MR. KUZELA: Mr. Hodgens, Superintendent of Shops, Santa Fe, Kansas City, asks: "When is GE going into full production on welded heads to liner cylinders and make this standard?" Does GE have a comment on that?

MR. W. A. BAILEY: [Manager Product Service, General Electric Company, Erie, Pennsylvania]: I know most people here realize we have tested a great number of electron beam welded cylinders, going back to the early 1970s. The results of these tests on almost every railroad have been very positive, and we are continuing to make a limited number of those types of cylinders available. We are currently investigating different types of welding processes as well as the facility requirements of making a quality product in large production quantities, and until we have that nailed down we won't make a decision about production.

MR. KUZELA: I hear there are vendors that can re-chrome them and rework them.

MR. BAILEY: Yes. We believe a welded assembly can be rebuilt the same way the current one is.

MR. KEN KELLER: Bill, when you are reclaiming a liner head that has been welded, would you leave it all as one assembly or would you cut it apart?

MR. BAILEY: Our current plan is that it would remain as one assembly.

VOICE: We have just received some locomotives with the SISMTR recorder system, and we are initially having some problems with this equipment. Particularly, the needle on the dial seems to want to bounce around when the locomotive is sitting still. This is not a particularly new system; it has been around for several years.

Are there other railroads that have similar problems? If so, what did they do to correct them? If

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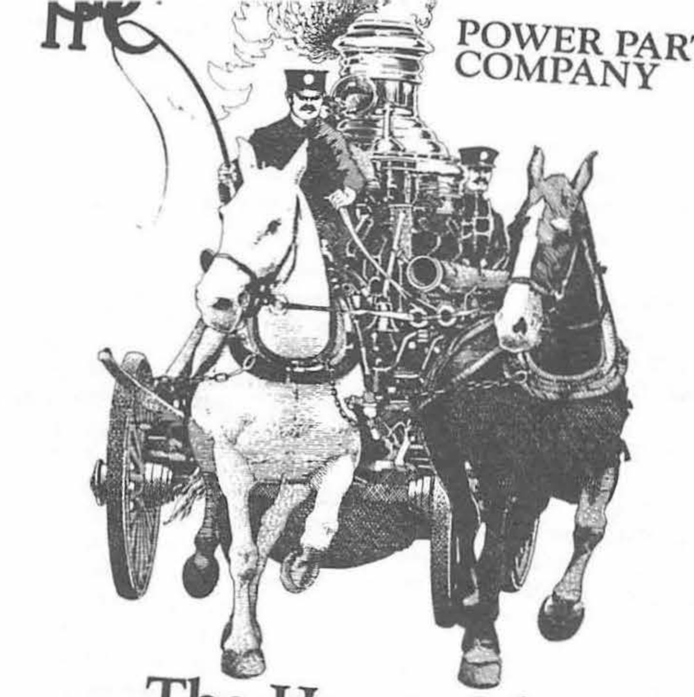

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failures.

MR. KUZELA: Are you still applying the modulating governor to the locomotives you are building today?

MR. WICKSTROM: Yes, we still apply a modulating governor, but we limit the modulating time.

MR. KUZELA: What is the time?

MR. WICKSTROM: I believe it is 19 seconds now. After an additional 77 seconds all load is dropped and the engine returned to idle.

MR. KUZELA: Here is a question from Merwin Miller, Union Pacific, Omaha: "Can retrofit be done on EMD and GE locomotives for hot traction motor protection?"

Does EMD or GE have a modification to retrofit existing locomotives?

MR. MALOVICH: The GE MTP panel is retrofittable primarily on the locomotives that were built from 1977 up to the present time. Going backward from 1977 the system for that has not been developed.

MR. EUGENE NIEMEYER [Electro-Motive Division, LaGrange, Illinois]: The M. S. function you are referring to is retrofittable to the 50 series if they are not already on, but not Dash 2s or pre-Dash 2s. We do not have a system for that.

ing plugged labyrinth ... turbocharger. Can you elaborate on this? This oil is also causing build-up on the impeller blades on the turbo."

Does Arrowsmith or EMD have a comment on that?

MR. VITEK: I think we have a comment to make on that. On our GP50 locomotives, when they were approaching approximately 4 years old and somewhat after that, we experienced units that were pumping oil excessively out the stack. When I approached the subject I was told to look at the head seat rings. We did that and found some GP50s with a seat ring problem. We did find units that were souping excessively. When we pulled the turbo screen, the screen was dry. Putting it back together again, the units were found to be still souping excessively.

We removed the turbocharger to our Oelwein rebuild shop and found the impeller labyrinth seal was completely plugged with oil and carbonaceous material. Subsequent to that, when we went into a conversion program on our GP50s to convert them from F to F-A type turbochargers and along with the rest of the GP modifications, we found that our criterion for sending the locomotives for this rebuild operation was units that were pumping oil out the stack ex-

the manufacturer is here and has any ideas, I would be glad to hear them. I know they are working on it. If they can come up with anything that can help us we will appreciate it.

MR. KEN KELLER: On the Burlington Northern we have more experience with Pulse than we do with Aeroquip. However, we do have Aeroquip recorders in service now. I am not aware of the problem you described, sir.

MR. STARR: I think you are talking about the speed indicator portion of it, which is the speedometer in the cab. I imagine we have well over 100. They are relatively new, only around for a couple of years. We have had fairly good experience.

I am not aware of the needle bouncing around at low speeds. We had a problem with needle failure. I don't remember what the fix was, but I know they went to an independent lab and had some microscopic cross-sections of the needle made to see if it was a fatigue problem or a manufacturing problem. We went through a bit of changeout on some of those movements, and to date I know of no other problems on the Southern Pacific.

MR. WARD: We bought some Barco indicators to go along with some Pulse recorders that we had. We put the Barco indicator along with the Pulse recorders. The first few we put on two locomotives happened to need load test, and during that test they read 4 to 6 mph while they were being load tested. We sent them back to Barco and they eliminated the problem. It solved our problem.

MR. KUZELA: I have a two-part question here from Mr. Travis Lux, Supervisor Locomotive Maintenance, Union Pacific: "Are other railroads having problems concerning unexplained rod bearing failures on GE U-30-C and C-30-7 locomotives?"

MR. CHACONE, Shop Superintendent, Union Pacific, asks: "Some railroads have tried to remedy this situation by removing the modulating governor on GE units. Has this helped?"

Any comments by GE or any member railroad?

MR. BROWN: The Mechanical Committee touched on that last year — connecting rod bearing problems. There was some interesting reading in last year's paper.

To answer the question, we removed the modulating portion of the governor along with some other things, and recently our single rod bearing failures have diminished significantly.

MR. KUZELA: Does GE have a comment on that?

MR. R. E. WICKSTROM [Senior Engineer, General Electric Company, Erie, Pennsylvania]: The situation Bill Brown was talking about, I believe, was the 430C coal fleet out at Alliance, Nebraska. We went through a modification to the governor circuit to do away with some of the modulation. We also went through a pretty intensive

cessively and not related to seat ring problems.

The more we looked at the problem, the more we saw that the oil was being carried over from the bag filters. We saw extremely heavy deposits on the impeller. We saw extremely heavy deposits on the compressor diffuser, and also plugged labyrinth seals. On those units we have operated with paper type air filters, we didn't see that kind of buildup on the labyrinth seals.

We had EMD out for the F-A program rebuild on the GP50s. Their men looked at it and said the oil deposited on the labyrinth seal was suspect as coming off the bag filter. We feel there is a problem associated with this carryover, in that the deposits on the compressor diffuser and deposits on the impeller are affecting the efficiency of the turbocharger. We now intend to run a test with one of the manufacturers, putting oil with a strontium trace element on bag filters and running it against paper filters to see what effects over time are going to develop on the interior of the turbocharger.

MR. J. K. SPARROW [American Air Filter Company, Inc., Louisville, Kentucky]: We have listened carefully to comments about oil carryover from our filter. We have talked to both GE and EMD to see if they have seen anything in teardowns between locomotives that have our filter on them and those that have paper. They have reported they can see no difference in the labyrinth seal area.

We did some calculations. EMD tells us that of the 10,000 CFM of air moved by a turbo into the combustion area on an SD40, 30 CFM goes to each labyrinth seal to make it operate. If we had 12 fluid ounces of adhesive from each set of filters migrate into the airstream, all of it, that would put .04 fluid ounce into each labyrinth seal every 90 days.

Considering the temperature in the labyrinth seals is in excess of 300°, the evaporation rate would be faster than the amount of material we could migrate. However, we have had a continuing program to try to eliminate oil separation. The adhesive we use is an oil base with a thickening agent and a wetting agent. The oil separation, sometimes seen in the poly bags which the filters are shipped in, is material that, instead of staying homogenized, has done some separation. However, we have now developed a modified adhesive which we have subjected to extensive laboratory testing and completed a field test on the Norfolk Southern. Experience to date indicates that adhesive separation has been eliminated. So, in the future, as soon as we can get into production, we don't think you will see that type of condition.

Thank you.

MR. BROWN: Were you able, Roger, to determine whether this oil was being pulled off the filter media or if it was being picked

up from the bottom of the air plenum? I have noticed that on locomotives that have bag filters installed in them, after a long period of time there is an accumulation of oil around the air chamber, and it could be that maybe a periodic cleaning of that chamber would eliminate that problem. I wonder if you were able to determine whether it was being pulled from the filter material or being pulled from a puddle in the bottom of the filter plenum.

MR. VITEK: In almost all instances, Bill, we didn't see any puddles in the bottom of the air plenum. We believe it was carryover off the filter media itself.

MR. JOHN SEFAKIS [Farr Company, El Segundo, California]: I travel throughout the United States and sometimes farther checking various air filtration problems. I am actually seeing the onboard problems on locomotives.

To start with, any type of filter that relies on adhesive to catch the dirt, and so on, is going to be in trouble sooner or later because of the fact that the adhesive will come off the fiberglass. So, from that standpoint alone I have seen bag housings with pools of oil that Bill Brown mentioned, many times in large pools.

At this time I would like to mention that Farr Company also supplies the RF 90B Fiberglass Bag.

We talk about labyrinth seals and plugging. If the railroad industry is satisfied with a 400,000 mile or 500,000 mile turbo, fine. Probably a fiberglass bag type filter will do the job. But if you are looking for a 1-million mile or 10-year service on turbochargers, then you should be looking for the best air filtration possible and eliminating the adhesive carryover problem.

I have been involved with the bags and housing many times during my 32 years of railroading. I have been involved recently on a Western railroad where they tore down a turbo and the buildup inside the diffuser area was horrendous. I have talked with other Western railroads that have been on teardown inspections on turbochargers. One particular person whom I will not name made the comment to me that every time he was involved in a turbo teardown inspection at EMD or Arrowsmith, he has never seen a labyrinth seal plugged on a barrier (paper) type filter application. He has seen some buildup. When he has seen that buildup he has been able to go back and find a leakage problem as far as the application is concerned.

I have also seen plugged aftercoolers. I believe almost anyone involved in air filtration or engine problems has seen these plugged aftercoolers and high air box temperatures resulting from plugged aftercoolers.

Although you are addressing the seal problem as rather a distinctive problem, you should also be looking at the efficiency of the turbocharger in regard to fuel consumption and even premature engine

wear because of the required overloading of the engine. In order to make the horsepower and do the job, you are actually sacrificing engine life by using an air filter that may not be the best one available.

MR. VITEK: That is exactly what we plan to do, John, in some of the tests we are going to run. We will get some baseline information and do some specific fuel consumption testing, and do some measured power assembly inspections prior to and after the test.

MR. SPARROW: We introduced the AMER-kleen bag type filter in 1970. It was approved by EMD and GE in 1972. It is not a new filter. During all the testing, comments regarding any oil carryover were brought up by both locomotive builders. In the case of EMD, I think the most recent inspection of aftercoolers probably was in 1976, when they pulled aftercoolers following a question raised by a competitor.

We also made an oil bath filter which did carry over oil and did require some maintenance to the aftercoolers. EMD wanted to be very careful that they did not adopt a filter that would require aftercooler maintenance without first identifying that situation and putting it in their service manual, so we pulled aftercoolers, and a lot of investigations were made concerning turbo performance. Studies between paper equipped and AMER-kleen Cartridge equipped locomotives were done, and in all cases the AMER-kleen came out looking very, very good.

MR. SEFAKIS: We talk about tests, following field tests, and so on. I believe sometimes it is better to go out in the field and just pick out locomotives at random rather than try to follow field tests.

As one who has railroaded for 32 years, I realize that many tests get lost in the stream, you might say, and sometimes tests are even made to show what is expected to be shown. Within the last three months I was on a locomotive on a Western railroad that had lost a turbocharger. The turbo was less than a year old. The aftercoolers were plugged. There were seven power assemblies in that engine that had scored pistons and liners. The air box showed signs of an air box fire. The bag housing was full of oil, and the compressor impeller area had a buildup of about .015.

Anyone who knows anything about turbochargers, I believe, can fit it all together and see what they have. This was just a random locomotive that was running and had a premature turbo failure. I believe there are many more turbochargers lost each year for these very same reasons.

MR. SPARROW: At the time we were working toward approval by the locomotive builders, they had engineering representatives at two of the locations where we had locomotives in service. They had those people there for a long period of time after we received approval.


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They looked at locomotives at random, and in no case has a builder reported to us any signs of adhesive carried to the aftercoolers or any damage to turbochargers.

When you consider it is 13 years that we have been the major supplier of filtration equipment for turbocharged locomotives, I think in that time if there were examples of problems in the field, we would have been made painfully aware of them. I think our performance speaks for itself.

As I said earlier, we are introducing a new adhesive which we believe eliminates oil separation and any carryover. We are talking about past history.

MR. KUZELA: I think we have been on that subject long enough. I will close it with one comment, Joe. I have noticed that since we went to the baggie air filters we have not had a major fire in the generator room of any SD40 Dash-2. That used to be a big item.

Here is another question from a Wheelshop Foreman in Omaha, Mr. R. C. Small: "Does the regrinding of axle gears affect the hardness of the gear enough to reduce the mileage after grinding, as compared to a new gear?" Does anyone want to comment on that?

MR. M. McCRACKEN [Mells Cargo Supply Company, San Francisco, California]: We have been operating an Arrowsmith gear reprofiling machine in our shop for six years, and maintained complete records on every gear we have reprofiled. We have reprofiled over 7000 gears now, including 250 gears the second time and 42 the third time. We have kept a record of the wear and date reprofiled, and find that the amount of wear per month between the new to first reprofiling, first reprofiling to second reprofiling, and the second to the third reprofiling, are basically equivalent. So, we are convinced that we have not reprofiled the gear to an area that would adversely affect the life in any way.

MR. KUZELA: "Have any railroad members verified a saving in reducing traction motor failures by periodical reprofiling of axle gears?"

MR. GOEHRING: I don't have all of our data available, except for the problem that Mr. Keller is talking about regarding flashovers, a problem we haven't been able to lick. However, there has been a definite improvement in Amtrak's traction motor performance since we began maintaining proper gear tooth profile.

MR. KUZELA: Here is another question: "Has any railroad calculated the cost of mechanical damage to engines when shutting down engines to conserve fuel, rather than leaving them idle?" Does anyone want to comment on *that?*

MR. VITEK: One of the items we discussed in some previous papers was problems relating to electric starters versus air starters. I see Mr. Brown is here, and perhaps he can make some comments on that.

MR. BROWN: As far as we are concerned, the answer to the question is no, but I am sure we have had occasions when we have had hydraulic problems with them. We haven't any documented evidence on it.

MR. KUZELA: Are there any railroads that still leave their engines idle or have a rule that they drain them or leave them idle? Any comments on that?

MR. BROWN: Roger asked me to say something about air starters. We have about a dozen sets on, and some of them have and others do not have limited energy cranking. To date we haven't had any problems with them.

I might add that there was quite a lengthy discussion here this morning on batteries. An alternative to a higher amperage cranking battery is air starters, for whatever that is worth.

MR. KUZELA: Does anyone want to comment on air start versus electric start?

MR. VITEK: We have put a set of air starters on a prototype SD45 that we have operated for about 1½ years now, and to date we have had virtually no problems with that locomotive in all types of operating conditions, temperatures and climates.

MR. KUZELA: "I understand a wheel problem has been experienced on GP50 locomotives. Would a wheel manufacturer or builder care to comment on GP50 wheel problems?" Maybe the railroad that is affected might comment.

MR. WECK: We have Mr. Curt Swenson with us today. I don't know if this is the forum for an indepth discussion of a single property with a single problem. I think we can give you the parameters of the problem and where we are at the present time, so I would like to ask Mr. Swenson to speak to this.

MR. CURT SWENSON: [Electro-Motive Division, LaGrange, Illinois]: So far in this discussion we haven't identified the railroad nor the wheel supplier, so I will say that what has been observed is that on one fleet of GP50 locomotives, one type of wheel has experienced a number of failures.

This is a very unique failure that has not been seen before. This is a fatigue type of failure that originates inside the rim of the wheel approximately across from the diameter index groove on the wheel, so that is could be anywhere between 1 and 2 inches below the surface of the tread. The fatigue failure then progresses. In most cases it first shows up on the outside of the rim fillet — the fillet between the rim and the plate.

I believe there have been 14 failures of this type found on a fleet of 90 locomotives, approximately half of which were equipped with this type of wheel.

In some cases there are multiple cracks in the wheel. In one case, the crack went all the way from the top of the flange to the bore of the wheel. Fortunately, there was no movement of the wheel on the

axle, and the press-off tonnage was still high. The other cases have been restricted to cracks within the confines of the rim of the wheel.

We are actively working with the railroad and with the wheel manufacturer to facilitate and understand what is going on. Various theories have been put forth regarding the possibility of thermal input and the possibility of mechanical input. I think there is a well-defined field program and a well-designed lab test program underway which is investigating various parameters such as the width of the striations in the fatigue cracks and how many cycles it takes for this crack to initiate and to show up.

Perhaps this gives you some idea of what the extent of the technical program is.

MR. KUZELA: Thank you.

MR. K. A. KELLER: This is a question that I raised two days ago, and it is directed to Mr. Vitek and EMD. It concerns failure of water pumps on the right bank of the engine, resulting in the right bank of the engine being cooked, and a lack of suitable low water pressure protection on the engine.

Does anyone have any experience with this problem, quick and dirty or otherwise? We need something. I would like to get it pretty soon.

MR. VITEK: I am going to quickly defer that to EMD. We have not had any problems of that nature that I am aware of, nor has anyone on our Committee. I will ask EMD if they would like to make any comments on that.

MR. DROZD: We touched on this subject briefly on Monday. The engine protector, per se, was not designed to save any specific components of the engine. It is a system-oriented piece of equipment. We accept Amtrak's criticism that it does not protect the right bank of the engine, and we will look into the possibility of providing such a device, but that won't be for another year to a year and a half.

MR. KUZELA: In that same category, I think EMD will probably agree with me that if you have a water pump failure the bearings are going to go, and you will have lost the water. I don't know in how many of these isolated cases you would have cooking on one side of the engine. My experience with the water pump is that the bearing and seal goes and you lose the water.

MR. K. A. KELLER: Our problem, when we cook an engine, is not that the seals go and you lose the water, but that the drive gear mechanism for the pump fails in one fashion or other, and consequently the engine has plenty of water but the right bank has no water pressure. You don't find that out until it is too late, until you get water leaks on that bank, and you start piling one head and then you put it back together again, and then you pressure the engine and you find, O God, this one leaks! Then you do that one, and here is

another one, and then "this is cooked". I had one just this morning.

MR. KUZELA: Mr. Chuck Kunkel asks this question: "Has anyone found a better method of detecting inhibitor levels in cooling water other than the Myron L meter?" Any vendor's comments on cooling water testing?

MR. VITEK: The only thing I know we use right now is the Myron L meter.

MR. K. A. KELLER: I hate to hog the microphone, but at Amtrak we have used something called the Color Comparator, which is nothing more than a strip of plastic with about seven different colored chips glued onto it. The colors range from almost white to dark purple. There is a number next to each chip, and it says 7 bags, 6 bags, 5 bags, 4 bags, or whatever. That gives somebody like me, who likes to go out and ride engines and look at the water sight glass, an idea of whether the water treatment on that engine is close to full strength, rather weak, or whatever.

We have taken some samples from our locomotives and have looked at the treatment levels. I know what we were doing before we had the Color Comparators. Our program was pretty poor. In the last couple of years, since we have been using the Color Comparators, it seems to be pretty good. Maybe that is one thing we are doing right. That has been our experience.

Those Color Comparators used to be available years ago when you used chromates. I can remember being criticized by my general foreman because I had an engine out on the ready track one day and it was a pale yellow, and he showed me how to use the Comparator. I subsequently took the message to heart.

MR. FRANK BOCHEK [Dearborn Chemical Company]: To address the question of whether or not there is a better method than the Myron L, or a better instrument, I might add that we have worked with another manufacturer to develop an instrument that does have the same function as the Myron L, and that is to measure the TDS or the parts per million strength of the coolant that contains the inhibitor.

We supply the Myron L and we also supply the newer version I have just mentioned. The Myron L is a sensitive instrument. It does have reproducible accuracy; it does have a straight line response; it has a problem insofar as it is fragile. It is a little bit bulky. It is a little expensive.

What happens is that a railroad, having a program of testing the TDS or strength of the coolant and determining how much coolant inhibitor is necessary, assigns testing to the people who service the engines. They are asked to handle a sensitive piece of equipment, and in the long run they damage it, drop it, or fail to have it with them when they are at the engine.

So, what we did was to address these problems with another manufacturer. We said we wanted to have something that was going to take a beating while in the hands of people who handle a lot of tools, also to be able to carry it around in their pocket. This is what we have and are able to supply today.

You get away from the sensitive dial, the swing needle, and so on. We use a "match light" system. It is waterproof, low profile in your pocket, and is in a high impact case that you can drop. I am not saying it is built to be dropped, but if you drop it you are not losing $150 to $200 worth of sensitive equipment. Myron L is good and, as I said, we do handle both.

I would like to expand on this for just a moment, if I may. There are several accepted methods of testing coolant inhibitors. Dearborn prefers to test directly for the strength of the primary inhibitor, which is the nitrite portion. If you do that, there is no question about whether or not your inhibitor is strong, too weak, or just right. You know where you are at.

We realize your men are not chemists, so we have developed a means of chemical testing that puts this in their hands without measuring a sample and without measuring reagents. They can do a "go-no go" type of test and still determine the primary inhibitor strength. Or, you can go to existing methods utilizing titration and drop tests.

We have dealt with the Color Comparator situation repeatedly. We have been asked why we can't do this when so much good was done with the chromate comparator in the past. It measured the strength of the chromate since the chromate color is stable.

There is one thing about the dyes that we have available to add to these treatments. The most popular are phenolphthalein or fluorescein which are organic dye compounds. The dye is adsorbed on metal surfaces. It is adsorbed on any surface that might be present, such as suspended solids. It is affected by the amount of oil contamination that might be in the water. Thus you have a problem with an organic dye as being an unreliable source of inhibitor strength.

So, if we had our druthers in our industry and yours, we would prefer to *measure the inhibitor* strength directly. Second, we would prefer TDS measurement using a reliable instrument that isn't going to discourage anybody's use. Our last choice would be the use of coolant color. Color variations are not dependable. They only indicate whether some inhibitor is present but do not assure proper, safe treatment level.

I think you would all agree to that. If you really want to control this inhibitor strength and have most of your engines properly treated against corrosion, scale and deposits, it is best to test directly

for the strength of the compound you are adding.

As a final comment on the Myron L, there are other instruments that are available, and I think the problems with the Myron L are its fragility and that it goes out of service very quickly when subjected to rough handling.

MR. KUZELA: Thank you. Any other questions? If not, we will have to close this session now. We have to vacate the room so it can be set up for the luncheon.

Thank you, gentlemen, for a nice What's Your Problem panel. I will now turn the meeting back to Mr. Ward.

MR. WARD: Thank you, Joe. That was an excellent session. Now I will turn the meeting back to our President, Dale Propp.

PRESIDENT PROPP: Thank you, gentlemen.

I have a couple of announcements. First, I would like to remind the Executive Committee that we will have an afternoon meeting in Private Dining Room 8 immediately following the luncheon.

As always, the What's Your Problem session is the finale and always needs more time. I promise we will dedicate more time to it next year.

Special thanks to each of the committee members and chairmen of all technical committees. We had great performances this year. Special thanks to all of you in the audience. Your participation has been tremendous.

Our next meeting will be on September 22, 1986.

Now let's give this panel and yourselves a rising vote of thanks as we adjourn until next year.

[The audience arose and applauded.]

[The meeting adjourned sine die at 11:40 a.m.]

PRE-CONVENTION PRESENTATIONS

INDEX

LOCOMOTIVE MAINTENANCE OFFICERS ASSOCIATION

MONDAY, SEPTEMBER 22, 1986

TUESDAY, SEPTEMBER 23, 1986

WEDNESDAY, SEPTEMBER 24, 1986

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	Advertisers	Associate	Active	Total
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1940	34	48	162	244
1941	38	48	210	296
1946	103	187	676	963
1947	101	284	937	1321
1948	113	295	1183	1591
1949	134	595	1789	2521
1950	123	595	2101	2822
1951	125	626	2912	3663
1952	135	510	2747	3392
1953	118	597	3288	4003
1954	118	545	2943	3606
1955	81	434	3235	3750
1956	110	419	3257	3786
1957	100	423	2678	3201
1958	82	350	2320	2752
1959	90	387	2395	2872
1960	98	393	2302	2793
1961	101	348	2201	2650
1962	118	316	2291	2725
1964	138	273	2345	2756
1965	155	289	2372	2816
1966	163	464	2368	2995
1967	180	408	2327	2915
1968	200	321	2575	3096
1969	192	335	2173	2700
1970	184	345	1929	2458
1971	140	283	1621	2044
1972	132	343	1777	2252
1973	108	345	1563	2016
1974	124	384	1735	2243
1975	103	326	1579	2008
1976	109	314	1610	2033
1977	114	317	1508	1939
1978	125	363	1367	1855
1979	120	391	1251	1762
1980	112	405	1200	1717
1981	114	445	1143	1702
1982	102	440	1261	1803
1983	92	386	1025	1503
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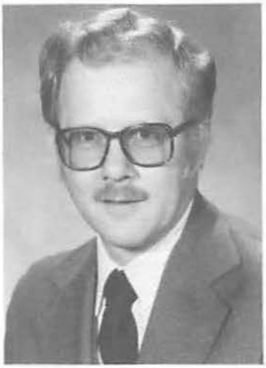

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Monday, September 22, 1986

2:15 P.M.

REPORT OF THE COMMITTEE ON FUEL AND LUBRICANTS

Pre-Convention Presentation Chicago Railroad Diesel Club

April 7, 1986 Midland Hotel Chicago, IL

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1986 TOPIC:

FUEL AND LUBRICANTS — EFFECT ON THE BOTTOM LINE

PERSONAL HISTORY
K. ALLEN KELLER

Mr. Keller was born in Fleetwood, Pennsylvania on August 15, 1940. He attended public schools in Kutztown and Topton Pennsylvania and graduated from Pennsylvania State University in 1962 with a major in Fuel Engineering.

He began his railroad career with the Pennsylvania Railroad in 1962 as a Junior Engineer in the Mechanical Department assigned to the Altoona Works. After completing the program in 1964 he served as a Gang Foreman at Philadelphia, Pa. He was promoted in 1965 to the position of Motive Power Inspector. In 1966 he was assigned to Cincinnati as Assistant Car Foreman. He returned to Philadelphia in 1969 as Supervisor of Locomotive Maintenance and he worked as Night General Foreman.

In 1976 he joined Amtrak as a Power Coordinator and was promoted in 1979 to Manager of Motive Power Performance.

He is married to the former Gwen E. Keller and they have two children. He enjoys model railroading and fishing.

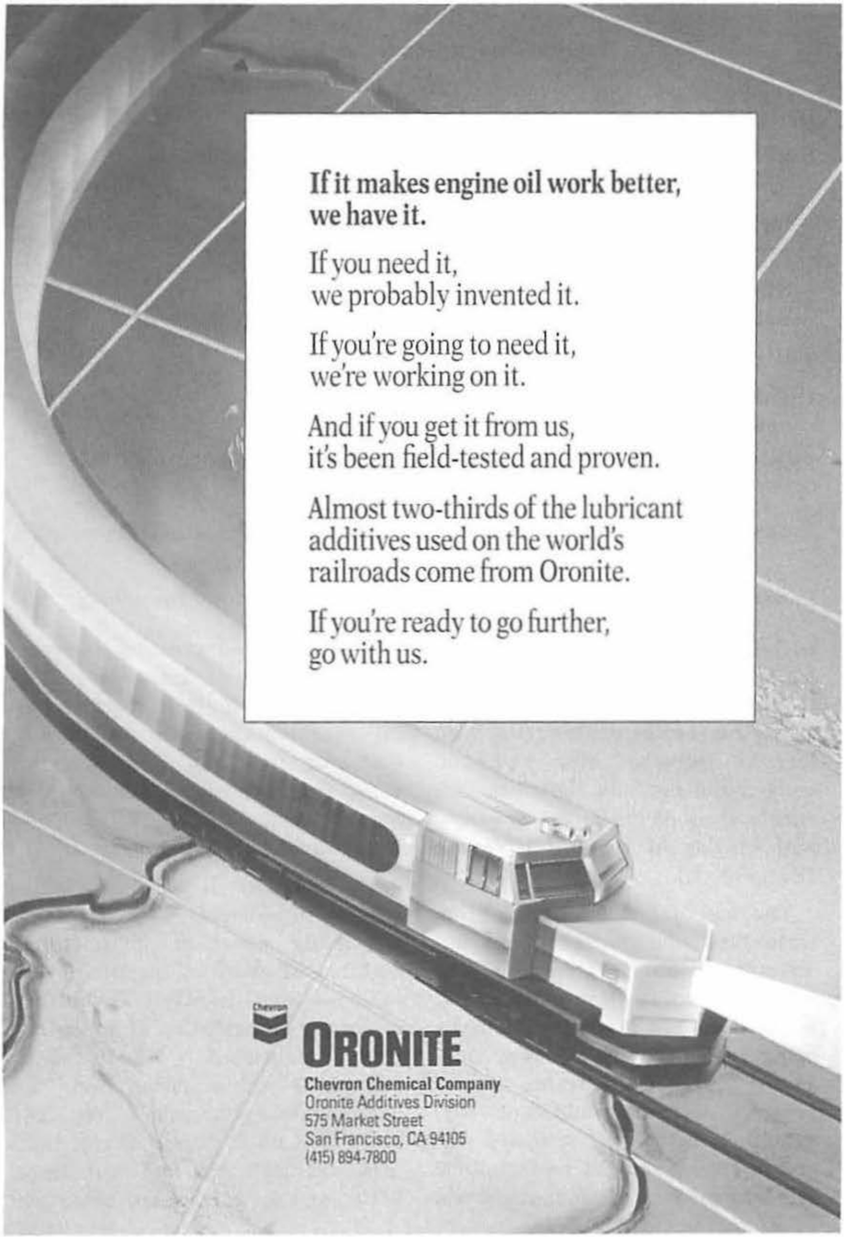
FUEL AND LUBRICANTS — EFFECT ON THE BOTTOM LINE

I.

EXTENDED PERFORMANCE LUBRICANTS THROUGH BETTER CHEMISTRY

An interest in longer life, extended performance railway diesel lubricants has emerged in recent years as a result of continuing evolutionary design changes occurring in both 2 and 4-cycle railway engines. Many recent design changes have been directed at increasing locomotive horsepower and operating efficiencies. The latest model locomotives provide increased operating efficiencies and reduced operating costs — relative to older motive power — through improved fuel economy, lower lube oil consumption and reduced power assembly wear. Engine design modifications needed to realize these goals often increase the stress placed on the lubricant and can shorten lube oil life. The impact of recent engine design trends on operating conditions and their effect on the lubricant is summarized in Table 1.

Table 1 shows that increases in horsepower, combustion pressure, compression ratio, engine speed and higher thermostat settings can cause higher engine operating temperatures that may shorten the useful service life of the lubricant due to more rapid oxidation and base number loss. A rule of thumb says that oxidation rates approximately double for every 10°C rise in temperature. Figure 1 illustrates the substantial and significant effect of temperature on the oxidation rates of a Generation IV railroad oil in a bench test that measures oxygen absorption characteristics of lubricants. Even though sump temperature increases are minimized or eliminated through increased cooling, shorten-


If it makes engine oil work better,
we have it.
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we probably invented it.
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Table 1
Engine Design Impact on Lubricant

Design Trend	Effect on Operating Conditions	Effect on Lubricant
Higher Horsepower	Temperature Increase	Oxidation, TBN Loss, Viscosity Increase
—Increased Combustion Pressures	" "	" "
—Higher Compression Ratio	" "	" "
—Higher RPM	" "	" "
Higher Thermostat Settings	" "	" "
Piston & Ring Mod.	Low Oil Consumption Less Make-up Oil	" "
Bronze Bearings	Copper in Used Oil May Increase	Oxidation Promoted
Lower Idle RPM	Inefficient Combustion	More Insolubles

ed lube oil life may still result if piston and liner oil film temperatures increase substantially. Higher operating temperatures can also lead to increased ring belt and undercrown deposits that interfere with cooling of the piston crown.
with cooling of the piston crown. (See Fig. 1.)

The use of low oil consumption piston and ring configurations can also increase the stress on the lubricant because less make-up oil is needed, resulting in additives being replenished at a slower rate. Figure 2 vividly illustrates the impact of decreased lubricant consumption rates on viscosity increase for a group of modern 3600 HP locomotives. Note that control of oxidation and viscosity increase in this group of locomotives becomes increasingly important as oil consumption rates fall below 0.5% of fuel and approach the 0.3% rate typical of some newer locomotives.
locomotives. (See Fig. 2.)

The increased use of bronze bearings in some locomotives may also negatively impact lube oil oxidation stability if used oil copper levels increase significantly. The effect of copper on oxidation of a Generation IV lubricant is illustrated in Figure 3 using data from an oxygen absorption bench test. Examination of Figure 3 shows that dissolved lead, tin and iron have little or no effect on oxidation

rate, but dissolved copper tends to promote more rapid oxidation as its concentration in the used lubricant increases. (See Fig. 3.)

Lower idle speeds can stress the lubricant in a different way. The inherently less efficient combustion occurring at low idle speeds often results in increased levels of soot, insolubles and unburned partially oxidized fuel in the lube oil. Partially oxidized fuel can also affect the lubricant by promoting more rapid oxidation and formation of insolubles during operation at higher throttle settings and temperatures. Insolubles also contribute to increased viscosity as shown in Figure 4. This illustration shows that high levels of insolubles can significantly contribute to viscosity increases that may mistakenly be attributed to oil oxidation. (See Fig. 4.)

Finally, certain other design factors, such as crankcase capacity, can affect lubricant service life under some circumstances. The effect of crankcase capacity on service life at assumed lubricant consumption rates of 0.3 and 1.0% of fuel is illustrated in Figure 5. At the higher oil consumption rate, crankcase size is relatively unimportant, but as lubricant consumption rates decrease and less make-up oil is required, crankcase capacity begins to affect lubricant service life. Operation of high horsepower, low oil consumption engines at consistently low crankcase oil levels for substantial periods of time can have a negative effect on lubricant service life analagous to that illustrated for smaller sized crankcases in Figure 5. (See Fig. 5.)

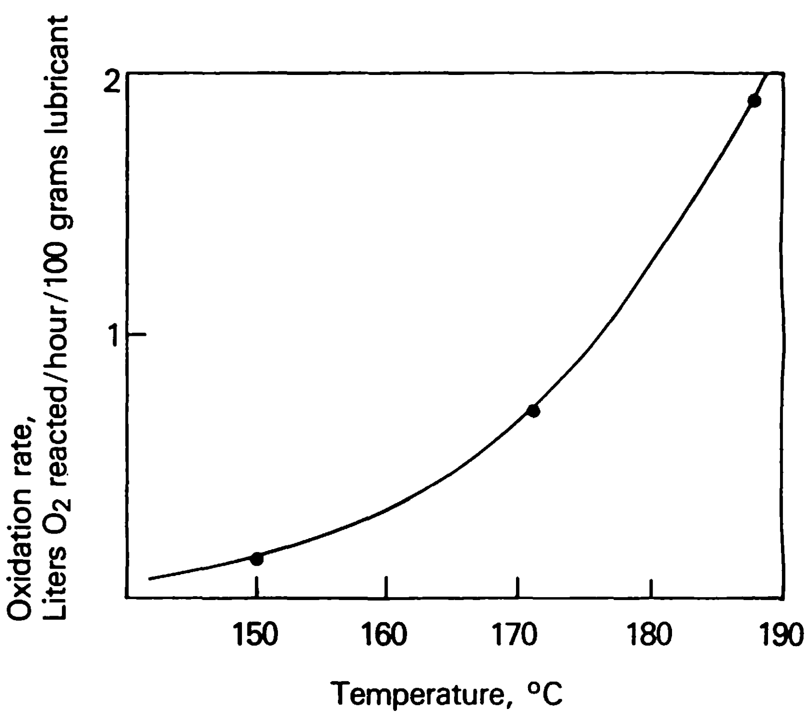
Since improved fuel economy is favored by higher engine and lube oil operating temperatures, future engine designs may continue to place increasing stress on the lubricant in the interest of improved overall operating efficiencies.

The previous discussion clearly indicates a need for improved oxidation stability in future generation lubricants. However, it is important to remember that improved oxidation stability alone will not necessarily result in longer lubricant service life. Modern railway diesel lubricants are balanced combinations of additives that possess a wide variety of properties needed to successfully lubricate modern railway diesel engines. These properties include oxidation resistance, deposit and wear control, dispersancy and alkalinity retention. New generation products must maintain or improve performance in all of the above areas in order to significantly extend lubricant service life.

Current Generation IV lubricants still give satisfactory service in latest model locomotives even under severe operating conditions. However, development of extended performance lubricants through better chemistry would provide a valuable assist to further reductions in locomotive operating costs.

Figure 1

Effect of Temperature on Oxidation Rate of a Generation IV Lubricant*



*In an oxygen absorption bench test

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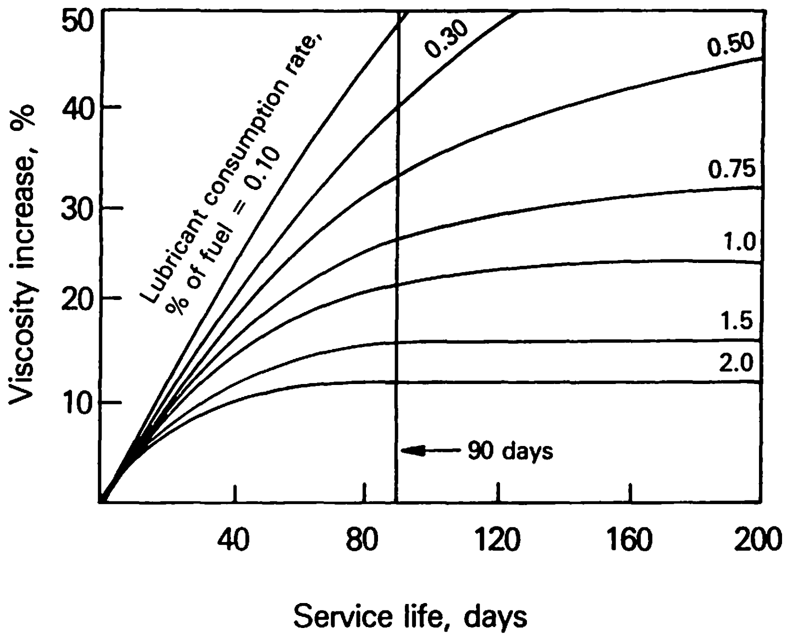
Figure 2

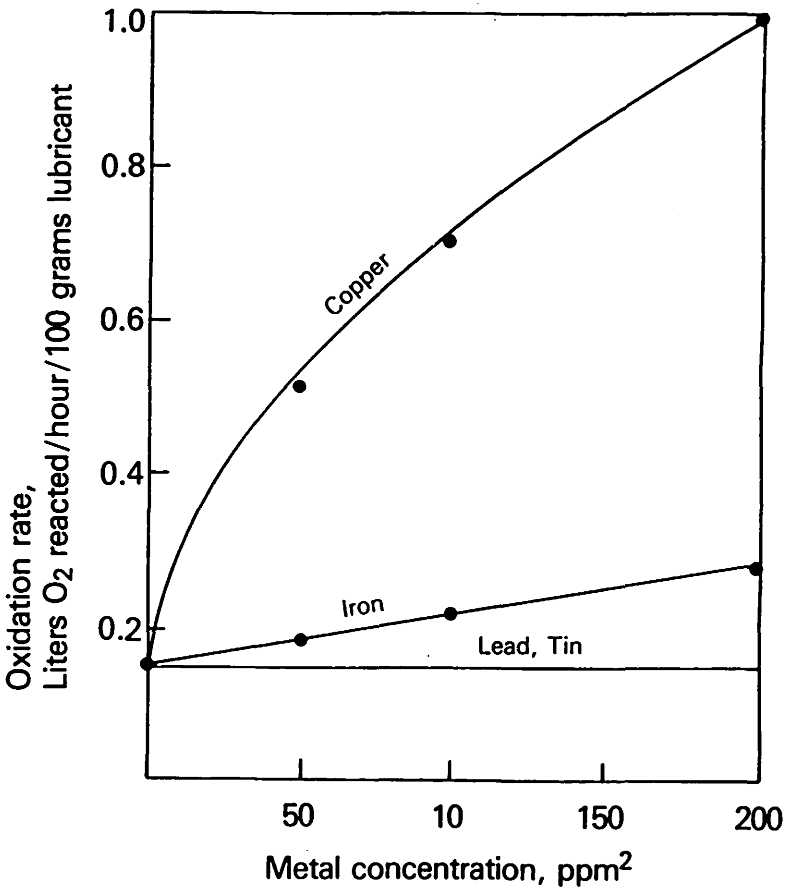
Effect of Lubricant Consumption Rate on Viscosity Increase*



*Calculations are based on the analysis of used oils from a modern fleet of 3,600 HP locomotives in mainline railroad service.

