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PROCEEDINGS OF THE 8TH EQUIPMENT MANAGEMENT WORKSHOP MAY 1990 DES MOINES, IOWA

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FOREWORD

State and local transportation agencies have developed Equipment Management Systems (EMS) during the past decade to provide a cost effective means of managing and controlling motorized equipment fleets. Cost control, preventive maintenance, repair, shop productivity, employee training, equipment replacement decisions, employee motivation, inventory control, commercial drivers license requirements, alternative fuel engines, environmental safety, privatization, electronically controlled diesel engines, and other related issues are involved.

A model equipment management system was developed in 1979 with pooled funds provided by twelve states. The results of the study were presented to a group of state highway department equipment managers at a 1979 meeting in Sacramento, California, and later tested by five states during 1979-1980. After the initial workshop in Sacramento, workshops were held in Albuquerque, New Mexico; Little Rock, Arkansas; Indianapolis, Indiana; Coeur d'Alene, Idaho (two workshops); and Gulf Shores, Alabama.

The proceedings of the Eighth Equipment Management Workshop, held May 28-31, 1990, in Des Moines, Iowa, are included in this *Circular*. Emphasis on the first seven workshops was on fleet planning, shop operations, inventory control, information systems, and progress reports by various states as they introduced changes indicated in the study. The emphasis of the Eighth Equipment Management Workshop was shifted toward human resources, environmental issues, new technologies, alternative fuels, and privatization. The program was structured around eight topics:

- Human Resource Management Dilemma
- Alternative Fuel Engines
- Environmental Concerns and the Work Environment
- Role of Privatization
- Computers in Equipment Management
- Electronically Controlled Diesel Engines
- Innovative Equipment Replacement/Purchasing Methods
- Reports From Regional Equipment Managers Meetings

The workshop was planned by the Maintenance Equipment Committee of the Transportation Research Board, and hosted by the Iowa Department of Transportation and Iowa State University.

Planning has been initiated for the 9th Equipment Management Workshop to be held in North Carolina in 1992.

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EQUIPMENT MAINTENANCE AND EQUIPMENT MANAGEMENT PERSONNEL

Thomas H. Maze, *Iowa State University*

Introduction

The 1980s were a period of tremendous change as new technology crept into most facets of life. For example, computer usage in the 1970s was restricted to either highly technical activities or activities that were number and record intensive (e.g., payroll and accounting systems). Today, computers are commonplace. Most school children know how to operate them and it is common for even the computer on the secretary's desk to rival the power of computers that, in the 1970s, "filled a room and required a specially-trained operator."

The purpose of this paper is to review the changes of the last decade, as they relate to equipment managers at state departments of transportation and local highway agencies. Then, by reflecting on these trends and forecasting their logical personnel resource implications for the 1990s, the paper attempts to highlight the human resource issues that are likely to be faced in the future.

Equipment and Equipment Management Change

To observe some of these changes at work in the equipment management area, all that has to be done is open the hood of a new-production automobile.[1] Several items of new technology that will be apparent at the surface are likely to be front wheel drive, several computer modules, fancy sensors, and wires and hoses going everywhere. Under the surface, the engine is likely to contain multi-port fuel injection, a turbo charger, four valves per cylinder, high energy ignition systems combined with clean-burn technology, electronic engine controls, electronic transmission controls, anti-lock brakes, and automatic seat belts or air bags. All of these gadgets are new technology and they are becoming commonplace in modern equipment.

Change is likely to accelerate even more quickly in the 1990s. As an example of accelerating change, automobiles in the 1950s had an average of roughly 20 electrical circuits. Today's vehicles average more than 160 circuits. Typical vehicles in mid-1990s will average more that twice the number of circuits that vehicles currently possess.[2]

The change in truck and tractor technology has not been quite as vigorous as the change within light duty equipment. However, the technology forcing elements of the National Ambient Air Quality Standards[3] are likely to result in most diesel engines produced in and after 1994 to be electronically controlled. It is also likely that many engine manufacturers will offer engines operating on alternative fuels (the most popular alternative fuels include methanol, ethanol, compress natural gas, and liquid petroleum gas).

Technology has created clear change in the type of skills that are necessary for maintenance personnel to possess. However, change has been as revolutionary in equipment management. Managers now have computer technology to help them make better decisions and provide better control over human and material resources. Also changes in management styles, skill requirements, and breadth of knowledge have been as robust in management.

Some of the mega-trends that are expected to impact the human resource requirements and skill levels at the: 1) mechanic and technician level, 2) shop supervision/management level, and 3) top equipment managers level include:

- Changes in technology to make equipment more efficient to operate, but require different mechanic/technician skills;
- Growing competition for a declining base of skilled and competent mechanics/technicians;
- A change in the mission of highway agencies from system development to system management;
- Growing use of new management technology and new management techniques;
- Stagnate budget levels; and
- Expanded environmental and safety regulation.

Mechanic and Technician Level Resources

Technology has changed the skill requirements for mechanics and technicians, and future technology is likely to create even more change. When interviewed, the manager of J.I. Case's customer service operation reported that they can no longer rely on years of experience as an indication of skill when recruiting mechanics and technicians.[4] Experience with past equipment does not automatically qualify a mechanic/technician to work on modern equipment.

In addition to higher skill levels, the growing demands for qualified mechanics (and other classes of skilled and semi-skilled labor) in the private sector are likely to place a premium on qualified mechanics and technicians. For example, in trucking, an industry with many of the same human resource requirements as public fleet operators, there is currently a shortage of qualified truck operators and mechanics. In addition, the trucking industry is experiencing a great deal of growth. Trucking growth, measured in ton-miles carried, has been increasing at a rate of roughly 3 percent per year throughout the 1980s.[5]

The trucking industry shortages will be exacerbated by the reduced pool of qualified individuals promulgated by the tougher requirement of the Commercial Drivers License (CDL)[6] and the drug testing requirements that have been imposed on the trucking industry by the U.S. Department of Transportation. Although passing the CDL test and staying drug-free may not seem like an onerous burden for truck operators and mechanics, it's likely that a minority may not wish to meet these requirements or are unable to meet them. The CDL requirements and drug testing will undoubtedly drive some mechanics and operators out of the job market.

When the operator and mechanic shortage get tighter, the trucking industry can raise wage rates for mechanics, attract more qualified mechanics and pass along the additional cost to their customers. Similar mechanisms do not exist for public fleet operators. In addition, although it is difficult to measure, fewer young people are interested in entering ranks of skilled labor. Thus further diminishing the future ranks of qualified mechanics and technicians.

Shop Supervision Level Resources

Shop supervisors and shop managers need to have technical knowledge of the work conducted by mechanics and technicians, and therefore, these employees are generally promoted from the shop floor. However, as a member of management, they need to have a variety of management and administrative skills. For example, even a foreman should have working knowledge of the union contract (if the employees are represented by a union), fundamental personnel management and administrative skills, and the ability to estimate and plan work. During the 1980s, safety and environment regulation provided an addition layer of rules for shop managers to interpret and apply.

As computerization has become more common, shop supervisors are more frequently required to operate and utilized automated information systems. Greater automation is also placing a new layer of skill requirements for shop supervisors.

Top Management Level Resources

Transportation is a central element of the U.S. economy. As the world market becomes more global, transportation will play a more important role in bringing manufactured goods and resources to market. As an example in the growth of transportation, heavy truck traffic on rural interstate highways in Federal Region VII (Iowa, Kansas, Missouri and Nebraska) grew roughly 25 percent between 1980 and 1986.[7]

The increase in truck traffic severally increases the resource demands for highway maintenance, restoration and reconstruction. However, real dollar resources (dollars multiplied by factors to adjust for inflation) available to highway agencies have been generally stagnate throughout the 1980s. Figure 1 shows federal expenditures on highways during the 1980s in constant dollars. Expenditures have been fairly constant despite a five cent per gallon gasoline tax increase in the Surface Transportation Act of 1982. In addition, the American Association of State Highway and Transportation Officials has projected that current annual funding levels for highways, at all levels of government, are roughly $14 billion below the needed resources simply to maintain highways in their current condition.[8]

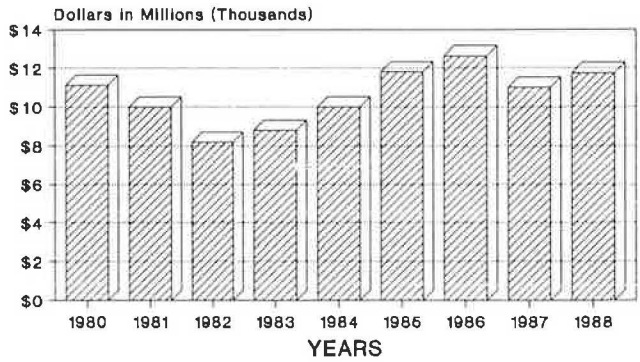

FIGURE 1 Federal highway expenditures in constant (1984) dollars[9].

The financial shortfall for highway agencies implies that all top managers will have to find methods for completing their work with fewer resources. For top level equipment managers, this suggests the development of techniques that improve work force productivity, the

formulation of motivational strategies, the application of better resource allocation methods, the use of innovative purchasing techniques and better specification writing, better assessment of training needs and effective training programming, and the use of exhaustive equipment management information systems with more analysis performed with the equipment maintenance and operating data to make more informed decisions. However, these skill requirements are generally a mismatch with the skill levels of top managers at state highway agencies. Almost three quarters of all professionals at state highway agencies and most of the top managers are civil engineers.[10] Traditional civil engineering educational programs focus on planning, designing and building of facilities and structures, and not on many of the skills necessary to more effectively manage with fewer resources.

Conclusions

Viewing the human resources involved in equipment maintenance and equipment management at highway agencies at three employee levels, (mechanics/ technicians, shop supervisor/managers and top managers), the likely trends of the 1990s present each level with one or more human resource dilemma. In summary they include:

Mechanics/Technicians. The qualifications necessary to work on new equipment are likely to require significantly different skills than those traditionally possessed by mechanics. Technology change mixed with increased demands for mechanics/technician from related industries are likely to make it more difficult to recruit qualified mechanics.

Shop Supervision and Management. The efficient operation of an equipment maintenance facility will require shop supervisors and shop management that possess administrative/management and analysis skills. Although technical knowledge of the maintenance procedures is generally believed to be essential for shop managers, solid management, and analysis skills have and will become more important knowledge areas.

Top Equipment Managers. Top equipment managers are likely to be faced the problems of providing increased equipment and equipment maintenance productivity with stagnate budgets. As a result, top managers are likely to be faced with obstacles requiring innovative solutions. Obtaining more productivity from equipment and more efficient equipment maintenance are inherently problems requiring an interdisciplinary approach. The need for interdisciplinary approaches is in sharp contrast to the highly engineering dominated ranks of top management at highway agencies.

End Notes

1. The example is taken from M.A.T. Bamford, "The Effect of Technology on Equipment and Equipment Management," presented to the InternationaL American Public Works Conference held in Orlando, Florida, September, 1989.
2. Bamford, p. 2.
3. For Federal Law, see: 40 CFR 80; also, 40 CFR 86.
4. Glenn A. Endicott and Larry Green, "Training Technicians," Equipment Management, March, 1990, pp. 21 - 23.
5. Association of American Railroads, "Railroad Facts: 1988 Edition," Information and Public Affairs Department, Washington, D.C., 1988.
6. Federal Commercial Motor Vehicle Safety Act of 1986 requires that all operators of vehicles with a gross vehicle weight of more than 26,000 pounds or a capacity of 16 or more passengers have a Commercial Drivers License by the summer of 1992.
7. Maze, et. al., "The Changing Role of Freight Transportation and Intermodal Freight," Midwest Transportation Center, Iowa State University, Ames, Iowa, 1990.
8. Francis Fancois, "Panel 1: Transportation Overview," Reported in "Transportation Infrastructure: Panelists Remarks at New Directions in Surface Transportation Seminar," prepared by the U.S. General Accounting Office, Report No. GAO/RCED-90-81B, 1990, pp. 32-37.
9. "Rebuilding the Foundations," Office of Technology Assessment, Congress of the U.S., Washington, D.C., 1990, p.8
10. Transportation Research Board, "Transportation Professionals: Future Needs and Opportunities," Special Report No. 207, Washington, D.C., 1985.

TRAINING OF EQUIPMENT MAINTENANCE PERSONNEL: APPROACHES AND APPLICATION

Robert Samuelson, *Iowa Department of Transportation*

Introduction

As of January 1, 1990, there were more than 112,000 miles of roads and streets in the state of Iowa. Despite being 25th in land area, Iowa has the 7th largest road system in the nation. Jurisdictional responsibility for Iowa's roads is vested in the Iowa Department of Transportation (IDOT), 99 counties, and 956 municipalities. IDOT currently maintains about 10,500 miles with the counties and cities maintaining the remaining.

IDOT is responsible for maintaining the entire primary road system, all state parks and institutional roads, and shares responsibility with the cities for maintaining the primary highways that extend into the

cities for a total of 24,884 lane miles. To accomplish this, the state is divided into six districts with each district divided into four resident maintenance engineer's (RMEs) offices. Each RME office is responsible for three to seven maintenance garages. Most of the garages are independent facilities staffed with a supervisor, one or more mechanics, and enough equipment operators to handle the work load.

In each garage, a supervisor is responsible for all of the equipment in the garage. The mechanics are required to repair and maintain a wide variety of equipment. They do most of the mechanical work for equipment operated from that garage. This includes activities required in the maintenance of:

- Push lawn mowers to large tractor movers;
- Subcompact pickups to eight cubic yard twin screw dump trucks;
- Replacing a hydraulic valve to servicing an electronic changeable message sign; and
- Tail blade to motor grader or erosion dozers.

The central repair shop in Ames has the resources to rebuild and exchange equipment components, such as:

- Hydraulic cylinders and pumps;
- Engines;
- Alternators, and starters; and
- Transmissions.

The field maintenance forces carry a big load. Not only are they responsible for maintaining the highway system, they must keep all of the equipment operational and operate it efficiently and safely.

The local shop mechanic must know if a piece of equipment is working properly or not and if not, what does it need. Anything short of a complete rebuild is done in the field. If the local mechanic feels a complete rebuild is necessary, he can pull the component, send it to the central repair shop in Ames, and exchange it for a previously rebuilt unit. The local mechanic must identify the problem. If it merely needs repairing, he must make the repair. The same is true with equipment operators. The field maintenance forces must choose the right piece of equipment and use it properly. This makes the task easier, more efficient, and produces a better quality product.

The equipment operators and mechanics in Iowa need training to accomplish these tasks. This is accomplished in some states with training academies while other states have many full-time trainers. Some of us have neither.

The lack of a full-time training staff need not prevent us from accomplishing our goals. IDOT accomplishes this by using new technology as it becomes available and utilizing the resources available to make that technology work.

Thirty-five years ago, IDOT had 16 mm films with one projector per district. Films were shown, then IDOT evolved to slide tape programs with one projector per residency. The first slide tapes were developed by a consultant. Several slide tape programs were developed in-house using people who had full-time jobs in other areas, but took time to put the programs together. They were shown to the equipment operator and mechanic with discussions following. When video became available, a consultant was hired to develop programs on equipment operation, preventive maintenance, and safety. Initially, one TV and VCR were purchased per residency. The goal now is one set per garage.

Development of the video program amounted to the preparation of instructors guides, lesson plans, a daily PM checklist, quizzes, operator observation sheets, and training the trainers. Then a team approach was used in presenting programs. The typical presenters included an experienced equipment operator, who was an expert in operating the pieces of equipment being covered by the training, and an experienced mechanic, who understood preventive maintenance of that piece of equipment. This team would take the program into each garage in each residency or district and conduct the training.

The basic approach included an introduction to the program, presentation of videos, demonstrate what they had seen, present additional videos, complete a written test, and discuss the quiz answers. Operators observation sheets were left with the local supervisor for his use in grading each of the crew on how well they retained what had been covered. A successful accomplishment card was then presented to each person who completed training. The effectiveness of these programs increased with strong support from local supervisor and resident engineer. These programs can be developed locally, each district has a camcorder for this very purpose. It is a good way to introduce a crew to a new concept developed in other areas.

Keeping our mechanics up-to-date with changing technology and to new types of equipment and components has always been a problem. Private mechanic schools have been used in the past and mechanics complained because they didn't use the same type of tools. The schools used different types of electronic testing equipment, and worked on different engines and components.

Factory trainers, such as engine manufacturers, transmission representatives and brake system representative, have also been tried. These people brought their training aides with them, set them up in the shops, and taught the mechanics. This was valuable, but there was not enough hands-on experience. In-house training has also been tried. Trainers were not available to teach the best mechanics how to be good trainers. Videos were purchased to be used on VCRs in the shops, but this was not the total answer.

For years mechanics have been reimbursed for registration and books if they attend night school classes at local area colleges on their own time. Few took advantage of this, possibly because much of the training did not apply directly. Mechanics are encouraged to attend training put on at local parts houses with the factory instruction concerning their product line.

Training with the Des Moines Area Community College

The Des Moines Area Community College (DMACC) has an auto mechanic course. This is a publicly supported two-year college. It is one of sixteen such schools in Iowa. These schools were established by the legislature in 1966. Their purpose was to meet the community interests, students abilities, and personal objectives of the citizens of all ages and levels of education. In the fall of 1985, the Economic Development group of DMACC was contacted to develop a training program where the mechanics could improve their job skills. The objective was to develop an annual one-week course, progressive in nature with repeats for the new mechanics.

A great need was with the diesel engines. Based on years of experience, the mechanics had learned gas engine but were struggling with diesel. DMACC met with the six district mechanics to learn first hand their specific needs. Everything in diesel mechanics could not be taught in one week. It was decided that the course would address basic diesel fuel system and diagnosis. A 32-hour basic course on diesel engines and fuel systems including disassembly and testing of parts was developed.

IDOT trucks were provided with diesel engines that could be disassembled and reassembled by the students. The students brought their own tools. The field mechanics desire to work on the same engines that they work on daily with their own tools. Sophisticated electronic testing equipment, that the mechanic did not have access to in his own shop, would not be used.

The course was designed to have a minimum classroom lecture time with a maximum hands-on experience in the shop. The course cost $3,220 to develop and $1,372 to conduct per 32 contact hours with a maximum of 15 students. One of the IDOTs district mechanics was present during each class to assist the instructor as needed and to handle policy questions. After the class instructional outlines were prepared, the district mechanic reviewed them and suggested changes. The course was a success beyond all expectations. This was due to the type of training--it was hands-on, and well presented.

The training was presented by an instructor who had years of experience in diesel engine repair before becoming an instructor at DMACC. Every questions or problem a student raised, the instructor could answer based on experience, not book knowledge. This is the type of training that can be obtained through community colleges in other areas. It is the type of training that fits the IDOTs needs. IDOT does not have a large training staff to develop programs. There is no time in the office staff's work schedule to dedicate to training activities. All the meetings with the district mechanics and the area college people were held at the regularly scheduled by-monthly meetings of the district mechanics. The shop meetings did not involve management except to set them up.

The district mechanics did have extra work in scheduling their mechanics to the schools and in being present to take their turn to help the instructor. Some attended two schools, meaning two total weeks of commitment. What the mechanics learned has reduced the workload on the district mechanics because they are now able to perform their work with less help from the district mechanics.

The first class was held in 1986. In 1987, the class was on Advanced Diesel System Training. This included 32-hours of continuation of the basic course and covered diesel engine performance problems and tune-up procedures. In 1988, the 32-hour class was on Automotive and Heavy Duty Electronics. This covered basic electrical theory and diagnostics of electrical problems on light and heavy duty vehicles. The course included an introduction to computerized electronic engine controls. In 1989, the 32-hour course addressed Diesel Engine Theory and Diagnosis. This course was given to new mechanics that had not had the previous two courses, to bring them up to the level of training that the other mechanics had received. An additional course was given in 1989 on Mobile Hydraulic Training. This covered basic hydraulic theory and the IDOT snow removal truck hydraulic system design and diagnosis. IDOT made a furnished cutaways of hydraulic parts and components of actual units. Detailed hydraulic schematic drawings of the hydraulic systems were also developed for the student manuals. In 1990, the course will address Brakes

and Brake Systems. Again, IDOT will assist by providing trucks and components for laboratory use.

