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AUTHOR	Wallace, Johnny M.; Carson, Cheryl
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ABSTRACT

This module presents a real-world context in which mathematics skills are used as part of a daily routine. The context is the industrial and engineering technology area, and the module aims to help students see the significance of mathematics skills in performing daily tasks. Materials in the module, most of which are designed for the teacher to duplicate and distribute to students, include the following: (1) information on careers in engineering technology; (2) a task to be performed and information sheets necessary to complete the task; (3) questions to be completed by the students; (4) answer keys to the questions; and (5) a handout and teacher's answer key. (KC)

MATHEMATICS FOR THE WORKPLACE

APPLICATIONS FROM ENGINEERING TECHNOLOGY

(Clark-Schwebel Industries)

A TEACHER'S GUIDE

Developed by:

Johnny M. Wallace
Associate Director / Curriculum Developer
Partnership for Academic and Career Education

and

Cheryl Carson
Graduate Student
Clemson University
Intern - Clark Schwebel

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Partnership for Academic and Career Education (PACE)
P. O. Box 587
Pendleton, SC 29670
(803-646-8361, ext. 2247)

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Introduction

The workplace of tomorrow will require a level of skills beyond the twelfth grade. Technological advances have necessitated higher levels of mathematics skills for employees to function efficiently in the workplace because employers need workers who can make calculations quickly and correctly.

Because of increased emphasis on higher levels of mathematics skills, teachers must ensure a strong relationship between what they teach in the classroom and what transpires in the real world. Unless students see the relationship between what is taught and what is important in real life, they may not be motivated to take their mathematics studies seriously and may not take courses which will challenge them as learners and thus not become proficient in the use of mathematics.

Examples from real-life settings often help students better understand the need to study and learn mathematics skills taught in the classroom. Real-life applications can provide the needed relevance to motivate students, not only to apply themselves to their studies, but also to take the highest level of mathematics they are capable of handling successfully. **Mathematics for the Workplace: Applications from Engineering Technology** is designed to present a real-world context where mathematics skills are used as part of a daily routine. The context for this module is the industrial and engineering technology area.

One intent of **Mathematics for the Workplace: Applications from Engineering Technology** is to help students understand the significance of mathematics skills in performing daily tasks. An additional purpose is to help students see the need for being precise and accurate when completing tasks which are part of job requirements.

How to Use This Module

The table of contents in this packet lists the materials encompassed within the module. This is a teacher's guide, not a packet of materials designed entirely to be duplicated and presented to students. There are, however, several sections which should be duplicated and given to students so they can complete the assigned tasks.

Pages 3-5 give the students an introduction to engineering technology. Included in this section is such information as types of engineering technicians, duties of technicians, high school preparation, sources of additional information and earnings and advancement opportunities. These pages can be duplicated and given to students as introductory information.

Page 6 gives an explanation of the task and the need for the task. This page can be duplicated and given to students as information.

Pages 7-8 give an explanation of the handout and the questions to be answered to complete the lesson. These pages should be duplicated and given to students.

Pages 9-25 are the answer keys to the questions. The answer key gives the solutions to each question. Many of the problems can be solved using one or more methods. In the case of more than one method, each method is presented in each question.

Appendix A contains the handout required to complete the lesson. Also, the teacher's answer key for the handout is in Appendix A.

EXAMINING THE PROFESSION: EngineeringTechnician

Engineering technicians apply theorems and postulates of science, mathematics, and engineering to solve problems in areas such as manufacturing, research and development and customer services. Most technicians work as assistants to scientists and engineers. Technicians can specialize in several areas. Included in these areas are

- electrical technicians who apply electrical theory and knowledge to examine and alter electrical machinery and control equipment in industrial plants;

- electronics technicians who apply electronic theory and related knowledge to lay out, build, troubleshoot, repair and modify the production of electronic equipment;

- mechanical engineering technicians who develop and test machinery and equipment using theories related to mechanical engineering; and

- industrial engineering technicians who examine production, maintenance, and other work operations to establish standard production output.

Duties of Technicians

Technicians perform a range of duties, depending on the area in which they gain expertise. Duties include

- building or setting up equipment,
- making prototype versions of equipment designs,
- testing prototypes to ensure quality,
- serving as field representatives,
- writing manuals, and
- testing products for production quality.

