CONTROL CLASS III AND PIPELINE OPERATIONS

Subcourse Number QM5099

EDITION A

United States Combined Arms Support Command
Fort Lee, VA 23801-1809

2 Credit Hours
Edition Date: March 1999

SUBCOURSE OVERVIEW

This subcourse was designed to provide the soldier with information on the proper methods for establishing, operating, and relocating a Class III supply point to include developing a Class III supply point flow plan, fire plan, equipment-loading plan, defense plan, and a review of safety precautions and identifying environmental impediments and viable resolutions.

There are no prerequisites for this subcourse.

This subject reflects the doctrine which was current at the time it was prepared. In your own work situation, always refer to the latest official publications.

Unless otherwise stated, the masculine gender of singular pronouns is used to refer to both men and women.

TERMINAL LEARNING OBJECTIVE:

ACTION: The soldier will learn to develop a Class III supply point flow plan, fire plan, equipment loading plan, and defense plan, observe fire and safety precautions, and identify environmental considerations.

CONDITION: Given all applicable information.

STANDARDS: To demonstrate proficiency of this task you must achieve a minimum of 70 percent on the subcourse examination.

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LESSON 1

THEORY OF FLOW

Critical Task:
101-519-4260

OVERVIEW

Lesson Description:
This lesson covers calculating various mathematical techniques.

Terminal Learning Objective:

Action: The soldier will calculate various mathematical techniques to include pressure, specific gravity and gravity, API gravity, Reynolds Number, and Darcy Weisbach and modified Darcy Weisbach equation pressure.

Condition: Given subcourse QM 5099.

Standards: The soldier must score a minimum of 70 percent on the end of subcourse examination.

INTRODUCTION

Fuel supply personnel are responsible for all aspects of fuel supply operations. One of the most complex, challenging and interesting aspects of petroleum operations is the study of hydraulics. Pipeline design offers an excellent opportunity to use those theories and principles in the classroom. A broad base understanding of pipeline distribution system will enhance your professional career because the possibility of conventional or limited nuclear warfare at any location in the world will result in demands for large quantities of fuel. Currently there is no better state of the art bulk delivery than by pipeline.

PART A - STATIC FLUID (FLOW OF FUEL IN PIPELINES)

Specific weight. The specific (or unit) weight of water is 62.3 pounds per cubic foot.

Specific gravity. The ratio of the weight of a volume of liquid to an equal volume of water. The specific gravity of water is 1.

API gravity. API gravity is an arbitrary scale accepted for general use by the petroleum industry. It is based on reciprocals of specific gravities and produces a range of numbers between 10° and 90° API between the heaviest and the lightest petroleum products. The standard (water) is established at 60° F. All other observations must be converted to this standard to make meaningful comparisons.

Conversion formulas. The following formulas are used for conversion between API gravity and specific gravity.

$$API = \frac{141.5 - 131.5}{SPGR}$$

$$SPGR = \frac{141.5}{API + 131.5}$$

PART B - PRESSURE

Pressure. All forces which produce pipeline flow velocity and all those that oppose it can be described or measured in terms of pressure or feet of head.

Static pressure. Static pressure is a measure of liquids at rest. It is the vertical height from a given point in a column or body of still liquid to its surface and is usually expressed in feet.

> **Example:** A column of water (at 60° F) 1 inch by 1 inch, 2.31 feet in height will exert one pound per square inch at its base. Then we can express this as: 2.31 feet of head is equal to one pound of pressure. If 2.31 feet of head is one PSI then one feet of head is .433 PSI (1 ÷ 2.31 = .433).

Dynamic Pressure: Dynamic pressure is a measure of potential energy or liquids in motion.

Example: The distance from the liquid level in a tank to ground level is the static pressure. As the liquid starts to flow down a pipe then it is expressed as dynamic pressure.

Conversions. The equation for converting feet of head to pounds per square inch is:

$$P = \frac{H \times SPGR}{2.31} \quad \text{or} \quad H = \frac{2.31 \times P}{SPGR}$$

Where:
P = pressure in PSI
H = Head (in feet of fluid)
SPGR = Specific gravity
2.31 = Conversion constant

We found out in the first part of this class that all products produce a different pressure at different heights. In the equation, the specific gravity compensates for the different products and the constant 2.31 takes care of the feet of head (hd)or the PSI.

Example: SPGR =.8448
Head = 250 ft

$$P = \frac{250 \times .8448}{2.31} = 91 \text{ PSI}$$

$$H = \frac{2.31 \text{ X } 91}{844} = 249 \text{ ft/hd}$$

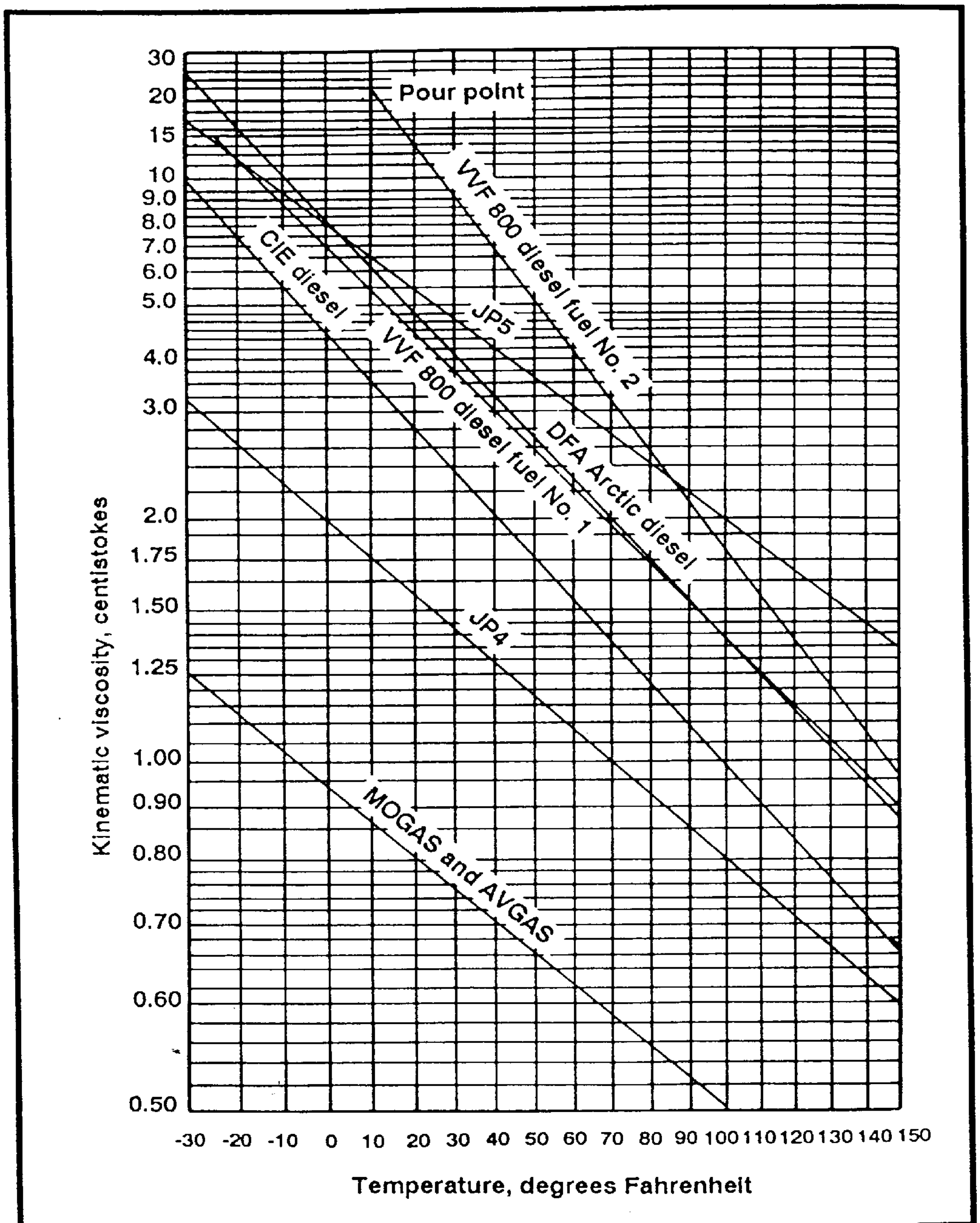
PART C – DESIGN FUEL

Design fuel: Fuels most likely to be transported by military pipeline are motor gasoline, JP-4, and diesel fuel. Properties of these fuels will be found in MIL-HDBK-200 (Federal specifications) and gravity range in Table 6-1. With such a wide variation, specific gravity becomes an important factor in the design of military pipelines. The heaviest fuel making up 24 percent or more of the total requirement will be taken as the design fuel.

Viscosity: Viscosity is a measure of the relative ease or difficulty with which a liquid can be made to flow. It is the internal force (resistance) or opposition to flow. Viscosity can be expressed as kinematic viscosity or dynamic viscosity. For our purposes in the U.S. Army we will use kinematic viscosity. The units of kinematic viscosity are centistokes and feet squared per second. The viscosity, in units of centistokes (cs), is found by using Figure 1-1. If the units of feet squared per second are desired, then the conversion factor of 92,900 cs equals one foot squared per second is used.

Example: To convert 20 cs to cubic ft/sec use, the following formula:

$$y = \frac{\text{Kinetic}}{92{,}900} = \frac{20}{92{,}900} = 0.000215285$$



F:

Figure 1-1, Kinematic viscosity.

PART D - DYNAMIC FLUID FLOW

Reynolds number. The Reynolds number is a dimensionless quantity that does not represent any particular unit.

Example: 4 inches divided by 4 inches = 1; in this case 1 does not represent inches but a number that represents the ratio of 4 inches to 4 inches. The Reynolds number is a dimensionless quantity which can be calculated using the following equation:

R = Reynolds number
Q = Flow rate in GPM
d = Inside diameter of pipe, in inches
K = Kinematic viscosity in centistokes (see Figure 1-1).

$$R = \frac{3160 \times Q}{d \times K}$$ (where 3160 is a constant)

In this equation we use field data and we will concentrate on it in the classroom. It is also the one used by the Army.

Reynolds number using design data.
V = Velocity in feet per sec
d = Inside diameter of pipe in ft
Y = Kinematic viscosity in feet squared (ft^2) per sec

$$R = \frac{V \times d}{Y}$$

Scientific Notation. Once you have obtained the Reynolds number you must be able to use it. We know that the Reynolds number can tell you whether the flow is laminar or turbulent. We can also determine a friction factor using the Reynolds number. The friction factor relates to the resistance to flow in pipeline operations. In our example using field data, we obtained a Reynolds number of 144881. Because of the large number we will express it in scientific notation. This is simply a way of expressing a number as a decimal with one integer to the left of the decimal point times the appropriate power of ten. For example: The number 144881 is expressed as 1.44x10 to the 5th power. In this case the decimal is moved 5 places to the left 1.4x10 to the 5th power. The reverse is true for numbers less than one, example: 0.00000064 becomes 6.4x10 to the (-) eighth. We just count 8 places to the right of the decimal.

Example: Determine the Reynolds number using field data, given the following information:

Q = 350 gpm
D = 6.415 inches
Fuel = JP-4 at 50°F

Figure 1-1 is a chart that gives you Kinematic viscosity for common military fuels. Across the bottom of the chart from left to right is the temperature in degrees Fahrenheit. On the left hand vertical side of the chart you will find Kinematic viscosity in centistokes. First, locate 50° F on the bottom horizontal line. Move up until the solid line intersects JP-4. Now move to the left and read 1.19 centistokes. Look at the graduations between 1.00 and 1.25, there are five graduations, each one is equal to .05 cs so you must visually interpolate.

$$R = \frac{3160 \times 350}{6.415 \times 1.19} = \frac{1106000}{7.63385} = 144881 \text{ or } 1.44 \times 10 \text{ to the 5th}$$

Example: using design data

Given: Rn = V = 3.48 ft per/sec

D = .53 ft
Y = .0000128 ft/sec

$$V = \frac{Q}{A} = \frac{3.48 \times .53}{.0000128} = \frac{1.8444}{.0000128} = 144093.75$$

= 144094 or 1.44 x 10 to the 5th

PART E - TYPES OF FLOW

Types of flow. How do you interpret the Reynolds number once you have calculated it?
Laminar flow. Laminar flow is undesirable in multi-product pipeline operations because it has a telescoping effect on the product and causes an increase in the spread of the interface.
Turbulent flow. Turbulent flow on the other hand will hold the spread of the interface to a minimum.
In laminar flow the Reynolds number is 2,000 or below, in turbulent flow the Reynolds number is 4,000 and above. The numbers between 2,000 and 4,000 are considered transition flow.

Friction Factor (resistance to flow in pipeline operations). After calculating the Reynolds number and changing to scientific notation, we can obtain a friction factor using Figure 1-2. Horizontally across the bottom are numbers in scientific notation, to the right and vertically is pipe diameters, to the left of the graph and vertically are the friction factors starting at .010 and ending with .032. Using our calculation 1.44 X 10 to the 5th, locate this on the bottom horizontal line. The pipe diameter is 6.415 inches; move up the chart until the line intersects the pipe diameter curve and move to the left and read .0188 for the friction factor.

