PREVENTIVE MAINTENANCE SCHEDULING

Preventive maintenance scheduling: A timely matter.

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An applied research project submitted to the National Fire Academy as part of the

Executive Fire Officer Program

August 2009

Certification Statement

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

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Abstract

The problem addressed was that the Kauai Fire Department (KFD) does not have a preventive maintenance program (PMP) for its emergency fire service apparatuses (EFSA), which may result in decreased readiness and shorten the life expectancy of a EFSA. The purpose of this research was to investigate strategies that KFD can use to improve its fire apparatus maintenance operations.

Descriptive research was employed to answer the following research questions:

1. What are the goals of an acceptable PMP for KFD? 2. What components are critical to an effective PMP? 3. What is the life expectancy for an EFSA? 4. What are other fire departments that are similar in size and demographics, to KFD, using for preventive maintenance?

Procedures used to answer the stated questions included a literature review of journals and magazines, manufacturer's manuals, books, two personal interviews and a survey of other fire departments.

The results of this descriptive research undeniably revealed the importance and value that a PMP has for any fire department.

The research showed that the goals of acceptable PMP should include readiness of EFSA, safety for firefighters and community, maintenance for extending life expectancy and protecting major capital investment and finally defense from ligation.

The research also revealed that there are many critical components to an effective PMP and it should mirror NFPA 1911.

The recommendations emerging from this research include a thorough review of KFD's current maintenance operations to identify deficiencies , creating new daily apparatus check list based on manufacturer's recommendations, train apparatus operators on how to do inspections and

what to look for, utilize current Records Management System (RMS) to enter, repair requests, set maintenance schedule and track maintenance and repairs for each EFSA, investigate possibilities and feasibility of contracting or combination maintenance operations, establish criteria for hiring new mechanics and continue to request for additional mechanic to alleviate current work load on KFD's current fire department menchanic.

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Introduction

Vehicle maintenance plays an important role in accomplishing the stated goals and mission for any organization public or private, who utilize a fleet of vehicles in their operations. This also holds true for the fire service who utilize a fleet of emergency fire service apparatuses. Within the fire service, an emergency fire service apparatus (EFSA) represents the single most costly purchase the fire service incurs on a semi-regular basis. Proper care and maintenance can help to ensure safety for firefighters riding on the EFSA and extend the life of that apparatus. This in turn, allows the fire departments to effectively serve their respective communities.

The problem addressed is that the Kauai Fire Department (KFD) does not have a preventive maintenance program (PMP) for its EFSA, which may result in decreased readiness and shorten the life expectancy of an EFSA. The purpose of this research is to investigate strategies that KFD can use to improve its fire apparatus maintenance operations. The research approach consisted of a thorough literature review; two interviews with industry experts, one from the fire service the other from the private sector and a survey of local and national fire departments.

Descriptive research was employed to answer the following research questions:

1. What are the goals of an acceptable PMP for KFD?

2. What components are critical to an effective PMP?

3. What is the life expectancy for an EFSA?

4. What are other fire departments that are similar in size and demographics, to KFD, using for preventive maintenance?

Background and Significance

The Kauai Fire Department is the western most fire department in the United States. It's located on the Island of Kauai, which is the north western most island in the Hawaiian Island chain. The island of Kauai has a land mass of 622 sq. miles and has a population of 60,000 thousand residents and approximately 20,000 visitors on a given day (United State Census Bureau, 2009).

Fire Department services were established on Kauai in 1939 operating out of five service stations with 30 gallon pumpers. By 1942 The County Civil Defense took control over fire department operations with 60 Firefighters and 7 fire trucks. Today the KFD serves its constituents from 7 stations, soon to be 8, beginning in early 2011, employing 140 career personnel, utilizing 20 EFSA and responding to over 5000 calls a year.

The Department's organizational structure is headed by the Fire Chief (FC). Directly under him is a Deputy Chief (DC) who supervises operations and the department's mechanic. An Administrative assistance supervises five office personnel.

KFD's only mechanic is responsible for all repairs and ordering parts on KFD's vehicles He is also tasked with repairs on small engine equipment, such as extrication tools, generators, positive pressure fans, chain saws and lawn mowers. He also assists with writing specifications and procurement of EFSA. In addition, KFD's current mechanic has no Emergency Vehicle Technician (EVT) or Automotive Service Excellence (ASE) certifications and is looking to retire early 2010. KFD has requested for an additional mechanic for the last three budget cycles starting in 2007, with request being denied.

Operations are divided into 3 battalions with 38 fire fighters working 24 hour shifts, each managed by a Battalion Chief (BC). In addition each BC is assigned a bureau. The Training Bureau consists of a Captain and a firefighter III, Prevention consists of a Captain and 3 fire inspectors and the Ocean Safety Bureau consists of a Supervisor IV,3 Supervisor III, a training Supervisor and 40 life guards..

Starting in August 2009, KFD will embark in a self assessment/risk hazard analysis in conjunction with the Center for Public Safety Excellence (CPSE) in an attempt to work towards accreditation.

Within the last seven years starting in 2002, KFD has gone through a complete replacement for its EFSA fleet. The average age the vehicles being replaced were 15 years. All of the new EFSA are outfitted for foam application and with four engines having compressed air foam systems (CAFS). Each of the seven stations houses a Pierce Manufacturing Inc. 1250 gpm rated pumper and a combination rescue/brush Ford 350 or 550. Station 3, KFD's central station also houses our Pierce Manufacturing Inc. Hazardous Materials (Hazmat) apparatus, Heavy Rescue apparatus, and spare engines along with our Rescue Boat.

Within the last ten years, there been a growing movement in the Fire Service directed towards apparatus maintenance. As more and more local officials, fire department administrators, firefighters, firefighter associations and national regulatory boards address this important issue (Elliott, 1999).

KFD, along with other Fire Departments throughout the United States, must continually deal with the necessity of maintaining the various highly technical, custom built EFSA's it deploys for daily operations.

Throughout the history of KFD, the department has never incorporated a PMP for its EFSA fleet. Maintenance has always been more reactive than proactive. Currently, the Fire Apparatus Operators (FAO) coming on duty discusses with relieved FAO any problems with the ESFA. Then they perform their daily maintenance check on the EFSA and record it on a check list. If there is a mechanical problem with our EFSA the department's mechanic is called out to remedy the problem. That EFSA is placed in "not mission capable" until repairs are finished. If the mechanical problem can't be addressed in a timely fashion, a spare apparatus is deployed until the unit is repaired. If the mechanical problem is with one of the Ford 350/550, the department will run daily operations without unit until that respective unit is repaired. If the mechanical problem is not a safety hazzard, a memo is sent to the mechanic and is repaired when he is available.

This type of maintenance operation that KFD is incorporating could lead to diminshed service and readiness of the EFSA to the community it serves.

Instead of a reactive approach to just replacing parts and making repairs, there needs to be a system approach to the whole fire department fleet's needs that include looking at the life expectancy of an EFSA and the types of preventive maintenance that it requires.

Despite some glaring deficienies , the current economic climate and KFD's recent fleet replacement, it's imperative that KFD continually evaluate their current maintenance operations to investigate strategies to move towards meeting or exceeding "industry standards" for maintenance of and life expectancy for an EFSA, so KFD's EFSA will be mission capable to respond to all types of emergencies and ensures the County of Kauai is getting a good return on investment on a major capital expense.

KFD's annual operating budget for fiscal year 2009-2010 was $17,755,738 million dollars with $125,500 budgeted for maintenance and repairs. This includes mechanic's salary (Kauai County Goverment, 2009). Fire protection equipment represents a major portion of the capital investment for any community (Brown, 1994), so the development of an appropriate PMP that is both cost–effective and efficient is a primary objective for KFD.

This research project was completed in accordance with the applied research requirements of the Executive Development (ED) course of the National Fire academy's Executive Fire Officer Program (EFOP). In addition, improving fire apparatus maintenance operations in KFD requires change within the organizational culture of the department, which was part of the curriculum addressed in the ED program. In complying with the United States Fire Administration's (USFA) operational objectives, a PMP will have a direct effect on the safety of KFD's firefighters and community as well.

Literature Review

The Learning Resource Center (LRC) at the National Fire Academy (NFA) was used to obtain the majority of the documentation used in this research. They included articles from periodicals, books, and online resources.

The literature review in relation to vehicle maintenance issues within the fire service and private industry has identified a number of areas that are likely to be significant for KFD to use to investigate strategies to improve its fire apparatus maintenance operations.

The goal of any fire apparatus maintenance program starts with preventive maintenance. There are several important reasons for establishing a PMP for your EFSA. First, due to the nature of the fire service, your EFSA must always be in top condition and ready to respond.

Secondly, the safety of the firefighters and the general public relies heavily upon the excellent working order of the EFSA. Thirdly, is that the high cost of modern fire apparatuses mandates that it be maintained in top condition to extend the life expectancy and protect a major capital investment for any department. Finally, legal action and financial judgments can also result from improperly maintained EFSA (Peters, Fire apparatus operator preventive maintenance, 2004).

There are many components relating to preventive maintenance in the National Fire Protection Association (NFPA) standards. These standards in relation to apparatus inspection, maintenance, testing, qualifications and retirement of EFSA are considered “industry standards”. Although most NFPA standards are not laws, these standards still carry considerable legal standing which would stand up in a court of law (Cavette, 2005).