Figure 3

Effect of Soluble Metals on Oxidation Rate of a Generation IV Lubricant[1]



[1]In an oxygen absorption bench test
[2]As metal naphthenates

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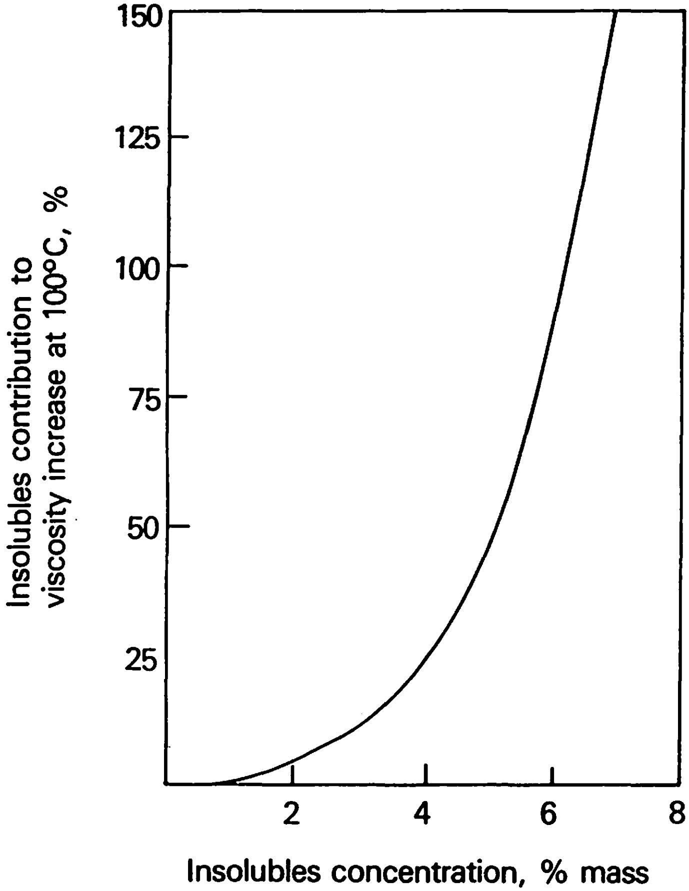
Figure 4

Effect of Insolubles on Viscosity Increase in a Railroad Engine



Calculated as follows:

$$\frac{\text{[Used oil viscosity - viscosity after centrifugation]}}{\text{Fresh lubricant viscosity}} \times 100$$

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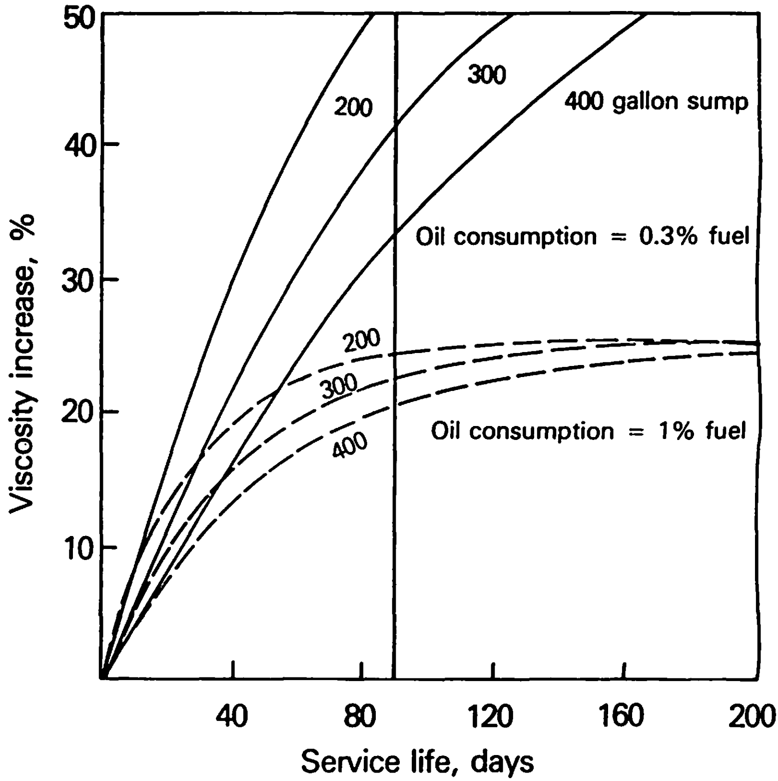
Figure 5

Effect of Sump Size on Viscosity Increase*



*Calculations are based on the analysis of used oils from a modern fleet of 3,600 HP locomotives in mainline railroad service.

Importance of Maintenance and Operating Practices

No discussion of extended performance lubricants would be complete without consideration of the impact of railroad maintenance and operating procedures on the life of the lubricant. Railroad practices that can or may contribute to a shortening of lubricant service life are listed below:

—Improved equipment utilization

—Increased maintenance intervals

—Deferred reduced maintenace

—Low oil level operation

—Incomplete oil change

—Lower fuel quality

As railroads become more efficient with respect to utilization of motive power, the stress placed on lubricants increases. Locomotives are pulling longer and heavier trains and logging more and more miles per month. Under these conditions, the lube oil is exposed for longer periods of time to higher temperatures and larger quantities of acidic combustion products. As a result, lubricant additives are depleated more quickly. The increased utilization of locomotives makes scheduling of shop time more difficult but also more important. Some railroads have extended maintenance intervals to coincide with federally mandated inspections. Lengthening of service intervals or deferral of needed maintenance can further stress the lubricant. In addition, these practices place increased responsibility on line operating personnel for frequent and regular checking of lube oil levels and other routine locomotive inspection items. Make-up oil additions — especially in new high performance locomotives — should be complete, with no short fills or pass through to the next service point without adding make-up oil. Stationary engine tests suggest that locomotives operating at consistently low oil levels may experience shortened lube oil life. The potential negative impact of operation at low oil levels on lubricant service life in low oil consumption engines was mentioned previously.

As schedules have become tighter and shopping less frequent, some instances of "short measure" oil changes have been reported. A simple calculation can show that 50 gallons of used oil left in a locomotive can reduce the additive concentration (and TBN) of a 13 TBN Generation IV oil to that of a Generation III lubricant and shorten the service life. A recent study summarized in Table 2 assessed oil carryover based on the copper content of oil samples taken before and immediately after an oil change. Oil carryover was as much as 51% and averaged 29% for the 10 locomotives surveyed. Obviously, this can have a significant impact on oil life. It should be emphasized that locomotive crankcase and filter compartments

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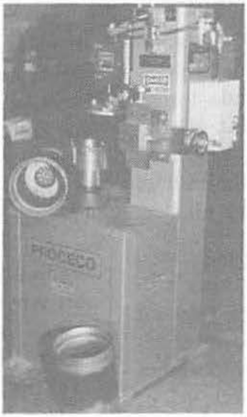

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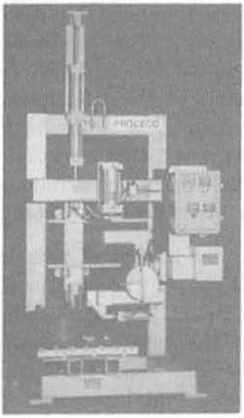

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must be thoroughly drained when the lube oil is changed or the useful service life of the new oil charged to the unit may be reduced.

Table 2
Calculation of Oil Carryover Based on Copper Concentration

Locomotive	Copper in Oil, PPM Before Drain	After Fill	% Oil Carryover
1	63	32	51
2	58	16	45
3	66	18	27
4	108	28	26
5	97	20	21
6	97	39	40
7	117	26	22
8	75	16	21
9	107	22	21
10	123	18	14

Average Carryover = 29%

Finally, lube oil life is also affected by the quality of the fuel in use. The availability of good quality No. 2 diesel fuels in most parts of the US and Canada is not currently a problem, but it should be noted that use of lower quality fuels on an experimental or interim basis can also shorten lube oil life.

The impact of practices discussed above will become increasingly significant as engine builders respond to the current demand for fuel efficient high horsepower locomotives. Maintenance practices or short cuts that are innocuous in older locomotives, especially those with high oil consumption rates, may have a more pronounced effect on engine life and lube oil service life in late model, high efficiency locomotives.

New Tests Needed for Future Railroad Diesel Lubricants

As a result of improvements in additive technology, current generation lubricants can easily meet engine builder requirements and oil quality differences are not readily distinguished by these tests. New standardized tests with improved repeatability are needed to screen and evaluate extended performance lubricants for current and future model locomotives. Various laboratories have used a wide variety of both thin film and bulk oil bubbling oxidation tests to compare the oxidation stability of railroad diesel lubricants. Detailed discussion of these tests is beyond the scope of this paper but results of several independent studies have indicated improved oxidation stability for *Generation IV* railroad lubricants formulated with high viscosity index (HVI) base stocks. The significance of these test data is uncertain due to lack of an established field correlation. However, as field service conditions become more severe, it will be increasingly important to screen new additive technology in a variety of base stocks — including high viscosity index stocks — to be sure that desired performance objectives are met.

Bench (and engine) tests that can be related to field service performance are needed. However, experience has shown that it is difficult, if not impossible, for bench tests to adequately predict all aspects of lubricant performance in the field. Until reliable predictive tests are developed, the only practical way to judge field service life and overall lube oil performance will be through extensive, closely controlled field trials.

Lubricant Improvements Through Chemistry

The increasingly severe operating conditions expected for future model locomotives have prompted investigations by lubricant and additive suppliers directed at development of extended performance lubricants. Formulation changes needed to develop extended performance railroad oils will likely be extensive and may involve both additives and base stocks. As field operating conditions become more severe, base stock availability and selection factors and the proper matching of additives to lube oil base stocks will increase in importance. The previous section of this paper discussed this fact. Other problems associated with the development of extended performance or extended life products include the lack of bench or engine tests that correlate with field service life and the current desire to coordinate locomotive maintenance and oil changes with required federal inspections. This means that for some railroads, service life extensions must come in 3 month increments to be of significant value.

To provide extended performance, additive chemistries will undergo substantial changes. "Extended performance" will require more than improved oxidation stability if lubricant lifetimes are to be significantly enhanced. New additive chemistries will need to maintain a balance for overall performance so that viscosity increase, filter life, deposit control and antiwear properties are all improved or maintained at current high performance levels. The following changes in additive chemistry are expected to be of particular importance to extended performance lubricants:

—Higher alkalinity or improved alkalinity retention
—Improved inhibitor systems
—Special antioxidants and metal deactivators
—Better dispersants/detergents.

Higher alkalinity products (>13 TBN) have been tested in the field, but in order to control costs, considerable effort is also being directed at improving the alkalinity retention and oxidation stability of 13 TBN, Generation IV additive systems through use of improved inhibitor systems, incorporation of special antioxidants and possible inclusion of metal deactivators that help offset the pro-oxidant effects of copper and other wear metals in used lubricating oils. If oil life is to be extended significantly, more efficient or increased amounts of dispersants may be needed to accommodate the higher levels of insolubles that could be encountered in extended field service. Finally, these changes must be achieved without depreciating the excellent deposit control and wear prevention characteristics of current generation lube oils.

In summary, increasingly severe field service operating conditions that result from engine design changes leading to higher lube oil temperatures and reduced oil consumption rates have created an interest in extended performance lubricants. More efficient locomotive utilization by railroads and changes in maintenance schedules and practices are also placing increased stress on the lubricant.

Development of extra performance lubricants has been hindered by the lack of bench and engine tests that correlate with field service. Several bench tests have shown promise for evaluating and discriminating differences in current and future generation lube oils, but further investigative testing and a development of field comparison data are needed before any test can be used to evaluate quality differences of future lube oils with certainty.

Development of extended performance lubricants is expected to involve both additives and base stocks. The importance of base stock selection and proper matching of additives to base stocks will increase as field service severity increases. Improvements in alkalinity retention, inhibitor systems, and dispersants with possible inclusion of special antioxidants and metal deactivators are anticipated in extended performance railway oils being developed for high performance locomotives.

II.

FUELS AND LUBRICANTS HANDLING AND HYGIENE

Introduction

The accelerating awareness of health hazards from exposure to petroleum fuels and lubricants is being prompted by recent regulatory legislation.

OSHA's Hazard Communication Standard is designed to provide a downstream flow of hazard information from the producers of chemicals to industrial users. Phase 1 went into effect November 25, 1985, providing that chemical manufacturers, importers, and distributors are required to label shipped containers of hazardous chemicals and to provide Material Safety Data Sheets (MSDS) to purchasers of these chemicals. Phase 2 calls for chemicals users to have developed formal hazard communication programs by May 26, 1986.

Further impact comes from the set of regulations known as the "right-to-know" laws. These laws provide for an employee's right to be informed of the potential hazard to which he or she may be exposed by working with materials possibly

designated or classified as hazardous.

Health Aspects of Handling Diesel Fuel and Lubricants

In the course of the daily operation of maintaining locomotives, shop employees are continually exposed to lubricants and No. 2 diesel fuel. The news media have done an excellent job in creating doubt in their minds whether exposure to liquids found in the work environment is safe for their health.

In an effort to find information about the actual hazard to an employee when exposed to petroleum products used in a locomotive maintenance shop, we referred to the CONCAWE Report No. 1/83 which is titled "Health Aspects of Lubricants". CONCAWE is the oil companies' European organization for environmental and health protection which was established in 1963.

The following is a summary of the sections of this report which refer to lubricating oil and diesel fuel.

Potential Health Hazards of Mineral Based Oils

ACUTE EXPOSURE

In this section the health hazards resulting from single or occasional short term (acute) exposures will be discussed.

SKIN: Mineral base oils may give rise to moderate skin irritation in animal tests. In actual practice this irritation is usually not important to a man, especially when exposures are of a short term nature as can occur with accidental spillage or splashes.

EYES: Mineral based oils are usually mildly irritant to the eyes of test animals, but normally cause no problems in man.

INHALATION: The inhalation of oil vapors or oil mist may cause a mild irritation of the mucus membranes of the upper respiratory track. At normal temperatures, however, typical lube oils do not produce any significant levels of vapor in the working atmosphere. Even a saturated vapor concentration at 100 degrees C (212 deg F) would not give rise to adverse health effects.

INGESTION: All types of mineral base oils have a low order of acute oral toxicity in experimental test animals. The main feature in man after accidental ingestion, will be signs of irritation of the mucous membranes of the digestive tract resulting in nausea, vomiting, and diarrhea.

With low viscosity products such as diesel fuel or spirits, ingestion presents a specific hazard, as aspiration of liquid into the lungs, followed by chemical pneumonitis may occur, especially during vomiting. This is the reason why vomiting should not be induced after ingestion of mineral oil products, particularly with those of low viscosity.

SUB-ACUTE EXPOSURE

In this section the health hazards resulting from repeated and

medium term or weeks to a few months exposure will be discussed.

SKIN: Primary irritation due to the defatting of the skin by direct contact can occur to varying extents, depending on the type of product and the degree of exposure. A diffuse erythema (redness) with some oedma (swelling) combined with broken hairs and occasional pustules are the main characteristics of this dermatitis in the affected area, e.g. the skin of the fingers, the back of the hands and the forearms. The lighter petroleum oils such as diesel fuel and spirits tend to be direct skin irritants.

EYES: Repeated exposure of the eyes to mineral base oils will lead to eye irritation. However, in practice, repeated eye exposure can be simply and effectively prevented.

INHALATION: As discussed in the acute exposure section, health hazards from vapors are unlikely, except with diesel fuel and spirits. When significant vapor concentrations are repeatedly inhaled, irritation of the mucous membranes of the upper respiratory tract may be expected. Additionally, systemic effects can occur from absorption of the lighter components and subjects may complain about headache, nausea, dizziness and other general symptoms of being unwell.

INGESTION: Repeated accidental ingestion is unlikely to occur.

LONG TERM EXPOSURE

In this section the health hazards resulting from many months or years exposures will be discussed.

SKIN: Skin rash and oil acne, recognized by the presence of blackheads, pimples and pustules, may occur at the site of exposure or contact on workers with poor personal hygiene when exposure is repeated and prolonged.

It should be noted that skin cancer, except that of the scrotum (sac containing the testicles) is normally less serious than other forms of cancer and is usually curable with early treatment. In the case of scrotal cancer the prognosis generally appears to be less favorable than for other skin cancers. Therefore any rash, wart or sore on any part of the body, particularly the scrotum, should be reported and medical advice should be sought without delay.

INHALATION: Prolonged and repeated exposure to concentrated lube oil or diesel fuel mists may lead to a benign form of lung fibrosis, possibly preceded by symptoms of bronchopulmonary disease.

Additives In Lube Oil And Diesel Fuel

In considering the general use of additives in lubricants, it should be recognized that engine oils, whether for gasoline or diesel engines, almost invariably contain additives. In many lubricants, additives are minor ingredients of low toxicity and the potential hazards are essentially those associated with the base oil.

Before use in lubricants, responsible suppliers ensure that additives are screened for toxicity and skin or eye irritancy. This is essential to assess potential hazards and determine any required handling precautions during blending of the finished lubricant. If additive screening indicates that a blended lubricant may present increased potential hazards, further assessment will be made. This will include consideration of likely exposures, the feasibility of safe handling requirements and the need for further testing before deciding whether the additive can be used or should be rejected. Results of this screening are available in your shop's copy of the OSHA Material Safety Data Sheet.

Synthetic Lubricants

The types of chemical materials used in synthetic lubricants to meet operational requirements which cannot be satisfied adequately with mineral oil products, are beyond the scope of this report. However, experience indicates that they do not generally present any significant additional hazards and the required handling precautions are essentially similar to those for mineral based lubricants.

Used Oils

There is strong evidence that carcinogenic contents of mineral based oil may increase during use. The extent of the increase appears to depend on the type of application, being up to about ten-fold for diesel engine oils and perhaps one hundred-fold or more for gasoline engine oils.

Recent animal studies have indicated that good hygiene practices and the avoidance of repeated skin contact will offset any increased carcinogenicity of used gasoline engine oils.

Reclaimed and Re-refined Oils

For environmental conservation reasons there are attractions in reclaiming or re-refining of used lubricants for further use. A variety of processes may be employed ranging from simple centrifuging and earth filtration for reclaiming, or distillation, solvent extraction and hydrofinishing for re-refining. As with other lubricants, the assessment of potential hazards and the required handling precautions will depend on the characteristics of the source of material and the process used. Results of this assessment are available in your shop's copy of the OSHA Material Safety Data Sheet.

Safe Handling Practices And Precautions

The previous sections give an insight into the potential hazards to personnel who use lubricants in the form of oils and fuels. The actual hazard depends on both toxicity and exposure. Even with extremely toxic materials there is no hazard if there is no exposure. Conversely, the least toxic materials may present a hazard if there is sufficient exposure.

Precautions Against Skin Effects

PRODUCT SELECTION: Where there is likely to be significant skin exposure, select products which are agreed by the supplier to be suitable.

INFORMATION: Advise personnel who are responsible for and who come into contact with fuels and lubricants of the possible harmful effects, the circumstances under which they occur, the need to minimize contact, the importance of personal hygiene, the need for medical supervision and the legal requirements.

PERSONAL HYGIENE: Provide adequate washing facilities, ensure use of suitable and clean work clothing, laundering facilities, barrier cream, skin cleanser and skin reconditioning cream. Where necessary, provision of locker and changing rooms for separate storage of clean and contaminated clothing should be considered. In particular make provision for changing contaminated clothing, underclothing and footwear.

PERSONAL PROTECTIVE EQUIPMENT: Certain aspects of personal protection need to be given detailed attention. Where the use of gloves is practicable they should be selected so that the fabric is impervious to the contaminant and resistant to perforation but allows the necessary degree of manual dexterity. Materials such as polyvinyl chloride, polyethylene and neoprene provide good resistance to most oils and fuels.

Where for comfort or other reasons, non-impervious protective garments are provided, or are the only practical alternative, they should be changed frequently and cleaned by any laundering process which produces visually clean garments. When clothing becomes grossly contaminated, it should be changed as soon as practicable. Regular changing of underwear is important if penetration of outer clothing occurs.

To avoid the temptation of stowing oily rags or tools near the groin area, overalls should not have trouser pockets. When practical, impervious butcher's apron style overalls with detachable absorbent fronts should be worn over work clothing. Sleeves should be short or rolled up to avoid friction between oil-contaminated clothing and the skin of the forearms.

SKIN CARE: Personal cleanliness is a most important factor in skin care. Although there is some disagreement as to the degree of protection barrier creams provide, there is no doubt that their use promotes awareness of the need for skin care and makes eventual washing more effective. However, it is important to use the correct type of cream for the fluid in use.

Use of skin reconditioning cream after work is also important to help replace the natural fats which may be removed by exposure to lubricants and skin cleansers. This is particularly important with older employees who tend to have drier skins, and in winter when low temperatures and low humidity tend to cause dryness and cracking of the skin.

A further important part of any skin protection program is to ensure that all employees exposed to any type of lubricant keep a careful watch on all areas of their skin and obtain medical advice at the first sign of any abnormality. Medical attention should be obtained for any cuts and scratches as well as discoloration, soreness, itching, swelling or warty growths.

Finally, it should be emphasized that, although the most serious potential hazard from excessive exposure to lubricants is the small number of reported cases of skin cancer, dermatitis is a far more common problem. However, implementation of the precautions required to minimize dermatitis would be expected essentially to eliminate the already very low risk of skin cancer.

Precautions Against Inhalation Effects

Although skin contact is the principal concern, some processes such as diesel injector maintenance generate oil mist and fumes which may be inhaled. Where necessary, exposure should be minimized as far as is reasonably practicable by an enclosure combined with appropriate ventilation. Local exhaust ventilation can be applied to small and large sources of release, given correct hood design and optimum air flow.

Precautions Against Eye Effects

There are no unusual eye effects associated with the handling and use of the majority of lubricants, but processes which release mist or cause splash may result in contact with the eyes. Where this occurs the emphasis should be on environmental control in the form of splash guards, enclosures and exhaust ventilation.

Summary:

The key relationship in exposure to toxic chemicals is how much for how long. A more toxic material requires less time to have a health impact. Conversely, less toxic agents require longer amounts of time during exposure to produce health impacts.

Findings by the American Petroleum Institute and others have demonstrated carcinogenic activity in a range of laboratory prepared naphtha and kerosene fractions from crude oils of widely different character. Taking into account, however, the low potencies reported and the long history of safe and very widespread use of products likely to contain the fractions in question, it is considered that the findings may not indicate a significant hazard.

Conscientious application of good and in many cases common sense practices of industrial hygiene are viewed as sufficient to protect against potential harmful effects of petroleum fuels and lubricants.

III.

FUELS AVAILABILITY AND PRICE OUTLOOK

The availability of fuels and pricing of those fuels has always been of great importance to the railroad industry. After the activation of the OPEC cartel in 1973 and subsequent supply disruptions, the importance of these concerns was greatly increased. In 1973 crude oil was selling for something under $3 per barrel and No. 2 diesel fuel could be bought for about 10 cents per gallon. In 1981 crude oil prices peaked at about $36 per barrel. No. 2 diesel fuel prices peaked in late 1981 or early 1982 at just over $1 per gallon.

This rise in pricing of crude oil, particularly the precipitous increases in the 1973/1975 and 1978/1981 periods, brought major forces to bear on the supply versus demand situation. In the period between 1981 and 1985, demand was reduced significantly due to increased conservation and economic stagnation throughout much of the world. In the same period production was increased as more and new facilities, developed in response to earlier increases in crude oil prices, came onstream. These forces created a downward pressure on crdue oil prices, led by spot market prices. In 1983 OPEC dropped its official prices and assumed the role of a cartel trying to defend prices by limiting production. OPEC was moderately successful in this effort, as long as Saudi Arabia assumed the role of swing producer.

By 1985, Saudi Arabian production had dropped to 2.5 million barrels per day, as other OPEC members ignored quotas and non-OPEC production remained at capacity. At the end of 1985 Saudi Arabia abandoned the role of swing producer and implemented net-back pricing. The result has been a precipitous drop in crude oil prices as Saudi production has climbed to over 4 million barrels per day. At the time of this writing crude oil prices had dropped to about $12 per barrel and refined products were following.

Due to the volatility and uncertainty of the current oil supply and pricing climate, it was decided that the bulk of this section of our paper will be a presentation of the fuel supply and pricing picture, as seen at the time of the LMOA Annual Meeting. The areas which will be covered are:

1. Historical and Economic Background
2. Supply/Demand Pricing and Predictions
3. Economic Effects
4. Alternative Fuels Viability

1. Historical & Economic Background

Since the rapid oil price increases in the 1979-81 period, a number of important developments have taken place in the world economy and energy markets. Declining demand for oil and natural

gas, a surge in non-OPEC production, declining share of OPEC oil, the emergence of the futures market, a rapid growth in the volume of spot sales, the demise of British National Oil Company (BNOC), the emergence of the Soviet Union as a major exporter of oil and natural gas, and growing discord within OPEC ranks are some of the important events that have taken place in the world energy markets within the past six years. In the economic arena, such events as sub-par economic growth in the industrialized countries, two back-to-back recessions in the United States, rapid growth in less-developed countries' (LDC) debt, huge U. S. budget and trade deficits, and severe currency exchange rate fluctuations have followed the 1979-81 oil price increases.

The influence of these events is already noticeable in world energy markets, but some of the potential consequences remain latent and are bound to manifest themselves in the years ahead.

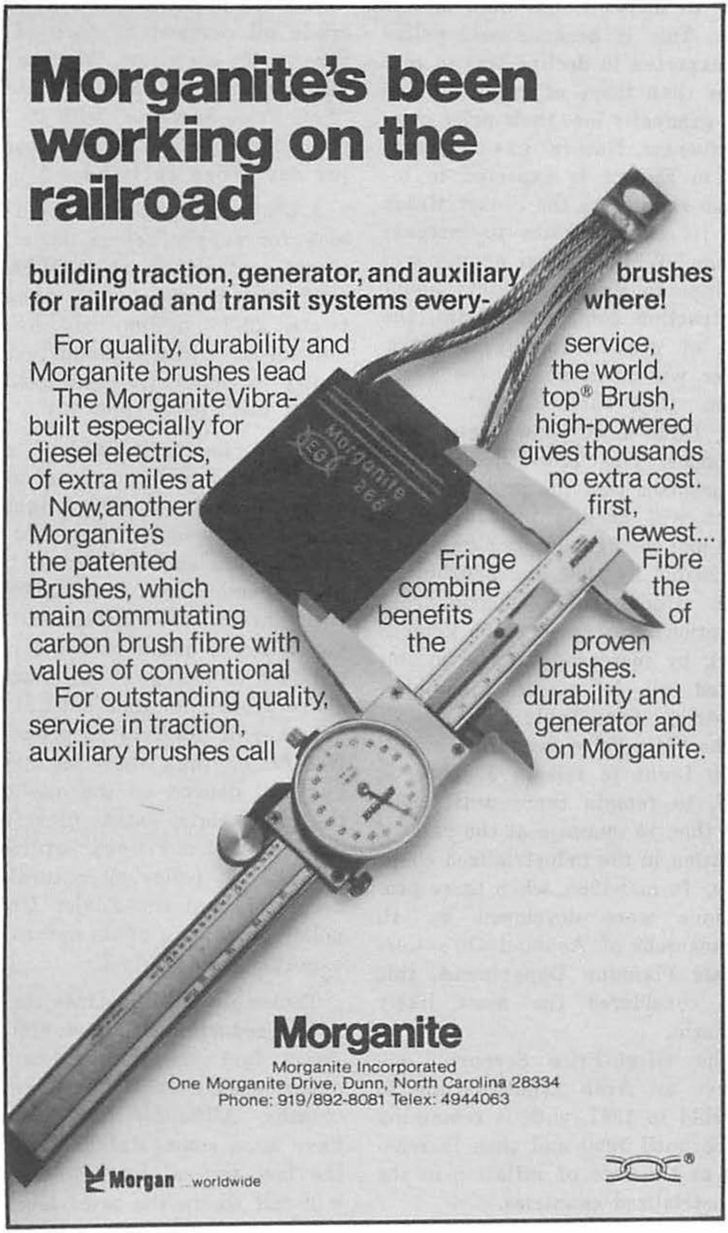
2. Supply/Demand and Pricing

In spite of a dramatic decline in price and some 2.3 percent real annual growth in Free World economic activity, demand for oil actually declined from 47 million barrels per day (b/d) in 1981 to 46.2 million barrels per day in 1984. In the United States oil consumption decreased by about 10 percent despite the price decline and a real GNP growth rate of 11 percent in the 1981-84 period.

The bulk of the demand decline has been in heavy fuel use. In the United States alone, demand for residual oil dropped by 33 percent, from 2.1 million barrels per day in 1981 to 1.4 million barrels per day in 1984. This drop has resulted from the decline of U.S. "smokestack" industries, conservation, substitution of other energy sources, and structural changes in the economy. Only a perception by consumers that the current price slump is a long term phenomenum will cause any significant reversal of this trend. Moreover, governments in the industrialized countries are not expected to allow imported oil to replace indigenous coal or natural gas. They are likely to levy new tariffs on oil to discourage its use.

It seems reasonable, therefore, to expect lower prices to have a greater effect on supply than on demand. In other words, a global equilibrium is more likely to result from reduced exploration and shrinking supplies of oil than from increasing demand.

Table 3 describes primary energy demand for five basic fuel types as experienced in the years between 1970 and 1984, with what we call a "Mid-Price Scenario" growth projection for the period from 1985 to 1995. Oil consumption is expected to increase from 46.2 million b/d in 1984 to 48.0 million b/d in 1990 and 51.5 million b/d in 1995, if prices move as projected in this case. Coal consumption will con-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For outstanding quality,
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tinue to increase, but at a slower pace. This is because coal prices are expected to decline less in real terms than those of crude oil and thus gradually lose their price competitiveness. Natural gas consumption in Europe is expected to increase rapidly as the Soviet Union cuts its export prices to increase volume. While nuclear energy will continue to grow as plants under construction come on stream, the pace of growth for hydroelectric power will moderate in the years ahead. (See Table 3.)

In Table 4 we show three price scenarios. The "Low-Price Scenario" assumes that the price of Arab Light will decline to $15/bbl in 1986 and then gradually climb back to $20/bbl by 1990 and $26/bbl by 1995. Under this scenario, consumption is assumed to be kept in check by increased tariffs on imported. oil in major consuming countries. (See Table 4.)

The "Mid-Price Scenario" allows Arab Light to fall to $23/bbl by 1987, to remain there until 1990, and then to increase at the rate of inflation in the industrialized countries. In mid-1985, when these projections were developed by H. Tahmassebi of Ashland Oil's Corporate Planning Department, this was considered the most likely scenario.

The "High-Price Scenario" assumes an Arab Light decline to $26/bbl in 1987, with it remaining there until 1990 and then increasing at the rate of inflation in the industrialized countries.

Table 5 illustrates the effect on crude oil demand of each of the three price scenarios. We are currently pretty well on track for the "Low-Price Scenario" with its 1995 projection of 54.5 million barrels per day. (See Table 5.)

A projection of the crude oil outlook for supply versus demand is shown in Table 6. Non-OPEC oil production is expected to range between 23-26 million b/d by the mid-1990s. OPEC's production capacity is currently estimated at 30MM b/d. (See Table 6.)

As we can see in Table 7, gasoline demand will continue to increase, despite improved fuel efficiency of vehicles. Residual fuel consumption should increase if oil prices remain low. Low oil prices will narrow the differential between No. 2 diesel fuel and residual fuel, as heavy oil gains market share from coal and natural gas. Whether or not fuel oil prices will fall faster than those of natural gas will depend on the quality of the crude slate, extent of refinery upgradings, refinery utilization rates, U. S. policy on natural gas decontrol, and the Soviet Union's policy on pricing of its natural gas exports. (See Table 7.)

Tables 8 and 9 illustrate the dramatic reduction in crude oil and diesel fuel prices that has been experienced over the past several months. Although there seems to have been some stabilization over the last several weeks, only time will tell where the price level will

Table 6

FREE WORLD CRUDE OIL DEMAND/SUPPLY OUTLOOK
(MILLION BARRELS PER DAY)

	ESTIMATE	MID-PRICE SCENARIO PROJECTIONS		
	1984	1985	1990	1995
DEMAND				
U.S.	15.7	15.7	16.3	17.2
Other	30.5	30.1	31.7	34.3
TOTAL	46.2	45.8	48.0	51.5
SUPPLY				
Inventory Adjustment	0.4	0.5	---	---
Non-OPEC Crude and NGL	24.3	24.8	25-26	23-26
CPE Net Export	1.8	1.7	1.0-1.5	1.0-1.5
OPEC NLG & Processing Gain	2.2	2.3	2.6	2.8
Subtotal	28.7	29.3	28.6-30.1	26.8-30.3
OPEC Crude Oil	17.5	16.5	17.9-19.4	21.2-24.7
TOTAL	46.2	45.8	48.0	51.5
OPEC's Share of Total	37.9%	36.0%	37%-40%	41%-59%

Table 7

FREE WORLD PRODUCT DEMAND OUTLOOK
(MILLION BARRELS PER DAY)

	ESTIMATE	MID-PRICE SCENARIO PROJECTIONS			AVERAGE ANNUAL PERCENT CHANGE	
	1984	1985	1990	1995	85-90	90-95
Gasoline	13.2	13.3	13.7	14.0	0.6%	0.4%
Middle Distillate	15.2	15.3	16.5	17.5	1.5%	1.1%
Residual Fuel	8.8	8.1	8.0	9.3	-0.2%	3.1%
Other	9.0	9.1	9.8	10.7	1.5%	1.8%

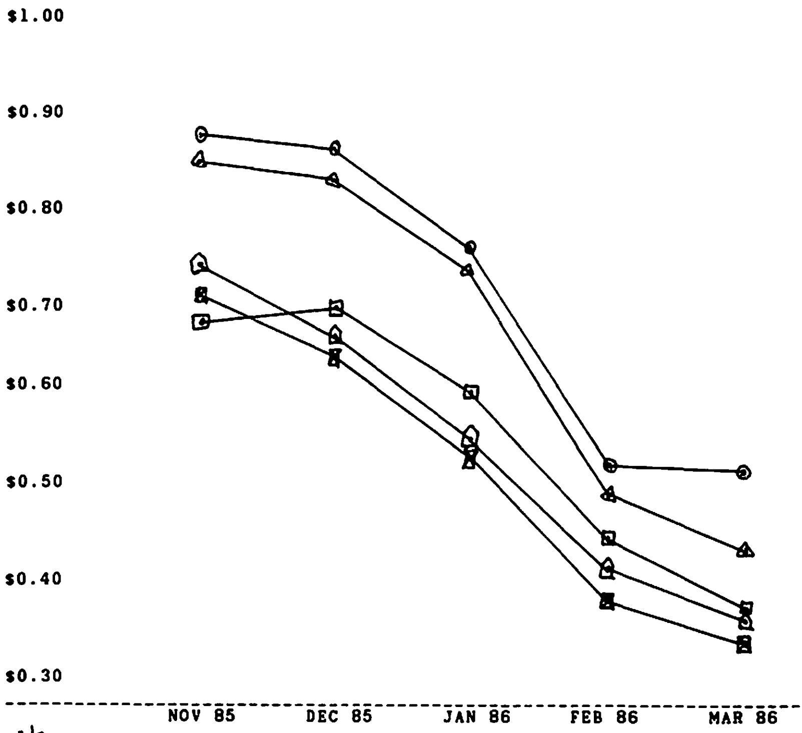
Table 8

PRICES SINCE NOVEMBER 1985
(FIRST OF MONTH)

	NOV 85	DEC 85	JAN 86	FEB 86	MAR 86	MAR 21
WEST TEXAS INTERMEDIATE						
Spot,$/bbl	29.47	26.64	21.91	15.40	13.50	
Contract,$/bbl	28.00	28.75	24.90	18.25	15.00	
BRENT NORTH SEA						
Spot,$/bbl	30.81	27.48	22.76	16.87	14.50	
NO. 2 DIESEL, SPOT						
New York Harbor,$/gal	.8700	.8575	.7500	.5125	.5050	.5325
Gulf Coast,$/gal	.8438	.8250	.7275	.4813	.4200	.4838

Table 9

Price Trends Since November 1985



~~Number~~ No 2 Diesel, New York Harbor - ⊙
No. ~~Number~~ 2 Diesel, Gulf Coast - △
West Texas Intermediate, Contract - ◻
Brent North Sea, Spot - ⌂
West Texas Intermediate, Spot - ■

4. **Alternative Fuels Viability**

Synthetic fuels will not become viable until the crude oil price is well beyond anything we can currently project. Certainly they will not be of any significance until after the year 2000.

Declining diesel fuel prices and a shrinking margin over residual fuel have made blending No. 2 with heavy oil unattractive. In the future declining stocks of low sulfur crude will make this option even more unlikely to be successful.

One Mid-Western railroad has successfully used a 35 cetane diesel fuel at a savings of about two cents per gallon. However, we would suspect that falling fuel prices would tend to erode this difference.

It currently appears that, at least for the next several years, No. 2 diesel fuel will be abundant at an attractive price which will ensure its continued place as the fuel of choice for the railroad industry.

IV.

SELECTION OF LUBRICANTS FOR WHEEL FLANGE AND RAIL LUBRICATORS

Recent literary searches for information concerning improved railroad operating performance as the result of flange/rail lubrication, has revealed that the application of "just any lubricant" to the flange/rail interface will not necessarily result in the improved performance claimed in recent publications of trade magazines.

Conversations with railroad test personnel whose responsibility is to gather the data necessary to substantiate the claims of reduced fuel consumption, rail wear, and wheel wear have indicated there is a dramatic difference in the performance of the various lubricants presently under evaluation.

Some of the problems mentioned include:

- Certain locomotive mounted flange lubricators are creating an undesirable accumulation of lubricant on the locomotive trucks.

- Certain locomotive mounted flange lubricator vendors cannot use suspended particles such as graphite or molybdenum disulfide in their grease because the high pressure will separate them from the lube and cause the particles to behave as a solid with the end result of plugged application nozzles.

- Several locomotive mounted flange lubricator vendors are requesting their equipment be evaluated with a particular brand or type of lubricant. The selection of that brand of lubricator for a fleet application would lock the railroad to a lubricant that may not provide the best performance or be the most cost effective.

- One grease used in a track mounted lubricator would not carry the full length of the curve.

- One grease used in a track mounted lubricator would collect at the base of the rail adjacent to the application nozzle instead of being evenly distributed on the gage side of the rail.

- Several greases used in track mounted lubricators will routinely plug application nozzles.

- Lubricators mounted on locomotives, boxcars, high rail vehicles and trackside are difficult to adjust for temperature induced viscosity changes of the lubricant. In the case of track mounted applicators, the lubricant can be pumped over the target because of low viscosity and will be applied to the top of the rail head or the lubricant can fall short of the target because of high viscosity and in the case of vehicle mounted applicators will be applied to the wheel tread.

- Excessive lubricant on the top of rail head provided enough electrical insulation between wheels of empty cars and the rail to open the grade crossing signal circuit. This allowed the crossing gates to open while a train was still moving through the crossing.

To better understand why these problems occur and what steps can be taken to correct them, let us review several laboratory procedures that can be used to screen potential flange/rail lubricant candidates. The results of these procedures have not been compared to field tests and are not to be considered as an endorsement by the Locomotive Maintenance Officers Association Fuel and Lubricants Committee.

Flash and Fire Points ASTM D-92 and D-93

The flash point of an oil is the lowest temperature at which it gives off vapors that will ignite when an open flame is passed over the surface of the oil.

The fire point is the lowest temperature at which an oil ignites and continues to burn for at least 5 seconds. (See Figs. 6 and 7.)

Cone Penetration of Lubricating Grease ASTM D-217

Penetration is the depth (in tenths of a millimeter) that a standard cone penetrates a sample of grease under prescribed conditions of weight, time and temperature. This penetration is a measure of the relative hardness of a grease or helps identify its thixotropic behaviour. (See Fig. 8.)

Grease Shear Stability ASTM D-217-A

Shear or mechanical stability of a grease is its ability to withstand repeated working with minimum change in its structure or consistency. (See Fig. 9.)

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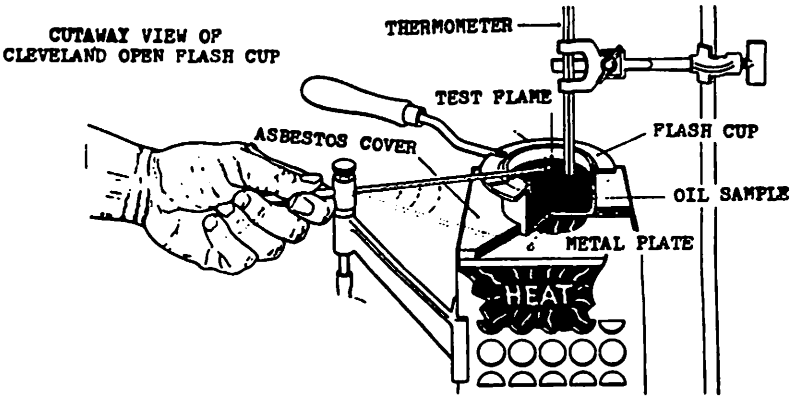

ASTM D-92 Flash Point Determination

Fig. 6

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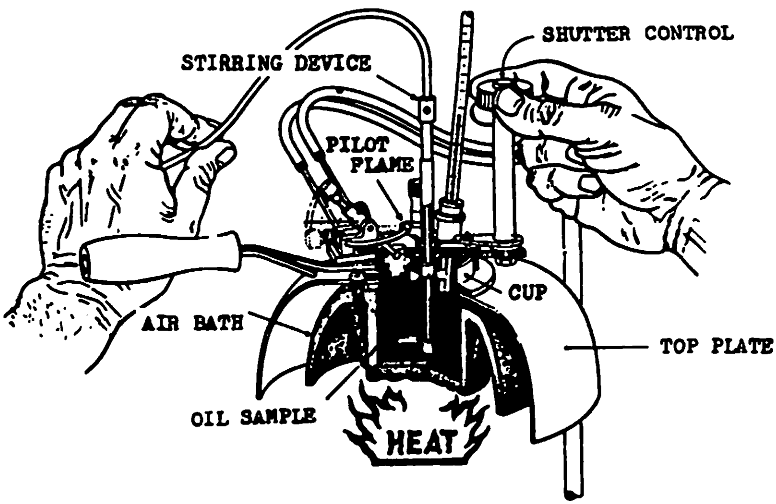

ASTM D-93 Closed Cup Flash Point Determination

Fig. 7

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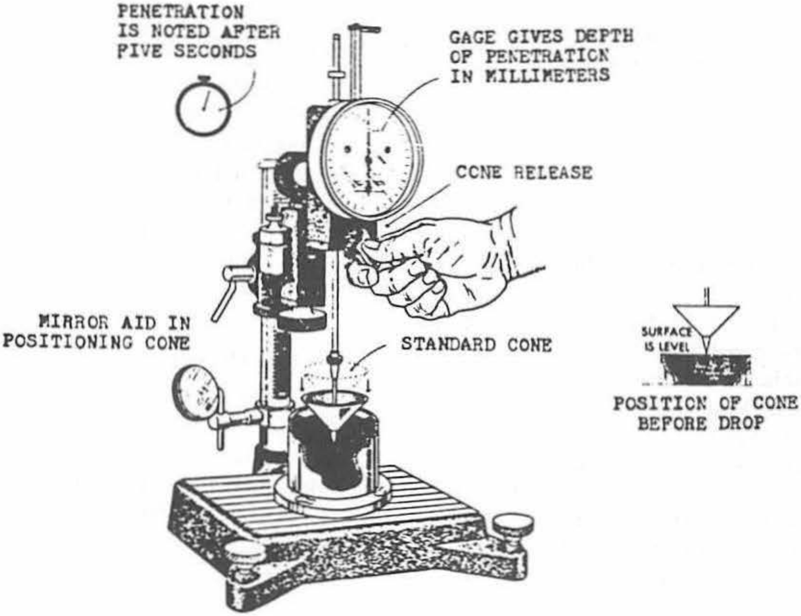
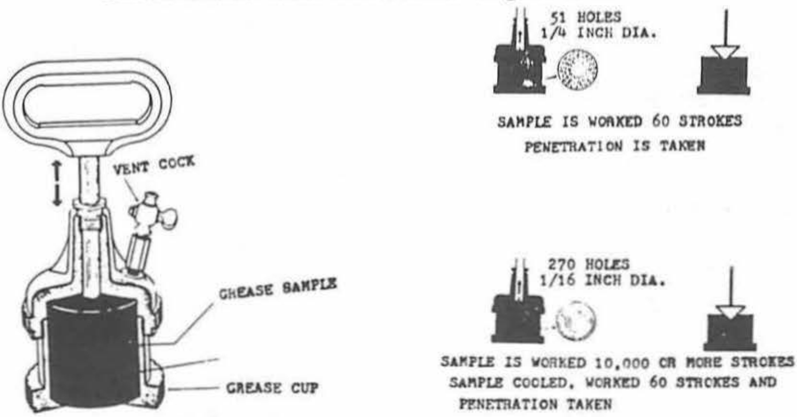


ASTM D-217 Cone Penetration of Lubricating Grease
Fig. 8

United States Steel Lubrication Engineers Manual



ASTM D-217A Grease Shear Stability
Fig. 9

Dropping Point of Grease
ASTM D-566

The dropping point of grease is that temperature at which it passes from a semi-solid to a liquid state. (See Fig. 10.)

Recent field measurements have indicated, that in severe curves, under conditions of maximum power or dynamic braking, the temperature at the flange-rail point of contact can exceed 177 deg. C (350 deg. F). If the dropping point of the grease is below this value, the locomotive wheels will heat the grease, causing it to be thrown from the flange or drop from the fail. In the absence of lubricant, the balance of the train will pass through the curve without benefit of rail lubrication.

Typical drop point ranges are:

Calcium base greases —
71-99 deg C (160-210 deg F)

Sodium base greases —
135-177 deg C (275-350 deg F)

Lithium base greases —
177-205 deg C (350-400 deg F)

Bentone base greases —
over 260 deg C (over 500 deg F)

Silicone greases —
over 260 deg C (over 500 deg F)

Grease Mobility

United States Steel method using Standard Oil Development cylinder and capillary tube.

Grease mobility is the measure of resistance to grease flow at prescribed pressures and temperatures which will predict the pumpability characteristics of lubricants under low temperature operating conditions. (See Fig. 11.)

Pressure Oil Separation Test

United States Steel method using Esso Laboratories' cylinder.