Darcy Weisbach Equation

The Darcy Weisbach equation provides an accurate method of calculating friction head loss in a pipeline. This equation should be used when a high degree of accuracy is required. An example would be the construction of a permanent pipeline system. The Darcy Weisbach equation states that:

Where:
Hf = friction head loss, in ft
f = dimensionless friction factor
V = velocity, in ft/sec
g = acceleration due to gravity (32.2 ft/sec)
d = inside diameter of the pipe, in ft
L = length of pipe, in ft

$$Hf = \frac{fxLxV}{2g \times d}$$

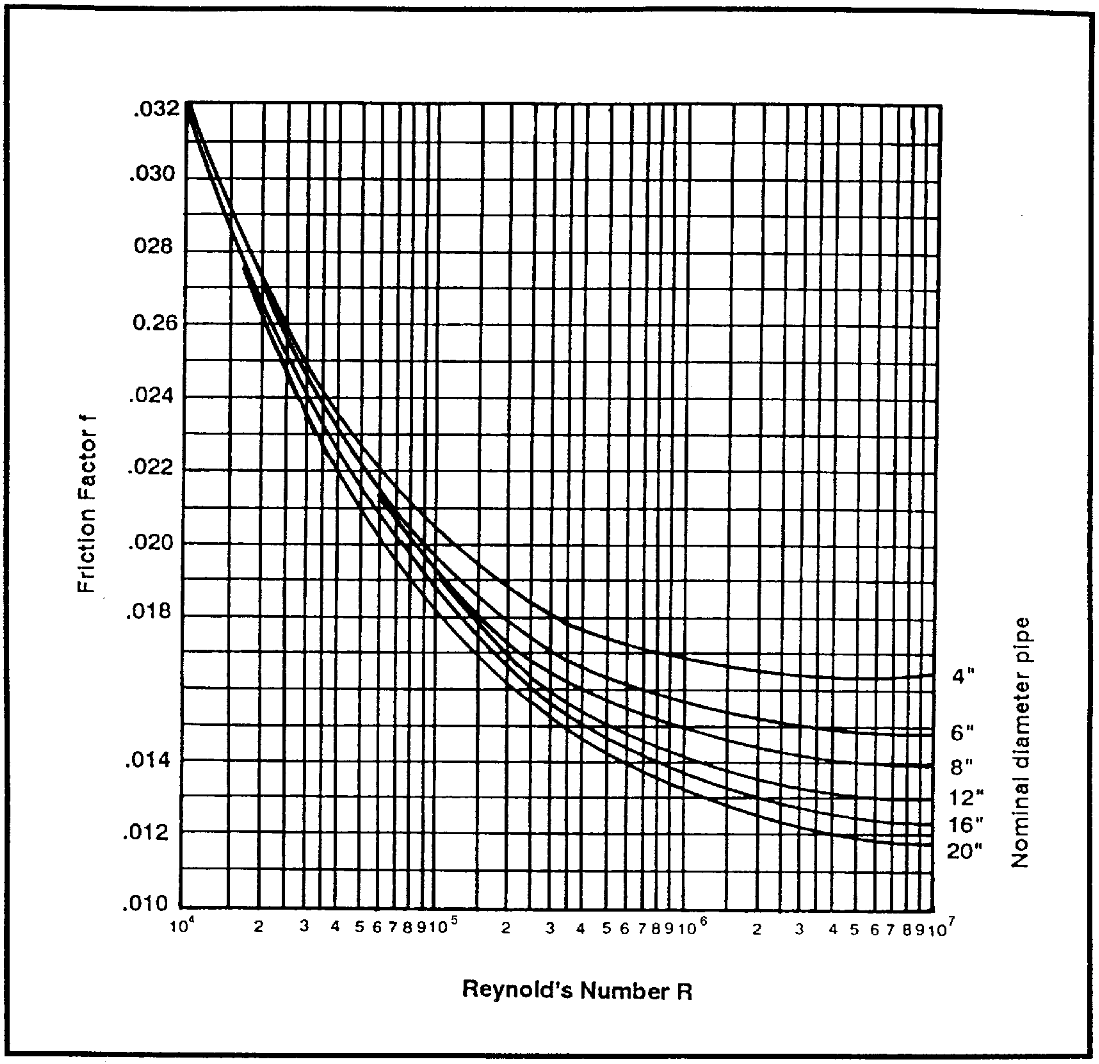


Figure 1-2. Friction Factor versus Reynold's number.

Since flow data is usually given in gallons per minute and pipe diameters in inches, it is more convenient to express the Darcy Weisbach equation as:

Where:
Hf = friction head loss, in ft
f = dimensionless friction factor based on the Rn and the inside roughness of pipe
L = length of pipe, in ft
Q = flow, in GPM
d = inside diameter of the pipe, in inches
0.031 = Constant

$$Hf = \frac{0.031xfLxQ^2}{d5}$$

Example: Calculate frictional head loss, given the following information and using the following equation.

Pipe size = 8.415 inches.
Fuel = DF-2 at 50°F.
V = 4 ft/sec
Length of pipe = 4000 ft.

$$Hf = \frac{fxLxV^2}{2gxD}$$

Step 1: Calculate Reynolds number

$$K = \frac{4.9}{92900} = 0.0000527$$

$$R = VD = \frac{4 \ x \ .701}{.0000527} = 53206.8317(52307) \text{ or } 5.3 \ x \ 10$$

$$R = \frac{3.160 \ xQ}{dxK}$$

To obtain Kinematic viscosity in centistokes, use Figure 1-1; move up the scale to DF-2, move to the left and read 4.9.

Step 2: find the friction factor using the Reynolds number. Figure 1-2. Locate 5.36 x 10, move up the chart to 8 inch pipe, move to the left and read .0216 or .022.

Step 3: $Hf = \frac{fxLxV^2}{2gxD}$

Step 4: 2g = 2x32.2 = 64.4

Step 5: Diameter of pipe in ft. = .701

Step 6: $Hf = \frac{.0216x4000x16}{64.4 \ x \ .701} = \frac{1382.4}{45.14}$

= 30.6 or 31 ft

Using the same information and the modified Darcy- Weisbach equation:

$$Hf = \frac{.031 x f x L x Q^2}{d5}$$

Step 1: Frictional factor is the same - .0216

Step 2: Length is the same - 4000 ft

Step 3: Q^2 = 700 x 700 = 490,000

Step 4: Figure 1-2 = 42,196

Step 5: $\frac{.031x.0216x4,000x490,000}{42,196} = \frac{1312416}{} = \frac{31.102853}{} \quad 42,196$

= 31 ft

You can see that the frictional head loss is the same using either of the two equations.

LESSON 1

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check your answers with the answer key. If you answer any items incorrectly, go back to the part of the lesson that contains the information involved and study again.

1. Given 5 gallons of liquid that weighs 32 pounds, what is the specific weight 5 gallons of fuel weighing 32 pounds?
   A. 3.20 lbs/gal.
   B. 4.50 lbs/gal.
   C. 5.30 lbs/gal.
   D. 6.40 lbs/gal.

2. What is the API gravity of a fuel that has a specific gravity of .6823?
   A. 70.783.
   B. 72.788.
   C. 74.702.
   D. 75.887.

3. If a product has an API gravity of 64.0, what is its specific gravity?
   A. 0.2378.
   B. 0.3782.
   C. 0.7238.
   D. 0.8327.

4. How much does DF2 fuel weigh in an above-ground storage tank that is 35 feet tall and 12 feet in diameter, if the tank is 85 percent full?
   A. 177,306.62.
   B. 277. 306.26.
   C. 717, 306.26.
   D. 762,603.77.

5. A 3,000-barrel storage tank has 22 feet of MOGAS stored in it (specific gravity = 0.7250). How much pressure (in psi) is exerted on the bottom of the tank?
   A. 4 psi.
   B. 5 psi.
   C. 6 psi.
   D. 7 psi.

LESSON 2

LINE FILL AND FRICTION LOSS

Critical Task:
101-519-4260

OVERVIEW

Lesson Description:
This lesson covers line fill and friction loss.

Terminal Learning Objective:

Action: The soldier will calculate to determine headloss on a pipe due to friction, equivalent pipe length for valves and fittings, and the amount of fuel required for pipeline and manifolds.

Condition: Given subcourse QM 5099.

Standards: The soldier scores a minimum of 70 percent on the end of subcourse examination.

INTRODUCTION

During previous instruction you were given an understanding of the flow of fluids in pipelines. We discussed equations that can be used to determine how fast the fluids flow and what effects the flow has on pressure. The purpose of this instruction is to teach you how to obtain information from other methods that are much easier. Although the information obtained may not be as accurate, it is suitable for Army pipelines.

PART A - FRICTION LOSS

Friction Loss Graph: The friction loss graph is an expedient method of obtaining friction loss per mile of pipe in military pipelines. Although the results are not exact, it is close enough and is a much faster way than using the Darcy Weisbach equation. The basic graph (Figure 2-1) contains the following information. Barrels per hour top horizontal line. Gallons per minute bottom horizontal line. Friction loss per mile of pipe left vertical line. The other lines on the graph represent pipe diameter in inches and velocity of the fuel in feet per second. The graph has been constructed using MOGAS at 60° F as the design fuel, Kinematic viscosity of 8 x 10 minus 6 ft per sec and absolute roughness of 0.00015. For this reason you must use a correction factor for fuels other than MOGAS and at temperatures other than 60° F.

Using Figure 2-1, given a flow rate of 700 gallons per minute and a pipe diameter of 8.415 inches: enter the graph at the lower right hand corner and move to the left to 700 gallons per minute. Move up the graph until you locate the pipe diameter (8.415). Read to the left and read 33 feet. This means that for every mile of pipe you will lose 33 feet of head. If the pipeline was 10 miles long you would lose 330 feet of head.

PART B – CORRECTION FACTOR

Correction Factor. To determine the friction head loss for fuels other than MOGAS at 60° F, it becomes necessary to correct the value obtained from Figure 2-1. Table 2-1 contains correction factors for all military fuels at temperatures ranging from -20° F to 80° F.

At temperatures other than these, interpolation must be used. These factors can be used for any flow rate and for API pipe or light weight steel tubing having the same nominal diameter as that shown in the tables.

If we use the same flow rate and the same pipe diameter (700 GPM and 8.415), we know that our head loss is 33 feet per mile. If we were pumping DF2 at a temperature of 80° F, we must use the correction factor.

Using Table 2-1, locate DF2 at 80° F and read the correction factor 1.17. Multiply 33 feet by 1.17 which equals 38.61 feet or 39 feet. You now have the friction loss per mile of pipe for DF2 flowing at 700 GPM through an 8.415 diameter pipeline.

Once computed, the head loss due to friction for one mile of pipe has a special name; hydraulic gradient (hg). Since hg is a constant ratio of two linear dimensions: head loss in feet over pipe distance in miles; it can be expressed graphically as the slope of a straight line.

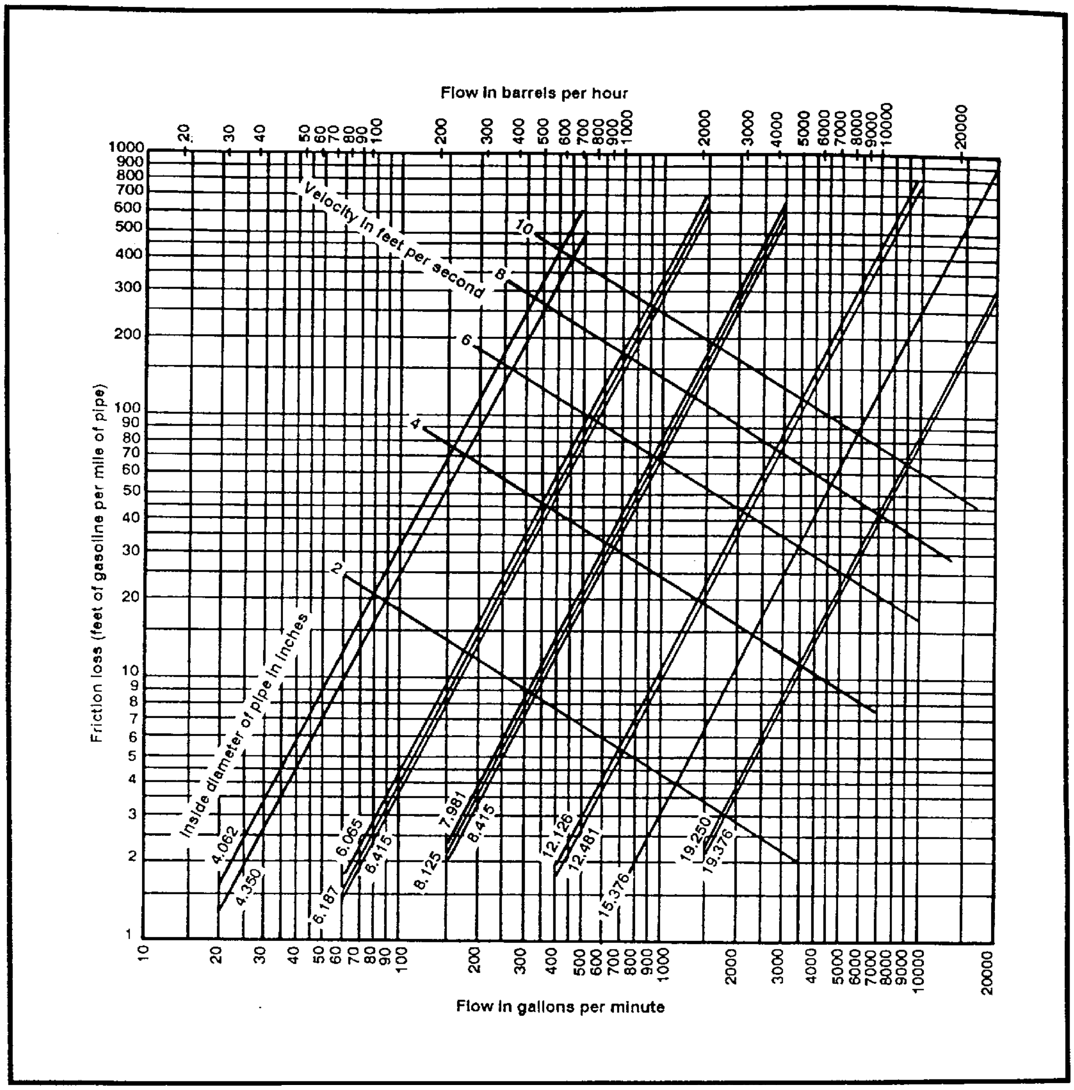


Figure 2-1. Head loss due to friction.