Working Conditions

Most technicians work an 8-hour day, 40-hour work week. Technicians may work in research and development laboratories, industrial or manufacturing plants, or electronics shops.

High School Preparation

In order to be best prepared for a program of studies in engineering technology, students in high school should take algebra, geometry, chemistry, and physics courses. Occupational related courses such as electronics/electricity and industrial maintenance or mechanics will provide a base of technical skills for persons entering technician careers.

Opportunities to gain experience in engineering technology can be obtained through apprenticeship programs.

Additional Information

Many employers prefer to hire technicians with technical training or college courses in the areas of science, engineering, and mathematics. Some technician positions require specialized training and experience.

Engineering technology programs are offered at the following two-year colleges. Listed with each college is a contact person for engineering technician programs.

Greenville Technical College
Contact: Eugene Yedinak
Dean of Engineering Technologies
Greenville Technical College
P. O. Box 5616
Station B
Greenville, SC 29606

Spartanburg Technical College
Contact: Kemp I. Sigmon
Dean of Industrial Division
Spartanburg Technical College
P. O. Box 4386
Spartanburg, SC 29305

Piedmont Technical College
Contact: Gerald R. Owens
Dean of Engineering and Industrial Technology
Piedmont Technical College
Drawer 1476
Greenwood, SC 29648

Tri-County Technical College
Contact: Dr. James Wood
Chairman of Industrial and Engineering Technology
Tri-County Technical College
P. O. Box 587
Pendleton, SC 29670

Earnings and Advancements

In South Carolina in 1988, engineering technicians earned between $14,000 and $29,000. Earnings vary, depending on the level of education and experience.

Technicians advance as they gain on-the-job experience and additional special training. Technicians move from routine work to assignments of increasing difficulty. Some technicians become supervisors or engineers if they receive additional formalized training.

Introduction to the Task

Kevlar®, a synthetic fiber of extraordinary strength, is manufactured by Clark-Schwebel Industries. Kevlar® is used in the manufacture of products such as helmets, ships, helicopter blades and chaps in leg coverings for loggers. Because it contracts when heated, Kevlar® is also used in the production of circuit boards for electronic equipment.

One of the biggest uses of Kevlar® is in the production of bullet proof vests. Because of the strength of this light-weight material, only a few plies of the material are sewn together to make a vest. The number of plies used in the construction of the vest may vary from eight to fifteen.

One task a technician performs is that of testing the Kevlar® to determine its quality. One such test is a ballistics test. In a ballistics test, the technician takes a certain number of plies of Kevlar®, such as the number used in a bullet proof vest, and binds them together.

Once these plies have been bound, a projectile, which represents a bullet, is fired into the sample. The number of projectiles used in the test may range from six to twenty. The projectile has a certain weight and is fired from a specific caliber weapon, such as a 22-caliber rifle.

Once the projectiles have been fired into the material, the technician makes a determination as to whether or not the hole made by the projectile is a "complete" or a "partial." A complete is one which allows light to pass through the material, and a partial is one in which the projectile penetrated but did not pass through the material. Many times the partial projectiles are lodged in the material.

After classifying each hit as a partial or a complete, the technician randomly selects a sample of hits. Fifty percent of the hits are completes and fifty percent are partials. Once the samples have been selected, the technician must perform various mathematical calculations to determine if the Kevlar® is of proper quality.

Understanding the Data

Handout 1 shows various information used in analyzing the results of the ballistics limit test on a sample of Kevlar®. (Because of needed security, information pertaining to certain specifics, such as type and weight of projectile, has been deleted.)

In the section entitled SAMPLE, size refers to the dimensions of the sample of material; number of plies is how many were put together for the test; and sample weight gives the weight of the completed sample used in the test.

The BALLISTIC THREAT section gives information on the type (Caliber) of the projectile, how much the projectile weighed, the length of the barrel and the angle at which the projectile was fired at the target (obliquity).

The RANGE section gives information telling the distance from the muzzle to the witness. Screens 1 and 2, or chronographs 1 and 2, are used as reference points in calculating the speed of the projectile along the projectile's path.

