Field-Expedient Maintenance Experiences of M60-Series Tank Crewmen

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Abstract

Although most tank crewman duties involve operating rather than maintaining their vehicles, the ability of crewmen to make expedient repairs in the field could be crucial to the crew's survival. Preliminary reports suggested that tank crewmen occasionally employ unauthorized field-expedient repairs during training exercises when a mechanic is unavailable. To determine the types and effectiveness of field-expedient techniques, 76 incidents of field-expedient maintenance were collected during interviews with 33 armor NCOs. The incidents were reviewed and grouped into eight categories representing different types of field-expedient techniques. Each of the eight categories represents a generalized maintenance approach that might be useful in a number of emergency situations where expedient repairs are essential.

Introduction

Standard Maintenance Procedures

Under normal circumstances, most troubleshooting and repair of complex military hardware such as tanks is performed by qualified mechanics and technicians. These mechanics and technicians, trained in approved troubleshooting and repair techniques, accomplish the repairs using procedures prescribed in detail in voluminous technical manuals. In theory at least, these mechanics and technicians make repairs by the book, using authorized parts and procedures to effect repairs in the required manner. In practice, however, technical manuals cannot possibly cover every problem that might occur with a complex weapon system; thus mechanics and technicians must depend to some extent on their troubleshooting skills to correctly diagnose system faults.

Siegel and Jensen (1955) have suggested that effective troubleshooting involves hypothesizing the cause of a malfunction from observed symptoms and testing the hypothesis by making diagnostic equipment performance checks. Not every malfunction, however, requires such careful troubleshooting. In some cases the cause of the malfunction will be obvious, even to a relatively inexperienced mechanic. Extensive experience in evaluating and repairing malfunctioning equipment often allows the experienced troubleshooter to go directly from the symptom to the repair without making any diagnostic checks. Such shortcuts may be effective, especially in those cases in which an observed symptom is almost always associated with a particular fault. On the other hand, shortcuts may lead even the most experienced technicians to misdiagnose the cause of a malfunction (Chalmers, 1957).

Field-Expedient Maintenance

Unlike trained mechanics and technicians, tank crewmen are given little formal training in troubleshooting and repair procedures. Crewmen are trained to perform routine checks and services and to refer all other malfunctions to organizational maintenance. This division of responsibility between tank crewmen and skilled mechanics works well enough in peacetime, but combat presents special problems. When their tank sustains damage or malfunctions during combat, and trained maintenance personnel are not readily available, crewmen may be forced to rely on their maintenance skills to extricate themselves from life threatening situations. Because of the immediacy with which the repairs must be accomplished and the lack of approved repair parts, crewmen in these situations may have to resort to the use of unauthorized materials and techniques for effecting the repairs.

While tank crewmen have long recognized the value of making a timely repair in the field, armor experts have only recently begun to see the advantages of field-expedient techniques. Some armor experts are now suggesting that senior NCOs and other leaders be trained to perform field-expedient techniques. But detailed information on field-expedient maintenance has been lacking. Only spotty informal reports of field expedient maintenance have been available.

Critical Incident Technique

Because performance of field-expedient maintenance does not occur with any predictable regularity, obtaining sufficient information about field-expedient maintenance through direct observation is not feasible. However observations of field-expedient maintenance can be gathered indirectly through a method known as the critical incident technique (Flanagan, 1954). This technique was developed by Flanagan and his colleagues for determining what behaviors were critical to effective and ineffective performance of job activities by Army Air Force aviators. The critical incident technique has since been used to determine the critical requirements for effective performance in a variety of different jobs (Fivars, 1973). The technique involves asking competent observers to describe incidents in which the behavior of an individual was particularly effective (or ineffective) in performing a prescribed activity or job. The critical incident technique is used in the present study to obtain information about the kinds of unauthorized procedures used by tank crews to repair their vehicles.

METHOD

Procedure

Thirty-seven armor NCO's were asked to describe incidents in which they, as members of tank crews, performed or saw others perform unauthorized maintenance techniques that were clearly effective in restoring a disabled or malfunctioning tank to operation. To ensure the inclusion of pertinent information, each NCO was asked a series of questions about the incidents described. Questions asked for: (1) the circumstances under which the maintenance occurred; (2) initial symptoms suggesting a malfunction; (3) troubleshooting checks made by the crew; (4) symptoms leading to fault diagnosis; (5) the

faulty system or component; (6) how the repair was made; (7) tools used in making the repair; and (8) how long the repair took. The NCOs provided the information anonymously during individual structured interviews conducted by interviewers from the Army Research Institute.

Analyses

The above procedure yielded two kinds of information: (1) field-expedient maintenance incidents based on the personal experiences of armor NCOs; and (2) profiles of the incidents, characterizing incidents along each of several dimensions. The field-expedient maintenance incidents were sorted into groups of similar incidents, which became the basis for eight distinct categories of field-expedient maintenance. Fifty of the 76 incidents were used to derive the categories initially; these categories were then used to classify the remaining 26 incidents. On the basis of the successes obtained and difficulties encountered in classifying the remaining incidents, the category definitions were refined. As a measure of the reliability of the categories, two persons not affiliated with the study independently classified the 76 incidents. The percentage of agreement among the classifiers was computed. The information contained in the incident profiles was evaluated by determining the proportion of incidents falling under the different levels of each dimension.

