

LWL
R-74-05
c.1

Report No. 74-05

20081021 116

IMPROVED LWL FUEL TABLET

Frederick M. Drake
Environment and Survival Branch

December 1973

TECHNICAL LIBRARY
BLDG. 305
ABERDEEN PROVING GROUND, MD.,
STEAP-TL
COUNTED IN

Final Report for Period 5 October 1971 - 2 October 1972

Approved For Public Release; Distribution Unlimited

U. S. ARMY LAND WARFARE LABORATORY

Aberdeen Proving Ground, Maryland 21005

LWL
R-74-05
c.1

DISCLAIMERS

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

The citation of trade names and names of manufacturers in this report is not to be construed as official Government indorsement or approval of commercial products or services referenced herein.

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) US Army Land Warfare Laboratory Aberdeen Proving Ground, MD 21005		2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED
		2b. GROUP
3. REPORT TITLE Improved LWL Fuel Tablet		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final Report for Period 5 October 1971 - 2 October 1972		
5. AUTHOR(S) (First name, middle initial, last name) Frederick M. Drake		
6. REPORT DATE December 1973	7a. TOTAL NO. OF PAGES 16	7b. NO. OF REFS
8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Report No. 74-05	
b. PROJECT NO. 07-S-72	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
c.		
d.		
10. DISTRIBUTION STATEMENT Approved For Public Release; Distribution Unlimited		
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY US Army Land Warfare Laboratory Aberdeen Proving Ground, MD 21005	

13. ABSTRACT

The results of field evaluations of an acetal resin (Delrin) fuel tablet developed by the US Army Land Warfare Laboratory were generally favorable. The reports from the evaluating troop units in the field indicated problems in igniting the fuel and also an insufficient quantity of fuel.

Various combustible coatings and pyrotechnic-type starters were studied as means of improving ignition. These techniques were discarded for a number of reasons, including cost and excessive smoking. The tablet was then redesigned to provide a hole in the center of the tablet. Ignition at the tapered edges of this hole permitted rapid ignition and a build-up of heat output much faster than the original LWL Fuel Tablet. To provide more fuel the tablet was made thicker.

TECHNICAL LIBRARY
BLDG. 305
ABERDEEN PROVING GROUND, MD.
STEAP-TL

INTRODUCTION

Under LWL Task No. 04-S-70, the US Army Land Warfare Laboratory developed a fuel tablet and devised a technique for making a stove out of an issue ration can. Evaluation of the "Improved Ration Heater and Fuel Tablet" as described in LWL Technical Memorandum No. 71-02 disclosed difficulties in igniting the fuel unit (two tablets) during cold and/or windy weather conditions. In some instances the field evaluators also expressed a need for more heat. The advantages of a stable, non-toxic, plastic fuel tablet over the current standard tablet were acknowledged. This task (07-S-72, "Improved LWL Fuel Tablet") was undertaken to correct the shortcomings noted in the evaluation.

DESCRIPTION

The fuel tablet is an acetal resin, a thermoplastic polymer, manufactured by the polymerization of formaldehyde. Table 1 gives some of the properties of Delrin.

TABLE 1. PROPERTIES OF DELRIN

	<u>British Units</u>	<u>Metric Units</u>
Specific Heat	0.35 BTU/Lb./°F.	0.35 kg. Cal./kg.°C.
Flame Temperature	19,000°F.	10,500°C.
Heating Value	7,000 BTU/Lb.	1,764 kg. Cal./kg.
Self Ignition Temperature	707°F.	376°C.
Flash Ignition Temperature	613°F.	323°C.
Chemical Composition	Formaldehyde	
Chemical Resistance	Outstanding	
Sublimation	Does Not Sublimate	
Odor	Just Detectable	
Packaging Required	None	
Smoke	None	
Flame Color	Light Blue	

TECHNICAL LIBRARY
BLDG. 305
ARWORTHY HALL

STUDY OF IGNITION TECHNIQUES

Since Delrin is a stable plastic and, according to the manufacturers, its physical properties cannot be altered by changes in production procedures, any improvement in ignition must be accomplished by coatings or pyrotechnic means, or perhaps by changing the configuration of the fuel tablet.

A small study was made of various combustible coatings. This included glues, epoxies, nitro-cellulose, and oxidants. They all improved ignition but they also smoked quite heavily and burned with a luminous orange flame, which would give a soldier's position away. The cost of the tablet would also have increased considerably, both from the cost of the additive coating and the extra operation required in manufacture.

Several pyrotechnic-type wire fuses were sealed in the outside edge of the tablets. When ignited, these burned too rapidly to ignite the fuel tablet. From a cost standpoint, these devices would have more than doubled the cost of the fuel tablet.

These studies were therefore discontinued and the investigation was directed toward improving ignition of the fuel tablet by a change in its physical configuration.

ANALYSIS OF CONFIGURATION

In its initial configuration, the disc-shaped fuel tablet, Figure 1, was molded with a thin tapered edge. The thin edge was easily ignited with a match, but the flame was too easily extinguished under windy conditions, particularly when held in the hand during this step and then transferred to the ration-can stove. It was difficult to light the fuel unit in the ration-can stove because of the narrow clearance between the edge of the tablet and the can.

After ignition, the flame had to propagate around the outside thinned edge of the tablet and burn inward to the center. Most of the heat generated was directed outward, away from the tablet and very little heat was available to initiate combustion of the main body of the fuel. Logically then, the best point to light the fuel tablet is in the center, allowing the heat from combustion to pass outward into adjacent material.