The origin and development of NFPA 1911 is a combination of three standards. They are, NFPA 1911, Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Automotive Fire Apparatus, NFPA 1914, Standard for Testing, Fire Department Aerial Devices and NFPA 1915, Standard for Fire Appparatus Preventive Maintenance Program (National Fire Protection Association, 2007). Due to the fact that KFD does not employ Aerial Devices in their operations we will for go examining NFPA 1914.

NFPA 1915 contends that it is the respondsibility of the authority having jurisdiction (AHJ) or fire department in this case, to develop and implement a preventive maintenance schedule for the EFSA. The history of this standard came about after the NationalTransportation Safety Board (NTSB) report “ Special Investigation Report –Emergency Fire Apparatus” that questioned the quality , type of service and repair that EFSA were recieveing.

This standard defines the minimum requirements for establishing a PMP for a EFSA. The standard also identifies systems and items to be inspected and the frequency in which they

should be inspected. The intent of a PMP, as stated in this standard, is to ensure that EFSA are serviced and maintained to keep them in a safe operating condition and are ready for response at all times. The servicing of a EFSA should still be based on the manufacturers recommendations , local experience, and operating conditions in order to maintain the apparatus and its components in proper operating condition. Documentation of maintenance records are also required under this standard (National Fire Protection Association, 2000).

Annex C of NFPA 1911, which is not part of the requirements of this standard, but is included for informational purposes, states the requirements that need to be included for establishing a PMP. These requirements include the those listed in NFPA 1911 that pertain to your particular EFSA and the manufacturer's manuals.

As the various maintenance tasks that needs to be performed are identified, each task should be assigned a schedule based on months, years, hours, or some time frame that will determine when and who should provide this the maintenance. It also provides samples of daily and weekly walk- around check list for an EFSA (National Fire Protection Association, 2007, pp. 75-85).

In section 5 , Service and lubriction intervals, of the Pierce Manufacturing Inc.'s operation and maintenance manual, was provided a maintennce schedule for a Pierce apparatus. The schedule included 9 different tables. It covered intial ,daily, weekly, montly, quarterly, semi-annual, annual, 3-5 years and vendor component maintenance schedules that is recommemded for its apparatuses (Pierce Manufacturing Inc., 2007). This schedule is included in Appendix D.

NFPA 1071 states the educational and technical expertise required to qualify as an Emergency Vehicle Technician (EVT). The EVT classification came into being after the 1988

annual confrerence of the International Association of Fire Chiefs (IAFC). At the conference, there was a forum dedicted to the issues that dealt with vehcle maintenace and safety. From this beginning, the IAFC created what is now known as the EVT certification program. The program offers five different types of certifications. They are: fire apparatus, ambulance, law enforcement technician, ARFF (Airport Rescue Fire Fighter) and a management track. These EVT certification exams are administered in conjuction with test conducted by the National Institute of Automotive Service Excellance (ASE). This program is now overseen by the IAFC EVT Certification Commission (IAFC, 2006).

An EVT is defined as an indivdual possesing a recognizable certification, professional standing, or documented skill who has aquired the knowledge, training, and experience needed to deal with the maintenance of a fire apparatus. In addition to establishing the minimum qualifications for EVTs. NFPA 1071 specifically identifies the driver/operator as part of the maintenance function. It makes the driver/operator responsible for performing certain vehicle checksand for participating in the PMP. (National Fire Protection Associtions, 2006).

In an initiative commissioned by the United States Fire Administration (USFA) in 2004 on Emergency Vehicle Safety, pointed out that each year a percentage of firefighter and Emergency Medical Services (EMS) injuries and deaths are the result of mechanical problems and apparatus failure. In cases like this, the AHJ adherence to maintenance standards are increasingly scrutinized by the legal system. So establishing and implementing standards, training and education and certification programs to support EFSA safety is a must. With approximately 60,000 emergency vehicle mechanics in the United States fewer than 25 percent have received certification meeting the requirements outlined in NFPA 1071. It goes on to state that it is a common belief that increasing the number of EVT within the fire service will have a direct effect on reducing the

number of injuries and fatalities related to equipment failure (IOCAD Emergency Service Group, 2004).

Each department is still respondsible for setting the minimum standards for its mechanic. It must weigh the risk-benefit associated with adopting something less rigid than NFPA 1071 and the inherent risks associated with that decision (Steffens, 2000).

NFPA 1915 and 1071 supplement existing requirements of NFPA 1500 (National Fire Protection Association, 2007), the Standard on Fire Department Occupational Safety and Health Program, which states “any fire department shall consider safety and health as primary concerns in the specifiations, design, acquisition, contruction, operation, maintenance, inspection, and repair of all fire department apparatus” (p. 13).

(National Fire Protection Association, 2007) Chapter 5 in NFPA 1911 states that “the fire department shall consider safety as the primary concern in the retirement of apparatus” (p.14).

These NFPA standards makes it clear that fire department’s maintenance operations need to be more proactive in ensuring that a movement from maintenance as a repair function to preventive maintenance take place within their departments (Steffens, 2000).

A study by the Federal Energy Management Program showed that over 50 percent of businesses in the United States that use vehicles and/or equipment still employ a primarily "reactive" maintenance strategy or a “fix it if it breaks” approach. While this strategy may have cost savings in the short term, long term cost associated with down time, equipment turn over and customer satisfaction far outweigh the initial savings. Predictive maintenance is another approach to preventive maintenance. Predictive maintenance bases services not only on schedule maintenance intervals, but also on actual wear indicators exhibited by the vehicle or equipment.

Benefits realized from initiating some predictive maintenance strategy can include reduced catastrophic repair costs, reduced vehicle down time, higher customer satisfaction and longer fleet aging cycles. Past studies have placed the savings from predictive maintenance in the 8% to 12% range over using preventive maintenance alone (Fleet Maintenance Magazine, 2008).

Peters (Peters, Fire apparatus operator preventive maintenance, 2004) noted that your PMP plays a vital role in accomplishing a departmental mission of saving lives and protecting property. He also believes that every PMP begins with the apparatus operator, as they are the first line of maintenance the apparatus receives. Pre-shift inspections of oil levels, fuel, and coolant as well addressing items such as wear, misuse, abuse and neglect should mirror that of a pre-trip inspection of the operator of a commercial vehicle possessing a commercial driver's license. These routine maintenance checks are an absolute necessity.

Glatts (Glatts, 2000) points out the importance to combine apparatus safety, maintenance and training. He mentioned the training of operators and firefighters on routine preventive maintenance is necessary and can enhance safety efforts for a department. For example, annual fire pump testing not only trains firefighters to run the pump more efficiently, but it test equipment, and potentially identifies any operational problems with the pump. This, in turn reassures the community that the fire department is ready to respond to emergencies.

Robertson (Robertson, 2009) believes that preserving the quality of your EFSA is vital to the success on the fire ground. Unlike other firefighter tasks that can be scheduled weekly, monthly or yearly apparatus checks must be done daily. Taking the time to properly inspect and maintain your EFSA will not only extend its life, but is essential to the safety of the firefighters, the department and the community. He goes on to list eight tips for proper apparatus maintenance. They are to start apparatus check first thing in the morning, communicate with outgoing shift, take

ownership of the apparatus, pay attention to details, use all your resources, check and recheck apparatus throughout the day and after each incident, document your check list, repairs and repairs needed and finally, be a expert on your apparatus.

Craven (Craven, Apparatus specifications: a guide to saving time and money, 1995) suggest that the useful life span of EFSA varies among fire departments and is affected largely by apparatus utilization, local environment, local operating conditions, routine workload, and the PMP of that department. He also identifies three categories of EFSA life span. They are service life, technological life, and economic life. Service life is defined as the length of time that an EFSA can be expected to perform in a functional and reliable manner, under the service demands and operating conditions to which it is exposed. Technological life is defined as the ability of the EFSA to continue to perform in a functional and reliable manner when changes in service demands, technology, and performance standards occur. Finally economic life is defined as the length of time that an EFSA can be operated and maintained in a cost-effective manner.

In January 2004, Pierce Manufacturing, in conjunction with the Chassis Technical Committee of the Fire Apparatus Manufacturer's Association (FAMA) conducted a study to provide guidance to fire apparatus manufacturers on the life expectancy and use profile for major types of fire apparatus. The study broke down the life expectancy of EFSA into the urban, suburban, and rural demographics. With urban being defined as: Area served by the fire department is obviously metropolitan and consists of high-density housing, or retail structures. Suburban being defined as: Area served is mainly single family housing, light retail or light industry and could be outskirts of metropolitan areas or smaller communities. Finally rural being defined as: Area served is small towns and low density population regions that would include significant distances between

the station and the structures being protected. The results revealed that the average life expectancy for urban EFSA was 15 years, suburban was 16 years and rural was 18 years (Lackore, 2004).

NFPA 1901, Standard for Automotive Fire Apparatus, Annex D, suggests that fire departments should seriously consider the value or risk to firefighters of keeping an EFSA older than 15 years in first-line service. It recommends that EFSA greater than 15years old, that have been properly maintained be placed in reserve status and upgraded in accordance with NFPA 1912, Standard for Fire Apparatus Refurbishing (National Fire Protection Association, 2009).