Analyzing the Results

The following questions are to be used in analyzing the information on HANDOUT 1, the Ballistic Limit Test.

1. Compute the velocity of each projectile used in the V50 test at chronograph 1 and chronograph 2.

2. Compute the average velocity and striking velocity for each projectile used in the test.

3. Compute the overall average velocity for the test.

4. What is the "high partial" velocity of the ten projectiles used in the test? The "low complete" velocity?

5. What is the range of results for the test? What is the range of mixed results (highest partial to lowest complete)?

6. In order to determine if the material is of top quality, the company sets minimum standards for control. In this specific test, the material is top quality if the overall average velocity for the test is no greater than the sum of a minimum preset velocity and the range of results. If the minimum preset velocity for this test is 1200 ft/sec, is this lot acceptable? Please explain your answer.

NOTE: The shots used in the final analysis of the test are denoted by an asterisk in the "Include in V50" column. Since the technician is only concerned about these shots, required information will only be computed for these shots.

To compute the velocity at chronograph 1 and chronograph 2, a proportion can be used. However, the travel time between each check point is written in scientific notation with negative exponents. Therefore, the time must be converted to non-scientific notation form before any calculations can be made.

ANSWER KEY

QUESTION 1

Shot 1 (Chronograph 1)

The time required to travel five feet, the distance from the muzzle to chronograph 1, is 361.4 X 10-5 or .003614 seconds. The distance from the muzzle to chronograph 1 is five feet. Using a proportion, we can compute the velocity in feet per second. If the projectile travels five feet in .003614 seconds, how far will it travel in 1 second?

The proportion is

$$\frac{.003614 \text{ seconds}}{\text{five feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplication gives

$$.003614x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.003614 \text{ seconds}}$$

or

$$x = 1384 \text{ feet}.$$

Shot 1 (Chronograph 2)

The distance from chronograph 1 to chronograph 2 is also five feet. The time required for the projectile to travel from chronograph 1 to chronograph 2 is 362.4 X 10-5 seconds or .003624 seconds. Using a proportion, we calculate the velocity in feet per second as

$$\frac{.003624 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplying we get

$$.003624x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.003624 \text{ seconds}}$$

or

$$x = 1380 \text{ feet}.$$

Shot 3 (Chronograph 1)

The time required to travel five feet, the distance from the muzzle to chronograph 1, is 382.0 X 10-5 or .00382 seconds. The distance from the muzzle to chronograph 1 is five feet. Using a proportion, we can compute the velocity in feet per second. If the projectile travels five feet in .003614 seconds, how far will it travel in 1 second?

The proportion is

$$\frac{.00382 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplication gives

$$.00382x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.00382 \text{ seconds}}$$

or

$$x = 1309 \text{ feet}.$$

Shot 3 (Chronograph 2)

The distance from chronograph 1 to chronograph 2 is also five feet. The time required for the projectile to travel from chronograph 1 to chronograph 2 is 382.8 X 10-5 seconds or .003828 seconds. Using a proportion, we calculate the velocity in feet per second as

$$\frac{.003828 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplying we get

$$.003828x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.003828 \text{ seconds}}$$

or

$$x = 1306 \text{ feet}.$$

Shot 5 (Chronograph 1)

The time required to travel five feet, the distance from the muzzle to chronograph 1, is 398.8 X 10-5 or .003988 seconds. The distance from the muzzle to chronograph 1 is five feet. Using a proportion, we can compute the velocity in feet per second. If the projectile travels five feet in .003988 seconds, how far will it travel in 1 second?

The proportion is

$$\frac{.003988 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplication gives

$$.003988x \text{ feet-seconds} = 5 \text{ feet-second}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.003988 \text{ seconds}}$$

or

$$x = 1254 \text{ feet}.$$

Shot 5 (Chronograph 2)

The distance from chronograph 1 to chronograph 2 is also five feet. The time required for the projectile to travel from chronograph 1 to chronograph 2 is 399.6 X 10-5 seconds or .003996 seconds. Using a proportion, we calculate the velocity in feet per second as

$$\frac{.003996 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplying we get

$$.003996x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.003996 \text{ seconds}}$$

or

$$x = 1251 \text{ feet}.$$

Shot 12 (Chronograph 1)

The time required to travel five feet, the distance from the muzzle to chronograph 1, is 375.1 X 10-5 or .003751 seconds. The distance from the muzzle to chronograph 1 is five feet. Using a proportion, we can compute the velocity in feet per second. If the projectile travels five feet in .003751 seconds, how far will it travel in 1 second?