Each course had the series of meetings with staff and mechanics and each course was redesigned during the first session with good report coming from all attendees. Each course was followed by a review of the just completed course and plans for the next one. Tests and student evaluations given before and after some of the early courses helped to identify the effectiveness of the training and future training needs. One of the early decision had to be how to divide the classes: by experience level of the mechanics; by district - all one district at a time; or mix them all up.

DMACC suggested that the classes be mixed. There was some hesitation to categorizing the mechanics skills. They didn't want to hurt anyone's feelings. The more experienced could help lead the less experienced. Discussions before, during and in the evenings are also a learning experience. Getting to know other mechanics from other parts of the state is also good.

The area college staff was professional in working with classes of varying degrees of expertise in the subject and a wide range in ages. This is typical of their classes. To smooth out some of the range in knowledge before the next class, all mechanics will be given an opportunity to take the AASHTO course on Brake Systems before their attending this year's brake course at DMACC. The DMACC instructor is also viewing the tape and reviewing the materials so he will know what has been covered before he starts his class. The AASHTO course is basic for our mechanics. It cannot replace the DMACC training, but it will supplement it.

Electronic Time and Attendance Reporting

Last winter, we expanded the college program to computer operator training. IDOT is transitioning to electronic time and attendance reporting, and soon hope to have a crew day card reporting system with a central office mainframe connected PC in each maintenance garage.

The course was developed using the same basic approach. In this case, the instructor spent several days in the IDOTs office:

- Learning programs and program applications;
- Using machines to work programs;
- Taking notes to develop a teaching and student notebook; and
- Making screen prints to include in the notebook.

Meetings were held with a sample group of people that would be taking the course to see how the instructor perceived their needs. The instructor and staff coordinator asked questions, and listened to answers and comments.

The course was held in the area college classroom, but used IDOT computers connected to the mainframe so the course would be taught on the identical machines used in the field. Students spent four days working on the computer programs--the same programs that they have available to them in the field offices and on the same machines. They returned home with a notebook with screen prints and complete instructions on each program. The success of the class was so great that the three scheduled classes had to be expanded to five to handle the number of students. Many good comments were received from the field. Two comments stand out. First, one student reported she had never been in a class that did not leave someone behind or bored. This was not the case in this course. Everyone felt they were learning together though some were much more experienced then others. A second comment came from an in-house resource person who helped develop the first class and encourage its development because she was unable to handle this size of a project with the time constraints. She commented after the first class that she had never seen a class become so interactive. They were like one family of students helping each other. Instructor providing the guidance and the students assisting the instructor as they worked through the programs.

Commercial Drivers Licenses

The newest project, with the area college, is to provide training to assist equipment operators in obtaining the new commercial drivers licenses. DMACC has developed a one-day (8 hour) course to meet this need. It will be taken to the field and presented just before taking the test for the new license. Again, the course was developed for the IDOTs specific needs. IDOT trucks will be used for the pre-trip inspection. DMACC has reformatted the commercial driver license manual to better fit their training course. They have developed short quizzes at frequent intervals in the course to test the progress of the class and to reinforce important points. The course has been piloted and found to be very good. The estimated cost will be about $60 per person for the full day course.

This type of training has worked in Iowa. The area college has solved a need. This success is because

- The area colleges in Iowa train rather than teach;
- They don't just tell you how, they show you how;
- Instructors are experienced practitioners of the trade not textbook learners;
- They use the IDOTs equipment; and
- They used our tools and programs.

Management also learned from these courses. The instructor in the mechanics schools identified some tools that could be added to the inventory to help the mechanics do their job. IDOT furnishes the mechanics with all the tools they need. The new tools were not expensive, but they were tools that the instructor had found by experience to be useful.

In summary, IDOT uses a wide variety of training aids. The area college is quickly becoming a very important part of the training program. It is a resource that should not be overlooked by anyone with training needs.

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION MECHANIC APPRENTICESHIP PROGRAM

John Burns, *North Carolina Department of Transportation*

The increased use of on-board electronic control devices and their related systems presents a challenge to every equipment operation. To keep NCDOTs work force at current manning levels with well-trained input, we have established an apprenticeship program certified by the North Carolina Department of Labor (NCDOL) and the U.S. Department of Labor (USDOL).

Apprenticeship establishes a formal training program that, through classroom training and on the job training (OJT) under the supervision of a journeyman mechanic, produces an individual at the journeyman level, trained according to our unique job requirements. Though certified by NCDOL, local program control is designed to require 3-1/2 years for completion.

The first step is to establish standards of apprenticeship. The proposed program includes, as a minimum:

- The work process or OJT description;
- Formal instruction identification and schedule; and
- A wage schedule.

The work process includes the plan for hours an apprentice will spend while obtaining OJT. Areas of OJT are broken down into engine overhaul, light equipment, truck, welding and various component rebuilding. Apprentices rotate through assignments, one per area on a 6 month cycle. Supervisors are urged to ensure meaningful job assignments that will benefit the apprentice and provide increased shop productivity.

Related classroom training describes a minimum of 144 hours of instruction per year for certification. This can be provided by a community college, manufacturer or the DOT training department. Our schedule currently requires 272 hours of instruction per year. Along with scheduled technical courses, we have included math, first responder first aid, oral and written communications and human relations.

A spinoff advantage to the apprentice training program is the opportunity it provides for field and depot mechanics to attend the same classes. In the technical college system, course expenses rarely exceed $35.00 per student. Courses provided by the industry may be no cost, if local, or require only travel and per diem expense.

Our training coordinator works closely with community colleges in designing courses and selecting instructors. Classes range from 40 to 80 hours in length. The NCDOL requires that apprentices receive compensation of at least 50 percent of a journeyman mechanic. They desire that apprentices receive a pay raise every six months if progressing satisfactorily. The sponsor must appoint a six (6) member committee and one (1) supervisor of apprentices to handle day to day program management. The Supervisor of Apprentices assists the committee in administering the program including being responsible for records and serving as guidance counselor for apprentices. NCDOTs program is off to a good start. We expect to expand to include traffic services signal technicians and other shop trades soon.

Retention of apprentices is a concern. All successful apprentices will be offered positions as they become available. The length of the program serves to promote retention with 3-1/2 years toward retirement, the accumulated sick leave, annual leave and additional benefits recognized as reasons for remaining with the DOT. NCDOT was surprised at the number and quality of applicants. Most came from students graduating from high school and technical college vocational programs. Individuals leaving the armed forces also provide motivated candidates.

THE IMPACT OF THE COMMERCIAL DRIVERS LICENSE ON EQUIPMENT MANAGEMENT--CALIFORNIA EXPERIENCE

Dale D. Phillips, ***California Department of Transportation***

General Overview of Caltrans

- Number of Employees 18,092
- Fleet Size 12,475
- Highway Miles 16,700
- Landscaped Acres 17,000
- No. of Employees Affected by CDL 5,500

Division of Equipment

- Number of Employees 749
- Mechanical Trades Employees 528
- Shops: 11 main, 10 sub-shops located throughout the State, Headquarters and fabrication facility is located in Sacramento.
- Mission: To support the Department by furnishing and maintaining fleet and telecommunications equipment.

Impact of the Commercial Drivers License

The Commercial Drivers License (CDL) has been in effect in the California approximately a year and five months, and is the result of California Senate Bill 2594 and the Federal Commercial Motor Vehicle Safety Act of 1986. The overall changes in drivers license classifications have had more impact on the equipment operation than the actual operating Department. The employer Statement Program is more restrictive. Caltrans has decided not to participate in it now. Employees are allowed time and use of equipment to get their CDL. Caltrans supports Division of Motor Vehicles in their on-site testing program. Caltrans is changing the drivers license requirements of its employees to conform with the new CDL classification requirements. The CDL requirements are a major step in improving highway traffic safety.

OREGON'S PERFORMANCE BASED INCENTIVE PROGRAM: A FEASIBILITY STUDY--HEAVY EQUIPMENT REPAIR SHOP--BEND, OREGON

Craig L. Holt, ***Oregon Department of Transportation***

Introduction

This abstract concerns a case history of one of 27 pilot groups currently involved in a study to test Performance Based Incentive Pay. This program is in a feasibility phase, which will continue through July 1991. The case history involves a heavy equipment shop, comprised of approximately 30 mechanics, storeroom, and administrative staff. The title given to this program is Gain Share.

Gain Share Program Development

The program development began with the creation of a steering committee, whose purpose was to establish: key organizational emphasis areas of performance; devise a measurement tool to be used to tract performance; develop an implementation strategy; and oversee all program development. This committee was comprised of the State Highway Administrator, four Senior level Managers within the Highway Division, Highway Division Budget Officer, Legal Council, and a program manager. This committee began meeting in November 1988. The committee identified the key organizational emphasis areas, that if managed correctly, would lead to organizational success. The committee also identified a tool for measuring those key performance areas, a Productivity Matrix. The committee then decided to embark upon a feasibility study to test their conceptual design and measurement tool. The feasibility study began July 1989.

Feasibility Study

The steering committee identified seven work groups to serve as "pilot units" for a feasibility study. The study was to last one year, and was given the following charge: identify key measures of performance with respect to the organizational key performance measures. These performance measures were to be results based, not activity or process oriented. The next charge was to establish bench mark or average standards of performance in each key performance measure. The last charge was to link the key performance measures to performance incentive pay. In January of 1990, the steering committee decided to expand the feasibility study to include "pilot units" in the areas of Project Development, Field Maintenance,

Field Construction, and Support & Enforcement. Currently 27 work groups and more than 400 employees are involved in the feasibility study. One of the pilot units which began in July 1989 was a heavy equipment shop.

Heavy Equipment Shop: A Case History

A seminar was conducted with the equipment shop personnel (including mechanics, storeroom, administrative support and management) to address the identification of the shop's key performance measures, considering the Divisions performance measures. The results based performance measures were identified, but it became apparent that some of those measures, had never been tracked. To facilitate the development of bench mark performance, certain "measurement tools" needed to be developed.

One of the outcomes of this process was the development of a shop coding scheme; developed, tested, modified, and finalized by the mechanics. This coding scheme is used to develop "shop standards" of performance. Once enough history has been gathered, these standards will then be used to develop a "flat rate" time manual.

This flat rate will then be applied to each repair completed by the shop. The total flat rate hours will then be compared to the actual hours worked by the shop, and the resulting percentage will be the measure of the shops labor efficiency.

The labor efficiency measure is then combined with quality measures, identified by the shop personnel. The quality measures include: percent of tasks requiring rework; percent of tasks completed late; parts unavailable or incorrectly ordered; number of "comeback"repairs; and customer satisfaction. Safety measures such as loss of time, time loss incidents, restricted day, housekeeping, as it relates to safety, and material and building expenses, were included.

The composition of these measures will result in a bottom line measure of performance. This measure is a monthly productivity index. The productivity index is compared to previous indexes, to detect if an increase in performance has occurred.

Customer Satisfaction

The equipment personnel (mechanics, storeroom, administrative staff and management) jointly developed a customer satisfaction survey post card to be distributed with each vehicle repaired through the shop. Thirty-eight percent of the survey cards distributed have been returned. The following are the results of that survey:

- How many times do you bring equipment to the shop each year? . . . . . 13 times
- Do you feel safe using the equipment after repairs? . . . . . 100% (yes)
- Were all the requested repairs completed? . . . . . 84.6% (yes)
- Were you satisfied with the quality of the work performed? . . . . . 88.5% (yes)
- Were your repairs completed on time? 76.9% (yes)

The first group of "pilot units" will be completing one year worth of gathering data, from which bench marks can be developed. Once bench marks are established, the process of linking incentive pay to an increase in performance will begin.

ALTERNATIVE FUEL ENGINES IN HEAVY DUTY VEHICLES

C. O. Henriksen, *Detroit Diesel Corporation*

The goals of Detroit Diesel Corporation's alternative fuel activities are to develop a heavy duty engine capable of complying with the 1991 vehicle emissions standards, and possibly, the 1994 standards.

Emission Standards

Looking at the Environmental Protection Agency (EPA) vehicle standards promulgated in 1989 and going through 1994, the hydrocarbons and carbon monoxides remain constant. The $BSNO_x$ (or NO_x) standard in 1989 was 10.7 grams per brake horse per hour. For 1990, it is 6 grams, and in 1991 it will be 5 grams and will remain constant through 1994. There are proposals being considered now that would reduce this standard to 4 grams in 1997. The emissions standards on particulate has caused all engine manufactures to expend considerable effort. In 1989, the standard was 0.6 gram where it remained through 1990. However, in 1991, it will drop to 0.25 gram and in 1994 to 0.1 gram. The urban bus market is already at the 0.1 gram level. In 1994, 0.1 gram will become the standard level for all certified on highway engines.

Complying with Emission Standards

There are a couple of different ways the engine manufacturers can improve engine emissions. One is through technology evolution to improve the basic engine components. The other is to improve exhaust treatment using particulate traps or, in case of methanol, catalytic converters.

The alternate fuels being studied are methanol and compressed natural gas (CNG). These studies are looking at strategies to comply with emission standards for the 1991-1994 period. The basic approach incorporates an electronic control system on all certified engines and improved injection technology. One of the ways to get a cleaner and more efficient combustion is to use higher injection pressure. The new injectors will function in the 20,000 to 23,000 pounds per square inch (psi) range. The increased pressure improves atomization, thus producing a cleaner, more efficient combustion. Improvements in turbo charger geometry can also improve efficiency. Through electronics, smoke control for diesel engines can be improved. Electronics can be used to keep smoke emissions at a reasonable level, for buses, below the visible range, and still maintain performance characteristics.

Oil consumption is another key element in reducing particulate emission levels. The average diesel powered vehicle in use today would not pass the particulate emissions test due to the rate of oil consumption. Some of the other variables for diesel fuels are low sulphur fuels and low aromatic. Regardless of the fuel, diesel, methanol or CNG, particulate traps and catalytic converters constitute major components of interest.

Multi-Fuel Engines

Multi-fuel engines represent an interesting area for development. The goal is to convert from one fuel to another based on availability or cost. There are some basic engine characteristics that would not change for a multi-fuel engine. For a 2-cycle engine, the block is the same. The head configuration and blower system would be the same. There are some aspects of an engine that should be different to utilize a specific fuel efficiently. For example, the air flow characteristics of the methanol engine are different from those for the diesel engine, so they require different turbo chargers. The cam profile, bypass blower, and electronic unit injector are also different for good combustion in a methanol engine. Methanol is also incompatible with some of the materials commonly used in diesel engines. The size of the holes in the tips must be increased since methanol has half the energy that diesel has by volume. Higher compression ratio pistons, additional glow plugs, and harnesses are also required for methanol engines. A controller for the by-pass blower, controlling the air flow in the engine, and a controller for the glow plug are also required. Based on these differences, additional training will be required for general maintenance and for trouble shooting the different components.

Methanol Demonstration Projects

The current methanol engine can meet the 1991 emission standards. The addition of a catalytic converter will reduce the hydrocarbon and carbon monoxide emissions by 90%, particulate by 70%, and formaldehyde by 50%. The methanol engine with the catalytic converter can

achieve emissions values lower than any other heavy duty engine. The catalytic converter is a ceramic monolith device, 9 inches by 6 inches, housed in a canister. The small size allows it to be installed in line with the turbocharger before the exhausts go into the muffler system.

Some methanol demonstrations are on-going. There are 54 methanol buses that have accumulated more than 1.6 million miles. They will have accumulated more than 3 million miles by January 1991. These methanol buses have accumulated more miles than all the other heavy duty low emission engine technologies combined. Three methanol buses are scheduled for delivery to Medicine Hat in Alberta, Canada. After they receive these buses, half of their fleet of 16 will be powered by methanol engines. There are 50 additional methanol powered school buses going to California. It is anticipated that 14 ethanol buses will go to Illinois in 1990. The ethanol engine is similar to the methanol engine with some minor changes in fueling and engine timing. The percentage "up-time," or percent availability, is often used to measure the effectiveness of an engine. The methanol engines at the demonstration sites have had "up-times" between 96-98%, which is comparable to that for diesel engines.

There are also 7 truck demonstrations of methanol engines being implemented. These are geographically distributed over the country. These demonstrations will address durability and reliability concerns. The implementation of this program has not gone real smooth and easy. One of the biggest problem areas was glow plugs. Glow plug failures at extremely early mileage and early hours were experienced. To correct this problem, the compression ration was increased from 18-1 to 20-1. The timing characteristics were modified with the electronic system to keep the cylinder pressures down. Sixteen units have been modified with a reduction in the glow plug problems noted.

Problem have also been noted with the unit injectors: plugging of the spray tip holes and injector seizure. The spray tip hole plugging is primarily a result of the reaction of methanol and oil. As injector comes up to the top, a small amount of oil gets down into the plunger. A fuel additive has been developed and introduced, at 0.06% by volume, to correct the problem. Plunger scoring is caused by the lack of lubricant supplied by the diesel fuel within the injector system. The lubrication characteristics in methanol are significantly different from those of diesel fuel. Reductions in the ash content of the oil may also be necessary. Changes in manufacturing process for the injectors will involve lapping the plunger with the injector. The use of ceramics within the injector is also being considered.

Some of the initial concerns with methanol were ease of starting and performance with the glow plugs and higher compression ratio, 23-1. The methanol engine actually starts better than a diesel in cold weather. This has been demonstrated at several locations in Canada. The acceleration and performance characteristics of the methanol engine are actually better than diesel. Below 10 mph the methanol engine accelerates quicker than the diesel, because there is no smoke control as is required on the diesel engine. Above 10 mph the acceleration rate is the same, due to the same horsepower characteristics.

Methanol fuel does not have the energy that diesel has, so there is a fuel penalty. Theoretically, diesel fuel has 2.3 times more energy than an equal volume of methanol. In practice, the best ratio has been 2.35 to 1 with the average for all pre-production type engines being 2.66 to 1. The fuel economy is duty cycle dependent and the ratios cited include 1986 and 1987 diesel engines which are in a range of 6 to 10 grams of NO_x.

Methanol engines require a little more maintenance than a diesel engine. Glow plugs should be changed at 50,000 miles, and injectors at 100,000 miles. A few components in the blower by-pass controls will also require some preventive maintenance. Oil and filter changes are no different. The initial change of the fuel filter will be at 1,000 miles, and then at intervals of 6,000 miles. The methanal filter is much finer and, because of the lubrication problems, it's critical that methanal fuel supply be clean. The fuel fittings for refueling are dryback with a vapor recovery tank. Stainless steel fuel tanks are required with approximately double the capacity with compatible lines and fittings. The electric fuel pump is outside the engine compartment because of the need for a "fuel cooler" to keep the fuel below its boiling point.

In conclusion the ethanol engine has demonstrated that it can exceed the 1991 emission standards. Catalytic converters can be added to achieve even lower emissions. It requires a little more maintenance than a diesel engine. Additional training will be required for trouble shooting the fuel system. Methanol engine technology is more costly than diesel, but not as costly as other reduced emission alternatives.

Particulate Traps

Another part of the reduced emissions program is particulate traps. The goal of particulate traps is to trap

soot and particles that are exhausted from an engine. The particulate trap does not change the hydrocarbons, the NO_x, or the carbon monoxides. However, the particulate levels will drop from 0.33 to 0.05 grams per hour. The negative impact of the particulate trap is that it requires a little more space than a standard muffler. The particulate trap, installed, costs about $4,000 to $8,000 per vehicle. Positive regeneration is also required.

CNG Programs

There are 2 CNG programs: a dual fuel, pre-chamber type engine, and a direct injection engine. The fuel tank will require four times the volume required for a diesel. The tank will also add from 2,500 to 5,000 pounds to the weight of the vehicle. A gas pressure regulators will be required as well as special fittings for refueling.