The first attempt to test this concept failed. Several tablets were modified by partially drilling out the center ($3/4$ inch diameter cut) and leaving a very thin section of material. Attempts to light this thin section were unsuccessful either due to the lack of sufficient oxygen at this point or to heat dissipation.

It was reasoned that an air hole, acting as a small chimney, was required to supply oxygen for ignition of the thinned edge. The tablets were modified as shown in Figure 2 and tested. Ignition was easily accomplished and it was possible to light the fuel unit by placing it in the ration-can stove, and simply dropping a lighted match into the ignition hole. The ration-can stove afforded some protection from the wind.

An added advantage of center ignition is the increased combustion rate of the fuel. When the fuel is ignited, it melts and eventually burns as a liquid. The time required to change from the solid to a liquid is $2\frac{1}{2}$ to 3 minutes. Optimum heat is given off when the fuel is burning as a liquid. The previous fuel unit with edge ignition required 5 to 6 minutes to convert to a liquid.

FIELD EVALUATION

The US Army Land Warfare Laboratory (USALWL) contracted for the fabrication of 100,000 fuel units for field evaluation. Over 50,000 fuel units have been distributed to various troop units, and sample evaluation questionnaires were provided. A typical cross-section of troops conducting these evaluations include: US Army, Alaska (5,000 tablets), 10th Special Forces Group, Fort Devens, Massachusetts (20,000 tablets), 1st Special Forces Group, Okinawa (3,000 tablets), US Army National Guard, Alaska (3,000 tablets), Eighth US Army, Korea (5,000 tablets), and the US Army Materiel Command Infantry Research and Developments Liaison Office (distributed to the Ranger Department, Fort Benning, Georgia, 1,000 tablets).

Evaluations were conducted under all types of weather and regional environments from the Arctic to the Tropics. Currently, Product Improvement Tests are being conducted by the US Army Test and Evaluation Command at the US Army Arctic Test Center, the US Army Tropic Test Center and the US Army Infantry Agency, Fort Benning, Georgia. The US Army Land Warfare Laboratory is supporting this test by providing 50,000 fuel units.

RESULTS

Tests of the USALWL Fuel Tablet were conducted in the Laboratory using a ration-can stove and the USALWL Grid. The tests were conducted with the standard Army canteen cup containing 8 ounces of water and with a ration can (larger size) containing 8 ounces of water. Typical results of these tests are shown in Figures 3 and 4.

Similar field tests were conducted at Aberdeen Proving Ground, Maryland by USALWL military personnel but in this case water at 0°C. was used in one series of tests and solid ice was used in another. Ambient conditions were mild with temperatures in the low seventies and approximately a five knot wind. The results of these tests are shown in Figures 5, 6, 7 and 8.

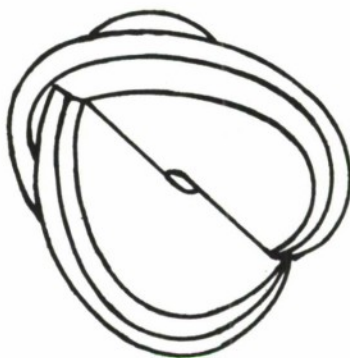
It can be seen from the graphs that dehydrated foods can be adequately reconstituted and hot beverages prepared. Canned rations were heated in from four to six minutes.

The results of the field evaluations, which were more subjective in nature, were in general very favorable. Two Commands, the US Army, Alaska and the US Army Southern Command, formally recommended Army adoption of the USALWL Fuel Tablet. Some unfavorable comments were received from various individuals participating in the field exercises. However, it was noted that most of these comments were elicited from individuals who had only used the fuel tablet three to five times, and usually under very adverse weather conditions. It is conjectured that (as with most new products), further dependence of the individual upon heating his food with the USALWL Fuel Tablet would have resulted in ways or methods of coping with the elements.

CONCLUSIONS

All objectives of the task were accomplished. The Improved USALWL Fuel Unit is easily ignited under adverse weather conditions and the total heat output has been increased by approximately 15%.

In addition, the combustion rate has been increased as a result of the center ignition point on the fuel unit.