The proportion is

$$\frac{.003751 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplication gives

$$.003751x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.003751 \text{ seconds}}$$

or

$$x = 1333 \text{ feet}.$$

Shot 12 (Chronograph 2)

The distance from chronograph 1 to chronograph 2 is also five feet. The time required for the projectile to travel from chronograph 1 to chronograph 2 is 376.1 X 10-5 seconds or .003761 seconds. Using a proportion, we calculate the velocity in feet per second as

$$\frac{.003761 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplying we get

$$.003761x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.003761 \text{ seconds}}$$

or

$$x = 1329 \text{ feet}.$$

Shot 13 (Chronograph 1)

The time required to travel five feet, the distance from the muzzle to chronograph 1, is 369.0 X 10-5 or .00369 seconds. The distance from the muzzle to chronograph 1 is five feet. Using a proportion, we can compute the velocity in feet per second. If the projectile travels five feet in .00369 seconds, how far will it travel in 1 second?

The proportion is

$$\frac{.00369 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplication gives

$$.00369x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.00369 \text{ seconds}}$$

or

$$x = 1355 \text{ feet}.$$

Shot 13 (Chronograph 2)

The distance from chronograph 1 to chronograph 2 is also five feet. The time required for the projectile to travel from chronograph 1 to chronograph 2 is 370.0 X 10-5 seconds or .0037 seconds. Using a proportion, we calculate the velocity in feet per second as

$$\frac{.0037 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplying we get

$$.0037x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.0037 \text{ seconds}}$$

or

$$x = 1351 \text{ feet}.$$

Shot 14 (Chronograph 1)

The time required to travel five feet, the distance from the muzzle to chronograph 1, is 369.3 X 10-5 or .003693 seconds. The distance from the muzzle to chronograph 1 is five feet. Using a proportion, we can compute the velocity in feet per second. If the projectile travels five feet in .003693 seconds, how far will it travel in 1 second?

The proportion is

$$\frac{.003693 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplication gives

$$.003693x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.003693 \text{ seconds}}$$

or

1354 feet.

Shot 14 (Chronograph 2)

The distance from chronograph 1 to chronograph 2 is also five feet. The time required for the projectile to travel from chronograph 1 to chronograph 2 is 370.0 X 10-5 seconds or .0037 seconds. Using a proportion, we calculate the velocity in feet per second as

$$\frac{.0037 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplying we get

$$.0037x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.0037 \text{ seconds}}$$

or

$x = 1351$ feet.

Shot 15 (Chronograph 1)

The time required to travel five feet, the distance from the muzzle to chronograph 1, is 363.7 X 10-5 or .003637 seconds. The distance from the muzzle to chronograph 1 is five feet. Using a proportion, we can compute the velocity in feet per second. If the projectile travels five feet in .003637 seconds, how far will it travel in 1 second?

The proportion is

$$\frac{.003637 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplication gives

$$.003637x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.003637 \text{ seconds}}$$

or

$$x = 1375 \text{ feet}.$$

Shot 15 (Chronograph 2)

The distance from chronograph 1 to chronograph 2 is also five feet. The time required for the projectile to travel from chronograph 1 to chronograph 2 is 364.7 X 10-5 seconds or .003647 seconds. Using a proportion, we calculate the velocity in feet per second as

$$\frac{.003647 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplying we get

$$.003647x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.003647 \text{ seconds}}$$

or

$$x = 1371 \text{ feet}.$$

Shot 17 (Chronograph 1)

The time required to travel five feet, the distance from the muzzle to chronograph 1, is 370.8 X 10-5 or .003708 seconds. The distance from the muzzle to chronograph 1 is five feet. Using a proportion, we can compute the velocity in feet per second. If the projectile travels five feet in .003708 seconds, how far will it travel in 1 second?