ALTERNATIVE FUEL ENGINES IN AUTOMOBILES
Richard Simmons, *Chrysler Corporation*

This paper provides a brief overview of Chrysler Corporation's efforts in the development of a flexible fuel vehicle (FFV) and how such a vehicle (cars and light trucks) will affect the equipment mechanic.

An FFV is a car or truck designed to operate equally well on gasoline or M85, 85% methanol and 15% gasoline, or any mixture of gasoline and M85. For example M20 is 20% methanol and 80% gasoline, M50 is 50% methanol, and so on. An FFV can be fueled with either M85 or gasoline, as well as the intermediate blends that will result from topping off a partially full tank with the either fuel. Methanol was selected since it can reduce smog formation; is an alternative energy source; and may be mandated by law, perhaps in fleets first.

Why was M85 selected rather than pure methanol? There are three reasons: the 15% of gasoline provides flame luminosity for safety, since pure methanol has an almost invisible flame; it provides the ability to start at lower temperatures than would be possible with pure methanol; it gives M85 the distinctive order and taste of gasoline, a safety factor.

There will be no readily discernable difference between a gasoline vehicle and an FFV. However, an FFV will have some additional systems that a gasoline only car does not have and it will have some material differences.

Systems. The FFV will have a sensor to detect the percentage of methanol in the fuel and a computer program to adjust the fuel delivery schedule, the spark advance schedule, and other engine operating parameters for the specific fuel mixture. If you pump M85 into an FFV, it adjusts itself to run properly on that fuel. If you pump gasoline into an FFV, it adjusts for gasoline. And if you mix the fuels as you would if you topped off a tank, it sets itself to run on the resulting intermediate mixture.

Materials. One of the undesirable properties of methanol is its tendency to be corrosive to many of the metals used in cars, such as steel, aluminum and terneplate. It also attacks many elastomeric materials, such as seals, gaskets, diaphragms. The solution to this problem is not an insurmountable design task - we simply go through the fuel system and wherever we find materials that are incompatible with methanol, we substitute materials that are compatible. This is repeated for the induction system, because air going into an engine does not flow in a steady stream but is full of instantaneous flow reversals. The average flow is in, but at any instant, the flow can be either way. This means that small amounts of fuel & fuel vapors can be found far upstream of where they are injected. So, the air cleaner, for example, must be able to survive when it is subjected to methanol vapors or liquid droplets.

Blowby in the crankcase contains fuel vapors, so anything that comes in contact with oil such as gaskets, oil filters, and positive crankcase ventilation system components must be made of methanol resistant materials. This also includes bearings, piston rings and other internal components. Finally, there is the evaporative control system. The canister, lines, switches and valves in this system must be modified to accommodate methanol. Since the FFV will more than likely be implemented in fleets first, you may be the first to maintain it.

Servicing Flexible Fuel Vehicles

The key areas for servicing an FFV will involve:

- Sensor system;
- Part substitution;
- Water in the fuel;
- Special oil;
- Travel range; and
- Toxicity of methanol.

Sensor System. The most intimidating difference between an FFV and its predecessors, is the fuel composition sensing system. But I am sure that will not be a problem

for you. You already deal with some pretty complex systems today - computer controlled fuel delivery and ignition systems, computerized transmissions and such like. If you have been servicing chrysler products, you are familiar with the DRB - the diagnostic readout box. You can expect that the fuel sensing system will be diagnosed using a similar tool.

Part Substitution. A trickier problem is the potential for installing a similar, but not substitutable, part - examples are gaskets, seals, fuel rails, fuel tubes, fuel pumps, fuel tanks and the like. Even worse, if the inappropriate replacement crates corrosion products, the contaminants may lead to failure of still other components. Fortunately we have some tools to deal with that. We are examining the feasibility of special identification of methanol compatible parts to set them apart from their gasoline-only counterparts.

For your part, this is not an unprecedented situation. You have some directly applicable experience, because you deal daily with parts which are mechanically interchangeable, but you substitute at your peril. You already know that if you put in the wrong spark plugs you may end up with a sputtering engine (if you were lucky and went to cold), or in the worst case, with bits and pieces of engine scattered on the pavement (if you went way too hot). Similarly, wrong injectors may fit but make the engine run rich or lean. A wrong part number electronic controller will plug in, but you might wish you hadn't used it. Put identical appearing valves for a naturally aspirated engine into a turbo and you will be replacing them again very soon. They may look alike, but the material is different. In an FFV there are just some more parts that you have to be sure you are putting in the right thing.

Compatibility of field add-on's is also an important area. Be cautious about miscellaneous accessories and replacement parts that will be in contact with liquid fuel or vapors from the liquid fuel system. Gasoline compatibility does not imply methanol compatibility. The same applies to components which come into contact with engine oil. Due to the fuel in the blowby gases, the oil will be contaminated with the fuel - to a greater or lesser degree depending upon the operating cycle. The oil, with methanol in it, can effect parts it touches. What this means is that after market devices or components that mount in fuel tanks, fuel lines, throttle bodies, air cleaners, positive crankcase ventilation systems, oil filters and so on, may or may not be compatible with methanol - and probably won't be. Methanol compatibility is not a common property of materials that are used in making these components. The materials used have been selected for other desirable properties that made them good choices in the past. For that matter, still good choices for gasoline only vehicles.

Water in the Fuel. Water in the gasoline can be a problem, but its rare, because water will stay on the bottom of a gasoline storage tank unless you pump out the dregs. Likewise, small amounts in you vehicle tank will mechanically disperse in the gasoline and the engine will consume it, more or less willingly, depending upon how much is there. Not so with M85. Methanol is "hygroscopic." The methanol component of M85 will absorb any water with which it comes in contact. This is important since wet methanol won't burn. Tanks containing M85 must be keep them clean and free of water. If you purchase M85, know you suppliers and use only dependable sources.

Special Oil. These vehicles will require a specially formulated oil to be compatible with the methanol and methanol vapors in the blowby gases. Like some of the parts, you would not want to substitute oil formulated for gasoline-only cars. When the FFVs are introduced, the oil companies will be marketing these special oils at their service stations. However, if not, it will be available from car manufacturers.

Travel Range. M85 has only about half the energy content that gasoline has - that means that you only go about half as far on a given amount. So, the range of FFVs, when operated on M85, will only be about half that when operated on gasoline.

Toxicity of Methanol. One item not directly related to the car, which you should take very seriously, is the toxicity of methanol. Do not confuse methanol, also call methyl alcohol, with ethanol, which sometimes goes by the name of ethyl alcohol. Ethanol is the familiar "alcohol" in alcoholic beverages. Methanol is a poison. Small quantities can do serious damage quickly.

You would not think anyone would intentionally drink anything that was 15% gasoline. But what about the person who decides to siphon some fuel from one vehicle to another and gets a mouthful of M85 while sucking the hose full of fuel? We as a manufacturer are concerned enough about this that FFVs will have an anti-siphon device - something to prevent the hose from going down the filler tube and into the tank.

Summary

- FFVs will look and operate just like conventional vehicles but will be more challenging to build and to service.
- The fuel will require some special care in handling, but then so does gasoline, M85 will just add some new concerns.
- Manufacturers - and purchasers - of add-on's will have to consider some new considerations.

If you think FFVs might be in you future, it might be a good idea to start exploring that future possibility with your conversion suppliers, so they can have warning of your new requirements.

To achieve the greatest benefit from an FFV in terms of reducing smog formation and our energy dependence on foreign sources, you must accept the responsibility of maintaining them and keeping them running efficiently.

ALTERNATIVE FUEL SUPPLY

Al Kordel, *AMOCO Oil Corporation*

To understand the supply characteristics of alternative fuels it is important to first understand the supply characteristics of the two predominant traditional motor fuels--gasoline and diesel. I will review the properties of traditional fuels and contrast those properties with those of the leading alternative fuels.

Petroleum Based, Traditional Fuels

Gasoline is a molecular mixture and therefore, it boils between a range of temperatures from about 80 degrees F to 437 degrees F. Its density ranges from about 6 to 6.5 pounds per gallon. Net energy of gasoline is about 18,000 BTUs per pound or about 115,000 BTUs per gallon. Another important characteristic of gasoline is its market demand. Currently there are about 110 billion gallons per year of gasoline consumed in the U.S. The wholesale cost of gasoline is about 70 cents per gallon (May, 1990) before taxes.

Diesel fuel is also a molecular mixture, but has a higher boiling range and is denser than gasoline. Diesel fuel boils from 370 degrees F to 700 degrees F. It's density is about 6.8 to 7.3 pounds per gallon. Net energy of diesel is about the same as gasoline per pound, but on a gallon basis it is higher, 130,000 BTUs per gallon. The U.S. market for diesel fuel is about 20 billion gallons per year. The wholesale cost is about 55 cents per gallon (May, 1990) before taxes.

If gasoline and diesel were introduced today, it is likely there would be considerable safety concerns. Both fuels have several safety concerns. Because gasoline and diesel fuels, however, have been in widespread use for almost 100 years, we have developed safe handling systems or have learned to live with any detrimental safety impacts. Similarly, many handling problems associated with alternative fuels could have been solved if they were given the attention that has been given to gasoline and diesel fuel. Before alternative-fueled vehicles can enter widespread use, however, supply and handling problems will have to be overcome.

An advantage of current petroleum fuels is that production and distribution systems are in place, established, and working. The distribution system supplies high volumes of petroleum products at very low costs. While the cost varies, moving petroleum products from refinery to product terminals via pipelines costs about one to two cents per gallon. Delivery from the terminals to service stations or commercial users in urban areas adds about another two cents. As can be seen, the petroleum industry has established an efficient delivery and distribution system.

Contrasting the existing motor fuel energy system with the pressure to convert to alternative fuels, two questions result: who should accept the costs of establishing new fuels in the market place and, which fuel(s) should be established?

Alternative Fuels

The discussion here will focus on four alternative fuels--methanol, ethanol, natural gas, and liquified petroleum gas. Reformulated gasoline and diesel fuels will also be discussed. Reformulated fuels are significantly different from traditional fuels and can be considered as alternative fuels, even though petroleum is a main component.

Methanol. One reason for the emphasis on methanol is that many consider it to be the leading alternative fuel. It was cited in the original Clean Air Act Amendment proposed by the Bush Administration. Its use is highly touted and it is certainly the fair-haired fuel of California's energy policy where a lot of methanol experimentation is being conducted and more is being proposed.

Structurally, the fuel is an oxygen-containing hydrocarbon. But unlike gasoline and diesel fuel, methanol has one set boiling point because it's structurally consistent

throughout rather than a molecular mixture. It boils at or about 149 degrees F. Its density is like current fuels, at 6.6 pounds per gallon. But the net energy content is a major drawback - methanol's net energy content is 8,600 BTUs per pound or about 57,000 BTUs per gallon. Therefore, methanol has roughly half the energy content of diesel fuel. A vehicle would require twice as many gallons of methanol as diesel fuel to do the same work.

Unfortunately, the supply of methanol is very limited. The current world supply from plants currently in operation is about seven billion gallons. If methanol were burned in motor vehicles instead of petroleum fuels, the world methanol supply would meet about two to three percent of the U.S. motor vehicle fuel requirement.

The raw material used to make methanol is usually natural gas. Methanol can also be made from coal, from garbage, and other forms of biomass. However, using feed stocks (not natural gas) results in methanol that is at least twice as expensive. Unfortunately, the conversion from natural gas to methanol results in a loss of about 35 percent of the energy initially contained in natural gas.

To be competitive with petroleum fuels, methanol production requires large sources of cheap natural gas. Currently, most of the methanol that is on the market comes from the chemical industry where it is produced for use as a chemical. To manufacture methanol in large volumes will require large sources of raw materials. Unfortunately, the largest low cost sources of natural gas are not in the United States. Some of the foreign countries with large natural gas reserves are not too friendly to the U.S.

To be competitive, methanol plants would probably have to be put near the largest reserves of natural gas. While U.S. natural gas reserves are significant, so to is the U.S. demand for energy. In addition, U.S. natural gas reserves are widely scattered and, therefore, it would be expensive to collect and to centralize gas at conversion plants. The most likely candidate locations for new plants are outside the U.S. and one of the primary candidates would be the Middle East, although there are some other areas around the world that would make good locations for new plants. Consequently, if methanol is viewed as a replacement for petroleum fuels, methanol does not do much to reduce U.S. energy dependence on foreign energy supplies.

Historically, the price of methanol has been quite stable and current prices are about 40 to 45 cents per gallon. However, in the last few years, prices have varied. Prices have risen from a low of 25 cents per gallon in 1986 to a high of 70 cents per gallon in 1988. Thus prices have tended to be volatile during the late 1980s but have settled at 40 to 45 cent per gallon range. One additional element related to the price of methanol is that as production increases and as more relatively cheap foreign natural gas is consumed as feed stock, the price could rise significantly as more expensive methods to extract gas are used.

In summary, the evaluation of methanol as a motor fuel leads to three important conclusions. Some are equally applicable to alternative fuels discussed later. These conclusions are:

- The supply and current methanol production capacity are too limited to displace any consequential portion of the U.S. motor vehicle fuel energy demands in foreseeable future.
- Methanol is substantially more expensive than both gasoline and diesel fuel at current market prices. Therefore, there are no market forces that would drive consumers to use methanol.
- In the absence of normal market incentives, industry is not going to invest in the plants necessary to produce methanol in substantial volumes.

In addition to supply/capacity problems, the development of an efficient, high volume methanol distribution system seems problematic. It is generally impractical to ship low volumes (less than one to ten million gallons) of any fuel through existing pipelines. The physical properties, however, of methanol present even greater problems for shipment through existing pipelines than just reaching a volume threshold.

Few, if any pipelines, can handle water-soluble materials like methanol. In addition to being water soluble, methanol is also very corrosive. Diesel fuel and gasoline are insoluble in water and normal housekeeping practices are adequate to separate water from petroleum fuels. This is not the case with methanol. With methanol, some difficult steps have to be taken to keep the system dry and to keep products shipped through the pipeline dry. Also, because methanol has different solvent properties than petroleum fuels, the tanks and pipelines would have to be cleaned to ensure the purity of the methanol handled. In addition, there is some concern that the corrosiveness of methanol may preclude it from transportation and storage in existing tanks and pipelines.

Making methanol available in large quantities will require a substantial investment in a supply and distribution infrastructure. On the other hand, limited qualities of methanol are likely to be readily available with delivery by jumbo rail cars or by barge.

Methanol's primary market is likely to be with self fuelers because of the supply and serious handling problems associated with methanol. Its future use is limited by supply and costs. There are opportunities, however, to increase the efficiency of methanol manufacturing. Improved efficiency in methanol production facilities may reduce plant costs.

The main difficulty of adding new methanol manufacturing capacity is the investment required for methanol plants. Initial capital costs makeup about half the cost of methanol production. If facility costs can be decreased, then there would be greater incentives for increasing supplies. In addition, if the conversion of natural gas to methanol can be done more efficiently, the demands for natural gas feed stocks and the cost of production would decline.

Ethanol. Like methanol, ethanol is an oxygenated hydrocarbon. Pure ethanol consists of one molecule and, therefore, it boils at a specific temperature, 172 degrees F. Its density is about 6.62 pounds per gallon. The net energy content of ethanol is about 11,500 BTUs per pound or 76,000 BTUs per gallon. Although ethanol has more energy per gallon than methanol, it is still less-energy dense than traditional petroleum fuels by a factor of about 1.5 to 1.75.

The entire U.S. supply of ethanol for motor vehicle fuel is about 700 million gallons per year. The current supply represents only about one-half of one percent of the energy provided by gasoline. Clearly, there are limited supplies of ethanol and most of it is consumed as an adjunct to gasoline in gasohol.

Ethanol is blended with gasoline at the terminal rather then at the refinery. This is done for several reasons. First, the use of ethanol blended fuels are quite dispersed and it would cost even more to deliver blended fuels to the terminal than it does to blend the fuel at the terminal. The second reason is one shared with methanol. Ethanol has a high affinity for water and makes refinery blending and pipeline transporting impractical because it will absorb water. Third, the terminal blending allows fuel suppliers to use ethanol in states that provide the best tax incentives. Ethanol is used only in those states that provide favorable tax treatment.

Most fuel ethanol is made from corn, although it can made from other grains. Ethanol manufacturing consumes about 280 million bushels of corn annually, or about four percent of the normal U.S. corn crop. Manufacturing costs range from about $.90 to $1.80 per gallon depending on the size and efficiency of the plant and the method used to mill the grain. The overall energy balance for ethanol is essential even. That is, the energy required to grow and process the grain approximately equals the energy contained in ethanol and its byproducts. Ethanol's market price is currently around $1.10 to $1.20 per gallon.

About 80 percent of the normal U.S. corn crop (about seven to eight billion bushels) finds a ready market in animal feed, food, and corn sweeteners. The remainder is exported or stored. Converting ethanol not used for feed or food would add only about three to four billion more gallons of ethanol per year. This is equivalent, on an energy basis, to about two percent of the total energy consumed as gasoline. Increasing corn production above current levels would require planting on marginal land and increase the demand for irrigation and fertilizer. This would tend to drive up the cost of ethanol and make the energy balance worse (energy used to produce ethanol versus energy derived from ethanol) and even result in a negative energy balance. Therefore, it is extremely difficult to see that ethanol will ever be a source of a major portion of motor fuel energy. It is likely that the major role for ethanol will be serving as an oxygenate.

Compressed Natural Gas. Compressed Natural Gas (CNG) is predominately methane. It boils at or about 216 degrees below zero F. Its energy content is about 1,000 BTUs per cubic foot and it actually has more energy on a per pound basis than gasoline or diesel fuel. The biggest difficulty with CNG is squeezing enough of it together to provide a motor vehicle with a reasonable range.

CNGs most attractive characteristic is that a distribution system is already in place, because CNG is also used in many U.S. homes for heating and cooking. Furthermore, natural gas is relatively inexpensive. It costs about two dollars per million BTUs at the well head, about half the price on an energy unit basis, of crude oil.

One disadvantage of CNG is the location of the world's natural gas supplies. Currently, the quantity of natural gas delivered to the U.S. exceeds the demand for natural gas. This creates the false impression that there are large supplies of natural gas. In reality, the U.S. has a relatively small natural gas reserve. In fact, the U.S.'s natural gas reserves amount to about the same proportion of the world's supply as its petroleum reserves. Therefore, the U.S. is likely to find itself still dependent on foreign supplies if a major switch were made to CNG as a motor fuel.

Another disadvantage of natural gas is compressing it for use in vehicles. Besides the cost of transporting natural gas from the well head, the gas will have to be compressed. Only when the gas is compressed to 4,400 to 3,400 psi is it practical to use in motor vehicles. The investment in compressors will be significant. The cost for a fast fill facility could easily reach $250,000 per site. In addition, CNG vehicles must have heavy tanks which further limits the amount of cargo the vehicle can carry and increases the vehicle's cost. In fact a recent study conducted by AMOCO found that a fleet operator would have to tank CNG at less than four dollars per million BTUs (including taxes, cost of the gas, and capital recovery costs of the fixed facility) to be equivalent in cost to conventional fuels. Once excise taxes are added to CNG, it also loses its cost advantage. For example, the State of Illinois currently taxes natural gas at one dollar per one million BTUs and the equivalent federal excise taxes would be about 80 cents per one million BTUs. When taxes, the cost of the gas, the cost of refill stations, and the costs associated with fuels tanks are added, CNG is not cost competitive in comparison to petroleum fuels.

Because of the costs associated with CNG and distribution difficulties, it is doubtful the CNG will receive widespread use without regulation encouraging its use. Nevertheless, CNG has the greatest potential of all the alternative fuels because it has an existing distribution system and its cost, on an energy basis, is closest to the cost of petroleum fuels.

Liquefied Petroleum Gas. Liquefied petroleum gas (LPG) is a mixture of propane and butane. It is a gas, but can be compressed to a liquid at or about 300 pounds per square inch. On a per pound basis, it has more energy than gasoline or diesel fuel but only about 75 percent of the energy on a per gallon basis.