The measure of oil separation and caking under fixed conditions simulates the stability of a grease under the high pressures and small clearances found in a centralized grease pumping system. (See Fig. 12.)

Grease Retention Test

United States Steel method by the Timken Lubricant Tester.

The purpose of this test is to simulate lubrication of sliding surfaces for long periods without lubricant replenishment.

This test uses the same equipment as described in ASTM D-2509, except the automatic lube feed is disabled. The lube is applied by spatula to the bearing surface of the test cup and block. The ring and block are rotated under load and the time to destruction of entire film of lube is measured. (See Fig. 13.)

Meausurement of Extreme Pressure Properties of Oils

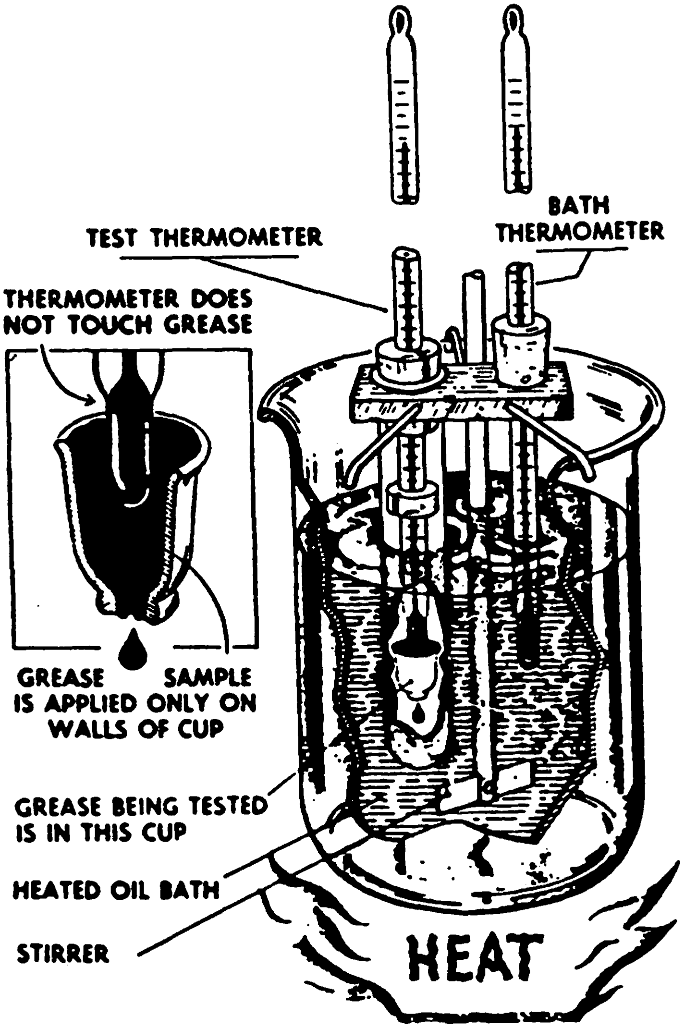
Four ball method ASTM D-2783.

The purpose of this test is to evaluate the EP characteristic of lubricants by a load scar curve and weld point. (See Fig. 14.)

Friction and Wear Test

Four Ball Wear Tester ASTM D-2266.

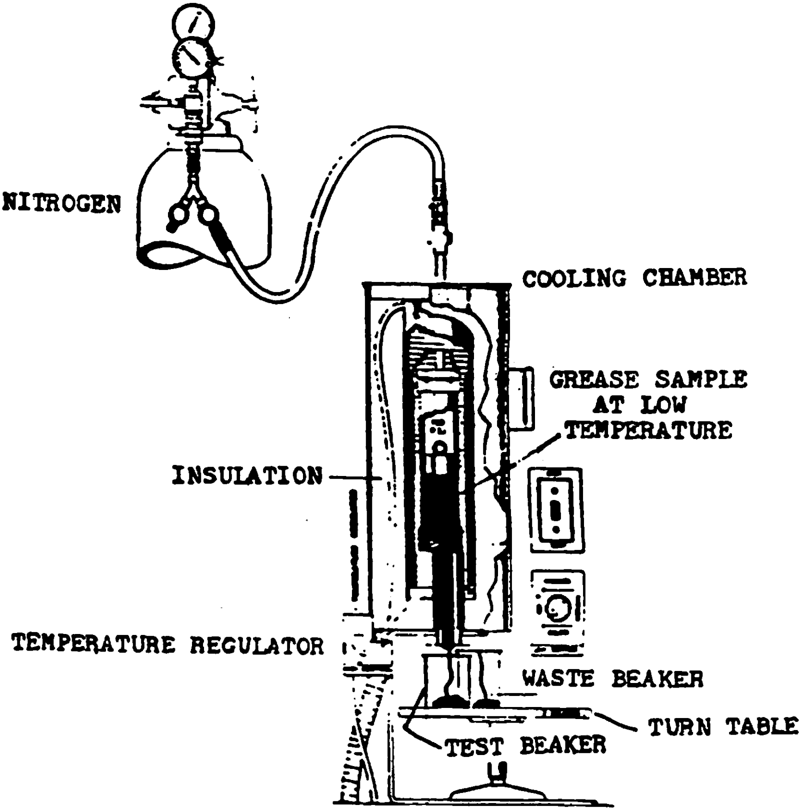
United States Steel Lubrication Engineers Manual



ASTM D-566 DROPPING POINT OF GREASE

Fig. 10

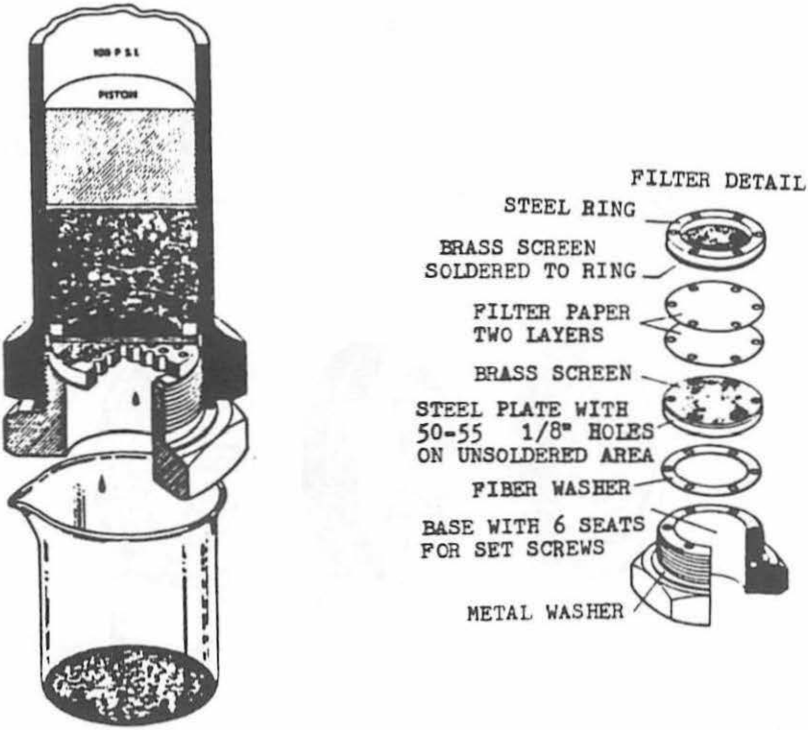
United States Steel Lubrication Engineers Manual



UNITED STATES STEEL METHOD USING STANDARD OIL DEVELOPMENT CYLINDER AND CAPILLARY TUBE TO DETERMINE GREASE MOBILITY.

Fig. 11

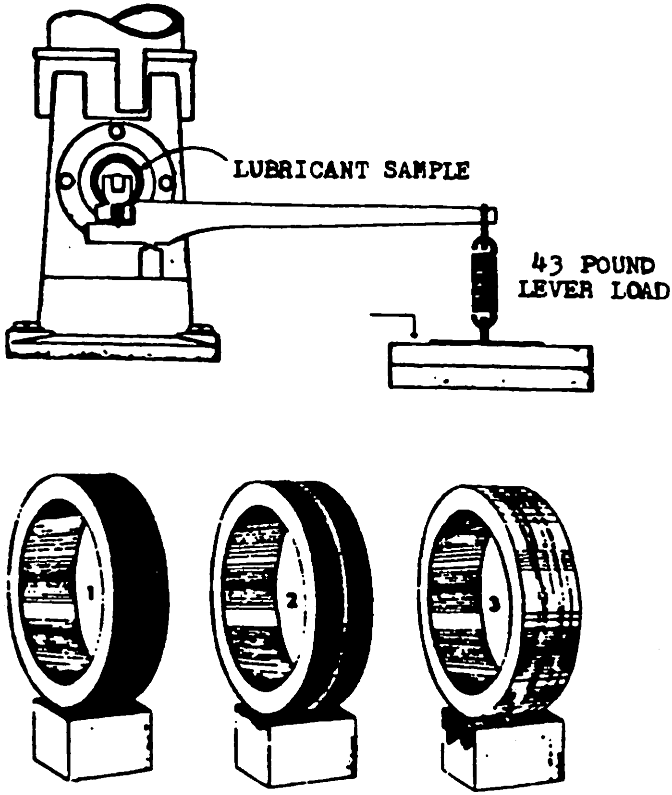
United States Steel Lubrication Engineers Manual



UNITED STATES STEEL METHOD USING ESSO LABORATORIE'S CYLINDER TO DETERMINE PRESSURE OIL SEPERATION CHARACTERISTICS OF LUBRICANTS

Fig. 12

United States Steel Lubrication Engineers Manual



1. Start of test—the block will not be scored as long as the film completely covers the entire face of the cup.
2. A line break is the first indication of failure 200 to 300 seconds prior to destruction of entire film.
3. The line break spreads to entire face of cup. Machine chatter, overheating, or sounds that indicate a scored block terminate the test.

UNITED STATES STEEL METHOD USING TIMKEN TESTER TO DETERMINE GREASE RETENTION

Fig. 13

This test is very similar to ASTM D-2783 except the torque required to rotate the ball is measured and the results are plotted against ball scar dimensions to determine friction and wear characteristics of a lubricant. (See Fig. 15.)

Plastic Plate Abrasion Test ASTM D-1404

The purpose of this test is to indicate the presence of gritty particles in lubricating greases which may scratch or abrade lubricant pump cylinder walls and cause pump failure. (See Fig. 16.)

Lubricant Performance Values and Limits

The literary search made prior to writing this report found no mention of what test result values indicated a desirable lubricant or which ones did not. Each type of operating philosophy, climatic region, track profile and type of oiler or lubricator will require a different lubricant performance characteristic to provide the railroad with optimum improved train operating performance.

Summary

The concept of using flange/rail lubrication to reduce fuel consumption, wheel wear and rail wear has been well documented by many sophisticated field tests. Proof that the concept has merit, has brought forth a multitude of vendors, each competing for the railroad's dollars by claiming their lubricant offers advantages the competition does not.

The problem of verifying the vendors' claims by the use of lengthy and expensive field tests can be significantly reduced by using the above mentioned laboratory tests to identify a lubricant which:

- can be reliably delivered to the metal wear surface by determination of flash point, grease mobility and pressure oil separation;
- will not migrate to the wheel tread/rail head area by determination of cone penetration and shear stability;
- will remain in place under elevated operating temperatures by determination of dropping point temperature and grease retention time;
- will withstand operating pressures by measurement of extreme pressure, friction and wear properties;
- will not cause applicator maintenance problems by evaluating the results of the plastic plate abrasion test.

The use of these criteria to evaluate your railroad's present lubricant will provide an excellent base line for comparison of proposed new lubricants.

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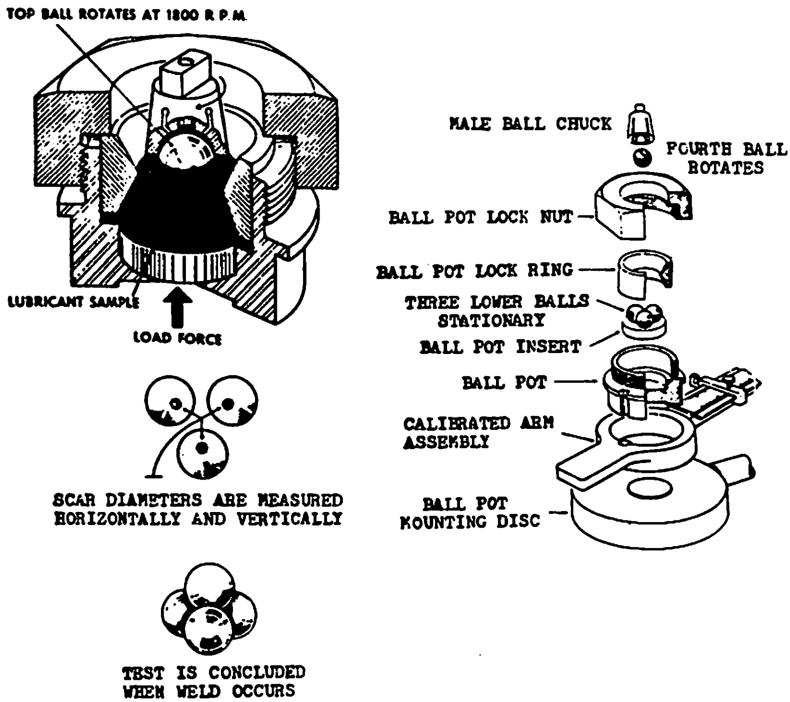

ASTM D-2783 FOUR BALL METHOD TO MEASURE EXTREME PRESSURE PROPERTIES OF OILS

Fig. 14

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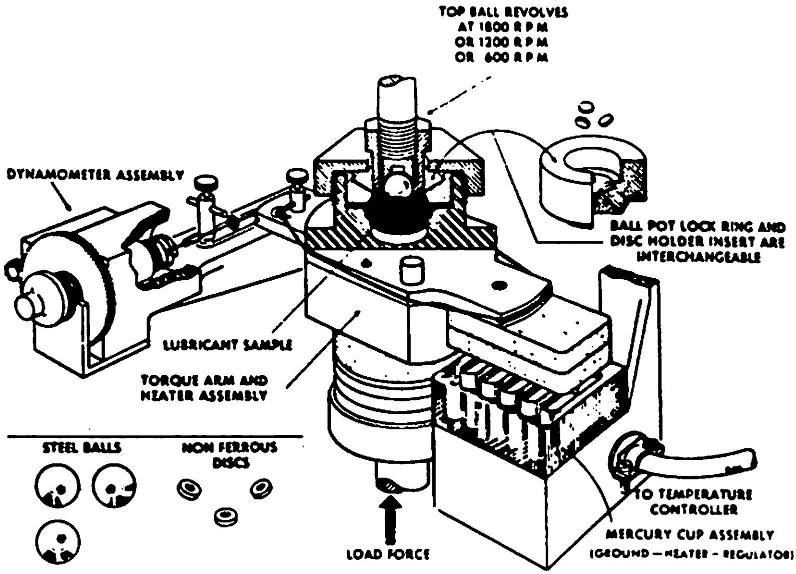
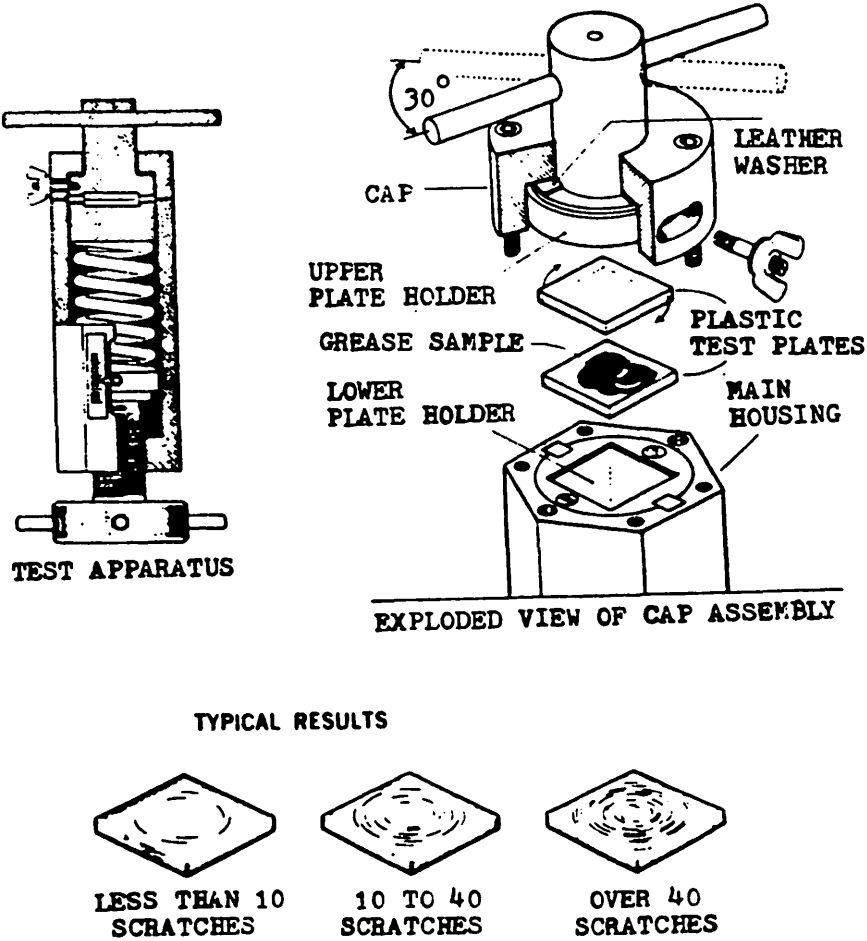


SCAR DIAMETERS ARE MEASURED
HORIZONTALLY AND VERTICALLY

ASTM D-2266 FOUR BALL METHOD TO DETERMINE FRICTION AND WEAR CHARACTERISTICS OF A LUBRICANT

Fig. 15

United States Steel Lubrication Engineers Manual



ASTM D-1404 PLASTIC PLATE ABRASION TEST

Fig. 16

FUEL & LUBRICANTS COMMITTEE

Six-Year Index

Southwestern Railway Club

Started in 1946, the Southwestern Railway Club this year is celebrating its 40th anniversary.

The organization consists of Railroad and Railroad Supply members who cooperate to discuss locomotive and freight car maintenance and other aspects of the Railroad Industry.

Railroad personnel and Railroad suppliers and builders are welcome members in the Southwestern Railway Club. Contact our secretary-treasurer for details on meeting dates and locations.

Application for membership should be directed to the Secretary-Treasurer, Southwestern Railway Club, P. O. Box 716, St. Louis, MO 63188.

D. W. BOLT
PRESIDENT
Director Research & Development
Union Pacific Railroad
Omaha, NE 68179

F. R. HICKERSON
SECRETARY-TREASURER
Master Mechanic
Union Pacific Railroad
North Little Rock, AR

Tuesday, September 23, 1986

10:30 A.M.

REPORT OF THE COMMITTEE ON-DIESEL MATERIAL CONTROL

Pre-Convention Presentation Southwestern Railway Club

April 24, 1986 Crown Center Hotel Kansas City, MO

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Engineering Assistant
Atchison, Topeka & Santa Fe Railway
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T. R. Gerbracht	Sr. Eng. Technical Support	GE	Erie, PA
R. M. Grimaila	Master Mechanic	UP	Houston, TX
H. H. Pennell	Director Material	BN	Naperville, IL
W. R. Powell	Material Supervisor	Santa Fe	Topeka, KS
T. J. Rohan	Genl. Supt. Production Matl.	Conrail	Altoona, PA
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1986 TOPIC:

ELECTRONICS: NEW METHODS FOR HANDLING MATERIAL WITH PROPER QUALITY AND SOURCES

PERSONAL HISTORY

LELAND G. SALTS

Born near Topeka, Kansas, July 22, 1933. He graduated from high school in 1951 and attended Washburn University. For nine years he worked for Pittsburgh Plate Glass Company prior to starting with Santa Fe Railroad in February, 1960, as a Machinist Apprentice.

After serving a four year apprenticeship, he worked as a Mechanical Draftsman in the Shop Extension Engineering Department for five years. He was then transferred to Kansas City in 1969 as a Safety Supervisor at Argentine Shops for a period of over seven years. In 1976 he was transferred back to Topeka as a foreman in the Wheel Shop and other areas in the shop.

In 1978 he went into the Mechanical Engineering Department at Topeka where he is presently employed as an Engineering Assistant. He and his wife, Martha, have one son and two daughters.

INTRODUCTION

The theme of the Diesel Material Control Committee's 1986 Technical Paper is:

Electronics: New Methods For Handling Material — With Proper Quality and Sources

Our subtopics are:

I. The In-House Electronic Requisition System
II. Electronic Data Interchange - Railroad Experience
III. RAILINC Corp. and Electronic Purchasing
IV. Quality Evaluation
V. Sourcing Decisions

To get better-rounded insights on the material required to keep our locomotive fleets running properly, the Diesel Material Control Committee is composed of members from both Mechanical and Materials departments of the major railroads.

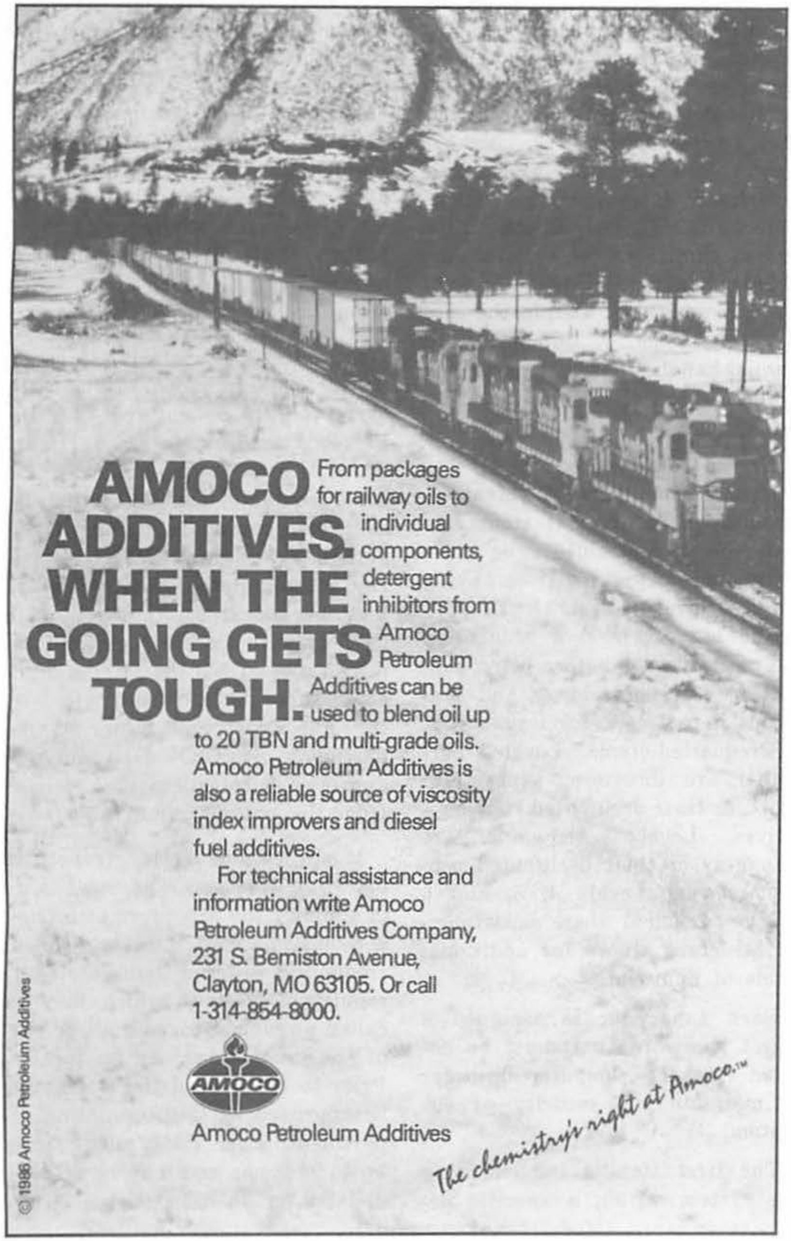
It is the intent of this committee to keep up with the latest material securing and handling methods and to present them for the use of all interested parties. In our 1983 paper we covered a topic entitled: **Improved Locomotive Productivity Through Computerized Data Transfer.** Our paper this year continues on the electronic methods being used.

The LMOA theme for 1986 is: E=MC2 or Excellence In Maintenance Culture Committed To The Bottom Line. We believe our paper to be consistent with this theme.

The Committee Report this year should be of interest to all in securing and evaluating material.

I.
THE IN-HOUSE ELECTRONIC REQUISITION SYSTEM

Increasing productivity and reducing costs are the goals of every company. One railroad found that one method to increase productivity was to use an electronic requisi-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tion system, developed to allow departments to expedite the flow of requisitions from the point of origin to the Purchases and Materials department for issuance. The current approval methods (requisitions approved by specific department supervisory personnel) will still be required. However, the system eliminates the time required for handling and mailing of typed requisitions; and, in the case of stock items, it eliminates all manual handling, as the requisition is directly entered into the computer.

The approval method under the electronic requisition system is based upon department structures with the vice-presidents or their designated representatives being the top level (Level 1). Level 1 is the highest level a requisition will need to reach before being submitted to the Purchases and Materials department for issuance of the requested items. Level 2 personnel are directors, superintendents, or their designated representatives. Level 3 personnel are managers or their designated representatives. Levels 4, 5, and 6 involve personnel where departmental structure allows for additional levels of approval.

Each supervisor is assigned a secret password that must be entered into the computer in order to maintain the security of the system.

The first step in implementing the system within a specific department is to establish the limits master with monetary item and user information. The monetary limit establishes the maximum amount for a requisition that each level may approve without the requisition needing further approval. Establishing item limits allows the user to alter the approval flow for a specified item while the user limits does the same for a requisition issued by a specified user.

Once the limits master is established, each intended user of the system must be entered into the Purchases and Materials User/Scope Authorization Table. This table contains the authorized issuers and approvers of requisitions and their assigned CRT's (cathode ray tubes). Before any requisition may be issued or approved on a CRT by authorized issuers and approvers, the CRT that was assigned to them must be authorized by the Purchases and Materials department. A CRT need only be approved once unless it is deleted from the authorization table.

If so desired, RML's (repetitive material lists) may be established to simplify the procedure of issuing a requisition. An RML is a list of frequently ordered items stored in requisition format which may be called up when ordering all or part of the items contained on the list. Prior to being used the RML must be approved by the Accounting department. Each RML may contain up to 99 items and may be created, updated, or an item deleted at any

time. When any changes are made to an existing RML, the updated RML must be approved by the Accounting department just as a newly created RML must be.

The RML contains the consignee name and address, accounting, quantity needed, Materials department item number, unit of measure, and description of the items wanted.

The issuance of requisitions may be made from any level as long as the user is listed in the Purchases and Materials User/Scope Authorization Table. The electronic requisition system may be used for stock and non-stock items; however, in some instances requisitions should be handled manually. These instances include call-in orders for stock items; when Purchases and Materials is called for a purchase order number to purchase item locally; whenever a sample needs to be sent in with the order; and requisitions for office furniture, office equipment, and special equipment (e.g. cameras, slide projectors, etc.).

Once a requisition is generated, it must be approved by the appropriate people. The levels of approval necessary on stock items depends on the monetary limits established in the limits master and occasionally the user and/or item limits. Non-stock items require approval at all levels. After the requisition is approved by the necessary departmental levels, it is transmitted to the Purchases and Materials department for handling.

Personnel responsible for approving requisitions should inquire into the computer at least once a day by each department to maintain efficient handling of requisitions. A list of any requisitions that have been in storage for over five days awaiting approval will automatically print in the office of the Level 1 user responsible for the requisitions. The Purchases and Materials department material supervisors are responsible for the handling of stock items that might be rejected because of exceeding the quantity limits established and make daily inquiries to resolve any discrepancies.

II.
ELECTRONIC DATA INTERCHANGE

The fastest growing field today is technology. The business world is being revolutionized by the progress made in this field. It is important that railroads recognize that the way we are conducting business is dramatically changing. In our deregulated environment, railroads should strive to be willing to open the door and welcome in the future.

Over a century ago, when railroads started moving their way across this country, business changed forever. Merchants, miners, and manufacturers had to rethink their business potential and had to face the exciting market possibilities that railroads offered through increased speed and increased capacity to move goods.

Now a new transporter has arrived on the scene. That new transporter is computer communication technology, the split second transporter of information.

Every year railroads haul millions of carloads of grain, coal, and manufactured goods throughout the United States. To keep locomotives and rail cars operating safely and efficiently, to keep tracks in top condition and to keep employees working productively, railroads purchase everything from paper clips to locomotives. Purchase order forms are used in requesting these materials from vendors.

Over the past few years, railroads have made significant progress in eliminating internal paper procedures primarily through computerization. At some railroads, with computerized ordering systems, the material requirement is entered into a computer terminal at the field location and transmitted back to a main office where the order is generated and approved by a purchasing agent.

Copies of these purchase orders, which may serve as receiving documents at material warehouses, are no longer mailed from one location to outlying areas. Instead, purchase order data are printed out in the warehouse on the material manager's printer. This computerized process has allowed railroads to change the amount of paperwork procedures involved. The clerks who used to burst, sort and envelope the purchase order copies destined for storehouses are now being utilized in other work areas. And the material managers now get receiving documents on their own printers the next day, instead of via mail after a three to seven day wait.

The next step in the move toward paperless purchasing is to eliminate paper exchanges between suppliers and railroads. The computer ordering system will take requisition data and print purchase orders. After printing, these orders are then mailed to the suppliers. They will spend days in the U. S. Mail system. And what will the receiving suppliers do when they receive these orders? Key the right data right back into a computer!

Invoicing works the same way. Many suppliers have computerized invoice systems that print paper invoices. The invoices are then mailed back to these railroads and a high price is paid to have all of that invoice data keyed right back into a computer for payment authorization.

Even though most business transactions are transported through the U. S. Mail as paper documents, statistics indicate that 70% *of the* U.S. Mail is computer generated, and 30% of that material is reentered into a computer by the receiver.

It is obvious that benefits would be enjoyed by both railroads and their suppliers if purchase orders

could be electronically transmitted from our computers to theirs and invoices received back the same way. Serious consideration has to be given to this concept along with research into how electronic data exchange could be accomplished.

First, a standardized method that could be adopted industrywide would have to be used in order to make this data exchange feasible. Such standards have already been developed by the American National Standards Institute (ANSI) and the Transportation Data Coordinating Committee (TDCC). The standards are referred to as the ASC X12 Standards.

The ASC X12 formats are nothing more than a standardized coding system that can be used to put purchase order data into a computer readable sequence.

Revisions are being made to these standards and, through the National Association of Purchasing Managers, some railroads are actively working to reach an agreement among the major U. S. and Canadian railroads to use these standards for electronic purchasing and invoicing.

This agreement is being pursued so that differences will be minimized on purchase orders received electronically from one railroad to the next. Differences on invoices the suppliers will be transmitting will also be minimized. This uniformity will obviate the need for different programs to transmit from one railroad customer to the next.

The electronic data interchange system does more than just transmit purchase orders electronically to suppliers. EDI allows purchasing agents to approve, change or cancel purchase orders on their computer terminals instead of on paper. At the end of the day's operations, approved orders are either printed for mailing or formatted for electronic transmission. And with the electronic acknowledgment system, invoices are received electronically and automatically entered into the computerized invoice system.

There are two levels of electronic acknowledgments to back the electronic purchase orders. The first level is a syntactical acknowledgment generated by a program that edits the orders as they are received by the supplier. This edit checks to make sure each order meets the X12 Standards. Are the numeric fields numeric? Are all mandatory elements present? Are all elements within the length specifications of the Standard? If so, the acknowledgement communicates that the transmission was acceptable. If not, the errors are identified and communicated back. A syntactical error would indicate that there is a programming bug at the individual railroad; or that some characters were dropped or altered during transmission.

The second level of acknowledgment is the application level. This


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is an acknowledgment that results from the file of orders being put into a supplier's order booking system or that result from orders being reviewed one by one by a customer service representative. This is where the actual data are edited. Are the prices correct? Do the part numbers and noun descriptions match? Do order quantities meet minimum packing requirements?

Orders accepted as is by the supplier are cleared for receipting and invoicing. Changes a supplier has made to orders are reviewed by the buyers on their computers and are either accepted as changed and cleared for receipting and invoicing; or are rejected and cancelled.

The supplier also has the option of rejecting an order or order line if the information is so inadequate that it cannot ship the material.

The invoices received from the suppliers will go through the same process. A functional acknowledgment will be transmitted back to the supplier indicating whether the invoices met the standard.

Invoice data will be automatically matched with the order data. Those matching on items, price, terms and quantity, will be approved for payment. Those not matching will be suspended. If the error is the railroad's, it is up to the railroad to have it corrected and rematch the invoice acknowledgment, by indicating which invoices have been cleared for payment, which invoices have not, and why.

What has enabled some railroads to receive such an enthusiastic commitment from their suppliers? One factor has been the development of softwear for personal computers, for mini computers and for mainframes that can facilitate the electronic exchange of data in the ASC X12 formats. For a hardware and software investment of less than $15,000, any supplier can be receiving and sending purchase crders, acknowledgments and invoices electronically; not just with the railroads, but with other customers and even *its own* suppliers — all with the same equipment and the same softwear.

Benefits to both railroads and suppliers are significant; clerical costs can be reduced and productivity increased. Data accuracy increases tremendously when the rekeying of data is eliminated. Lead times are reduced by eliminating mail time and clerical processing; and finally, safety stock inventories can be reduced.

The key to advancing the practice of electonic purchasing and invoicing is STANDARDIZATION of electronic data interchange formats.

The X12 Standards go a long way to answering what gets transmitted. However, another question that has to be answered is how do two or more parties communicate?

Computers can communicate either via a dedicated line or via a dial-up connection. Leased lines are very costly, $1,000 to $2,000 per month. Dial-up over regular phone lines is less costly, but it may not be the best communication solution either.

A supplier dialing up four customers, might well have to allow for four different communication requirements. As more suppliers and customers become involved, scheduling phone calls, having an adequate number of lines and all other sorts of considerations have to be taken into account.

Fortunately, companies known generically as third party communication services or electronic clearing houses have jumped into the market place to untangle communication problems and act as post offices for electronic messages.

One phone call to an electronic service to drop off and pick up messages, saves all parties a lot of hassles. If a supplier chooses to use an electronic service different than the one a particular customer has chosen, no problem. The supplier and that customer still only have to make one phone call to drop off and pick up all messages.

Electronic clearing houses provide additional services as well. They have consulting groups that can help a company get started or provide a company with software development. They can take business data from one standard and format it into another standard. For example, they can take X12 purchase orders and translate them into another file format, if that is required. Or they can take an invoice file in a unique company format and put it into an X12 format so that X12 users can read it.

The service can also mailbox messages, that is store messages, for scheduled deliveries and pick up; or provide immediate transmission on to the intended receiver.

Several railroads have set up a system whereby they can communicate with their suppliers either through a third party service or through a direct dial-up connecttion. Most prefer just using a third party service.

The point to emphasize is that by using an electronic clearing house, customers and suppliers can call ONE electronic service to handle ALL data exchange. Just one phone call is needed to transmit and receive; the service sorts and forwards outgoing messages and consolidates all incoming messages. This spares the customer and suppliers the hassle of making multiple phone calls and of programming for various protocols that individual computer systems require.

In the brief space available in this committee report, we have tried to give you an idea of what some railroads are doing and what

some railroads are planning on doing. We cannot emphasize enough the benefits of STANDARDIZING data formats. One of the key things to remember about it is that it is not just large Companies that will be exchanging business data electronically. Personal computers, software packages and third party services have made it possible for operations of all sizes to cash in on the benefits of EDI.

Business is changing. The future is here. Participating in the relatively new area of EDI will prove to be an exciting start in the revolution of the business world.

III.
RAILINC
And Electronic Purchasing

RAILINC is a data processing and telecommunications subsidiary of the Association of American Railroads (AAR). Originally the Management Systems Department of the AAR, its principal users were the rail carriers themselves. However, in March of 1982, RAILINC became a for-profit subsidiary of the AAR and now has the flexibility to expand its services to other companies that are associated with the railroad industry such as rail shippers and suppliers.

RAILINC provides all computer services for the AAR as well as large data processing jobs that affect the entire railroad industry. One example of this type of job is TRAIN II, the national freight car database that RAILINC maintains for the railroad industry. Based on information supplied by rail carriers, TRAIN II contains movement and waybill information on every railcar in the country (over three million characters of information!). RAILINC supplies these data to rail carriers for car location, car accounting, car maintenance and other purposes. RAILINC also maintains UMLER, a computerized version of the Railway Equipment Register. Most importantly, RAILINC maintains a telecommunications network for the railroad industry used for electronic data interchange (EDI), the paperless exchange of information among railroads and other companies.

In the mid 1960's, the railroad industry decided to construct a telecommunications network that would allow railroads to transmit information electronically among each other. *Essentially, they had* two options — a private line network where a carrier would maintain a separate line to each other carrier or a centralized message switching network where each carrier would have one line to a central site and electronically switch data to all other carriers through this central site. The industry chose this type of central message switching network which is now the network operated by RAILINC.

With this network, every major rail carrier in North America has a leased communications line connected to RAILINC's computer in

Washington, D.C. These lines are open 24 hours a day, seven days a week to send or receive data to or from carriers. A carrier sends a piece of information down its communication line to RAILINC. RAILINC automatically transfers this information from the sending carrier's line to the receiving carrier's line. It does not process or look at the data but merely "switches" it to its destination. The types of information switched over RAILINC's network include data such as waybills, advance consist information, billing information, automobile inspection reports, embargo notices, and other types of administrative data.

This type of electronic exchange of information, called "message switching", has grown termendously in the railroad industry over the past five years. In 1980 approximately 4,500 messages a day were transmitted among rail carriers using RAILINC's network. In 1985, that number grew to 112,000 messages a day and over 3 billion characters a month. Clearly, EDI is being used increasingly by railroads and will soon be the dominant method of communicating information among carriers.

Besides message switching among railroads, the railroad industry also encourages EDI with non-railroads. A variety of shippers such as General Motors, Ford, and Cargill use the network to electronically receive car location messages (CLM's) from carriers. In addition, service bureaus such as SCM Kleinschmidt and McDonnell-Douglas have communication lines to RAILINC that allow them to pick up data from rail carriers and pass it to other companies. Other companies such as car lessors, rate bureaus, and private car companies also maintain lines to RAILINC's network.

The most prevalent type of information switched on RAILINC's network between railroad and non-railroads is CLM's. However, shippers also use RAILINC to transmit fleet updates, freight bills, waybills, and bills of lading with carriers. In fact, any type of message can be transmitted electronically between a rail carrier and a non-railroad, the most recent being purchase orders and invoices between railroads and rail suppliers.

RAILINC's network is now used by railroad suppliers to electronically transmit purchase orders and invoices to rail suppliers. Railroads use their leased lines with RAILINC to send purchase orders electronically. RAILINC puts these data in a supplier's electronic mailbox and stores it until the supplier dials in to retrieve it. Conversely, a supplier can electronically send an invoice to RAILINC for a certain carrier and RAILINC will automatically "switch" that invoice to the appropriate carrier.

RAILINC offers various types of EDI services to facilitate the use of EDI between suppliers and rail carriers. The most basic EDI serv-

ice RAILINC provides is electronic mailbox facilities. When railroads send electronic purchase orders, they are formatted by the carrier according to standards set by the American National Standards Institute (ANSI). RAILINC puts these data in this ANSI format in the supplier's mailbox. The supplier can dial in anytime to receive these data.

Another RAILINC EDI service for suppliers is message reformatting. A major difficulty in EDI is data format differences between railroads and suppliers. Some suppliers are unable to accept electronic information in ANSI format. RAILINC's message reformatting service will accept an EDI message in ANSI format from a carrier and translate it into another format that the supplier can accept. This eliminates the need for a supplier to change its internal computer systems in order to participate in EDI with railroads.

RAILINC can also purchase IBM PC hardware and communications equipment for suppliers that are just beginning to use EDI and are unfamiliar with computer equipment. Various types of software that format purchase order/invoice data are also available.

RAILINC offers special EDI programming for suppliers that have unique EDI computer requirements such as special formatting, different record lengths, special translations, etc. RAILINC's data processing expertise and railroad orientation make it particularly qualified to assist suppliers in EDI.

RAILINC's network is one of the largest privately operated networks in the country. Since railroads use this network 24 hours a day, seven days a week to transmit critical transportation data, the network boasts several important features, including:

Security: All dial-in users to RAILINC's network use a password protected log-on procedure to guard against unauthorized access to data. This password must be changed annually or a user cannot receive information.

Reliability: RAILINC is proud to have a 98% availability rate on its network. Maintaining this high level of reliability is critical to the railroad industry as carriers continue to use EDI in their daily operations.

Integrity: Data can be retransmitted upon request if notified within 24 hours.

Connectivity: RAILINC's network can link to various types of EDI software as well as other value added EDI networks.

RAILINC also maintains a network control center with its network which is open 24 hours a day, seven days a week. The center is equipped with the latest technology to assist users with communication's problems and answer questions.

The biggest feature of RAILINC's network is that it is the

centralized source of electronic information for the railroad industry. Instead of dialing-in to each individual carrier to receive electronic information, a supplier places a single phone call to RAILINC to get purchase orders and invoices from all major carriers. This eliminates the need to maintain separate lines to every carrier, each with its own log-on procedure, protocols, start-up requirements, etc.

EDI is the business practice of the future and the railroad industry is leading the way. As the operator of the network that supplies electronic information from rail carriers, RAILINC is in the forefront of this exciting new way of conducting business. It works to encourage EDI between rail carriers and other firms as well as assists the railroad community in implementing EDI with rail carriers.

EDI benefits the railroad industry as well as shippers, suppliers and other railroad related companies. It reduces paperwork, clerical effort, data entry, postage, and expensive communications equipment such as TWX and TELEX machines. More importantly, it eliminates the expensive and often time consuming errors that are associated with the manual handling and keypunching of information. The result is increased productivity, accuracy, timeliness, and cost savings that have been estimated to equal millions of dollars a year for certain companies.

IV.

QUALITY EVALUATION OF MATERIAL

In order for today's railroad's to compete successfully in the market place, they must continually improve the overall quality of their operations, which in turn will improve their service to customers. This requires an organized approach to quality improvement, and therein lies the problem. Quality is one of those elusive attributes that is easy to evaluate but difficult to define and achieve. The reason is simple. A quality evaluation consists of a range of individual perceptions formed by knowledge, experience and even culture. Quality isn't one thing . . . it's everything.

A quality evaluation sometimes involves a comparison. If two products are visually the same but are from different suppliers, they are usually perceived as being "the same" to the user. Many manufacturers differentiate their products from those of competitors by advertising and distinctive packaging. Most railroad suppliers do not use brighly colored packaging, but there are real and significant differences between similar products from different suppliers.

There are two things to remember when evaluating two products:

1) Two things that look identical often are not.

2) You usually get what you pay for . . .

In a critical application, one wrong decision can offset gains realized by many correct decisions.

Product quality is defined by a quality assurance organization as "meeting the specs". This definition of product quality is a narrow view since there are other types of quality determinations than those measured by specifications. The human eye can detect a light source 3-4 microns in diameter. A human eye can reslove an arc of 1/60 of a degree or 100 microns at 10 inches. A human finger can detect a vibration of .02 microns amplitude at some frequencies. Modern measuring instruments can amplify these detection levels hundreds of times in a production process. Product quality is more than numbers. The question remains, "How much quality is enough?" The goal for you and your business should be to obtain enough product quality and performance to keep the railroad running smoothly and at minimum life cycle cost levels.

Let us present two examples. The first example provides a means to determine how much quality to purchase. The second example proposes a method of evaluating similar products from two different vendors. (See Fig. 1.)

A curve similar to the one in Fig. 1 exists for every item. The curve is a product life cycle cost curve and it graphically depicts several important points:

1) Every product has a finite life.
2) Long before its finite life is used up and given a reasonable sample size, some quantity of the item will fail, thereby incurring a replacement cost.
3) Point of initial failure will be determined by the materials and processes used to manufacture the item and also how hard/long the item is used.
4) At some point in time, the failure rate begins to occur at an accelerated pace, which greatly increases the life cycle cost required to keep the part in service.
5) Finally, and perhaps most importantly, many parts through interaction negatively affect other parts of the system, decreasing their life.