RESULTS & DISCUSSION

Descriptive Analyses

Descriptive analyses of the incident profiles revealed some interesting results. Approximately two-thirds of the field-expedient maintenance experiences occurred during collective training exercises, such as ARTEP's, field problems, and gunnery. In looking for the source of malfunctions, crewmen seldom reported making troubleshooting checks, other than a quick visual inspection of the suspected component. Only 24% of those interviewed reported using troubleshooting procedures to isolate the problem. When tools or supplies were required to make the repair, soldiers reported selecting from issued items (e.g., wrenches, sockets, track jacks, flashlight batteries) and non-issue items such as sticks, electrical tape, or a spring from a ball-point pen. Some soldiers carry special tools and supplies for the express purpose of making field-expedient repairs, such as vise grips, 90-mile-an-hour tape, a green sticky tape for repairing air hoses, and canned ether for starting a cold tank engine. Some repairs are made without using any tools or supplies whatsoever. For example, a soldier might manually operate a broken steering linkage or spit on the back of a round to increase conductivity so that it fires. Using available tools and supplies and their imagination, the soldiers completed the typical field-expedient repair in an hour or less.

Maintenance Categories

Table 1 shows the eight categories of field-expedient maintenance. While the categories listed in Table 1 were based entirely on the experiences of M60-series tank crewmen, the categories may apply to field-expedient maintenance on other systems as well. Due to the relatively small number of incidents collected, however, new categories may appear when maintenance of other

weapon systems is considered. Still, the categorization of field-expedient maintenance has identified various approaches that may be used to make field-expedient repairs in a wide variety of situations. For example, soldiers might be taught that when a faulty part or component is known to be interfering with carrying out their mission, and cannot be mended, then they should consider using a substitute part, bypassing the part, or removing the part completely and operating without it. Similarly, soldiers could be made aware of other approaches (e.g., mannual assist) that might be useful in certain kinds of situations.

The adequacy and reliability of the categories of field-expedient maintenance were determined by comparing the author's classification of the 76 incidents with that of each of two independent classifiers. The first classifier placed 72% of the incidents in the same category as the author, and the second classifier categorized 82% the same as the author. Working independently the two classifiers agreed on 72% of the incidents.

Table 2 contains one example from each category of field-expedient maintenance as reported by the armor NCOs. Incidents are listed for illustrative purposes only, and their

Table 1. Field-Expedient Maintenance Categories

Preventive Maintenance (Unauthorized) - Unauthorized maintenance performed to avoid anticipated problems.

Manual Assist - The soldier physically inserts himself as part of a malfunctioning system and manually assists the system as it operates.

Bypass/Remove w/o Replacement - A faulty component is taken out of the system and the system is operated without it, or the component is bypassed so that it no longer functions as part of the system.

Reposition or Adjust - A component that has become displaced, bent, jammed, locked, loose or out of adjustment is returned to its normal operating position.

Substitute Component or Part - A part or component is removed and replaced with an unauthorized substitute part.

Remove & Replace With Authorized Part - Either a component is removed and replaced that the crew is not authorized to remove or replace, or the manner in which the removal/replacement is accomplished (e.g., tools used, method used) does not follow accepted procedures.

Clean or Mend - A component is cleaned, patched, or mended by unauthorized personnel using approved methods or materials or by any personnel using unauthorized methods or materials.

Mechanical/Electrical/Chemical Assist - A vehicle is induced to operate or assisted in operation by applying an external mechanical, electrical, or chemical stimulus or boost.

Table 2. Examples of Field-Expedient Maintenance by Category

Preventive Maintenance - Due to vibration, the wedge bolt worked itself loose during an ARTEP. To prevent the wedge bolt from working loose again and eventually falling off, a hammer and chisel were used to notch the wedge bolt.

Manual Assist - During a field exercise at Fort Irwin (National Training Center), a tank was making a hasty attack across an open field laced with gulleys. The tank, moving at a fairly rapid clip, hit a deep gulley, causing the shifting linkage at the back of the engine to snap. The crew had to move the tank to avoid artillery shells that were being dropped behind them as they moved across the field. To move the tank, the TC got out on the back deck and, directing the driver's actions through the external phone system, manually operated the shifting linkage.

Bypass/Remove w/o Replacement - An M60A1 tank was on line preparing for an inspection at Fort Sill, Oklahoma. The start button was pushed, and nothing happened. Under the direction of a turret mechanic, one crewman used a wire to short across the starter relay, and the tank started.

Reposition or Adjust - The gunner was unable to adjust the brightness on the passive sight during a gunnery exercise. In examining the problem, the tank commander (TC) noticed that the whole reticle switch rotated when any attempt was made to adjust it. He knew immediately what was wrong with it. He took the plate off of the back of the switch and tightened a small nut that keeps the switch steady.

Substitute Component or Part - When the driver's seat does not move properly, the tank is normally deadlined. During an ARTEP a pin broke in the mount of the driver's seat where the handles are so that the seat would move neither up, down, forward, or backward. The tank commander substituted an Allen wrench for the broken pin and the seat worked perfectly.

Remove & Replace With Authorized Part - On a road march in Germany, during operations preventive maintenance checks and services suggested that the blower motors were defective. To return the tank to operation the malfunctioning blower motors were removed and replaced with good blower motors from a deadlined tank.

Clean or Mend - During tank gunnery exercises at Fort Polk a crewman on an M60A1 tank smelled a wire burning. The crewman visually checked for a burnt or broken wire. When the wire was located the soldier used WD1 (comm) wire to splice the broken ends back together. The exposed wire where the splice was made was then wrapped with tape.

Mechanical/Electrical/Chemical Assist - During cold weather in Germany, a tank would not start even when the crew tried to jump start it. To get it started, the TC injected "Start Pilot" (canned ether) into the air intakes. By using ether the TC was able to start the engine.

inclusion does not constitute a recommendation for their use. In the interest of brevity and clarity, the examples in Table 2 are paraphrased versions of the actual incidents. The incidents in Table 2 comprise only about 10% of those collected in this study, but even this small proportion demonstrates the ingenuity and creativity that tank crewmen exhibit in performing field-expedient maintenance.

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