The proportion is

$$\frac{.003708 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplication gives

$$.003708x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.003708 \text{ seconds}}$$

or

$$x = 1348 \text{ feet}.$$

Shot 17 (Chronograph 2)

The distance from chronograph 1 to chronograph 2 is also five feet. The time required for the projectile to travel from chronograph 1 to chronograph 2 is 371.5 X 10-5 seconds or .003715 seconds. Using a proportion, we calculate the velocity in feet per second as

$$\frac{.003715 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplying we get

$$.003715x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.003715 \text{ seconds}}$$

or

$$x = 1346 \text{ feet}.$$

Shot 19 (Chronograph 1)

The time required to travel five feet, the distance from the muzzle to chronograph 1, is 370.8 X 10-5 or .003708 seconds. The distance from the muzzle to chronograph 1 is five feet. Using a proportion, we can compute the velocity in feet per second. If the projectile travels five feet in .003708 seconds, how far will it travel in 1 second?

The proportion is

$$\frac{.003708 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplication gives

$$.003708x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.003708 \text{ seconds}}$$

or

$$x = 1348 \text{ feet}.$$

Shot 19 (Chronograph 2)

The distance from chronograph 1 to chronograph 2 is also five feet. The time required for the projectile to travel from chronograph 1 to chronograph 2 is 371.6 X 10-5 seconds or .003716 seconds. Using a proportion, we calculate the velocity in feet per second as

$$\frac{.003716 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplying we get

$$.003716x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.003716 \text{ seconds}}$$

or

$$x = 1346 \text{ feet}.$$

Shot 20 (Chronograph 1)

The time required to travel five feet, the distance from the muzzle to chronograph 1, is 373.5 X 10-5 or .003735 seconds. The distance from the muzzle to chronograph 1 is five feet. Using a proportion, we can compute the velocity in feet per second. If the projectile travels five feet in .003735 seconds, how far will it travel in 1 second?

The proportion is

$$\frac{.003735 \text{ seconds}}{\text{five feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplication gives

$$.003735x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.003735 \text{ seconds}}$$

or

$$x = 1339 \text{ feet}.$$

Shot 20 (Chronograph 2)

The distance from chronograph 1 to chronograph 2 is also five feet. The time required for the projectile to travel from chronograph 1 to chronograph 2 is 374.2 X 10-5 seconds or .003742 seconds. Using a proportion, we calculate the velocity in feet per second as

$$\frac{.003742 \text{ seconds}}{5 \text{ feet}} = \frac{1 \text{ second}}{x \text{ feet}}.$$

Cross multiplying we get

$$.003742x \text{ feet-seconds} = 5 \text{ feet-seconds}.$$

Solving for 'x' we get

$$x \text{ feet} = \frac{5 \text{ feet-seconds}}{.003742 \text{ seconds}}$$

or

$$x = 1336 \text{ feet}.$$

QUESTION 2

The average velocity is the velocity at chronograph 1 plus the velocity at chronograph 2 divided by 2.

The striking velocity is the average velocity minus the loss of velocity (given on the handout) due to wind resistance.

Shot 1

The velocity at chronograph 1 is 1384 feet/second.
The velocity at chronograph 2 is 1380 feet/second.

The average is $\frac{1384 + 1380}{2}$ or 1382 ft/sec.

The striking velocity is the average velocity, 1382 ft/sec, minus the loss due to wind resistance, 40 ft/sec or

1382 ft/sec - 40 ft/sec or 1342.

The average velocity for Shot 1 is 1382 feet/second.
The striking velocity for Shot 1 is 1342 ft/second.

Shot 3

The velocity at chronograph 1 is 1309 feet/second.
The velocity at chronograph 2 is 1306 feet/second.

The average is $\frac{1309 + 1306}{2}$ or 1308 ft/sec.

The striking velocity is the average velocity, 1308 ft/sec, minus the loss due to wind resistance, 37 ft/sec or

1308 ft/sec - 37 ft/sec or 1271.

The average velocity for Shot 3 is 1308 feet/second.
The striking velocity for Shot 3 is 1271 ft/second.