The goal here is to repair or replace the item at the "knee" of the curve, at Point A for critical applications with possible secondary and/or severe failure modes and before B for minimum life cycle cost. (See Fig. 2.)

If you have two vendors for this part, in all probability the products from these vendors fall on two separate performance curves. A comparison for the same generic product from two different vendors, shown in Fig. 2, allows us to make some interesting comparisons regarding product performance and cost.

The question we will try to answer is: "Does the product sold

PRODUCT LIFE CYCLE COST VS. TIME

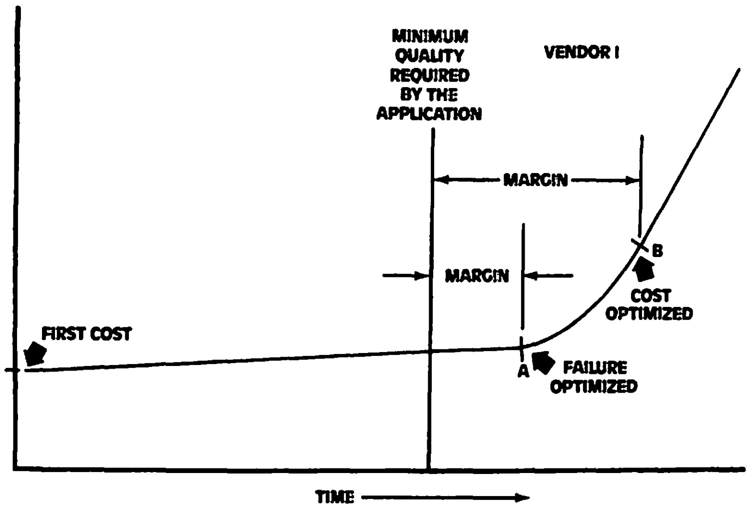

Fig. 1

PRODUCT LIFE CYCLE COST VS. TIME

TWO VENDORS COMPARED

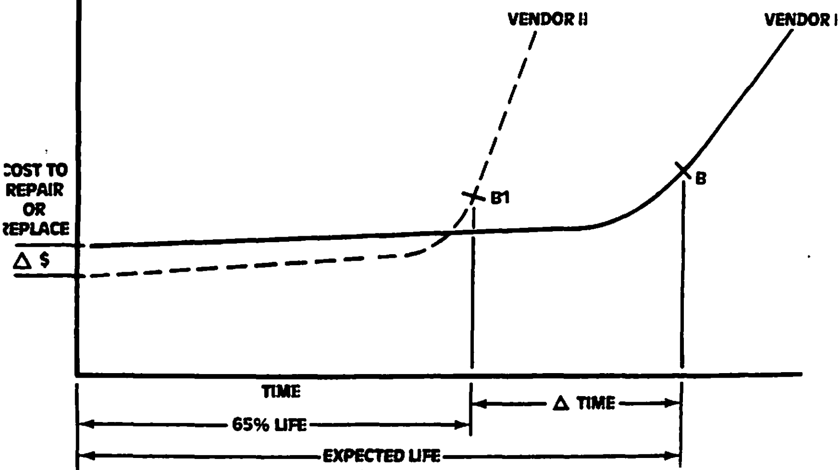

Fig. 2

at a higher price by Vendor I result in significantly longer life and therefore lower overall life cycle cost?" This is the key to a quality evaluation. We will make a few assumptions regarding first cost and product life. If you have actual data you will greatly improve the decision making process in your situation. (See Fig. 3.)

For this example which assumed a 20% fist cost advantage by Vendor II and a 54% life advantage to Vendor I, Vendor I has an overall 19% life cycle cost advantage. Note that this example does not include labor and overhead to repair, secondary failure modes, cost of out of service time, cost of money or the ultimate cost, the cost of reduction in service. Cost of reduction in service is a permanent cost which leads to loss of market share and failure of the enterprise itself.

The type of analysis presented in Fig. 4 can result in some interesting "what ifs?". For example: HOW LOW MUST THE INITIAL PURCHASE COST BE OF THE VENDOR II PART TO BE COMPETITIVE WITH VENDOR I? (See Fig. 4.)

This example demonstrates that on a life cycle cost basis, a higher first cost translates into tangible life cycle cost savings for the railroad. If the intangible and not directly assignable costs of replacement are included, the advantages to the premium product are even greater.

For Vendor II to compete with Vendor I, he has to reduce his price by another 19% (a total of 35%) or increase his product life by 35% to compete on a life cycle cost basis. It is doubtful that Vendor II has the pricing or design flexibility to recover the advantage while remaining the low cost vendor. It appears that the two items from the two different vendors really are different. Actually, so are the vendors.

The original equipment supplier and his reputation are critical to understanding and evaluating this trade-off. A major supplier has a commitment to his total product and its overall performance. He has several inherent advantages, all of which accrue to his customers in terms of improved quality of the item itself and in the system on which it is used:

- He builds the entire device on which the part is applied. He specifies the materials and methods that will match the system. He knows what will work and what won't.
- Most original equipment suppliers send the supply parts down the same production line they use for their apparatus. Materials, tolerances, inspection and quality levels are indentical.
- The purchaser obtains the advantage of all technological input to the entire product.
- The original equipment supplier maintains design control and materials and processing re-

LIFE CYCLE COST COMPARISON

THE LIFE CYCLE COST COMPARISON IS EASILY DEVELOPED USING A FEW ASSUMPTIONS:

	ASSUMPTIONS		LIFE CYCLE COST	
	FIRST COST	LIFE	12 YEARS	16 YEARS
VENDOR I	$100	4.0 YEARS	$300	$400
VENDOR II	80	2.6 YEARS	369	492
ADVANTAGE	VII 20%	VI 54%	VI 19%	VI 19%

NOTE: THIS EXAMPLE DOES <u>NOT</u> INCLUDE:
- COST OF OUT-OF-SERVICE TIME
- COST OF REDUCTION IN SERVICE
- SECONDARY AND SEVERE FAILURE MODES
- LABOR AND OVERHEAD TO REPAIR
- COST OF MONEY

Fig. 3

WHAT IF . . .?

THIS TYPE OF ANALYSIS CAN RESULT IN SOME INTERESTING "WHAT IFS?" FOR EXAMPLE: HOW LOW MUST THE FIRST COSTS BE OF THE VENDOR II PART TO BE COMPETITIVE WITH VENDOR I?

	ASSUMPTIONS		LIFE CYCLE COST	
	FIRST COST	LIFE	12 YEARS	16 YEARS
VENDOR I	$100	4.0 YEARS	$300	$400
VENDOR II	80 ↓	2.6 YEARS	369	492
ANSWER	$65	2.6 YEARS	$300	$400

WHAT LIFE MUST THE VENDOR II PART HAVE TO BE COMPETITIVE WITH VENDOR I?

	ASSUMPTIONS		LIFE CYCLE COST	
	FIRST COST	LIFE	12 YEARS	16 YEARS
VENDOR I	$100	4.0 YEARS	$300	$400
VENDOR II	80	2.6 YEARS ↓	369	492
ANSWER	$80	3.2 YEARS	$300	$400

Fig. 4

sponsibility for any parts he resources and assures quality using his in-place inspection and quality assurance systems.

- The original equipment supplier has a multifunctional, multidisciplined staff who can solve a wide variety of problems.

A non-OEM also enters the market with several advantages which he uses to assure his continued participation:

- His size can sometimes permit him to react somewhat quicker to changes in the market place.
- He is usually willing to work closely with customers to adapt his design to their particular maintenance or assembly habits.
- He is usually well versed in personal selling; he knows his customers and is committed to a high level of personal service.

While the advantages just mentioned are not directly attributable to product quality, they contribute to the reputation of a non-OEM as a quality supplier to the railroad.

When an equipment supplier has facilities, including robotics, for a high volume combination of apparatus and spare parts, he is capable of shipping consistently higher quality levels. (See Fig. 5.)

The curve in Fig. 5 shows a comparison of human operator vs. robot output for a part. A correctly programmed robotics operation makes a greater percentage of parts with ideal dimensions. This repeatability permits tighter tolerances. A robotics operation achieves this repeatability by eliminating the variables introduced by the human element. The result — quality.

Most major manufacturers enjoy the production volume which justifies the use of robotics in a variety of applications. Capabilities of major suppliers in this regard should be considered in any make vs. buy decision, especially if large capital expenditures are involved. (See Fig. 6.)

A reliable, long life product with low life cycle cost is the goal of the complex process which is designed to maintain and improve quality. Fig. 6 shows the organizations and the interaction required to ship quality consistently. The key features of this process are:

1) It is multifunctional
2) It uses a team approach - including the customer
3) It makes extensive use of feedback.

In our comments on the subject of product quality, we have seen the large role of the supplier and the railroad. In fact, a Notch 8 supplier and railroad, in partnership, are essential requirements in order to bring:

$$E \sim MC^2$$

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HUMAN VS. ROBOTIC OUTPUT

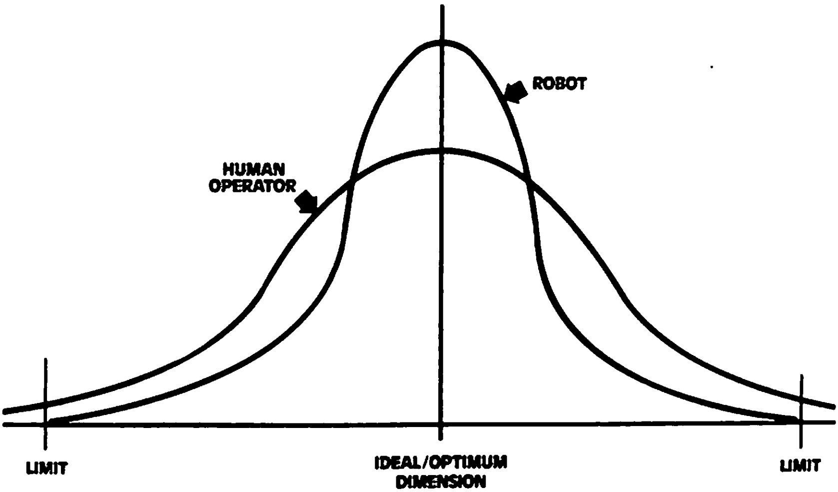

Fig. 5

MATERIAL AND QUALITY PLAN

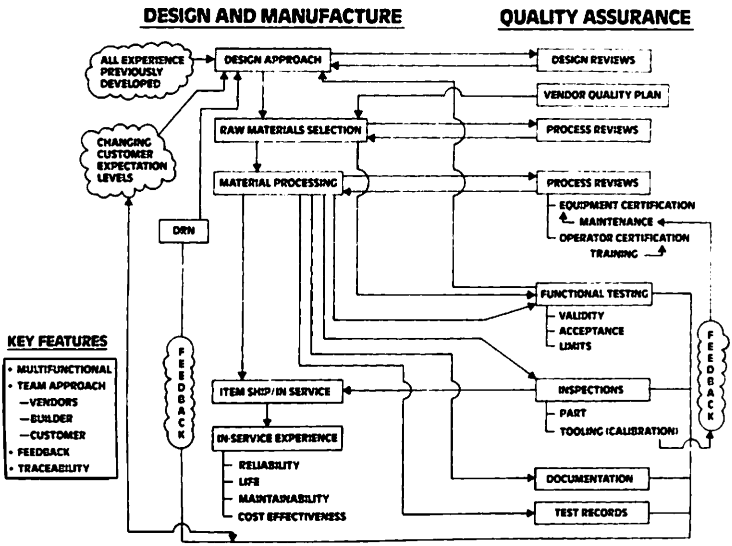

Fig. 6

V.

SOURCING DECISIONS

Past presentations have focused on such issues as the need for accurate inventories, improved methods of identifying and locating material using bar-coding technology and improved material handling equipment, applying discounted rate of return techniques to locomotive maintenance, the costs associated with the holding of inventories, and the application of advanced computer techniques to inventory management. Our intention this year is to review how these various topics can be integrated into one analysis on sourcing decision-making. In other words, once you identify a requirement, your next challenge is that of procuring the stock.

The first challenge, identifying the requirement, may seem obvious but in many cases your possible choices are determined based on this initial decision. Care must be exercised when evaluating the intended use. Do you want to maintain the original specification requirements as defined by either your Mechanical department or the original equipment manufacturer or upgrade to current technology? This is a question which must be answered in advance. The replacement of an item with a comparably engineered component will provide expected performance but it may also provide performance which is not needed. For example, servicing which is performed annually may not necessarily require material which is designed for longer life and it may be more economical to replace most components during the annual servicing period than to recall the unit for a mid-year replacement. It is also reasonable to assume that you will pay a premium for this extra serviceability.

Another alternative is to upgrade units to the current technology by using improved design components. Better reliability and serviceability are often achieved by upgrading, but additional training of your personnel may be required in the proper installation and maintenance of this new equipment. During recent years, a great deal of emphasis has been placed on fuel economy. Consideration should be given to the initial expense required to upgrade your units as opposed to anticipated fuel savings. As reviewed in last year's paper, a variety of discounted rate of return techniques can be used to help you decide.

Once the intended use is defined, a decision must next be made regarding sources of supply. These are either "in house" (from remanufactured components or from existing inventories) or from outside suppliers. The remanufacture (or requalification) of components was discussed in detail in last year's paper, "Reconditioning Material In-House vs. Vendor", and is obviously an approach that more railroads are considering. There

are two basic advantages associated with in-house component remanufacture. Firstly, the railroad can carefully monitor the manufacturing process so that material can be made available more quickly as it is needed. Because work is routed through its own shop, the railroad is aware of its status at all times permitting more direct input when establishing priorities. A second advantage of in-house remanufacture is cost. Reduced unit costs are possible through the use of less expensive labor in some cases. In-house sourcing may also result in reduced lead times which equates to less inventory and may also act as a vehicle to help assist in supplier negotiations.

Each of the in-house remanufacture advantages has a corresponding disadvantage which must be considered.

Although basic labor costs may be lower, the possibility of significantly increased capital investment for new machinery, tooling, and maintenance as well as available facilities space which might replace other productive functions is possible. Administrative expenses for supervision and supporting systems will also be increased. Once these costs are included you must also consider the employee liability assumed by the added work volume as well as the loss of the vendor's warranty and possible inefficiencies resulting from labor turnover in your shop. The possible longterm risk also is that the original equipment manufacturer's research and development may be jeopardized, thus limiting the introduction of innovations and creating a need for expanded engineering resources in your own organization.

A second in-house source of material results from the efficient utilization of existing stock. This was also discussed in our 1985 paper, "Identification and Disposition of Surplus Material." There often exists a requirement at one location with material at another. Whether to issue a new purchase order or elect to pay the freight to have it transported to where it is required is a decision that must be made after considering the value of the material and the urgency of need.

Substitute material is often a source which is overlooked when requisitioning stock. The substitute may be either one-for-one or the use of higher level assemblies. A component of lower tolerance may be interchanged with one of higher tolerance providing that all the requirements of serviceability, reliability, and safety are met. An example of such a swap could be the use of available power assemblies to replace a failed component such as a head or cylinder liner.

Once in-house sourcing has been exhausted, sourcing from outside suppliers must then be considered. Your choices are to source from the OEM or the non-OEM. Non-OEM suppliers may not always offer the

full range of both new parts and remanufacturing services which are offered by the original equipment manufacturer.

Several factors come into play when selecting suppliers:

Cost. Unit costs are fairly well defined by the outside supplier. It is the price quoted in his catalog or by his sales representative and it is the price normally charged on his invoices. Prompt payment incentives or quantity discounts may further reduce the unit costs from the list price. Unit costs for in-house manufactured components may not be as clearly defined. Labor measurement techniques, assignment of direct labor charges, raw material costs, coupled with the application of operating expenses often make in-house costing difficult. "How much does it cost?" is not always as simple a question as it sounds.

Freight. It is often overlooked. Freight paid by the railroad may obliterate unit cost savings based on the cost of the material alone. Perhaps your Purchasing department places several different orders each day with the same supplier when fewer but larger orders would be more economical by taking advantage of lower freight rates and internal consolidation of clerical effort. Less than full load shipments cost money. In some cases business has been transferred from one competitor to another based on relatively small unit cost differentials. Later reviews have proven that the increased freight charges were more than enough to negate the original cost differential.

Supplier prepay is yet another option. However, you may discover that the supplier is less anxious to make less than full load shipments or provide special air service if he is paying the bill. Chances are good that he has already given traffic expense some consideration when developing his pricing structure.

Railroad pick-up is the final alternative. The customer picking up the material is not charged by the supplier, nor is he paying the hidden cost buried in supplier prepayment. However, there is a cost. The wages paid to the employee, the cost of equipment along with its maintenance, depreciation, and fuel charges which should be prorated back over the costs of each individual item being delivered if possible.

Inventory carrying cost. By being able to maintain stock which can be readily interchanged you will not be forced to carry excessive safety stocks. Suppliers providing dependable material delivered to schedule will minimize carrying costs. These costs are seldom reflected back in the unit cost but must be taken into account.

Consigned inventory. In this case the supplier maintains an inventory conveniently located on (or near)

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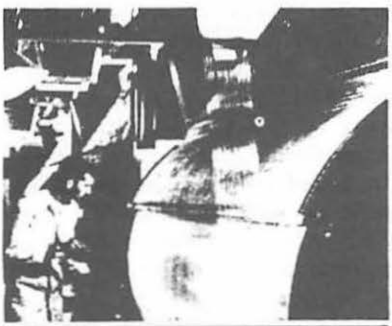

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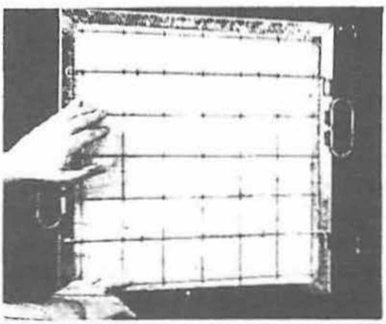

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the customer's premises. The railroad pays for the material only when it is placed into service. Inventory carrying costs are therefore minimized or are non-existent. Additional costs may be encountered due to special handling to maintain segregated stock as well as periodic inventery reconciliations.

Part number proliferation. This provides for better opportunity for substitution but often at the expense of holding more inventory. Supporting systems need to be developed to report the availability of material having multiple applications, otherwise inventories will expand. Information systems are also required to insure the efficient reallocation of inventory throughout the organization to wherever it is needed, Ideally, a good information system should provide you with available substitutes as soon as an order is placed for an item which is temporarily out of stock.

Ease of ordering. This is often referred to as the "transaction cost." You may find it advantageous to place fewer, but larger, orders with certain suppliers if you do not have to issue and review purchase orders as frequently, insert the orders in envelopes, pay postage, and process supplier invoices.

Long-term contracts are one method of reducing transaction costs. Issuing one order covering deliveries throughout the entire year helps minimize administrative costs while also providing the possibility of price concessions based on the volume being purchased and the elimination of much of the market uncertainty for the supplier. Most major suppliers now offer this type of program, particularly for routinely consumed high volume material. Both the supplier and the railroad benefit by the reduced necessity for maintaining large safety stocks to cushion the uncertainties of the marketplace.

Product Reliability. Both cost and reliability must be considered together. Poor reliability yields higher operating cost. Maximum and minimum performance criteria must be adhered to otherwise units will be returning to the shop for rework more frequently.

Good records of component failures must be retained so quality concerns can be addressed with the supplier, as well as to locate alternative sources if problems persist.

Reliability can also apply to the timely receipt of material. The supplier needs to demonstrate a consistent record of timely delivery. Longer lead times cost money and your lead times used for scheduling must be re-evaluated often. This is particularly true if lead times are based on the most recent experience with that specific supplier. A railroad issuing a planned order today for receipt of material in two months based on the most current performance will have to consider two months worth of uncertainty and plan for some

additional safety stock. It is possible that the supplier could ship sooner but prior manufacturing, labor, or traffic problems had caused a temporary delay which has since been rectified. Unless the supplier knows that he can ship sooner and demonstrate improved performance then the lead time record will never be updated.

Technical Support. This is a cost which is often hidden by the supplier in the cost of his products. Such support may be in the form of service engineers, engineering research and development, the electronic interchange of information, or the availability of maintenance instructions or technical manuals. The accurate assessment of costs for these functions is difficult to define much less to assign with any certainty to specific products.

Only consider what your costs would be if these functions were not made available from outside your company.

Returned Goods Policy. These are costs which are real but difficult to measure. The effectiveness of the supplier's warranty policy, how quickly he replaces failed components, or how he compensates his customers for damage resulting from component failures are costs which vary with each supplier. Effective warranty service results in reduced downtime and decreases the need to maintain back-up inventory.

Some suppliers will also permit the railroad to return surplus material providing that it is resaleable. In some cases the return is based solely on the discretion of the vendor and in other cases it may be calculated as a percentage of the business done with that supplier. The precise terms and conditions of such credits vary widely.

In summary, total value analysis is the most effective method to use to make your sourcing decisions. There is a distinction between cost and value. Additional material, labor, or overhead increases cost — but not *necessarily* value. If added cost does not improve the ability to perform the required functions, then value is reduced. Tangible costs are typically the unit cost, transportation expense, and the cost of carrying inventory. The intangibles such as interchangeability, transaction costs, reliability, technical support, and the supplier's return policy are benefits which are difficult to value but are still real. Sometimes you may find that the lowest cost is not the best value.

In order to reach the optimal decision, you must consider assigning values to the intangibles. Some are more easily defined than others. An accurte measurement of the total value will make your sourcing decisions much easier.

DIESEL MATERIAL CONTROL COMMITTEE

Five-Year Index

1985

Controlling the Material Investment — A Requirement For Deregulation

1. Evaluating Locomotive Maintenance Projects
2. Reconditioning Material: In-House vs. Vendor
3. Identification and Disposition of Surplus Material
4. Cost of Carrying Surplus
5. Evolution and Future Directions of Material Handling Equipment in Railroad Use

1984

Material Control In A Changing Environment

1. Bar Coding of Material
2. Forecasting Material Requirements
3. a. Fuel Security — Are You Getting What You Pay For?
   b. Fuel Oil Is Expensive
4. Pros and Cons of Material Purchasing Contracts (Single Source — Just In Time Inventory)

1983

Material Systems — Action Through New Ideas

1. Improved Locomotive Productivity Through Computerized Data
2. Inbound Material Inspection
3. Minimize Maintenance Cost Through Material Management Systems
4. New Ideas In Material Storage Containers

1982

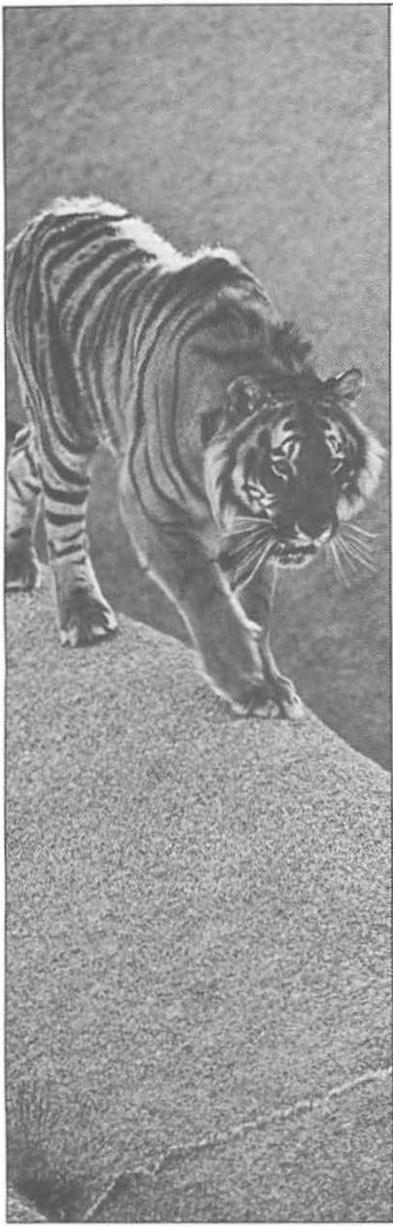
Maintaining Product Quality Through Improved Material Handling

1. Use of kits in locomotive maintenance
2. Cost effective methods of shipping material from vendors
3. Union Pacific's Component Inventory Maintenance System (CIMS)
4. Advantages of using shipping containers

1981

Diesel Material Control: Innovations In Material Handling and Control

1. Disposal of Unserviceable Component Parts: What is the Most Profitable Method?
2. Innovations in Stores Material Handling, Via Computer Technology
3. Locomotives Held for Material: An Update for the 80's
4. The Best Approach to Procuring Material; New, UTEX, Repair and Return or Shop Repair



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Wednesday, September 24, 1986

8:30 A.M.

REPORT OF THE COMMITTEE ON SHOP EQUIPMENT

Pre-Convention Presentation: Southern and Southwestern Railway Association

April 24, 1986
Holiday Inn (Gateway)
Huntington, WV

M. S. ANDERSON, Chairman
Manager-Mechanical Services
Duluth, Missabe & Iron Range Railroad
Proctor, MN 55810

VICE CHAIRMAN

W. R. Doyle, Asst. Mechanical Engineer, Union Pacific Railroad, St. Louis, MO

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1986 TOPIC:

LOW COST THROUGH QUALITY TOOLS AND FACILITIES

PERSONAL HISTORY
MERRILL S. ANDERSON

Born in Duluth, Minnesota. He attended Duluth public schools and graduated from high school in 1973, and then a degree in mechanical Engineering completed in 1977 from the University of Minnesota in Minneapolis.

For one year, he worked as a design engineer in a midwest manufacturing firm before joining the Duluth, Missabe and Iron Range Railway Company as a Locomotive Foreman in August of 1978. Later that year, he was appointed Shop Engineer, and in 1983 was promoted to Manager - Mechanical Services which is his present position.

He and his wife, Kim, have one son and are living in Duluth.

LOW COST THROUGH QUALITY TOOLS AND EQUIPMENT

Introduction

Overall shop capital expenditures by United States railroads have risen sharply over the past several years. These increases are partly due to catching up on projects deferred earlier. However, much of the increase can also be explained by an effort in the industry to more closely control quality and reduce costs through improved facilities, equipment, and tools.

Some fine examples of the latest railroad plant and machinery will be featured in this paper, which includes an update on robotics technology and new applications, a review of CNC machinery, a new GE Power Assembly area, and a fully automated brush type locomotive wash system.

I.
ROBOTICS UPDATE 1986 — NOW WHAT?

During the past few years since our original report on the applications of robotics, significant gains in robotic technology have occured that will directly influence the future of robotic applications in the railroad industry. While technologies have advanced, the rate of progress has not been significant. Earlier sales projections by experts in the robotics field were indicative of rapid growth. Several robotic companies have already entered and left the market. While the market has greatly expanded, actual sales have fallen far short of earlier anticipated estimates. Basically, these shortages have directly resulted in a reduction of the monies available for research in robotics and their related systems. But even though research and development has been curtailed, a number of advances in technology have transpired which should be mentioned.

Vision systems which provide the robot with the capability of sight have made the greatest advancements. Several new competent manufacturers of vision related equipment have entered the market in recent years. These systems offer the greatest promise for future developments and enhance-

ments to robot intelligence. Vision systems will furnish the greatest potential for the robot to adapt to changes in its working environment through the visual input of the camera. Systems have evolved to the point where they have excellent interface capabilities with the robotic equipment, are very reliable and have dropped in purchase cost enough to justify their installation. Some of the current applications for vision systems are:

1. Weld Seam tracking — The camera follows the seam to be welded and makes any necessary directional changes required if the actual weld path differs from the original program.
2. Inspection — The camera can be programmed to recognize the correct configuration of manufactured parts. Any deviations are quickly noted and the incorrect part rejected.
3. Part Orientation — In cases where a part to be handled or welded is not presented to the robot in the same position in every instance, the camera will locate the part and change the program in the robot control to accommodate the new part position. This change to a new environment is known as adaptive control. It is an important part of applications which have known process variables.

Advancements have also been made in other sensor fields such as lasers and complicated mechanical devices which give the robot greater intelligence and the capability of performing a wider range of manufacturing tasks. Welding systems have progressed considerably with a variety of manufacturers offering component systems. Two-dimensional seam tracking adjusts for not only seam variances but also adjusts the welding head height as well. Seam gap sensing capable of internally changing welding amperages and wire feed rates to compensate for unforseen variances in the weld seam gap are now under development.

Robotic systems are *currently* being successfully implemented in numerous industries to perform a variety of diversified tasks that include the following:

1. Spot, MIG, TIG and submerged arc welding processes for new manufacturing, rebuild and hardfacing applications.

2. Material handling of large and small components that vary in weight from 2000 lbs. to less than an ounce. The assembly of electronic components using robotic systems has become prominent. Accuracies of robotic equipment have increased with tolerances of .0001" available in some machines.

3. Cutting of shapes in various materials using laser, plasma arc, oxy-acytelene or water jet systems.

4. Painting of materials or equipment as large as a commercial airliner.
5. Loading and unloading of production machinery.
6. Assembly of components such as circuit boards.

In general, the overall intelligence of the robotic system has improved considerably, allowing a wider range of applications in the railroad industry. The next portion of this paper will pertain to existing applications now being accomplished by robotics and possible future considerations based on the current trends in the robotics field.

The first and certainly utmost consideration in any robotic application is that of safety. A Robot is an automated piece of equipment which is not directly influenced by human control and thereby incapable of being stopped by an operator should a threatening situation arise. Intentional hesitations or waiting periods are frequently programmed into the robot's normal working routine. This mode can project a false image that the machine is not actually operating, perhaps leading an individual to believe that it is safe to enter the working envelope of the equipment.

In order to insure that the possibility of personal injury is eliminated, it is mandatory to install several items which will shut down the robotic equipment should personnel enter its working envelope. The first is a fence or railing. This will prevent people from inadvertently wandering into the area by placing known boundaries on the working perimeter limitations. This perimeter protection can be equipped with interlocks that will automatically shut down the robot should a gate be opened or chain removed. Secondary devices can include pressure sensitive floor plates, photocell sensors such as light curtains, infra-red and ultrasonic detectors and pressure sensors built into the robot's arm. Arm sensors are not the most desirable since contact with the robot must actually be made. Some robotic arms weigh upwards of 2000 to 3000 lbs. and can move at velocities of up to 40 inches per second. It is frequently necessary for a programmer to work within the perimeter of the robot working envelope for exacting placement of welding heads or positioning of materials. In these cases, the programmer has an emergency stop button built into the programming pendant which he may actuate at any time. Caution must still be exercised by the programmer while working within the robotic working envelope.

Are robots applicable to your needs? Good question. The first basic of robotic applications is that you do not buy a robot and then look for a place to put it. The robot must be purchased to fit exacting specifications for each individual project application. Each proposal must be evaluated for application feasibility and cost justifications. Non-repetitive environments such as component rebuilding will require greater analysis because of the numerous variables involved with wear conditions. Past experience in this area has indicated that rebuilding operations are at best difficult to deal with utilizing currently available technologies and will require the use of extravagant sensor or vision systems. If you are planning your first time project, it would be advisable to stay away from the comparatively complicated rebuilding types of applications. Following are the basic justifications for installation of robotic systems:

1. Saftey — While robotics may contribute to the overall safety problem if unprotected, they also are capable of removing your personnel from potentially hazardous processes such as painting, handling of toxic materials or welding.

2. Force Reductions — Robots will replace personnel with reductions in labor cost and shop expenses. It should be noted that manpower requirements will remain for programming and maintenance of the robotic equipment. Robotic justification obtained by force reduction carries the prerequisite of making sure that the operator's time is actually eliminated as a direct result of the robot installation. In more than one instance, it has been noted that an operator will watch the robot perform its programmed procedure. This not only voids the obtainable savings, but actually increases the cost of production considerably over the original non-automated operation. During the robotic welding procedure, the operator must be performing other productive functions such as component set-up or completed part finish work.

3. Quality Improvements — Robot repetitive accuracy is always consistent, providing excellent work quality with fewer rejected parts. Once programmed for optimum performance and accuracy, the robot will repeat this optimum performance on every consecutive part.

4. Reduction in Equipment Expenditures — Since a robot will directly replace a human in conjunction with its installation, it will eliminate expenditures for normal consumable items such as personal safety equipment, welding hoods and related supplies. When applied in hostile environments such as painting or handling of hazardous waste, it will eliminate considerable expenditures involved with purchase of environmental control systems.

When considering any robotic installation, the one basic question that you must ask is "Can the robot adequately perform all of the tasks currently being accomplished by the person it is to replace." If any aspect of the existing operation is questionable, it will be necessary to re-evaluate the entire application for feasibility. It should be noted that a robot is simply another tool to use in our manufacturing processes.

Current Applications

One locomotive component which is currently being rebuilt is the traction motor. One railroad has purchased and programmed a single arm welding robot to perform the build-up welding operation on several areas of a worn out motor frame. The robot is of a basic configuration with standard hardware and software programs with the exception of seam tracking options. The robot is programmed to weld each of the worn areas of the traction motor as a specifically different entity. This allows the capability of welding only those areas of the frame that actually require build-up. The traction motor is bolted to a shop-made holding fixture mounted to the robot positioner. After the correct sequence of programs to meet weld requirements is selected, the robot program is started and the positioner places the traction motor in the correct attitude for the first welding procedure. During this time, the operator will complete the touch-up welding of the previously completed traction motor and prepare the next motor to be welded, eliminating any idle time on his part. The robot will continue the welding build-up process, completing the following areas on the motor:

1. Axle bearing bores.
2. Axle cap mating surfaces.
3. Axle bearing thrust faces.
4. Commutator and pinion end armature bore.
5. Commutator and pinion end inner and outer bore faces.
6. Main and inter-pole pads.
7. Brush box holding pads.

After the traction motor frames have been completed, a special fixture is mounted to the robot positioner to accomplish the welding of the axle caps to include the axle bearing bores, frame mating surfaces and axle bearing thrust faces.

Another robot has been installed to complete the welding of locomotive sub-assemblies such as draft gear pockets, front and rear draft stops, center plates, journal boxes and other miscellaneous locomotive assemblies. This machine is also equipped with seam sensing and is capable of following welded seams which deviate from the normal programmed welding path. This option is required in cases where it is not possible to control fit-up and manufacturing tolerances to less than 1/16". This robot is equipped with a double ended positioning table that will allow the operator to prepare parts to be welded on one end of the table while the robot accomplishes the required welding to the second part. Upon completion, the operator simply rotates the

positioner to orient the new part to the robot for welding. As with all robotic equipment, this machine has the capability of storing a large quantity of different sub-assembly welding programs for easy retrieval, permitting simple change-over to allow the achievement of a wide variety of different parts configurations.

One railroad has been using a robotic welding system equipped with vision for some time now to weld wear plates onto freight car side frames. In this case, the vision system is used as a corrective device to properly re-align the entire pre-established wear plate welding program to accommodate any differences in the initial positioning of the plate. The vision system performs this re-alignment by focusing on a pre-cut weld slot within the plate. The program is then shifted automatically to match the new plate position.

Future Applications

As robotic technology advances, the possible applications increase accordingly. The robot must be able to reason or think at least to some extent. It is not capable of accepting or coping with any changes in its preprogrammed environment without having built in adaptability. This adaptability or artifical intelligence is derived by informational sensing sources such as vision systems or other external sensors. As the complexity of these input systems advances and they become economically feasible, increased robot intelligence makes more applications a reality. Some of the areas which could be investigated are the following:

1. Painting and stenciling of locomotives. While the technology for this application is present, there are robots currently in the late stages of development which have working envolpes capable of reaching all parts of the locomotive without the use of elevators or lifts. The robot is mounted on a guided vehicle for increased mobility.
2. Rebuilding of sub-assemblies such as heads, injectors, and air brake equipment.
3. Installed in conjunction with manufacturing cells for fabrication of locomotive parts such as gaskets, bushings and other machined or fabricated components.
4. Loading and unloading of production machinery.
5. Welding of new or rebuild components.

On a final note, we would like to briefly discuss the reason for purchase of new robotic or manufacturing equipment. That reason is specifically to rebuild or manufacture components within our railroad systems. All of us do this because we believe it saves money over purchase from outside sources. Of course, this isn't always true. There has been a trend by several

railroads to use outside contractors because they offer the same work at lower pricing. In many instances, vendors do our work at low cost and with high quality. However, the following facts are pertinent when making a decision about work being done internally or externally.

1. While wages outside the railroad industry are generally lower, the vendor supplying the components must make a profit. This profit will usually counteract the higher wages being paid by the railroad industry, provided our productivity and quality are equivelent.

2. There is no better place to control the quality of a product than in your own environment.

3. Each project should be analyzed for its own merits before making a decision on contracting. It may be found that through a minimal investment in new equipment, or a change in production procedures, you are able to directly compete with outside vendors.

4. One of the reasons outside vendors can often be competitive is that they can readily dictate production quotas to their employees, and also readily remove them from service if quotas are not met. To maintain the rebuilding of components in house, we will have to maintain production standards equivalent to or surpassing those of the outside concern. As managers, we must insure that our labor forces are utilized to their full potential. If for no other reason, we require the capability of component rebuilding as a stabilizing factor that will keep prices competitive. In more than one instance, as soon as vendors were informed that the railroads would start to build components in house, their prices dropped dramatically in order to retain business.

5. The bottom line is: We are here to save our railroads money by whatever ways possible. If contracting of work to outside vendors is determined to be the most economical method, fine. But don't arbitrarily give up an existing repair operation or pass up evaluating new applications without conducting studies to determine their feasibility and possible cost savings potential.

II.

CNC Machine Tools

Numerical control (NC) was first successfully tried at MIT in 1952, and has progressed to computerized numerical control (CNC) today. While NC and CNC have been used in the manufacturing process for more than thirty years, their use in the railroad industry has just begun. There are two reasons for this:

1. Until the advent of the interactive CNC controller, it was not economically possible to manufacture small lot quantities.
2. Until the advent of the touch probe, it was not economically possible to remanufacture components in small lot quantities.

Computerized numerical control as it pertains to machine tools transfers the work piece and tool positioning requirements from the operator to the control of a computer. Positioning can be simultaneously accomplished in three dimensions with an accuracy of ± 0.0004 inch over the full movement length. The CNC can repeat that positioning to within ± 0.0002 inch.

Machine Types

For railroad applications there are four basic types of machine tools; CNC turning centers, CNC vertical machining centers, CNC horizontal machining centers, and CNC "pantograph" acetylene or plasma shape cutting marchines. CNC turning centers are slant bed lathes with automatic tool changing turrets (either one or two per machine). The bed is slanted to allow the hot chips to fall away from the bed and not induce heat into the bed which could distort the machine's accuracy. (See Fig. 1.) Most CNC turning centers are two-axis machines with the "Z" axis being the spindle (chuck) axis, and the "X" axis being the tool cross feed. Controllers with graphics display generally only show the upper half of the part geometry since the lower half is a mirror image of what is shown.

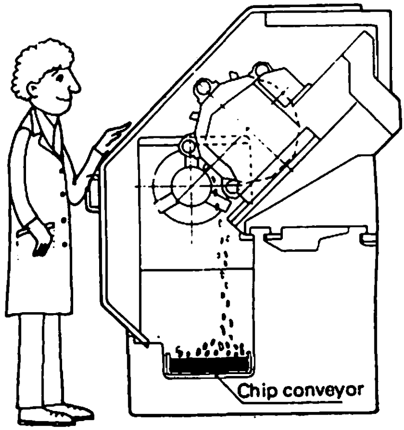

Fig. 1
Slant Bed Turning Center

Some CNC turning centers have two independently controlled tool turrets and are known as four-axis machines. This allows for faster part generation since two tools can cut at the same time. Other CNC turning centers have light milling capability built into the tool turret. This allows for more work to be done in one chucking of the part. More recent machines (those introduced in the last year) have tool changing capability using a tool magazine versus a tool turret. This greatly increases the number of tools that can be programmed into the controller. Both live milling tools and regular turning tools are stored in the tool magazine.

CNC vertical machining centers are knee brace machines or Arc "C" frame type. Most CNC vertical machining centers are three-axis machines with the "Z" axis being the spindle or vertical axis. The "X" axis is the long axis from right to left under the spindle. The "Y" axis is the short axis from front to back under the spindle. Controllers with graphics display show the three dimension image of the part, and this is where color differentiation is really helpful.

Generally, CNC vertical machining centers have a tool magazine that holds anywhere from 20 to 100 tools per magazine. The larger magazines are used in automatic processes and store several tools of the same type in the magazine. The machine is equipped with a tool monitor and when a tool wears out or breaks, the program automatically calls up the backup tool from the magazine.

CNC horizontal machining centers are more rigid and more flexible than CNC vertical machining centers. They also cost more. Like vertical machines they have three axis. The "Z" axis is the spindle and moves in towards and away from the part mounted on the work table. The "X" axis is from right to left in front of the spindle. The "Y" axis is the vertical movement of the spindle.

A CNC horizontal machining center equipped with a rotating table is a very versatile machine. It allows five sides of the part cube to be exposed to the cutting tool. A machine supplied with a pallet (work table) shuttle allows one part to be machined while another part is being loaded on the second pallet. CNC horizontal machining centers also have tool magazines which hold from 20 to 100 tools.

In addition to machine tools, CNC controls are also available on sheetmetal punches, plasma cutting machines, planers, EDM cutting machines, and grinders. Any machine whose operations are a function of distance can be controlled by a computer. The applications are endless and innovative processes are being adapted every day.

Controllers

The heart of a CNC machine is the controller and its microprocessor (computer). (See Fig. 2.) It is the microprocessor that monitors and controls the movement of the tool and work piece as directed by the program. Like any computer, the controller is only as smart or efficient as the individual who is doing the programming.

In the past, part programs were prepared by transferring the geometric requirements from the shop fabrication drawings to a manuscript. A manuscript was a form used to list all control instructions such as.

- sequence of operation
- distance travel in "X" direction

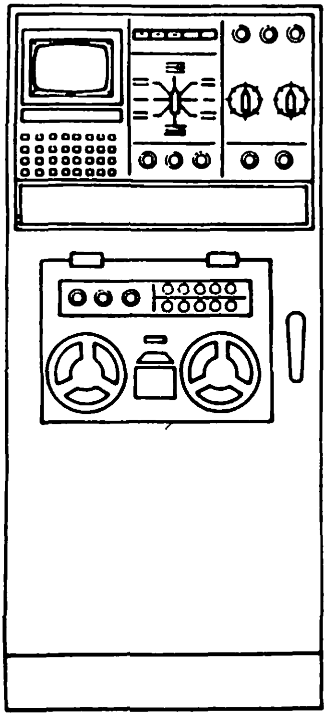

Fig. 2
Typical CNC Control Unit

- —distance travel in "Y" direction
- —distance travel in "Z" direction
- —Spindle speed and direction
- —coolant on or off
- —end of block.

This information was converted to a paper tape which was fed through the controller's tape reader. The controller read the tape and executed the instructions as programmed.

Today, controllers are equipped with CRT tubes and programming is done through a conversational process by the programmer answering questions about the process to be performed. It is no longer necessary to prepare a manuscript. The programmer can program the part directly from the part print into the controller. Some controllers allow programming to be accomplished in the background while a part is being manufactured by the machine. This is an important consideration if the machine operator is to do part programming.

Another important feature of the recent controllers is that they show the part geometry as it is being programmed. Controllers now have dry run capability which means the tool path is traced on the CRT to be sure the tool does not crash into the part. Also, controllers are available with color monitors and this helps to clarify the part geometry versus the various tool paths being traced.

Some machine tool manufacturers build their own controllers, and others apply generic controllers on their machines. The selection of the controller is the most critical question to be answered when buying a CNC machine tool. Fanuc (General Numeric in the USA), General Electric, Allen Bradley, and Bendix are some manufacturers of generic controllers.

Stand Alone Programming Systems

Another key question that must be answered is, "Do I want the operator to program the machine?" Programming can be done by a technician away from the machine, or by the operator.

There are now hunderds of stand alone, inexpensive, parts programming systems available on the market. (See Fig. 3.) In most cases they use a personal computer with a plotter and tape preparation punch. In many cases the companies offering these services have only been in business for five years or less. The key issues regarding the procurement of a stand alone programming system are:

1. Does the supplier use hardware of a well established computer manufacturer? The same question should be asked regarding the plotter.
2. How are software updates obtained and what is the cost?
3. What is the cost of the post processor and is it a universal type? The basic software will produce the part geometry and tool path requirements in general terms. The post processor converts that information into the specific requirements of the machine tool and its controller.
4. What training is included in the purchase price?
5. How will the supplier handle any problems that develop?