The total U.S. production is about 20 billion gallons per year. Most LPG is obtained as a byproduct of petroleum and natural gas extraction. Some of it is also generated in chemical plant and refinery operations. It is used in a variety purposes--chemical feed stock, process fuel, fuel for space heating and cooking, and about 2 billion gallons are being used for motor vehicle fuel.

LPG is transported from the production source mainly in jumbo rail tank cars and then distributed in trucks with capacities ranging from two thousand to six thousand gallons. Obviously, this is a more expensive distribution system than the one used to distribute petroleum products. Its current wholesale price is about twenty cents per gallon.

The largest drawback of LPG is that it is a crude oil and natural gas byproduct. Therefore, it is difficult to increase supply of LPG without increasing crude oil and natural gas production. Therefore, its share of the market will always be limited by the cap on LPG supply. Even if all the LPG were shifted from other uses, it would provide only ten percent of motor vehicle energy needs. Also, other fuels would have to be found for the uses that LPG no longer serves.

Reformulated Gasoline and Reformulated Diesel Fuel. These are included with the alternative fuels because they will be significantly different from the gasoline and diesel fuel used today. The objective of future fuel reformulation is primarily to improve the emission properties of the fuel. Actually, reformulated fuel is not a new idea. Removing lead from fuel to create unleaded gasoline is an example of fuel reformulation.

A new era of reformulation is starting. It begins with reductions in Reid Vapor Pressure (RVP) to help control fuel volatility. Another step of reformulation is blending in oxygenates to help control carbon monoxide emissions. Other reformulations will involve reducing benzine, an identified carcinogen, and other aromatic compounds. Reformulation is also likely to include a reduction of olefin, a hydrocarbon structure, to reduce reactive hydrocarbon emissions in older vehicles without catalytic converters. Closer control of the 90 percent distillation temperature, the temperature at which 90 percent of the fuel is evaporated, is also being considered to reduce hydrocarbon emissions. Reformulation will incur some additional costs and have some impact on reformulated fuel supply as the necessary processes are incorporated into the refining process. These factors are likely to translate as cost increases in the range of ten cents per gallon. However, there is a lot of work left to be done to determine the desired properties of reformulated gasoline.

Reformulated fuels are particular attractive compared to other alternative fuels because they can use existing distribution systems. Another attraction is that existing vehicles can burn reformulated fuels without modification. This would mean that emissions from all vehicles, not just those modified to burn alternative fuels, would be reduced.

Reformulating diesel fuel is more familiar than reformulating gasoline. The specific composition changes of diesel fuel include a ten fold reduction of sulfur

content--sulfur is a direct contributor to particulate emissions. Furthermore, because there is a relationship between aromatic content and cetane, aromatic levels will cap at what they are today by requiring a minimum of 40 cetane index. These two changes require an investment at most refineries and result in about a five-cent cost increase.

Future reformulation of diesel fuel may include a reduction in aromatic and other additives to reduce engine emissions and/or prolong the engine's emission--reducing features. This may include additives that reduce engine deposits to keep emission control systems clean.

Reformulated diesel fuel benefits from its acceptance in the market place and from its proven, efficient distribution system. It would also have a broad impact by improving the emissions of all diesel engines regardless of their age or technology.

Conclusions

This presentation has explored the leading alternative fuels from a distribution and marketing perspective. Clearly, there are no easy answers.

It is likely that the future fuel market will see a larger variety of fuels, each with its own specifications and properties. Except reformulated gasoline and diesel fuel, all will suffer from problems related to distribution, compatibility with existing engines, and cost per unit of energy. Clearly, any shift to an alternative fuel will only be achieved through a governmental mandate or regulation. This is even true for a shift to reformulated fuels due to the necessary expenditures to produce reformulated fuels.

MAINTENANCE SHOP RELATED REGULATIONS AND REGULATIONS IN THE 1990s

Daniel W. Mencucci, *New York State Department of Transportation*

Using New York State Department of Transportation's experiences with a state OSHA plan in place since 1980, it was my intention to create an awareness by the participants of the importance of occupational safety and health in the work environment, specifically in the equipment management setting. I discussed our efforts to meet "the letter of the law" compliance with OSHA standards, and roadblocks encountered in that endeavor. More important was the realization that our efforts were not succeeding, and subsequent identification of the changes necessary to meet our program objectives. They were:

- Developing better lines of communication among Department managers regarding OSHA full compliance;
- Hiring an Industrial Hygienist to identify exposures;
- More emphasis on engineering controls;
- More reasonable time tables for phasing compliance with other standards; and
- More precise interpretation of standards by the Labor Department, the enforcement agency.

As a result of these actions, our compliance efforts are "back on track."

In closing, I asked the audience to:

- Give safety their personal attention--get involved, be supportive;
- Think as if OSHA exists in their state, whether it does or not, use the standards as guide;
- Realize that all states will probably adopt OSHA by the year 2000;
- Develop safety standards voluntarily, before it becomes the law,this will make the transition easier;
- Be proactive, not reactive;
- Develop a safety program appropriate for their specific needs--no more, no less;
- Pay attention to safety in their own program area, before someone in their organization tries to do it for them;
- Get the employees involved in the process;
- Use engineering controls, when feasible; and
- Institutionalize safety into their operations--everyone benefits.

LEAKING UNDERGROUND FUEL TANK MANAGEMENT SYSTEM

Thomas C. Niver, *North Carolina Department of Transportation*

The North Carolina Department of Transportation (NCDOT) leaking underground storage tank (UST) management system was developed as a result of state regulations for underground storage tanks, which have been under development since 1985 when the General Assembly authorized the Environmental Management Commission to develop and adopt such regulations. These regulations have provided technical standards for construction and installation of new UST systems, for corrective action in cases of leaking systems, for closure of systems taken out of service, and for release and action of new and old systems.

The NCDOT is composed of 14 divisions in 100 counties with 108 refueling facilities. An active program of installing new fiberglass tank systems along with removing existing out of service tanks and piping was initiated in 1988. In 1989 an annual tank testing program was started for 24 year old tanks and older. Tank testing was eventually expanded to include the State Highway Patrol, Ferry Divisions, and Welcome Centers. Currently, 200 underground storage tanks are scheduled for testing in 1990.

Shortly after the program was initiated, several petroleum contaminated sites were discovered and it became apparent that an organized approach to deal with leaking UST sites was needed. A standard operating procedures manual was drafted and distributed throughout the NCDOT. This draft outlines procedures for initial response, remediation and sampling, should contamination be encountered, as well as, basic site closure steps for clean sites.

Detailed preliminary site investigations are being conducted by NCDOT personnel. These investigations explore the lateral, vertical and horizontal extent of petroleum releases. They include all aspects of regional hydrology, site hydrogeology, magnitude and direction of groundwater flow, delineation of contaminant plume, and proposed remedial action plans and systems. Re-

ports and permit applications are prepared and submitted to the local Environmental Health and Natural Resources office. The outline, shown in below, describes the minimum data/information requirements for review and evaluation of remedial action plans and supporting site characterizations in North Carolina. This outline provides a step-by-step approach for site investigations.

It is the intent of the NCDOT to utilize staff personnel for tank abandonments, environmental assessments, and soil and groundwater remedial activities. Outside consultants will be used, on an as needed basis, for environmental investigations and cleanup. They will also follow the state site characterization outline which should eliminate unnecessary work.

Outline for Evaluation of Site Characterization Data and Remedial Action Plans for Groundwater Restoration in North Carolina

1. Introduction--including a statement of objectives and a definition of the scope of the investigation.

2. General Locus Map (e.g., 7-1/2 min. topographic map where available; otherwise, segment of county highway map) showing location of contamination site.

3. Discussion of Regional Hydrogeology
   a. Delineation of the occurrence of geological units or formations including lithologic character and structural features (from published literature, files and personal knowledge);
   b. Reference to relevant geological features such as faulting, fracturing, dip of bedding planes, etc.;
   c. Information pertaining to local groundwater usage including type of use (public, industrial, private domestic, irrigation, etc.) and identification of aquifer; and
   d. Identification of all water supply wells within 1500 feet of the source of contamination including location and construction details, if available.

4. Base Map(s)* upon which the following information is exhibited:
   a. Location of source(s) of contamination;
   b. Locations of all sampling points, logged borings, and observation/monitoring wells;
   c. Locations of all points of potential exposure to contaminants (water supply wells, surface water bodies, underground utilities, etc.); and
   d. Locations of all relevant physical features (buildings, roads, etc.) and hydrogeological features (recharge and discharge areas) in the immediate area.

* Base map should be to scale (preferably 1" less than or equal to 100') and include all relevant physical features (buildings, roads, etc.) in the immediate area.

5. Description of Site Hydrogeology
   a. Stratigraphic logs of all boreholes using a standard classification system and/or borehole geophysical methods. Log should include identification of system or method used and (geophysical) and referenced to location on base map;
   b. Minimum of two cross sections (preferably intersecting at approximate right angles and extending across the contamination site) exhibiting major hydrogeologic units (bedrock, gravel, sand, silt and clay layers) as determined by the logs; and
   c. Evaluation of relevant aquifer parameters, including results of aquifer tests, if available.

6. Direction of Groundwater Flow
   a. Static water level measurements (referenced to a common datum) from a minimum of three (3) observation wells. Discretion should be used in selecting appropriate number and location of observation wells to ensure accurate representation of groundwater flow. Data should include depth to static water level, relative elevations of points from which depth is measured, and date of measurement;
   b. Description of methods used for water-level measurement--including time interval between well development and water level measurement;
   c. Well construction records for all observation wells showing total depth of well, depth of screened interval, date of construction, etc.;
   d. Identification of significant features or activities which may affect local groundwater flow patterns; and
   e. Flow net superimposed upon base map showing equipotential lines and selected flowlines which exhibit direction(s) of groundwater flow. Static water-level measurements used in flow net construction should be shown on the equipotential map.

7. Delineation of Contaminant Plume
   a. Identification of the contaminants responsible for violations of groundwater quality standards (i.e., qualitative characterization of the plume);
   b. Plan of contaminant plume superimposed upon base map, the distribution of selected parameters may be shown by isometric lines.
   c. Profile vertical component of plume geometry or contaminant profile referenced to hydrogeologic cross sections described in 5 (b);
   d. Analytical reports for all sampling activities including date of sample collection and references to sampling points shown on base map;
   e. Description of sampling methods used - flushing time, extraction volume, etc.; and
   f. Well construction records for all wells utilized as sampling points showing total depth of well, depth of screened interval, date of construction, etc. (may reference well construction records compiled under item 6(c)).

8. Objectives of the Remedial Action Plan (RAP)
   a. Statement of goals and expected accomplishments of the RAP (e.g., source control and/or removal, reduction in contaminant concentrations, removal of "free product," contaminant or retardation of plume migration, reduction in areal/vertical extent of contamination, protection of nearby water supplies, etc.); and
   b. Proposal for establishing target clean-up concentrations based on groundwater water quality standards.

9. Design and Operation of the Remedial Action System (RAS)
   a. Construction details (including design sketches) and facility layout (superimposed on base map) of all components of the RAS including recovery wells, interceptor trenches, infiltration galleries, groundwater treatment units, discharge facilities, etc.;
   b. Operational characteristics and performance standards of all system components (e.g., information on recovery wells should include duration of pumping, anticipated yield, and expected radius of influence. Data on treatment units should include influent concentrations, expected effluent concentrations, and flow rates). Discussion should address such factors as effectiveness, reliability, maintenance, and safety; and
   c. Consideration of all permits and approvals required for disposal of waste materials and/or discharge of effluent.

10. Follow-up Site Monitoring and Evaluation of RAS
   a. Plan for periodic monitoring to detect changes in groundwater movement, plume geometry, and qualitative characteristics of the plume and to assess site response to disposal of effluents; and
   b. Plan for continuing re-evaluation of the effectiveness of the RAS in accomplishing objectives established under item 8.

THE IMPACT OF ALTERNATIVE FUELS ON HAZARDS IN THE WORK PLACE

Mark E. Maggio, *Iowa State University*

Introduction

This paper takes an in-depth look at the work place hazards which arise with the growing use of alternative transportation fuels. This shift in emphasis toward alternative fuels has been predicted upon provisions of the 1990 U.S. Clean Air Act, as well as on some state-level initiatives, for instance in California. The Act establishes tailpipe emissions standards, which in most cases cannot be met by vehicles running on diesel fuel or gasoline. However, use of these fuels may be hazardous to maintenance and refueling personnel if proper precautions are not taken.

The Clean Air Act is still in conference committee, with the Senate Bill (S. 1630) differing from the House version (H.R. 3030). It is clear, however, that the regulated emissions levels for 1994 will include 1.3 g/bhp-hr of reactive hydrocarbons, and 15.5 g/bhp-hr of carbon monoxide. These standards were effective in 1987, and have by and large been met with current engine and fuel technology.

However, an 83% reduction in emissions of particulate matter over the period 1989-91 will be required for urban buses. The 1991 bus standard is 0.1 g/bhp-hr. Heavy duty trucks are subject to an interim standard of 0.25 g/bhp-hr for 1991. In 1994, the bus and trucks standards converge to 0.1 g/bhp-hr. Nitrogen oxide emissions are to be reduced by 53% over the period 1989-1991 from 10.7 g/bhp-hr to 5.0 g/bhp-hr. The fuels and engines which meet emissions standards and cost criteria in the transit industry will most likely be candidates for use in the trucking industry.

Discussion of Alternative Transportation Fuels

The alternative fuels in the study are methanol, ethanol, compressed natural gas (CNG), and liquefied petroleum gas (LPG). Some thirty fleets which currently utilize alternative fuels vehicles were identified and their experiences were analyzed. These fleets are primarily transit bus operations and utility company service fleets. Many fleets are conducting performance tests with engine manufacturers or fuel suppliers.

Comparisons of the delivered wholesale prices and energy density of each fuel are noted, relative to diesel fuel. Along with required engine modifications and additional vehicle fuel tank costs, the alternative fuels are not found to be cost effective when compared with diesel fuel vehicles. Aggregate demand for these alternative fuels is not large, and their distribution and supply is limited in many regions. However, several non-economic benefits have enticed transit bus operators and utility companies toward greater use of alternative transportation fuels.

The primary advantage for transit operators is that the alternative fuels offer the greatest promise of meeting the 1991 standard for urban bus emissions. In fact, methanol is the only fuel which has proven, in field demonstrations, that it can meet all 1991 tailpipe standards in a two-cycle heavy duty engine. With these environmental benefits come significant issues involving industrial hygiene and work place safety.

Hazards in the Work Place

Managers are well as maintenance shop workers must understand and take seriously the potential hazards inherent in the various alternative fuels.

The alternative fuels which are liquids pose a significant hazard if ingested. For methanol, studies suggest that permanent blindness may be caused by ingestion of two teaspoonfuls, with death occurring from ingestion of about four teaspoonfuls. Methanol toxicity through eye contact or prolonged skin exposure is also documented. Toxic inhalation levels for all four fuels are discussed, including the need for improved passive and mechanical ventilation.

The risks of fire and explosion are well known with the gaseous fuels, CNG and LPG. However, the flash points for methanol and ethanol are lower than gasoline or diesel fuel. Also, methanol and ethanol vapors are within their ignition limits at normal atmospheric pressure and temperature. Fire fighting and fire prevention procedure, including the elimination of all ignition sources in the shop or refueling area, are critical. The reader is referred to several National Fire Protection Association codes.

Work place health and safety may also be compromised as a result of a fuel leak or spill. Fuel storage tanks and dispensing and transfer equipment must meet hazard-class specifications. Some widely-used materials are incompatible with some of the fuels. The hazards are compounded when alternative fuels are present.

Training Plan

It will be necessary to implement a multi-step training plan to reduce workers' exposure to potential hazards in the maintenance shop and refueling areas. The elements of a suggested training plan are:

1. Introduce properties of the fuel and the engine
   a. Flammability/luminosity/combustion/explosion
   b. Typical ignition sources, fire suppression devices
   c. Toxicity: skin, eyes, ingestion, inhalation
   d. Vapors and ventilation requirements
   e. Incompatible materials
   f. Electrical wiring safety requirements
2. New equipment operations
3. Securing all combustibles in the shop
4. Fuel-specific fire fighting techniques
5. Establish and monitor proper shop ventilation
6. Required protective clothing and equipment
7. Inventory, mileage, and maintenance record-keeping
8. Differences in driving and maintaining vehicles
9. Changes in facility design if necessary

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USING A FULL SERVICE CONTRACTOR

Marty Frederickson, Finance Director, *City of Des Moines, Iowa*

The City of Des Moines, Iowa, has contracted for vehicle maintenance services with one contractor since 1983. The city's experience has been very positive. To provide insight into equipment vehicle maintenance contracting and why it has been a success, my presentation will cover the following:

- The condition of equipment maintenance for the City of Des Moines and the chain of events that led us to contracting for maintenance services;
- The development of the contract and the city's relationship with the contractor; and
- In conclusion, I will attempt to identify how contracting has affected vehicle maintenance performance and point out attributes that make for a good relationship between contractor and public agency based on the city's experience.

Structure Prior to Privatization of Equipment Maintenance

The city's equipment maintenance operation was funded from a revolving account. Revenue for the account came from charging users for maintenance work conducted at the garage. This is important in understanding the sequence of events leading to privatization because the charge back system meant that the using departments were all aware of service costs.

The second key item in the sequence of events was that the equipment maintenance center was part of the Public Works Department. The Public Works Department was also the greatest user of equipment maintenance services.

The equipment maintenance center conducted comprehensive maintenance and vehicle servicing, including body repairs. It also conducted equipment management operations, including specification writing, and building and specialized repairs. The fleet they maintained included about 1,300 pieces of equipment.

Chain of Events

The privatization process started with a series of blue ribbon committee hearings on the management and administration of city departments. One of the committee's findings was that action needed to be taken to improve the operation and management of the equipment maintenance department.

During the same time period as committee hearings and departmental budget hearings, top city management received numerous complaints about the equipment maintenance center. The most frequent complaint was the poor performance of the garage as measured by repeat repairs, high cost, and poor employee attitude.

After discovering the level of dissatisfaction with the garage, top management decided to investigate new management arrangements. One effort was to assign new personnel to supervise garage employees by promoting new supervisors from existing maintenance workers. The new supervisors lacked appropriate management training and could not function efficiently as managers. The second approach was to hire a professional manager. The third approach assigned the assistant public works director to manage the garage. All approaches failed to improve performance.

After the unsuccessful attempts to improve the equipment maintenance center, city management examined the department itself. It found that, in fact, the maintenance shop did perform poorly when compared to most reasonable performance standards. In addition, the mechanics were either under trained or not current with modern technology. The facility was in poor condition, and the shop lacked modern maintenance equipment. Scheduled maintenance (preventive maintenance) was not being regularly conducted. Many employees in the shop had a great deal of seniority and, as a result, a great deal of job security. Because of the job security implicit in the city's civil service system, there was little that could be done to motivate employees to improve performance.

After its attempts to improve performance failed and after studying the department, the city considered privatizing the facility. The city felt that if it privatized the shop, it could have the contractor establish additional management controls, such as computerizing maintenance records and inventory control. The city also felt that it could contract for greater management expertise than what it could have hired given the city's civil service system.

A proposal was made to the city's top administration to privatize the garage. Based on the evidence provided in the staff study, the city manager and council approved

contracting for maintenance service in 1981. It was not until 1983 that a contract was signed with the firm that still manages and operates the equipment maintenance center today.