ASSEMBLED TABLETS

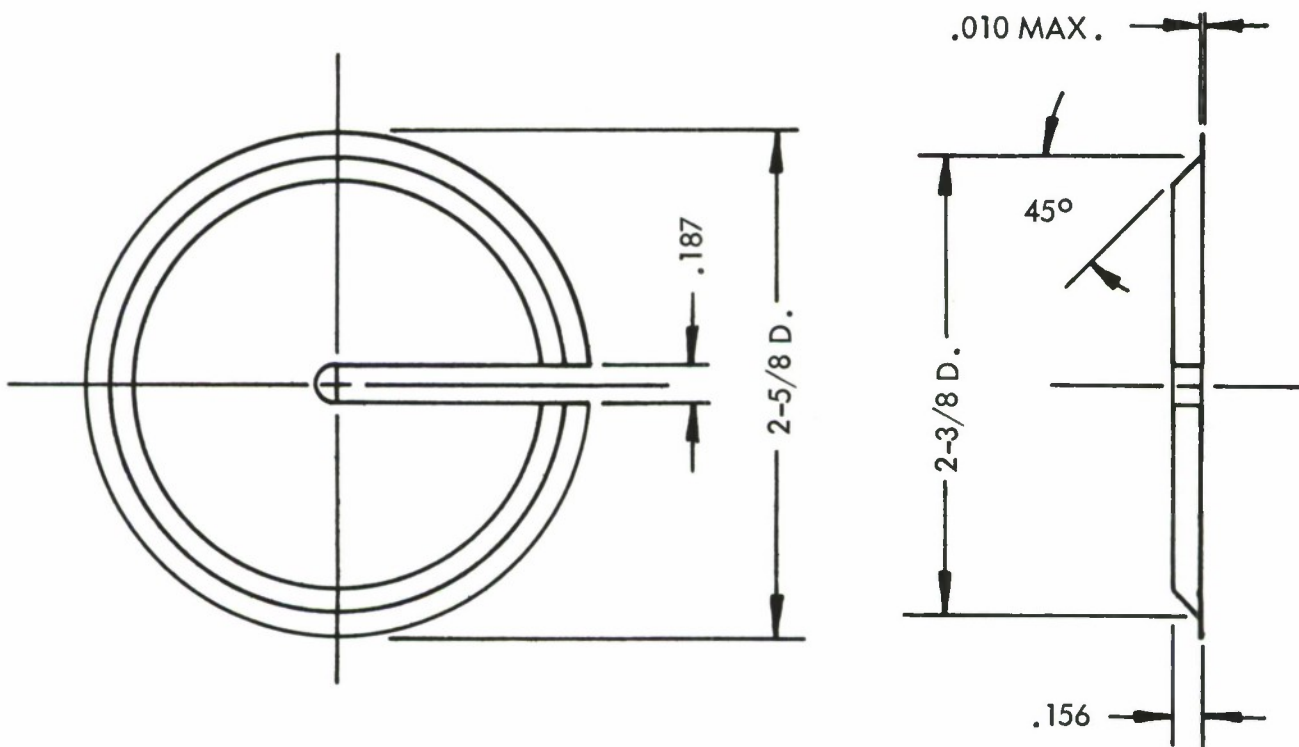
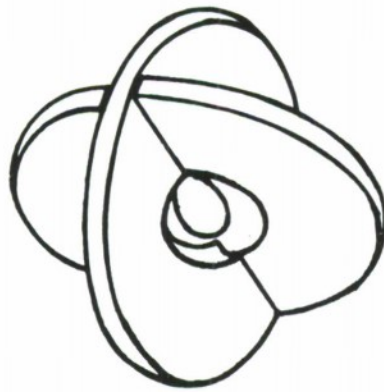