Temperature °F	MOGAS	JP4	CIE Diesel	JP5	DFA or VVF 800 Diesel No. 1	VVF 800 Diesel No. 2
For 12-inch Pipe						
80	1.00	1.03	1.05	1.15	1.10	1.16
60	1.00	1.05	1.09	1.19	1.13	1.23
40	1.01	1.06	1.13	1.24	1.19	1.35
20	1.01	1.09	1.16	1.32	1.26	1.54
0	1.03	1.12	1.26	1.40	1.37	(*)
-20	1.05	1.16	1.38	1.53	1.53	
For 16-inch Pipe						
80	1.00	1.04	1.07	1.17	1.11	1.18
60	1.00	1.05	1.10	1.23	1.16	1.25
40	1.01	1.07	1.13	1.27	1.20	1.39
20	1.02	1.10	1.19	1.34	1.28	1.56
0	1.04	1.13	1.27	1.42	1.39	(*)
-20	1.06	1.19	1.39	1.55	1.55	
For 20-inch Pipe						
80	0.99	1.04	1.08	1.21	1.14	1.22
60	1.00	1.07	1.12	1.27	1.19	1.32
40	1.01	1.09	1.17	1.32	1.26	1.44
20	1.03	1.12	1.26	1.42	1.35	1.71
0	1.05	1.17	1.35	1.53	1.49	(*)
-20	1.08	1.23	1.53	1.71	1.71	
For 4-inch Pipe						
80	1.00	1.04	1.07	1.18	1.11	1.18
60	1.00	1.05	1.09	1.23	1.16	1.25
40	1.01	1.08	1.14	1.27	1.20	1.40
20	1.03	1.10	1.19	1.34	1.28	1.62
0	1.04	1.14	1.27	1.45	1.39	(*)
-20	1.07	1.19	1.43	1.62	1.55	
For 6-inch Pipe						
80	1.00	1.04	1.06	1.17	1.11	1.17
60	1.00	1.05	1.09	1.21	1.15	1.25
40	1.01	1.08	1.13	1.25	1.20	1.37
20	1.03	1.10	1.19	1.32	1.28	1.57
0	1.04	1.14	1.27	1.43	1.40	(*)
-20	1.07	1.19	1.41	1.57	1.57	
For 8-inch Pipe						
80	1.00	1.03	1.06	1.17	1.10	1.17
60	1.00	1.05	1.09	1.20	1.18	1.25
40	1.01	1.07	1.13	1.25	1.19	1.37
20	1.03	1.10	1.18	1.32	1.27	1.56
0	1.04	1.13	1.26	1.42	1.39	(*)
-20	1.06	1.16	1.39	1.56	1.56	

*The pour point of VVF 800 Diesel No. 2 is 10°F.

Table 2-1. Friction head loss correction factors.

Being able to measure the head at a point downstream or head loss between points downstream becomes academic. For example:

Head available = 390 feet
Pipeline distance = 10 mile (52,800 feet)
H = 38.61 feet per mile (or 39)
Head available after one mile = 351
Head loss after three miles = 117

390
351
312
273
234
195
156
117
78
39
1 2 3 4 5 6 7 8 9 10
MILES

In order to determine how much head is used and how much head is available, draw a line from the lower left hand corner; as if the gradient was a rectangle. Locate 4 miles on the X axis and move up the graph until you intersect the sloping line. Move to the left and read 156 feet of head; this gives you the head used and the head remaining which is 134 feet.

390
351
312
273
234
195
156
117
78
33
1 2 3 4 5 6 7 8 9 10
MILES

PART C – FEET OF HEAD AVAILABLE

Feet of Head available. Given a storage tank containing DF1 at an elevation of 225 feet above the feeder pump, the feeder line is 6 inch LWST, 9000 feet long, with a flow rate of 400 BPH. Determine how many feet of head are available at the suction side of the pump.

STEP 1: Determine the true gradient (400 BPH and 6.415 inch pipe) using Figure 2-1. Hg = 24 ft/mi

DF1 at 40° F Correction Factor = 1.20

True Gradient 24 ft/mi x 1.20 = 28.8 ft/mi

STEP 2: Determine the miles of pipe

$$\frac{9000 \text{ ft}}{5,280 \text{ ft/mi}} = 1.70 \text{ mi}$$

STEP 3: Determine head loss

Hf = 28.8 ft/mi x 1.70 mi = 49 ft

STEP 4: Determine head remaining

225 ft - 49 ft = 176 ft

PART D – FRICTION LOSS

Friction Loss in Valves and Fittings: Friction losses in valves and fittings result from the same surface friction losses in straight pipe. So far we have only considered the losses in pipe. Now we are going to find out how to compute the losses through valves and fittings. Valves and fittings have been mathematically evaluated to determine the friction loss and the information has been put in graph form. Special consideration must be given to terminals and tank farms because of the numbers of valves and fitting used. This friction loss must be carefully evaluated to ensure that feeder pumps can meet the required pressure to feed the mainline pumps and to transfer fuel from tank to tank within the terminal.

Now we can calculate the equivalent length for a pipeline that has a certain number of valves and fittings. This number would then be added to the pipeline length. For example:

3 rising stem gate valves
2 swing check valves
1 90 degree welding elbow
All valves and fittings are 8.415 inch diameter

Gate valve - 6.2 x 3 = 18.6
Swing check valve - 70.0 x 2 = 140
90 degree welding elbow 95.0 x 1 = 9.5
Total = 168 ft

Given: JP-5 at 80° F

Q = 700 GPM
d = 8.415 inches
Valves and fitting equivalent length = 188 Feet
Pipe length = 2.5 mi

Find: Total head loss due to friction (Hf)

STEP 1: Determine Hg

NOTE: Using Figure 2-1, at 700 GPM and 8.415 inch pipe Hg = 34 ft/mi

STEP 2: Determine correction factor using Table 2-1.
Correction factor = 1.17

STEP 3: Determine True Gradient

34 ft/mi x 1.17 = 39.78 ft/mi

STEP 4: Determine length of pipe and fittings

$\frac{168 \text{ ft}}{5280}$ = .03 mi   2.5 mi + .03 mi = 2.53 mi

STEP 5: Determine Hf

Hf = 2.53 mi x 39.78 ft/mi
Hf = 101 ft

PART E – LINE FILL

Line Fill. The amount of fuel in pipelines and manifolds must be taken into account for several reasons. In the initial planning stages of the pipeline, this becomes a requirement above that required for the units supported. Taking into account the fact that the pipeline is always full but must be accounted for on the books is very important. The length of the line and the size of the pipe can be obtained from blue prints or drawings.

The volume of fuel in the line can be obtained by use of the following equation:

V= 5.13 constant
$V = d^2 \times 5.13$

V = Bbls per mile

d^2 = Inside diameter of pipe in inches squared
5.13 constant

Example: $d^2 = 8.415$
Pipeline length 3 miles

8.415 x 8.415 x 5.13 = 363 Bbls/per mi

363 x 3 = 1089.8 or 1090 BBLS in 3 miles of pipe.

LESSON 2

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check your answers with the answer key. If you answer any items incorrectly, go back to the part of the lesson that contains the information involved and study again.

1. A petroleum pipeline, with an 8-inch inside diameter is pumping crude oil with a kinematic viscosity of 5.7 10-4 ft^2/sec at a rate of 325 gpm. What is Reynolds number for this pumping condition?
   A. 2,244.2.
   B. 2,422.2.
   C. 4,224.4.
   D. 4,422.2.

2. You are operating a 9.7-mile-long pipeline (4-inch LWST) which supplies an airbase with JP4. The average product temperature will be 75 degrees Fahrenheit and the desired flow rate is 8,520 bpd. Your assistant was tasked to compute the head loss due to friction for this situation. Thus far, it has been determined that the 8,520 bpd was the same velocity as 5.38 ft/sec and the Reynolds number was 188,041. Your assistant is not familiar with the Darcy-Weisbach equation and asks you for your help. What is the total head loss due to friction in the system?
   A. 1129 ft/hd.
   B. 1192 ft/hd.
   C. 1292 ft/hd.
   D. 2192 ft/hd.

3. What is the head loss due to friction for any 1 mile of pipeline if the flow rate in question 2 were to change to 350 gpm?
   A. 214.9.
   B. 241.9.
   C. 291.4.
   D. 412.9.

4. How far can you pump JP4 at a flow rate of 1,320 bph and a temperature of 40 degrees Fahrenheit through a pipe with an inside diameter of 7.981 inches if you have 1,150 feet of head available to overcome the friction loss?
   A. 15.5 mi.
   B. 15.9 mi.
   C. 19.5 mi.
   D. 19.9 mi.

5. You are pumping AVGAS at a flow rate of 650 gpm and a temperature of 10 degrees Fahrenheit through a pipe with a diameter of 6 inches and a wall thickness of 0.12. In order to pump the fuel 9 miles, how many feet of head must you have available to overcome the friction loss?
   A. 1467 ft/hd.

B. 1647 ft/hd.
C. 1674 ft/hd.
D. 1764 ft/hd.

LESSON 3

DESIGN

Critical Tasks:
101-519-4260
101-519-4310

OVERVIEW

Lesson Description:
This lesson covers basic principles necessary to plan and design a petroleum pipeline operation.

Terminal Learning Objective:

Action: The soldier will learn the basic principles necessary to plan and design a petroleum pipeline operation.

Condition: Given subcourse QM 5099.

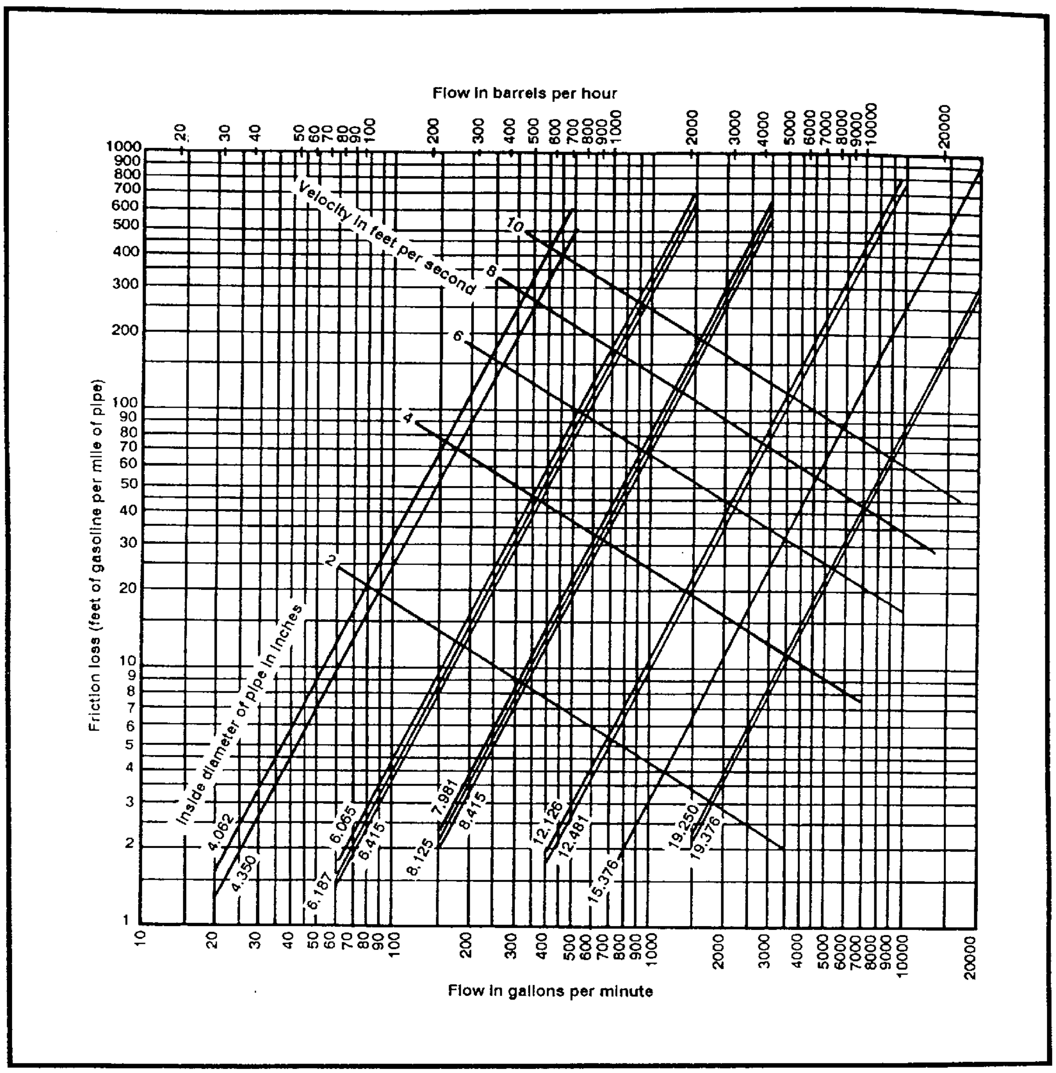
Standards: The soldier must score a minimum of 70 percent on the end of subcourse examination.