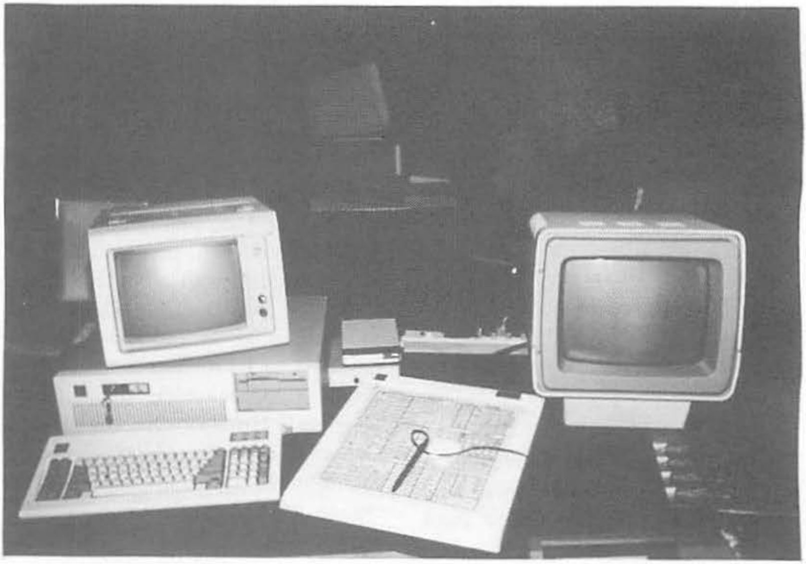

Fig. 3
Stand Alone Programming System

Touch Probe

The touch probe is the key element in any remanufacturing operation. In most cases, remanufacturing in the railroad industry means machining to standard over sizes or standard under sizes. But the controller does not know what it should do until it finds the part in space. The controller then adjusts the program to machine the part based on what it found in the probing operation. It is the touch probe that finds where specific surfaces are in the "X", "Y", and "Z" directions.

Railroad Application

CNC machine tools are currently being used in railroad shops for the following applications:

1. Grinding serrations of main bearing caps.
2. Machine traction motor frames.
3. Cutting end plates and pilots on a pantograph.
4. Boring wheels.
5. Machining axles and shafts.
6. Endless variety of machining tasks.

The productivity gains achieved by using CNC equipment are significant. Considerable study is required to get the right machine tool that can handle many applications. Flexibility is the key factor because the application for which the CNC machine tool was originally purchased will change over time and the machine must be usable for other work. If more than one machine is contemplated, then standardizing on one machine tool manufacturer and controller is very important. Part programming and training are greatly reduced by standardizing on one manufacturer, particularly one controller manufacturer.

III.

A New G. E. Power Assembly Area

Introduction

When two major railroads merged, the Mechanical department found itself with two EMD power assembly facilities. Expansion of the more modern of these facilities permitted all EMD power assembly work to be transferred to that facility by the fourth quarter of 1983. At the same time, the older facility, which had produced EMD, Alco and GE power assemblies, switched to the exclusive production of General Electric power assemblies for the combined locomotive fleet. Recognizing the need to improve this facility, shop supervision made a series of visits to other GE power assembly facilities. From these visits, a plan for a new GE power assembly area was developed by early 1985. Presentation to management included detailed estimates, projected savings and a scale model. Relocation of existing equipment and some capital improvements began in July of 1984. By the end of 1985, capital improvements approaching $1 million were complete.

Objectives

A series of roundtable discussions with shop supervision and members of the Mechanical department staff, led to a number of design criteria for the new GE power assembly area. These included the following:

1. Locate the new facility in the 11,000 square foot area already used to rebuild power assemblies.

2. Design a facility capable of rebuilding 32 GE power assemblies per day.

3. Retain the "freezer method" of assembly where the cylinder head is chilled to —125 deg. F rather than heating the cylinder jacket.

4. Improve methods of cylinder tear down.

5. Reduce labor for parts cleaning.

6. Reduce repetitive manual handling of power assembly parts, such as the cylinder jacket.

7. Improve the high pressure fuel test device and the water test device.

8. Eliminate delays while shopcraft personnel wait on overhead cranes.

9. Use programmable controllers rather than relay logic for equipment control.

10. Keep the existing parts washer accessible for cleaning parts from other areas of the locomotive shop.

Planning The Facility

1. The first area addressed in planning the facility was cylinder tear down. Of special concern was improving the method of pressing the head and liner out of the jacket. In the old facility a portable press was suspended from a crane while the head and liner were pushed out the bottom of the jacket.

A survey of other shops led to the design of a tear down press mounted in the floor. Power assemblies, less rod, pass through the press on a cart rolling on four casters. The head and liner are pressed out and hoisted away.

Expanding on the cart concept, a loop track flush with the floor was designed. Moving about the loop, sixteen carts could be at any of four work stations for cylinder teardown. The cart was designed to permit access to the manifold sides of the power assembly and to rotate the power assembly 360 degrees.

2. Two areas were targeted to reduce labor in parts cleaning. One was the hand scraping of the inlet ports on the cylinder head and jacket to remove carbon build up. The second was use of a manual air blast cabinet to clean jackets, heads, crowns and other parts after washing.

Experience with the existing parts washer and investigation into alternative machines showed many cycles through the wash and/or hand scraping would be required to clean carbon off the inlet ports of the cylinder jacket and head.

At the same time, contact was made with blast booth manufacturers about using a spinner hanger blast booth with centrifugal wheels to clean parts instead of the manual air blast cabinet. A sales representative from one of these companies suggested preliminary cleaning of the cylinder jacket and head with a burn-off oven rather than a washer. The oven would remove moisture from the carbon to prepare the castings for effective blast cleaning. Trial tests in the oven of a neighboring service shop showed the burn-off process to be an effective preparation for blast cleaning even in the dirty inlet port area.

3. After production of GE power assemblies for the combined railroads began, it became apparent a great deal of labor was used moving parts, particularly the cylinder jackets, heads and liners. Hoisted off pallets, parts proceeded through the stages of cleaning, inspection, repair and machining only to be placed back on pallets and moved by fork lift to the next step. This problem was addressed in three ways.

a. It was decided to rebuild the power assemblies on the same cart used for cylinder teardown. Just like the tear down area, an in-floor loop track formed the rebuild area. Unlike the roller conveyor once considered for handling the power assembly during rebuild, the loop track permits fork lift access and does not present a tripping hazard.

b. A chain driven roller conveyor system was designed to convey parts passing through the existing parts washer directly to their respective work areas. An alternate destination for outcoming parts is a return loop in the conveyor system for bringing parts back alongside the washer. Parts from other areas of the locomotive shop can be unloaded here.

c. At the suggestion of a Mechanical department engineer, a power and free conveyor was chosen to carry the cylinder jacket and head through the power assembly area. A completely separate system from the chain driven roller conveyor, the power and free system is located overhead.

The power and free conveyor uses two tracks, a power track and a free track. A motor driven chain suspended from an I-beam forms the power track. Below the power track two pieces of channel form the free track. Trolleys travel between the channels with their carrier suspended below. Through a system of cylinders and solenoids, loads suspended from free trolleys can be accumulated at stops in the track. Programmed routing of parts is also possible. Two drop sections in the system lower the cylinder jackets or heads to near

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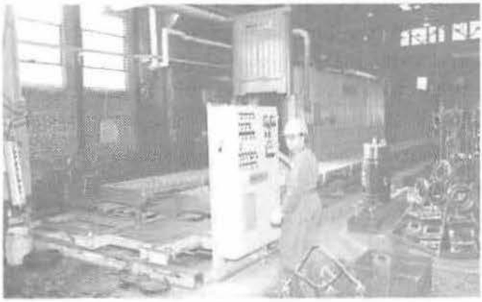
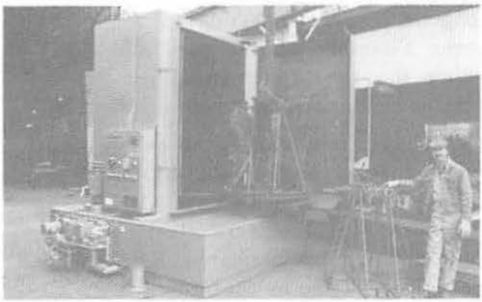


(10) TM Varnish Curing Oven With Automatic Material Handling.



(11) Batch Type Gear Case Spray Washer.
May also be used to wash other components.

(12) Conveyor Gear Case Spray Washer.
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floor level as required in the rebuild process.

The overhead installation relieves storage problems on the shop floor. More importantly, the power and free conveyor passes through the shot blast booth to automate the blast cleaning process. After blasting, these parts are raised above the shop floor for delivery to the assembly loop track.

4. With the power assembly being rebuilt on the cart, it was desirable to build new test devices for the water test and high pressure fuel test of the combustion chamber. These test devices were designed to permit testing of the power assembly on the cart and reduce the time for manual connections of fuel and compressed air.

5. Delays from waiting on overhead cranes were eliminated by installing Mannesman DeMag KBK equipment over the work stations Manufactured in Germany, KBK enclosed track can be configured in monorail or bridge crane arrangements. Ease of movement and an unusual two speed hoist combine to make this an efficient system for moving loads up to 550 lbs. Bridge cranes traveling overhead supplement the DeMag system for lifting heavier loads.

Operation

1. Tear down.

Complete assemblies are lifted off the racks and separated from their piston-rod combination. The piston-rod assemblies are placed on a twenty foot gravity conveyor, split down the middle to accommodate the rods. At the end of the conveyor a powered turnover fixture is used to disassemble the piston crown, piston skirt and rod from one another. Parts are separated for washing.

The so called "short" assembly is placed on one of sixteen specially designed carts. The carts roll on V-grooved casters around a sixty foot loop track. With the assembly upright, the fuel system, rocker arm shafts, rocker arms and related parts are removed. All parts are separated into baskets for washing. Air tools hang from overhead on a tool drop system. Next, the power assembly is rolled under a "C" frame press. A pneumatic cylinder is used to depress the springs for removal of the valves, keepers and rotators.

With valves removed, the short assembly is turned upside down on the cart for removal of the clamping ring.

Reduced to three components, the power assembly is rolled under the tear-down press. A hydraulic cylinder below the floor is equipped with four fingers to reach around the cylinder head valve guides. With the jacket remaining on the cart, the head and liner are pressed out of the jacket. The liner is hoisted away for washing. The head is delivered to the valve guide press where the guides are pressed out and scrapped.

All that remains on the cart is the cylinder jacket. The jacket is carried by overhead bridge crane to the burnoff oven.

2. Parts cleaning.

Small parts are grouped together in baskets and fed through a Stoelting belt washer. Baskets are coneveyed to and from the washer on a chain driven roller conveyor. Cylinder rods and piston crowns pass through the washer on trays. Cylinder liners are conveyed without trays.

Upon exiting the washer, parts are identified by height and routed by a programmable controller. Should the liner, piston rod or crown conveyor be full, the programmable controller will direct the parts to the return loop of the conveyor.

Cylinder jackets and heads are loaded into the burnoff oven. A six hour, 700 deg. F cycle in the oven reduces oil and carbon buildup to an ash-like substance.

From the oven, cylinder jackets and heads are loaded onto the power and free conveyor by a lift table. The power and free conveyor delivers parts to the blast booth for cleaning. Jackets and heads suspended on work hangers queue up at the entrance of the blast booth. Programmable controllers for the conveyor system and blast booth interface to control movement of parts into the blast booth. Inside the booth uniform cleaning is achieved by rotating the parts on a sprocket-equipped work-hanger while simultaneously moving the part lengthwise through the booth at a speed matching the blast time.

Valves are blasted with glass bead in a special valve blast machine. Loading of the valves in and out of the blast cabinet is done automatically.

Other small parts are cleaned with air blast on a twin table blast cabinet. Such parts include the piston crown.

Piston pins are polished in a cylindrical grinder. A spongy-like abrasive wheel cleans the pins. Pins are spot checked for the proper RMS finish.

3. Parts inspection.

Parts such as the piston crown, cylinder rods and piston pins are conveyed to the Magnaflux inspection booth. After particle inspection, parts are conveyed through a washer and accumulated at the piston rod work station.

4. Modifications.

Most modifications to the GE power assembly pertain to the cylinder jacket. As many as seven modifications to the jacket are performed at the radial arm drill press. The drop section from the overhead conveyor lowers jackets to the drill press for inspection and repairs. Tapped holes are cleaned and lubricated before the jacket is hoisted away by the drop section.

5. Liner work.

Cylinder liners are delivered to the hone on an accumulating conveyor. Hoisted off the conveyor on a KBK monorail section, the liners are positioned on the hone. After honing, liners are moved to a liner washer. After the liner is cleaned, it is delivered to the liner lathe for machining of the second o-ring groove and the liner tang. Digital readout on the lathes improves accuracy and efficiency in this machining operation.

6. Piston-rod assembly.

Rods are inspected for twist or bend. Piston skirts are inspected. A keyway type slotter is used to remove defective bushings. An oven heats the skirt for bushing installation. Then the bushing is bored to specifications.

Pistons are reassembled and torqued to the cylinder rod on a specially designed piston pin torquing machine. Upon completion, piston, rod assemblies are stored by type on this gravity conveyor.

7. Cylinder assembly.

Rebuilding the power assembly begins when the cylinder jacket is lowered onto a cart at the assembly loop track. Frozen heads are lowered into the jacket bore. Liners are pressed in with a hydraulic press and held under 35 tons of force while the clamping ring bolts are torqued to 100 ft lbs. Assemblies then proceed through the water test and high pressure fuel test. The operator's identification number and test results are documented on hard copy. After testing, rocker arms and the fuel system are applied. When the short assembly is completed, it is lifted over the piston rod conveyor. After being lowered onto the piston, the complete power assembly is hoisted to the shipping rack for transportation to the engine, locomotive or running repair shop.

Conclusion

While substantial work in the industry has been done at various shops to improve the rebuild process for EMD power assemblies, less progress has been made in developing rebuild techniques for the GE power assembly. Construction of this GE power assembly facility is a significant advancement in the maintenance of the General Electric 7FDL engine in railroad service.

Future improvements may include the following:

1. Installation of a personal computer for storing data downloaded from the test devices.
2. The addition of a spur track on the power and free conveyor to accommodate more jacket and head storage.
3. Installation of a vertical carousel for cylinder rod storage.
4. Design of an automatic cylinder rod checking fixture.
5. Modifications to the equipment to accommodate the new welded head to liner assemblies.


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IV.

Locomotive Wash System 1986

Are the railroads ready to wash their locomotive units with brush type washers?

One railroad decided it was time to find a better and more economical system to clean its locomotives than the high pressure system presently used. Working with a wash system manufacturer, a prototype washer was set up to test each type of brush to be used — to help refine the various design ideas and to help properly size all of the various components such as electric motors and gearing.

The complete train wash design shown in Figure 4 is the result of the manufacturer's years of experience and results from the various tests performed.

The locomotive wash consists of a chemical arch, system on/off wands, truck brushes, top brush, window brushes, nose brushes, side brushes, inside handrail brushes, flood rinse arch and a 250 psi high pressure fresh water rinse arch.

The chemical arch was designed slanted because in tests it was proven that adding chemical from the bottom up breaks the film better. The bottom dirt breaks first, allowing the upper portions to slide down. The arch is also split, allowing a heavier concentration of chemical to the truck and

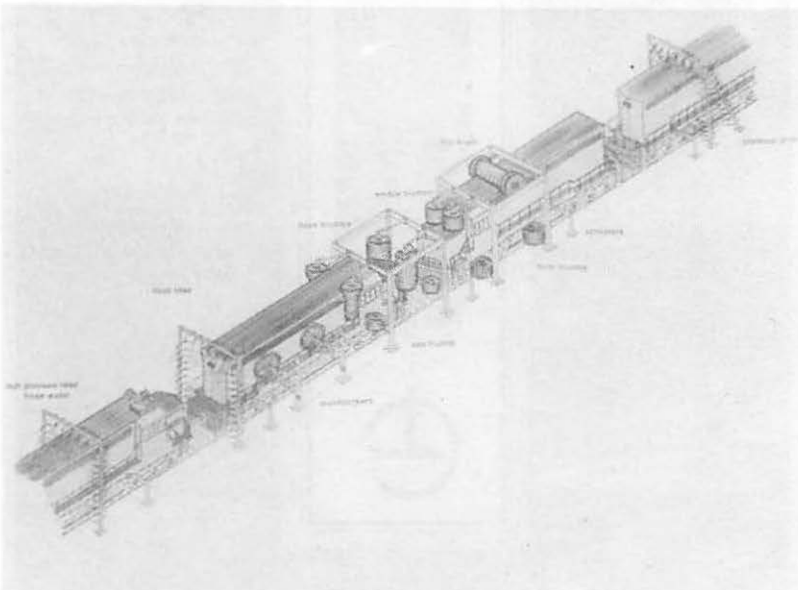

Fig. 4 — Locomotive Wash System

walkway areas and a lesser concentration on the cleaner areas, thus providing more effective chemical usage.

Feedback was provided by many locomotive and chemical people regarding which chemicals were best to use. The manufacturer in turn did a lot of testing and came up with some recommendations on chemicals. In all tests, however, it was proven that only one alkaline chemical would normally be needed to do the job properly.

The actual brush portions of the wash are as follows: The first brush is the top brush (Figure 5). Its sole purpose is to wash the top of the locomotive. The sides of the brush have longer bristles to compensate for the rounded contour of the locomotive top. This top brush is able to move up and down a total of three feet and its center core at its lowest position will not interfere with any of the EMD or GE locomotives. It is approximately 17 ft. 2 in. from the rail to the center core of the brush.

As the locomotive engages the top brush, the brush moves up. The penetration of the top brush bristles is controlled by the counter weights on the brush arm. The ideal compression of the brush bristles in washing is approximately four inches. This compression is accomplished by a simple counter weight adjustment.

The window brush (Figure 5) cleans the nose of the locomotive hood and then the windows.

This brush's sole purpose is to clear the nose and wash the front windows of the locomotive, whether or not the unit enters frontwards or backwards. As the locomotive continues to pass through, the rotational direction of the brush moves it out towards the side of the locomotive. This whole brush operation is based upon gravity, the rotation of the brush and the movement of the locomotive.

A flexible coupling that mounts the brush to the motor allows it to pivot in any direction. This coupling allows the brush to bend so that it can fit the contour of the locomotive. This brush design was built by the manufacturer for drive-thru vehicle washes. Flexibility of the coupling allows the brush to fall in behind the cab as the locomotive proceeds. The brush also washes part of the side of the locomotive including the uneven contour of the side.

The sole purpose of the truck brushes (Figure 6) is to wash the fuel tank and truck areas visible from the side. They are yoke mounted and fall into place by gravity and the rotation of the brush. Their center core at no time will interfere with the locomotive. They pivot horizontally from right to left when required to get out of the way. Bristles are 70 inches in diameter. The truck brush cleans the fuel tank and reservoir area.

The truck brush has the roughest job to do and a five horsepower

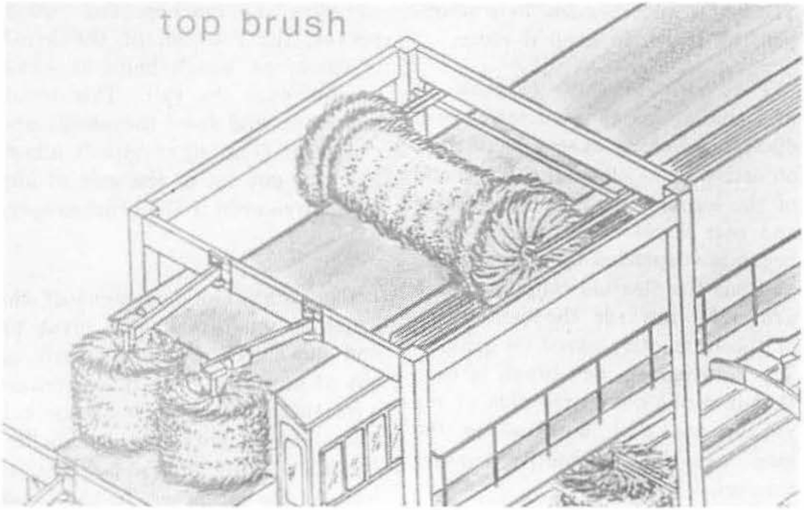

Fig. 5 — Top and Window Brushes

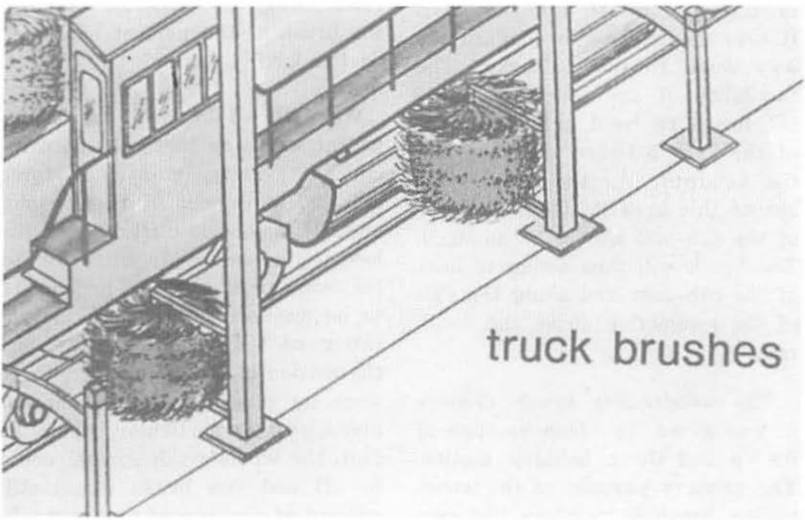

Fig. 6 — Truck Brushes

drive is necessary to do the job. The water and chemical help shampoo the brush to keep it clean.

The nose brushes (Figure 7) are similar to the window brush discussed before except that their objective is to clean the front end of the locomotive, then along sides and rear above the handrail. Each brush is suspended by a single arm and has the flexible coupling. Each arm falls towards the center line of the locomotive based on gravity. The rotation of each brush is such that it walks out to the side of the vehicle and then down along the side as the locomotive passes through.

The nose brushes encounter the nose of the locomotive just above the handrail. Each nose brush cleans a part of the front and side of the nose up to the cab door. It also cleans the cab door all the way down to the walkway. The flexibility of the coupling allows the brush to bend and climb out of the area between the nose and the handrail. As the brush pops out of this area it cleans the side of the cab just above the handrail. The brush will then swing in back of the cab door and along the side of the locomotive above the handrail.

The woodpecker brush (Figure 8, was given its name because of its up and down bobbing motion. The primary purpose of the woodpecker brush is to clean the area from the handrail down to and including the walkway. As the locomotive approaches the woodpecker, the rotation of the brush is clockwise which helps it climb up and over the rail. This brush has an up and down movement and can pivot from right to left allowing it to get out of the way of any locomotive even if the brushes were not on.

The rotational movement of the brush is what makes it pivot up and down. It wants to climb up out of any area once it encounters a verticle surface such as the cab door. It will not only rise up but it will also pivot from right to left. As the cab proceeds, the brush drops down into its normal operating position to clean the side and walkway behind the handrail. A sleeve at the base of the brush rolls along the handrail to keep the brush at the perfect height to do the job.

As with all brushes, the woodpecker works on three simple principles: gravity, rotational force and the movement of the locomotive. It makes no difference if the locomotive comes in forward or backward or the type of locomotive to be washed. Other than the rotation of the brush, gravity and the motion of the locomotive, there were no other controlling mechanisms on this particular brush. In fact, the whole wash system could be off and this brush would still get out of the way of an approaching locomotive.

Flood Rinse

The reclaim flood rinse arch rinses the locomotive with approximately 150 gallons per minute at 70 to 80 psi. It rinses off any of the larger particles left that have been loosened by the brushes. The high pressure fresh water rinse at 250 psi will use 120 gallons per minute to do the final rinsing of the unit.

This brush wash system can save a lot of money when compared to most of the high pressure wash systems in operation today. It does such an excellent job of cleaning the vehicle that many of the hours spent handwashing can be eliminated or the intervals extended tremendously.

Some of the statistics on this locomotive wash: It uses approximately 350 to 400 gallons of water per minute of which the majority can be reclaimed. It will use approximately four to five gallons of chemical per wash and will require less horsepower than most high pressure washes. The total horsepower for all of the brushes is 52. The total horsepower for the complete system with reclaim is approximately 112.

A liquid recovery system is available for the locomotive wash. Water is becoming a very precious commodity and should be treated as such.

The primary benefit of the brush wash system is that it will really clean a locomotive. It will do it at less money than most of the pressure washes in operation today. It will either eliminate the need for hand washing altogether or stretch out the intervals, therefore, reducing costs. The water recovery system is proven and provides quick investment payback on its own.

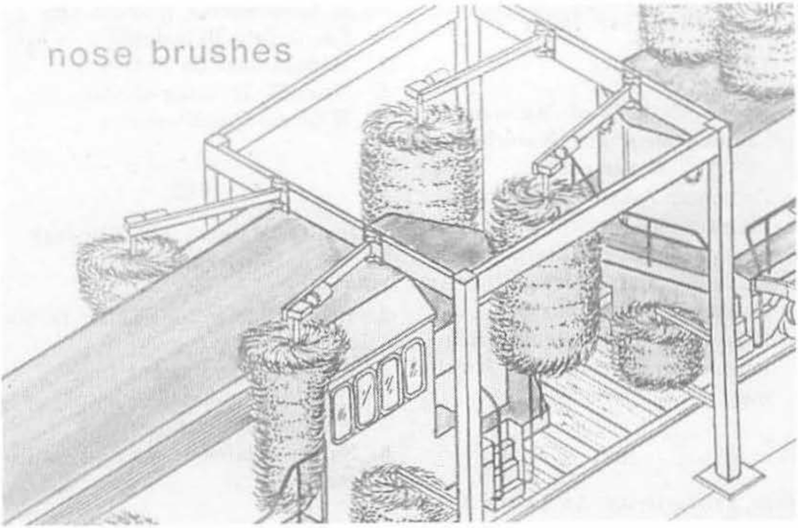

Fig. 7 — Nose Brushes

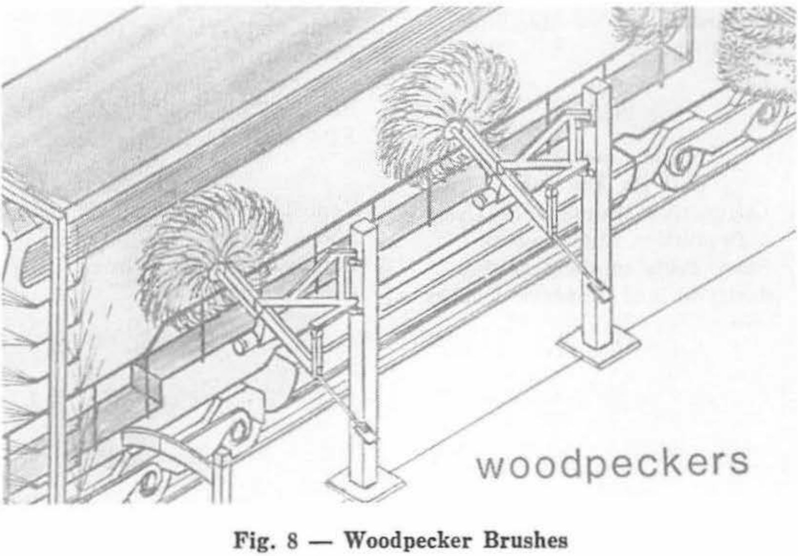

Fig. 8 — Woodpecker Brushes

SHOP EQUIPMENT

Five-Year Index

1985

Improved Methods of Maintenance Management and Material Movement

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2. New Tools for Material Handling and Overview of Balancing Technology
3. Effect of Governmental Regulations on Locomotive Finishing

1984

More Productivity At Lower Cost

1. Shop Tools
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   B. Shop-Made Tools
2. Traction Motor Shop Equipment Up-Date
3. Hazardous Waste Handling and Disposal

1983

Training and Tools Will Do The Job

1. Locomotive Maintenance Using a Production Line Process
2. Shop Tools to Increase Productivity and Improve Quality
3. Dynamic On-Line Performance of Locomotives Without On-Board Tele-Metering
4. Management in Action
5. New GE Training Center
6. Welding Qualifications

1982

Quality Maintenance Through Modern Tools

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2. Rebuild line for EMD turbochargers
3. Air brake equipment line
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5. Automated machines
6. Safety related items and equipment

1981

1. Training Aids
2. Testing Devices Inspired by New FRA Laws
3. Tools and Training for Productivity
4. Changes to Shop Facilities Required by Newly Adopted EPA & OSHA Regulations
5. Tour Through Conrail Altoona Shop
6. Supply/Service Facilities
7. GE Assembly Shop

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Assistant Vice President and
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Roanoke, VA

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

Our Diesel Electrical Maintenance Committee was well received in what we trust was a mutually beneficial experience.

Our thanks to Mr. Mayberry and others responsible for and participating in the program.

Tuesday, September 23, 1986

9:00 A.M.

REPORT OF THE COMMITTEE ON DIESEL ELECTRICAL MAINTENANCE

Pre-Conventior Presentation: Roanoke, VA

April 17, 1986 Hotel Roanoke Roanoke, VA

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PERSONAL HISTORY
ROSS T. GILL

Ross was born in Albuquerque, New Mexico on July 24, 1939. Following high school he attended Colorado State University before receiving a federal appointment to White Sands Missile Range as a coop student mathematician in 1959. In 1965, he received his BS degree in Mechanical Engineering at New Mexico State University. Ross joined the Southern Pacific in 1961 holding several positions in the Maintenance of Way Department at El Paso, Texas. He was promoted to Assistant Engineer in San Bernadino, California for the construction of the Southern Pacific's Colton Cutoff in 1966. In 1967, he joined the Mechanical Department as Equipment Engineer headquartered in San Francisco. Major projects included the Vert-a-Pac and Stac-Pac automotive rail cars. In 1970 through an exchange agreement, he joined the U. S. Department of Transportations, Office of High Speed Ground Transportation (now the Office Research and Development in Washington, D. C.). After two years in Washington, he was promoted to General Engineer at the Transportation Test Center in Pueblo, Colorado. At Pueblo, he was responsible for construction planning and test operations at this facility. Major projects included the Linear Induction Motor Research Vehicle Test Track, Rail Dynamics Laboratory, Tank Car Torch Facility, Transit Car Test Track and the Facility for Accelerated Service Testing (FAST), a joint AAR and DOT funded program. In 1977, he returned to Southern Pacific in San Francisco to become Manager of Research and Development in 1978. In 1980, he joined the Sacramento Locomotive Works where he presently serves as Manager of Production, Engineering and Quality.

He resides in Fair Oaks, California with his wife, Donna, and four children, Michael, Sandy, Randy and Karen. His major hobbies are classic automobiles and playing golf.

CLEANING, HANDLING & STORAGE OF ELECTRICAL EQUIPMENT

Introduction

When one looks at infant mortality rates of new and rebuilt electrical components on locomotives, it is clear that a significant saving could be made if they can be reduced.

Quality workmanship is one very important aspect of infant mortality. However, the proper cleaning handling and storage of this equipment make a significant contribution to the end quality of the product. The Diesel Electrical Maintenance Committee has decided to examine part of the problem in this paper.

I.
SOLID STATE COMPONENTS

A. Handling & Storage

Among the many economic and technical realities railways are having to confront is the advent of more and more sophisticated solid state devices on locomotives. These range from very sophisticated logic and control systems based on the microprocessor to applications of the recent advances in power electronics. While these devices have proven to be more durable than their predecessors, this may not apply to other conditions they may encounter outside of locomotive operation. One component reliability problem beyond the manufacturing process is the control of static electricity.

1. **Electrostatic Discharge (ESD)**

ESD Discharge—A hidden cause of component failures. We all know of static electricity from our everyday world as the mild shock received when something conductive is touched after having walked across a particular surface, or as annoying "static cling". Beyond this, it does not seem that it should concern us at all. However, ESD is a major cause of component failure, and hence, of equipment failure. The damaged component will rarely exhibit any obvious signs of damage, thereby allowing it to evade routine quality control systems.

This lack of immediate evidence causes individuals to be less wary of this particular hazard. ESD discharges well below an individual's range of sensory perception can cause significant damage.

While it is the small geometry, low power, low voltage technologies that are most subject to ESD damage, the investigation of the problem had led researchers to believe that passive components such as metal film resistors are also susceptible.

In order to address this problem, storage and repair areas must be set up as antistatic environments. To do this floors, floor polishes and cleaners, bench tops, shows, carts and wheels and dozens of other everyday items must be brought into question to ensure they are not contributing static electricity.

Static electricity damages components when a charged person or part comes into contact with the "target" part. In order to avoid static, one must understand how the three types of ESD can be generated.

a. **Triboelectricity**

This type of static generation is the result of two surfaces being separated or rubbed together such as removing masking tape from a roll which can generate in excess of 5,000 volts or walking across a vinyl floor which can generate up to 12,000 volts (3,000 volts is about the beginning of ESD perception). Judicious selection of the

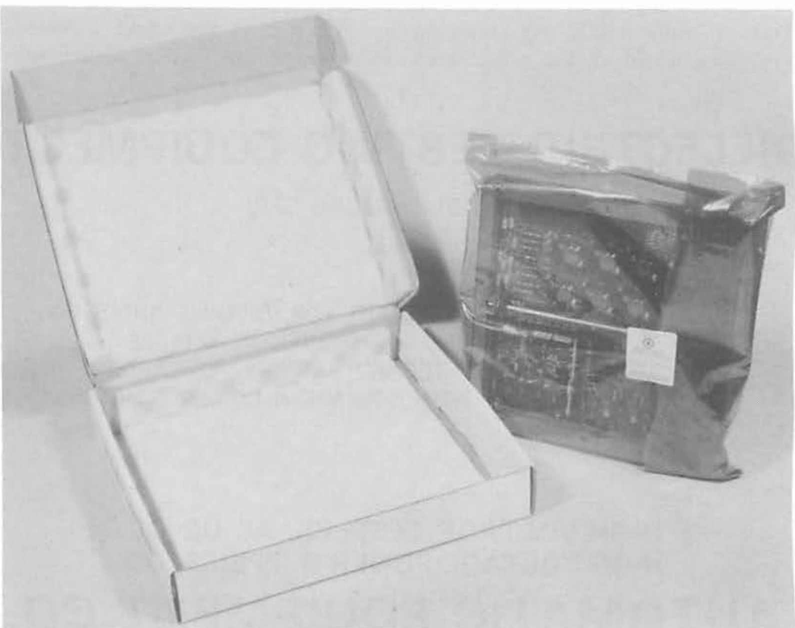

Fig. 1

materials in the environment can avoid most triboelectric problems.

b. **Induction**

When the electrostatic field of a charged surface induces polarization of a nearby conductive body, the polarized body will discharge if a discharge path exists. This can occur, for instance, if a person were to handle components inside a plastic bag. Use of anti-static packaging will eliminate most inductive problems and still protect the device from triboelectric effects. (See Fig. 1.)

c. **Capacitive**

This effect is a result of a change in capacitance of a body which is already charged. For a fixed charge, voltage is inversely proportional to capacitance. If the capacitance is suddenly reduced (such as by lifting a board from a table) a dangerously high voltage will result. When the board is put down the resulting discharge can damage components. Diffusive rather than conductive anti-static techniques are the best approach to prevent this type of static damage.

2. Prevention of ESD

What are the steps that can be taken to prevent ESD and to create a static free environment? The following list involves actions that management should take in terms of acquisition of equipment, and instructions which should be included in shop training programs to ensure ESD awareness. Anti-static environments should be set up wherever solid state devices are stored, examined or repaired. It is clear that because of the expense of setting up such an environment a separate section of the stores be set up for solid state components.

B. Packaging for Storage and Transportation. 12 Precautions

1. Always use anti-static packaging.
2. Pack tightly to prevent motion which may generate static.
3. An appropriate anti-static container is a Faraday cage constructed of carbon-loaded plastic, metal or metallized plastic containers. The transparency of the metallized plastic bag allows for visual inspection and thus has the advantage over the others. However, all three types provide adequate protection. (See Fig. 2.)
4. "Pink poly" bags are not adequate because they do not guard static being generated by induction. Faraday type bags "shield" components from inductive static.
5. Always ensure that tubes used to store and transport integrated circuits are anti-static. Plastic types will cause a charge to be generated due to triboelectric effect.


ATTENTION
OBSERVE PRECAUTIONS
FOR HANDLING
ELECTROSTATIC
SENSITIVE
DEVICES

6. Place warning labels showing the JEDEC/EIA (Joint Electron Device Engineering Council/Electronic Industry Association) symbol indicating the sensitivty of components inside.

7. Transportation and storage apparatus such as carts, wheels, frames and shelves should always be grounded. Without this precaution, the large amount of relative motion which takes place in the transportation process will generate significant triboelectric static.

8. Keep insulating material away from sensitive components (e.g. do not stack electronic devices on top of insulated traction motor cables, or on top of fiberglass or polyethylene liner).

9. When removing, handling or examining electronic components on board a locomotive, personnel should employ portable antistatic techniques. Portable wrist straps should be worn at all times. Portable workstations consisting of grounded antistatic mats should be used to provide a safe work area if any prolonged study of components is to be done on the locomotive. (See Fig. 3.)

   Any devices to be removed and then transported to another location should be placed in an antistatic container before antistatic protection is removed, and should not be reopened until in the appropriate antistatic environment. Power should always be turned off before electronic modules are disconnected or removed.

10. Do not use electrical tape on any solid state device for any reason.

11. Integrated circuits should be packed in conducting foam in order to short out all the pins. A clip or ring may be used but does not physically protect the pins. Do not use styrofoam.

12. Always ensure that electronic components and assemblies are protected against physical damage.

C. Anti-static Work Stations for Repair and/or Inspection of Static

SENSITIVE DEVICES

1. Outer clothing, especially sleeves and gloves shoud be cotton and not made of synthetic materials. Some antistatic clothing is available. Avoid contact with components. Short sleeves are best where possible.

2. Keep work area clear of all insulators. These consist of most plastic, synthetics, polyethelyne, cardboard and ungrounded metal.

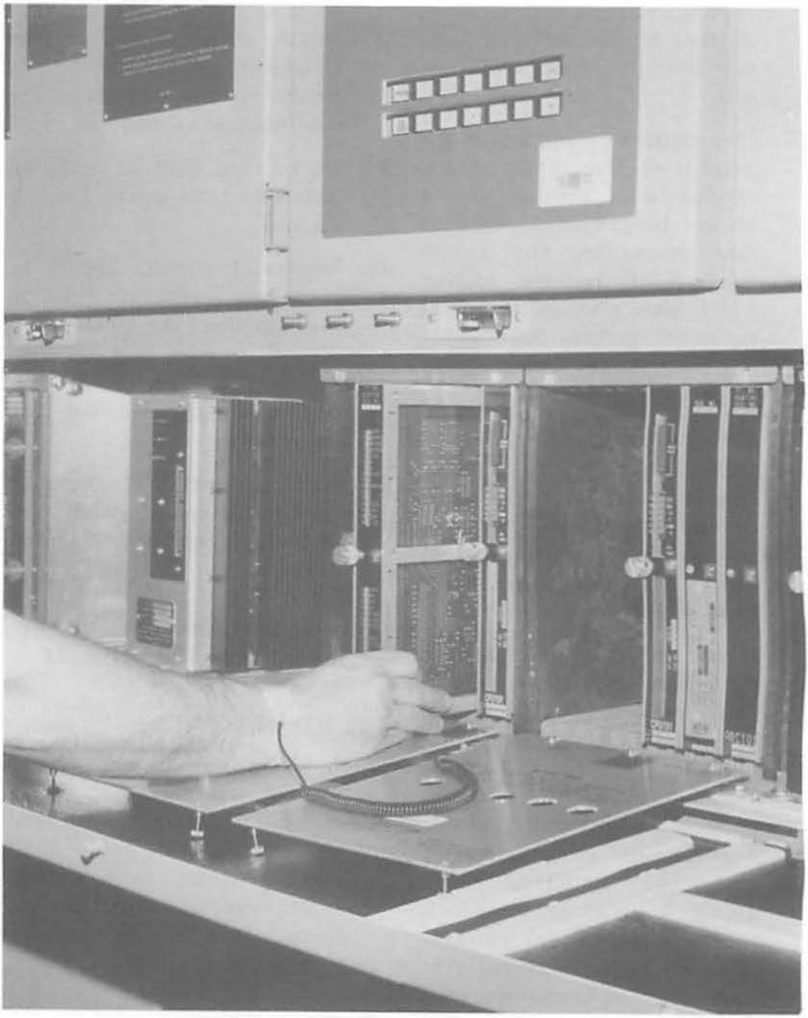

Fig. 3

3. Antistatic table and floor mats should be installed at each work station. Wrist straps should be available and strapped directly to bare skin. If more mobility is required, heel straps or antistatic footwear may be used. All antistatic devices in the environment should be connected to a common ground point through a one megohm resistor. Provide extra ground straps for visitors.

4. Soldering irons, work benches, stands, electrical equipment or any other metal objects should be grounded to the common ground point. Cabinets, shelves and other storage equipment should be antistatic types and grounded to the common ground point through a one megohm resistor.

5. Any proper AC ground point may be used as the common ground point of the environment. AC ground plugs should be verified.

6. Use antistatic containers for storage, and do not stuff labels inside of packages.

7. Any cleaning utensils such as rags and brushes should be made of natural or antistatic material.

8. Ionizers may be used to reduce the susceptibility of an area to static buildup. They also have the added advantage of removing some dust particles from the air. AC, DC, and nuclear types are available. However, the ionizer should be the balanced type, (i.e. equal number of positive and negative ions formed) so that it does not create the very problem (unbalanced charges) we are trying to avoid.

The ions will find the statically charged areas and help neutralize them before they can do any damage. Ionizers are the only effective way to deal with insulators in the environment.

Floors are the single greatest source of static generation in the environment from triboelectric effects. The best solution is the application of conductive floor tiles. For repair facilities these may be applied as a false raised floor to allow for passage of cables underneath allowing easy and neat installation of new equipment, and some extra storage space. Where economics prevent a new floor installation, grounded floor mats may be used exclusively but may present a safety hazard due to curled up edges or corners. However, under no circumstances should carpeting be present in an antistatic environment. If a hard floor is used dissipative floor finishes are available which remain effective for approximately two months of normal wear.

10. Post appropriate warning signs in the area.

The relative humidity has a significant effect on the voltage levels which may build up. The following chart gives some indication of the effect.

Source	ESD Value 70-90% RH	10-20% RH
	KV	
Walking across vinyl floor	0.25	12
Walking across synthetic carpet	1.5	35
Sitting on foam cushion	1.5	18
Picking up standard plastic bag	0.6	20
Pulling tape from PC board	1.5	12
Cleaning circuit with eraser	1.0	12

A humidifier should be used to ensure that relative humidity in an antistatic environment remains above 60%.

D. Some Simple Precautions

1. Avoid touching electronic components, pins, leads or traces. Handle by the plastic or metal parts of an assembly not associated with the circuitry.
2. Ensure you are grounded before handling any solid state parts.
3. Do not slide devices around.
4. Spread the word. Courteously notify others when you see a static control problem.
5. Static detection devices are available to help detect problems.
6. Various antistatic liquids and wipes are available for cleaning purposes.

E. Receiving/Shipping

1. Keep parts in original antistatic containers until ready for use. If your railway qualifies components or assemblies upon arrivial, they should not be opened until in the antistatic environment.
2. Part number and count verification should be performed only at a static controlled work station. If no other way is possible, one should be set up in shipping and receiving.
3. When repackaging ensure the ESD-sensitive warning label is present.
4. Verify that ESD precautions are adhered to by outside contractors.

Employee education is a key to the ESD problem. Employees should be trained about ESD, to recognize labels and what to do with these labeled items.

The cornerstone of a static control strategy is grounding. This may present a shock hazard under certain conditions in your shop. Please take care when setting up antistatic work areas.