FIGURE 1. ORIGINAL FUEL TABLET



ASSEMBLED TABLETS

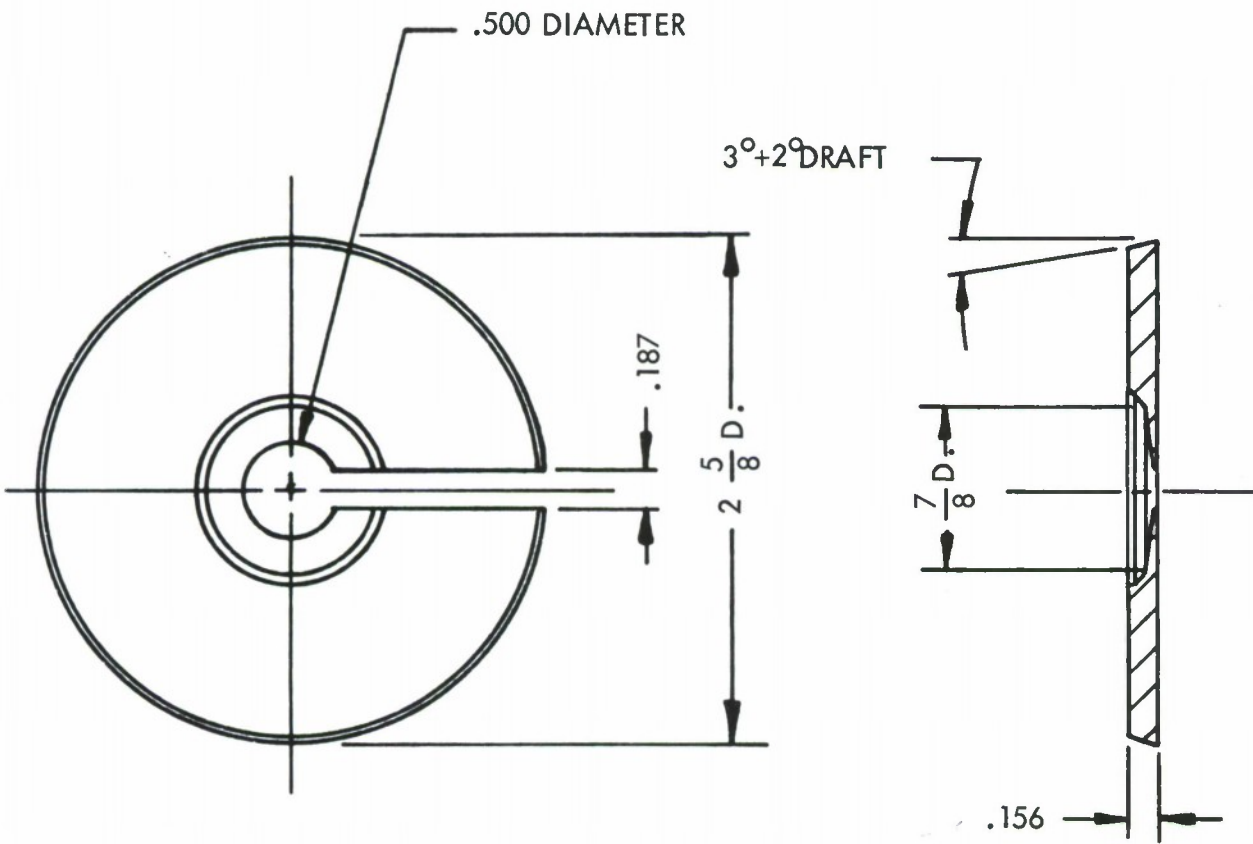


FIGURE 2. IMPROVED FUEL TABLET

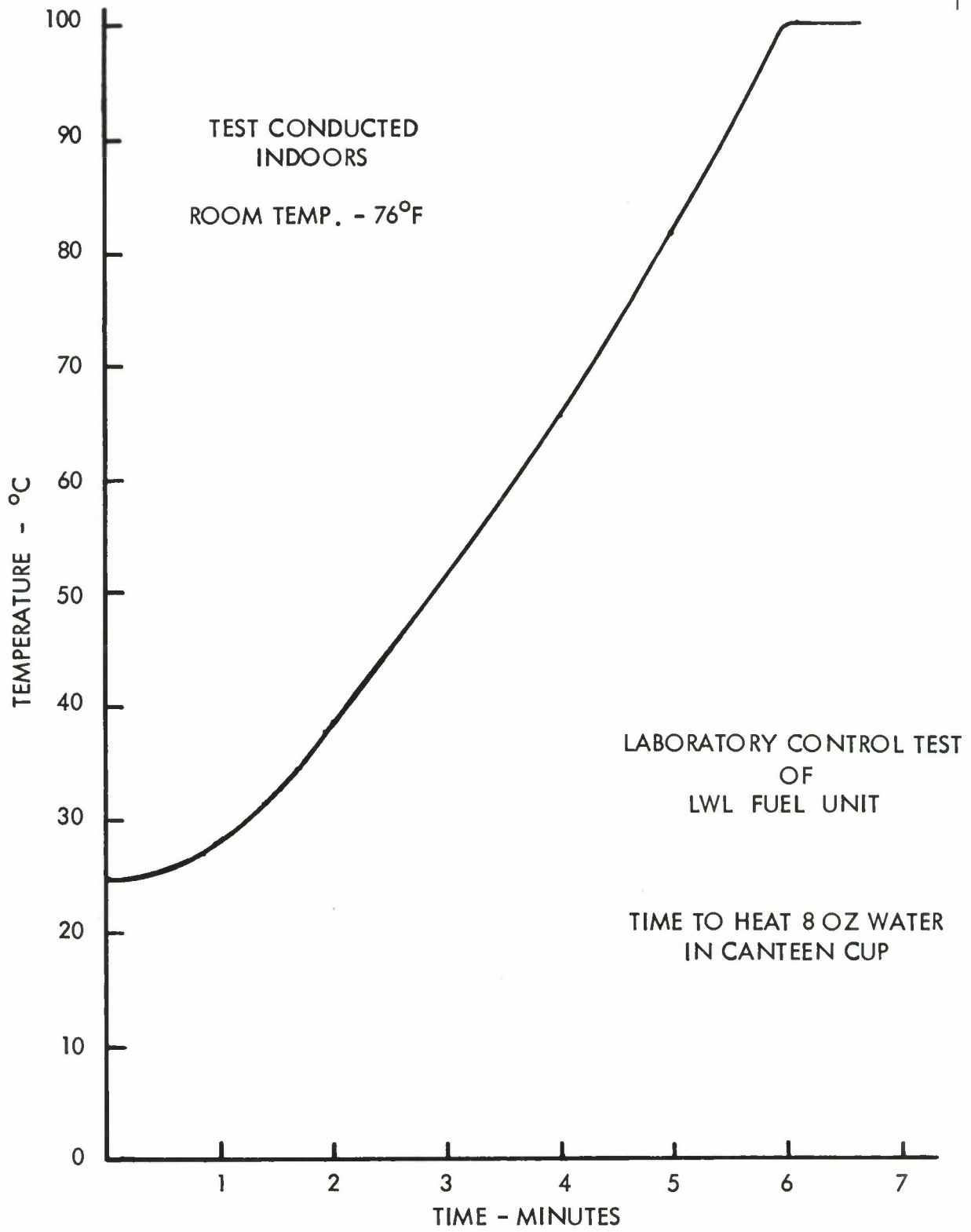


FIGURE 3. HEATING RATE

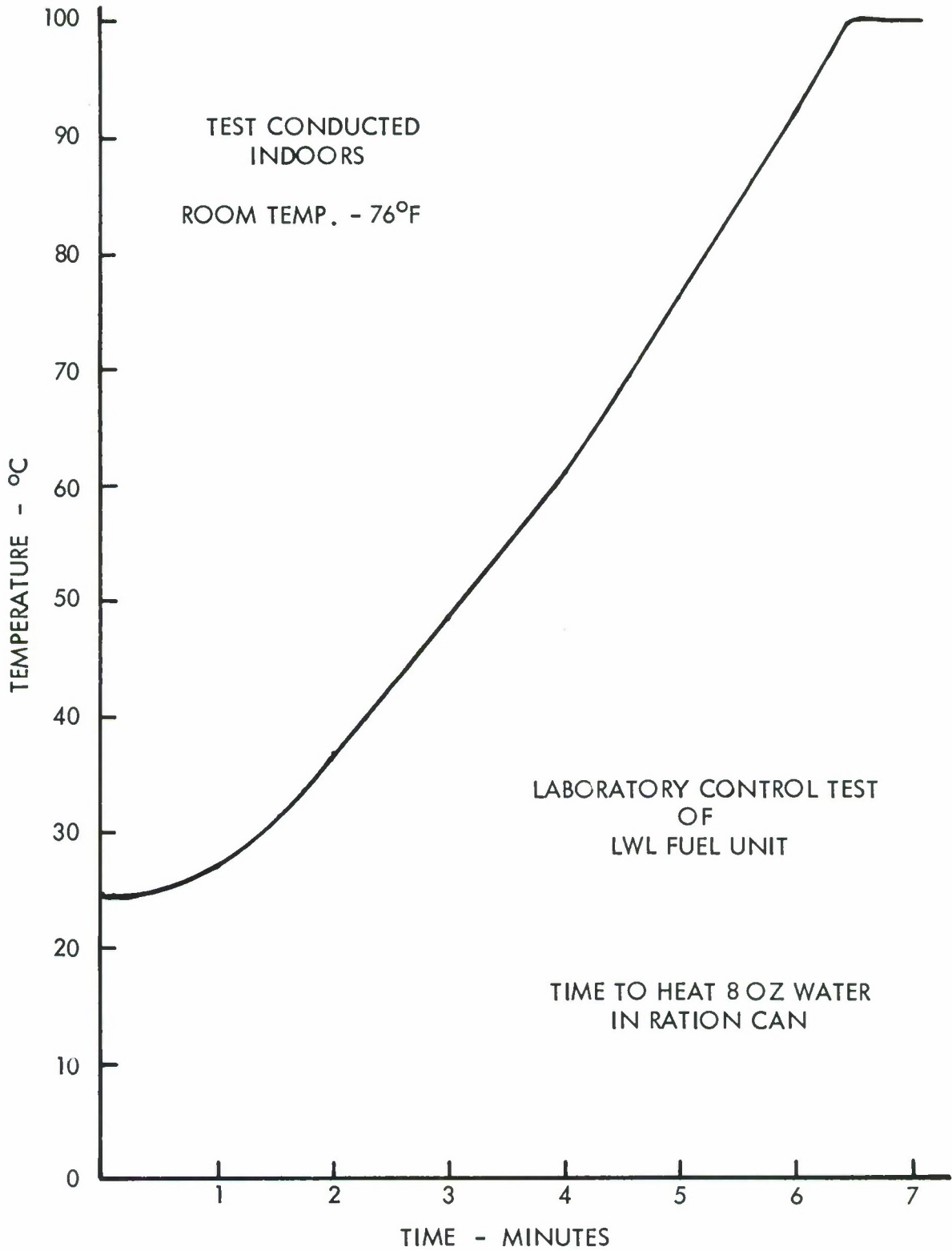


FIGURE 4. HEATING RATE

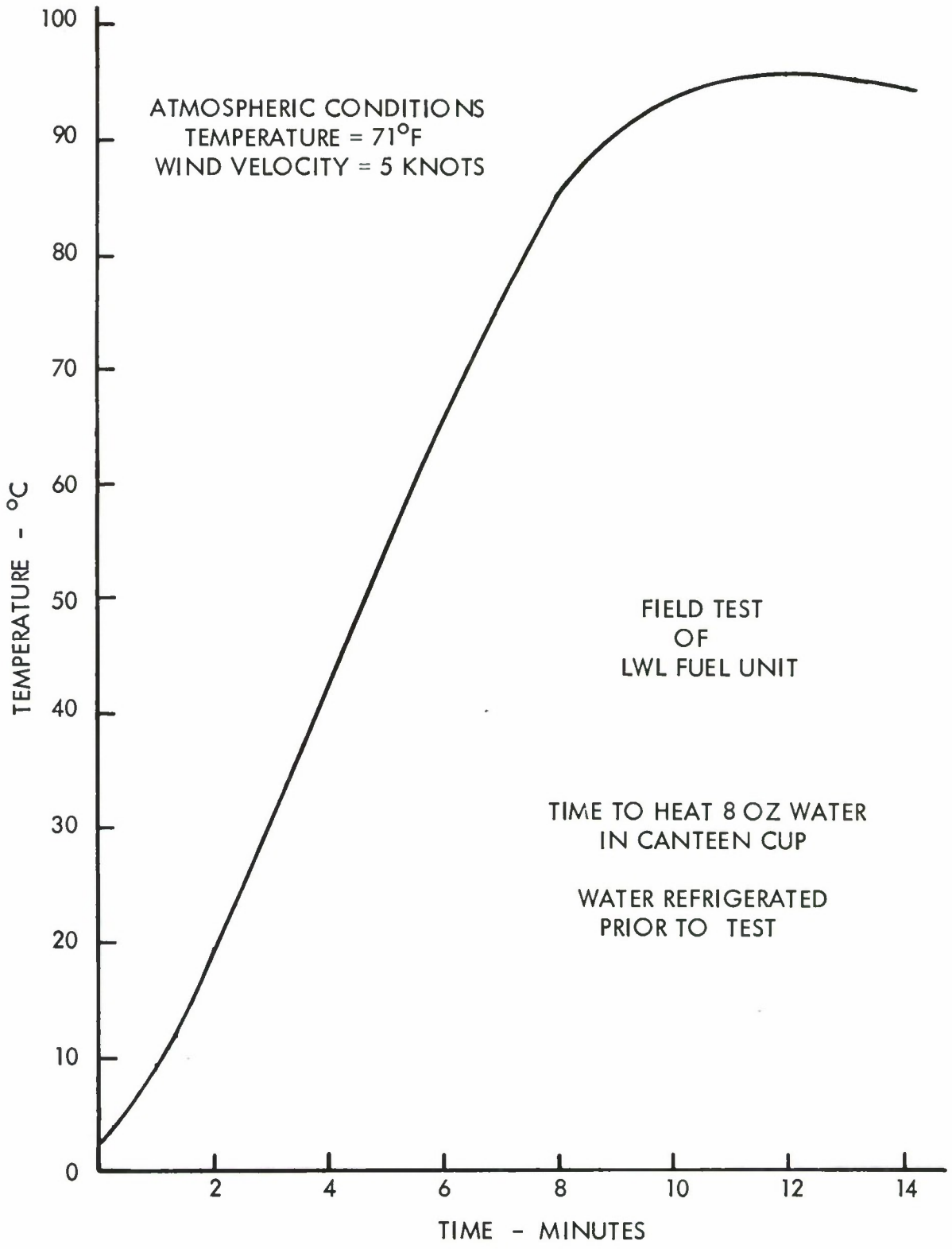


FIGURE 5. HEATING RATE

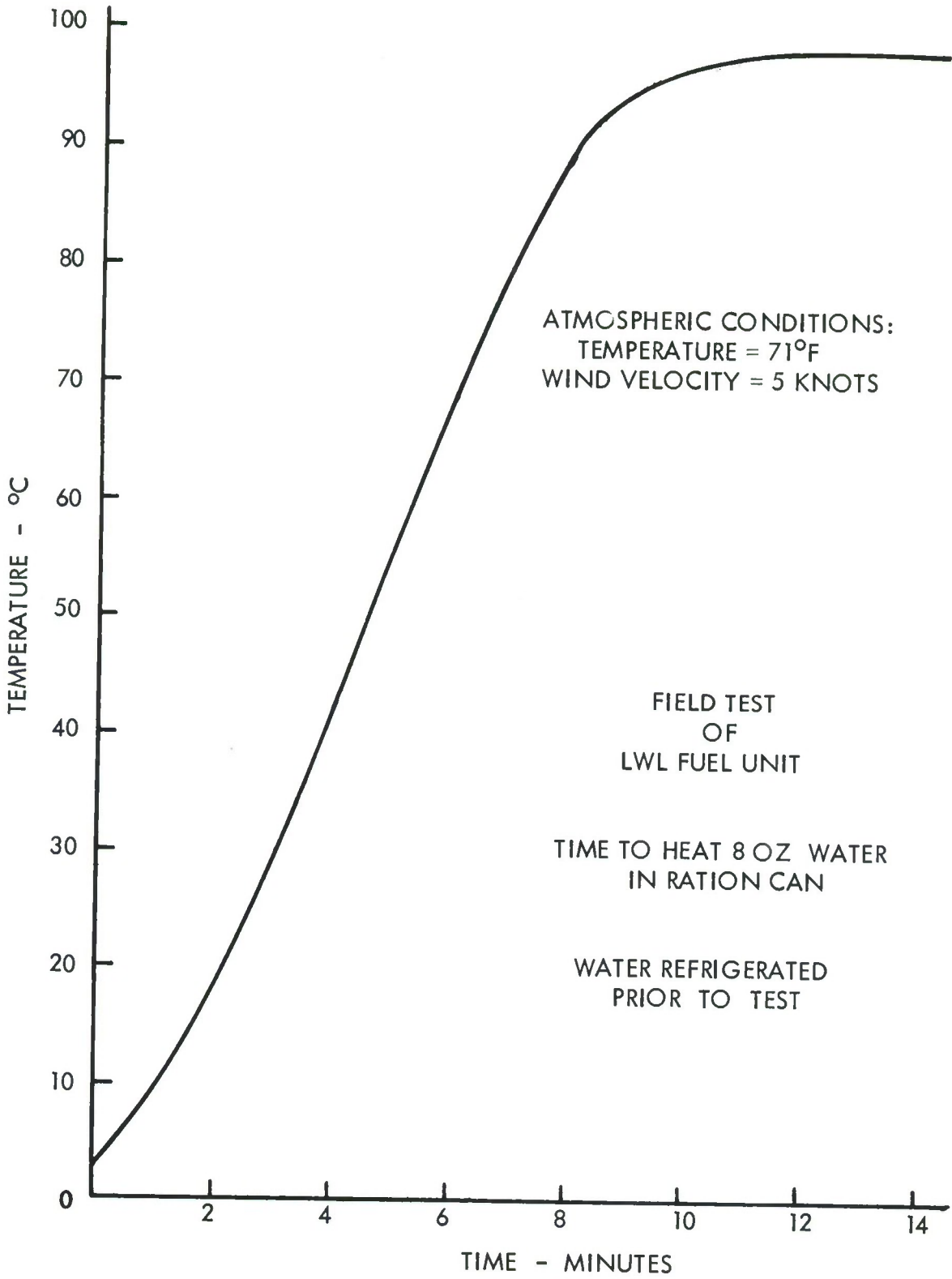


FIGURE 6. HEATING RATE

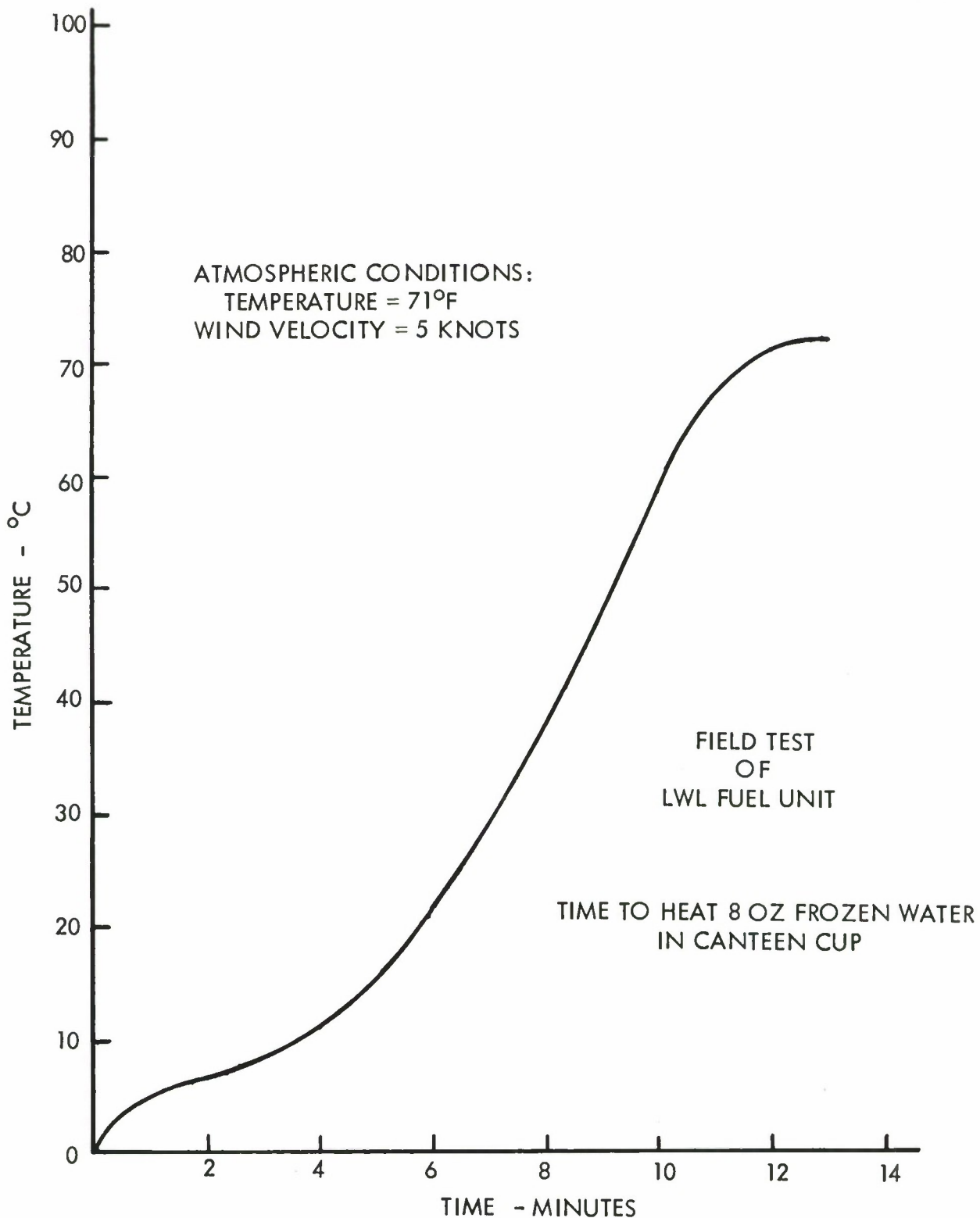


FIGURE 7. HEATING RATE

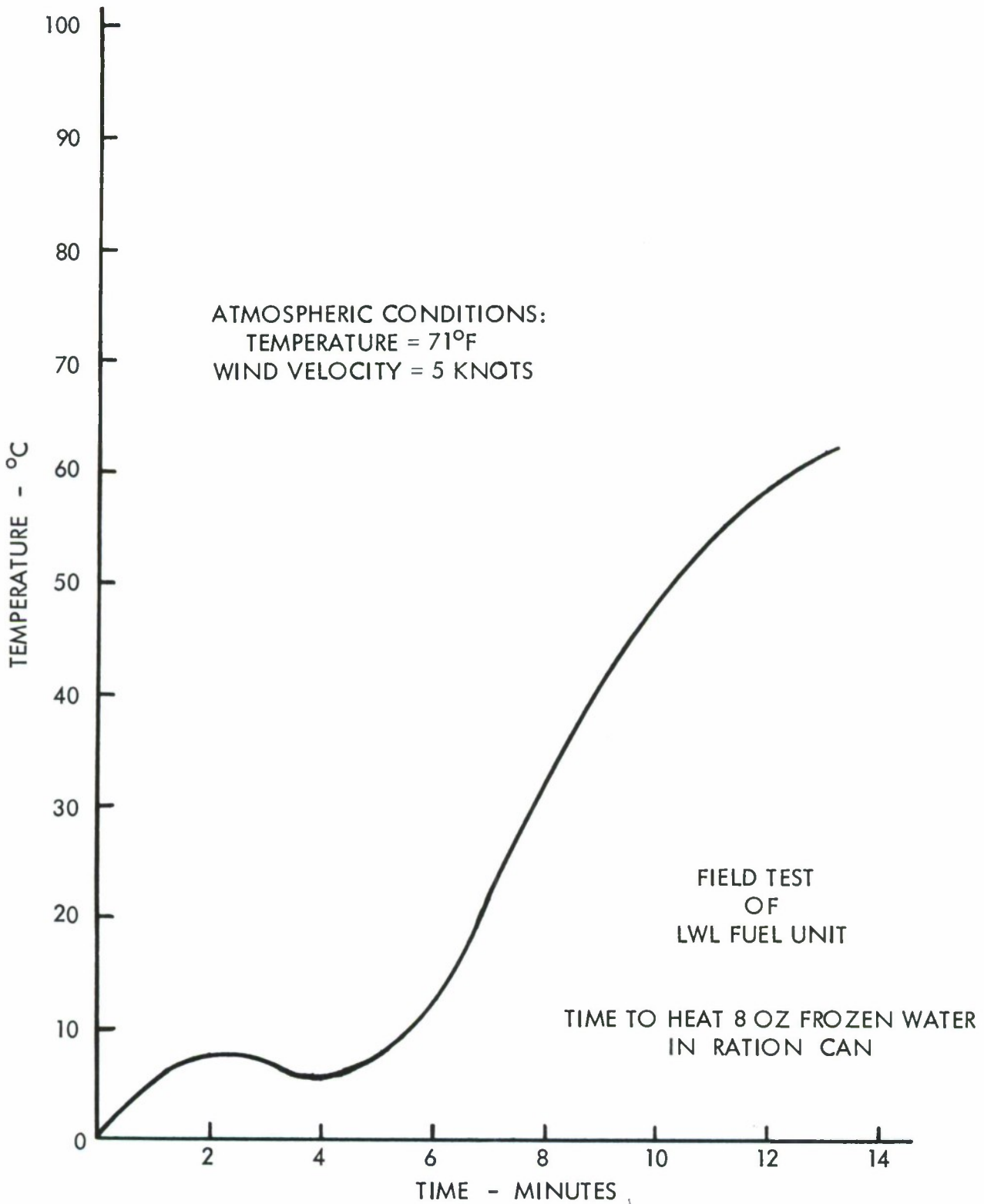


FIGURE 8. HEATING RATE

DISTRIBUTION LIST

	<u>Copies</u>
Commander US Army Materiel Command ATTN: AMCDL 5001 Eisenhower Avenue Alexandria, VA 22304	1