Peters (Peters, Fire Department Apparatus, 1995) states that EFSA life expectancy varies greatly from one location to another. The two main variables that contribute to the life span of an EFSA are workload and the amount of preventive maintenance the unit receives. 10 to 15 years is considered normal for an EFSA used daily in moderate to heavy-response areas. EFSA used in light- duty situations in rural and suburban areas can remain dependable for longer periods of time if operated and maintained properly. EFSA older than 25 years old is not recommended for first-line service.

In a personal interview with John Burton, who is the Vice President of Burton's Fire Inc., whose company provides maintenance services for many surrounding fire departments in northern California, noted that 15 years is the normally the usable life for a EFSA and 5 more years for reserve life. He stated that for any fire department, the primary goal for a PMP is firefighter safety. He goes on to relate PMPs to extending the life of an EFSA and cost saving in the long run due to prevention of catastrophic failures. But said the bottom line of any PMP, is liability, not only to the fire department but also to county or state. Burton goes on to state, that as a service center for EFSA, that Burton's Fire mechanics need to be certified as EVTs and ASE. Their mechanic's also carry specialized certifications such as pump, CAFS, electronic and transmission. This is due to the

increasing technology that taking place in the fire service industry. These certifications are a must to protect his company against litigation (J. Burton, personal communication, May 2, 2009),

In a one on one personal interview, Don Christensen, repair shop supervisor for Kauai Freight Service Inc. (KFS), a local trucking company, also noted that their primary objective for their maintenance program is safety, but was quick to note that preventive maintenance is there to protect the company against liability. He goes on to note that any truck not on the road is lost revenue for the company, so it's important to keep the fleet operational. They have a fleet of 50 trucks with 3 fulltime mechanics. They all have ASE certification, yet each mechanic still specialized in either electronics, tire repair or transmission work. KFS has a strict maintenance schedule, partly due to the fact that their operations are regulated by the Department of Transportation (DOT). The life expectancy of their trucks runs 10-12 years. The short life span is due more to the salty air climate that deteriorates the body of the truck than the preventive maintenance the truck receives (D. Christensen, personal communication, May 5, 2009).

In summary, the literature review has been very helpful in writing this research paper. It has illustrated the importance and value a PMP has for any fire department. It was invaluable in addressing the critical nature and NFPA requirements of a PMP. Sources that were researched revealed how PMPs are vital to firefighter and community safety, to the readiness and life expectancy of an EFSA, to long term cost savings, to ensuring return on investment for major capital expenses and ultimately vital in protecting fire departments from possible litigation.

Procedures

The primary method of research used in this applied research project was descriptive. The reason for choosing this method was to gain a comprehensive understanding of preventive

maintenance so KFD could identify strategies for improvement of its EFSA maintenance operations. It started with a thorough literature search using the NFA's Learning Resource Center (LRC) online card catalogue, while attending the academy in January 2009. Maintenance, preventive, fleet, apparatus and vehicle, were the keywords used in the reference search of the card catalogue. This search revealed many sources of information that were helpful in writing this paper. Due to the fact that preventive maintenance in the fire service is ongoing issue, some sources fell outside the 5 year standard for current sources, but were still very pertinent to the subject matter. The internet and search engines were also utilized to access electronic periodicals, organization web sites, reports, and county, state and federal government web sites.

The department's library was used to research NFPA standards. The information provided set the tone for answering questions on minimum requirements for preventive maintenance and mechanics from a fire service or "industry standard" perspective.

A survey was developed to gather additional information on how other departments, similar in size and demographic to KFD, ran their perspective preventive maintenance operations. Questions also included, if NFPA 1915 standards were adopted, number of apparatuses used in operations, where were EFSA maintained, number of mechanics employed and if they were certified EVT, life expectancy of apparatuses and current budget for maintenance and repairs, including mechanic salaries.

Using surveymonkey.com, 80 surveys were sent out via email. The sample field included the three other county fire departments, Honolulu, Maui, and Hawaii County, EFO classmates and similar size fire departments nationwide. Forty seven surveys were completed, for 57 % return rate. The survey questions are included in Appendix A.

Two interviews were conducted to gain insight on how “for profit” companies run their maintenance operations. The first interview was a phone interview with John Burton, the Vice President of Burton Fire Inc., which is a complete fire apparatus repair shop in Modesto California. The purpose of this interview was to get a perspective from an industry expert on preventive maintenance for EFSA. The second interview was a face to face interview done with Don Christensen, supervisor of the maintenance shop of Kauai Freight Services Inc., a private trucking company located here on the island of Kauai. The purpose of this interview was twofold. The first was to see how a private business with a fleet of trucks handles their preventive maintenance. Secondly, it was to look at a fleet of vehicles that was exposed to the same weather conditions as KFD and the effect it had on the life expectancy of their vehicles.

After reviewing resources obtained in the literature review and in particular NFPA 1911, it gave great insight into answering research questions (RQ) 1 & 2, on the goals of an acceptable PMP and the components that are critical to an effective PMP for KFD.

The report done by FAMA that profiled the life expectancy of fire apparatuses, question #8 on the survey, the two personal communications, review of NFPA 1901 Annex D and the reference of Peters (1995) assisted in answering RQ # 3 on the life expectancy of an EFSA. RQ # 4, on what are other fire departments that are similar in size and demographics, to KFD, using for preventive maintenance, was answered by analyzing the data collected in the survey.

Limitations

By using the NFA’s LRC, most of the resources used in this study consisted primarily of fire service trade journals, which are limited in scope. Some of the resources did not fall within the 5 year criterion for current data.

There was limited control on who responded to the survey used in this research and may have narrowed the sample field. The return rate was 57 %. The survey also asked an open ended question on each department's current budget for repair and maintenance including mechanic salaries.

The six month time limit allowed by NFA for completion of this applied research project combined with a researcher full time responsibilities, does not allow for a more comprehensive literature review.

Definitions of Terms

Emergency Fire Service Apparatus (EFSA): Any vehicle used in daily operations to respond to any fire service related or medical emergencies. Engines, HAZMAT and rescue trucks, are examples. A chief, deputy or prevention bureau vehicle is not considered an EFSA

Preventive Maintenance: The care and servicing by mechanic or personnel for the purpose of maintaining equipment and facilities in satisfactory operating condition by providing for systematic inspection, detection, and correction of incipient failures before they develop into major defects.

Authority having Jurisdiction (AHJ): An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation or a procedure.

Results

In the process of conducting this applied research project, a survey was used to gain insight on what other fire departments similar in size and demographics to KFD, were using for preventive maintenance. The results from survey are found in Appendix B.

In summary the survey revealed that 96% of the respondents currently used a preventive maintenance schedule in their operations and 98% keep records on the EFSA maintenance. Where the EFSA were maintained varied proportionately among respondents. With 16%, in house, 16% at the Department of public works, 18% contracted and 38% used a combination. Forty three percent of those departments performing maintenance in house employed only one mechanic. Of that, only 26 % of departments surveyed employed mechanics with EVT certifications. Surprisingly, 28% of the sample field showed a life expectancy of their EFSA to be 17-20 years.

Due to the open ended question on current maintenance budget for each department, there was a wide range of responses given depending on the type of PMP used. The research did gather that those that maintained operations in house spent an average of $5500 dollars per EFSA per year on preventive maintenance.

The following research questions that were initially posed were answered as a result of this descriptive research, the two interviews and survey data obtained.

1. What are the goals of an acceptable PMP for KFD?

NFPA 1915 states that it is the responsibility of the AHJ or KFD to develop and implement a PMP. It also states that the intent of a PMP is to ensure that EFSA are serviced and maintained to keep them in safe operating condition and ready to respond (National Fire Protection Association, 2000).

The survey revealed that of the 47 responses, 96 % or 45 departments had a current PMP for their EFSA, with only two departments or 4% didn’t. This clearly shows that KFD is in the minority when it comes to having a PMP for their EFSA. With that being said, the primary goal for KFD is to develop and implement a PMP.

Goals of an acceptable PMP for KFD involves maintaining your EFSA in top condition and ready to respond, firefighter safety, extending life expectancy and ensuring return on a major capital investment and protecting KFD from litigation (Peters 1994).

John Burton from Burton Fire Inc. noted that PMPs can result in cost saving in the long run, by preventing catastrophic failures (J. Burton, personal communication, May 2, 2009). The study done by Federal Energy Management Program stated that a reactive maintenance many have short term cost saving the long term cost associated with down time, equipment turn and customer satisfaction far outweigh the initial saving (Fleet Maintenance Magazine, 2008), so a PMP that is efficient and cost effective should also be a determining factor as an acceptable goal for KFD.

2. What components are critical to an effective PMP?

There are many components that are critical to an effective maintenance program. First NFPA 1915 defines the minimum requirements for establishing a PMP. It also identifies the systems and items that should be inspected and the frequency. Documentation of maintenance records is also required under this standard. The documentation is critical to protect KFD from litigation (National Fire Protection Association, 2000).

Another critical component for an effective PMP is the daily, weekly and periodic inspections of EFSA to ensure that the EFSA is in top operating condition and ready to respond (Peters, Fire Apparatus Purchasing Handbook, 1994).