INTRODUCTION

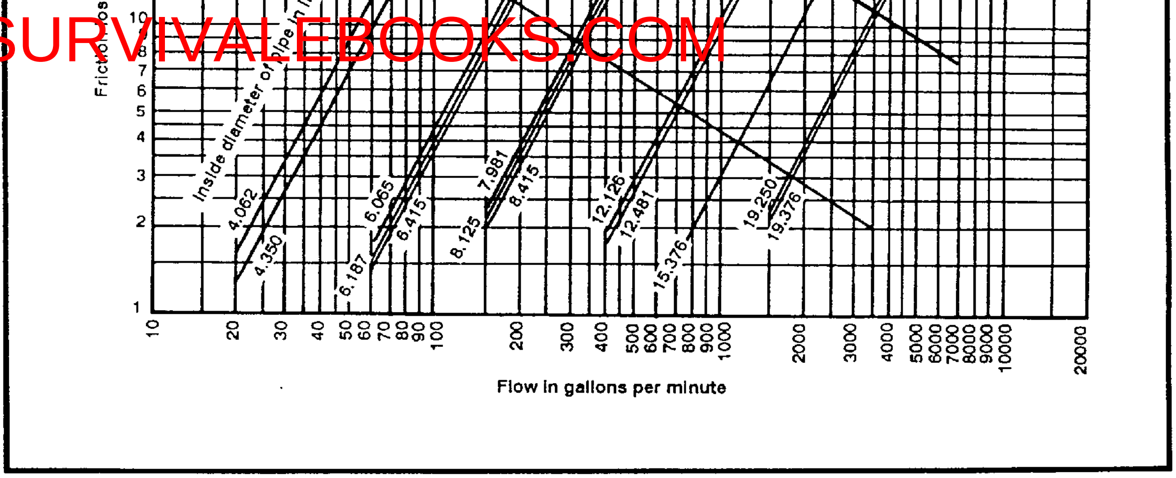
It is very important to fully understand the layout and design of a petroleum pipeline for effective and safe movement of fuel. As a result of this instruction you should be able to apply the basic principles to plan and design a petroleum pipeline.

PART A - HYDRAULIC GRADIENT

Placing Pump Stations Using the Hydraulic Gradient: Although you will not be required to place pump stations while you are here in the school, it is very important that you understand the principles of how it is done. Given a flow rate (Q) of 600 gpm, Mogas at 60° F and a pipe diameter of 6.415 inches, we can determine Hf = 97 ft/mi (Figure 3-1). This chart is constructed to show miles on the horizontal axis starting at zero on the left and ending at 80 miles on the right hand side of the chart. The left



vertical column shows elevation in feet of head starting at zero and ending at 4000 feet of head. The pipeline trace is represented by the ground



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Determin+e the Hydraulic Gradient: To determine the hydraulic gradient for the chart, multiply 97 ft/mi by 10 miles = 970 ft. Locate 10 miles on the bottom horizontal axis and 970 ft on the left vertical axis. Draw a straight line between the two; this establishes the slope of the Hg. Find the total head for a 6 inch pipeline 1362 ft/hd (Figure 3-2). Using the hydraulic gradient as a guide, draw a parallel line from 1662 ft/hd down to the pipeline trace at 950 ft/hd at 7.5 miles. This is your True Gradient. From the True Gradient back up 64 ft of head to meet the minimum requirement of 20 psi at each pump station. Using the hydraulic gradient as a guide, draw a parallel line from 1598 ft/hd down to the pipeline trace at 900 ft/hd at mile 7. This is your Design Gradient. We will locate pump station 2 at this point. At pump station 2, draw a vertical line up 1362 ft/hd, now draw a parallel line down to the pipeline trace at mile 22.75 and 810 ft elevation. This is the location of pump station number 3. Simply continue this procedure to place the remaining pump stations. The end of the profile is the Head Terminal (HT). From pump station 4, you can see that the line does not come in contact with the pipeline trace, at this point there is a terminal and the fuel will enter the terminal at 1190 ft/hd or 373 psi. Use the formula shown below.

Where:
P = pressure, in psi
H = head, in feet
SG = specific gravity

$$P = \frac{(h)\ (SG)}{2.31} \quad \text{or} \quad P = (0.433)\ (h)\ (SG)$$

and

$$h = \frac{(2.31)\ P}{SG} \quad \text{or} \quad h = \frac{P}{0.433\ (SG)}$$

Fi ... ions

Size of Line Nominal (in)	Pump Units per Station		Normal Design Capacity							Emergency Capacity						
	Number	Type	Number of pumps operating	Net available head (ft)	Net available pressure (psi)	Barrels per hour	Barrels per day (24-hour operation)	Engine speed (rpm)	Hydraulic horse-power	Number of pumps operating	Net available head (ft)	Net available pressure (psi)	Barrels per hour	Barrels per day (24-hour operation)	Engine speed (rpm)	Hydraulic horse-power
4	2	A	2	1,072	336	355	8,520	1,800	48.7	2	1,321	614	393	9,432	2,000	66.4
6	4	A	3	1,362	427	785	18,840	1,800	136.8	4	2,233	700	1,000	24,000	2,000	285.7
6*	2	C	1	1,800	565	857	20,570	2,000	197.7	1	1,800	565	1,143	27,429	2,100	263.3
8	4	B	3	973	305	1,355	35,520	1,850	168.7	4	1,522	477	1,730	41,520	2,100	336.8
8	2	B	2	313	98	2,860	68,640	1,850	114.4	2	354	111	3,570	85,680	2,100	161.7
12	4	B	4	201	63	7,150	171,600	1,850	183.8	4	217	68	11,400	273,600	2,100	316.4

[1]Based on fuel of 0.725 specific gravity and normal operating conditions
A - 4-inch, 4-stage
B - 6-inch, 2-stage
C - 6-inch, 3-stage
*6-inch aluminum pipe based on 0.85 specific gravity fuel

Figure 3-2. Operating characteristics of standard pipeline pumping stations.

Design Gradient/True Gradient: The difference between design gradient and true gradient is important for you to understand because of the suction pressures required. The normal suction pressure required is 20 psi or 64 ft/hd and the minimum is 5 psi or 16 ft/hd. Knowing this when we placed the pump stations using the true gradient our suction pressure is zero at pump stations 2, 3, and 4. The true gradient is represented by a solid line. The design gradient we will show as a dotted line 64 ft/hd below the solid line, insuring that each station will receive 20 pounds of suction pressure.

NOTE: For temperatures over 100 °F suction pressure required is 30 psi. Atmospheric pressure is comparable to static pressure in liquids. So, elevations above 3,000 ft design loads are decreased by 4 percent for each 1,000 ft of elevation. Hydraulic gradient is the rate of head loss due to friction. Pressure reducing stations are installed on long downhill slopes or grades.

PART B – PUMP STATION SUCTION AND DISCHARGE PRESSURE

Determining Pump Station Suction and Discharge Pressure:
Since the design gradient was used to place the pump stations we can now use the operating gradient to determine suction and discharge pressures. Our flow rate is 600 GPM, MOGAS 60° F. Our gradient is based on a loss of 97 ft/mi times 10 miles or 970 ft/hd loss over 10 miles. Starting at pump station number 1 (using our gradient) it will take 1398 ft/hd (439 PSI) discharge pressure to reach pump station 2 at 20 PSI (64 ft/hd).

If the fuel is DF with a gravity of .8448 this changes the head from 64 ft to 55 ft in order to maintain 20 PSI suction. At pump station 2 the parallel line will give you the suction and discharge head required. At pump station 4 we have a little different situation, assuming we must enter the terminal at 20 PSI or 55 ft/hd, using the hydraulic gradient and parallel lines our discharge head must be 100 ft/hd (37 PSI). This procedure can be accomplished by starting at the end of the pipeline on the right hand side of the graph or at pump station 1 on the left hand side of the graph. If we start at the end of the pipeline and work backwards the procedure is called back chaining; either way the system will work and becomes a matter of preference.

Using graph number 3 the procedures are the same except we will consider whether we can bypass any of the pump stations in case of an emergency or for efficiency. To accomplish this lets look at pump station 3. We must create enough head to get over the peak at mile 35. If we create 960 ft/hd (351 PSI) we can bypass pump station number 4 and enter the terminal at 510 ft/hd (187 PSI). Caution should be used in doing this as you run the risk of creating an over pressure on the pipeline on the long down hill slope at mile 28. Counting down from the gradient at this point we have 1,060 ft/hd

(388 PSI). The pipe will withstand 740 PSI (2,390 ft/hd) so we are well within our working pressure (Figure 3-3).

OD (in)	ID (in)	Barrels (per hour)	Velocity (ft/sec)	Average station spacing (miles)	Maximum safe working pressure (psi)
Normal Design Capacity					
4.500	4.350	355	5.5	7.9	600
6.625	6.415	785	5.4	16.6	600
6.625*	6.249	857	6.3	15.0	740
8.625	8.415	1,355	5.6	16.6	500
12.750	12.481	7,150	12.5	1.1	400
Emergency Design Capacity					
4.500	4.350	393	6.1	7.9	600
6.625	6.415	1,000	6.8	16.6	600
6.625*	6.249	1,143	8.3	9.0	740
8.625	8.415	1,730	6.7	16.6	500
12.750	12.481	11,400	20.0	0.5	400

* Aluminum pipe, based on fuel of 0.85 specific gravity; all others based on 0.725 specific gravity. Station spacing on level terrain.

LESSON 3

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check your answers with the answer key. If you answer any items incorrectly, go back to the part of the lesson that contains the information involved and study again.

1. What is the suction pressure required for temperatures over 100 degrees Fahrenheit?
   A. 10 psi.
   B. 20 psi.
   C. 30 psi.
   D. 40 psi.

2. What type of gradient is used to determine suction and discharge pressures?
   A. True.
   B. Operating.
   C. Hydraulic.
   D. Design.

3. What does the term "chaining" refer to?
   A. Start at the end of the pipeline and work backwards.
   B. Bypass any of the pump stations in case of emergency.
   C. Counting down from the gradient.
   D. Suction pressure required.

4. What is the normal suction pressure required?
   A. 10 psi.
   B. 20 psi.
   C. 30 psi.
   D. 40 psi.

5. What is the rate of head loss due to friction?
   A. Operating gradient.
   B. True gradient.
   C. Design gradient.
   D. Hydraulic gradient.

LESSON 4

SUPERVISE THE SELECTION AND PREPARE A CLASS III SUPPLY POINT

Critical Tasks:
101-519-3304
101-519-4316

OVERVIEW

When selecting and preparing a Class III site, an NCO should choose a site that is suitable for the fuel system layout and that is adaptable to factors such as cover and concealment, road nets, dispersion factors, terrain, and site preparation requirements. Proper movement and layout of the FSSP is important since it is the source of all petroleum products to a number of divisions stationed in any given area.

Lesson Description:
This lesson covers the principles of selecting a Class III supply point and using the Global Positioning System, movement of the Fuel System Supply Point (FSSP), how to identify the type and number of transporters needed to move equipment, fuel, and personnel, and how to perform supervisory skills required to accomplish this task.

Terminal Learning Objective:

Action: The soldier will learn to select a Class III supply point, operate the Global Positioning System, identify the number of transporters needed to move equipment, fuel, and personnel, and identify environmental considerations.

Condition: Given subcourse QM 5099.

Standards: The soldier must score a minimum of 70 percent on the end of subcourse examination.

PART A - PREPARATION FOR MOVEMENT

Tactical Operations. As the petroleum platoon sergeant, you can expect to be either in the advance party or main body during a movement operation. Since it is the advance party that does that actual on-the-ground site selection, the majority of this block of instruction will be based on your role as a member of the advance party.

As a platoon sergeant, the first notice you would receive of an impending move would be a warning order from your company commander. The warning order will probably be an oral order with general information on the time and date of the move, information on the destination, and the probable route.

After you get the warning order, the commander will probably leave the area and begin a route and site reconnaissance of the area assigned to him by the battalion operations S-3. While that is occurring, you should be preparing to move. Information needs to be passed out to your platoon, equipment needs to be checked, PMCS needs to be performed on your equipment, and if you have the time, all of your equipment needs to be laid out and checked for serviceability before it is loaded into the vehicles.

When the commander returns, he should have a sketch map of the route and the site. The map/diagram should show the route to the site and the general locations where each platoon will set up. If at all possible, the site should be as close to supported units as the tactical situation permits. The site should also be large enough to provide for two balanced storage sites because you don't want to put all of your product in one location. By splitting your storage assets, you reduce the possibility of losing all of your product to one accident or attack. The site should also have easy access to road nets with at least one road running through the supply point, but never near populated areas. These conditions should be discussed with the commander prior to you leaving with the advance party because you will be the one making the final site selection from the area allocated to you by the commander.

Advance Party. The commander will make the personnel selection for the advance party. The advance party should consist of at least one member from each section of the company. The executive office (XO) or senior lieutenant will usually be the advance party leader. Your local SOP should detail what equipment should go with the advance party, but at the very least, you will want to bring some engineer tape and marking devices to mark off the areas where you want the equipment to go.

Designated Area. Once you have identified exactly where you want each operation to go, designate the areas with engineer tape and signs. When the main body arrives, you or your representative should personally escort each truck to its designated area.

PART B - PLANNING AND ENGINEER SUPPORT

Planning. Before you begin to move the Class III and FSSP supply point, you must develop a plan. You will need to make sure you have all your personnel and equipment on hand when you begin to move the supply point. Find out how much time you have in which to prepare your crew and equipment for the move. There are some tasks that should be taken care of before you move. These include surveying the area to which you will be moving, coordinated with an engineer unit, and developing a flow plan.

Area Survey. Go over the area where the supply point will be located. Decide where to place the entire supply point. Choose an arrangement for the FSSP that fits the situation and the terrain. Also, decide where you want the truck parking, bulk storage (50,000-gallon collapsible tanks), and bulk reduction storage areas and other bulk reduction equipment.

Coordinate Engineer Support. When you go to look over an area for the first time, take a member of an engineer unit with you. After you choose a site for each part of the supply point, you can give this information to the engineers. With this information, the engineer unit can prepare individual tank sites, remove underbrush from bulk reduction areas, clear truck parking areas, and build an improved road through the site (if one is needed). If you do not have engineer support, your unit needs to prepare the site before you start setting up the equipment at the new site.

