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FAILURE OF FUEL TANK, M113A1 ARMOURED PERSONNEL CARRIER

by

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SUMMARY OF RESULTS

Examination of a cracked section taken from the end wall of the fuel tank in a M113A1 Armoured Personnel Carrier revealed that failure had occurred because of fatigue induced by the movement of fuel in an unbaffled container. A possible contributory factor was that the fuel tank formed an integral part of the hull structure and, as such, was subjected to the cyclic loads imposed on the vehicle during service.

It was recommended that a separate, suitably baffled fuel tank be used. This tank should be attached in a manner that would dampen vibrations from the hull during service.

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INTRODUCTION

Mr. S. L. Gertsman, Chief, Physical Metallurgy Division, received the following message on July 16, 1966 from Chief of Defence Staff (D.V.F.E.), Canadian Forces Headquarters, Ottawa.

"A section of welded aluminum alloy from a M113A1 Armoured Personnel Carrier has been sent to your Welding Section. It would be appreciated if you would conduct an investigation to determine the cause of failure of the weld and provide a short report on your findings."

The letter was signed by K. Black, Major, for Colonel W. J. Owens (File No. L 12320-103-6-15 (DVFE)).

The section referred to in the letter had been removed from an armoured personnel carrier overseas and was delivered, along with necessary drawings, by Major Black.

PROCEDURE

The section was examined visually. Several cross-sections were removed for macroscopical and microscopical examination. The construction of the vehicle was discussed with Major Black. Members of the Non-Ferrous Metals and Engineering Physics Sections were consulted for confirmation of findings.

The section consisted of a portion of the welded junction of the end wall of the fuel tank with a sponson. Both the sponson and the fuel tank formed integral parts of the hull structure. The end wall was made from an irregularly shaped plate of 3/8-in.-thick 5083 aluminum alloy in the annealed condition. It was approximately 33½ in. high with a width varying from 45 in. at the top to 40 in. at the bottom end. It had been inserted against a 1/4-in.-high backing strip which was tacked to the top of the sponson.

Full fusion welds had been used to join the back and side plates to the sponson and hull. The inner side of the joints had been treated with a rubber-type sealant. The tank thus formed had a capacity of 96 imperial gallons.

Cracking had occurred at approximately mid span of the width in the region of the weld joining the end plate to the sponson. It was reported that additional cracking had been located in an area of the side plate where a reinforcement had been welded into position, but no specimens from this location were examined.

A visible crack extended from one end for three inches along the six-inch length of the sample submitted and appeared to be located at the junction of the plate and weld reinforcement. Because the crack started at one end, it was not possible to know if the section included the full length of the crack.

A two-inch cross-section was taken in the cracked area. The surfaces of the metal in the crack were examined visually. It was apparent that the crack had started from the outside surface and proceeded inward in a manner characteristic of low-stress fatigue failure. There were no signs of yielding except for a small area near the inside surface of the plate. The irregular progression and changes in level of the failure indicated that there could have been several locations from which cracking originated; a typical indication of low stress failure.

A section was taken from the end of the crack to confirm that cracking had progressed from the outer surface inward. This is shown in Figure 1. It will be noted that the crack has started on the outer surface and had not yet progressed through the plate thickness. The location of the crack in this figure is not characteristic of its normal location with relation to the weld. The crack had turned slightly away from the weld at this point and appears not to be related to the junction of the weld reinforcement with the plate.

A more typical illustration of the crack is shown in Figure 2. The origin of the crack is shown at the sharp increase in section caused by the weld reinforcement. It proceeds inward through the parent metal to final failure. A sudden increase in section such as this acts to concentrate stress rather than to distribute the loading equally through the unit. This is a cause of fatigue failure.

Hardness traverses were made through the weld metal and into the unaffected base metal on both sides of the crack. The average hardness was 68 Brinell with no area showing a significant variation.

Microscopical examination revealed additional cracking in the root of the weld where the end plate and backing strip meet (Figure 3). These extended for varying distances into the weld and appeared to be caused by fatigue.

DISCUSSION

The fuel tank of the M113A1 armoured personnel carrier consists of an unbaffled enclosure with a capacity of 96 imperial gallons. It is constructed as an integral part of the hull structure. Because cracking started from the outer surface of the end plate at a place where the cross-section size was increased by weld reinforcement and about midway along the length of the plate, it is suggested that the primary cause of failure was the flexing of the end plate induced by the movement of fuel in an unbaffled container. However, additional cracking was found in the root of the weld and it is possible that, had failure not occurred where it did, the cracks in the weld metal would have extended to failure after a further short period of service. The cracks at the root of the weld indicate that cyclic stresses other than those caused by the movement of the fuel existed in components of the fuel tank. It is believed that these stresses result from the fact that the fuel tank is an integral part of the hull structure and, as such, is subjected to the same cyclic loading as the hull. It is further believed that, had the fuel tank been baffled to reduce the movement of the fuel and the flexing of the end plate, failure may have occurred through the weld due to vibrations transmitted through the hull of the vehicle during service.