Annex C of NFPA 1911, states the requirements that needs to be included for establishing a PMP. These requirements include those listed in NFPA 1911 that pertain to your particular EFSA and the manufacturer’s manual. It also outlines the various maintenance tasks that need to be preformed and by whom. Each task is assigned a schedule based on months, years, hours or some

time frame. Daily and weekly walk around check list samples are provided (National Fire Protection Association, 2007).

Taking a look at Pierce Manufacturing Inc. operation and maintenance manual section 5, service and lubrication, and their recommended initial, daily, weekly, monthly, quarterly, semi-annually, annually, 3-5 years and vendor component maintenance schedules are also critical to effective PMP (Pierce Manufacturing Inc., 2007).

The apparatus operator plays a vital link to scheduled and routine maintenance of EFSA (Peters, Fire apparatus operator preventive maintenance, 2004). (Robertson, 2009) Gives 8 tips to apparatus operator to improve preventive maintenance and encourages the operator to become an expert on his or her EFSA.

Finally, the last component that is critical to an effective PMP is the certification of the mechanic. NFPA 1071 states the educational and technical expertise required to qualify as an EVT. An EVT is defined as an indivdual possesing a recognizable certification, professional standing, or documented skill who has aquired the knowledge, training, and experience needed to deal with the maintenance of a fire apparatus (National Fire Protection Assocition, 2006).

3. What is the life expectancy for EFSA?

The results from the literature review repeatedly acknowledged that the life expectancy for EFSA is about 15 years (Lackore, 2004) (Peters, Fire Department Apparatus, 1995)(J. Burton, personal communication, May 2, 2009),

NFPA 1901, suggests that fire departments should seriously consider the value or risk to firefighters of keeping an EFSA older than 15 years in first-line service. It recommends that EFSA

greater than 15years old, that have been properly maintained be placed in reserve status and upgraded in accordance with NFPA 1912 (National Fire Protection Association, 2009)

Craven (Craven, Apparatus specifications: a guide to saving time and money, 1995) suggest that the useful life span of EFSA varies among fire departments and is affected largely by apparatus utilization, local environment, local operating conditions, routine workload, and the PMP of that department. He also identifies three categories of EFSA life span. They are service life, technological life, and economic life.

Twenty eight percent of the departments that responded to the survey had a life expectancy of 17-20 years for their EFSA

4. What are other fire departments that are similar in size and demographics, to KFD, using for preventive maintenance?

The survey revealed that 96 % of other fire departments similar in size and demographics to KFD are using a PMP rather than a reactive maintenance program. There was a lot of variation in where these respondents performed their preventive maintenance operations. With 16%, in house, 16% at the Department of public works, 18% contracted and 38% used a combination.

Discussion

While conducting this descriptive research for the problem stated, that the Kauai Fire Department (KFD) does not have a preventive maintenance program (PMP) for its emergency fire service apparatuses (EFSA), which may result in decreased readiness and shorten the life expectancy of a EFSA, the researcher gained valuable knowledge on preventive maintenance programs and its requirements.

The purpose of this research was to investigate strategies that KFD can use to improve its fire apparatus maintenance operations to increase readiness and life expectancy of its apparatuses. The researcher gleamed helpful strategies from the literature review, personal interviews and survey.

As stated in the background and significance, KFD has a reactive rather than proactive or preventive maintenance operation. The primary strategy for KFD to improve its fire apparatus maintenance operations is to develop and implement a PMP.

The Survey emphatically revealed that KFD is in the minority when it comes to not having a PMP (See Appendix B). It is apparent that a PMP is an important function for any fire department and plays a vital role in accomplishing the department's mission of saving lives and protecting property (Peters, Fire apparatus operator preventive maintenance, 2004). (National Fire Protection Association, 2000) According to NFPA 1915, it is the responsibility of the AHJ or KFD to develop and implement a PMP. Although the process will need some cultural change within the department, the benefits that will be reaped are immense.

The first benefit reaped is safety. In the initiative commissioned by the USFA on emergency vehicle safety, undeniable revealed that a PMP will provide KFD a greater level of safety for its firefighters and the community it serves (IOCAD Emergency Service Group, 2004). From the two interviews conducted, both John Burton (J. Burton, personal communication, May 2, 2009), from Burton Fire Inc. and Don Christensen (D. Christensen, personal communication, May 5, 2009), from Kauai Freight Service stated that safety was their number one priority for their PMP.

The second benefit to KFD would be the readiness of and the extended life of their EFSA (Peters, Fire Department Apparatus, 1995), (J. Burton, personal communication, May 2, 2009), (Peters, Fire Apparatus Purchasing Handbook, 1994), (IOCAD Emergency Service Group, 2004). Although KFD has been very fortunate to avoid any major accidents or catastrophic mechanical failures due to lack of preventive maintenance, the fact still remains that once is too much. KFD has its share of maintenance failures on brakes, rotors, electrical and transmissions like any other department, but it has not resulted in a major accident or someone getting hurt.

There are many factors that determine the life cycle of an EFSA (Craven, Apparatus specifications: a guide to saving time and money, 1995) KFD's 15 year life expectancy for its EFSA fall within the national average (Lackore, 2004), (Peters, Fire Department Apparatus, 1995), (J. Burton, personal communication, May 2, 2009). The survey showed that 96% of the departments had a PMP. It also showed that 28% of those respondents had a life expectancy of 17-20 years which is greater than the industry standard of 15 years. Maybe with better preventive maintenance, KFD can even extent the life of its EFSA and in turn, get a better return on investment and save the County of Kauai much needed revenue.

The final benefit afforded KFD by developing and implementing a PMP and probably the most far reaching is protection against litigation (D. Christensen, personal communication, May 5, 2009), (J. Burton, personal communication, May 2, 2009), (Peters, Fire Apparatus Purchasing Handbook, 1994) (Cavette, 2005). KFD could be exposed to a lot of liability due to the fact that they currently have no maintenance tracking records on their EFSAs. The only documentation KFD has is repair memos and daily check list.

EVT certification is highly recommended by the NFPA (National Fire Protection Assocition, 2006) but due to limited resources on the island of Kauai and the impending retirement

of KFD's current mechanic, that NFPA recommmendation is probably not attainable at this current time. With the hiring of a new mechanic in the coming years it is something that should be considered.

The survey discovered that there are a number of stategies that fire departments are using to address preventive maitenance. With 38% employing a combination strategy. The variables are many and each department must weight the cost and effectiveness of their own PMP.

The three other Hawaii county fire departments, Honolulu Fire Department (HFD), Hawaii County Fire Department (HCFD) and Maui Fire Department (MFD), all have a PMP that is preformed in-house. None of their respective mechanic's are EVT. They are all working towards NFPA 1915 and 1071 standards. Both HFD and MFD have a life expectency of 10-15 years and HCFD is 17-20 years. They all have mutiple mechanics where KFD has one. KFD has requested addition mechanic in budget requests but have continuely been turn down.This shows that KFD needs to do a self assesment and evaluate their current maintenance operations.

Recommendations

The Kauai Fire Department is ripe for change within its orgainazation culture including its maintenance operations. With the upcoming self assesment/risk hazzard analysis, KFD is in the process issueing new nomex uniforms and redisigned patch. This is the foundation for cultural change for KFD.

Based on the the current research, these are the author's recommendations.

1. Use KFD's newly formed Self Assesment Committee (SAC) to look throughly at KFD's current maintenance operations and weigh it against NFPA 1915 to identify where KFD is defecient and address the problems.

2. Create new apparatus check list based on Pierce's Manufacturing Inc.'s maintenance schedule found in in the operation and maintenance manual.
3. Train FAOs on how to correctly inspect and what to look for on daily inspection of EFSA.
4. Utilize current Records Management System (RMS) to enter, repair requests, set maintenance schedule and track maintenance and repairs for each EFSA.
5. Investigate possibilities and feasibility of contracting or combination maintenance operations.
6. Establish criteria for hiring new mechanics.
7. In county budget continue to request for additional mechanic to alleviate current work load on KFD's current fire department mechanic.

Recommendations to assist future readers or organizations studying preventive maintenance operations are.

1. Evaluate current PMP and weigh against NFPA 1915, and if there is no PMP, seriously consider instituting one.
2. Conduct a financial audit of current maintenance operations and due cost analysis on maintenance per EFSA.
3. Investigate different preventive maintenance options available in their respective areas.
4. Conduct evaluation of current mechanic certifications.