Classes of Electrostatic Susceptibility

		Typical Applications
1A — Extremely Sensitive (0-170 volts)	MOS Devices	Dash-8 60 series
	JFET	
	LSI micro-circuits	
1B — Highly Sensitive (170-1,000 volts)	CMOS Devices	Dash-8 60 series
	Bipolar transistors	Dash-7 50 series
	ECL Hydrid	E-Type 40 series
	SCR	
	Thin film resistors	
2 — Moderately Sensitive (1,000-4,000 volts)	Schottky Diodes	
	Precision resistor networks	Dash-8 60 series
	ECL circuits (Less than 1 ns)	Dash-7 50 series
	TTL microcircuits	
3 — Marginally Sensitive (over 4,000 volts)	Zener Diodes	
	Power rectifiers	All Locomotives
	Power diodes	

F. Cleaning of Electronic Components

Dirt and other debris which may be found on electronic components may interfere with normal operation by degrading components, insulation, and conductors or by allowing a path for current discharge thus causing short circuits and/or damaged components. Dirty connectors may cause open or high resistance connections. Although this problem is much less serious than in the past due to the introduction of pressurized cabinets, a card or module should always be cleaned before returning to service to remove any incidental debris.

The key to any cleaner that is used is that it should remove dirt while leaving as little residue as possible. Different pressurized sprays are available on the market for removing flux, or degreasing. A can of pressured air is also very useful. Acrylic sprays are available which will protect a large amount of residue, such as dishwasher types, are not generally recommended.

Ultrasonic baths are available which do complete cleaning jobs leaving very little residue on the components. Where extensive cleaning is required, ultrasonic baths which use heat will return devices to good-as-new condition. Various manufacturers offer a wide range of cleaning products and have a technical support line.

Dirt may also interfere with the shedding of heat from electronic components by acting as an insulator. It is important to assure that all heat sinks mounted on P.C. boards are clean before they are returned to service. In the case of power electronics on the locomotive, it is important to do a periodic visual inspection of heat sinks mounted in areas where they are susceptible to dirt.

These should be cleaned as required. Heat sink mountings should be checked for corrosion to ensure that heat transfer is still adequate between device and sink.

Summary

Some of the suggested procedures may seem a little elaborate, but with the exception of new floors, none of these items is overly expensive. If the railways wish to benefit from the increased locomotive productivity offered by solid state devices, these precautions should be observed. The cost calculation must not only include the cost of the damaged components but also the cost of reduced reliability due to reduced performance and increased over-the-road failures. Remember that a static zap, imperceptible to human sensitivities, could at some time later cause a 10,000 ton train to stall.

II.
ROTATING EQUIPMENT

Preface:

This section of this paper will cover cleaning, handling and storage of rotating electrical equipment. Since there are so many different cleaning methods and types of cleaning material, only the most prevalent will be discussed.

One cleaning method that is quickly gaining popularity at this time is high pressure spray washing. This method has been refined to be very effective in all cleaning requirements of the railroads and is finding its way into many railroad rebuild shops across the country. In its analysis, each repair facility must choose the method that best suits its scale or needs of operation.

Thorough cleaning of parts is necessary —

To remove bulk grease and dirt from all surfaces of the parts. On all rotating equipment, maintenance personnel find that these bulk contaminants are a main reason for failures. The dirt and carbon tend to hold moisture around insulated areas and allow weak spots to go to ground or short sooner than normal. These contaminants also cause mechanical abrasion on rotating parts. Parts that vibrate in normal operation and expand or contract due to ambient temperature and load changes will also mechanically abrade.

To maintain high insulation resistance to ground. Any kind of contaminant that may reduce the intended resistance of insulation will create problems. These problems are accentuated during high voltage situations. Contaminants that could reduce resistance are carbon from brush wear, copper particles coming from commutator or slip ring wear, steel particles from mechanical abrasion or slip ring wear, or chemical contaminants from past cleaning where the cleaning material was not rinsed off thoroughly. Dirt and some chemical contamination will hold moisture in a continuous film rather than beading up, causing a path to ground. This is very evident if the V-ring string band seal on a traction motor armature is not kept clean.

To accurately inspect and test rotating equipment to determine the extent of electrical and mechanical repairs needed. Once all grounds or shorts due to contamination are cleared, the equipment can be tested for more positive evidence of failure. Also, once the bulk type contaminants are removed, the parts can be inspected closely for mechanical problems.

To prepare the parts that are insulated with varnish for vacuum pressure impregnation (VPI). Once all contaminants are removed, varnished surfaces can be revarnished for another service life. If dirt filled air passages are revarnished, that dirt will be secured there forever, thus limiting cooling air flow and causing an overheated part. The contaminant could also break loose at some time during operation and interfere with rotation and cause electrical or mechanical failure. Balance of the armature could also be thrown off and create severe vibration of the motor. Dirty components that are VPI'd may also contaminate the varnish in your VPI system.

Whenever people are made to work with very dirty parts, they are less satisfied with their work. They do not take good care of the parts or tools. Quality also suffers not only because defects can be hidden, but also because the people don't take as much care.

When all parts are thoroughly cleaned there is less chance of getting contaminants on other parts.

A. Methods of Cleaning (General)

1. **Dry compressed air.**
   a. Used to remove loose, dry contaminants only.
   b. Not recommended as the sole method of cleaning.
2. **Steam.**
   a. Wets and depends on heat and force of steam to soften grease and oil.
   b. Does not remove dirt mechanically bonded to or imbedded in surfaces.
   c. Is chemically neutral since no alkaline agent is used.
   d. Parts must be dried in oven.
3. **Manual spray washing.**
   a. Uses steam or hot water and non-caustic, alkaline cleaning solution. Depends on heat, force of water or steam and chemical action. (A caustic is an alkaline solution containing sodium or potassium hydroxide.)
   b. Wets and penetrates contaminants.

c. Scrubs and breaks down contaminants into small particles so they can be washed away with water.

d. Removes oil, grease and loose dirt. Does not remove dirt mechanically bonded or imbedded in surfaces.

e. Not chemically neutral due to alkaline cleaning solution. All parts should be promptly rinsed when exposed to alkaline cleaning solutions (Kapton is particularly sensitive). If not rinsed thoroughly a residue will be left that will absorb water in normal service and cause leakage to ground.

f. Parts must be dried in oven.

g. Indoor cleaning will require ventilation, depending on the cleaning solution. Suitable protective equipment must be used for eyes, skin and respiratory system.

4. **Spray or immersion in solvent.**

a. Hot or cold solvent and compressed air wets, penetrates, scrubs and dissolves contaminants.

b. Removes oil, grease and loose dirt, but does not remove dirt mechanically bonded to or imbedded in surfaces.

c. Results in saturated insulation which should be air dried.

d. Expensive nature of solvents may result in re-use of dirty solvent, which allows dirt to soak into porous insulation and cracks. This can result in leakage to ground if surfaces are recontaminated. This is especially true for the immersion method. Often armatures will never recover from low resistance readings because conducting contaminants become trapped in cracks which may have been present or were opened up during immersion. Commutators should never be immersed since contaminants can be carried into inaccessible and critical areas. Filtration or distillation equipment for separating dirt from solvent can be expensive.

e. Dusty residue may remain after solvent has evaporated. This should be blown off with clean, dry compressed air.

f. Insulating varnish may be removed and certain insulation may decompose if armature or frame is exposed too long to a hot solvent.

g. Some solvents are explosive and can be hazardous if stored or used improperly.

h. Indoor cleaning requires modern ventilating equipment to remove harmful fumes. Indoor or outdoor cleaning requires a breathing apparatus for operators. Suitable protection is also required to prevent solvent from getting on skin or in eyes.

5. **Solvent vapor-degreaser.**

a. Hot solvent vapor condenses on cooler part being cleaned thereby wetting and dissolving contaminants. Fresh, clean solvent condenses on part until part attains temperatures of vapor.

Further scrubbing is obtained by spraying a strong jet of liquid solvent.

b. Removes oil, grease and loose dirt but does not remove dirt mechanically bonded to or imbedded in surfaces unless strong jet of solvent is used.

c. If solvent has substantially higher boiling point than water, part becomes hot enough to drive off moisture, thereby eliminating the need to use an oven for drying.

d. Cleaning time is reduced to minutes versus hours with methods requiring oven drying.

e. Parts with pocket areas must be tilted or up-ended to spill out the solvent before leaving degreaser. Dusty residue generally must be blown off with clean, dry, compressed air after solvent has evaporated.

f. If parts are exposed too long to solvent vapor, insulating varnish may be removed and/or decompose on armatures and frames.

g. Some solvents are explosive and can be hazardous if stored or used improperly. Suitable protection is required to prevent solvent from getting onto skin and into eyes. Breathing apparatus may also be required. Indoor cleaning requires proper ventilation equipment to remove fumes from the shop to prevent them from spreading to other areas.

6. Abrasive blast.

a. Compressed air and abrasive material such as ground walnut hulls, glass beads, rice hulls, corn cobs or aluminum oxide powder are used to remove hardened deposits of oil, grease and dirt by blasting the contaminant loose. When abrasive particles are to be reclaimed, contaminants must be removed. This method removes dirt that is mechanically bonded or imbedded in surfaces.

b. Sand should not be used as an abrasive since its sharp cutting action can peen over edges of laminations, shorting them together, and causing additional iron losses in rotating equipment. Sand also damages insulation more quickly than any other method.

c. Air pressure and pellet size, density and hardness must be carefully selected to avoid damage to insulation. Heavy, soft pellets driven at high speed will pound the surface and may loosen the bond between layers of insulation and the part without cutting. Abrasive pellets also wear out hoses and nozzles which then require periodic replacement.

d. The abrasive blast method only cleans areas that are directly exposed to the blast of the abrasive material. All other areas are left dirty.

e. Cleaning is dry and will not require oven drying except to drive out moisture that is already in the part from normal operation.

f. Indoor and outdoor cleaning requires breathing apparatus and goggles to keep fine particles from the operator's lungs and eyes. The cleaning facility must be designed to keep abrasive material from spreading to other areas of the shop. An open air facility makes reclamation of abrasives difficult.

7. **Ultrasonic vibration and vapor degreaser.**

a. Cleaning solution in an ultrasonic tank is excited by high frequency vibration, (20,000 Hz or higher) to produce extremely rapid oscillations in the solution. This sets up alternating high and low pressure waves which mechanically scrub submerged parts. This scrubbing action combined with solvent action results in thorough, efficient cleaning of large as well as small parts.

i. Many ultrasonic systems utilize an integral vapor degreaser for precleaning and final cleaning of parts. This reduces cleaning time and minimizes solvent contamination in the ultrasonic tank.

ii. Some ultrasonic systems have a refrigeration module that takes the place of water cooling of the vapor condensing coils. This eliminates the continuing expense of a water supply and discharge system.

b. Transducers, which change electrical energy to ultrasonic vibrations, can be installed to the bottom or sides of most standard vapor degreasers that were discussed in Section 5, thus increasing the capability of present equipment.

c. Everything mentioned previously under "Solvent Vapor Degreaser" in Section 6 applies to this method of cleaning.

8. **Power Spray Washer.**

a. Spray wash machine equipment.

i. Totally enclosed automatic machine.

ii. Machines that clean very dirty parts generally have a sludge conveyor to remove settled contaminants from bottom of holding tank(s).

iii. Electronic timers are interlocked to control length of prewash, wash and rinse cycles automatically.

iv. Motor driven turntable swings out with door for each loading and unloading.

v. High horsepower motor drives a high flow rate pump.

vi. Many spray nozzles are positioned inside cabinet to permit spray action from all angles (side, top and bottom). Some washers include a center pipe with nozzles to clean the interiors of some parts.

b. Cleaning solution.

i. Cleaning solution is largely made up of heated water (120 F to 180 F). Solution is heated electrically or with high or low pressure steam or gas.

ii. A medium alkaline cleaner is generally used.

iii. Since cleaning solution is pushed through nozzles at pressures of about 60 psi, the cleaner should contain defoamers. Where applicable, a layer of oil may be allowed to settle on top of solution in holding tank.

iv. If aluminum parts will ever be washed, the cleaner should be silicated to protect the aluminum.

v. Another principle behind a power spray washer is that much of the grit removed from previously cleaned parts is suspended in the cleaning solution. This grit is recirculated and when pushed through the nozzles at high pressure results in an abrasive blast type of cleaning. It does not peen over any edges.

vi. If the cleaner is alkaline, a power rinse cycle with fresh water to remove and neutralize cleaner residue is required. If this feature cannot be added to the washer, an external rinse tank should be used with apparatus to agitate water and to check PH for alkalinity.

c. This type of cleaning does require oven or vacuum drying of rotating equipment.

d. When fine particle grit is recirculated, there is a possibility of some of the grit being metallic. It has not been found that this metallic grit creates ground or short problems on commutators. In shops where commutators are turned and undercut, personnel should never see this kind of problem.

e. Operator does not need any special protective equipment under normal operation of machine since entire operation is enclosed. Machine cabinet should be ventilated properly to keep fumes from entering shop. Depending on cleaner used, a respirator, gloves and eye protection may be required when adding cleaner to water in holding tank.

B. Recommended Method of Cleaning Traction Motors Prior to Rebuild

As you can see from the "Methods of Cleaning" section of this paper, there are many ways to clean traction motors. Any one of the methods has proven effective in cleaning at least the minimum amount of contaminants from the parts being cleaned. Each method has good and bad aspects regarding health hazards, waste disposal, cleaning effectiveness above the minimum required, damage to the part, expense or time consumption.

In recent years there has been one method that has been tried and proven to meet the majority of demands imposed by traction motor repair shops. This method is the power spray washer. This is the method that will be referred to in the rest of this paper.

1. Remove armature lock if it was applied to prevent brinelling during shipment.

2. Remove pinion/shaft protector and remove paper from pinion.

3. Remove pinion from armature shaft as instructed by vendor publications.

4. Remove all covers.

5. Remove brushes.

6. Remove armature as instructed by vendor publications.

7. Disassemble frameheads as instructed in vendor publications.

8. Since most power spray washers have large wash cabinets and turntables, many parts can be washed at one time. Load armatures onto a rack designed to hold armatures vertically. Load rack into washer turntable. Weight on turntable should always be distributed so table bearings are loaded evenly.

9. Close washer door and set timers for required amount of time for all cycles.

10. The prewash cycle is the first of three cycles. This cycle removes the bulk contaminants from the parts. These contaminants settle quickly at the bottom of the pre-wash tank where they are usually removed by a sludge conveyor that disposes them into a proper waste disposal container. In all wash cycles, the parts are rotated by the turntable to orient all surfaces of the parts to numerous pressure nozzles. The pre-wash water has the manufacturer's recommended concentration of cleaning solution and is heated to 120-180 F.

11. The wash cycle is the second cycle. Once the prewash cycle times out, the wash cycle begins. This cycle also has the manufacturer's recommended concentration of cleaning solution and the water is heated to 120-180 F. It is usually the longest cycle to enable the pressure heated, alkaline solution to dissolve and wash away any contaminants that are usually difficult for most cleaning methods to remove. The wash tank may or may not have a sludge conveyor since the majority of bulk contaminants are removed in the prewash.

12. Once the wash cycle times out, the rinse cycle begins. The rinse cycle is heated to 120-180 F. No cleaning solution is needed. It is used to wash away any remaining contaminants but its main duty is to remove any trace of the alkaline cleaning solution. If this alkaline solution were to remain on the armature and dry, it would leave a film that might allow current flow if armature got wet in the future.

13. When the rinse cycle times out, the turntable stops moving.

Now the door can be opened and the armatures removed.

14. While armatures are still warm, they must be placed in a drying oven or a vacuum dryer. Drying ovens are found in most motor shops. Oven temperatures should be about 300 F. Baking time will vary depending on the number of parts being dried, frequency, and duration oven doors are open during baking and ventilation inside oven. Armatures should reach a surface temperature of at least 257 F. At this temperature, moisture vaporizes from the parts. This is why ventilation is important since the moving air will remove any water vapor from the oven. Each shop should estimate the baking time for its specific oven, type and quantity of parts being dried. Temperature checks could be done with a pyrometer at predetermined intervals at the core laminations between the wedges to estimate drying times.

The vacuum dryer is also used in some shops. A vacuum pump is piped to the chamber where atmospheric pressure is reduced to 0 psia. This absence of air pressure reduces the temperature that water boils. This way, insulated parts can be dried much more quickly than when using an oven while using a lower temperature. This will save shop energy costs. When using either of the above drying methods, their effectiveness will be proven when the armature is tested with a megger. If the commutator to shaft resistance is less than 1 megohm, the armature must be dried again and retested.

15. If brush holders are cleaned at a later time, they can be left in the frames. Otherwise remove them and place them in a cleaning basket.

16. The traction motor frame is loaded onto the washer turntable so the pinion end bore faces upward and is centered on the turntable. This allows the center nozzle pipe to extend down into the frame and clean the interior. All leads must be tied to the frame so none of them are pushed around by the pressure spray and get caught in the machine. Since the center nozzle pipe does such a thorough job of cleaning the interior of the frame, if required the frame can be varnished without the problem of sealing in contaminants around the field and interpoles.

17. Close and lock the door. Set the cycle timers to thoroughly clean the frame. Start the machine. The machine cycles repeat the same steps as noted in 10 through 13 for armature cleaning.

18. When the machine stops and the frame is moved to a qualifying area, brushholders are removed. The insulated studs can then be cleaned by putting them through the washer again with other parts or the abrasive blast method can be used if done carefully.

19. As the traction motor is disassembled, all the framehead parts and brushholders should be placed

in a wash basket designed to be placed on the washer's turntable. Parts should be oriented so they are exposed to the pressure nozzles as much as possible. One style of basket that works well in this type of washer is a "christmas tree" shaped basket that allows the center nozzle pipe to extend through the center. It should have hooks to hang parts on and a bottom platform to lay parts down that cannot be hung.

20. Close and lock the door. Set cycle timers to thoroughly clean the parts. Start the machine. The machine cycle repeats the same steps as noted in 10 through 13 for armature cleaning.

21. When machine cycles are complete, unlock and open the door. Remove parts baskets from the machine. Since parts are very hot when removed from the washer, moisture evaporates quickly from most surfaces.

22. When cleaning armatures, frames and other parts, if there are any pocket areas, the parts should be tilted or up-ended to drain standing cleaning solution or rinse water. When used with caution and correct protective equipment, compressed air can be used to blow the standing water off the part.

C. Recommended Method of Cleaning Main Alternators and Generators Prior to Rebuild.

1. Remove rotor or armature lock if it had been applied.

2. Remove shims if they were placed between rotor or armature and frame.

3. Remove all protective paper and tape.

4. Remove auxiliaries if they were left on the alternator.

5. Disassemble the alternator or generator as suggested by the locomotive manufacturer's publications.

6. Place rotor or armature on the washer turntable with the slip ring or commutator end up.

7. Follow steps 9-14 and 22 as described for cleaning insulated traction motor parts in the washer.

8. Place frame on the turntable either standing on its feet or laid down on its side. When the frame is laid on its side, the center nozzle pipe can extend down through the frame and do a better job of cleaning than when it is left standing on its feet.

9. Follow steps 9-14 and 22 as described for cleaning insulated traction motor parts in the washer.

10. Place end housing on the turntable. Because of the size of most end housings, several of them can be stacked on top of each other as long as they will not fall or keep the pressure spray from cleaning the parts.

11. Follow steps 9-13 and 21 and 22, as described for cleaning metallic traction motor parts in the washer.

D. Recommendations for Cooling Fans, Auxiliary Generators, Grid Blower Motors, Inertial Motors and Other Miscellaneous Rotating Equipment.

Because of the large variety of small motors and generators, this section will discuss their shipping, handling, storing and cleaning in general terms.

1. When shipping small motors, generators, fans and blowers, the following preparations should be done:

a. Secure all covers provided with equiment.

b. Place waterproof tape over any openings where a cover is not provided.

c. Thoroughly clean and apply rust preventive compound to any unpainted machined surfaces.

d. Use tie-wraps or rope to secure any leads that may drag or get crushed.

e. Place the item on a standard sized pallet and secure with metal banding. A special shipping container can also be built for cooling fans and grid blowers. This allows them to be stacked.

If small rotating equipment is secured to a pallet, a forklift can easily transport the item(s) anywhere they are needed. Without a pallet, all of these items can be lifted by an overhead crane with chain or wire rope slings where a lifting eye can be mounted. Fabric slings can also be used on cooling fans and grid blowers by wrapping the sling around the edge of the frame.

When storing small rotating equipment, the preparation for shipping should be sufficient for storage. Inertial blowers, auxiliary generators and other motors or generators should be stored inside to keep moisture from entering them. Cooling fans and grid blowers are designed with shrouds so they can be left outside in the weather. Care must be taken not to set these items where flooding could affect the component.

Dust and dirt may be blown into this rotating equipment on windy days. This is why it is important to cover all openings with waterproof tape.

2. Recommended method of cleaning needing-repair small rotating equipment for rebuild.

a. Remove equipment from pallet.

b. Remove protective coverings.

c. Disassemble each item as instructed by locomotive manufacturer's instructions.

d. As each item is stripped, place parts into parts cleaning baskets designed to expose as many surfaces to the spray nozzles as possible.

e. Several parts of this small rotating equipment are made of aluminum. The cleaning solution in the wash tank must be

silicated so the aluminum will not be etched.

f. Place basket(s) onto turntable, evenly distributing the weight.

g. Follow steps 9-14 and 22 as described for cleaning insulated traction motor parts in the washer. An exception would be to consult the locomotive manufacturer's maintenance instructions for minimum megger readings after drying.

h. Follow steps 9-13 and 21 and 22, as described for cleaning only metallic traction motor parts in the washer.

E. Recommendations for Electrical Cabinets

This section will discuss reasons why electrical cabinets need to be cleaned and methods to get them clean. Electrical cabinets usually are neglected since most methods of cleaning are not sufficient, take too much time to do a good job, require the locomotive to be removed from service to allow all components to dry or create electrical problems that normally wouldn't happen.

With present designs of electrical cabinets, dirt is kept out much better than on older models of locomotives. Locomotive manufacturers have been forcing filtered air into the cabinets to create a positive interior pressure relative to atmospheric pressure. This way air is always being pushed out of the cabinets so no dust filled air can enter. Compartment doors are also sealed better with material that will not deteriorate as quickly as some material used in the past.

It is important that maintenance personnel inspect control compartment doors, seals, door fit and control compound air filters. If there is a defect, repairs should then be made to keep dirt from accumulating on electrical components. When there is evidence of dirt accumulation on electrical components, an inspection should be made to find the problem. Usually the problem can be located in the area of most dirt accumulation.

Electrical cabinet pressure can be checked with a U-tube manometer. The cabinet should have a minimum static pressure of 1.5 inches of water. There are a few reasons for cleaning electrical cabinets.

1. To allow normal mechanical operation. Dirt may get into moving components and cause them not to move correctly.

2. To prevent some components from overheating due to dirt building up on the component and preventing heat dissipation.

3. To prevent dirt from holding moisture and causing a short or ground.

4. To minimize chafing of wires and cables. Even though wires and cables are secured in the cabinets, they still move and vibrate due to normal operation of the locomotive. Then when the abrasive dirt is

added to the movement, insulation wears more quickly.

5. To provide cleaner components and wiring for quick identification when troubleshooting or modifying.

6. To give the craftsman a cleaner work area.

F. Suggested Steps for Cleaning Electrical Cabinets

1. **Low Voltage**

a. Pull battery switch and open low voltage cabinet doors.

b. Blow dirt and dust off cards, relays, diode, panels, resistors, capacitors and compartment sides with dry compressed air at 40 psi. Where compressed air is used, protective eyewear and a respirator must be worn.

c. A fine bristle brush may be used for dislodging any accumulations that the compressed air did not remove.

d. Use a vacuum cleaner to remove any dislodged dirt and dust.

2. **High Voltage**

a. Pull battery switch and open high voltage cabinet doors. Make sure cabinets being cleaned are in a well ventilated area. A ventilated hood should be used to protect the operator against breathing solvent vapors and to keep cleaner from getting into the operator's eyes and face. Protective clothing should be used to protect the skin on the rest of the operator's body where necessary.

b. Remove plugs from the bottom of the compartment to allow cleaning solution and water to drain out. It is not recommended to clean electrical cabinets in the following manner if there are no drain holes for liquids to escape.

c. If necessary, dilute cleaning solution to manufacturer's recommended standard.

d. Use a cleaning spray gun with an air supply hose connection and a siphon hose to spray cleaner into the cabinet. Thoroughly soak all contactors, relays, switches, resistors, wiring, cables and cabinet sides with cleaner. Allow cleaner to soak into the dirt for a couple of minutes.

e. Thoroughly rinse with clean water so no residue can remain on the components.

f. Leave cabinet doors open and allow to dry for 4 or 5 days. Because of this long drying time, this type of cleaning should only be used when a locomotive is undergoing a rebuild.

Summary

The quality of work we perform today will have a significant effect upon the survival of the industry. Productivity can only be increased by continuously re-evaluating work procedures, both new and old, in order to develop and make use of new methods and technologies. The Diesel Electrical Maintenance Committee has examined industry practice for the cleaning, handling, and storage of electrical equipment, and hopes this paper will be a useful instrument towards our larger goal.

QUALIFICATION OF LOCOMOTIVE POWER PLANTS THROUGH SELF LOAD

The basic advantage of locomotive self load compared with enroute testing is that the operator, equipment and geographic variations are neutralized. Results of the test should thus be very repeatable at a particular location excluding only temperature and atmospheric pressure changes. Locomotive self load provides the ability to perform the following functions with a high degree of confidence in the results for comparison purposes:

1. Performance Monitoring

   a. Periodic measurement of performance (horsepower at the alternator).

   b. Correcting to rated performance under working condition.

   c. Tuning to desired performance following major repairs.

2. Fuel Consumption

   a. Optimize system adjustments for controlled conditions of load, temperatures, type of fuel, air density, etc.

   b. Restore optimum fuel combustion for engines not normally operating at optimum load, i.e., units from long layover or out of storage.

3. Troubleshooting

   a. Duplicate actual load condition for purposes of causing recurrences of failure mode.

   b. System checkout following major repairs.

   c. Environmental checks (exhaust fumes, noise).

4. Testing

   a. Static (stationary) testing to obtain data under simulated road conditions.

   b. Comparative system testing under controlled condition of temperature, vibration, etc.

   c. Checking out the utility of new/different tools, maintenance procedures or similar items that may affect road performance, personal safety.

   d. Obtaining data or investigate previously unknown phenomena.

GE LOAD TEST

To determine if a repaired unit is ready for service, a load test must be performed. This involves checking and testing numerous items. Various electrical outputs must also be determined, as well as the general mechanical and electrical condition of the unit.

By following the proper testing procedure, you can help eliminate potential operating problems in General Electric locomotives.

Safety is always important. Before working on any unit outside the shop, the first step is to apply a blue flag. Next, the hand brake must be set. Before power checking or loading the unit, make sure it is isolated from the rest of the consist by disconnecting the 27 pin train line cable.

Before starting the engine, several items must be checked. These include the engine lube oil and the fan drive lube oil. Inspect the radiators to insure they are not plugged. The air compressor oil level must be checked. Also, the governor oil level and the auxiliary drive lube oil must be checked.

At the same time the test must be made for low voltage grounds. Be certain all circuit breakers are on, and qualify the test light. In order to do this, connect the light across the battery switch. This should cause the bulb to light. Now, ground one lead while the other is connected to the positive side of the switch.

Next, move the lead from the positive side to the negative side of the switch. In either case, if the light glows, a ground exists.

Before testing for a high voltage ground, place the ground relay switch in the "off" position. Remember to qualify the megger. Connect the two leads and crank the megger. A reading of zero should be obtained. Now, attach one lead to ground and the other to the ACCR BUS bar. When the megger is cranked, a reading of at least one megohm must be obtained.

If all levels are satisfactory, start the fuel pump. On older units, this will require pushing the reset button. On newer units, turn the fuel pump switch to prime. Fuel pressure should be 40 psi. Now, start the engine. At idle, lube oil pressure should range from 35 to 45 psi.

Now check the independent brakes to make sure they are cut in, and applied, brake shoes are against the wheels, and that piston travel is not excessive. Make certain the unit has enough fuel and shut the engine down with the emergency fuel cut off switch.

Determine the condition of the air filters by looking at the service indicator. If the red band is visible, you must take a manometer reading to see if the filters require changing. Now, reset the fuel pump and restart the engine.

Open the carbody doors and listen for any unusual sounds which might indicate misfiring, improperly set racks or problems with the fan drive or couplings. Also visually check for exhaust leaks or any leakage of lube oil, water or fuel. Carefully inspect the low pressure fuel lines for leaks or improperly applied clamps.

Increase engine speed to eighth notch. Using a calibrated tachometer and an overspeed test lever, slowly increase engine speed and make sure that overspeed trips at 1717 RPMs, ± 15 RPM.

Now, before the engine dies, reset the overspeed trip. Be certain the overspeed link is completely compressed. Check the rack settings. With the engine in idle, the racks should be at 5½ to 6 millimeters, with a tail rod gap of one inch ±1/32. At this time, each cylinder must be test fired. The racks should not be pulled further than 3 to 5 millimeters for the test.

Allow the cooling water to reach normal operating temperature and check and mark its exact level.

After ensuring that all personnel are in the clear, power check the unit in both directions. With the generator field switch on, and watching the load meter, place the reverser in the forward position and advance the throttle to notch one. Then return the throttle to idle. Place the reverser in reverse position and advance the throttle to notch one. In both cases, the load meter should show from 300 to 350 amps. Return the throttle to idle and center the reverser.

You should also test the operation of the ground relay. To do this, place the load box switch in the load position. Connect a jumper from either the GA test jack or the BB terminal of the EXP terminal board to the car body. Place the generator field switch in "On" position. With the reverser handle in the forward position, advance the throttle to notch one.

This will cause the ground relay to trip and ring an alarm bell. Then the ground relay will reset. This sequence will repeat three times; however, the fourth time the ground relay will lock out. Once this has been accomplished, return the throttle to idle and remove the jumper wire. Now, reset the ground relay.

The next step in the load test procedure is to make electrical checks. Before doing this, inspect the condition of the meter and leads. To check the main alternator voltage, connect a 0 to 1500 voltmeter to either the GA and GN test jacks or to the BB and BE terminals of the EXP terminal board.

Watch the ammeter on the control stand to make sure there is no current flow through the traction motors. Observe the voltmeter while the throttle is slowly advanced to eighth notch. The voltage should not exceed 1135 volts. If this voltage is exceeded, check for an open grid circuit.

Before you remove the meter, return the throttle to idle. Next, connect the voltmeter to the blue test point on the MP card marked 300 kilowatts per volt.

Again, advance the throttle slowly to notch eight, and leave in this position. A normal meter reading is from 7.0 to 7.2 volts. To compute horsepower, multiply this reading by 424.

At this time, the machinist should be checking the racks, which should read 19.5 millimeters. He should check the power piston which should be at .344 or .343, and he should check the load regulator which should be at the 5:00 o'clock position.

With these checks complete, apply the meter to the test point on the filter card marked ACCR 600 amps per volt. A normal meter reading should be from 3.5 to 3.67.

Multiplying the meter reading times 600 will give you the current output of the main alternator.

The voltage output is determined at the filter card test point marked VCR 150 volts per volt. A normal reading should be from 6.75 to 7.3 volts. This reading is multiplied by 150 to determine the voltage output.

While the unit is still under load in the eighth notch, you should also check the following items:

Lube Oil Pressure —
This should be 90 to 115 psi

Fuel Pressure —
25 psi minimum

Turbo Air Pressure —
18 to 25 psi.

When these readings are determined, return the throttle to idle and place the load box switch in the run position.

Again, after ensuring all personnel are in the clear, power check the unit in both directions. Remember, the load meter must indicate 300 to 350 amps in both directions. With the load test completed, return the throttle to idle, center and remove the reverser handle, and place the generator field switch in the off position.

Before leaving the unit, with water temperature the same as previously observed, check the water level to be sure it is the same as before load testing.

When the various tests and checks have been completed and any problems corrected, remove the blue flag, and the unit is again ready for service.

EMD SD40-2 LOAD TEST

In order to determine if a repaired unit is ready for service, a load test must be performed. A properly conducted load test can simulate most operating conditions and allows various mechanical and electrical problems to be isolated and corrected.

Before working on any unit outside the shop, first apply a blue flag. To further insure safety, remember to set the hand brake. Also be certain that the unit is isolated from the rest of the consist by disconnecting the trainline cable.

Before attempting to start the unit, several checks must be made: Check the condition of the engine air filters; be certain they are not plugged or collapsed. The engine lube oil level must also be checked. The dynamic brake grids must be checked for obstructions. Also be certain the grid blower motor blades are intact. It is important to check the governor oil and engine water levels. The radiators must be inspected to be sure they are not plugged. Also remember to check the air compressor lube oil level.

The thermometer well located in the temperature switch manifold must be filled with oil and a glass thermometer placed in the well. Now, a thermometer must also be suspended below the oil level in the lube oil strainer housing. Next, be certain to open all the flashcocks. Then manually turn the engine over one revolution. If no water was discharged, tighten all of the flashcocks.

Now close the battery switch. This will start the turbo lube oil pump. To verify that turbo lube oil system is working, remove the number 16 crankcase cover and determine if the oil is being returned from the turbo to the crankcase.

After replacing the cover, turn the start switch to prime and when the fuel return sight glass is full, start the engine. With the engine at idle, open the carbody doors and listen for any unusual sounds or vibrations. Be certain that various engine gauges are functioning properly. This includes the engine oil pressure, engine water temperature and air compressor gauges.

It is important that the overspeed setting be checked. At this time on 645E3 engines, the overspeed should trip between 1045-1060 RPM. Returning to the cab, cut in the air brakes and apply the independent brake. Check to be certain the brake rigging is complete and that piston travel is not excessive. At this time, check to see that the unit has a sufficient amount of fuel.

The next step is to check for lower voltage grounds. First, the test light must be qualified. To do this, connect one lead to each side of the battery switch. This should cause the bulb to light.

To test for a ground, attach one lead to the positive side of the switch and ground the other lead. Now attach one lead to the negative side of the battery switch and ground the other lead. In either case, if the test light glows, a low voltage ground exists.

At this time, the engine temperature switch should be tested. Depressing the button on the ETS should cause an alarm bell to ring and cause a hot engine indication in the cab. On the annunciator module, the hot engine LED will light.

Now the low water and low oil shutdown devices must be tested. When the petcock is turned to the horizontal position, a short stream of water will be discharged from the valve. This should cause the low water shutdown device to trip. With the engine at idle, approximately one minute will elapse before the low oil button on the governor will trip. An alarm bell will ring. A low oil indication will be shown in the cab, and the engine will shut down.

After turning the petcock to the vertical, reset the low water and low oil devices, and restart the engine. Next, check the emergency fuel cut-off to determine that it will cause the engine to shut down. While the engine is shut down, a check must be made for high voltage grounds. Before this test can be made, the megger must be qualified. To do this, connect the leads to each other. When the megger is cranked, a zero reading should be obtained. Separate the two leads and crank the megger again. This time a reading of infinity should be observed.

Next, remove the seal from the ground relay cut-out switch and place the switch in the "off" position. Also, before actually conducting the test, all of the modules must be pulled out so that they are not making contact. This is done to protect them from high voltage if a ground is present.

A jumper is now connected between the positive and negative test points. One lead from the megger is then connected to either test point, and the other lead is grounded. The megger should show a minimum of one megohm. Disconnect the megger and the jumper. Return all of the modules to the proper position. Place the switch in the "on" position and apply a new seal.

When the engine has been restarted, it must be determined that the unit will load in both directions. Place the generator field switch "on", move the reverser to forward and advance the throttle to notch 1. Return the throttle to idle and place the reverser in reverse, then advance the throttle to notch 1. The load meter should indicate from 200 to 350 AMPS in both directions. Return the throttle to idle and center the reverser. Now, turn the test switch to the load test position.

In order to obtain readings for later use, two meters must now be attached. Remember to inspect the meter leads for damage. The 0-50 millivoltmeter is attached to the load test shunt test points. The 0-1500 voltmeter is attached to the GP and GN test points.

Next, connect one end of a 5-amp fused jumper to ground. Connect the other end to either the GN or GP test point, and advance the throttle to notch 1. This will trip the ground relay and cause an alarm bell to ring. When the ground relay has tripped and reset twice, return the throttle to idle.

Move the jumper to the other test point and advance the throttle to notch 1. When the ground relay has tripped a third time and locks out, return the throttle to idle. Remove the jumper and reset the ground relay. Again, advance the throttle to notch 1. The 0-50 millivoltmeter should read approximately 4.0, and the 0-1500 voltmeter approximately 180 volts and be certain that the grid blower motors are rotating.

Return to the cab and push the DG module test switch. This will cause the engine speed to return to idle, and an LED to light on the AN module. When this occurs, the throttle must be returned to the idle position. Pushing the test switch again will reset the DG and AN modules.

Now the AN module and the LED's must be verified. This is done using the AN test switch. All of the LED's should light. After resetting the AN module, advance the throttle to notch 3. Be certain that the load meter now shows amperage.

When the water engine temperature has reached at least 130 F, check and mark the water level. Return the throttle to idle and begin to advance the throttle slowly. Allow the engine speed to stabilize in each notch and record the readings shown on the two meters.

Now, using the thermometer in the temperature switch manifold, check and record the fan pick-up temperatures. The proper pick-up temperature is indicated on a plate attached to each end of the three switches and on the ETS. As each of the three switches picks up, record the temperature and remove the plug from that switch. Be certain that the shutters open when the TA switch picks up.

When the ETS trips, an alarm bell will ring, a hot engine light will be displayed, and the engine speed will be reduced to 6th run. Now, starting with the TA switch, begin to re-attach the wires which were removed. Allow approximately 30 seconds between each connection to avoid overloading the D-14 companion alternator. After recording the pick-up temperatures and re-attaching the plugs, move the thermometer to the well in the water inlet pipe near the right hand water pump.

With all of the engine compartment doors closed, allow the engine to run at full load. The water temperature should be checked at 15 minute intervals until no further increase is noted. Now compare the water temperature with the temperature of the lube oil in the strainer. Refer to the chart in the maintenance instructions. If the oil temperature is more than 15° F higher than the line on the chart, a problem exists with the lube oil cooler.

When the governor is balanced at the point indicated on the governor name plate and the water temperature and other conditions are stable, check the load regulator. It should be between the 9:00 and 11:00 o'clock positions. Now begin to record the information required on the load box sheet. Readings should be recorded approximately every 15 minues. With the engine under load in the eighth run, engine horsepower can be calculated. Horsepower is determined using the following formula:

$$\text{Volts x Amps} = \frac{\text{Watts}}{700} = \text{Horsepower}$$

Voltage is determined with a digital meter by moving the decimal point in the reading one place to the right. Decimal conversions may vary depending on meters used for this application.

115.5 = 1155 volts

On the SD40-2 units, the load meter shunt is rated for 4000 amps at 50 millivolts, or 80 amps for each millivolt. This allows amperage to be determined by multiplying the meter reading by 80:

12.2 mv x 80 = 1856 amps.

Multiplying amperage by the voltage gives the available wattage:

1155 volts x 1856 amps = 2,143,680 watts

Dividing watts by 700 equals horsepower:

2,143,680 ÷ 700 = 3062 Horsepower

The engine speed is now slowly reduced to idle. With the throttle in idle, place the generator field switch in the "off" position and return the load test to normal. Remove the meters from the test points. When the water temperature has cooled to approximately 130 F, check the level to determine that no water was lost during the load test.

The unit must now be power checked again. Place the generator field switch "on", the reverser in forward and advance the throttle to notch 1. Return to idle and place the reverser in reverse, and advance the throttle to notch 1. In both cases, the load meter should indicate from 200 to 350 amps.

Return the throttle to idle and turn the generator field switch "off". Center and remove the reverser handle.

When all of the checks and tests have been completed and any repairs made, the unit is again ready for service.

In summary, we have prepared a troubleshooting guide listing the most common problems found by our locomotive personnel. The guide is included as part of this report.

GENERAL TROUBLE GUIDE FOR E.M.D. LOCOMOTIVES

Operating or Test Condition	Engine Speed	Horsepower V X A/700 Test Shunt A=M.V.X80*	Gov. Rack Position Indicator Stop=1.96	Load Reg. Position (9:00 to 11:00)	Type of Trouble to Suspect
Load Test or Road Operation TH 8 over 25 MPH	Normal	Low or No Load	Long	Max. Field	-Electrical- Excitation too low** Wheel slip correction
Load Test or Road Operation TH 8 over 25 MPH	May Vary	Variable	Hunting	Hunting	-Electrical/Mechanical- Excitation too high** Fuel rack and linkage Fuel supply, filters
Load Test or Road Operation TH 8 Over 25 MPH	Normal	Low	Normal	Balanced	-Mechanical- Fuel supply, hot fuel Fuel Quality, Water in Fuel Injectors or Governor
Load Test or Road Operation TH 8 Over 25 MPH	Normal	Low	Long	Balanced but toward Min. Field	-Mechanical- Engine air pressure*** Governor/pressure line
Load Test or Road Operation TH 8--Over 25 MPH	Normal	Low or High	Short	Balanced	-Mechanical- Governor
Load Test or Road Operation TH 8--Over 25 MPH	Low	Low or High	Short	Minimum	-Electrical- Overload/Over Excitation**

*50 Series Units: Amps = M.V.X100

**High excitation can result from high reference or low feedback signals. Low excitation can result from low reference or high feedback signals.

***Compare air box pressure to that of a similar engine.

For specific information, refer to the appropriate Maintenance and Service Manuals for the locomotive.

GENERAL TROUBLE GUIDE FOR GENERAL ELECTRIC LOCOMOTIVES

Operating or or Test Condition: TH Run 8	Engine Speed 1.48XRPM	HP= VXA/700 HP Pwr. 7-7.4V	Gov Rack Position .344 in 19.5 MM	Load Pot Position 4:00- 5:00	Turbo Air:20+ RPM:8V+	Type of Trouble to Suspect
Load Test or Road Operation Above 25 MPH	Normal	*Low or No Load	Long	Maximum	Low	-Electrical- Excitation set too low Reduced excitation** Wheel Slip Correction Turbo Speed Signal
Load Test or Road Operation Above 25 MPH	May be Variable	Variable	Hunting	Hunting	Low	Electrical/Mechanical Excess load/engine B.O. High excit/LCP voltage fuel supply Rack linkage/governor
Load Test or Road Operation Above 25 MPH	Normal	Low	Normal	Balanced	Low	-Mechancial- Hot fuel/fuel quality Engine B.O./settings Engine air supply
Load Test or Road Operation Above 25 MPH	Normal	Low	Long	Balanced but toward Min.	Low	-Mechanical Governor/engine air Fuel supply very low
Load Test or Road Operation Above 25 MPH	Normal	Low or High	Short	Balanced but toward 12:00	Low or High	Electrical/Mechanical Excess load/high excit. Engine settings; Gov.
Road Test or Road Operation Above 25 MPH	Normal	No Power	Long	Minimum	Low	Electrical/Mechanical Governor ORS operating Hot engine*** Gov.
Load Test or Road Operation Above 25 MPH	Low	Low	Long	Balanced 12:00 to Maximum	Low	-Mechanical- Low oil pressure Low water pressure (Governor modulation
Load Test or Road Operation Above 25 MPH (If red excit. active EE relay should drop and reduce load)	Low to Normal	Low or High	Short	Minimum	Low to Normal	Electrical/Mechanical Load pot circuit open Load pot voltage high ACCR or VCR feedback Engine B.O./settings

*Some units reduce power to 2/3 during hot lube oil.
**Reduced excitation inactive on some C30-7 units.
***Units with energize CRS during hot engine.
For specific information, refer to the appropriate Maintenance and Service Manuals for the locomotive.

DIESEL ELECTRICAL MAINTENANCE

Five Year Index

1985

Innovations, Maintenance and Troubleshooting Locomotive Electrical Systems

1. Locomotive Microprocessor Technology in Retrospect
2. Dynamic Brake Protective Devices and Trouble-Shooting EMD-2 and GE-7 Locomotives
3. Indicators and Recorders for Locomotive Retrofit Application — Fuel, Speed, Power and Selected Events

1984

Electrical Technology To Improve Performance

1. On-Board Diagnostics
2. GE's CATS (Computer Aided Troubleshooting System)
3. Fuel Conservation Through Electrical Modifications
4. Performance of Locomotives After Storage

1983

New Solutions to Locomotive Electrical Problems

1. Ground Relay Trouble Shooting
2. Traction Motors
3. Locomotive Storage (Electrical)
4. Water Cooling and Refrigerating Methods for Locomotive Cab Application

1982

Quality Maintenance — Assuring Thorough Repairs

1. Tests on Traction Motors
2. Transition Trouble-Shooting
3. Onboard Diagnostic Systems
4. Starting Systems

1981

Innovation: Past and Present

Traction Motors

  Evaluation of Improved Test Methods

  Teflon Bands

New Generation Locomotives

Electrical Troubleshooting

Batteries and Charging Systems

  Troubleshooting EMD AC Auxiliary Generator System

Selection of Locomotives for Major Locomotive Overhauls

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

LMOA wishes to express its thanks to the Canadian Railroads for hosting and participating in the Pre-Convention Presentation of our Diesel Mechanical Maintenance Committee in Montreal on May 1, 1986.