The Request For Proposal (RFP) development process was a difficult step for the city. Staff was very concerned about having an outside firm take over an important city function. Some of the major concerns that the contractor was asked to address in the proposal included:

- The contractor should be able to provide the city with a significant savings over in-house staff. A target of 20 percent was established;
- The contractor should possess significant personnel and equipment management capability;
- The contractor must be financially responsible. To help diminish financial concerns, the city required a performance bond in the amount of the entire contract;
- The contractor must have had prior experience with similar agencies;
- The contractor must design and establish a regimented preventive maintenance management program;
- The contractor must develop a transition plan that would identify how the contractor would takeover the facility and identify how the contractor planned to deal with existing employees;
- The contractor must develop a staffing plan that identifies the contractor's employees, their salaries, and experience;
- The contractor shall provide a list of references including prior agencies he/she has contracted with previously and vendors that have sold the contractor supplies;
- The contractor must develop a billing plan that only charged the city for repairs that were made and did not charge the city for repeat work. The contractor could only charge cost for parts, which partially eliminated the incentive for making unneeded repairs;
- The contractor will provide the city with a specific vehicle downtime guarantee. (Before the contractor initiated maintenance, downtime was a great concern. Department managers would complain as their vehicles were tied-up for days. After the contractor took over, downtime was reduced to less than four percent of available utilization time.);
- The contractor shall prepare a plan for an employee training program;
- The contractor will provide a list of maintenance equipment, shop tools, and subcontractors that they will utilize to repair city equipment;
- The contractor will develop a detail operating plan including the system for scheduling work, the work schedules, numbers of employees, etc.; and
- The contractor will develop a contingency plan to take into account a disruption in the contractors ability to service the contract. Disruptions could include a strike by the contractor's employees.

As a requirement of the contract, the contractor would have to establish their own parts and component inventory management system (using contractor owned parts and components). The bidding documents were sent to consultants for review and some revisions were made.

In deciding whether to proceed with the contract, several anti-contractor issues were raised. Issues ranged from economic concerns to whether the quality of services provided by a contractor would live up the city's expectations. They included:

- Fears that the contractor would be controlled by organized crime;
- The contractor would purposely bid low ("low-ball") to win the contract and latter coerce the city into increasing payments to the contractor;
- The contractor would not use local vendors, thus diminishing the business revenues within the city;
- The contractor would attempt to break the union and pay employees wages below the norm; and
- The Public Works Department (the current operator of the maintenance garage), argued that a contractor would not understand the needs of the city's citizens and using departments.

The city council appointed a committee to address those issues and to determine whether the city should proceed with its plans to contract for equipment maintenance services. In a series of meetings held by the committee, those issues were addressed and several rules were developed for the contractor to follow. The rules included:

- The contractor would have to first consider existing city employees when hiring staff.
- No city employee would lose his/her job as a result of the contractor taking over the maintenance function. If the contractor did not want to hire an employee, the individual would be assigned to another function. The displaced employee would be carried as an overage in the budget until an appropriate vacancy occurred. Then the employee would fill the vacancy.
- Current employees that were within two years of retirement would have their public employees retire-

ment pension program maintained regardless of whether they were employed by the contractor or continued with another position with the city.

With these constraints, the Request For Proposals (RFP) was finally prepared and distributed. Two proposals were received from contractors and a bid was also solicited from the Public Works Department. One of the contractor's proposals was viewed to be non-responsive to the conditions of the RFP. The other proposal conformed to the requirements of the RFP. One of the key attractive elements of the remaining contractor's proposal was its cost. The contractors bid was $330,000 less than the Public Works Department's bid on the service.

The city began to negotiate the transfer control of the maintenance facility to the contractor. The contractor wanted to start work as soon as possible and identified a 45-day transition period. The final agreement was a three-year contract with the ability to terminate the contract at the end of each year. Other service requirements were negotiated but the final contract did include the $330,000 savings over the Public Works Department's bid.

One major source of the contractor's costs saving was reducing the maintenance work force. The size of the staff at the maintenance garage was originally 75 employees; the Public Works Department's bid called for 68 employees and the contractor's proposal included only 44 employees. This work force reduction created some disbelief that the contractor could actually keep up with the work flow. However, the contractor did in fact meet the downtime requirement.

The contractor leases the existing maintenance facility and equipment at a cost of one dollar per year. The city maintains the building. The contractor agreed to purchase all the non-obsolete parts in the city's existing inventory at the cost of the parts. The contractor found that roughly half of the inventory was obsolete.

The contractor's profit for services was set at ten percent of the contract price. This is considered a management fee. This fee is set at the beginning of the contracting period and remains the same regardless of the work flow. As an incentive for the contractor to perform as efficiently as possible, any savings below the contract price (the budgeted amount), is split between the contractor and the city. Each party receives half of the savings. Any overage, up to ten percent above the budgeted amount, is split equally between the city and the contractor. Above a ten percent overage, the contractor pays 100 percent. The contractor provides a performance bond for the amount of the contract and has the operation audited annually.

The city has retained the management of fuel and lubricants and procurement of these products. This was done to avoid the management fee on the cost of fuel. One of the contractors employees, however, fuels and services vehicles. The city employee responsible for managing the fuel and lubricants also manages the replacement program, and licensing and registration of vehicles.

Contractor's Operation

The contractor has established a training program, employees are becoming certified, and the quality of repairs has improved. This has resulted in a general increase in employee morale.

The contractor has established a computerized information system which automates the record-keeping process, including invoices to the city for work conducted. The data processing system has aided in establishing time standards for repairs.

Experience With Contracting

The vast majority of the city's vehicle maintenance employees eventually became employees of the contractor. Most of the management and supervisory personnel retained the positions they held when they were city employees. Some of the mechanics decided to move to another city department and continue as city employees. The employees that were retained by the contractor, continued at the same salary as the city paid them. The contractor's salary increases have maintained parity with city increases. The contractor's benefit package is different from the city's. The contractor's benefit package, for example, includes profit sharing, while the city cannot collect profits to share. The contractor's benefit package is considered to be at least as good as the city's and may be better in some respects.

Fears of union busting held by former city employees proved unfounded. They are still represented by the same union as before. Working conditions are at least as good as they were with the city and are felt by some workers to have improved.

The contractor's budget, over the years of operation since the initiation of operation in fiscal year 1983-84, has increased only minimally. During the second year of operation, 1984-85, the budget was increased by 4.9

percent. The next year, 1985-86, the budget was increased by 1.1 percent. During 1986-87 the budget was increased by five percent and the next year by 4.7 percent. In 1988-89 the budget was not increased and in 1989-90 the budget was increased by 1.6 percent. The average increase in seven years has been 2.9 percent. It is likely that had the city operated the equipment maintenance garage, the budget increases would have been far greater. The contractor's most recent budget (1989-90), is still less than the budget proposed by the department of public works bid proposed in 1983.

The contractor buys parts from the same vendors that supplied the city with parts. However, the contractor has more freedom to negotiate better prices.

Conclusions

Contracting for equipment maintenance services has, in general, exceeded expectations. Some of the factors that indicate the satisfaction with the contractor include:

- Costs to the city's user groups are down;
- The equipment maintenance facility is clean and is well kept. The internal layout of the facility has been changed to make it more efficient;
- The management of equipment maintenance is professional and competent;
- The attitudes of the employees have improved due to better training and the availability of modern tools and diagnostic devices;
- The parts inventory is under control;
- About two-years after initiation of the contract, the contractor's preventive maintenance program began to provide noticeable increases in vehicle reliability;
- Equipment is lasting longer and needs to be replaced less frequently. This is particularly noticed in equipment with harsh duty cycles, like the city's garbage packers;
- Downtime is less than the contractor's target level of four percent;
- Repeat repairs are very low. In a typical recent month they were at 0.6 percent of the total maintenance work flow; and
- The number of complaints by user groups has diminished down to almost none.

Seven years of experience indicate there are two key factors that lead to good performance by the contractor. Other public agencies that are contemplating contracting for any type should endeavor to select a contractor with the following two attributes:

- Select a contractor that is financially sound. The contractor should have the financial capability to allow the on-site manager to gather the resources necessary to complete a job correctly; and
- It is important to select contractor with on-site management that is flexible, cooperative and able to work with city and its many departments. Because of the importance of the on-site manager, the public agency should reserve the right to interview the manager and see the company's policy on the authority granted to the on-site manager.

SERVICES OFFERED BY MAINTENANCE CONTRACTORS

Noble Beardsley, *Managed Logistics Systems*

Managed Logistics Systems (MLS) started providing contract fleet management and maintenance services to municipalities in 1978. The City of Gainesville, Florida, was its first contract. Since 1978, MLS contracts have grown to 23 in number across the country. The company currently has contracts with counties, cities, the federal government, public utilities, and one private firm.

A maintenance service contractor can offer a variety of services including all normal maintenance shop activities. The most important service a maintenance contractor provides, however, is "managed maintenance." Minimizing the resources consumed by maintenance is the key to efficient maintenance. Resource controls include monitoring purchase of parts, tires, and fluids, monitoring maintenance technicians' time, and creating an efficient layout and utilization of shop space. Managed maintenance controls the allocation and use of all maintenance resources.

One of the primary difference between an in-house maintenance organization and a maintenance contractor is the difference in missions that the two groups carry out. The main mission of an agency that operates equipment is to conduct the work accomplished by the equipment--equipment maintenance is secondary. For example, a state highway agency's mission is to maintain, construct, and operate roads and not to maintain the equipment used to perform that mission. Therefore, equipment maintenance tends to be a secondary responsibility. For the maintenance contractor, however, equipment maintenance is the primary mission and the primary point of management focus.

Because the contractor's focus is equipment maintenance, incentives, training, management systems, and support systems, all aim to promote and enhance the

efficiency of the maintenance function. In addition, because the maintenance contractor focuses only on equipment maintenance, maintenance employees that excel in their work may be promoted within the maintenance field and into the contractor's management ranks. Maintenance employees within an agency tend to be denied this career path and remain in maintenance. Because the main mission of the agency is not maintenance, promotion through the ranks of the agency is likely to require a broadening of the employees background.

Approaches to Organizing Contractor Management

There are several approaches a contractor may take in managing maintenance for an organization. These range from providing complete maintenance services to providing only a maintenance manager. The complete maintenance services would involve providing employees, maintenance materials, and management; similar to MLSs agreement with the City of Des Moines. Providing only management would involve the contractor's employee managing the agencies staff, equipment, and facilities.

Contracting for a manager only has the added advantage of diminishing resistance by employees and their union. The employees or their union may resist the change in employer when contracting for complete maintenance management services. By contracting for maintenance management services only, however, the agency can still receive the benefits of the contractor's management procedures such as computerized management systems and shop operating procedures.

Summary of Advantages

There are several advantages to using contractors, including the following points.

- The contractor's primary mission is to manage maintenance resources in the most efficient manner possible. Public agencies that use equipment generally do so to achieve other objectives (i.e., maintain streets roads, maintain drainage, construct facilities). The public agency is likely to concentrate more control in other areas related to their primary mission. As a result, public management of equipment maintenance is likely to be more re-active while maintenance contractors are likely to be pro-active.

- The contractor has more flexibility in hiring, promoting, and employee reward practices than most public agencies. Therefore, the contractor has greater flexibility to hire and retain the best employees.
- Because the contractor can specialize in equipment maintenance, the contractor has more opportunity to develop specialized knowledge of the equipment industry and equipment technology. Specialization is likely to provide better and more up-to-date services.
- The contractor can develop specialized skills and knowledge in maintenance management because the contractor can spread the cost of the specialized talent across several clients. Where any single organization, may not have the necessary flow of work to warrant the same degree of specialization.

THE ARMY'S PAPERLESS EQUIPMENT MANAGEMENT INFORMATION SYSTEM

Milton Emory, ***U.S. Army Logistic Center***

Historic problems found in maintenance reporting include illegible writing, transposition of numbers, data entry errors, and the cost of recording low cost parts.

Repair orders are the heart of all maintenance operations. Historically, this is an area vulnerable to many problems such as the interpretation of handwriting, transposition of numbers, and key in data entry. In our maintenance shop, as in most similar operations, record keeping has been a persistent source of problems. Shop mechanics have normally recorded labor hours and parts on repair orders. Understandable, clerical accuracy was not their primary skill.

Too often poor records made it hard to schedule and prioritize shop operations. Inaccurate inventories led to shortages or overstocking of parts and supplies. Preventive maintenance got off schedule and maintenance jobs were overlooked or unnecessarily duplicated.

In January 1988, Fort Lee implemented the Paperless Shop System which applies to use of bar code technology in maintenance reporting. The system made a dramatic difference.

The Paperless shop System begins with a blank sheet of paper. The computer automatically assigns sequentially generated Repair Order (RO) numbers. These RO numbers and all related RO activities are bar coded. This, provide an accurate method for building precise, fully detailed reports covering every aspect of the maintenance operation without any pre-printed forms.

Records information whether critical or something as simple a comment, has always been a clerical function and thereby subject to errors. The application of bar codes overcame this problem by enabling even the smallest detail to be recorded and extracted at any time without writing.

Bar codes provide the capability to record information in the field as well as in the maintenance shop. Each shop employee is assigned an individual bar code reader (Readers may be shared on a different shift). The portable bar code reader is used to log the individual's personal ID number. The built-in time clock automatically date/time stamps each transaction or event as they occur. This provides an ideal audit trail by using the bar code reader with pre-printed bar code work sheets. Readers track all labor transactions, whether direct or indirect, and numerous other duties as determined by management. Direct labor includes work on items such as equipment, clutch, tires, lights, engine. Indirect labor includes time spent on items such as fueling, meetings, lunch, picking up parts, etc. Bar codes are used to receive, issue, transfer and inventory parts. This eliminates the need to write at any step of the process, or from ordering until the parts have been used on a piece of equipment or vehicle.

Parts transaction can be done from a parts work station, parts room or from the mechanic's portable reader. The system can record receipt of incoming supplies and maintains inventory of parts on hand as well as a record of parts used, basic stock level, and basic re-order point. The system can generate bar codes for parts not already bar coded. When a mechanic wands a part, it automatically records the information against the mechanic, repair, charges the vehicle, and updates the parts inventory system.

When a new repair order is initiated, the associated vehicle's identification number is entered through the keyboard. This ties the vehicle number to the repair order for all future processing.

The appropriate meter reading (odometer, hubometer, hour meter, etc.) is entered through the keyboard now. This positions the data in proper perspective relative to the vehicle's history. This information is critical whether filing a warranty claim or analyzing the vehicle's performance. Each RO is automatically date/time stamped.

Down time is automatically recorded when on RO is opened and closed. Other information, such as reason for repair, repair site, repair classes, are entered at the work station with the bar code wand. All data collected through these readers are automatically charged to the appropriate RO and vehicle history file through the software.

The bar code reader contains a built in microprocessor. This places the power of a computer in the mechanic's hand. The software employed in the bar code reader is user friendly and incorporates instructions for the user. It monitors all input and will immediately screens input at the time of entry. This approach eliminates most data input errors right at their source, on the shop floor or in the field, thereby eliminating going back to the work station.

Employees may transfer from one RO to another or from a RO to indirect labor. Multiple mechanics can be

logged onto a single RO. The bar code readers are down loaded at the end of each shift or to fit the need of each operation. It is capable of recording and storing approximately 2,000 individual transactions. The standard unit has a 32K memory with provisions to increase memory to 250K.

When the readers are down loaded, all raw data is automatically edited. Any ROs with errors are printed. All completed ROs have to be viewed on the screen or printed before putting into history. At the end of the day or shift, all files such as parts inventory, PM schedules, fuel reports, labor and campaign reports, are updated.

Since the Paperless Shop System was implemented, the mechanic's efficiency has improved by 20%. Preventive maintenance records being updated daily has allowed us to keep our maintenance under control. As a result, break downs are few and duplicated maintenance has been eliminated.

Total parts inventory has decreased by 50%. The system allows the shop to anticipate what parts are needed in inventory. Remember, bar codes by themselves do nothing. It's the combination of a bar code symbol, bar code reader, computer terminal, communications network, and computer software that provides a window of opportunity to resolve age old problems and to obtain accurate and timely information about what is happening on the shop floor or in the field as it occurs on a daily basis without writing. The system has achieved a positive return on investment in one year.

You need the right tools to do the right job. We have them--the mechanics, the bar code, the future!

THE EVOLUTION OF AN ON-LINE INTEGRATED EQUIPMENT MANAGEMENT SYSTEM

Richard W. Hunter, ***Illinois Department of Transportation***

The title of this presentation--The Evolution of an On-Line Integrated Equipment Management System--contains some key words on which I would like to build. The first is evolution. The concept behind Illinois Department of Transportation's (IDOTs) Maintenance Management information (MMI) System goes back to the late 1970s. Initial development work on the system was completed in 1980 and the system was fully operational and in use, statewide, July 1987. Like most large systems, our MMI System experienced numerous problems during the development phase. In the end, the product initiated in 1987 only remotely resembled the system conceived and presented during the development in phases in the early 1980s. Today, the evolution continues. Since July 1987, numerous enhancements, improvements, additions and revisions have been made with more planned in the near future.

The second key word in this presentation is integrated. What exactly is an integrated system? When the title for this presentation was put together, integrated seemed to be the best word to describe the MMI System concept. That concept, from the early development stages, was to incorporate all facets of a comprehensive highway maintenance program.

You might be asking yourself way in an Equipment Management Workshop, am I talking about highway maintenance, as a whole. Well, before development and implementation of the MMI System, the Illinois Department of Transportation had several fragmented systems including a very limited vehicle fleet management system and no automated system for collecting management data on off-highway maintenance equipment. While improving equipment management in Illinois had been a topic of discussion for several years, it became apparent that the best opportunity to develop a solid equipment management system would involve incorporating equipment management into the total maintenance management concept. Perhaps, this can best be explained by taking a few minutes to present the overall concept and operating design of our MMI System. The MMI System is based on the classic concept of the cycle of management; that is, planning and budgeting a work program, executing the program, and reporting and evaluating the program in preparation for the next cycle.

In highway maintenance, three basic components are necessary for an effective program. These are: labor, materials, and equipment. To execute effectively the work necessary to maintain the highway system, the planning phase must identify the requirements for all three components-labor, materials, and equipment. To this end, extensive efforts have been made within the MMI System to develop realistic models which permit development of work plans based on the availability and cost of each component. Furthermore, using spreadsheet what-if programming, MMI provides the IDOT Maintenance Engineer with the ability to look at several plans with different factors in a very short time.

Incorporating equipment inventories, equipment operating costs, and equipment downtimes into these planning tools ensures that the highway work plan created by the system can be accomplished without question as to sufficient equipment to carry out the task. Your question at this point probably is, "on what basis

are we modeling equipment availability, as well as availability of labor and materials?" To address this question, we need to return to the cycle of management and look at the next two phases in the cycle.

Execution of work requires good field level management and supervision and not only a commitment to perform the work in an effective professional manner, but also to record and document the "where, when, and how" the work was accomplished. It is only through good records that we can develop effective models for plans. As in the classic cycle, each portion of the MMI System depend on the other. How do you collect sufficient information to build an effective plan?

It is at this point that another phrase emerges. That is, On-Line. Like most systems of their time, early IDOT management systems were of a batch design. We all recognize the inherent problems with batch systems, the most significant of which is lost time between that time at which work is performed and that time at which work is reported and available as system output. Although many things can be done to improve the efficiency of batch systems, it is recognized by most that, when economically possible, on-line systems are the way to go.

IDOTs MMI System is a large on-line system with main frame support in our Springfield office and 250 remote terminal sites throughout the state. Each terminal site is connected on a series of dedicated telephone line drops linking each terminal with Springfield and providing on-line access for a minimum 20 hours everyday. In addition to terminal access at each remote site, a dot matrix printer is available for reports from the system.

The MMI System has been developed to promote field level use. We do not use dedicated data entry personnel, but rather train and encourage appropriate field level people including our field line supervisors and our highway maintenance workers to utilize the system to their advantage in their area of work. Various levels of security have bene developed to provide access at the appropriate level, while making every effort to ensure the integrity of critical management data. On-line access to the system allows field personnel to input necessary information continuously throughout the workday and at most time of the day during emergency operations, including around-the-clock snow removal activities.

Because of the integrated approach, we can collect required data in all areas including labor, materials, and equipment used. We are able to pinpoint the location of the work and the work activity as well. Equipment used on any given maintenance activity is reported by its inventory control number and the number of hours assigned to the particular work activity. These hours represent time on the job site. Actual operating hours are collected on fuel and repair tickets.