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Appendix A

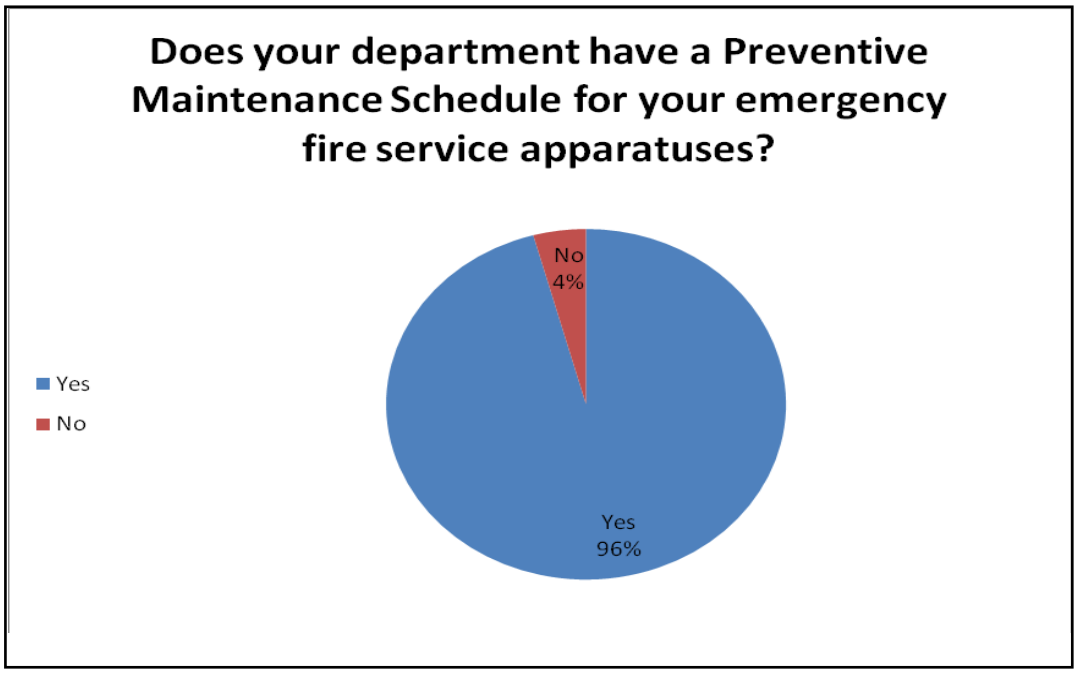
Survey Questions

1. Does your department have a preventive maintenance schedule for your emergency fire service apparatuses? Yes No
2. NFPA 1915 defines the minimum requirements for a preventive program for a fire apparatus. Does your department follow NFPA 1915? Yes No
3. How many fire service apparatus does your department utilize in operations? 0-10, 10-15, 15-20, 20-25, 25-30,35-40, over 35
4. Where are your apparatus maintained? In house, Department of public Works, Sent Out (contracted) or a combination
5. If your department is performing maintenance in house or a combination, how many mechanics do you employ? 1,2,3,4,5, more than 6
6. If your department is employing a mechanic, are they certified emergency vehicle technicians (EVT's)? Yes, No
7. Does your department track and record maintenance records for your apparatuses? Yes, No
8. What is the life expectancy for your department's emergency fire service apparatuses? 5-8 years, 8-11, 11-14, 14-17,17-20, over 20 years
9. What is your current budget for apparatus maintenance and repairs? (including mechanic's salary)

Appendix B

Survey Question Results

Survey question number 1



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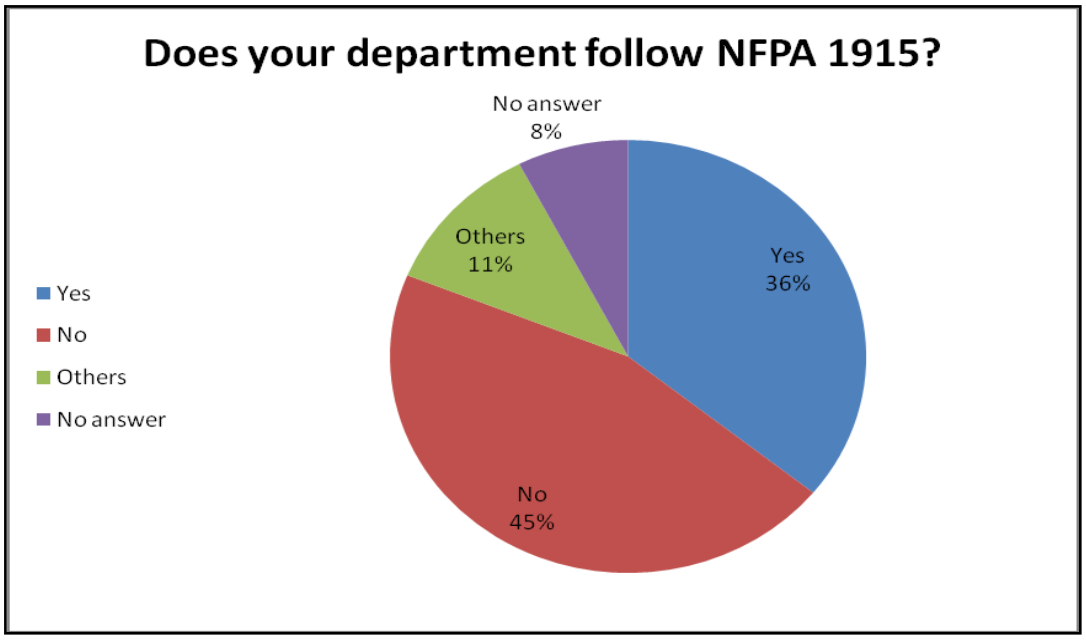

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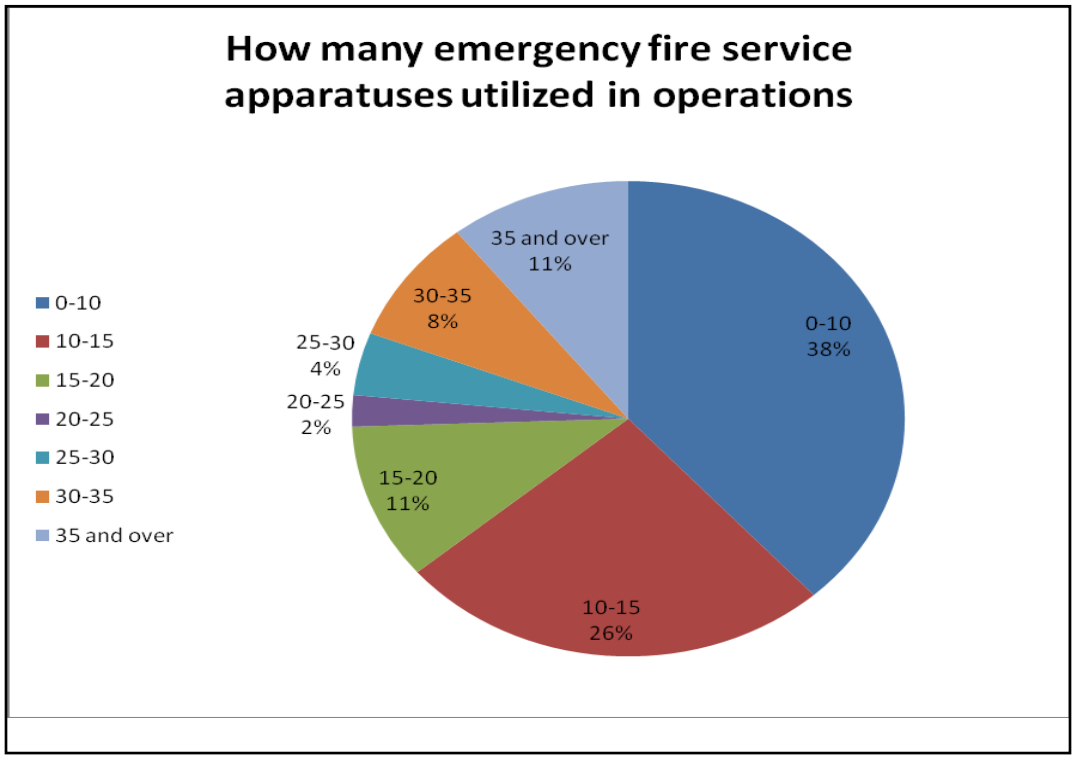

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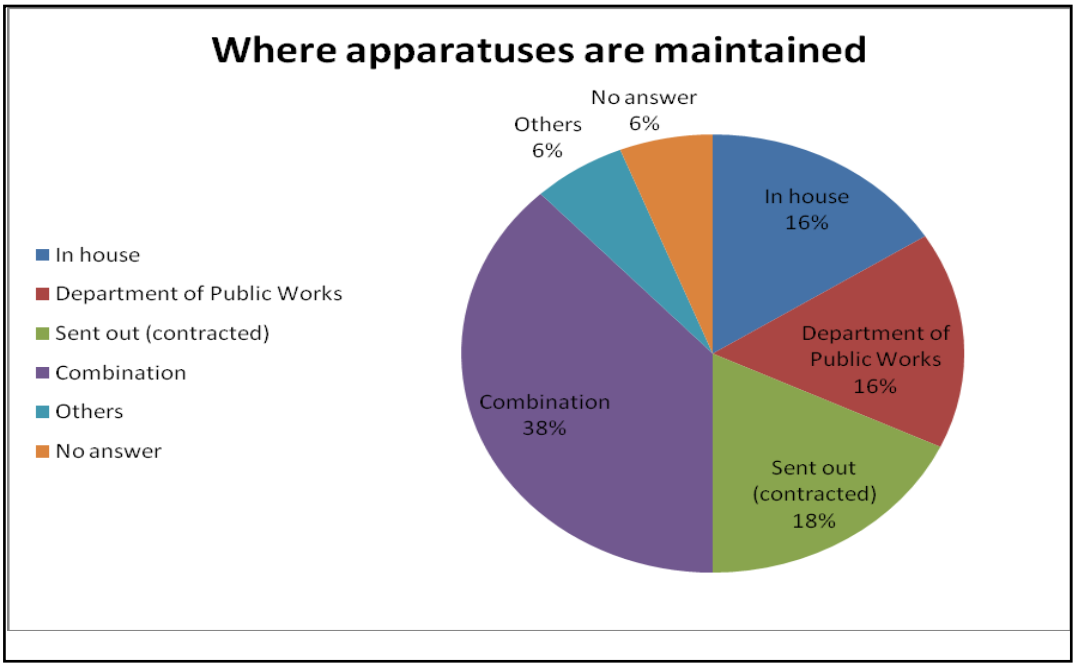