The attendance and interest exhibited was most gratifying.

Our special thanks to Mr. Bartley for the fine arrangements and tour of the CP Shops.

Tuesday, September 23, 1986

2:00 P.M.

REPORT OF THE COMMITTEE ON DIESEL MECHANICAL MAINTENANCE

Pre-Convention Presentation: Montreal, Quebec

**May 1, 1986
Le Chateau Champlain Hotel
Montreal, Quebec**

M. L. VARNS, Chairman
Superintendent Shops
Burlington Northern Railroad
Livingston, MT

VICE CHAIRMAN

M. C. Fair, Manager-Locomotive Maintenance, Duluth, Missabe & Iron Range Railway, Proctor, MN

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J. M. SantaMaria	Shop Superintendent	Conrail	Conway, PA
J. H. Sheridan	Superintendent Shops	UP	N. Little Rock, AR

PERSONAL HISTORY

MARVIN L. VARNS

Born in Missouri Valley, Iowa on June 4, 1934. Began Railroad career in 1952 serving S.M.W. pipefitter apprenticeship with the Union Pacific Railroad. After ten years with the Union Pacific Railroad, left the Railroad industry and returned in 1964 with the Chicago, Burlington and Quincy Railroad. In 1967 was promoted to Roundhouse Foreman. After the CB&Q Railroad became a part of the merged Burlington Northern Railroad in 1970, was appointed as Foreman at Dale Street Shops, September, 1974, Foreman of Locomotives, Superior, Wisconsin, May 1977, Assistant General Foreman, West Burlington Shops, May, 1978, Superintendent Shops at Hillyard Shops and January, 1982, Superintendent, Shops, Livingston, Montana.

Marvin is married to the former Phyllis Walkins of Modale, Iowa. They have four children and two grandchildren. Marvin's hobbies include walking, community service, gardening and when time permits, taking motorcycle trips.

I.

REBUILD OF VALVE BRIDGE ASSEMBLIES

A. Introduction

It is recognized that proper maintenance of EMD valve bridges is important to ensure the reliability of the diesel engine. When the bridge or lash adjuster fails, the necessary zero lash clearance cannot be maintained between the end of the valve stem and the bridge. This will result in valve breakage and premature engine failure with probable damage to other engine components.

It is the intent of this section to review reconditioning specifications, procedures, and practices and make recommendations for handling valve bridges at the time of engine overhaul.

B. Qualification and Reconditioning

1. Valve Bridges

a. Qualification

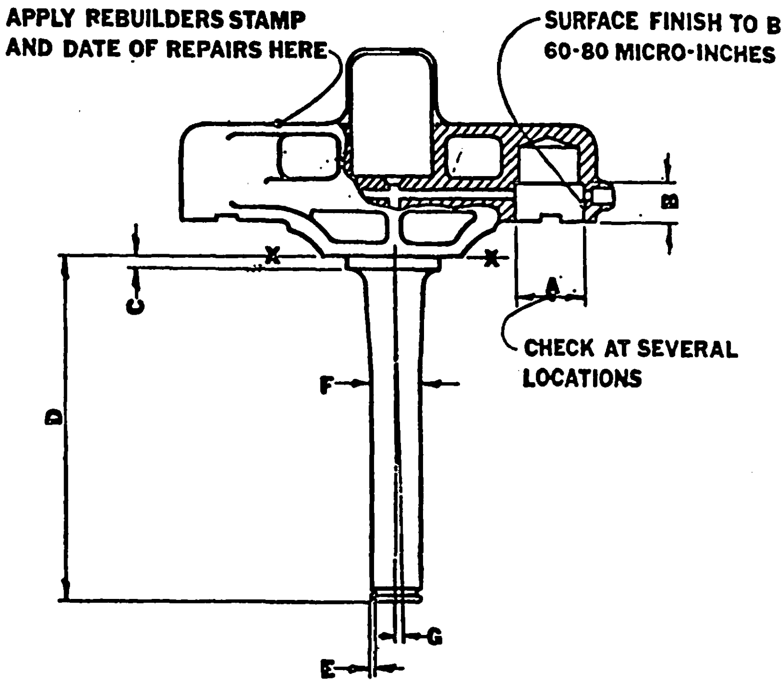
The chart indicates EMD's basic dimensional standards for the qualification of valve bridge bodies. Important aspects of these specifications are:

1. Spring seat wear step (x - x dimension) .015".
2. Lash adjuster socket diameter .8738" - 8748" to be checked with internal tri-point micrometer.
3. Retaining ring groove depth (dimension E).
4. Insure no cracks or damage around circumference by making a visual check.
5. No wear step on shank diameter to a point 2.5" where shank taper begins (dimension F, Figure 1).

b. Reconditioning

Of the above listed points

VALVE BRIDGE BODY EMD P/N 8054088



A···LASH ADJUSTER SOCKET DIA.	.8738-.874
B···LASH ADJUSTER SOCKET DEPTH	.3125 MIN.
C···BODY SPRING SEAT	.187 MAX.
(MAX. WEAR STEP ON SURFACE X-X)	.015
D···VALVE BRIDGE SHANK LENGTH	4.082-4.09
E···RETAINING RING GROOVE DEPTH	.031±.005
F···SHANK DIA., FROM SHANK END TO 2.50 IN. ABOVE END	.8220-.823
G···SHANK CONCENTRICITY, MAX. DEVIATION	.031 IN 4

Fig. 1

the two that have received the most reconditioning attention are the shank and socket (see 2 and 5).

c. Shank Reconditioning

Valve bridge shanks can be brought back within dimensional specifications by nickel or chrome plating. Reliability and quality have not been a problem to railroads utilizing this type of reconditioning.

d. The valve bridge socket must be within precise dimensional specifications. Current methods of reconditioning valve bridge sockets include plating (nickel or chrome), knurling, sleeving, and threading. Of these, plating has been the most widely utilized. However, maintaining out of round specifications after plating has resulted in high rejection rates ranging from 15% to 55% depending on the vendor. This has led railroads to try other reconditioning procedures, such as threading.

e. Threading.

Threading the lash adjuster socket is a relatively new concept. This feature is offered either on newly manufactured (not O.E.M.) or as a conversion to conventional heavy wall bridge bodies requiring reconditioning. It eliminates the need for an interference fit between body and adjuster. Problems experienced to date with threaded valve bridge bodies include seal leakage, loss of torque and cracking of the body bridge. These problems have been addressed by the application of a vitron seal, proper torque value, and eliminating thin body bridges from reconditioning.

2. Lash Adjusters.

a. Qualification.

The lash adjuster is completely dismantled before qualification can begin. EMD specifies minimum leakdown time as measured with an approved tester; however this does not insure that internal dimensions and components are within specifications.

b. Reconditioning.

Important aspects of lash adjuster reconditioning are listed as follows:

1. Internal bore and plunger clearance, .001" to .002" with a surface finish of 32 RMS maximum.

2. Outside diameter of the interference fit surface between .8750" - 8755".

3. Plunger hardness minimum 55 Rockwell "C".

It is also recommended that when lash adjusters are dismantled for reconditioning return springs and plunger ball checks be replaced unconditionally.

c. Qualification and Reuse.

It is the recommendation of this committee that at the time of engine overhaul lash adjusters be unconditionally replaced with either new or reconditioned units. The results of tests indicate an adjuster cannot be properly qualified to insure reliable operation through another life cycle without disassembly.

d. Reconditioning vs New.

Adjusters can be reliably reconditioned at approximately two-thirds the cost of new if close adherence to specifications is maintained. Also a leakdown test of the assembled bridge and adjuster on a test stand is recommended. Several roads have developed or purchased a test stand which cycles the complete bridge assembly.

C. Recommendations

The committee recommends the dismantling of the valve bridge and lash adjuster assembly for qualification at power assembly removal.

Valve Bridges — The valve bridge body may be qualified and reused if within specifications. If the valve bridge body is out of specifications, reconditioning is only recommended if the adjuster socket is within specification and doesn't require rework. The committee doesn't recommend reconditioning valve bridge body sockets at this time due to high rejection rates. If quality assurance could be maintained, reconditioning could become an efficient alternative providing the assembled adjuster and body are tested as a unit as described earlier.

Lash Adjuster — At the time of removal, the committee recommends the replacement of lash adjusters with either new or reconditioned units. We do not feel qualification and reuse of an adjuster which has not been disassembled will adequately assure quality performance throughout a second life cycle. Additionally we recommend extra consideration be afforded to quality control of the reconditioned product.

II.
UPDATE OF NEW LOCOMOTIVE SERVICE PROBLEMS, EMD AND GE EFFECTING QUALITY PERFORMANCE

Referring to last year's paper dealing with specific engine related failures and defects on model GP and SD-50 locomotives equipped with 16-645F3B engines, and B30-7A GE locomotives with 7FDL-12 engines, we present an update on some of the specific problems.

A. EMD

1. L6 hardened upper bore (HUB) cylinder liner part no. 9318833.

Stud Boss Cracking
Fig. 2

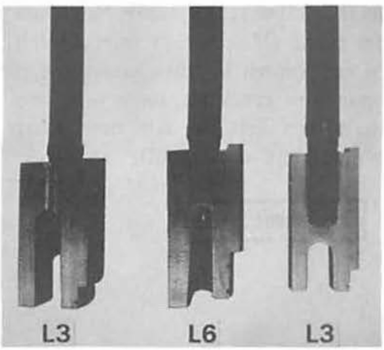
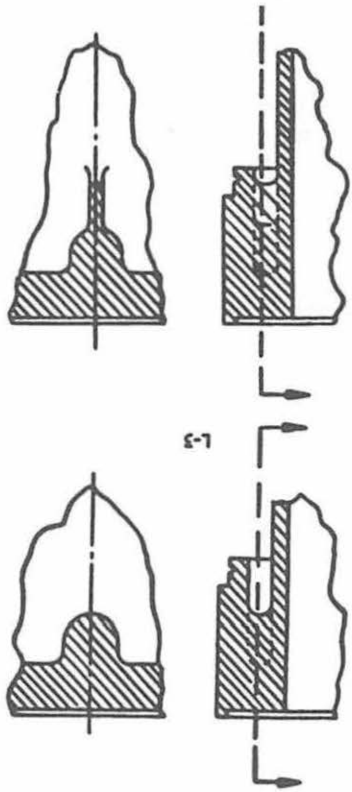


Fig. 3

Cylinder liner upper bore cracking at the stud boss area, typical of the photograph in Figure 2, has plagued the hub liner configuration since the introduction of the L3 HUB liner part number 9318833.

Initially, the problem was considered to be associated with the cylinder head to liner stud nut bolt-up torque resulting in increased liner bolt-up stress levels. To reduce the cylinder liner bolt-up stress levels, two changes were implemented. One, the liner stud nut torque specifications were lowered



Liner Design Comparison
Fig. 4

from 270 ft lbs to 240 ft lbs, and secondly, a design change was made to the L3 HUB liner to a new configuration (L6). This new design L6 HUB liner part number 9318833 featured an extended stud boss rib, see Figures 3 and 4, designed to reduce bolt-up stresses.

The continuation of upper bore cracking on this new design and stud boss, under controlled liner bolt-up stresses eliminated liner bolt-up stresses as the major cause of the upper bore cracking problem.

In determining the actual dynamic stress levels at the stud boss on the L6 HUB liner, it was established that the major contributing factor for cylinder liner upper bore cracking was the residual stress level in the liner caused by the laser hardening process. See Figure 5.

Strain gauge instrumentation revealed that a 20,000 lbs per square inch (20 ksi) stress was introduced in the cylinder liner wall at each rib section during the laser harening process. Stress levels in excess of 30 ksi were observed after the liner stud nut bolt up. The residual stress in the liner by itself is not sufficient to cause cracking in the upper bore area; however, the composite stress levels, residual bolt-up, in excess of 30 ksi are the actual cause for liner bore cracking.

Proper bolt-up torque cannot be overlooked as a condition in eliminating liner stud bore cracking.

This development along with the determined composite stress levels for the 9318831 L6 laser hardened port relief (Mae West) liner, which are not known to have experienced upper bore cracking, have provided the design criteria for new liner development work L-6D.

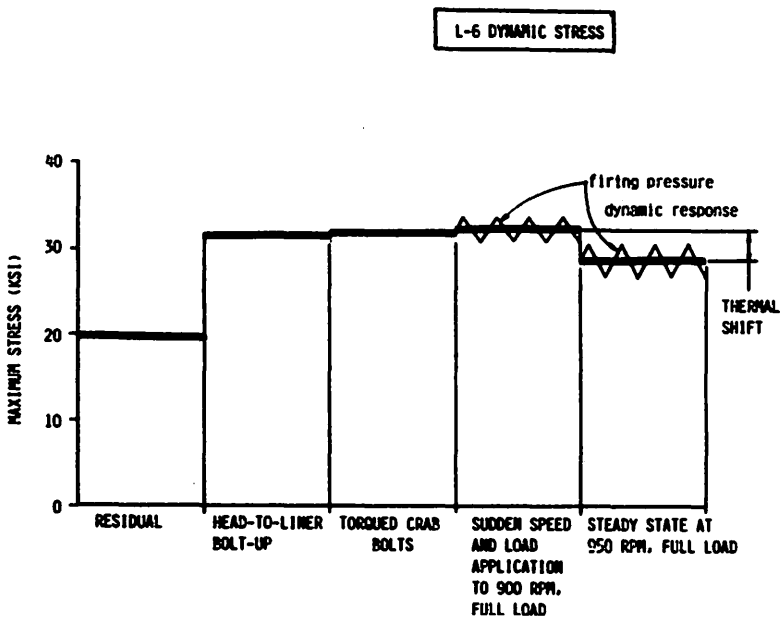


Fig. 5

This interim development work (L-6D) has resulted in the introduction of the L-9 liner incorporating a new longer stud boss ridge which is blended at a one-half inch radius into the inner wall. Reference Figure 6.

This new design reduces the liner stress levels at the stud boss and as can be seen in Figure 7, results in a reduction in composite stress levels of the 9318833 (L-9) hub liner as compared to the 9318831 L-6 Mae West hardened liner.

The stress levels of this new 9318833 (L-9) hub liner are now comparable to that of the original L3 configuration.

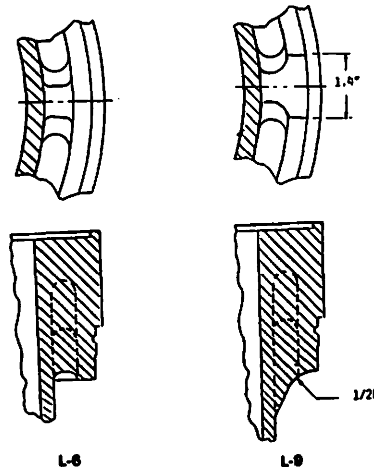


Fig. 6

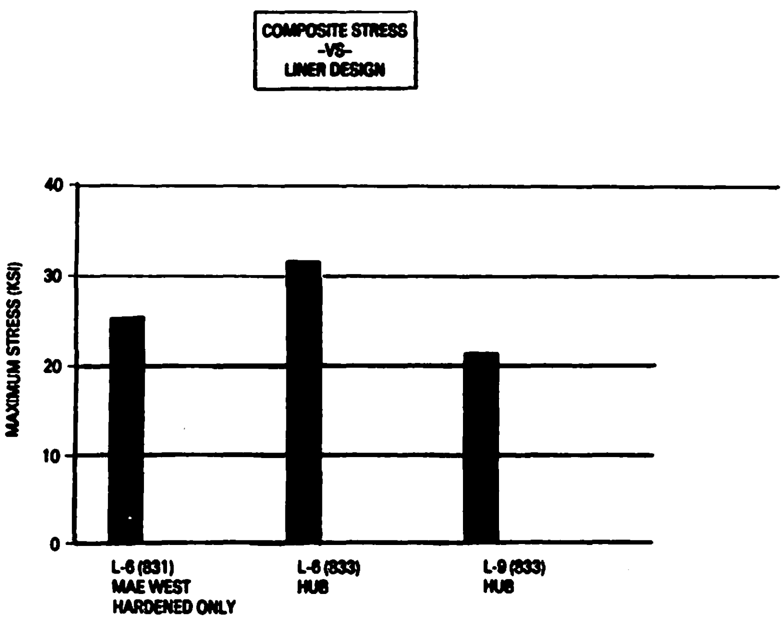


Fig. 7

2. F3B turbocharger part no. 9529223 17.9:1 turbo gear ratio — high capacity planetary gears.

The new design high capacity turbocharger planetary gear drive train system (17.9:1 ratio) was introduced into railway applications on the F40PH locomotives and the change was made to reduce planetary gear wear, which was at the time considered to be the primary cause of a high frequency vibratory impact, responsible for fatigue failures of turbine vanes in high speed light load applications.

Experience with marine installations also revealed that the clutch roller ramp failures were associated with the same high frequency vibratory phenomenon. This association was revealed when, in efforts to save fuel, marine operations were operating their vessels at reduced throttle positions, increasing the incidence of power being transmitted through the turbocharger gear train.

With the introduction of the SD-GP 50 locomotive in May 1980, the "high capacity" gear train has become basic and all subsequent rail models including the 645EC configuration utilize this planetary drive system.

Initially the new design planetary gear drive system (17.9:1 ratio) did not experience any failures in service. However, through time, the performance started to deteriorate, whether due to changes in manufacturing technique, material specifications, adherence to dimensional tolerances or a combination of these factors.

The investigations through the program revealed the following discoveries and resulted in the implementation of the necessary corrective measures.

a. August, 1984, carrier shaft dimensional specifications confirmed to be under strict control. See Figure 8.

b. October, 1984, sun gear material hardness and gear tooth profile under strict control. The problem of "notched" sun gears was overcome by improving the grinding process by the manufacturer. Gears which underwent the improved process were identified by a Blue Dot. See Figure 9.

c. May, 1985, (effective serial no. 85E), the "Torx head" screw part number 9578219 replaced the "Allen head" screw part number 9436588 as the improved clutch retainer screw in production and Utex turbochargers.

Failure of the 5/32 Allen head ¼ x 28 x ⅝' screws occured as a result of extending the hole depth beyond the specified allowable tolerance, which resulted in insufficient material stock. The additional staking operating compounded this situation and the combination resulted in fractures occuring in the head area of the screw from the edge of the drilled hole to the outer wall. See Figure 10.

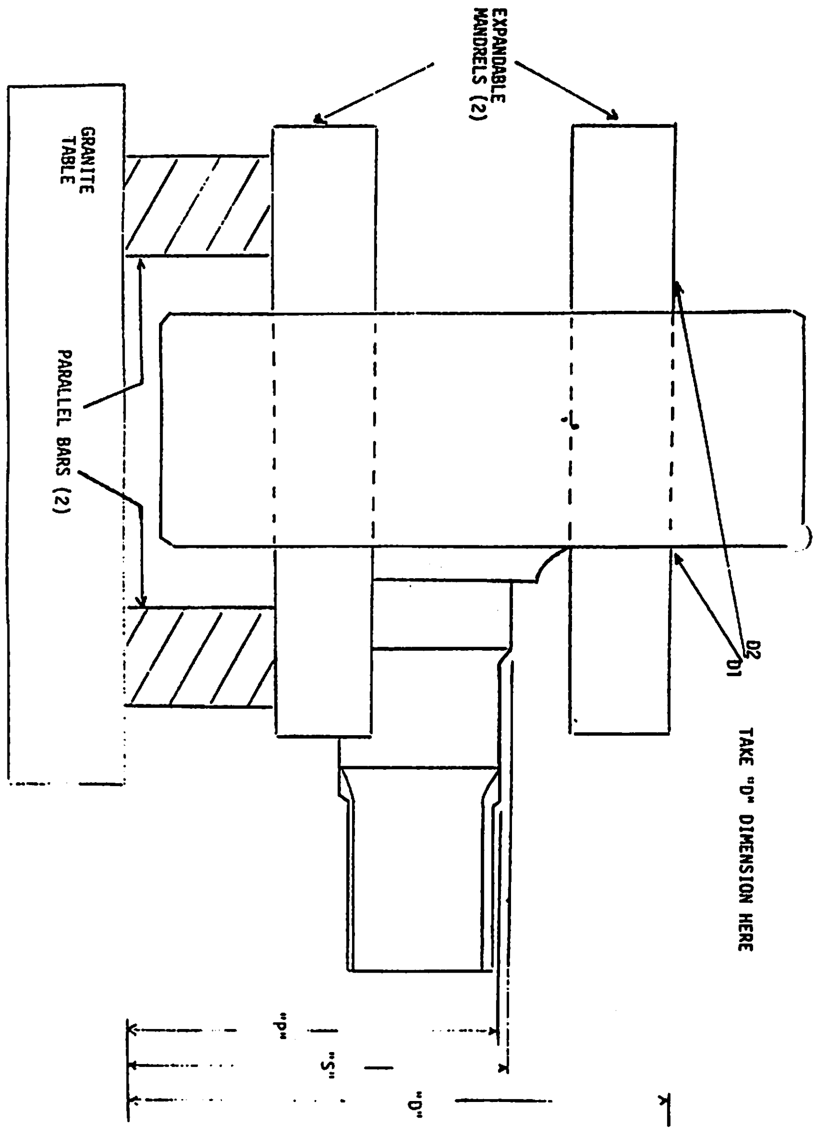

EXPANDABLE
MANDRELS (2)
GRANITE
TABLE
PARALLEL BARS (2)
D2
D1
TAKE "D" DIMENSION HERE
"P"
"S"
"D"

Fig. 8

The "Torx head" screw eliminated the previously necessary "staking" operation and through design also eliminated the need for the previously required counterbore bolt head clearance. The new "Torx head" screws are also applied with high temperature epoxy. It should be noted that no planetary system failures have occurred on turbochargers built with the new clutch retainer screws. See Figure 11.

3. Differential pressure detector (EPD) assembly part no. 9320130 Delta "P".

One member road has experienced failures on a total of eight of these devices in short periods of service time (one to six months approximately).

The failure mode on all of the assemblies has been as a result of water leaking from the telltale hole in the spacer - diaphragm, part no. 9549027, located between the housing assembly - air, part no. 9552496 and the housing - low pressure, part no. 9549028, as per Parts Catalogue no. 300 Plate C159-13 listing F159 page 23.

Observation on one dismantled device reveals a cut or rupture in the fold area of the diaphragm as part of the spacer - diaphragm part no. 9549027.

Presently the locomotive winterization configuration is thought to be the cause of failure in that, in the winterized position, outside air is drawn into the engine room freezing the EPD devices. See Figure 12.

More recent diaphragm failures have not entirely been confined to those locomotives that are or have been operated in the winterization mode, although the numbers reported have been few.

In addition, and also recent, are reports of erratic tripping on test stands of railroad rebuilt EPD's where the simple changeout of the diaphragm in question corrects the problem. Presently, the diaphragm's integrity is under investigation.

B. GENERAL ELECTRIC

1. Radiator and dynamic cooling fan column inspection.

One member road has experienced, at the time of overhaul, distortion of the rotating seal and bearing retainer on the upper column of the fan clutch drive.

Initially, this distortion was believed to be the result of the bearing retainer's failure to support the thrust load in operation. Supporting this belief was the observation of grease escaping from between the bearing retainer and bearing housing mating surfaces.

Investigations into the actual cause of the bearing retainer's distortion have established that the dismantling procedure permits and results in the angular contact of one of the two upper ball bearing inner races to clamp on the shaft during removal. This interference, or hanging up of the ball bearing's inner race is thought to be a result of disassembly and is not due to

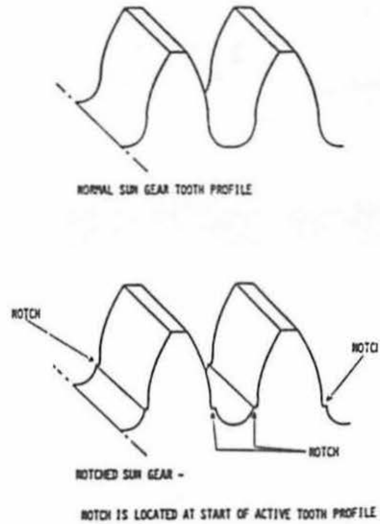


Fig. 9

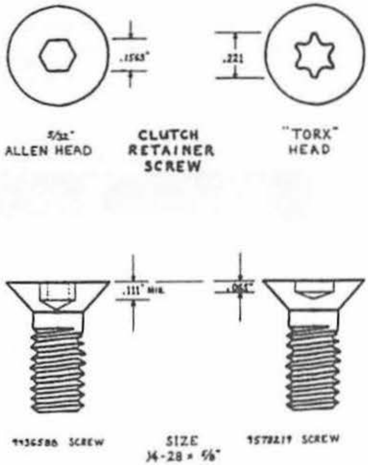


Fig. 11

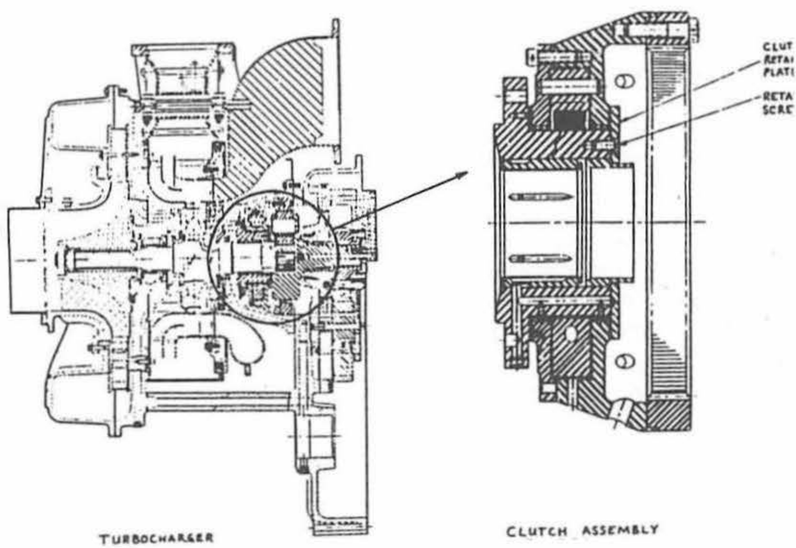


Fig. 10

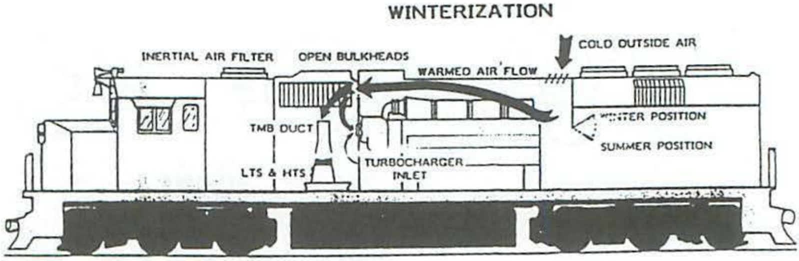


Fig. 12

normal operation or assembly procedures. The assembly clamping stresses are low and the fan thrust load is in the direction opposite to the rotation. There is no pressure build-up in the bearing cavity which might force the bearing grease out of the bottom labyrinth seal. The cap on the upper end of the column prevents the bearing assembly from seeing the increased static pressure above the fan. There will be some "slumping" of the grease through the bearings and down the column into the labyrinth seal due to gravity and vertical forces encountered during normal road operation. Through normal scheduled relubing intervals excessive lubrication will eventually escape. This is normal and does not compromise the operation of the Eddy Current coupling. See Figure 14.

The builder has reviewed the design criteria and more recently rewritten the maintenance manual to provide updated information and improve the clarity of the tear down and reassemble procedures. In addition, the tooling drawings have been revised to improve tooling and assure proper fits during tear downs and reassembly. It is still of the opinion of one member road that an alternative or improved design should be considered by the builder to *facilitate* a procedure more accessible to repair and lubrication.

2. Traction motor rubber nose supports.

One member road has reported two conditions concerning the traction motor rubber nose support. First, a condition whereby the rubber in the nose support has taken a set after a period of three to four years and has required their replacement. The second problem with the nose supports concerns the cracking of the wear plate welds. This cracking extends beyond the wear plate welds, where over 50% of these supports are cracked in the main body of the seat.

The builder has reviewed the design criteria of the traction motor support and manufacturing is being changed to improve on the

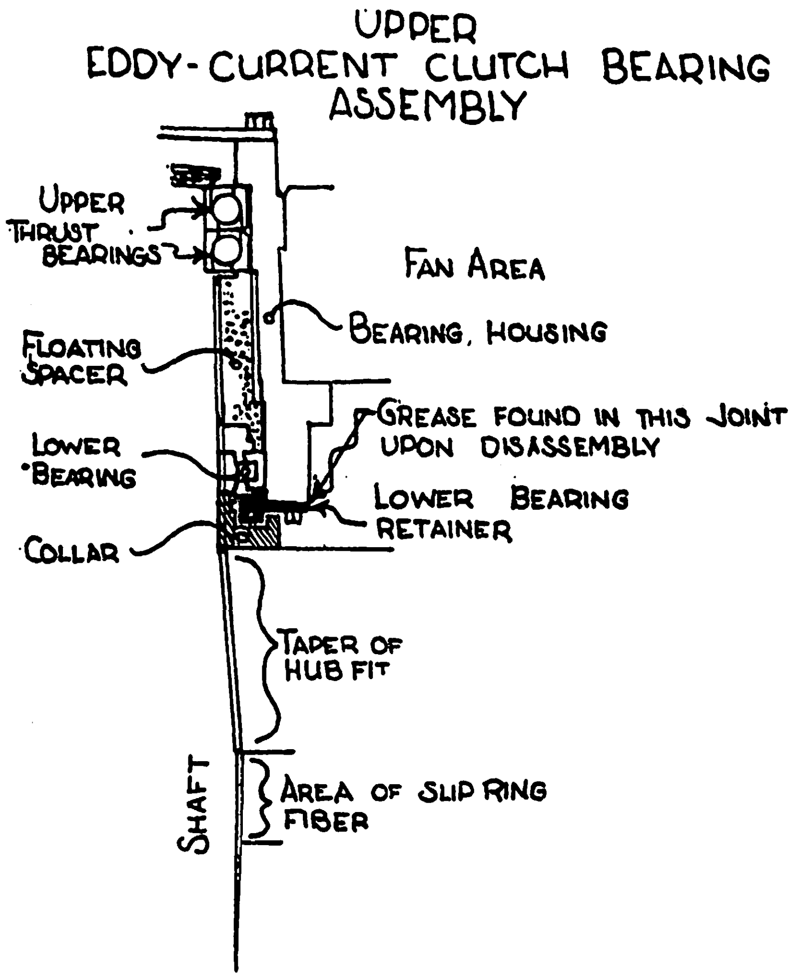


Fig. 14

performance. The effective changes on the traction motor nose supports are:

a. increase in the thickness of steel from ¼" to ⅜" for the box section;

b. the top of the box section and wear plate machined to provide for a flat mating surface;

c. the increase in the number of welds on the wear plates.

All of these three improvements

are directed at reducing oil canning of the wear plate which breaks welds.

The builder has also provided a procedure for the repair of existing nose supports with cracked wear plate welds. The following procedure is outlined:

a. Remove the wear plate from the motor suspension support using a grinder or air arc.
b. Air arc cracks in the base box section and repair by welding. If cracks are longer than two inches it would be advisable to scrap the section.
c. Grind all welds on the box section and wear plate so the wear plate is in intimate contact with the box section.
d. Clamp the wear plate to the box section and weld four sides using a .25" weld 1.5" long. Apply three equally spaced welds on the long side and one weld on the end. It is recommended that the weld rod normally used to weld high carbon steel wear plates be used. See Figure 15.

3. 12 cylinder 7FDL engine versus the 16 cylinder 7FDL engine.

Member roads are experiencing increased maintenance costs as a result of the increased horsepower per cylinder on the 12 cylinder 7 FLD engine.

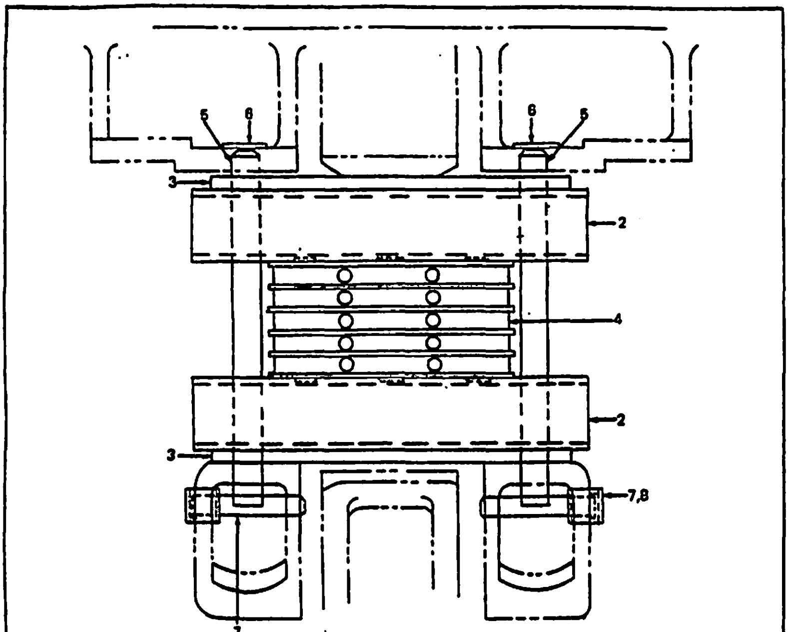
General Electric has developed a welded cylinder head and liner assembly to improve diesel engine reliability. These assemblies have been field tested for over five years on several domestic and overseas railroads and engineering has now released them for production.

The welded head-liner is a single assembly, replacing the individual cylinder head and liner. The spiral wound top liner seal and the back-up silicone seals are eliminated, replaced by a strong, full penetration weld. This assembly utilizes a steel liner with a hardened (Melonite) bore.

Member roads agree that the welding of the head and liner developed to overcome compression gases from entering the water system, which is commonly referred to as "black water fever," will reduce and/or eliminate the compression leaks. However, the builder in doing so has developed a unique combination for the railroads. This welded head-liner assembly does not permit the railroads to rework the liner bore, cylinder heads, valves or valve seats, with their present tooling.

The fire deck seals are among the most difficult design tasks on diesel engines. This seal area has been under continuous engineering development and testing for many years.

The processes used to manufacture the welded head-liners are sophisticated, mating nearly finished machined parts. This joining must leave very small head affected zones and low residual stresses. Liner bore distortion must be kept to a minimum and correct head



Ref. 1
(Representative Illustration)

Ref. No.	Part No.	Quantity Required Column A	Quantity Required Column B	DESCRIPTION
1	41B515916G2	1	-	MOTOR SUSPENSION
1	*41B515916G4	-	1	MOTOR SUSPENSION
2	41B515915G1	2	2	* SEAT with wearing plate
3	41B515915P2	2	2	#PLATE, wearing
4	41B515914P1	1	1	MOUNT
5	4768526P4	2	-	PIN, guide
5	*4768526P10	-	2	PIN, guide
6	41A210496P8	2	2	#WASHER, guide pin
7	6851284P2	2	-	PIN, stop
7	*6851284P3	-	2	PIN, stop
8	N503P2224B	2	2	COTTER PIN, retainer, 1/4 in. dia. by 1 1/2 in.

ILLUSTRATION

C-9996

*Added or changed since last issue.
#Must be welded in position when furnished separately.

GENERAL ELECTRIC

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Fig. 15

to liner concentricity maintained. Electron beam welding (in a vacuum) has been acceptable and inertia welding is under development.

It is projected that this combination will significantly reduce the number of cylinder changes due to leaks between scheduled maintenance intervals. However, cylinder assembly service life continues to depend on many factors including duty cycle, valve wear, jacket seal, liner bore and piston ring wear, etc.

General Electric will make available a unit exchange service on welded assemblies. Tooling to recondition valve seats is being developed along with other repairs. Liner replacement will be available if economical. Chrome plating remains available to salvage worn bores. Additionally, tooling is being developed to allow for cylinder head rebuilding and application of a new steel liner, in an effort to reduce modernization costs and allow the railroads to convert to EB assemblies at a more economical cost.

It should be understood that used cast iron liners cannot be used in this type of conversion because they can not be welded successfully.

4. Rotor assemblies in turbochargers have experienced more damage on 12 cylinder 7FDL engines and the cause appears to be the higher exhaust temperatures, not foreign material.

5. Camshaft lobes are experiencing a higher rate of pitting and/or etching. Nearly 100% of all cam sections have to be ground with a scrap rate of one section in twelve on 7FDL 16 cylinder engines. Camshafts on 12 cylinder (7FDL) engines are scrapped at a rate of three sections to one.

The builder has reviewed with member roads the necessity of the volume of grinding involved, and has provided to the railroads information in the form of a manual, GET 6337, to establish a more selective grinding criteria of the cam lobes to be ground.

Member roads are concerned as to whether the *increased* wear rates on the camshaft lobes are a result of the increased operating pressures on the 12 cylinder engine.

III.

CHROMIUM PLATING AND ITS USES

In the late 1930's, research was performed to develop a chromium plating process to utilize the exceptional hardness of chromium metal as a wear surface. There were many major problems to be solved such as bath concentrations, a proper catalyst and good bond. These problems as well as many others that were encountered were finally overcome. In the 1940's, the use of chromium as a running surface became a major factor, not only on new parts but as a method of restoring worn parts such as cylinder liners, crankshafts, piston rods and other machine parts.

The two predominant types of chromium deposits used in the industry are dense hard chrome and porous chrome. Some of their applications.

Dense Hard Chrome

Electroplated main and pin bearings of crankshafts

Camshaft main bearings

Piston ring grooves

Piston rods of all kinds

Porous Chrome

Internal bores of cylinder liners

Piston rods of all kinds

Piston ring grooves

Piston rings

DENSE HARD CHROME is primarily used on surfaces where extreme hardness is necessary. This type of chromium is usually plated from a conventional chromium bath. Various combinations of temperature and current density can be utilized for this type of plating, though they make little visible difference in the finished product.

POROUS CHROME is plated from the same baths as dense chrome, and at various temperatures and current densities. The plating parameters, however, strongly influence the resulting porosity. There are three types of porosity that can be developed, each with distinctive characteristics: channel, intermediate and pinpoint.

Porosity is developed after plating by: 1) etching the surface with reverse current in a chromic acid solution without sulfate; and 2) honing with aluminum oxide stones. The etch process opens up the inherent channel structure, and the hone breaks up that structure to the desired finish and size.

All of the processes involved, however, must have been done correctly to get the correct result.

The second method of inducing porosity, such as on the internal bore of a combustion cylinder, is to hone the plated surface with diamond honing stones. Since a diamond is harder than chromium, it is used as a honing medium to induce porosity into the chromium surface.

The plating bath is a solution of chromic acid, H_2CrO_4, a very strong, oxidizing acid. The concentration of this acid is about 33 oz/gal. An additional necessary ingredient is a small amount of some other anion, usually sulfate, at a concentration of about 0.33 oz/gal. The ratio of chromic acid to sulfate should be in the range of 90-110 to 1.

The part to be plated is the cathode, or negative electrode. The positive electrode, the anode, is made of lead. The anode and cathode are usually in some kind of fixture that holds them close together with considerable accuracy.

The plating current is then passed thru this cell: direct current is

used, plus to anode, minus to cathode. Fairly massive currents are used.

What actually happens below the solution surface is quite complex. At the cathode surface, hydrogen is discharged and most of it escapes uselessly as hydrogen gas. A very small amount of the hydrogen reacts with the chromium chemicals and the sulfate to produce the metallic chromium on the cathode, and some trivalent chromium in the solution.

At the anode, the oxidizing conditions re-oxidize the trivalent chromium back to useful chromate ions.

HARDNESS: There are several methods of measuring the hardness of materials, notably Brinell, Rockwell and Knoop. Brinell and Rockwell are usually used in testing materials that have hardness ranging from low up to the mid-60s on the Rockwell C scale. These two methods of checking hardness are in most cases considered non-destructive, but they can not be utilized in checking hardness of chromium.

The Knoop test is a destructive method of testing, where a sample of the material to be tested is physically removed from the surface, cross-sectioned and mounted in plastic. This exposes the chromium and the basis metal. After metallographic polishing, the specimen is mounted in the Knoop indentor and the cross-section of the chromium is indented under very light load. The indentations are measured under high magnification. The Knoop Hardness Number is then calculated from the length of the indentation and the constants of the indentor. Chromium hardness on the Knoop scale usually ranges from 800 to 1150.

SURFACE FINISH can be measured with a profilometer. This instrument has a diamond stylus which is moved over the surface either manually or mechanically. The electrical impulses from the stylus are amplified, and indicated or recorded as a weighted average reading.

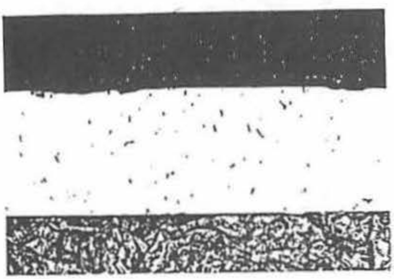
A more sophisticated instrument is the Talysurf, which not only indicates average surface roughness, but which also extensively analyses the data. Skewness, for instance, shows the extent of subsurface porosity if there is any.

Surface finishes in the liner industry are routinely viewed through a borescope. This instrument allows the user to look at a surface at 50x magnification; it is portable and can easily be traversed over the entire liner surface.

A permanent record of a porous surface can be made with Faxfilm. When properly done, the Faxfilm makes an accurate impression of the surface. This can be projected on a screen, even several years later, faithfully reproducing the original surface.

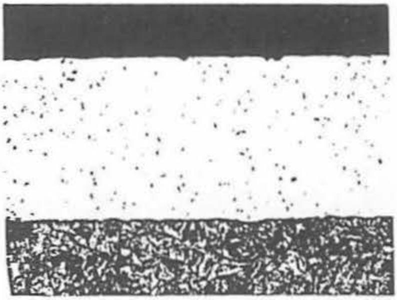
CONCLUSION. The use of chromium as a running surface for new and used parts has proven to be very beneficial. Chromium has many unique properties which make it ideal for this service: high hardness, low coefficient of friction, excellent heat transfer, high resistance to corrosion in most cases, and it provides an excellent, lubricated running surface. Utilizing chromium as a method of repair is usually done at a considerable saving in cost, in most cases 20 to 50% of new, and the life of the repaired part is usually equal to or better than new.

The chrome plater's lot is not a happy one. Consider just one item: all of the chromium that is plated comes from purchased CrO_3, chromic anhydride. A hundred pounds of this is quite expensive, but what do we find? Only 52 pounds of chromium metal in the drum! See Figures 16-25.