Commander US Army Materiel Command ATTN: AMCRD 5001 Eisenhower Avenue Alexandria, VA 22304	3
Commander US Army Materiel Command ATTN: AMCRD-P 5001 Eisenhower Avenue Alexandria, VA 22304	1
Director of Defense, Research & Engineering Department of Defense WASH DC 20301	1
Director Defense Advanced Research Projects Agency WASH DC 20301	3
HQDA (DARD-DDC) WASH DC 20310	4
HQDA (DARD-ARZ-C) WASH DC 20310	1
HQDA (DAFD-ZB) WASH DC 20310	1
HQDA (DAMO-PLW) WASH DC 20310	1
HQDA (DAMO-IAM) WASH DC 20310	1
Commander US Army Training & Doctrine Command ATTN: ATCD Fort Monroe, VA 23651	1

Commander US Army Combined Arms Combat Developments Activity (PROV) Fort Leavenworth, KS 66027	1
Commander US Army Logistics Center Fort Lee, VA 23801	1
Commander US Army CDC Intelligence & Control Systems Group Fort Belvoir, VA 22060	1
TRADOC Liaison Office HQS USATECOM Aberdeen Proving Ground, MD 21005	1
Commander US Army Test and Evaluation Command Aberdeen Proving Ground, MD 21005	1
Commander US Army John F. Kennedy Center for Military Assistance Fort Bragg, NC 28307	1
Commander-In-Chief US Army Pacific ATTN: GPOP-FD APO San Francisco 96558	1
Commander Eighth US Army ATTN: EAGO-P APO San Francisco 96301	1
Commander Eighth US Army ATTN: EAGO-FD APO San Francisco 96301	1