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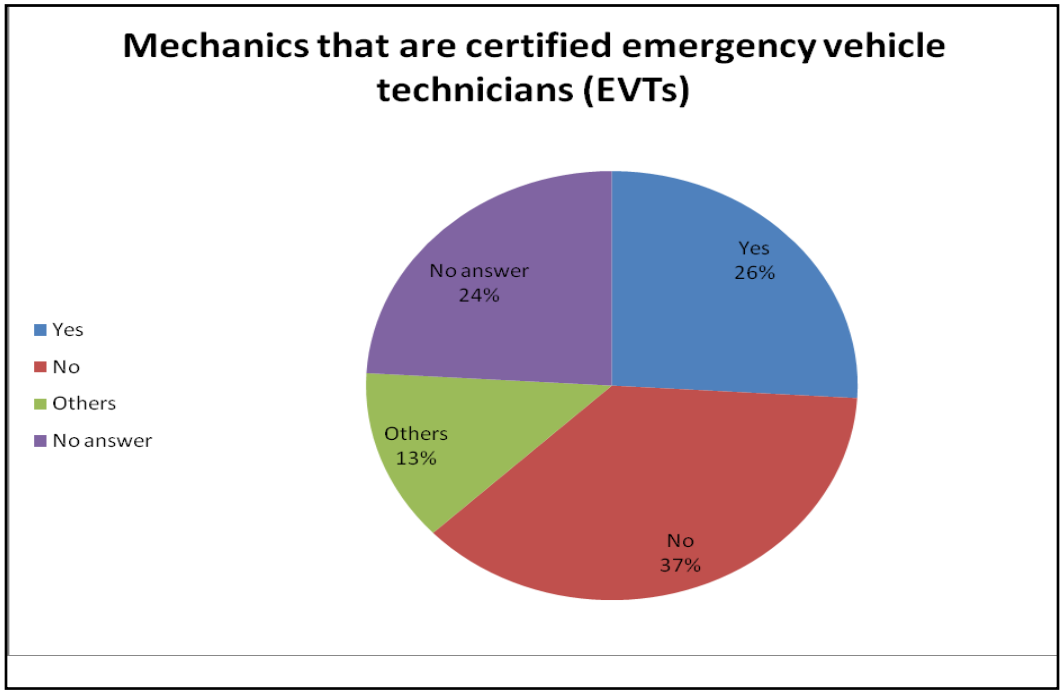

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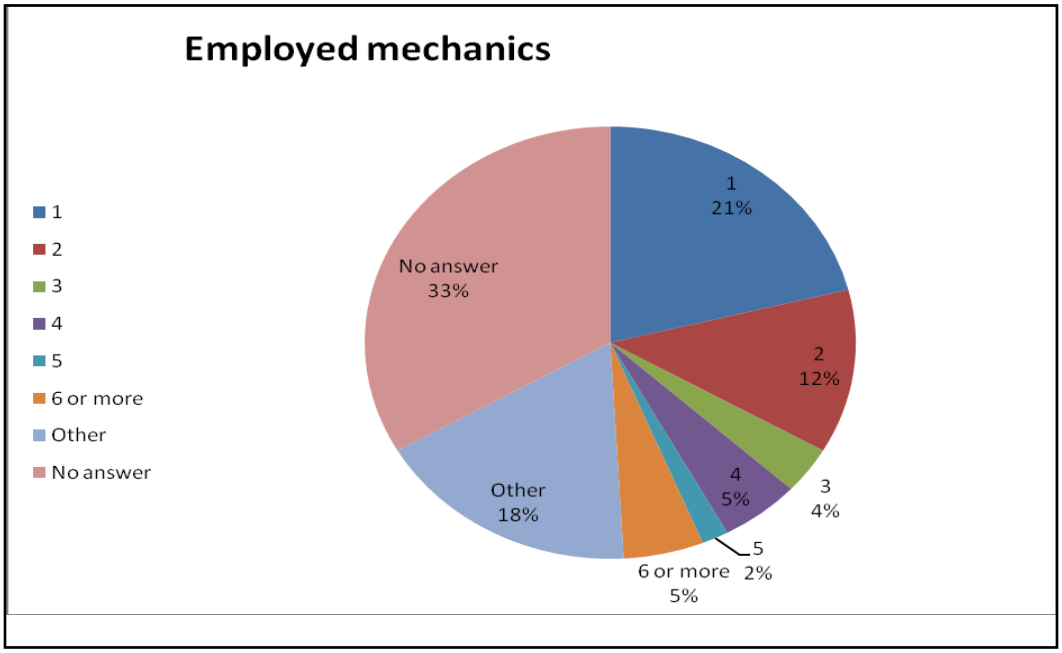

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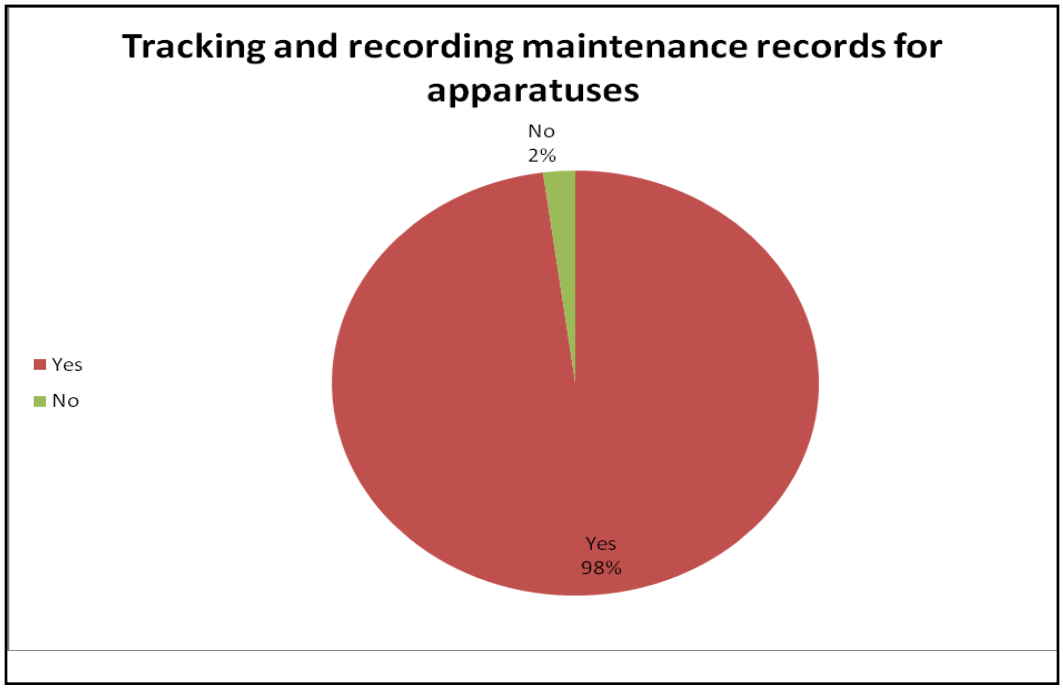

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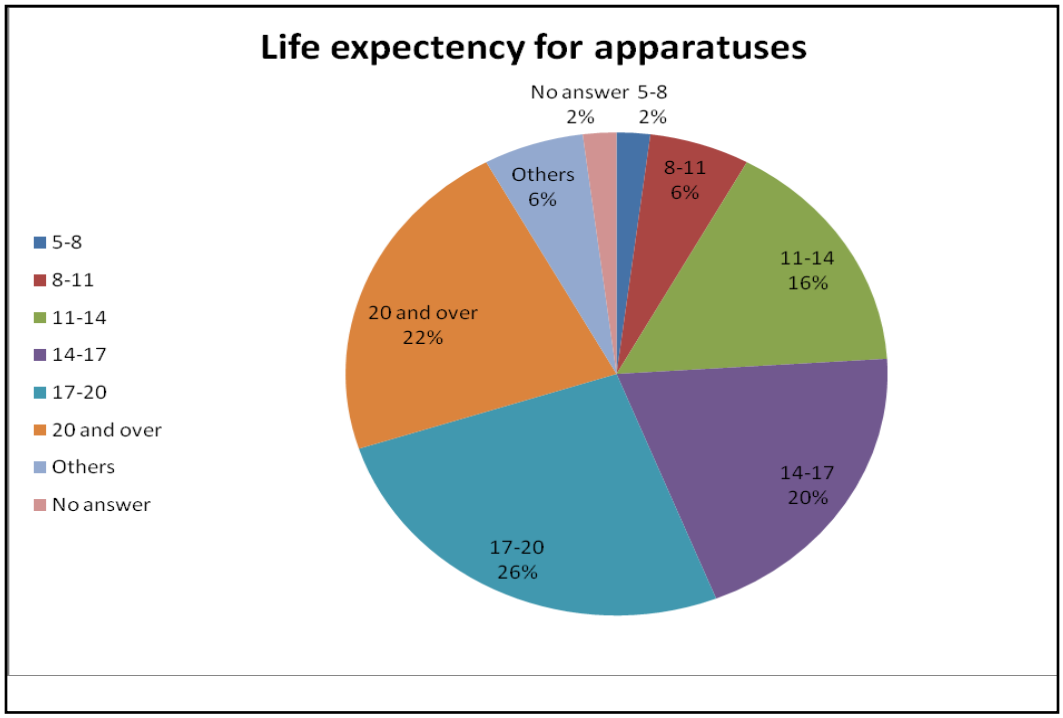