To simplify reporting of equipment and reduce the number of inventory number entries, we recently developed an attachment file which allows us to capture field usage of component attachments, simply by reporting the 6-digit number assigned to the prime mover. For example, when reporting a snowplow truck used in the work activity--snow removal, the system automatically includes the snowplow and salt spreader assigned to that truck. If the same truck is used for another activity, such as aggregate stockpiling, the assigned snowplow and spreader are ignored. By actively collecting equipment assignment hours, we can improve the management cycle by predicting equipment availability.

In addition to availability, the MMI System provides for field collection of operating costs and downtime information. Because Illinois DOT does not operate its own repair facilities, our maintenance personnel enter repair data, along with fuel consumption, on the basis of repair and fuel tickets provided by repair and fuel source. These sources include state garages operated on a revolving fund charge basis by the Illinois Department of Central Management Services and by private repair and fuel suppliers. Our original concept incorporated downtime reporting as a part of the repair collection process. Today, however, we have found this method to be somewhat ineffective and are exploring alternate approaches to collecting downtime.

Another key area of equipment management addressed by the MMI System is improving Preventive Maintenance (PM). For years, IDOT published and provided, to field forces, a PM Program. Unfortunately, no system ever exited to remind field personnel of the time to provide PM, and consequently, programs were either ignored or modified to suit local ideas as to appropriate time and appropriate PM actions. Within the MMI System, we have created a detailed PM reminder program based on vehicle and equipment usage with secondary calendar parameters. While we met with some initial resistance to the statewide PM criteria established to drive the reminder system, we have recognized a significant improvement in PM and a significant reduction in the number of unscheduled repairs, as well as overall operating costs.

Today, equipment management issues continue to evolve within our system. Recently, we incorporated additional enhancements in the PM system to ensure a minimum level of annual PM, irrespective of vehicle or machine utilization. With accurate records of utilization, we are now utilizing MMI data to project eligible replacement candidates in our annual budget process. In

the months ahead, we are looking forward to including, in our MMI database, an equipment evaluation system which will permit additional input from field personnel--the actual users of our equipment in rating and evaluating equipment performance and supplier support.

Today, our system continues to evolve. We are expeditiously developing an enhanced field level, work scheduling module to provide line supervisors with a tool to plan and schedule on a week-to-week basis. In addition, a tool and supply inventory control module is being installed on a district-by-district basis, to be completed next year.

It is important to identify some of the disadvantages and advantages of a large system integrating many facets of the Department. Perhaps, the most obvious disadvantage in building a large sophisticated system is the time required in development and implementation. MMI took nearly 7 years to develop and implement. Cost, also, is a factor. While predominantly developed in-house, our MMI System still has required a tremendous amount of support staff to develop and, even today, to maintain and enhance. Development costs for the system are estimated at $3 million and our annual operating costs are approximately $1 million. Enhancements don't always occur as quickly as we would like. Resources require prioritization of enhancements sought by the various users of the system. Despite these negatives, we believe the positives far outweigh the drawbacks.

By developing an integrated system, we have created a tremendous database which can be accessed by numerous users for numerous activities from budgeting, to scheduling, to inventory control, to work efficiency. We have a dynamic system, with potential for even greater expansion. We have reduced training time and user demand using one device to collect all important information. We have eliminated repetitive paperwork by feeding numerous items such as time reporting and inventory control directly to other systems. We have provided all of our users with convenient local access to regular production and special reports. By taking the time to analyze thoroughly current and future needs, we firmly believe we have a system which can be expanded, enhanced, further developed and refined to meet our needs well into the 21st century.

ELECTRONICALLY CONTROLLED DIESEL ENGINES, C. O. Henriksen, *Detroit Diesel Corporation*

Electronically controlled diesel engines are designed to meet customer performance requirements and emission control standards. The basic approach used by various engine manufactures to produce these engines should be similar since each is attempting to satisfy the same customer requirements and emission standards.

Electronic Components

Electronically controlled diesel engines represent the integration of basic diesel engine design with the speed and accuracy of modern computer technology. The electronic system is composed of an electronic control module and several sensors used to monitor the engine's performance. The control module is the brain of the electronically controlled engine and contains the system memory and programming elements. There is also an electronic foot pedal assembly which contains a potentiometer. It senses the request for power from the operator. There is also a coolant level sensor which monitors the coolant level of the system. If it gets below a safe level, it will notify the operator of the problem. There are two temperature sensors: one for oil and another for fuel. The oil temperature sensor is used to adjust the engine timing on cold starts to allow rapid engine warm up. In addition, it provides an engine protection feature. If the engine gets too hot, the engine can be powered down to reduce the potential for engine damage. The fuel temperature sensor is used to calculate fuel consumption. This keeps a running tab on how much fuel has been burned. An oil pressure sensor is used for diagnostic purposes and engine protection. At dangerous oil pressures, the engine can be shut down to protect it. There are also two timing sensors: a synchronous reference sensor and a timing reference sensor. The synchronous reference sensor counts the engine's speed in revolutions per minute (RPM). The timing reference sensor notes when cylinder #1 is at top dead center. This is important when trouble-shooting an engine that will not start. There is also an electronic unit injector. It controls the movement of fuel into the injector plunger.

These sensors and others are located on the engine as well as inside the vehicle. Harnesses go into the cab to the ignition switch, to the foot pedal, and to the cruise control switches. They also go to panel lights for check engine (a yellow light) and stop engine (a red light).

Engine Performance

The amount of hysteresis or reaction time in response to speed and load changes compared to a mechanical system is much shorter for the electronically controlled engine. For pumping or power-take-off (PTO) applications, the system reacts quickly and maintains a stable engine speed. Torque curves can be customized to specific applications. There are preselected power and speed readings to initiate a boost power condition. This can be programmed into the electronics system which is not available in mechanical control engines. The variable speed governor is very load sensitive. With a small change in load it can respond almost instantaneously. For hydraulic pumps powered from the PTO, a maximum speed for the PTO system can be set to avoid excessive RPM of the pump. Minimum and maximum RPM settings can be made. For fire truck applications, the water pump pressure can be the controlling factor. Power control protection can be provided to shut down the engine when certain conditions could cause transmission or rear axle failures. Marine system controls at the rear of the cement mixer or controls at the rear of a fire truck can also be integrated into the protection system.

Recording Events

Diagnostic equipment can be attached to the electronics system to obtain stored data. The data can be used to determine if a specific condition exists now or was present at some time in the past. They can be provided on the complete engine or on a cylinder by cylinder basis. The data can be extracted from the electronic system with a hand held reader.

When the ignition switch is first turned on, two warning lights come on: a yellow, check engine light and a red, stop engine light. They will be on for a couple of seconds and then go off. If either of these lights come on at any other time, it indicates that something is not working properly. The problem could be with a sensor, a loose wire, or in an injector. It could be a non-harmful engine problem, such as an intermittent electrical problem. If this is the case, the check engine light may come on and then go off. The driver does not have to tell the mechanic that the check engine light came on.

The event is stored in the electronic system memory. Before that unit goes back into service, the mechanic has access to all of the sensor data related to the event. If the yellow, check engine light comes on and stays on, the driver can push the engine check button and a defect code will be transmitted to the driver. With a pocket card, the driver can determine the exact nature of the problem and determine if it is safe to continue operating the vehicle.

There are certain events where the engine protection system will shut down the engine. These events include loss of coolant, low oil pressure, or engine overheating. If any of these conditions exist, both the yellow and the red light will come on, indicating that a major problem exists. In the engine shut down mode, the driver has thirty seconds to move the vehicle to a safe position. If additional time is needed, there is an override button. All that does is start the shut down sequence over.

A diagnostic data reader is used to extract the event date from the electronic system memory. The reader is similar to the General Motors or Chrysler electronic cards introduced a few years ago. The reader has some programming capabilities. If a vehicle comes in with a problem, data is recorded just prior and just after the incident. This information will be available for the mechanics and technicians to determine what has happened. It records not only the fuel consumption, but also the number of engine hours, how many times it has been set at idle, and how much time in PTO mode. There is also a printer interfaced. The capabilities of the diagnostic data reader to provide information are extensive.

Electronic System Programming

Programming, modifying, or calibrating the electronic system may involve changing the password security, modifying the idle time or PTO setting, modifying the shut down criteria, or changing the governor procedures. Changing the PTO settings could involve selecting the initial speed, the minimum speed, and the maximum speed. Historical trail codes or audit codes are recorded in memory to describe the time of the event and conditions monitored by sensors. The electronic system can also record when an operator has tampered with the vehicle to make it go faster. It can record at what engine hour an event occurred. The data can be fed into personal computer or transmitted by modem to the home office to assist in diagnosing problems.

Programming security

There are three levels of security which can be programmed into the electronic system. The first is no security. The ID code is set to four zeros. Anyone can gain access to the system. The second level is when the ID code is left blank for operators to program in their own four digit number. Anyone with the four digit code can have access to make system changes. The third level is what is called lock out. This is typically used when a customer has exact specifications. The customer then controls who has access to program. Note that no ID code is needed to obtain data for diagnostics. Programming is a separate function from the diagnostic portion in the reader.

Summary

The use of electronics will continue to increase in the future. The software for the electronics system can be changed for specific customer applications. Diagnostics with an electronic system is similar to investigating why one of the trail lights does not work. The system is checked out one wire or one circuit at a time. The electronic system appears to be complicated but it is no different from any other trouble shooting on any other electrical component on the vehicle.

1990-93 ENGINE TECHNOLOGY

Jeff D. Jones, *Cummins Engines*

The trucking industry is facing a new set of challenges as the 1990s begin: rising operating and equipment costs, increasing competition, more complex systems requirements, driver shortages, and safety and environmental concerns. There is an innovative new lineup of engines to address many of these challenges.

The first step in the process of introducing advanced technology engines began several years ago with a simple goal: to create a new truck engine designed from a customer point of view. This goal led to an extensive 18-month market research effort which laid the foundation for the new generation of diesel engines. During this period, countless truck owners, drivers, dealers and other industry personnel were interviewed to define new products based on customer needs. One point became crystal clear: every truck operator has unique requirements.

Based on this research and the customer-led philosophy, Cummins decided to design and develop heavy-duty truck engines for the 1990s. These new products provide truck owners and operators the choice in engine weight and size to match closely their particular equipment, trade cycles, and business needs. Another important part of the customer-led strategy was the decision to offer customers the choice between the new electronic fuel system or the familiar mechanical fuel system with optional electronic controls.

Electronic Choices

Cummins adds a new dimension for customers with a new electronic fuel system. As more and more owner operators and fleet owners request electronic technology to cover their individual needs. The fuel system is a proven technology featuring electronically controlled unit injectors. It lets truck owners select many performance-improving options.

- Cruise control for increased driving comfort and fuel efficiency. In-cab switches area available for setting and maintaining road speed above 30 mph and 1000 rpm.
- Adjustable low idle speed that can be set up or down in 25 rpm increments.
- Power take-off (PTO) control switches, which provide a convenient method to set and maintain a precise engine speed for a PTO operation.
- Road speed governing which allows you to fix maximum road speed within a range for improved tank mileage. Test results show that for every mile per hour that road speed is lowered, up to one-tenth of a mile per gallon can be saved.
- Gear-down protection that limits maximum road speed to the top gear for greater fuel efficiency.
- An idle shutdown feature that can be adjusted to shut automatically the engine off after a specified amount of idle time between three and 60 minutes.
- A choice of automotive or variable speed engine governors to match driver preference or application.

Standard features on the fuel system include an engine protection system and self diagnostics. The engine protection system monitors coolant temperature, oil temperature, intake manifold temperature, oil pressure and coolant level. This investment protection feature will also alert the driver with a visual and audio alarm when critical conditions appear. Operators will see improved fuel economy through the electronic control of fuel injection timing and metering, excellent cold starting capabilities, reduced cold smoke and improved driveability.

Keeping individual needs in mind, mechanical fuel systems are available on new engines so customers can choose the most appropriate system for their operation. The mechanical PT fuel system, with it's high injection pressure capabilities, is very efficient at the 1991 emission levels. A wide range of models equipped with the PT system will be offered in 1991, from 260 to 410 horsepower. We anticipate that these mechanical engines will remain the preferred choice of many vocational applications such as dump trucks, refuse trucks, mixers and local pick up and delivery operation. A road speed governor is available and will be popular among line-haul fleets that favor the familiar mechanical fuel system, and value the benefits of electronics in controlling the top speed of their trucks.

COMMAND Performance

We've paid special attention to the driver as we developed these truck engines. As a result, Cummins is introducing a revolutionary concept in performance which puts the maximum horsepower output in the rpm range where most of the driving gets done. These engines offer a wider operating range than ever before. Maximum power is generated below governed speed, where drivers often cruise and the engine delivers the best fuel economy. At the lower rpm, when in a hard pull, these engines deliver constant peak torque over a wide rpm range, resulting in fewer downshifts and stronger driveability.

TRAINING REQUIREMENTS FOR MECHANICS WHEN ELECTRONIC DIESEL ENGINES ENTER THE FLEET

Mike Wilinski, *Robert Bosch Corporation*

What happened to the simple engines and systems of yesterday? In the past twenty-plus years we have advanced to what we call total engine management systems - not just fuel injections. Electronics in the motor vehicle has evolved into ignition and timing control, knock control, ABS, ASR, air bags and more. Just switch on your on-board computer and it will give you your average fuel usage, speed, distance traveled and more.

In a typical diesel fuel injection system a low pressure feed pump draws fuel from the tank and supplies it to the injection pump. The injection pump supplies high pressure fuel to the engine mounted injectors. The injectors atomize the fuel directly into the combustion

chamber where it is combined with air and ignited. The speed of the engine is now controlled by an ECU (Electronic Control Unit) or microprocessor. The ECU monitors dynamic engine operating conditions via the use of many sensors. At the driver's foot pedal we now have installed a potentiometer which relates the driver's wishes through a wire--instead of the usual linkage--to the ECU. If there is trouble, it's the responsibility of the vehicle mechanic or technician to determine where the problem is located. He still has to pinpoint the fault of one of the mechanical systems as he has done in the past.

We've added a whole new system or series of electronic circuits that must be diagnosed in addition to the mechanical systems. We've added: sensors, wires and cables, connectors and plugs, and ECUs. So what will it take for the diesel mechanic/technician of the future to correctly service vehicles? Troubleshooting now requires the use of new tools and test equipment, and terms that most mechanics/technicians may never have seen or heard of before. To make the vehicle mechanic's job easier, we have developed plug-in diagnostic scan tools that help to pinpoint problems.

Variables such as loose connections, shorted and open wires, intermittents, bad grounds, weak signals and the like will have to be traced with digital multi-meters and perhaps even oscilloscopes.

Our experience in automotive fuel injection has taught us that very few problems are the fault of the ECU. So just replacing one may not fix the problem. Most often, the only way to find a problem is to trace it through a systematic step by step procedures. If the technician needed help, he looked in the manual. Today there are more than 500,000 pages in the service manuals that the average mechanic/technician must sort through to find an answer to his problem. Good reading ability is now a must.

I've recently talked with educators both in industry and the private sector, and they agree that most diesel mechanics or mechanics in general were educated by the OJT method - on the job training. Today that's not good enough. Today's technician need as excellent understanding of the systems. The demands of OSHA, EPA, DOT, CAFE, SAE, and ISO are steering the automotive and diesel industry to a higher and higher level of sophistication. What will we do when multi fuel engines or electric vehicles become common place - how will they be serviced? The answer is simple. The mechanic/-technician of today must constantly updated by going to school. The technician must be skilled in reading, math and basic electronics.

ARKANSAS' EQUIPMENT BUY-BACK PURCHASING METHOD

Doug Nielsen, ***Arkansas State Highway and Transportation Department***

For the last five years, the Arkansas State Highway and Transportation Department has bought wheel tractors and backhoe/loaders on a guaranteed buy-back basis. Two prices are requested on the bid invitation: one for purchase and one where the bidder, at the State's option, repurchase the units at the end of one year at a price stated by the bidder. Recently, the bid price for the repurchase option has been lower than the price for purchase. Most of the repurchases have been for 100%, or more, of the original purchase price. The State uses the tractors one year, with the dealer fixing any breakdowns under warranty. At the end of that year, the dealer gives all the money back, or in some instances, more than was paid for the tractors. The State is responsible for damage beyond regular wear and tear. All repurchase units are inspected jointly by dealer and highway personnel before pickup. The State has final say on what constitutes regular wear and tear. The dealer must pay the repurchase payment within 30 days of pickup.

Here is a summary of these buy-back purchases.

Wheel Tractors (47-78 HP)

Fiscal Year	No. Units	Vendor	Purchase	Repurchase	Difference
1986	33	Ford	$ 294,550	$ 294,550	0
1987	87	Case	869,549	829,886	39,663*
1988	126	Case/Ford	1,188,460	1,118,860	69,600*
1989	132	Case/Ford	1,473,869	1,469,432	4,428
1990	158	Case/Ford	1,861,064	1,874,559	(13,495)*

Backhoe/Loaders

1986	8	Ford	178,280	178,280	0
1987	12	Ford	277,224	277,224	0
1988	16	Case	364,720	364,720	0
1989	21	Case	473,025	473,025	0
1990	36	Case	813,852	813,852	0

* Some equipment retained (sickle mowers, external hydraulic systems, etc.)

ABSTRACT: MINNESOTA'S 1981-1990 EXPERIENCE WITH GUARANTEED REPURCHASE OF 4WD LOADERS

George M. Felt, ***Minnesota Department of Transportation***

This presentation is an overview of the Minnesota Department of Transportation's (MNDOTs) experience with purchase of 4WD Loaders under total cost bidding. Total cost bidding requires a performance bond for both maximum repair cost and guaranteed repurchase price.

The main points of MNDOTs program are:

- Total cost bidding requires the vendor to bid guaranteed maintenance costs for a 4-year period.
- Vendor is responsible for providing replacement or paying rental cost on any unit down for repairs for 3 consecutive days or more during the 5-year contract.
- Vendors may bid total cost with or without guaranteed repurchase.
- Time value of money is applied to repurchase price to bring all costs into today's dollars. Present worth at 5 years at 8% - factor 0.6806.
- Guaranteed repurchase has been at a high of 156% of original price (1981) to a low of 49% in 1990 (see Figure 1).
- Decision to resell is based on market value of machine at the end of the 5 year period, and condition and usage of the loader.

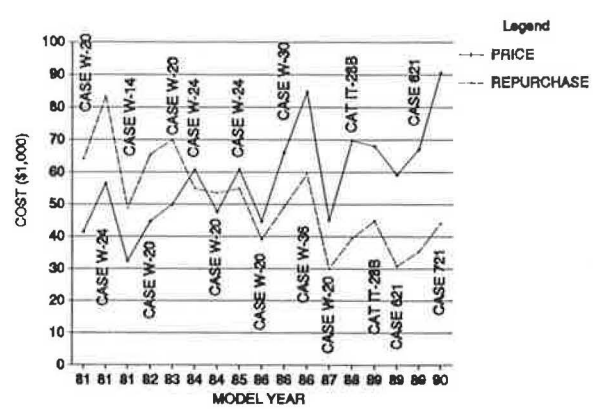

FIGURE 1 Minnesota DOT 4WD Loaders 1981-1990 Guaranteed Repurchase Program.

The following is an example of the rules used in the Special Total Cost Bid Provisions, and the Total Cost Bid Form For 4WD Loaders (with & without the Buy-Back Provision). MN/DOT will continue to use this program in 1991 and 1992 for bidding 4WD Loaders.

Special Total Cost Bid Provisions

The following rules shall be used to govern and enforce the Total Service Contract entered into and supplementary to the warranty covering machines herein bid.

It is understood that:

Equipment purchased under this agreement are operated by the Minnesota Department of Transportation (MNDOT) personnel for loading or grading, repair, maintenance, construction, snow-plowing, clean-up, and other purposes for which the equipment is designed.