Develop a Flow plan. After you select the specific sites for the parts of the Class III supply point, develop a flow plan so that you do not handle products and containers more than is needed. The flow plan identifies steps which can be eliminated, combined, or changed to make the operation more efficient. It can also show unnecessary delays in handling and transporting. When developing the plan, consider the location of bulk storage, packaged product storage, bulk reduction, and can and drum cleaning areas. Also consider the flow of traffic through the supply point. Only one-way traffic should be permitted in the supply point. Study the area, and make a flow plan before the supply point moves to the new location.

PART C - SELECTION OF CLASS III SUPPLY POINT

Layout Design. Once the area has been declared safe for use by the advance party and communication has been established with the main body, actual site selection begins. In determining the layout of the system, you should use some of the factors the commander used in making his site selection such as:

- Adequate space to provide storage space and truck parking requirements for both your vehicles and your customer vehicles.
- A good road net with at least one road running through your operations. A good road is not a trail. A good road will hold up under heavy traffic and will not turn into a mud trap when it rains.
- Location is away from populated areas.

In addition to the above, you need to consider the following when you are making your selection:

- Use vacated forward sites or existing facilities if possible. Many times you will be able to inherit a site that was previously occupied by some other units. Usually they will leave behind improvements such as foxholes to the existing road network that you will be able to use for your operations.

- Avoid low areas so vapors do not get the chance to collect.
- Use reasonably level ground with no more than a 3-degree incline on any surface. If you set up on a larger incline, your storage tanks could roll when you start to fill them.
- Do not set up upstream of troop concentrations. Spills and accidents could pollute their water supply.
- Maximize the use of cover and concealment. Often, many of the components of a class III supply point can be concealed inside a wooded area or along a tree line. Other components can be hardened with sandbags.
- Distance between each storage tank. Forty feet is recommended for safe operations; however, the physical terrain features of the final site will dictate the actual distance between the tanks.
- One-way traffic flow with checkpoints at the entry and exit points.
- Different space requirements for bulk, retail, and packaged operations. The operating space to service retail customers may not be the same as for bulk customers. Usually, you will need a much-larger operating space for your bulk customers than your retail customers,
- Availability of other transportation modes. You should always try to take advantage of any rail loading facilities or barge loading points whenever possible.

Site Selection. Select a reasonably level site that can hold container stacks. Choose a site with good drainage so that water does not damage the containers. Avoid low areas because dangerous vapors collect in them. Do not use an area with a cinder base or marshland and wasteland overlaid with peat; they are usually damp. Use such areas only if no other site is available. Be sure the site has natural cover and concealment and is large enough for future expansion. Do not locate near other areas of operation (Figure 4-1). Stay at least 500 feet away for low-flash products and 200 feet for high-flash products. Your site must be away from overhead electric lines so a broken wire cannot fall on the drums. Clear the site of all underbrush that may get in the way or present a fire hazard. Spread sand, gravel, or similar material over areas where you store containers. They help drain the area and provide a more stable base for the stocks. Do not use ashes or cinders because they are corrosive. Build a dike at least 18 inches high around each major storage division in which low-flash products are stored. This dike must be able to hold all the liquid in the drums stored in the area and have a freeboard of at least 6 inches. Choose a site for at least two clearing (incoming and outgoing) areas. These will be used to segregate incoming and outgoing mixed loads (railroad cars or truckloads). Each area should have its own site. The sites should be located next to each other so that the same personnel can operate both areas.

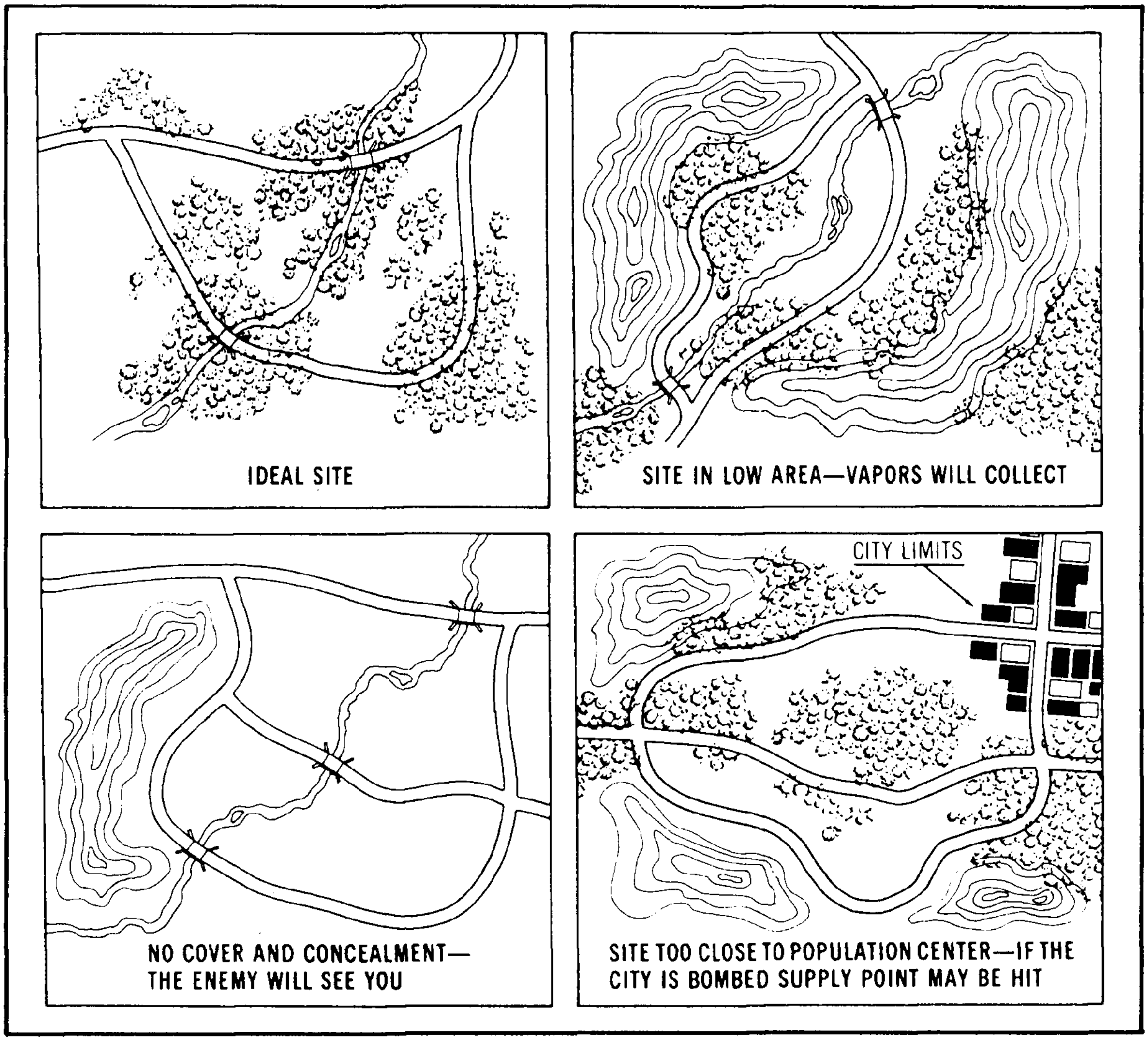

Figure 4-1. Site selection guidelines for a Class III supply point.

Selection Criteria for Equipment. You must also select a site for other equipment in the Class III supply point. This equipment includes 20,000-gallon collapsible tanks, 50,000-gallon collapsible tanks, and 500-gallon collapsible drums.

The site you choose for the 20,000-gallon collapsible tanks should be similar to that for the 10,000-gallon collapsible tanks. Choose a site that is nearly level with a gentle slope toward the manifold end of the tank. Space the tanks about 150 feet apart. Build a fire wall around each tank. Make it large enough to hold the contents of the tank and 1 foot of freeboard. To do this, build the fire wall 4 feet high and 18 inches wide at the top, and make the inside dimensions of the fire wall 35 feet long and 31 feet wide. Maintain a distance of 4 feet from the edge of the tank to the base of the fire wall. If an engineer unit prepares the site, you must ensure they follow these design factors. Place the discharge pumps at a level lower than the tanks to aid pump suction.

Choose a site for the 50,000-gallon collapsible tanks that is similar to that for the 10,000- and 20,000-gallon collapsible tanks. Build the fire wall 4 feet high and 18 inches wide at the top, and make the inside dimensions of the fire wall 73 feet long and 33 feet wide. Place the discharge pumps at a level lower than the tanks to aid pump suction.

For the 500-gallon collapsible drums, select a firm, level site near the source of supply. Select a site that allows drums to be easily lined up for filling and rolled away after filling.

PART D - PLANNING THE MOVEMENT OF THE FSSP

The FSSP is used at distribution points to provide storage facilities for transferring bulk fuel from one means of transport to another and at dispensing facilities for bulk reduction or delivery of fuel to using vehicles. The FSSP can receive product from tank trucks, railway cars, pipelines, hoselines, and aircraft. Since it can also receive fuel from ocean tankers, it is capable of supporting beach operations. It can store 60,000 gallons of bulk petroleum. It can store even more if additional or larger collapsible tanks are added. However, this expansion requires additional hoses, fittings, and valves. The FSSP can be easily moved from one location to another, and it can be divided in half to handle two different types of fuels at two different locations. It can also be changed to a 10-point, rapid-refueling system for rotary aircraft.

The first step in moving an FSSP is to receive the mission. Normally, as a section chief you receive the mission from the platoon sergeant or even the platoon leader. The mission can come in one of three different ways. A warning order, an operation order, or a fragmentary order. Once received, there are some questions you need to ask yourself:

- What is the mission?
- What is known about the enemy?
- How will the terrain affect the operation?
- What troops are available?
- How much time is available?
- What supplies and equipment are needed?
- What special tasks need to be assigned?

Personnel. Make sure that all personnel are on hand for the move to the new site. The usual strength level of a supply section in a petroleum supply company consists of a section chief E7, petroleum heavy vehicle operator E5, petroleum inventory control E5, two petroleum heavy vehicle operators E4, five petroleum supply specialists E4, and ten petroleum supply specialists E3. In some situations, you will have to augment personnel.

Equipment. Make sure your Class III supply point equipment is on hand and ready for use. If any items are not working properly, try to have them repaired or replaced before you move. The equipment may vary according to the situation.

- One Fuel System supply point.
- One collapsible fabric tank repair kit.
- Three 500-gallon collapsible drums.
- Three Pressure controls for filling nonvented drums.
- One 500-gallon collapsible drum tie-down kit.
- One 500-gallon collapsible drum towing and lifting yoke.
- Six 50,000-gallon collapsible tanks.
- Four 20,000-gallon collapsible tanks.
- Four 10,000-gallon collapsible tanks.
- Ten 350-GPM pumping assemblies.

- One fuel handling hose line outfit (assault hose line).
- One electric floodlight.
- One gas engine generator (3 kW).
- Eight filter/separators.
- One FARE system.

Make sure you have the necessary vehicles needed to transport the equipment to the new site.

- Four semitrailers, stake, 12-ton, with equipment.
- Four tractor trucks and 5-ton, 6x6, long wheelbase, with equipment.
- Two cargo trucks and 5-ton, 6x6, long wheelbase, with equipment.
- Two cargo trailers, 1-1/2 ton, 2-wheel, with equipment.

Loading Plan. Next you must develop a loading plan, a tentative plan, and issue a warning order to give soldiers time to prepare for the mission. Determine the total number and types of fuel transporters needed to move the product on hand. Determine the type and number of transporters needed to move the system. Determine the type and number of transporters needed to move personnel.

Your plans for loading personnel and equipment should apply to every type of transport that may be used in a movement. Make the plan before the move to allow time for packing. Base your plan on the type of transport to be used; the number of persons involved; and the type, size, weight, and quantity of supplies and equipment to be moved. When preparing the plan, consider the priority of loading and the safety of equipment and supplies in transit. Design the plan to permit quick and orderly unloading and regrouping of personnel and equipment. Once the equipment is loaded, make sure it is properly secured and make sure the pumps are braced, blocked, and tied.

Before you complete your plan, you need to have an idea where you will operate and what the terrain looks like. Consult the latest intelligence map or, if possible, conduct a reconnaissance and walk around the area. This will give you an idea about the type of terrain in which you will be working. Information from the reconnaissance can either change or delay the mission.

Once you complete your plan, issue an operation order. Once you complete the operation order, issue your order orally. Whenever possible, issue the order from a location where your soldiers can see their objective. If this cannot be done, use a terrain model or a sketch. When you issue the complete order, make sure your soldiers understand it. Be sure they know how you expect to accomplish the mission and how they fit into the overall plan. Explain to them what to do if you lose communication, and make sure you give the order in language they understand. The final step in troop-leading procedures is supervision. After you issue the warning order, you must diligently and constantly check details, conduct back briefs, rehearsals, and before the operation begins, inspect. Troop-leading procedures help you prepare your soldiers for any type of operation using logical step-by-step procedures. Use it as a mental checklist to make sure you do not overlook anything important. Keep in mind that no single individual can do everything by himself or herself, not even you. Use your subordinates and get the job done right.

Communications and Status Reports. The unit status report produces information to help the Army manage its resources. The payoff is military readiness. The Army wants the company to have it is authorized personnel on board, the authorized equipment available in working order, and the required supplies on hand. Additionally, the Army wants the company to do what it is supposed to do--turn out soldiers who assist the unit mission.

The Petroleum Supply Sergeant assists the platoon sergeant by supervising two shift operations and maintains close coordination with the petroleum operations sergeant. Every 24 hours the status report data from the supply sections will be consolidated, and a report will be sent to the supply control section. The format for the status report should be detailed in both the company and battalion SOPs.