Shot 5

The velocity at chronograph 1 is 1254 feet/second.
The velocity at chronograph 2 is 1251 feet/second.

The average is $\frac{1254 + 1251}{2}$ or 1252 ft/sec.

The striking velocity is the average velocity, 1252 ft/sec, minus the loss due to wind resistance, 35 ft/sec or

1252 ft/sec - 35 ft/sec or 1217.

The average velocity for Shot 5 is 1252 feet/second.
The striking velocity for Shot 5 is 1217 ft/second.

Shot 12

The velocity at chronograph 1 is 1333 feet/second.
The velocity at chronograph 2 is 1329 feet/second.

The average is $\frac{1333 + 1329}{2}$ or 1331 ft/sec.

The striking velocity is the average velocity, 1333 ft/sec, minus the loss due to wind resistance, 38 ft/sec or

1331 ft/sec - 38 ft/sec or 1293.

The average velocity for Shot 12 is 1331 feet/second.
The striking velocity for Shot 12 is 1293 ft/second.

Shot 13

The velocity at chronograph 1 is 1355 feet/second.
The velocity at chronograph 2 is 1351 feet/second.

The average is $\frac{1355 + 1351}{2}$ or 1353 ft/sec.

The striking velocity is the average velocity, 1353 ft/sec, minus the loss due to wind resistance, 39 ft/sec or

1353 ft/sec - 39 ft/sec or 1314.

The average velocity for Shot 13 is 1353 feet/second.
The striking velocity for Shot 13 is 1314 ft/second.

Shot 14

The velocity at chronograph 1 is 1354 feet/second.
The velocity at chronograph 2 is 1351 feet/second.

The average is $\frac{1354 + 1351}{2}$ or 1353 ft/sec.

The striking velocity is the average velocity, 1353 ft/sec, minus the loss due to wind resistance, 39 ft/sec or

1353 ft/sec - 39 ft/sec or 1314.

The average velocity for Shot 14 is 1353 feet/second.
The striking velocity for Shot 14 is 1314 ft/second.

Shot 15

The velocity at chronograph 1 is 1375 feet/second.
The velocity at chronograph 2 is 1371 feet/second.

The average is $\frac{1375 + 1371}{2}$ or 1373 ft/sec.

The striking velocity is the average velocity, 1373 ft/sec, minus the loss due to wind resistance, 39 ft/sec or

1373 ft/sec - 39 ft/sec or 1334.

The average velocity for Shot 15 is 1373 feet/second.
The striking velocity for Shot 15 is 1334 ft/second.

Shot 17

The velocity at chronograph 1 is 1348 feet/second.
The velocity at chronograph 2 is 1346 feet/second.

The average is $\frac{1348 + 1346}{2}$ or 1347 ft/sec.

The striking velocity is the average velocity, 1347 ft/sec, minus the loss due to wind resistance, 38 ft/sec or

1347 ft/sec - 38 ft/sec or 1309.

The average velocity for Shot 17 is 1347 feet/second.
The striking velocity for Shot 17 is 1309 ft/second.

Shot 19

The velocity at chronograph 1 is 1348 feet/second.
The velocity at chronograph 2 is 1346 feet/second.

The average is $\frac{1348 + 1346}{2}$ or 1347 ft/sec.

The striking velocity is the average velocity, 1347 ft/sec, minus the loss due to wind resistance, 38 ft/sec or

1347 ft/sec - 38 ft/sec or 1309.

The average velocity for Shot 19 is 1347 feet/second.
The striking velocity for Shot 19 is 1309 ft/second.

Shot 20

The velocity at chronograph 1 is 1339 feet/second.
The velocity at chronograph 2 is 1336 feet/second.

The average is $\frac{1339 + 1336}{2}$ or 1338 ft/sec.

The striking velocity is the average velocity, 1338 ft/sec, minus the loss due to wind resistance, 38 ft/sec or

1338 ft/sec - 38 ft/sec or 1300.

The average velocity for Shot 20 is 1338 feet/second.
The striking velocity for Shot 20 is 1300 ft/second.

QUESTION 3

The average velocity for the V50 test is the sum of the average striking velocity for each shot divided by the number of shots.