MNDOT will assume responsibility for all repair costs resulting from damage due to fire, windstorm, flooding and rising waters, lightning, theft and pilferage, vandalism, accidents, and operator's and mechanics' negligence. Total cost of the repairs due to the above circumstances will be included as part of MNDOTs responsibility.

Dealer shall pay for all repairs (including parts and labor) to the portions of the equipment covered by the manufacturer's warranty, and these costs are not included in the maximum total cost of repairs. The period of this initial warranty shall be one full year from date of delivery to MNDOT. (Effective guaranteed repair cost to cover 4 year period). Delivery date to be date unit accepted by MNDOT. Dealer to furnish at time of delivery one extra set of fuel, oil, hydraulic, and air filters, and also shall include at first inspection service procedure, all lube oil, hydraulic fluids, greases, and labor needed.

MNDOT will assume, at its expense, costs to repair or replace parts and components not under warranty such as: tires, tubes, tire repairs, lubricating oil, filters of all types, grease, fuel, anti-freeze, cutting edges, scarifier and ripper teeth, bucket teeth, batteries, headlights, glass breakage, belts, brake linings, cleaning and painting, and electrical components except alternators, generators, starters and electrical meter and gauges.

MNDOT will maintain equipment in accordance with manufacturer's recommendation as prescribed in the operator's handbooks and service books provided with each machine, and with any supplemental recommendations for repairs, improved maintenance, etc., in keeping with the requirements of the manufacturer in the shop manual for the maintenance and repair of the piece of equipment.

Dealers will be fully responsible for the total cost of repairs, to the equipment furnished in excess of the guaranteed repairs for a specific period of time or operating hours from the date of delivery.

In determining the guaranteed total cost of such repairs, the following rules shall apply in order to maintain effectively constant machine availability for MNDOT.

In the event that the cost of repairs, including parts and labor, as computed by the Maintenance Department, is less than $250.00 for an individual repair, MNDOT shall have the right to have repairs made in MNDOTs shop and need not give notice to the dealer prior to the repair being made. Hourly labor rates to be current MNDOT mechanics rate at time of repair and any travel at current MNDOT rental rate for field mechanics trucks at time of repair. Transportation of equipment for repair purposes is to be charged to repair costs.

If the costs of repairs as estimated by MNDOT is in excess of $250.00 then the dealer will be duly notified by collect phone call, so he may prepare an estimate of the repairs and determine where the repairs are to be made. Such repairs may be made by the Service Department of the dealer and billed to MNDOT at the dealer's published prevailing rate. If, however, the dealer agrees, then such repairs will be made in the MNDOTs shops, in which event the cost of such repairs will be computed on the same basis as that set forth in the paragraph above.

Under some circumstances, repairs may be made in Service Departments other than of the dealer and/or MNDOT. Then the dealer and MNDOT must agree to the repairs which will be made and the Service Department which will make the repairs.

Dealer shall provide an approved listing of parts and service facilities where parts may be purchased and service obtained.

Downtime. In the event that a breakdown occurs, MNDOT will immediately notify the dealer's Service Department of the nature of the trouble and the parts which may be required, if known. Should the machine not be back in operating condition within three (3) consecutive days after said notification, then a credit to MNDOT equal to the hourly rental paid to others by MNDOT for like equipment will be due MNDOT as liquidated damages for such downtime.

In the event of a disagreement at to the interpretation or application of this contract, an arbitration board shall be set up to arbitrate and resolve any disagreement and/or to help interpret this contract as the need may arise. This arbitration board shall have one person appointed by MNDOT and one appointed by the Dealer, and a third person to be selected by the two previously named. The ruling of any two members of the arbitration board will be binding on both parties.

The Vendor shall furnish a performance bond in the amount of the total net cost plus the guaranteed maximum total cost of repairs or the full amount of guaranteed repurchase price whichever is larger. The bond shall be in effect for the life of the agreement to guarantee that the dealer will fulfill all of his obligations under this agreement.

In case of breach of any provision of the contract by the dealer, then MNDOT shall have the option of returning the machine and being reimbursed by the vendor or bonding company for the full repurchase price at any time before the expiration of the contract period.

In case of change of corporate structure or loss of identity by assimilation or merger with other companies, this agreement shall remain in effect and be binding on the successor company(ies).

MNDOT reserves the right to sell, trade, or otherwise dispose of the equipment, purchased under this agreement, at its discretion at any time.

Minnesota Department of Transportation

_____

Title _____

TOTAL COST BID FORM FOR 4WD LOADERS
(Without Buy-Back Provision)

Item 1 ( ) 1990 FWD loaders per MNDOT Specification 76.0-0003 (Costs not to exceed mfg. adv. list pricing structure, a copy of which must be attached to this bid)

MNDOT to pay this amount. Each $_____ Total $_____

Item 2 ( ) Guaranteed maximum total cost of repairs for 6000 operating hours or 5 years (whichever comes first) will not exceed: (All costs in excess of amount shown per unit to be borne by the vendor.) The cost up to the guaranteed figure per unit to be borne by the State as the repairs become necessary.

Each $_____ Total $_____

Total Cost Bid Without Buy Back Provision -

Item 1 plus Item 2 above. Each $_____ Total $_____

Bidder_____

Signature_____

Date_____

TOTAL COST BID FORM FOR FWD LOADERS
(With Buy Back Provision)

Item 1 ( ) 1990 FWD loaders per MNDOT Specification 76.0-0003 (Costs not to exceed mfg. adv. list pricing structure, a copy of which must be attached to this bid)

MNDOT to pay this amount. Each $_____ Total $_____

Item 2 ( ) Guaranteed maximum total cost of repairs for 6000 operating hours or 5 years (whichever comes first) will not exceed: (All costs in excess of amount shown per unit to be borne by the guaranteed figure to be borne by the State as the repairs become necessary.

Each $_____ Total $_____

Item 3 ( ) Item 1 plus Item 2 above

Each $_____ Total $_____

Item 4 ( ) Guaranteed Repurchase Price at end of the 6000 hours operating time or the 5-year period (whichever comes first)

Each $_____ Total $_____

Item 5 ( ) Multiply Item 4 by 0.6806 (Time value of money factor)

Each $_____ Total $_____

Item 6 ( ) Total Cost Bid - Item 3 less Item 5

Each $_____ Total $_____

Bidder_____

Signature_____

Date_____

POINT METHOD FOR EQUIPMENT PROCUREMENT

Robert L. Montgomery, *West Virginia Division of Highways*

After determining what requirements will have to be met by the unit being purchased, with the help of user defined needs, information supplied from manufacturers and input from the Divisions Equipment personnel, specifications are prepared and a "Request for Quotation" is sent to the Purchasing Section, Division of Finance and Administration of the West Virginia Department of Administration. The Purchasing Section of the Division of Finance and Administration advertises for bids for equipment purchases for all state agencies. Quotations are received and opened by the Purchasing Section of the Division of Finance and Administration. Bids received are then sent to the Spending Unit for evaluation.

The "Request for Quotation" is broken down into three categories: (1) Specifications and Guidelines-General; (2) Specifications-Unit to be Purchased; and (3) Bidder's Evaluation Report. Category one contains general information which includes the Purpose, Bidder's Evaluation Report, Bidding Procedures, Exceptions to Specifications, Delivery, Representative Unit for Test and the Award Criteria. Category two contains the specifications of the unit to be purchased for which compliance is required. Category three contains the bidder's compliance to the specifications for the unit the vendor is offering.

The award criteria include cost, specification, previous experience, warranty, and delivery. Each criteria area has been assigned a maximum possible score. The West Virginia Division of Highways (WVDOH) Evaluation Committee, consisting of four individuals, rank the unit and award a percentage of possible points based on the ranking.

Areas of Award Criteria

Cost:

Maximum 80.00 Award Points
Maximum 100.00 Percentage Points - This Example

The proposal with the lowest overall cost will be given 80 award points. Each remaining proposal's overall cost will be given points in direct proportion to the ratio between it and the lowest overall cost. For example, if the lowest cost bid was $35,774 per unit, it would be awarded 80 award points in this category. If the second lowest cost bid was $36,109.25 per unit, or 0.94% higher than the lowest bid and it would be awarded 99.06% (100.00 percentage points - 0.94) of 80.00 or 79.25 award points.

Specifications:

Maximum 40.00 Award Points
Maximum 2900.00 Percentage Points - This Example

Specifications of the unit being purchased contains 58 individual line items. Each line item is assigned a maximum of 50.00 percentage points. Thus, 58 line items times 50.00 percentage points for each item equals 2900.00 possible percentage points.

The lowest cost bid offered 57 of the 58 items that met or exceeded the specifications. The one specified item that it did not meet was fuel capacity and fuel consumption rate to provide a 10 hours working time. The lowest cost bid offered a fuel tank capacity of 23 gallons and a fuel consumption rate of 2.8 gallons per hour. Thus, 2.8 gallons per hour times 10 hours requires a fuel tank capacity of 28 gallons. Twenty-three gallons offered divided by a 28 gallons required for a 2.8 consumption rate equals 82% of the requirement. 82% of 50.00 percentage points equals 41.00 percentage points awarded. For the 57 items they were awarded 2850.00 percentage points for a total of 2891.00 percentage points. Then, 2891.00 divided by 2900.00 possible award points would be 39.88 award points for this bid. The second lowest cost bid met all items of the specifications and were awarded 2900.00 percentage points and 40.00 award points.

Previous Experience:

Maximum 5.00 Award Points
Maximum 100.00 Percentage Points - This Example

Previous experience of bidders may be evaluated under this category as follows:

- Past performance under similar RFPs with the WVDOH
- Past performance as a vendor of parts to the WVDOH
- Past performance as a vendor or manufacturer's representative of the equipment offered in the proposal
- Past performance of the equipment offered in the proposal.

Both the lowest cost bid and the second lowest cost bid were registered to do business with the State and an authorized dealer of the proposed units for 34 years and 82 years. The WVDOH has done business with both vendors on several occasions in the past and have not had any problems with either vendor in the above areas. Therefore, both vendors were awarded 100.00 percentage points and 5.00 award points for previous experience.

A new vendor bidding on proposed purchases is also awarded the same until such time as problems may arise in any of the above areas. In cases where problems do arise, a Vendor Complaint Form is initiated describing the nature of the complaint and sent to the vendor, with a copy to the Purchasing Section of the Division of Finance and Administration. If problems continue, a recommendation is made to the Purchasing Section of the Division of Finance and Administration to have the vendor removed from the accepted bid list.

Warranties:

Maximum 5.00 Award Points
Maximum 800.00 Percentage Points - This Example

In this example, standard warranty was assigned 500.00 percentage points. Locations where warranty work would be performed was assigned 100.00 percentage points; and locations where parts would be stocked and parts availability was assigned 200.00 percentage points for a total of 800.00 percentage points.

Of the 500.00 percentage points for the standard warranty: 100.00 percentage points were assigned to the entire unit; 100.00 percentage points were assigned to the engine; 100.00 percentage points were assigned to the drivetrain; 100.00 percentage points were assigned to the frame; and 100.00 percentage point were assigned to corrosion.

- The entire unit has two levels of warranty. The first level was 24 months, unlimited miles, 100% parts and labor and that level was assigned 100 percentage points. The second level was 12 months, unlimited miles, 100% parts and labor and that level was assigned 50 percentage points.
- The engine had four levels of warranty. The first level was 60 months, 100,000 miles, 100% parts and labor and that level was assigned 100 percentage points. The second level was 36 months, 150,000 miles, 100% parts and labor and that level was assigned 75 percentage points. The third level was 24 months, unlimited miles, 100% parts and labor and that level was assigned 50 percentage points and the fourth level was 12 months, unlimited miles, 100% parts and labor and that level was assigned 25 percentage points.
- The drivetrain had two levels of warranty. The first level was 24 months, unlimited miles, 100% parts and labor and that level was assigned 100 percentage points. The second level was 12 months, unlimited miles, 100% parts and labor and that level was assigned 50 percentage points.
- The frame had two levels of warranty. The first level was 60 months, unlimited miles, 100% parts and labor and that level was assigned 100 percentage points. The second level was 12 months, unlimited miles, 100% parts and labor and that level was assigned 50 percentage points.
- Corrosion had two levels of warranty. The first level was 60 months, unlimited miles, 100% parts and labor and that level was assigned 100 percentage points. The second level was 12 months, unlimited miles, 100% parts and labor and that level was assigned 50 percentage points.

The lowest cost bid was awarded 50 percentage points for the entire unit; 50 percentage points for the engine; 100 percentage points for the drivetrain; 100 percentage points for the frame and 100 percentage points for corrosion for a total of 400 percentage points for standard warranty. The second lowest bid was awarded 50 percentage points for the entire unit; 25 percentage points for the engine; 50 percentage points for the drivetrain; 50 percentage points for the frame an 50 percentage points for corrosion for a total of 225 percentage points for standard warranty.

Of the 100.00 percentage points assigned to locations where warranty work would be performed: 50.00 percentage points were assigned to the number of vendor locations where warranty work would be performed; and 50.00 percentage points were assigned to warranty work performed at WVDOH facilities. The highest number of vendor locations where warranty work would be performed was 16 locations and that level was assigned 50 percentage points. The other levels were awarded 3.125 percentage points for each location offered by each vendor. For work performed at WVDOH facilities, 50.00 percentage points were awarded. If vendors did not offer any warranty work at WVDOH locations, no percentage points were awarded.

The lowest cost bid offered six locations where warranty work would be performed and were awarded 18.75 percentage points. They state that no warranty work would be performed at WVDOH facilities and were not awarded any percentage points for that item.

The second lowest cost bid offered five location where warranty work would be performed and were awarded 15.63 percentage points for that item. They state that no warranty work would be performed at WVDOH facilities and were not awarded any percentage points for that item. They were awarded a total of 15.63 percentage points in this category.

Of the 200.00 percentage points assigned to locations where parts would be stocked and parts available: 100.00 percentage points were assigned to locations where parts would be stocked and 100.00 percentage points were assigned to parts availability. The highest number of vendor locations where parts would be stocked was ten and that level was awarded 100.00 percentage points. The other levels were awarded 10.00 percentage points for each location offered by each vendor. The specifications requested parts availability of 85% in 72 hours.

The lowest cost bid offered six locations where parts would be stocked and were awarded 60.00 percentage points for that item. They offered an availability level of 85-90% in 72 hours and were awarded 100.00 percentage points for that item for a total of 160.00 percentage points in this category. The second lowest bid offered five locations where parts would be stocked and were awarded 50.00 percentage points for that item. They did not offer any parts availability and were not awarded any percentage points for that item. They were awarded a total of 50.00 percentage points in this category.

Warranty Summary. The lowest cost bid was awarded 400.00 percentage points for standard warranty, 18.75 percentage points for locations where warranty work would be performed and 160.00 percentage points for locations where parts would be stocked and parts availability, for a total of 578.75 percentage points and 3.62 award points in this category. The second lowest cost bid was awarded 225.00 percentage points for standard warranty, 15.63 percentage points for locations where warranty work would be performed and 50.00 percentage points for locations where parts would be stocked and parts availability, for a total of 290.63 percentage points and 1.82 award points in this category.

Delivery

Maximum 5.00 Award Points
Maximum 100.00 Percentage Points - This Example

Of the 100 percentage points assigned to delivery: 50 percentage points were assigned to representative unit for test; and 50 percentage were assigned to time for delivery of the balance of the units. The specifications requested that a representative unit for test be provided within 60 days from the date of the purchase order and 50 percentage points were assigned to that item. The specification requested the time for delivery of the balance of the units to be 90 days from the date of the purchase order and 50 percentage points were assigned to that item.

The lowest cost bid stated they would deliver the representative unit for test within 100 days from the date of the purchase order and they were awarded 30 percentage points for that item. They state time for delivery of the balance to be 160 days and were awarded 28.13 percentage points for that item. They were awarded a total of 58.13 percentage points and 2.91 award points in this category. The second lowest bid stated they would delivery the representative unit for test within 90-120 days from the date of the purchase order and they were awarded 25 percentage points for that item. They state time for delivery of the balance to be 120-150 days and they were awarded 30 percentage points for that item. They were awarded a total of 55 percentage points and 2.75 award points in this category.

Recap of Example

	LOWEST COST BID		SECOND LOWEST COST BID	
Award Criteria	% Points	Award Points	% Points	Award Points
Cost	100.00	80.00	99.06	79.25
Specification	2891.00	39.88	2900.00	40.00
Pre. Experience	100.00	5.00	100.00	5.00
Warranty	578.75	3.62	290.63	1.82
Delivery	58.13	2.91	55.00	2.75
TOTAL AWARDED	3727.88	131.41	3444.69	128.82

In this example, a recommendation would be made by the Equipment Evaluation Committee to the WVDOH Equipment Review Board, a group consisting of 11 WVDOH Management Personnel and the Buyer from the Purchasing Section of the Division of Finance an Administration, to award this purchase order to the lowest cost bidder, which received the highest number of award points.

Once the WVDOH Evaluation Committee's evaluation has been completed, the results are presented to WVDOH Equipment Review Board. A comparison of the point awarded on each proposal in each area of

award criteria is presented to the Review Board for their use in determining whom to recommend the awarding of the contract. Once the Review Board has voted to recommend the awarding of the contract to a vendor, a report is prepared reflecting resultant point allocations to each vendor, an analysis of each vendor's awarded points and a summary analysis of awarded points explaining point differences along with the recommendations of the Equipment Evaluation Committee and Equipment Review Board and sent to the Purchasing Section, Division of Finance and Administration for preparation of a Purchase Order and/or for further handling.

EQUIPMENT ACQUISITION CHOICES

Arlen Swenson, *John Deere Industrial Equipment Company*

As capital budgets continue to come under closer scrutiny and tighter spending reduction pressures, individual agencies and public officials often are faced with having to use alternative equipment acquisition methods to secure needed machines for key maintenance operations.

Understanding the true costs of alternative machine acquisition methods can sometimes be rather confusing. What appears to make sense at the time of bid opening, often can prove to be a very expensive or impractical choice when considered on a long-term or entire fleet basis.

Determining which acquisition alternative is the best choice for a particular agency or operation will require detailed study, however, many times the best way to start is simply to ask, "do I have a real need to own the equipment, or do I simply want to have use of the equipment?" Depending on local acquisition laws, a public agency is normally in an excellent position to consider the benefits of paying to "use" a piece of equipment versus paying to "own" a piece of equipment.

There are many choices offered today for acquiring machines. Closed-end leases, open-end leases, municipal leases, residual values, short-term rental, total cost, skip payments, balloon payments, low A.P.R., fixed payments, variable payments, and many other choices. All of these different choices, however, can normally be grouped into one of the following six common categories of equipment acquisition methods, shown in Figure 1.

When renting or leasing (often called a true lease or operating lease) a piece of equipment, you are paying for the "use" of the equipment. Normally, a purchase option can be provided as part of the rent or lease contract, however, the purchase option when combined with the monthly rental or lease payments will often prove to be a higher "owning" cost than other acquisition methods.

When cash purchasing, lease purchasing, or cash purchasing with a trade or buy-back guarantee, you are paying to "own" the equipment. Paying to "own" the equipment, however, normally requires a higher initial cash flow than "use" acquisition methods such as rentals or operating leases.

- Rental of equipment.
- Lease of equipment.
- Cash purchase of equipment.
- Lease Purchase of equipment.
- Cash purchase with trade or buy-back guarantee.
- Any of the above methods combined with a guarantee of repair, parts, labor, and/or maintenance costs.

Figure 1 Common Equipment Acquisition Methods.

Renting Equipment

Renting equipment is often a good choice for short-term use of equipment. Rental contracts normally have minimum customer obligations and requirements compared to other acquisition methods. The customer is paying for only the "use" of the equipment and not its ownership. Renting normally has a relatively low cash flow requirement for the "use" of the equipment and can serve as an excellent tool for "trying before buying" a particular model or make of equipment.