PART E - SELECTING THE SITE FOR CLASS III SUPPLY POINT AND FSSP OPERATION

Selection Criteria for FSSP. When you select the FSSP site, consider cover and concealment, road nets, dispersion factors, terrain, and site preparation requirements. Make sure the site is suitable for the fuel system layout (Figure 4-2).

Select a site for the collapsible tanks, pumps, and filter/separators that is in the woods or in a tree line where the natural shadows disguise the telltale shapes. Use camouflage nets if you have them. When you lay hoseline, make use of natural terrain contours and vegetation to break up straight lines. One way to do this is to cut branches, stick them in the earth under the hose, and then weigh them down with the hoseline. Where you have deep grass or other vegetation, bend it over the hoseline to hide the hose so that it is not seen from the air.

Choose a site for the receiving, truck bottom loading, and vehicle refueling points that is next to a road in the Class III supply point. You can then load or unload trucks and refuel vehicles without leaving the road nets in the supply point.

You must consider the distance between items when you select the sites for the equipment in the FSSP. The distances can vary with the terrain, natural cover, concealment, hose available, and road nets. However, you must put the 10,000-gallon collapsible tanks at least 40 feet apart.

Select level terrain for the FSSP. Look for a tank site without slopes. A large slope may cause filled tanks to roll sideways, backwards, or forward. Put the pumps and filter/separators on level ground. Try to place the discharge pump at a lower level than the collapsible tanks so that there will be good suction to the pump.

Deal with these three major items of equipment in the FSSP--the collapsible tanks, the pumps, and the filter/separators. Slope the tank sites gently toward the manifold end to help drain the tanks when they are removed. Slope the site for each tank no more than 3 to 6 inches in the direction of the tank's fill port. Build a fire wall around each tank. Make it large enough to hold the contents of the tank and 1 foot of freeboard. To do this, build the fire wall 3 feet high and 18 inches wide at the top. Make the inside dimensions of the fire wall 26 feet by 26 feet and maintain a distance of 3 feet from the edge of the tank to the base of the fire wall. If an engineer unit prepares the site, you must ensure they follow these dimensional and procedural specifications.

The pump and filter/separator sites must be cleared of any dry grass, leaves, and trash.

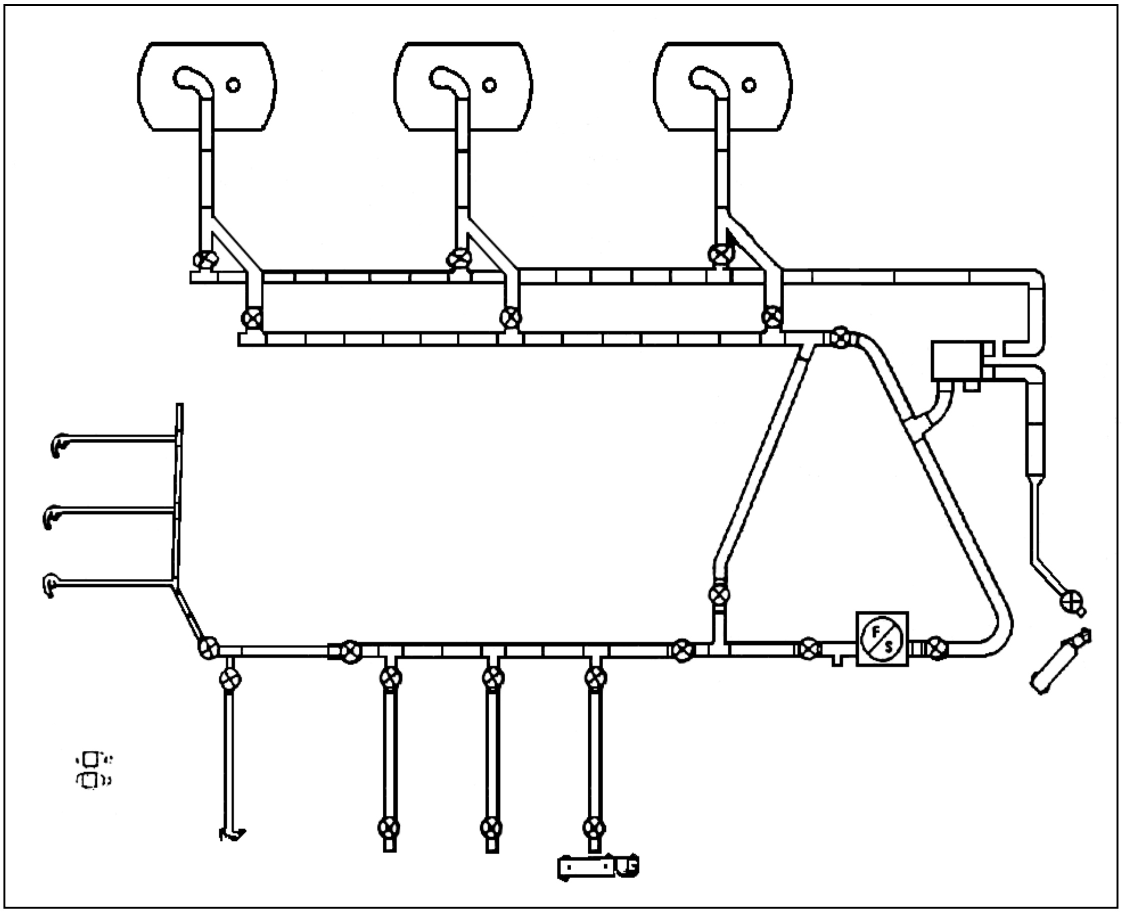

Figure 4-2. FSSP layout.

GPS Navigation. Each satellite transmits a unique signal that contains data needed by the SLGR to determine your location. The signal cannot penetrate objects such as buildings, metal, mountains; or very thick vegetation and your body tend to block it. Clouds, rain, snow and even severe weather have little effect on it. Canvas and kevlar covers do not effect it either. If you are not receiving signals from enough satellites, the SLGR will tell you this.

Move to a more open position, away from buildings and steep slopes so the antenna can receive the signals. Since the satellites are always moving, sometimes a short wait is needed until three or four satellites have moved into the view of the receiver.

Operation.

- Inspect the GPS and ensure that all required accessories are available.
- Turn the unit on and go to the SETUP Screen.
- Set SV Type to "MIXED" or "ALL-Y" in war time.
- Go to the SETUP UNITS page and set Elevation, MSL, DEG, MAG.
- Go to the SETUP MAGVAR page and set CALC and DEG.
- Set the time.

- Perform the SETUP I/O if required.
- Set the AUTOMARK Mode to OFF.
- Set the BULLSEYE screen as required.
- Set the OPERATOR ID if required.
- Set the APPROACH if required.
- Set the REHEARSAL if required.
- Initialize the unit.
- Obtain a position, record the Estimated Position Error, time, time error, date/day, speed, satellites being tracked, datum, magnetic variation, and if required, the azimuth and range to the bullseye.
- Enter and store the waypoints.
- Set the Navigation mode to 2D FAST and DIRECT.
- Select a waypoint.
- Record the distance, tracking azimuth, and azimuth to the waypoint.
- Navigate to a waypoint.

PART F - SUPERVISING THE MOVEMENT OF THE FSSP

Your next task is to direct the preparation of the FSSP equipment for transport. Make sure the system is drained of all product. Ensure that all spills are cleaned up and reported as required by unit policies and procedures and applicable environmental laws. Dispose of contaminated fuel and materials in an environmentally safe way in accordance with unit policies and procedures and applicable environmental laws. Direct personnel to roll or fold all collapsible tanks and put them in their storage containers, attach all caps and plugs to the hose assemblies as they are dismantled and place hose assemblies in canvas bags. Make sure equipment is properly loaded and that components are correctly placed, blocked, or braced as needed to prevent damage during transport.

Movement Methods. Moving (or displacing) the supply point consists of taking it down at one place, loading it on transporters, and moving it to the new site. There are two ways you can do this, and the one you use depends on your situation. One way is to move the entire supply point to the new site and the other way is to move by leapfrogging. This means you move one-half of the FSSP to the new site and leave the other half at the old site to give limited service. In this way, support to the user is not interrupted during the move. Divide the system in half. The first thing you do when moving is to transfer product at the supply point to fuel transporters. Tell the drivers of these vehicles how to get to the new site or to meeting points where they can exchange trailers or transfer the load to other tank vehicles. You can also use these transporters to store and issue product on a temporary basis at the old and new supply points. You can start to take down the supply point just as soon as you move the fuel. The sequence in which you take down the equipment should be based on the requirements at the old and new sites. Usually, you dismantle the FSSP first unless you are using the leapfrogging method. In any case, it is important that you work quickly once the order is given. Your main concern is to get to the new site as soon as possible and get set up.

Bulk Reduction Storage Area. Ensure that personnel set up, in the bulk reduction storage area, a separate stocking area for each product and type of package. If you have an area for each, you can inventory and control the stock more easily, and you are not as likely to identify the product incorrectly. Use a block system to separate large amounts of stored supplies so that the entire stock of one product is not lost if there is an enemy attach or a fire. Plan the exact layout and size of the stacking area according to local conditions and safety requirements. Aisles between double rows of drums (units) are usually 9 to 10 feet wide. You can reduce the width to 4 feet if this leaves you enough room to handle the product. Allow 15 to 30 feet for aisles between sections of containers and 50 to 150 feet between blocks. A specific layout of a stacking area for 5-gallon cans is suggested.

PART G - ENVIRONMENTAL CONSIDERATIONS

Supply and storage facilities often contain HM. Ensure that personnel take precautions when storing and transporting these materials. Keep a copy of the applicable MSDS for each HM on hand in a binder in the storage area. You can support your installation's environmental goals in supply areas by doing the following:

- Compliance. Ensure that personnel store materials according to the manufacturer's guidelines, as stated on the MSDS.
- Prevention. Ensure that personnel reduce the amount of solid wastes and HW in the supply room by avoiding stockpiling or keeping items around "just in case they are needed." Reuse containers whenever possible. Recycle materials as required by your installation's recycling program.
- Conservation. Ensure that personnel dispose of all solid wastes and HW according to local policy.

LESSON 4

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check your answers with the answer key. If you answer any items incorrectly, go back to the part of the lesson that contains the information involved and study again.

1. When directing the preparation of the FSSP equipment for transport, what should you do first?
   A. Make sure the system is drained of all product.
   B. Make sure equipment is properly loaded.
   C. Direct personnel to roll all collapsible tanks.
   D. Dispose of contaminated fuel.

2. The first notification that the FSSP is to be moved can come as which of the following?
   A. A caution order.
   B. A preparation order.
   C. An operation order only.
   D. A warning order, an operation order, or a fragmentary order.

3. When creating a loading plan for movement of the FSSP, what factors should the plan be based on?
   A. Amount of contaminated fuel to be moved and distance to new site.
   B. Weight of transport and availability of suspension kits.
   C. Type of transport to be used and quantity of supplies.
   D. Operation order guidelines and reconnaissance results.

4. The last thing you should do as an NCOIC before a FSSP movement operation begins is
   A. Prepare a loading plan.
   B.. Conduct a reconnaissance of the new site
   C. Issue the operation order.
   D. Inspect all aspects of the plan including all equipment to be used for the movement and operation of the FSSP
   .

5. Where should you issue your oral operation order for movement of the FSSP whenever possible?
   A. From a position of concealment.
   B. From a location where your soldiers can see their objective.
   C. On the reconnaissance site.
   D. Close enough to your soldiers so they can continue preparing for movement.

LESSON 5

SUPERVISE THE OPERATION OF THE FSSP

Critical Tasks:
101-519-4305
101-519-4313

OVERVIEW

Proper operation and maintenance of the FSSP is important since it is the source of all petroleum products to a number of divisions stationed in any given area.

Lesson Description:
This lesson covers supervising the operation and performance of operator maintenance on the pumps and filter/separators of the Fuel System Supply Point (FSSP), including the preparation of advance sheets and proper safety precautions.

Terminal Learning Objective:

Action: The soldier will learn to supervise the operation of the FSSP and performance of operator maintenance on pumps, filter/separators, and related equipment.

Condition: Given subcourse QM 5099.

Standards: The soldier must score a minimum of 70 percent on the end of subcourse examination.

PART A - SUPERVISING THE OPERATION OF THE FSSP

Flow Through the FSSP. Inspect the fuel when it arrives. The product then enters the system through the receiving manifold. It usually moves under suction from one of the 350-GPM pumps used as a receiving pump. The product may also move under positive pressure from a transporter, pipeline, or hoseline. When you have both filter/separators installed on the delivery side of the system, the receiving pump distributes the product directly to the tanks through the hoseline manifold. The other 350-GPM pump is used to draw fuel from the tanks and discharge it through the two filter/separators into the hose header system. When you leave one filter/separator installed on the receiving side of the system, the receiving pump distributes the product to the receiving filter/separator and then to the collapsible tanks. After than, the flow of product is the same, except the fuel is drawn through only one filter/separator on the discharge side of the system instead of two. You can also draw from the supply source directly to the discharge side of the system. This procedure bypasses the storage tanks. You need only one pump and one filter/separator for this operation.