It is suggested that better service life would be obtained from a separate and suitably baffled fuel tank attached so that hull vibrations are dampened,or from the use of a bladder-type tank.

CONCLUSIONS

(1) Cracking was caused by fatigue failure in the end plate in an area where weld reinforcement caused an increase in section size.

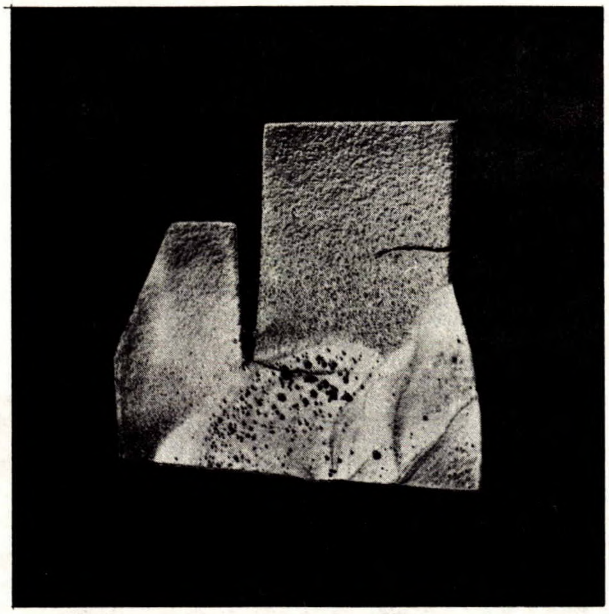
(2) The primary cause of failure was flexing of the end plate resulting from movement in an unbaffled container.

(3) Secondary cyclic stresses transmitted through the hull caused fatigue cracking in the weld which could have resulted in the failure of a baffled tank.

RECOMMENDATION

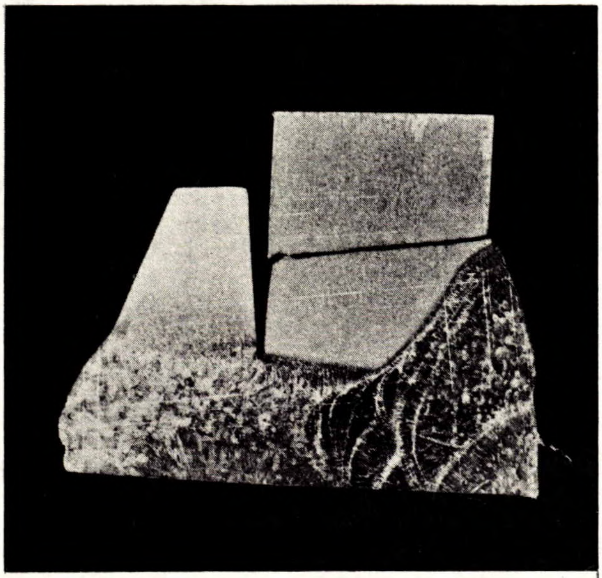
Better service life would be obtained from a separate, suitably baffled tank attached in a manner that will dampen hull vibrations, or from the use of a self-damping bladder-type container.

MJN/KW



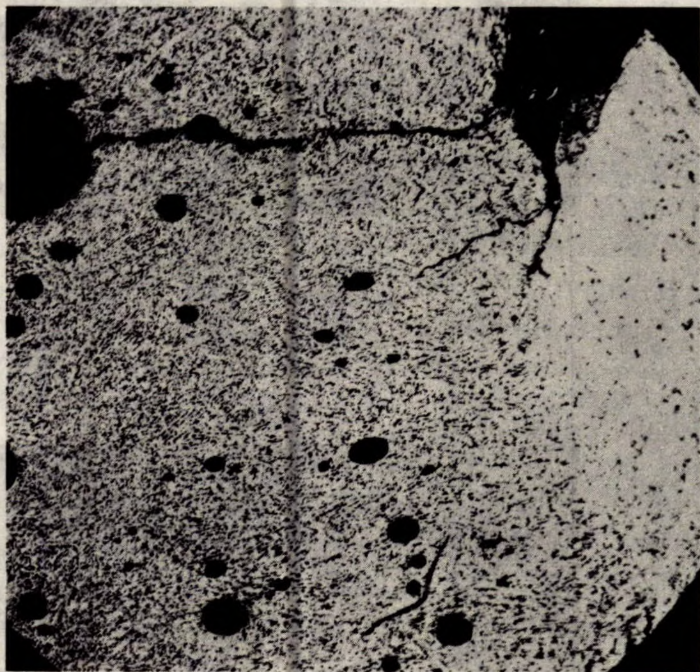
X2.5

Figure 1 - Crack progressing inward from outer surface. Note also root crack in weld.



X3

Figure 2 - Typical cross-section of failure.



X36

Figure 3 - Cracks starting in the root of the weld. Note: Globular dark areas are porosity in weld metal.