The striking velocity for each shot is as follows:

Shot 1	1342
Shot 3	1271
Shot 5	1217
Shot 12	1293
Shot 13	1314
Shot 14	1314
Shot 15	1334
Shot 17	1309
Shot 19	1309
Shot 20	1300

The total of the average striking velocities is 13003.

Since ten shots were used in the sum, the average velocity for the V50 test is
13003 ÷ 10 or 1300 ft/sec.

QUESTION 4

The high partial for the 10 projectiles used in the sample is either Shot 13 or 14 or 1314 ft/sec.

The low complete for the 10 projectiles used in the sample is Shot 5 or 1217 ft/sec.

QUESTION 5

The range of results for the test is the difference between the highest and lowest average velocity for the projectiles that made a complete hole.

The highest complete average velocity was Shot 1 at 1342 ft/sec. The lowest complete average velocity was Shot 5 at 1217 ft/sec. The range is average velocity of Shot 1 minus the average velocity of Shot 5 or

1342 - 1217 or 125 ft/sec.

The range of mixed results for the test is the difference between the highest partial average velocity and the lowest complete average velocity.

The highest partial average velocity was Shot 13 at 1314 ft/sec. The lowest complete average velocity was Shot 5 at 1217 ft/sec. The range of mixed results is average velocity of Shot 3 minus the average velocity of Shot 5 or

1314 - 1217 or 97 ft/sec.

QUESTION 6

The quality of the material is based on a preset average velocity and the range of results. The preset average velocity for this test was 1200 ft/sec. The range of results was 125 ft/sec. The average striking velocity for the test cannot be more than the sum of the preset velocity and the range of results. The sum of the preset average velocity and the range of results is

1200 ft/sec + 125 ft/sec or 1325 ft/sec.

1325 ft/sec is the maximum amount for the average striking velocity for the overall test results. Since the average striking velocity was only 1300 ft/sec, this lot of Kevlar® is considered of top quality.

APPENDIX A

HANDOUT 1

PROBABLE BALLISTIC LIMIT (V50)

Date Rec'd
Via : UPS
Returned : na
File (HPWLI): CS8140-A.V50

Job No. :
Test Date:
Client

SAMPLE

Size : 15 x 15 ins.
No. Plies :
Thickness : na

Avg. Thickness : na
Sample Weight : 0.97 lbs.
Weave Count :

BALLISTIC THREAT

Projectile :
Weight :
Powder : BULLSEYE
Barrel Length : 28 ins.
Obliquity : 0 deg.
Specification : (d) SEE REMARKS

RANGE

A. Muzzle to Scr. 1 : 5.0 ft
B. Scr. 1 to Scr. 2 : 5.0 ft
C. Scr. 2 to Target : 2.5 ft
D. Target to Witness : 6.0 ins
E. Midpoint to Target: 5.0 ft

SAMPLE NUMBER HPW-1

SAMPLE DESCRIPTION

Gunner : UNGER
Recorder : HITCHEM

Shot No.	Powder/ Seating	Chronograph 1 Time (sx10-5)	Chronograph 1 Velocity (ft/s)	Chronograph 2 Time (sx10-5)	Chronograph 2 Velocity (ft/s)	Velocity (ft/s) Average(a)	Velocity (ft/s) Loss(b)	Striking	Results Partial/ Complete	Include in V50 Yes
1	5.0	361.4		362.4			40		C	*
2	4.4	412.7		413.6			33		P	
3	4.7	382.0		382.8			37		P	*
4	4.9	345.0		345.8			42		C	
5	4.7	398.8		399.6			35		C	*
6	4.6	453.5		455.0			29		P	
7	4.7	421.2		422.2			32		P	
8	4.8	432.3		433.4			31		P	
9	4.9	424.3		424.9			32		P	
10	5.0	393.2		394.2			35		P	
11	5.1	416.5		417.6			32		P	
12	5.2	375.1		376.1			38		P	*
13	5.3	369.0		370.0			39		P	*
14	5.4	369.3		370.0			38		P	*
15	5.5	363.7		364.7			39		C	*
16	5.4	361.9		362.9			40		Bad Hit	
17	5.4	370.8		371.5			38		C	*
18	5.3	383.5		384.3			37		P	
19	5.4	370.8		371.6			38		P	*
20	5.5	373.5		374.2			38		C	*