Flow Through the 50,000-Gallon Collapsible Tank. The first step is the inspection of the product. The fuel then enters from the transporter through a receiving manifold made up of a suction hose and gate valve. The product usually moves under suction from a 350-GPM pumping assembly that distributes it into the 50,000-gallon collapsible tank. Another 350-GPM pumping assembly acts as a discharge pump and distributes the fuel from the tank to the discharge hose assembly. The discharge hose assembly consists of a gate valve and discharge hose. From the discharge hose assembly, the product moves into a transporter (Figure 5-1)

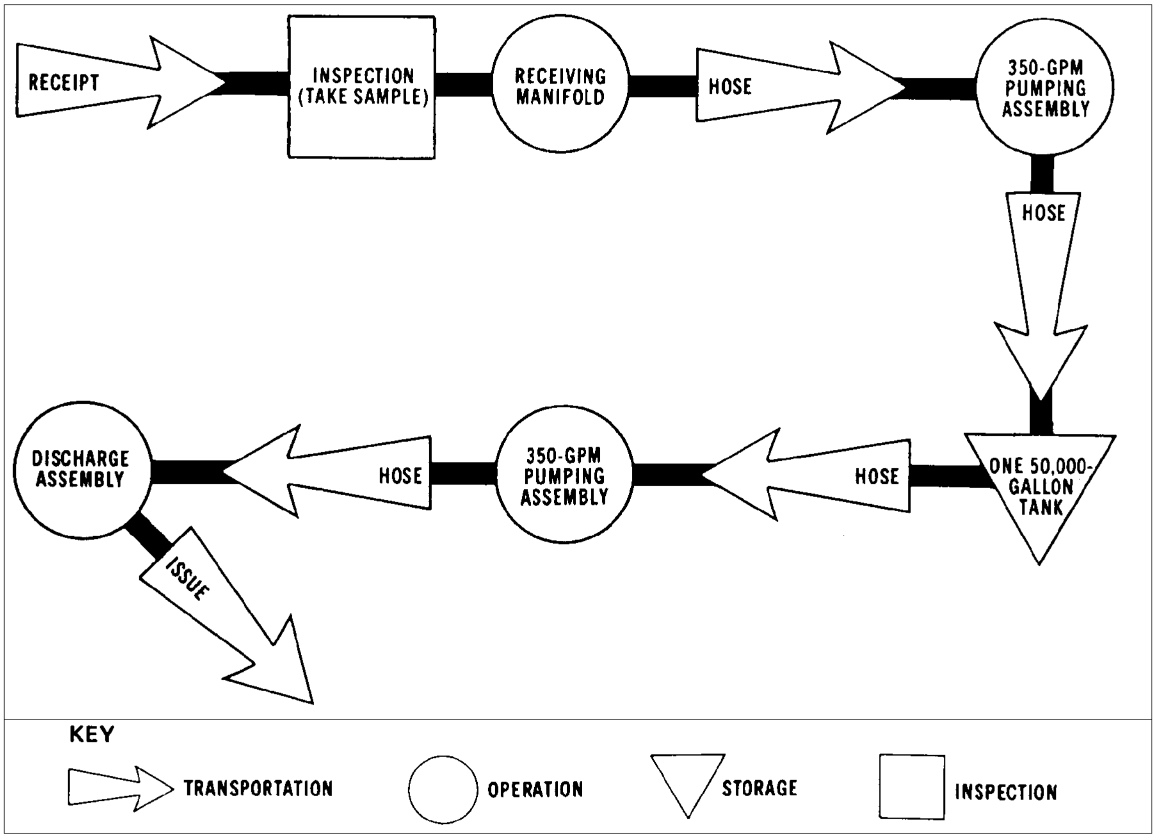

Figure 5-1. Flow process chart for a 50,000-gallon collapsible tank.

Personnel. How you use your personnel is one of the most important parts of managing a Class III supply point. In other words, how many do you need for a specific operation? Where should you place them in relation to the equipment? What tasks should you give them to do? It is important that you assign specific tasks to your personnel at the Class III supply point, but you should also try to be flexible. The best way to use all of your personnel wisely is to let the job determine the assignment. For example, if you have no issues scheduled for the FSSP, you can use the workers assigned there to improve the fire walls around the collapsible tanks. On the other hand, there may be a time when the supply point, or a section of it, is not busy. You may then use your workers to improve the camouflage and concealment of the area, improve drainage ditches and roadways, make sure the safety equipment is serviceable, and do operator and organizations maintenance on the equipment in the supply point. Although the number of persons you assign to a specific task may vary greatly with your mission, it is still possible to obtain an average number for each operation.

For a single shift, you need eight workers to operate the FSSP efficiently. Place them at certain strategic points in the operation. Assign two workers to the receiving manifold. They operate all valves at the receiving point and make all necessary hose connections. Assign three workers to the pumps and control valves. Have one worker operate each pump, and the third worker operate the discharge and receiving manifold of the collapsible tanks. Assign three workers to the delivery side of the system. Make them responsible for dispensing petroleum and controlling the fuel flow. When tank vehicles are filled, have the truck driver help dispense the fuel.

Receipt. Before a product arrives, you should be notified of the type and amount of product and the approximate date and time it will arrive. This will give you time to prepare a delivery schedule to avoid delays and interruptions at a Class III supply point.

Storage. At the tactical Class III supply point, you should always store bulk petroleum in collapsible tanks. If you are in a supply section of a petroleum supply company, you can store up to 420,000 gallons of bulk petroleum (120,000 gallons in the FSSP and 300,000 gallons in the six 50,000 gallon collapsible tanks.) But storage is much more than putting product in a tank. It involves such things as inspections, product circulation, tank repair, and even the disposal of excess product. The storage of bulk petroleum can be as dangerous as its receipt and issue, so always follow applicable procedures.

Inspection. Inspections are the key to finding out how well your Class III supply point is performing. They give you first hand information on how the equipment and products are maintained from day to day. Inspections let you make on-the-spot corrections. They also give you information on the availability of required publications, accuracy of supply records and procedures, supply economy practices, care of tools and equipment, and status of authorized stock levels of equipment and repair parts.

Product Consolidation and Circulation. When you consolidate or circulate product, you simply move it from one storage tank in the supply point to another. You should consolidate your stock so that several storage tanks are filled with product and several are empty. This way you can be ready to receive and issue large quantities of bulk petroleum on short notice. You also cut down on the number of tank switches you have to make during receipt and issue. Circulate the stock in your supply point so that the heavier portions of the product do not settle to the bottom of the tank and the light ends do not come to the top. Also, circulation ensures a good mixture of all the additives in the fuel.

Disposal of Excess. If you are in CONUS or an overseas activity and you have an excess in bulk or packaged fuels of 500 gallons or more per product grade, report the excess by sending a message to the Commander, USAPC. Include in your message the quantity, type of product, NSN, and the latest laboratory, test results. If you are in an overseas command, also report the excess to the appropriate DESC field office or the JPO.

Issue Considerations. Issuing bulk petroleum is perhaps the most important responsibility you have at the Class III supply point. The reason you are in the field is to get large quantities of petroleum to the units you support. In the theater of operations, you issue liquid petroleum in bulk as far forward as the tactical situation permits. Usually the units you support pick up the bulk petroleum from the supply point in their own vehicles. When you use the FSSP, make your bulk issues from the bottom loading points. Before issuing bulk petroleum from your Class III supply point, preferably before any transporters arrive, you must prepare an issue schedule. Start by telling your customer how much and what type of product you have on hand and when he can pick it up. If your transporters are delivering the product, tell the customer when it will arrive at this supply point. Try to avoid delays and interruptions when you are scheduling issues, that is, do not schedule more transporters to arrive at your supply point than you can handle at one time. Also, ensure that you have enough product on hand to fill all scheduled issues.

Safety and Security Items. Once your supply point is set up, you must take steps to make sure it is safe and secure. Ensure that personnel set up a checkpoint at the entrance and one at the exit of the operating area. Give personnel coming to the area a safety briefing at entrance checkpoint. Use the checkpoints not only to control the vehicles going in and out, but also to account for the receipt and issue of petroleum in the supply point. Develop a fire plan. You must set up many different types of signs in the area of operation. Place stock locator signs at petroleum storage areas, including bulk reduction storage sites. Place signs identifying NO SMOKING areas and dangerous areas throughout the supply point. You must also set up speed control and traffic direction signs.

PART B - DEFENSE PLAN

Rear Area Protection (RAP). Rear area protection operations may be defined as all actions taken to prevent or neutralize localized enemy threats to units, activities, and installations in the rear area. It includes area damage control (ADC) prevention and control measures which are taken before, during, and after an attack or natural disaster to minimize its effects. Together, these actions represent an added dimension to the responsibilities of theater army area command (TAACOM), corps support command (COSCOM), and division support command (DISCOM) commanders. Thus, combat service support units may have to be diverted temporarily from their primary missions to rear area protection tasks such as local security, base defense, firefighting, decontamination, emergency medical treatment, and traffic control. The commander responsible for rear area protection operations determines the manner and extent to which these units will be diverted.

The theater army commander has overall responsibility for RAP operations within the COMMZ. In the corps, the deputy corps commander is the RAP officer who directs the rear area battle. To assist these individuals in defining and assigning RAP responsibilities, a rear area operations center (RAOC) is assigned to each TAACOM, area support group, and corps. The RAOC's mission is to plan, coordinate, advise, monitor, and assist in directing the execution of the rear area battle. Petroleum units interface with the RAOC.

Phases. Rear area protection may be divided into two phases -- the preparation phase and the operational phase.

The preparation phase includes preventative readiness measures taken before an enemy attack. These operations range from the initial planning to the actual reconnaissance, surveillance, and counterintelligence operations. Measures taken during this phase include establishing local security elements; organizing, equipping, and training units specifically designed for these missions; assigning area responsibilities; and establishing communications and warning systems. SOPs are written and rehearsed, and route patrolling and convoy escorting are carried out.

The operational phase includes measures taken during or after an attack or a natural disaster. These actions begin when an incident occurs and include units sending reports to the commander concerned on the nature and extent of the damage. These reports allow for necessary estimates and orders for establishing route clearances and redirecting supply flow. Thus, interruption of support to combat forces is reduced. Combat forces receive data in time to change priorities and tactical plans if needed. Fire prevention and firefighting actions are conducted. Salvage and search and recovery operations begin on order. Traffic and personnel movement controls are established. If necessary, nuclear, biological, chemical (NBC) decontamination is begun. Emergency supplies are distributed, and communications are reestablished.

Petroleum Group. The extent to which the petroleum group becomes involved in rear area protection is prescribed by higher authority. The group and its units stand ready to participate in these operations as directed. Consequently, the group security officer stays in close contact with the RAOC. The group security officer also supervises development of petroleum group rear area protection plans and procedures. He directs implementation of plans and procedures by subordinate elements.

Protection of Petroleum Supplies. Protective measures for petroleum supplies include special packaging, proper storage, and dispersion of supplies and installations. Protection against chemical contamination and nuclear fallout, and maximum use of natural and artificial protective shelters or other shielding devices. Every advantage is taken of natural cover and camouflage for pipelines located above ground. Underground pipelines are use whenever possible. Embankments and underground storage facilities can be effectively used to reduce blast damage. Dispersion of packaged supplies limits and keeps under control fires that start as a result of a nuclear explosions. Care is taken to keep combustible materials to a minimum in and around petroleum supply installations.

Demolition. Demolition is a command responsibility. It is performed only as a last resort and only to prevent supplies and equipment from falling into enemy hands. Except in emergencies, demolition is performed only on orders from higher headquarters. Unless otherwise specified, petroleum stocks are destroyed by burning.

PART C - ENVIRONMENTAL CONSIDERATIONS

Supply and storage facilities often contain HM. You must ensure that personnel take precautions when storing and transporting these materials. Keep a copy of the applicable MSDS for each HM on hand in a binder in the storage area. You can support your installation's environmental goals in supply areas by doing the following:

- Compliance. Store materials according to the manufacturer's guidelines, as stated on the MSDS.

- Prevention. Reduce the amount of solid wastes and HW in the supply room by avoiding stockpiling or keeping items around "just in case they are needed." Reuse containers whenever possible. Recycle materials as required by your installation's recycling program.
- Conservation. Dispose of all solid wastes and HW according to local policy.

PART D - PREVENTIVE MAINTENANCE CHECKS AND SERVICES (PMCS)

Emergency Tank Repair. If any of the collapsible tanks develop a leak, repair them at once with emergency repair items. There are two methods of repair: one uses sealing plugs and one uses sealing clamps. The one you use depends on the size of the rupture. Use a sealing plug if the hole in the tank is 3/8 of an inch or smaller. Use a sealing clamp if the hole is larger than 3/8 of an inch. Whatever method you use, ensure you put on rubber gloves and the protective hood before starting the repair operation.

Forms. During operation of the FSSP, operator maintenance is performed on pumps, filter/separators, and related equipment. Forms are prepared to schedule inspections and preventive maintenance and to record the results of inspections and the need for repairs. They are also used to report preventative maintenance performed, to note repairs made, and to request services of support maintenance. In addition, forms are used to keep track of the time equipment is in use or out of service, and to provide data for reports on the condition and status of equipment.

- DD Form 314 (Preventive Maintenance Schedule and Record) is used to show when equipment is scheduled for periodic preventive maintenance and when maintenance has been performed.
- DA Form 2404 (Equipment Maintenance Schedule and Report) is used to report faults or malfunctions discovered by an equipment operator.
- DA Form 2407 (Maintenance Request) is used by organizational maintenance personnel mainly to request support maintenance.
- DA Form 2409 (Equipment Maintenance Log (consolidated)) is used to keep a complete maintenance history on a piece of equipment.
- DA Form 4177 (Utilities Inspection and Service Record) is used to schedule inspections and preventive maintenance on a fixed utility or structure such as a storage tank.

LESSON 5

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check your answers with the answer key. If you answer any items incorrectly, go back to the part of the lesson that contains the information involved and study again.

1. For a single shift, how many workers do you need to operate the FSSP efficiently?
   A. Four.
   B. Six.
   C. Eight.
   D. Ten.

2. What are the three workers on the delivery side of the FSSP system responsible for?
   A. Making all necessary hose connections.
   B. Dispensing petroleum and controlling the fuel flow.
   C. Operating each pump.
   D. Operating the discharge and receiving manifold of the collapsible tanks.