Commander US Army Europe ATTN: AEAGC-ND APO New York 09403	4
Commander US Army Alaska ATTN: ARACD APO Seattle 98749	1

Commander MASSTER ATTN: Combat Service Support & Special Programs Directorate Fort Hood, TX 76544	1
Commander US MAC-T & JUSMAG-T ATTN: MACTRD APO San Francisco 96346	2
Senior Standardization Representative US Army Standardization Group, Australia c/o American Embassy APO San Francisco 96404	1
Senior Standardization Representative US Army Standardization Group, UK Box 65 FPO New York 09510	1
Senior Standardization Representative US Army Standardization Group, Canada Canadian Forces Headquarters Ottawa, Canada K1A0K2	1
Director Air University Library ATTN: AUL3T-64-572 Maxwell Air Force Base, AL 36112	1
Battelle Memorial Institute Tactical Technical Center Columbus Laboratories 505 King Avenue Columbus, OH 43201	1
Defense Documentation Center (ASTIA) Cameron Station Alexandria, VA 22314	12
Commander Aberdeen Proving Ground ATTN: STEAP-TL Aberdeen Proving Ground, MD 21005	2
Commander US Army Edgewood Arsenal ATTN: SMUEA-TS-L Aberdeen Proving Ground, MD 21010	1

US Marine Corps Liaison Officer Aberdeen Proving Ground, MD 21005	1
Commander US Army Natick Laboratories ATTN: STSNL-CCP Natick, MA 01760	1
Commander US Army Natick Laboratories ATTN: STSNL-EQ Natick, MA 01760	1