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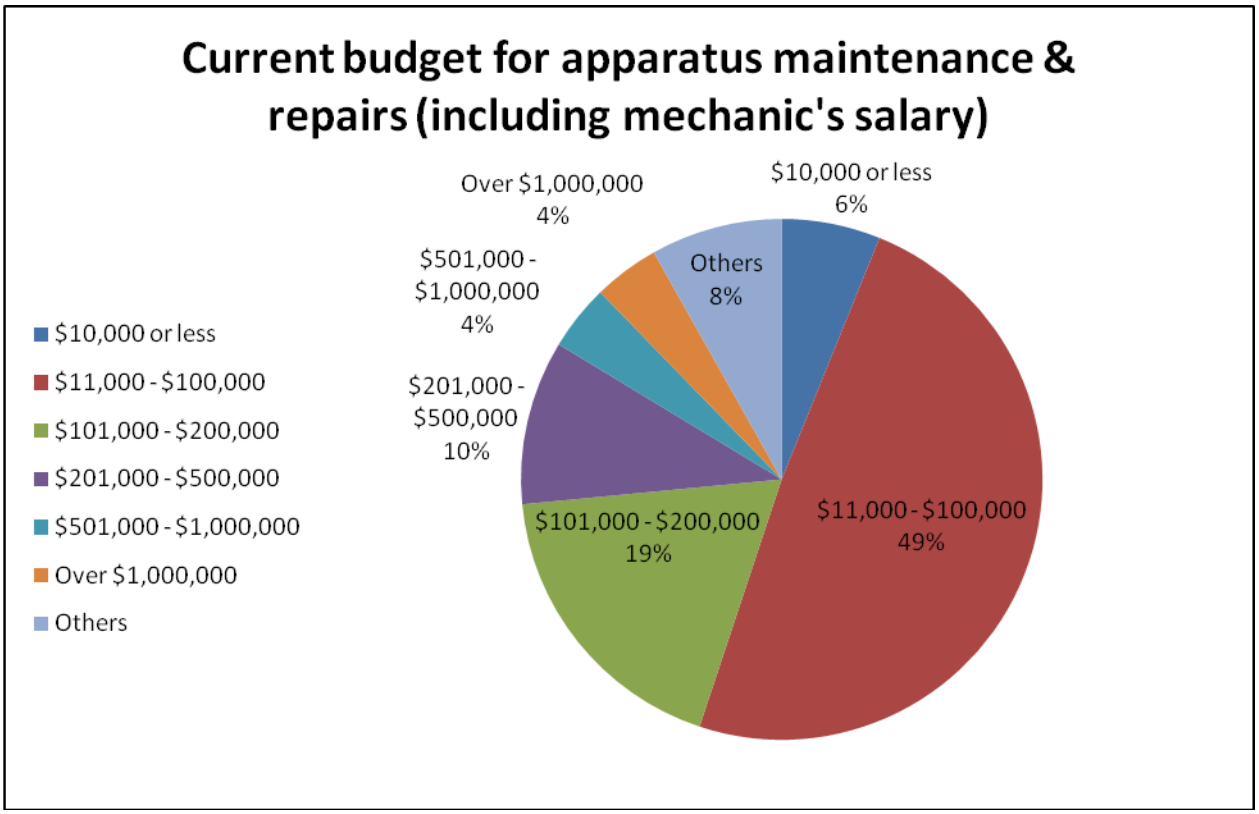

Appendix C

Fire Departments that responded to the Preventive Maintenance for Emergency Fire Apparatus Survey

Nikiski Fire Department
P.O. Box 8508
Nikiski, AK 99635
(907) 283-4202

Mountain View Fire Prot Dist
9119 County Line Rd
Longmont, CO 80501
(303) 434-8416

Bend Fire & Rescue
1212 SW Simpson Ave
Bend, OR 97702
(541) 322-6311

Honolulu Fire Department
636 South St.
Honolulu, HI 96813
(808) 723-7104

Hawaii County Fire Dept.
25 Aupuni St, Ste 103
Hilo, HI 96720
(808) 981-8394

Hudson Fire Department
39 Ferry St
Hudson, NH 03051
(603) 886-6021

Star Joint Fire Prot Dist
10831 W State St
Star, ID 83669
(208) 286-7772

Goshen Fire Company
1320 Park Ave
West Chester, PA 19380
(856) 256-4450

Grand Forks Fire Dept
1124 Demers Ave
Grand Forks, ND 58201
(701) 746-2566

Pike Twnp Fire Dept
4881 W 71st St
Indianapolis, IN 46268
(317) 347-5860

Las Vegas Fire Rescue
500 N Casino Ctr Blvd
Las Vegas, NV 89101
(702) 383-2888

Virginia Beach Fire Dept
2408 Courthouse Dr
Virginia Beach, VA 23456
(757) 385-1075

Las Cruces Fire Department
P.O. Box 20000
Las Cruces, NM 88004
(575) 528-3473

Rapid City Fire Department
10 Main St
Rapid City, SD 57701
(605) 394-4185

Wells Fire Department
P.O. Box 398
Wells, ME 04090
(207) 646-7912

Salt Lake City Fire Department
315 E 200 S
Salt Lake City, UT 84111
(801) 799-4110

Wilmington Fire Department
22 S Heald St
Wilmington, DE 19801
(302) 571-4595

Helena Fire Department
300 Neill Ave
Helena, MT 59601
(406) 447-8472

Fort Worth Fire Department
1000 Throckmorton St
Fort Worth, TX 76102
(817) 392-6854

Moraine Division of Fire
4200 Dryden Rd
Moraine, OH 45439
(937) 535-1141

Larkspur Fire Prot Dist
9414 Spruce Mtn Rd
Larkspur, CO 80118
(303) 705-7412

Cedar Rapids Fire Department
222 Third Street NW
Cedar Rapids IA 52405-3939
(319) 286-5200

Bridge Port Fire Department
6204 Dixie Hwy
Bridgeport, MI 48722
(989) 777-2400

Regional Fire Dept Sasebo
PSC 476 Box 65
FPO AP 96322-1155

Endicott Fire Department
224 Madison Ave
Endicott, NY 13760
(607) 757-2463

Dania Beach Fire Rescue
100 West Dania Beach Blvd
Dania Beach, FL 33004

County of Louisa
1 Woolfolk Ave
Louisa, VA 23093
(540) 967-3491

Littleton Fire Rescue
230 West Main St
Littleton, NH 03561
(603) 444-2137

Minooka Fire Protection District
P.O. Box 736
Minooka, IL 60447
(815) 467-5637

St. Tammany Fire Prot Dist 4
709 Girod St
Mandeville, LA
(985) 626-8671

Maui Fire Department
200 Dairy Rd
Kahului, HI 96732
(808) 270-7561

Kokomo Fire Department
215 West Superior St.
Kokomo IN 46901
(765) 456-7516

Hamburg Township Fire
Hamburg, MI 48139
(734) 878-9513

City of Brodhead Fire Dept
1100 West 3rd Ave
Brodhead, WI 53520
(608) 897-4270

Cedar Falls Fire Rescue
1718 Main St
Cedar Falls, IA 50613
(319) 273-8622

Sandy Fire District
P.O. Box 518
Sandy, OR 97055
(503) 668-8093

Ft. Lupton Fire Protection Dist
1121 Denver Ave
Fort Lupton, CO 80621
(303) 857-4603

Kernersville Fire Rescue Dept
316 West Bodenhamer St
Kernersville, NC 27284
(336) 996-4885

City of Hallandale Beach
Department of Fire Rescue
121 S.W. 3rd Street
Hallandale Beach FL 33009
(954) 457-1474

Hood River Fire Department
P.O. Box 27
Hood River, OR 97031
(541) 386-3939

Payson Fire Department
400 W Main St
Payson, AZ 85541-5388
(928) 474-5242

Waycross Fire Department
Waycross, GA 31503
(912) 287-2938

Village of La Grange Park FD
447 N. Catherine Ave
La Grange Park, IL 60526
(708) 354-0225

Hales Corners Fire Department
10000 W. Forest Home Ave
Hales Corners, WI 53103
(414) 529-6168

Sweetwater County Fire Dist
P.O. Box 2940
Rock Springs, WY 82902
(307) 362-9390

Avon Fire Department
150 Main St
Avon, MA 02322
(508) 583-5361

Bellingham Fire Department
1800 Broadway
Bellingham WA 98225-3133
(360) 676-6831

Appendix D

SECTION 5 SERVICE AND LUBRICATION INTERVALS

Refer to the following charts for service and lubrication requirements. Perform services at the indicated interval of miles or time, whichever comes first.