REMARKS:
(a) Vel. measured at 7.5 ft from the muzzle.
(b) Vel. loss computed using std. G tables & P = 29.94 in. Hg, T = 75.0 deg. F
(c) PC. NUMBER 1866 012 01
1866 013 03
(d) MIL-C-44050A TYPE 1/CLASS 2

REMARKS CONTINUED:

These tests were performed in accordance with the specification requirements and the results properly reflect the ballistic performance of the listed sample.

SUMMARY:

V50	HIGH PARTIAL	LOW COMPLETE	RANGE OF RESULTS	RANGE OF MIXED RESULTS

(03-01A)

HANDOUT 1

TEACHER'S ANSWER KEY

PROBABLE BALLISTIC LIMIT (V50)

Date Rec'd
Via : UPS
Returned : na
File (HPWL1): CS8140-A.V50

Job No. :
Test Date:
Client

SAMPLE

Size : 15 x 15 ins.
No. Plies :
Thickness : na

Avg. Thickness : na
Sample Weight : 0.97 lbs.
Weave Count :

BALLISTIC THREAT

Projectile :
Weight :
Powder : BULLSEYE
Barrel Length : 28 ins.
Obliquity : 0 deg.
Specification : (d) SEE REMARKS

RANGE

A. Muzzle to Scr. 1 : 5.0 ft
B. Scr. 1 to Scr. 2 : 5.0 ft
C. Scr. 2 to Target : 2.5 ft
D. Target to Witness : 6.0 ins
E. Midpoint to Target: 5.0 ft

SAMPLE NUMBER HPW-1

Gunner : UNGER
Recorder : MITCHEM

SAMPLE DESCRIPTION

Shot No.	Powder/ Seating	Chronograph 1 Time (sx10-5)	Chronograph 1 Velocity (ft/s)	Chronograph 2 Time (sx10-5)	Chronograph 2 Velocity (ft/s)	Velocity (ft/s) Average(a)	Velocity (ft/s) Loss(b)	Striking	Results Partial/ Complete	Include in V50 ***=Yes
1	5.0	361.4	1384	362.4	1380	1382	40	1342	C	*
2	4.4	412.7		413.6			33		P	
3	4.7	382.0	1309	382.8	1306	1308	37	1272	P	*
4	4.9	345.0		345.8			42		C	
5	4.7	398.8	1254	399.6	1251	1252	35	1217	C	*
6	4.6	453.5		455.0			29		P	
7	4.7	421.2		422.2			32		P	
8	4.8	432.3		433.4			31		P	
9	4.9	424.3		424.9			32		P	
10	5.0	393.2		394.2			35		P	
11	5.1	416.5		417.6			32		P	
12	5.2	375.1	1333	376.1	1329	1331	38	1293	P	*
13	5.3	369.0	1355	370.0	1351	1353	39	1314	P	*
14	5.4	369.3	1354	370.0	1351	1353	38	1314	P	*
15	5.5	363.7	1375	364.7	1371	1373	39	1334	C	*
16	5.4	361.9		362.9			40		Bad Hit	
17	5.4	370.8	1348	371.5	1346	1347	38	1309	C	*
18	5.3	383.5		384.3			37		P	
19	5.4	370.8	1348	371.6	1346	1347	38	1309	P	*
20	5.5	373.5	1339	374.2	1336	1338	38	1300	C	*

REMARKS:
(a) Vel. measured at 7.5 ft from the muzzle.
(b) Vel. loss computed using std. G tables & P = 29.94 in. Hg, T = 75.0 deg. F
(c) PC. NUMBER 1866 012 01
1866 013 03
(d) MIL-C-44050A TYPE 1/CLASS 2

REMARKS CONTINUED:

These tests were performed in accordance with the specification requirements and the results properly reflect the ballistic performance of the listed sample.

SUMMARY:

V50	HIGH PARTIAL	LOW COMPLETE	RANGE OF RESULTS	RANGE OF MIXED RESULTS
1300	1314	1217	125	97