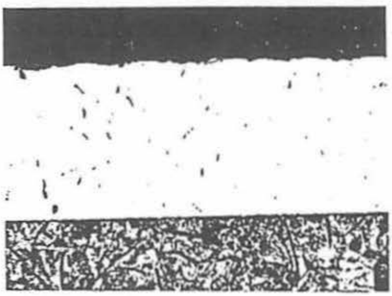
100X

Metallographic Section of
#1 Chromium Plate on Cast Iron
Fig. 16



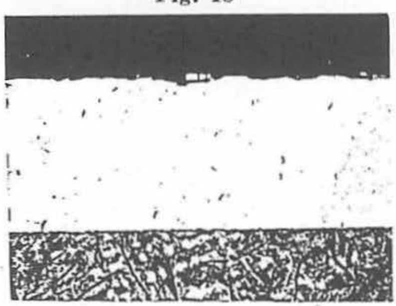
100X

Metallographic Section of
#2 Chromium Plate on Cast Iron
Fig. 17



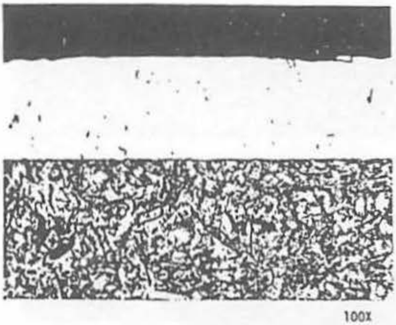
100 X

Metallographic Section of
#3 Chromium Plate on Cast Iron
Fig. 18



100X

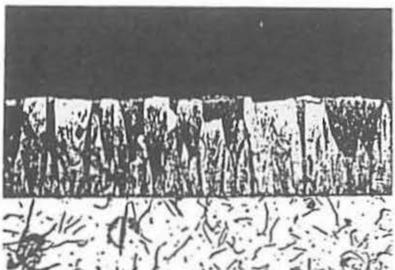
Metallographic Section of
#4 Chromium Plate on Cast Iron
Fig. 19



Metallographic Section of
#5 Chromium Plate on Cast Iron
Fig. 20

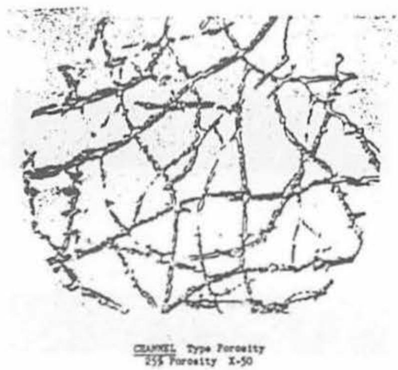
Metallographic Section of C-78B301
Chromium Plate on Cast Iron
Showing Details of the Bond
Interface
Note that the interface between the chromium and cast iron is essentially a grain boundary. There are no gaps or contaminating layers between the plating and the substrate.

Fig. 22

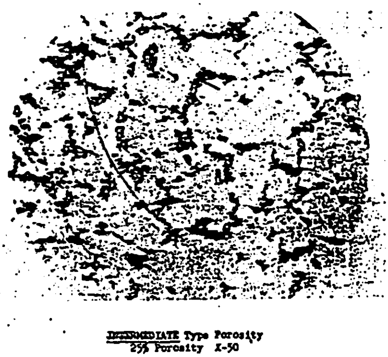


Columnar grains with growth axis normal to the cast iron interface. There was no indication of intergranular porosity. Porosity was essentially within grains.

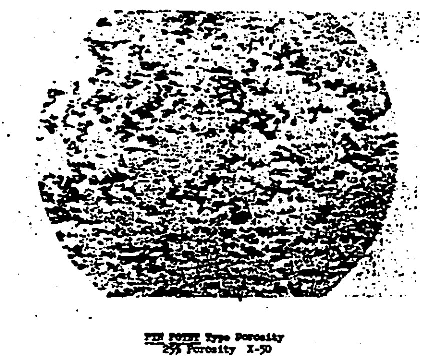
Fig. 21



CHANNEL Type Porosity
25% Porosity X-50
Fig. 23



INTERMEDIATE Type Porosity
25% Porosity X-50
Fig. 24



PIN POINT Type Porosity
25% Porosity X-50
Fig. 25

IV.

DEVELOPMENT OF A NEW DIESEL ENGINE FOR HEAVY-DUTY LOCOMOTIVE SERVICE

R. M. Dunton
Director, Research & Development
Rail and Diesel Products Division
Bombardier, Inc.

Abstract:

Future trends in locomotive operation indicate the need for continuing improvement in efficiency and reliability as the pressures of fuel cost and labor cost increase. In addition, ongoing improvements in electric traction equipment and controls will increase adhesion capabilities, which, in turn, will only be fully utilized when horsepower is increased.

To meet the above requirements in the future, a new diesel engine has been designed. It is currently undergoing prototype testing to prove performance and durability. When introduced to the market in a few years, this engine will have higher specific power than any current locomotive engine, while consuming less fuel.

This paper describes the design work done, outlines the important features of the engine, and discloses the preliminary performance of the prototype engines.

DIESEL MECHANICAL MAINTENANCE

Six-Year Index

1985

Maintaining Today's New Technology For Quality Performance

1. Procedures for Storing Serviceable Locomotives for Quality Performance
2. New Locomotive Service Problems, EMD and GE
3. 92 Day Service Requirements: EMD, GE and Bombardier

1984

Will Today's New Technology Simplify Tomorrow's Maintenance?

1. Mechanical Aspects of New Locomotive Designs
2. Maintenanace of Locomotive Components

1983

Cost Control and Extended Service Life Through Improved Maintenance

1. Leaks: Cooling Water, Lube Oil, Fuel Oil and Air
2. Torquing Recommendations
3. Update on Fuel Efficient Locomotives
4. Radiator Screens
5. Alternate Starter Systems

1982

Quality Maintenance — The Key To Fuel Conservation

1. Fuel Conservation — Effects on Maintenance
2. Fuel Conservation — What It Costs
3. Diesel Fuel Receipt and Disbursement
4. Turbochargers

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Increased Service Life Through Improved Technology

1. Running Gear
2. Filtration
3. FRA Rules
4. Follow-up on Previous Topics

1980

Fuel Economy through Improved Maintenance in the Coming Decade

1. Fuel conservation
2. Winterization
3. Utilization of on-board load test
4. New FRA Rules
5. Welded crankshafts

J. F. McDONOUGH
Asst. Vice President Mechanical
Union Pacific Railroad Co.
Omaha, Nebraska

LMOA wishes to express its thanks to Union Pacific Railroad for again hosting Pre-convention Presentation in Omaha.

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

Our thanks again to Mr. J. F. McDonough and others responsible for and participating in this activity.

Monday, September 22, 1986

10:00 A.M.

REPORT OF THE COMMITTEE ON NEW DEVELOPMENTS

Pre-Convention Presentation: Omaha, NE

April 2, 1986
Red Lion Inn
Omaha, NE

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Senior Engineer-Locomotive
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PERSONAL HISTORY
MICHAEL M. STARR

Native of Pennsylvania, Mr. Starr grew up in the Pittsburgh area. He received his Bachelor of Science Degree in Electrical Engineering from Carnegie-Mellon University and then went to work for the United States Navy. He served on board nuclear submarine USS Kamehameha SSBN642 as a nuclear-trained officer where he held positions as Ship's Electrical Officer, Communications Officer and Operations Officer.

He left the Navy to work with Ford Motor Company in their design department at Dearborn, Michigan in the Heavy Truck Division. He later relocated to the San Francisco Bay Area to work for the Southern Pacific Railroad.

Mr. Starr began his career at Southern Pacific as Electrical Design Engineer and presently holds the position of Senior Locomotive Engineer.

Mr. Starr is presently taking prerequisite graduate courses for the MBA program at the University of California, Berkeley.

He and his wife Karen have a daughter, Christina Marie. Mike and Karen both enjoy backpacking, going to the symphony, and their salt-water fish aquarium.

I.
FUTURE TRAIN CONTROL SYSTEMS

In the railroad industry since the second world war, two major technological changes stand out from all others. The first was the shift from steam to diesel. The second was the change from pencil and paper to data processing. We believe that the shift to microprocessor control of train movement will provide a third change, at least of equal importance with the other two, shifting emphasis from railroad signaling in the traditional sense to the broader issue of train control.

There are two major future train control systems being developed in North America. One of these is the Advanced Train Control Systems project funded jointly by the AAR and the Railway Association of Canada; another is the *ARES* (Advenced Railroad Electronics) Project being developed by Rockwell Collins.

This paper will address the first of these systems, the Advanced Train Control System (ATCS).

This project began with a special task force charged with developing a single all-encompassing specification that could be used to provide leadership to the supply industry on how the rail industry wants to control train operations in the future, and what elements of control are needed.

The principal objective of the ATCS is to improve the economic, operational and safety performance of North American railroads through the application of microelectronics technology to train movement control. In other words, the railroad industry is looking for ways of improving its competitive position by using recent advances in micro-electronic technology for controlling train movements and monitoring mechanical operations.

Advanced Train Control Systems will:

1. Expand and enhance train control capabilities by adding new features and improving the flexibility of present train control systems. The modular approach will make it operationally and economically feasible to implement train control systems on low traffic lines where installation of existing technology cannot be justified.
2. Maximize utilization of existing fixed plant — that is, line and yard trackage — in some cases reducing the need for costly plant expansion expenditures, and accommodate required plant modification and expansion more easily, with minimum hardware replacement and traffic disruption.
3. Provide more precise control over train operation leading to higher productivity through better utilization of the railroads' major resources — personnel, physical plant, fuel and rolling stock — and more accurate management of train conflict.
4. Improve decision-making by providing more comprehensive and timely operating information to train dispatchers and control centers; and...
5. Provide more positive controls than currently exist to prevent unauthorized train and engine movement, overspeed operation, and to protect track maintenance forces. Currently, complete safety depends on human alertness and strict obesrvance of operating rules. A data signal in the locomotive cab will close the control loop. It will be possible to enforce speed limits; provide positive enforced protection of field forces, and so on. Safety is enhanced with this more positive, enforceable and comprehensive control system.

The overall design concept is that of a modular system with sufficient flexibility to allow the user railroad to apply the degree of simplicity or sophistication that best suits its scale of operation. To achieve these objectives, ATCS will consist of six main subsystems, each made up of from two to 14 optional modules.

The presence detection, train identification and location subsystem is the most basic, required for every implementation of ATCS beyond conventional train order or the most basic form of manual block. The modules will detect the presence of trains, locomotives and cars; detect the presence of track equipment; make positive identification of locomotives and monitor the location and movement status of trains. One module of this subsystem would also identify the engineer and automatically record employee data for use with crew management and payroll systems.

The optinal track and route integrity subsystem would continuously monitor track and route integrity. And more sophisticated detection systems would, for example, distinguish between stop indications caused by wet ballast, broken rail, and track occupancy. Depending on the level of complexity installed, this subsystem would be able to identify the types of track or route abnormality and make these data available to the dispatcher and/or the locomotive cab.

The ancillary systems interface subsystem consists of two optional modules. One module would interface with automatic grade crossing devices and various detection systems, such as defective equipment detectors. The other would interface with onboard locomotive sensing devices for both diagnostic and historical data purposes.

The switch control subsystem consists of four optional modules which would monitor and control switches - from the dispatcher's office, or, conceivably. from the locomotive itself.

The train control subsystem is the heart of ATCS. It consists of 14 modules, most of which are optional, and will provide the route and interlocking logic, an ability to put all movement authorities and operating instructions into the locomotive cab and display them, speed regulation, and automatic enforcement of movement instructions. It will also provide the necessary interface with track forces to ensure optimum productivity and safety with minimum detriment to train operations.

An optional module would provide on-board train handling assistance, by analyzing route characteristics and train handling parameters, and offering train handling advice aimed at controlling buff and draft forces, and optimizing fuel consumption.

The final subsystem is the management of train operations subsystem. This is a high level management system that will tie together train control and other related management information systems.

ATCS will be an extremely flexible system of train control, adaptable to the needs of the users. The 39 modules making up the six subsystems can be configured to provide the user railroad with the degree of control that best suits its scale of operations. And it will be upgradable — that is, each additional module will be upwardly compatible with the existing systems; therefore, a user railroad can enhance its present form of train control without throwing out its existing system.

ATCS will be a very communications-intensive system. It will expand communications between the

trains and dispatchers' offices, change information back and forth from voice to data transmission, and finally, make data communications to the locomotive a vital function.

The most promising communication links appear to be conventional radio (VHF or UHF) or satellite.

A special task force representing 18 railroads, the AAR, and the Railway Association of Canada is directing development of this project. The task force is addressing the following issues:

System Engineering
Economic Assessment
Operations
Communications Engineering
Signal Engineering
Computer Systems
Locomotive
Track & Roadway Engineering
Research
Regulatory Liaison

In February of 1985, a contract for system engineering was signed with a consortium led by ARINC Research Corporation. ARINC has already delivered a functional review of ATCS. The report includes:

1. An identification of the components of ATCS;
2. A preliminary assessment of where the functions will be performed;
3. A preliminary architecture for the components that will be located on the locomotive;
4. A description of five levels of ATCS implementation; and
5. Documentation of the various systems with which ATCS will have to interface.

Some preliminary work has also been done to define message structure — that is, the number and types of messages that will be transmitted to the locomotive. Simulations have also been run to determine the load on communications channels.

A system architecture has been agreed to leading to test installations this year and implementation in 1987 and beyond.

Preliminary indications suggest that the economics of ATCS will be favorable. As yet, there is no detailed estimate of the costs of providing each ATCS function. Cost estimates are currently being developed by ARINC; however, the analyses are still at an early stage. Meanwhile, the benefits are being assessed by the railroads.

ARINC's preliminary estimates of cost are somewhat lower than expected. Generally, ATCS should cost less to install than CTC; however since ATCS will provide substantially greater capabilities than CTC, the real costs will be significantly lower. ARINC estimates that the cost of equipping a major dispatcher's office should not exceed $500,000. Simple basic systems, which would provide train location information on low traffic routes, may cost as little as $3,000 per mile; more complex mainline installations, which would provide most of the control options out-

lined earlier, may be available for less than $25,000 per mile, or about half the cost of CTC.

The cost of equipping a locomotive has been estimated at $25,000 to $50,000, depending on what information is to be provided. It is unlikely that all road locomotives would be equipped as lead units . . . but all locomotives might be wired to accept various components in order to allow a single control module to be moved from one unit to another as needed.

Although a firm dollar estimate of the benefits to be derived from Advanced Train Control Systems is not yet available, preliminary indications of potential benefits are also very encouraging. First and foremost, ATCS will provide overall higher quality service through smoother, more predictable operation with fewer and shorter disruptions. Here are some of the operational benefits:

1. The track and route subsystem will eliminate many unexplained stop indications.
2. Flagging, to protect situations such as impassable track or a train stopped by an emergency brake application, will no longer be necessary.
3. With more and better information, there will be less reason for conflict between trains and track forces.
4. The modular nature of ATCS will significantly reduce disruptions as a result of plant changes, and ATCS will require less field testing than conventional relay-based signal technology.
5. And, very stringent performance standards will be specified for any new system; failures cannot be altogether eliminated, but when failures do occur, they will be on the safe side, and the self-diagnostic features of ATCS will significantly reduce recovery time.

Savings in fuel and train crew costs are expected to produce reductions in overall operating costs. These benefits will be derived from:

1. Improved fuel efficiency and better train handling: More precise speed control will enhance fuel conservation. For example, the automatic look-ahead capability of ATCS will permit more efficient pacing as trains are slowed instead of stopped when they are early for a meet or approach areas of congestion.
2. Crew savings are expected to be achieved through reduction in costs due to deadheading, overtime, and initial and final terminal delay.

Some possible additional benefits are:

1. Reduced maintenance cost: ATCS will be more reliable on a system level than CTC, and is seen ultimately as a potential replacement for conventional wayside signal systems.

2. Improved train dispatcher productivity and the probable elimination of the traditional inefficient train order method of train control.
3. Improved safety of operation: It is estimated that at least 15% of the cost of derailments can be avoided with ATCS by providing overspeed protection and stopping the train if the engineer fails to respond to instructions.
4. Important implications for expanded cabooseless train operation. ATCS can provide rear end protection in dark territory.
5. Positive block-out enforcement, to improve the safety of track maintenance personnel and equipment.
6. Enhanced utilization of locomotives, cars, and facilities.

It is generally recognized that efforts to estimate the benefits to be derived from the implementation of computers and related microelectronic technology have consistently understated full operational and economic impact. Therefore, estimates probably err on the conservative side. And no attempt has been made to predict the potential benefits of an improved ability to compete with other transportation modes. This might prove to be the largest benefit of all.

The time has come for future train control systems. There is a large base of industry support.

Many believe that there can be no better way to develop these systems than to make use of the full range of industry ingenuity and expertise available to us. In this committee's opinion, the technology is available and the potential economic benefits should make future train control systems a high priority for the industry.

II.
BRINGING FUTURE TRAIN CONTROL SYSTEMS BACK TO EARTH

With the technological capabilities that exist today, the industry can virtually eliminate the commercial signal systems, through wayside automatic marker systems or through remote satellite communications.

The determination to be made is one of cost/benefit and not technology or manufacturing; to determine the R.O.I. for such a change.

Assuming that the R.O.I. is sufficient to cost-justify such a change with the signal and communications system, then we as officers of the Mechanical departments must address the issue of how these systems of communications can be utilized to enhance unit reliability and real time condition reporting of unit performance while enroute.

If we were to let emotions address this issue, we could become very excited about the capabilities that such future system could afford the Mechanical department with respect to enroute unit performance; however, to survive in the business climate of today, we must set our emotions aside and perform a thorough cost/benefit analysis to determine need and performance.

It seems that reliability is basically a function of design, which becomes optimal when the designer clearly understands the environment in which the equipment will operate.

If that is a reasonable assessment, then it would appear that our interests would be best served by having on-going dialogues with the originial equipment builders, leading to the preparation of well-conceived specifications covering the building and rebuilding of locomotives. Also it is necessary that the following conditions exist:

— proper facilities available,
— proper tooling available,
— adequate work force skill levels,
— sound materials procurement, distribution systems, educational programs for supervisors, and craftsmen, and an on-going, effective "quality assurance program."

If the real issues of reliability are not addressed, then the most modern communications system will only advise us of our failings in a more timely manner.

Perhaps money would be better spent in developing a more reliable unit with on-board computers that provide enroute circuit/performance analysis.

This is the path the industry must take to gain train performance superiority and to reduce the costs that are incurred today through high unit out-of-service time due to unreliable equipment.

A survey was made of the major railroads concerning future train control systems and the advantages they might have for locomotive fleet availability and reliability.

The views expressed in the survey indicate that the most obvious advantages to the railroads would relate to safety. The system would produce exact data on train identification, speed and location; it could replace all existing signal systems and it could control high-rail and track maintenance equipment. The locomotive information system could receive and display data such as clearance, slow orders, consist information, wayside detector interface and train annuciation.

Future train control systems are technically appealing in the area of maintenance cost savings. Having the ability to monitor on-board parameters such as horsepower, fuel utilization/consumption, engine/turbo temperatures, oil pressures, and overall locomotive performance would have many advantages in terms of both identifying failure trends and providing pertinent trouble-shooting information. For example, if a locomotive was reported as partially loading, it could be checked while it was in operation to confirm that the partial-loading condition existed and the accompanying engine operating conditions identified. This information would do much to reduce misinterpretation and identify the causes of partial-loading or no-loading situations.

Likewise, similar information could be developed with regard to dynamic brake operation by transmitting locomotive operating conditions to a maintenance facility prior to the locomotive actually arriving there; significant savings in down time for trouble-shooting and system evaluation would exist. Prior to shopping units at scheduled maintenance and intervals a data dump could be made of the historical performance and appropriate corrective action taken to correct deficiencies as necessary. Finally, this system would also allow an easy method of monitoring horsepower hours to record the amount of work performed. This would allow an accurate method of determining scheduled maintenance and overhaul intervals.

The ATCS Locomotive Task Force is addressing what information about locomotive health should be gathered, processed, and transmitted over the data link. While full instrumentation of the engine, engine support systems, air compressor, and electrical system is possible, it's clear that it is not cost-effective to monitor everything. For example, it may be possible to monitor cylinder firing pressure to determine if injectors and power assemblies are functioning properly. However, if the pressure transducers are only as reliable as the power assemblies and injectors, there would be as many shoppings for failed transducers as for legitimate failures, which is clearly not desirable. More useful information would involve measuring generator power output and determining if proper power is being produced. This would help eliminate operation of "sick," inefficient, and potentially unreliable locomotives by ensuring that they receive attention at the first opportunity.

More detailed advance information on where the trouble lies would reduce trouble-shooting time and could ensure that locomotives are shopped at locations that have proper repair material on hand. However, the sensors and intelligence that need to be built into the locomotive to provide this detail must be cost effective.

The FTCS equipment necessary for train control can affect the railroads' Mechanical departments in two ways. First, FTCS may control certain equipment now on locomotives such as cab signal/train stop equipment, speed/event recorders, speed indicators, MUTH "fuel saver" switches, deadman/alerter systems, and EOT displays, thereby eliminating the maintenance of presently installed equipment.

FTCS equipment can also be used to help detect substandard and inefficient performance of lo-

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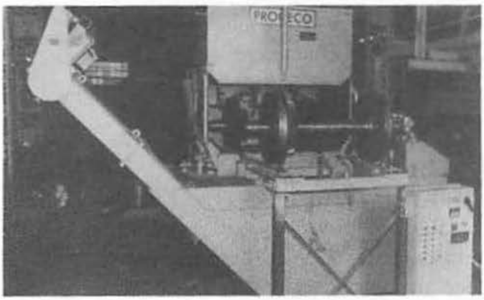

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comotives in a very timely manner, providing savings from avoided road failures and train delays, decreased fuel consumption, and less shop time. These are the same benefits that are derived from increased reliability. It is hoped that the incremental cost to add this capability to FTCS will be sufficiently small to justify these benefits.

Several areas must be addressed in order to enhance locomotive availability and performance. There is no substitute for well designed quality equipment to improve the reliability of operations. However, further enhancement in "on condition" monitoring of equipment performance will reduce maintenance costs and increase locomotive availability.

III. LOW MAINTENANCE LOCOMOTIVE BATTERIES

Although the lead-acid type of storage battery has been in use since the introduction of the diesel locomotive, it is one of the items most often forgotten when new developments are discussed.

The locomotive battery has come a long way over the years, as have the systems that support it. The most obvious changes have been in the packaging, which has gone from groups of four-cell batteries to 16-cell unitized batteries with maintenance intervals of up to five years.

To better understand the significance of the term "low maintenance" when applied to the locomotive battery, it is helpful to understand its uses, principle of operation, and its environment.

The locomotive battery provides large quantities of power over a short period of time, essential for starting high horsepower diesel engines, and can be recharged at low rates over long periods, consistent with the intervals of time that locomotives operate between shutdowns. The reduced charging rate requirements allow axiliary generating equipment to be sized primarily for continuous operating requirements rather than for rapid battery charging.

The battery also provides a reservoir to supply make-up current when auxiliary generator output is less than demand. It also acts as a filter that tends to smooth out voltage spikes caused by the cycling of control relays and power contactors.

The principle of operation of the storage battery is based on electrochemical action, where two different types of lead are acted upon by a solution of dilute sulphuric acid or electrolyte (H_2SO_4).

In a fully charged battery cell, the active material of the positive plate is lead peroxide (PbO_2) and the negative plate is sponge lead (Pb).

As a cell is discharged, the electrolyte (H_2SO_4) divides into H_2 and SO_4. The H_2 combines with oxygen (O_2) formed at the positive plate, and produces water which

dilutes the remaining electrolyte and reduces the specific gravity.

The SO_4 combines with the lead of both plates forming lead sulphate ($PbSO_4$).

When the cell is placed on charge, the reverse takes place. The acid in the sulphated material is driven out, and the specific gravity increases. The cell is fully charged when all of the acid has been driven back into the electrolyte and the specific gravity is at its maximum. Additional charging will not raise the specific gravity any higher.

As the cells approach full charge, they cannot absorb all of the energy from the charging current. The excess current will cause electroysis of the water in the electrolyte, into hydrogen (H_2) and oxygen (O_2) which will bubble from the cell and be vented from the battery. It is this gassing of the cell that is the primary reason for the required periodic addition of water.

It is the charging of the battery cells that has the greatest effect on the overall life and performance of the battery. The battery should receive the "correct" amount of charge (controlled by charging voltage) sufficient to fully charge the battery and maintain that level of charge, but not more. Undercharge or overcharge should be limited to that which is practical under the particular application.

Continued insufficient charge, even to a small degree, can cause gradual sulphation of the negative plates with a resultant loss of cell capacity and reduced battery life. An undercharged cell will have a low specific gravity, which could lead to freezing in cold weather, resulting in destruction of the battery.

Continued excessive charging will tend to corrode the positive plates, physically weakening them and also decreasing their conductivity, resulting in high internal losses. Overcharging at relatively high rates will cause excessive gassing which can not only cause physical damage to the plates, but also will result in excessive water use.

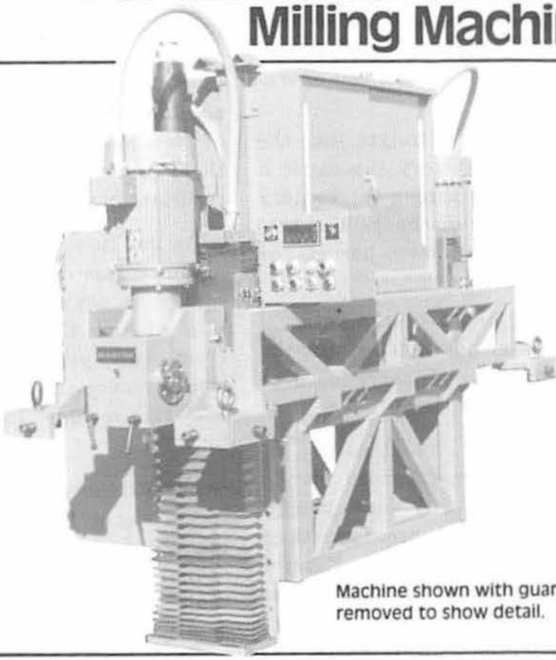
It is therefore essential that the battery charging system be properly maintained in order to obtain the maximum life from the batteries whether they are of the older types or new "low maintenance" types.

As indicated earlier, the gassing of the battery cells during the charging cycle is the primary cause of water use and required periodic addition of water, that is normally referred to under the term "battery maintenance".

Much battery damage can be done during the periodic addition of water if care is not taken. In many cases, the battery cells are overfilled, resulting in excess dilution of the electrolyte, and if filled to the point of overflowing, electrolyte will be lost. Electrolyte washed into the battery compartment can cause undesired corrosion

MASTER®

Portable Pedestal Jaw Milling Machine



Machine shown with guards removed to show detail.

EXCLUSIVELY FROM MASTER.

MASTER MACHINE TOOLS' Portable Pedestal Jaw Milling Machine is a heavy duty portable machine tool designed exclusively to machine pedestal jaws on any diesel locomotive truck frame.

The Mill clamps in minutes to a locomotive truck frame that has been turned upside down. Jaw faces are then quickly & accurately machined to close tolerances. Opposing jaw faces are milled without remounting the machine.

TWO MODELS AVAILABLE

- Single ended to mill one side, then be turned and mill the other.
- Double ended that will mill both sides of the frame without being reset or turned.

INCREASED ACCURACY AND JAW LIFE

REDUCED MACHINING AND HANDLING COSTS

Actual user reports have shown savings as high as 50% over old methods of grinding and machining and the need for fewer repacements due to the increased accuracy of the machining operations.

MASTER MACHINE TOOLS, INC.

AMSI Subsidiary

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of the battery compartment. Over flushing is a major cause of battery failure.

If the proper type of deionized or distilled water is not used, contaminants can be introduced into the cell which can damage the cell plate material or inhibit cell operation.

Spillage of electrolyte on the surface of the battery can cause a conductive path across the battery that can slowly discharge the battery during shutdown periods or short it to ground.

Extending the required interval between water addition reduces the chances for improper servicing over the life of the battery.

As locomotive maintenance intervals have been extended due to continued component development, changing maintenance practices and lengthened mandated Federal inspection intervals, it has become essential to develop locomotive batteries that would operate for the extended intervals without the addition of water.

Many of today's locomotive batteries have been designed to operate up to 24 months between watering, accomplished primarily by increasing the level of free electrolyte above the active battery plates.

The 24 month interval coincided nicely with the two-year Federal inspection requirement. However, as the requirement has been extended to three years and could possibly go to four years, it would be of great benefit to extend the required battery maintenance interval to coincide.

True "low maintenance" batteries have been introduced that will extend the required watering interval up to five years. This has been accomplished through development of "low loss" active plate materials that greatly reduce gassing and resultant water usage.

As mentioned earlier, one of the major causes of premature battery failure is over-flushing. A reduction of the flushing requirement from two years to five years, would reduce the chances of short-life failure due to over-flushing by 60%.

The extended interval will allow scheduling periodic battery maintenance during a major locomotive shopping in which the batteries could be removed for proper inspection, servicing and cleaning. In fact, the newest "low maintenance" five-year interval battery is equipped with a snap-on cover over the filler/vent caps that requires removal of the battery from the locomotive in order to remove the cover for service.

While most of the development work on "low maintenance" batteries has been in the area of extended water addition intervals, work has also been done on cell plate construction, improved battery case materials, and battery case sealing.

It should be noted that the maintenance intervals stated are preceded by the words "up to". It is essential that charging systems, cable connections, and battery compartment securements and covers are properly maintained in order to obtain the maximum maintenance intervals designed into the batteries by the manufacturers.

Extremes of temperature will also have an effect on maintenance intervals. High ambient temperatures can contribute to higher than normal water usage raes.

Battery manufacturers have made great strides in the development of "low maintenance" locomotive batteries. Now, how about a "no maintenance" battery!

IV.
ELECTRONIC ENGINE CONTROL SYSTEMS

In the past, locomotive engine governing has for the most part been accomplished with mechanical-hydraulic governors with either electrically or pneumatically operated speed settings. Four valves or solenoids are actuated in various combinations to give a series of engine speed settings. In most cases eight speed settings are used but as many as 16 can be established with the four inputs available.

Recently electronic locomotive engine controls have been developed which obtain speed settings from and interface with the same

ENGINE SPEED CHART

THROTTLE POSITION	GOVERNOR SOLENOIDS ENERGIZED				NORMINAL ENGINE SPEED RPM
	A	B	C	D	
STOP				*	0
IDLE					315
1					315
2	*				395
3			*		479
4	*		*		560
5		*	*	*	649
6	*	*	*	*	734
7		*	*		815
8	*	*	*		900

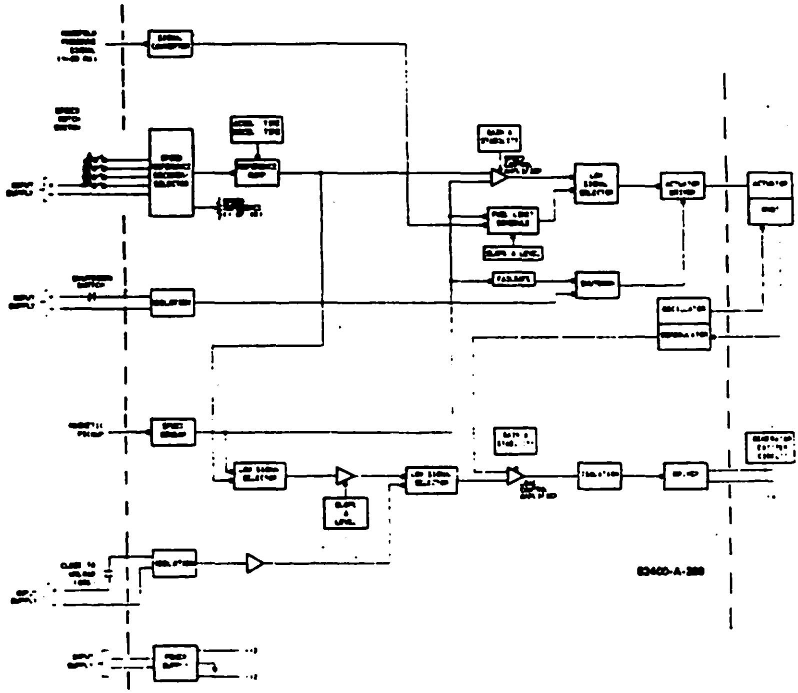


Figure 1. Block wiring diagram for electronic control for use on locomotives.

four inputs available from the existing locomotive throttle controls. The individual speed settings can be programmed at whatever set points are needed. Options available include voltage and current outputs to control the excitation and therefore the load on either an alternator or DC generator.

The electronic engine control system consists of the electronic control box, engine speed sensor, rack position sensor and rack actuator.

The electronic control box determines what the engine speed and load should be based on the individual locomotive operating parameters which have been programmed into the integrated circuits of the appropriate module and these inputs: throttle notch selector, fast/slow acceleration selector, operator shutdown, generator load, and wheel slip. The electronic control box continually monitors the engine speed and load. It makes corrections to the engine fuel setting and to the generator

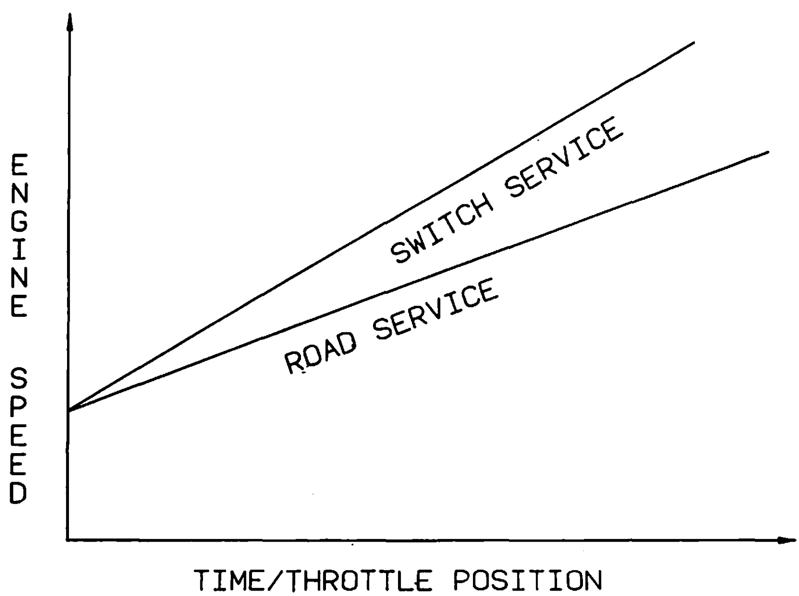
excitation. Thus engine speed and load are precisely controlled.

The engine speed sensor consists of a magnetic proximity detector which is mounted adjacent to a gear which is driven directly by the engine. The sensor detects gear teeth as they go by and generates a corresponding AC voltage. Electronics change this AC voltage into a digital voltage signal. This signal is supplied to the electronic control box as a measure of engine speed.

The fast/slow acceleration selector may be desirable for locomotive units which are used in both switching and road service. This is accomplished by the use of two different ramp rates or rates of response of engine speed and load to throttle signal change. A fast ramp rate can be programmed into the electronic governor for the quick acceleration needed in kicking cars. A slow ramp rate can be programmed for road service where it is desirable to avoid rapid changes in train forces. Selection of the acceleration rate is made with a manual switch at the control stand.

The rack position sensor measures the fuel rack setting. Fuel rack setting controls the fuel being injected into the engine. The output of the rack position sensor is another digital voltage signal which is supplied to the electronic control box.

The rack actuator is generally an electro-hydraulic device mechan-



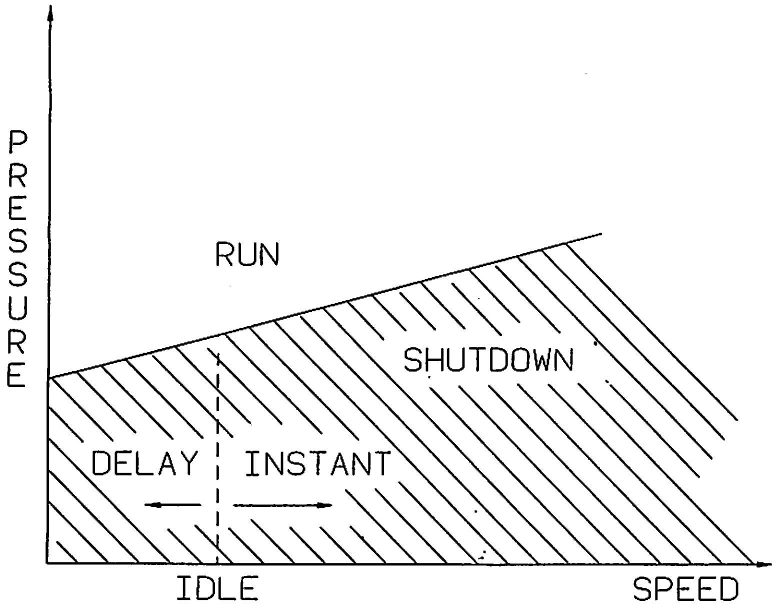
ically connected to the fuel rack. The actuator converts the electrical signal from the electronic control box into a fuel rack setting. The electrical signal controls solenoids which actuate an armature that is connected to a pilot valve. This pilot valve controls the flow of oil between an oil pump and a power piston. The power piston is linked to the fuel rack shaft. The oil pump is driven by the engine. The oil supply may be self contained in the actuator or may come from the engine sump. When there is an increase or decrease in engine load, the movement of the power piston operating through mechanical linkage will move the fuel racks to the new fuel setting to maintain the correct engine speed at the new load condition.

The electronic control box compares the engine speed as measured by the engine speed sensor to the desired speed as determined from the throttle input. If the engine speed and the desired speed are not the same, the control box will send a corrected DC voltage signal to the solenoid coils of the rack actuator. The actuator will now adjust to a new fuel setting to make the engine speed the same as the desired speed. The solenoid force is always in the direction of increasing fuel. The solenoid force is opposed by a spring. Therefore in the case of a loss of electrical signal the spring will move the power piston and rack to the minimum fuel position thus preventing engine overspeed.

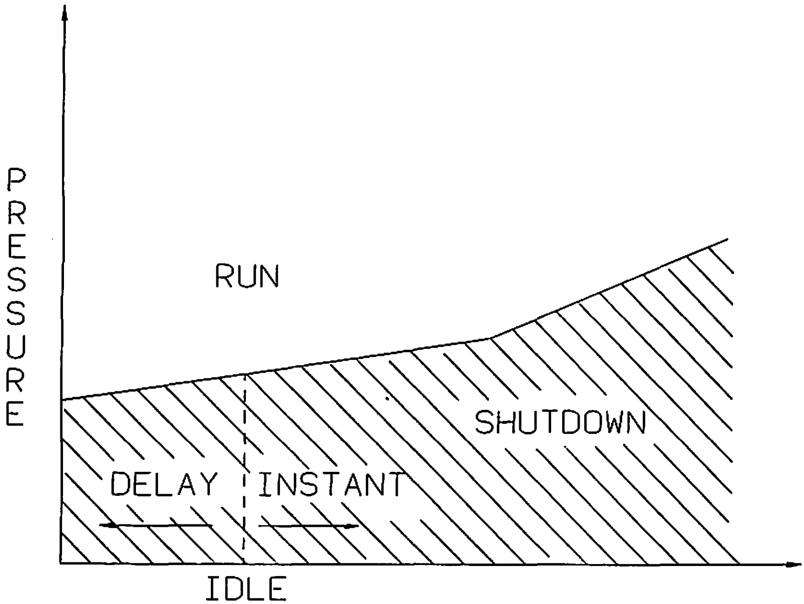
Additional inputs to the electronic control box are water pressure, oil pressure, and manifold air pressure. Minimum water pressure and oil pressure schedules may be established so that the shutdown pressures are higher at higher engine speeds. This, of course, is because higher pressures are required to protect the engine at higher operating speeds and loads. Annunciator lights will indicate the cause of engine shutdown. The manifold air pressure schedule is established to limit fuel according to air pressure and therefore achieve optimum fuel/air ratio for combustion efficiency. Wheel slip and transition signals may be used to momentarily reduce excitation current of the main alternator.

Testing and set-up of a mechanical - hydraulic governor requires three to 3½ hours by a well trained technician. Initial set-up time of the electronic governor is greatly decreased and is accomplished with a suitcase size electronic tester. Accuracy of the various set-points and schedules is also improved.

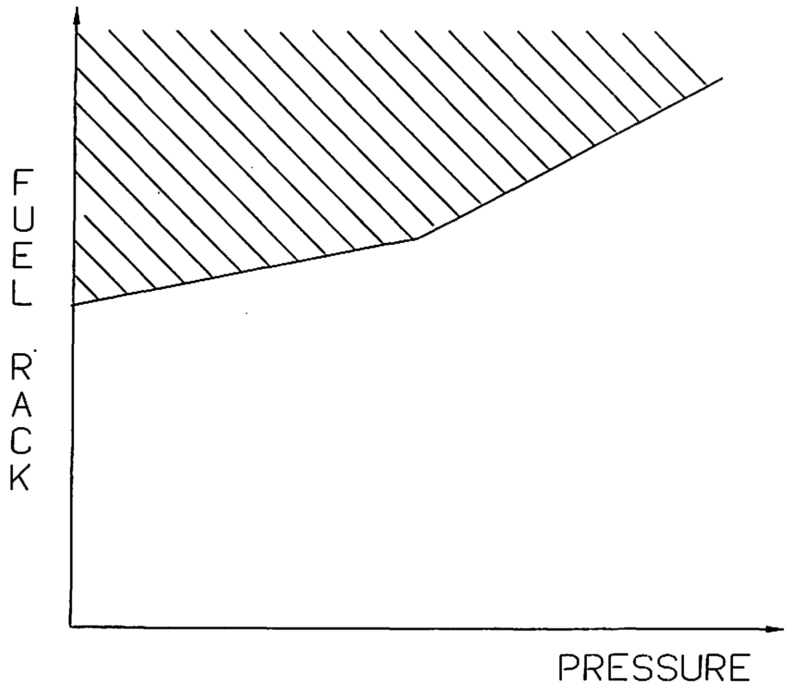
The advantages of the electronic governor over the mechanical-hydraulic governor are: faster response time; more precise control of speed and load; improved fuel efficiency; acceleration rate selector; and reduced set-up and maintenance cost. The electronic governor should also integrate very well with the microprocessor and future train control systems which will be available on new locomotives.



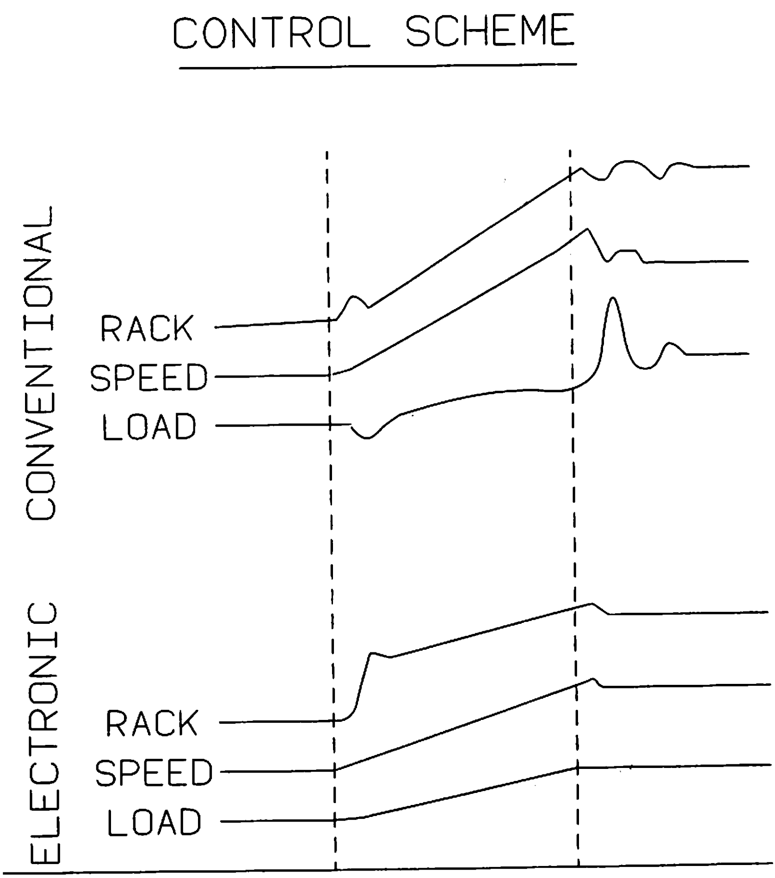
WATER PRESSURE SCHEDULE



LUBE OIL PRESSURE SCHEDULE



MANIFOLD PRESSURE FUEL LIMITER


CONTROL SCHEME
CONVENTIONAL
RACK
SPEED
LOAD
ELECTRONIC
RACK
SPEED
LOAD

ADVANTAGES OF ELECTRONIC GOVERNOR

1. FASTER RESPONSE TIME
2. MORE PRECISE CONTROL OF SPEED AND LOAD
3. IMPROVED FUEL EFFICIENCY
4. ACCELERATION RATE SELECTOR
5. REDUCED SET-UP AND MAINTENANCE COST
6. INTEGRATE WITH MICRO - PROCESSOR AND ADVANCED TRAIN CONTROL