Table 5-1: Initial Inspection Maintenance Schedule

Description	Action	Miles	Time
Spring U-Bolts	Check torque and tighten as required (after initial delivery).	500	Initial Inspection

Table 5-2: Daily Maintenance Schedule

Description	Action	Miles	Time
Air Cleaner	Check air intake restriction indicator.		Daily
Air Intake Tubes and Clamps	Inspect for leaks and clamp tightness.		Daily
Air Tanks	Drain water.		Daily
Coolant	Inspect for signs of coolant leaks. Check coolant level using sight glass or electronic monitor.		Daily
Engine	Inspect for signs of oil or coolant leaks.		Daily
Engine Oil	Inspect for signs of oil leaks. Check oil level using dipstick, sight glass, or electronic monitor.		Daily
Exhaust	Inspect for leaks and clamp tightness.		Daily
Throttle Pedal	Check for smooth operation and return ability.		Daily
Tires	Check inflation pressure. Inflate to correct pressure per the tire manufacturer's load/inflation recommendations.		Daily
Transmission Fluid	Inspect for signs of oil leaks. Check level using dipstick or electronic monitor. Also note physical appearance of transmission fluid.		Daily

Table 5-3: Weekly Maintenance Schedule

Description	Action	Miles	Time
Aerial Boom Support	Inspect fasteners for tightness and integrity.		Weekly
Air Dryer	Test purge pressure.		Weekly
Air Inlet	Inspect engine air inlet for dirt, debris, or plugging.		Weekly
Axle, Front	Inspect for signs of wear, damage, or looseness.		Weekly
Belts	Inspect for damage and check tension.		Weekly
Brake Linings	Inspect for sufficient lining thickness.		Weekly
Brakes	Inspect all brake parts for integrity. (See *"Brakes – General"* on *page 4-2*.)		Weekly
Cab Tilt System	Check fluid level. (See *"Cab Tilt System"* on *page 4-5* for fluid type.)		Weekly

SERVICE AND LUBRICATION INTERVALS

Description	Action	Miles	Time
Driveshafts	Inspect for signs of damage.		Weekly
Electrical Connectors	Inspect for tightness, corrosion, and integrity.		Weekly
Electrical Harnesses and Wires	Inspect for rubbing, fraying, or looseness.		Weekly
Fan Drive - *Quantum®*	Check fluid level using sight glass. Fill with MOBIL SHC 630 synthetic oil. Inspect coupling for wear or misalignment.		Weekly
Frame Fasteners	Inspect for looseness, wear, or corrosion.		Weekly
Fuel System	Inspect for signs of damage, leaking, or chafing.		Weekly
Fuel-Water Separator	Check water collection bowl and drain condensate.		Weekly
Mirror Hardware	Inspect fasteners for tightness and integrity.		Weekly
Seat Belt Assemblies	Inspect for signs of damage, wear, or corrosion.		Weekly
Springs	Inspect for signs of wear, cracking, or bending.		Weekly
Steering Hydraulic System	Check oil level using dipstick, sight glass, or electronic monitor. Fill with DEXRON III.		Weekly
Steering System	Inspect all steering parts for integrity. (See *"Steering"* on *page 4-41* for additional information.)		Weekly
Suspension Hangers and Shackles	Inspect for signs of wear, corrosion, or damage.		Weekly
Tires	Inspect tread depth and check for damage.		Weekly
Wiper Blades	Clean wiper blades.		Weekly

Table 5-4: Monthly Maintenance Schedule

Description	Action	Miles	Time
Axle, Rear	Check oil level in carrier.	10,000	Monthly
Battery Posts	Clean and grease after cleaning.	3,000	Monthly
Cab Step Pivot - *Quantum®*	Lubricate with Lubriplate low temperature grease.	3,000	Monthly
Cab Tilt Pivot Pins - *except Velocity™/ Impel™*	Lubricate with Lithium NLGI Grade EP2 grease.	3,000	Monthly
Cab Tilt Remote Control Receptacle	Lubricate with NYK corrosion preventative compound (Trucklite 97944 or equivalent).	3,000	Monthly
Driveshaft Slip Joints	Lubricate with Lithium NLGI grade EP2 grease.	3,000	Monthly
Driveshaft U-Joints	Lubricate with Lithium NLGI grade EP2 grease.	3,000	Monthly
Radiator and Charge Air Cooler Cores	Clean debris to ensure unimpeded air flow through cores.	3,000	Monthly
Spring Pins	Lubricate with Lithium NLGI grade EP2 grease.	3,000	Monthly
Steering Intermediate Links	Lubricate with Lithium NLGI grade EP2 grease.	3,000	Monthly

Description	Action	Miles	Time
Wheel Bearings, Oil (Front Axle)	Check fluid level and add as required.	3,000	Monthly
Wheel Nuts	Check torque and tighten as required.	3,000	Monthly
Windshield Wipers - *Dash®/Lance®, Velocity™/Impel™*	Check torque and tighten as required.	3,000	Monthly

Table 5-5: Quarterly Maintenance Schedule

Description	Action	Miles	Time
Cab Lift Cylinder Trunnion Joints - *Dash®/Lance®*, Enforcer®, Arrow XT™	Clean and lubricate cab lift cylinder trunnion joints. See *"Lift Cylinder Trunnion Cleaning & Lubrication - Dash®/ Lance®/Enforcer®/Arrow XT™"* on *page 4-5* for additional information.	2,000	Quarterly

Table 5-6: Semi-Annual Maintenance Schedule

Description	Action	Miles	Time
Air Conditioning	Inspect sight glass. See *"Air Conditioning Sight Glass"* on *page 4-38* for additional information.		6 Months
Automatic Slack Adjusters	Lubricate with clay-based NLGI Grade 1 or 2 grease. (See Meritor lube chart for additional information.)		6 Months – See Axle Manual
Disc Brake Calipers	Lubricate with clay-based NLGI Grade 1 or 2 grease (See Meritor lube chart for additional information.)		6 Months – See Axle Manual
Door Hinges	Inspect and Adjust. Spray with silicone lubricant.		6 Months
Door Latches	Lubricate with Lubriplate105 grease or equivalent.		6 Months
Door Strikers	Inspect and adjust.		6 Months
Door Window Regulators	Lubricate with Lithium NLGI grade EP2 grease.		6 Months
Fifth Wheel - *Tiller Only*	Lubricate the fifth wheel bearing connecting the tractor to the tiller trailer. See *"Fifth Wheel Lubrication (Tiller Only)"* on *page 4-35* for additional information.	3,000	6 Months
Hood - *Velocity™/ Impel™*	Lubricate hinges with Lithium NLGI grade EP2 grease.		6 Months
Seat Adjuster Slides	Lubricate with Lithium NLGI grade EP2 grease.		6 Months
Shock Absorbers, Front - *Arrow XT™*	Replace.	6,000	
Steering Gear	Lubricate with Lithium NLGI grade EP2 grease.		6 Months
Tire Alignment (Front Axle)	Check toe-in on front tires.		6 Months
Transmission Fluid	Trucks in *severe duty* applications, or trucks equipped with *transmission retarders*, should have transmission fluid tested for water and glycol contamination. See *"Transmission Fluid Analysis – Allison Transmissions"* on *page 4-48* for additional information.	12,000	6 months or 500 hours

SERVICE AND LUBRICATION INTERVALS

Table 5-7: Annual Maintenance Schedule

Description	Action	Miles	Time
Air Cleaner	Replace air cleaner or filter element.		Annual or as required
Axle, Front Kingpin	Lubricate with Lithium NLGI grade EP2 grease.	100,000	Annual
Axle, Tie Rod Ball Joints	Lubricate with Lithium NLGI grade EP2 grease.	100,000	Annual
Spring U-Bolts	Check torque and tighten as required.	24,000	Annual
Steering Drag Link Ball Joints	Lubricate with Lithium NLGI grade EP2 grease.	100,000	Annual
Steering Hydraulic System	Replace filter and hydraulic fluid in power steering reservoir(s) with DEXRON III.		Annual

Table 5-8: 3-5 Year Maintenance Schedule

Description	Action	Miles	Time
External Transmission Cooler	Replace external transmission cooler. See *"External Transmission Coolers"* on *page 4-49* for additional information.		3-5 years

Table 5-9: Vendor Component Maintenance Schedule

Description	Action	Miles	Time
Air Dryer Desiccant	Replace desiccant.		See Air Dryer Manual
Axle, Rear	Replace lubricant (initial drain and fill).		See Axle Manual
Axle, Rear	Replace oil & oil filter (if applicable) in carrier.		See Axle Manual
Coolant	Replace coolant after flushing system.		See Engine Manual
Coolant Filter	Replace.		See Engine Manual
Engine Oil	Replace with engine manufacturer's recommended grade and viscosity.		See Engine Manual
Engine Oil Filter	Replace.		See Engine Manual
Engine Thermostats	Test and replace if defective.		See Engine Manual
Fuel Filter	Replace element.		See Engine Manual
Transmission Filters	Replace with transmission manufacturer's approved filters.		See Transmission Manual
Transmission Fluid	Replace with DEXRON III or TRANSYND. (See the yellow Federal Motor Vehicle Safety Standard (FMVSS) information decal for fluid type.)		See Transmission Manual
Wheel Bearings, Grease (Front Axle)	Lubricate with Lithium NLGI grade EP2 grease.		See Axle Manual
Wheel Bearings, Oil (Front Axle)	Replace lubricant.		See Axle Manual