Leasing Equipment

Leasing equipment is normally a good choice for longer-term equipment "use" without making a relatively high investment. The customer usually has a longer term obligation with a lease than a rental, however, the monthly lease payment will often be lower than the rental due to the longer term of the lease. Like a rental, with a lease, the customer is paying for the "use," not the "ownership" of the equipment. Low cash flow options are available with leases that can help justify the development of newer equipment fleets or the replacement of higher quantities of machines. Numerous terms and options are available with leases, including master lease packages, which can reduce traditional acquisition paperwork and procedures.

Cash Purchase of Equipment

"Cash on the barrel head" is the most common method used today by governmental agencies to acquire equipment. It is the lowest cost method for acquiring a machine that you want to own. When combined with an effective machine repair, parts, and labor coverage contract, cash purchase is also the lowest cost method for owning, operating, and disposing of equipment. Properly structured, cash purchase can be a near ideal method for long-term use of equipment by a governmental agency. The biggest barrier to cash purchase for many agencies, however, is the high initial cash flow requirement.

Lease Purchase of Equipment

Properly structured, lease purchase (often called municipal lease purchase) contracts normally offer one of the lowest financing costs for owning equipment. As such, lease purchasing is an excellent ownership acquisition tool for matching existing equipment budgets to equipment needs by reducing initial cash flow requirements. Normally the financing cost associated with a lease purchase is lower than the costs incurred by an agency in issuing a bond for raising capital to pay cash for the equipment. The lease purchase contract can be written so there is no early payment penalties and also provide non-appropriation of funds clause protection for the customer.

Cash Purchase with Trade or Buy-Back Guarantee

On a long-term fleet management basis, cash purchase of equipment that includes a trade or buy-back guaranteed of those same machines will normally be the highest cost acquisition method for owning, operating, and disposing of equipment. The main reason for its high relative cost is that the customer is asking the bidder to be responsible for costs that the bidder has little control over. To protect himself, the bidder must add some cost cushion to his guarantees. In addition, this method of acquisition normally has extensive customer record keeping requirements, that if not performed, make the contract guarantees null and void. Due to the record keeping requirements, required maintenance, required inspections, required operator maintenance, required mechanic qualifications, instability of some dealers and resultant unenforceable performance bonds, force majeure, and/or a combination of these or other factors; a low percentage of the contracts have the trade or buy-back guarantee effectively utilized, which negates any possible "real" benefit of this type of acquisition method.

Along with the high cost, this method normally also has the highest initial cash flow requirements and a few bidders are usually willing to participate. With all these problems, why would an agency want to consider this acquisition method? Although the costs are higher, if dealing with a reputable supplier, the costs are guaranteed and can be accurately budgeted. Accurate budgeting, in some cases, is worth the additional cost to some agencies.

Analyzing Acquisition Costs

When considering the six basis acquisition methods, it's sometimes helpful to layout the choices and look at their relative, bottom-line costs. Figure 2 details a sample four-wheel-drive loader that an agency might consider for acquisition.

Base machine price	$75,000
Front axle hydraulic lock	800
17.5x25 12 PR L2 tires	500
ROPS cab and deluxe cloth seat	3,400
Bucket w/teeth & return-to-dig	4,850
Counterweight, drawbar, and fenders	1,950
M.S.R.P.	$85,600

Figure 2 Sample 2.5 cubic yard wheel loader.

Now that the basic machine configuration has been considered, it can be helpful to see how the dealer might first look at the opportunity to price the machine to the governmental agency.

Figure 3 provides some general overview on pricing considerations by the dealer. The figures shown in the following tables are for examples only and show how an agency might develop a method for evaluating their best choice in acquiring equipment. The best choice available at any given time, on any given bid, in any given area, from any given bidder may vary from the examples shown.

For example purposes, let's assume that the customer bid price in figure number three of $70,655 is acceptable and that the customer now wants to consider various acquisition alternatives. The customer in this example is considering the acquisition of twenty-five (25) machines and wants to compare the investment requirements of various "pay to use" and "pay to own" options.

Dealer Pricing Sheet

M.S.R.P.	$ 86,600
Factory freight	1,800
Dealer prep, inspection, delivery	400
Suggested Window Sticker Price	$ 88,800
Customer Bid Price	$ 70,655

FIGURE 3 Sample 2.5 cubic yard wheel loader.

Figure 4 compares four acquisition alternatives and investigates the initial cash flow requirements, the first twelve month cash flow requirements, and the total investment over the term of the contracts. Using this approach, a governmental customer can quickly see which plan is the smarter choice in terms of initial cash flow or total investment. In two of the examples, the customer is paying to "own" the equipment and in the other two examples, the customer is paying for only the "use" of the equipment. The costs for machine repair, parts, and labor are assumed to be the same in each example. To compare single unit costs, divide totals by twenty-five.

Customer Bid Price = $ 70,655
Quantity Acquired = 25 Units

Cash Purchase Option		Lease Purchase Option (48 months @ 8.5%)	
First month cash	=$1,766,375	First month cash	= $ 43,538
First year cash	= 1,766,375	First year cash	= 522,456
Total investment	= 1,766,375	Total investment	= 2,089,824
Rental Option (12 months)		**Operating Lease Option (36 months)**	
First month cash	= $ 38,750	First month cash	= $ 28,916
First year cash	= 465,000	First year cash	= 346,992
Total investment	= 465,000	Total investment	= 1,040,976

Figure 4 Analysis of Acquisition Costs.

In the above example, if the agency is interested in "owning" the equipment, the lowest investment is represented by the straight cash purchase option. If, however, the agency does not have $1.766 million to purchase the units, they might consider the lease purchase option which requires only $0.522 million in cash the first year. If taken to full term, the lease purchase contract would carry $0.323 million in finance charges compared to no finance charges with the straight cash purchase.

Another use of the lease purchase contract is to "leverage" an existing capital budget into covering additional items compared to the straight cash purchase method. For example, if the agency had $1.766 million in cash to purchase the loaders, but decided to use the lease purchase contract, they would have more than $1.243 million left after paying for the first year of the lease. These funds could then be applied to other purchases, capital, or personnel requirements and still have "use" of the twenty-five loaders. The agency could then pay-off the amount owed on the lease purchase the next year or continue the contract to its full term.

The rental or operating lease option offer even more "leverage" of an existing capital budget. If the agency was considering the purchase of the loaders, but trading them for new units after twelve months (commonly called rolling), they could save substantial cash flow ($1.301 million) by simply renting the machines for twelve months with an option to rent new units at the start of the next twelve months.

More cash flow could be saved if the agency could commit themselves to a longer-term "use" of the equipment through an operating lease. Although the agency would not own the equipment at the end of the operating lease, they would have full "use" of the machines for thirty-six months and save $0.725 million in cash flow compared to the cash purchase method and $1.048 million in cash flow compared to the full-term lease purchase method. Because of the significant cash flow savings available with an operating lease compared to other acquisition methods, it's expected that this method will become more and more popular with agencies as budgets continue to be tightened.

True, an operating lease can provide cash flow savings. What about the straight purchase of a machine and considering it's trade-in or guaranteed repurchase value to figure the total investment? Many times this type of acquisition method is called a total cost bid or life cycle cost bid. Unfortunately, the total cost bid method of acquisition does not cover all the total machine or acquisition costs. Fuel consumption rates, ground engaging tool wear, and time-value of money are often overlooked or deliberately avoided in the total cost methods of acquisition. To avoid potential pit falls with this method of acquisition, it's often helpful to make a comparison to conventional purchasing techniques to determine total investment costs. Figure 5 outlines a

possible comparison of the loaders shown previously in Figure 4.

Customer has asked bidders to provide purchase price for unit, a guarantee for repair, parts, and labor, and a guarantee for repurchase price of unit in five years or 5,000 hours of use.

Shown below are two sample bidder responses. Bidder A has chosen not to bid the guaranteed repurchase price. Bidder B has submitted a guaranteed repurchase price.

Can you tell which one is the better choice?

Bidder A		Bidder B	
Purchase price	$ 70,655	Purchase price	$ 80,655
Gtd pts/lab cost	4,500	Gtd pts/lab cost	3,500
Gtd repur price	no bid	Gtd repur price	40,300
Total Cost	$ 75,155	Total Cost	$ 43,855
Bidder A Claims:		Bidder B Claims:	
Pur Price Saving	$ 10,000	Cost Savings	$ 31,300
Total Savings	$250,000	Total Savings	$782,500

Figure 5 Evaluating Bid Claims.

With only the information provided in Figure 5, it's difficult to know which bidder is the smartest choice for the agency. One might be tempted to conclude, however, that since bidder B had the confidence to provide a guaranteed repurchase price of the machine at the end of five year or 5,000 hours of use, that bidder B might be the smarter choice for the agency. To determine which bidder is the right choice, requires some additional analysis.

One technique that can help determine which bidder represents the best choice for the agency is to compare the bidders on the time value of money and wholesale equipment value basis.

The funds invested row in Figure 6 takes the position if the agency is going to accept bidder B and spend the whole $2,016,375, why not purchase bidder A and invest the purchase price difference and take advantage of the time value of money? The interest earned was computed on a $250,000 investment earning 10% A.P.R., compounded monthly, for sixty months.

The wholesale value of bidder A was computed by taking equipment bid price and projecting the machine would have a wholesale value, as-is where-is, in five years or 5,000 hours of 55% of the bid price ($70,655 x 55% = $38,800).

An interesting note in this comparison, if the agency selects bidder A and spends the whole $2,016,375 as shown, the agency saves $99,300 in total investment and has $250,000 remaining in the bank at the end of five years.

Based on this type of analysis, it would appear that bidder A, even with his higher repair costs, is the smarter choice if his machine is capable of performing the work assignment.

Bidder A		Bidder B	
Purchase Cash	$ 1,766,375	Purchase Cash	$ 2,016,375
Maximum Repair	112,500	Maximum Repair	87,500
Funds Invested	250,000	Funds Invested	0
Interest Earned	(161,300)	Interest Earned	(0)
Wholesale Value	(970,000)	Gtd Repur Price	(1,007,500)
Total Investment	$ 997,075	Total Investment	$ 1,096,375
Funds in Bank	$ 250,000	Funds in Bank	$ 0

Figure 6 Comparison of total acquisition costs.

Making the right acquisition choice will not always be as simple as the examples detailed on the previous pages. However, it is hoped that armed with some of the analysis on acquisition choices covered here, a public official can better answer, "do I have a real need to own this machine, or do I simply want to have use of this machine?"

SECTION VIII REPORTS FROM REGIONAL EQUIPMENT MANAGERS MEETINGS

SOUTHEAST EQUIPMENT MANAGERS MEETING

Francis E. Allred, *Alabama State Highway Department*

The equipment managers in the Southeastern states have developed a very active series of regional meetings. Every year the level of activity and the number of participants increase.

At each annual meeting, the states represented are asked to present information on equipment programs they are conducting and that are of interest to the other participants. For topics of special and current interest, a round table discussion (RTD) is used to encourage discussion regarding the topic.

Through 1990, four meetings have at locations throughout the southeast. The state agencies that have been involved include Alabama State Highway Department (ASHD), Arkansas State Highway and Transportation Department (ASHTD), Florida Department of Transportation (FDOT), Kentucky Transportation Cabinet (KTC), Louisiana Department of Transportation (LDOT), Mississippi State Highway Department (MSHD), North Carolina Department of Transportation (NCDOT), South Carolina Department of Highways and Public Transportation (SCDHPT), Tennessee Department of Transportation (TDOT), Texas State Department of Highways and Public Transportation (TSDHPT), Virginia Department of Transportation (VDOT), and West Virginia Division of Highways (WVDOH). The locations of the meetings and topics covered were:

1987 - Montgomery, Alabama

- Automatic Fueling, FDOT
- Equipment Specifications, MSHD
- Fleet Standardization, VDOT
- Problem Equipment, TDOT
- Underground Fuel Storage, VDOT

1988 - Cannan Valley, West Virginia

- Equipment Purchases, ASHTD
- Quality Assessment Reviews, FDOT
- Replacement Criteria, ASHD
- Specialty Equipment, WVDOH
- Tire Specification, NCDOT
- Training Programs, WVDOH
- Underground Fuel Storage, WVDOH
- Vehicle Assignments, ASHD

1989 - Hot Springs, Arkansas

- Automated Refueling, VDOT
- Bonding, ASHTD
- Centralized Hydraulic Repairs, ASHTD
- Commercial Drivers License, KTC
- Employee Assistance Programs, SCDHPT
- Equipment Disposal, ASHD
- Equipment Information Exchange Newsletter, TSDHPT
- Guaranteed Buy Back Update, ASHTD
- Lease Purchase Procedures, WVDOH
- Rental Rates, MSHD
- Specification Review, TDOT
- Tire Retreading, NCDOT and SCDHPT
- Truck Mounted Attenuators, LDOT
- Underground Storage Tanks, VDOT

1990 - Williamsburg, Virginia

- Air Conditioning Policy, RTD
- Anti-lock Brake Systems, Eaton Corp.
- Apprentice Training, NCDOT
- Commercial Driver's License, VDOT
- Coolant Maintenance, ASHD
- Disposal of Tires, Batteries, Waste oil, Antifreeze and Mufflers, VDOT
- Electronically Controlled Diesel Engines, Caterpillar Corp.
- Engine & Transmission Selection for Single Axle Dump Trucks, TDOT
- Fuel Spill and Site Cleanup, VDOT
- Maintenance, Use and Testing of Special Purpose Equipment, RTD
- Mechanic Training, VDOT
- Preventive Maintenance, RTD
- Reconditioning Used Equipment, KTC
- Replacement Criteria, TDOT
- Specification Review, RTD
- Underground Storage Tank Update, VDOT
- Warranty Provisions in Specifications, TDOT

MIDWESTERN STATES EQUIPMENT CONFERENCE

Mike Sherfy, *Iowa Department of Transportation*

Until recently, attempts to organize a conference of fleet managers from the state transportation agencies within the Midwestern region were unsuccessful. On October

17, 1989, we managed to hold our initial conference in Peoria, Illinois. The eight states represented at this meeting were: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri and Nebraska. States unable to attend but within the Midwestern region include: North Dakota, Ohio, Oklahoma and South Dakota.

Those attending the conference were all involved with the daily management of equipment fleets. Common job elements of the mangers participating in the conference included replacement selection, specification development, receiving acceptance, and maintenance policy formation.

The conference started with reports from the fleet managers in attendance. Considerable differences in organizational structure and range of equipment responsibilities were identified. For example, Missouri builds some of its own equipment while Illinois does no in-house maintenance. This portion of the conference provided everyone with an understanding of how the different states handle equipment management.

A large portion of the conference was concentrated on round-table discussions of vehicle and equipment specifications. The agenda provided an opportunity for individual state representatives to explore areas of special concern. We found it interesting to hear about the problems other states were having with equipment that we were considering buying. Learning how other states were solving problems similar to those that we were experiencing was also informative.

Those attending the conference decided they wished the group to remain independent. It was decided not to seek affiliation with a national organization. We decided to have specification summaries made in advance of the next meeting and that agendas for future meetings would attempt to emphasize equipment innovations.

As equipment becomes more expensive to purchase and more complicated to maintain and repair, purchasing the correct equipment becomes even more important. Equipment expenditures have been forced to compete with other programs for funding. Fleet managers must plan equipment purchases and practices to support the organizational objectives of his agency.

Participation in professional activities, such as regional equipment conferences, can assist fleet manager to be technically proficient concerning the equipment that they purchase, maintain and repair. This type of conference provides information on how other managers are resolving equipment problems. We continue to discuss equipment matters with the individuals who attended the conference. This has become the most significant benefit that we gained from participating in the Midwestern States Equipment Conference.

Many of the challenges facing fleet managers in the 1990s will be the same equipment challenges we faced in the past. The challenges that we expect to faces in the next decade are presented below.

Challenges in the 1990s

- Responding to budget restraints.
- Obtaining value added support.
- Practicing effective management of time and people.
- Providing adequate training for mechanics.
- Acquiring multi-functional equipment.
- Determining who should make repairs.
- Meeting environmental concerns.

Working with fleet managers from other states at future Midwestern States Equipment Conferences will help us to respond better to many of these challenges.

WESTERN EQUIPMENT MANAGERS MEETING

Robert W. Kuenzli, ***Oregon Department of Transportation***

The Western States Equipment Managers group was formed in 1969 at a meeting in San Francisco, California. The meeting was initiated by three states equipment fleet managers from Washington, California and Oregon. Contracts were made with other states equipment managers from the west, including Wyoming, Colorado, Montana, Idaho, Utah, Nevada, Arizona, New Mexico, Alaska and Hawaii. Seven years ago the State of Texas was invited as a guest and subsequently has become a member and participant of the western group.

The structure and makeup of the group follows:

- No bylaws, officers, secretary, dues.
- An informational/participant workshop.
- One member preferred from each state.
- One or two additional representatives from each state may attend, but not as an active participant (at the table).
- Exception, encourage host state to have additional personnel attend the meeting. This benefits the host state and its participants and the group at large.
- Agenda, usually 2 to 2-1/2 days, with each state having 1 to 1-1/2 hours of presentations and discussions, depending on the subjects.
- Host state is chosen at conclusion of annual meeting, usually on a rotational basis. Location "city" and meeting dates are usually determined at this time, or within a month or two after the meeting.

- No manufactures or vendors allowed in meeting, except on occasion when invited by host to make a short, 15 to 20-minute presentation on a subject related to the manufacturer's products or a generic subject that would be of interest to the majority of the group. Usually there are no more than two such presentations during each session. The manufacturer is dismissed after the presentation.
- No advertising by vendor or manufacturers. No hospitality rooms. Occasionally, a manager or vendor with approval of host state, may provide lunch or evening "information and awareness" session.
- Controlled by host, a limited (few) manufacturers products may be displayed outside the building during off hours. Products must be of interest to majority of states.
- Agenda consists of topics furnished by each state, two to four items are the norm. Sometimes the presentation on a specific subject (i.e., specifications, type of equipment or component, management or operational topics of concern); questions or "poll" of states or specifics, comments on concerns of products, types, components or manufacturers.
- The host state arranges for meeting rooms, program agenda, coordinating and chairs the meeting.
- Periodically, a participating state has a problem with out-of-state travel, discouraged participation by upper management (usually caused by an unawareness, new equipment manager or upper management). In a few instances, the "cycle of meeting location" will be altered and the group members solicit the "state of concern" to "host" the next annual meeting. This has been successful in several instances.
- On several occasions, we have been asked to be included in AASHTO and WASHTO. We have declined. We continue to support and endorse "bare bones/technical format in a workshop atmosphere."
- No formal spouse program. Spouses often take non-structured tours/shop during the daytime. They participate in any evening activities. Periodically, they gather for lunch and sometimes with spouses on closing day.
- Often, a portion of the last day, an hour or two, is allocated for review of the host state's equipment and equipment facility or shop that may be in the area. This has become a popular event and allows the participants to become familiar with the host state's equipment types and configurations.
- One of the major and most beneficial benefits, in addition to the annual meeting, is the "information and communication" provided by knowing and sharing with member states throughout the year on a variety of subjects. These contacts have been one of the major benefit. Some of the areas often discussed are equipment types, manufacturers, comparing models, specifications, bids, warranties, and problems with repairs. Others include work site structures, employees relations, testing the waters and comparing manufacturers and peddlers "statements of facts" or one state loves them and the other state hates them. Now, many of the member states from various geographic areas are contacting other regional member states for similar input and discussions.
- The western group believes we have been successful with minimal problems, restrictions by:
  - Being small, with limited person representing each state.
  - No formal bylaws, rules, policies and officers.
  - No commercial/manufacturers/vendors at meetings, except for a specific time for short presentations.
  - No hospitality rooms and with controlled and limited manufacturers present.
  - Workshop and sharing by equipment-oriented state highway department representatives.
- The western group continues to support other geographical regional state highway/transportation equipment groups and similar organizations to be formed around county governments within state and possible some cities of similar sizes.
- The western group has worked well for its members, and if properly presented and structured, will work well for others.

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