3. Which phase of a RAP includes measures taken during an attack?
   A. Preparation.
   B. Combat service support.
   C. Operational.
   D. RAOC.

4. Which of the following is a method of supporting your installation's environmental goals in supply areas?
   A. Avoid stockpiling or keeping items around just in case they are needed.
   B. Storing all HM in one centralized, controlled location.
   C. Replace containers whenever possible.
   D. Recycle all solid wastes.

5. When supervising operator PMCS on the FSSP, what information does DA Form 2404 provide?
   A. Inspection schedules.
   B. Requests for support maintenance.
   C. Faults or malfunctions discovered by an equipment operator.
   D. Complete maintenance history on a piece of equipment.

LESSON 6

DIRECT ASSAULT HOSELINE OPERATIONS

Critical Task:
101-519-3315

OVERVIEW

The assault hoseline can be considered a major artery of the Army mobile forces. It is used to supply petroleum products quickly to forward areas. Proper handling and operation of the hoseline is essential for the successful outcome of many missions.

Lesson Description:
This lesson covers the procedures to layout, operate, perform PMCS, and retrieve the assault hoseline.

Terminal Learning Objective:

Action: The soldier will learn to supervise the layout, assembly, testing, and repair of the assault hoseline, and use evacuation and displacement for retrieving the assault hoseline.

Condition: Given subcourse QM 5099.

Standards: The soldier must score a minimum of 70 percent on the end of subcourse examination.

INTRODUCTION

The assault hoseline system is intended to be used as a temporary pipeline and can transport fuel at a maximum rate of 500 to 550 barrels per hour across 10 miles of flat terrain. The use of the assault hoseline for transportation of bulk petroleum has become increasingly important as an expedient means of providing adequate quantities of bulk petroleum in the shortest time possible.

PART A - THE ASSAULT HOSELINE SYSTEM

Six soldiers and the following equipment are needed to lay out and assemble the hose line:

- Thirteen flaking boxes.
- One 350-gallon-per-minute (GPM) pumping assembly.
- A flow control kit.
- Ten steel roadway crossing guards.
- A hose suspension kit.
- A hoseline displacement and evacuation kit.
- A hoseline packing kit.
- A hose repair kit.

PART B - SAFETY AND ENVIRONMENTAL CONSIDERATIONS

Prior to the start of the mission, the troops must be briefed on any safety or environmental hazards they may encounter. The briefing should include the proper response to such hazards and other information which will enable them to correctly address less serious infractions independently. Each mission encompasses different situations and unit interactions so you need to develop a mission-specific briefing for each; therefore no one solution can or will be presented in this lesson. If your experience does not afford you a basis for preparing a briefing, contact a supervisor for additional information.

PART C - SUPERVISING THE LAYOUT, ASSEMBLY, AND TESTING OF THE ASSAULT HOSELINE

Choosing a Route. Select a direct route which is free of obstacles. If possible, try to parallel an existing road to aid construction, operation, and security. A route parallel to a secondary all-weather road is better than a heavily traveled main supply route. Take advantage of natural cover such as fencelines, woods, and hedgerows. However, do not disturb the natural cover by grading or leveling. Try to avoid rocky areas which might damage the hose.

It is possible to distribute the hose at speeds up to 35 MPH. However, the recommended maximum speed is 20 MPH. As the hose is distributed, men spread out along the route (at least two each 1/4 mile), walk the line to straighten out undesirable kinks or bends, and remove small obstructions which might cause damage when the hose is pressurized. When distributed on a road, the hose must be picked up from the roadway itself and moved to a position in the road ditch (Figure 6-1).

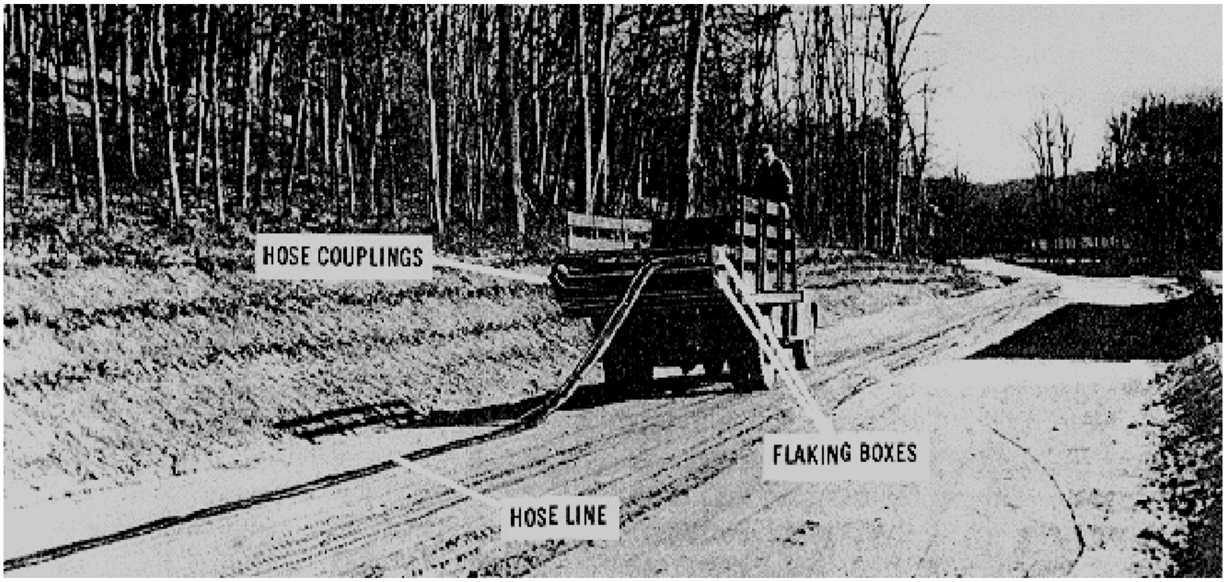

Figure 6-1. Laying the assault hoseline on a road.

Crossing Streams. There are several ways you can ensure that personnel lay the hoseline across a stream or water course. If there is a bridge, suspend the hoseline on improvised brackets outside the bridge railing. If there is no bridge, personnel may lay the hoseline directly in the streambed if it is narrow and not apt to flood. Use the hoseline suspension kit to cross a wide stream. Fabric saddles, with eyes for easy wire attachment, come with the kit.

Crossing Gaps. Personnel should also use the hoseline suspension kit to span small gaps with steep sides. For a wide crossing, ensure that personnel build a suspension bridge with a flat deck or floor to hold the hose. This eliminates the sags that occur when the suspension kit is used.

Crossing Roads. To cross a highway or railroad, run the hoseline under a bridge or through a culvert, if possible. Personnel can pull the hoseline through the culvert with a rope or push it through with a piece of lumber or a small-diameter pipe. If there is no bridge, ensure that personnel install the roadway crossing guard to protect the hoseline. Never bury unprotected hoseline in a railbed. When crossing a railbed, personnel can either install a piece of heavy wall pipe in a shallow ditch under the rails or suspend the hose over the railbed at a suitable height. As soon as possible, replace the hoseline at a railway crossing with welded pipeline because of the fire hazards caused by trains.

Pumping Stations. Assault hoseline pumping stations have one 350-GPM pumping assembly. If you are using only one hoseline outfit, ensure that personnel place the pumping assembly at the beginning of the hoseline system. Because this pump does not have a pressure-regulating device, you must monitor it at all times for changes in hoseline pressure. Personnel must set up pumping stations when they connect hoseline outfits together. There is a formula you can use to locate pumping stations on level ground using motor gasoline in the hoseline. If you use a product other than motor gasoline, the distance between pumping stations (given by this formula) changes. For example, if you use a product heavier than motor gasoline, the pumping stations should be closer together. If the product you use is lighter than motor gasoline, the pumping stations should be further apart. The distance between pumping stations (given by this formula) also changes with the height of the terrain. For example, if you place the hoseline on an uphill slope, the pumping stations should be closer together. If you place the hoseline on a downhill slope, the pumping stations should be farther apart.

Hoseline Testing. Once personnel have set up the assault hoseline, they should fill it, pressurize it, and check the hoseline for leaks. Ensure that personnel start the pumps slowly and raise the fluid pressure in the system gradually in increments of 50 PSI. Ensure that personnel hold the pressure each time they raise it, and inspect the hoseline for leaks. Keep doing this up to and including 150 PSI. Even though the design burst pressure of the hose is higher, your test should not exceed the rated safe-working pressure of 150 PSI. If the line pressure doesn't build up, personnel should stop and check the hoseline for a leak. Personnel can usually fix leaks at couplings, fittings, or valves by tightening, adjusting, or replacing gaskets.

Observe operations for safety and environmental infractions. Immediately shut down operations and correct any problems detected.

PART D - SUPERVISING THE EVACUATION AND DISPLACEMENT OF THE ASSAULT HOSELINE

Removing fuel, vapor, and air from the hoseline causes the hoseline to collapse into a flat ribbon-like form. This allows for the most compact storage of the hose for transportation to the next site. The hoseline is evacuated by personnel as follows:

- Remove the ball from the ball receiver; replace with an airtight cap (use a blank cap with grooved coupling).
- On the inlet end, disconnect the compressor hose from the ball injector.
- Attach the suction connection of the air eductor.
- Attach the air compressor hose to the inlet side of the eductor, and set the pressure at 20 to 25 PSI.
- Operate the eductor approximately 10 minutes for each 1,000 feet of hoseline.
- When the hose has flattened as much as possible, fold it back and tie a knot.
- Remove the ball injector and eductor.

When displacing the assault hoseline, ensure that personnel pack the hose into the flaking box making successive folds from left to right until you reach the front. Ensure that personnel bend the hose so that it fills the entire width of the box. Also, make sure the folds are packed tightly together so that you can get 1,000 feet of hose in the box. If the temperature is below 40 degrees Fahrenheit, personnel may have to use the hoseline packing kit to get the hose in the flaking box.

PART E - MAINTAINING COMMUNICATIONS

Communication breakdown is the single non-equipment-related item which can start a domino effect capable of bringing an entire mission literally to a halt. A missed communication regarding the emergency shutdown of the assault hoseline could leave a FSSP or FARE system without a source of fuel and strand dozens of aircraft and vehicles miles from a secondary source of fuel. The vulnerability of such vehicles and the loss of them to the enemy cannot be overstated. Accurate and timely communications with all levels of the supply team and command headquarters is imperative for the success of any mission requiring the use of the FSSP, FARE, and assault hoseline.

An efficient communication system is a must for the operation and maintenance of military pipelines. The system must be separate, continuous, and dependable. The communications system must have high-quality transmission to keep errors to a minimum, enough channels or circuits to carry the traffic load efficiently, prompt connections to avoid delays, and immediate alternate systems so there will be no interruptions in pipeline operations.

LESSON 6

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check your answers with the answer key. If you answer any items incorrectly, go back to the part of the lesson that contains the information involved and study again.

1. How many soldiers are needed to lay out and assemble the assault hose line?
   A. Six.
   B. Eight.
   C. Ten.
   D. Thirteen.

2. What should the safety briefing held prior to the start of the mission include?
   A. Procedures for guarding against tampering or pilferage.
   B. The standardized safety briefing provided in the unit SOP.
   C. Proper responses to any safety or environmental hazards.
   D. Detailed scenarios and solutions for all possible hazard situations, no matter how small the infraction.

3. If the temperature is below 40 degrees Fahrenheit, personnel may have to
   A. Apply heat tape to the length of the hoseline.
   B. Use the hoseline packing kit to get the hose in the flaking box.
   C. Decrease the distance between pumping units.
   D. Increase the distance between pumping units.

4. When testing the assault hoseline prior to use, the pressure should be increased in increments of
   A. 20 PSI.
   B. 30 PSI.
   C. 40 PSI.
   D. 50 PSI.

5. What qualities should an efficient communication system have for the operation and maintenance of military pipelines?
   A. The system must keep traffic to a minimum to avoid enemy interception.
   B. The system must be easy to disassemble and prepare for movement.
   C. The system must be dependable, separate, and continuous.
   D. The system must be monitored constantly for encryption purposes.

LESSON 7

DIRECT THE ASSEMBLY, OPERATION, PMCS, AND DISASSEMBLY OF THE FORWARD AREA REFUELING EQUIPMENT (FARE)

Critical Tasks:
101-519-3215
101-519-3317

OVERVIEW

All Army mobile forces must be ready to mobilize at all times. As a petroleum supply specialist you are responsible for the delivery of sufficient quantities of high quality petroleum products to all forward areas. Proper operation and maintenance of the FARE system is extremely important.

Lesson Description:
This lesson covers the use of the Forward Area Refueling Equipment (FARE) System, hot refueling of aircraft, and proper safety and environmental procedures.

Terminal Learning Objective:

Action: The soldier will learn to direct the placement, assembly, and operation of the FARE system.

Condition: Given subcourse QM 5099.

Standards: The soldier must score a minimum of 70 percent on the end of subcourse examination.

INTRODUCTION

Unit-level refueling operations in theaters of operation are usually carried out by individual aviation units. A lightweight, air-transportable, refueling system is used at the unit level. At present, the system authorized to most units that have the mission to refuel aircraft in forward areas is the Forward Area Refueling Equipment (FARE) system. This system can be set up by skilled personnel with 15 minutes of delivery to a site.

The FARE system is designed for refueling helicopters in forward areas. It is lightweight and can be flown to the refueling point by helicopter or fixed wing aircraft. The fuel for the system is usually flown to the site in 500-gallon collapsible drums. The FARE system can also use various size collapsible tanks, tank vehicles, or semitrailers as fuel sources.

PART A - FARE COMPONENTS

Components. The FARE system consists of a pumping assembly, filter/separator, and valves and fittings.

Pumping Assembly. The pumping assembly is made up of a 100 GPM centrifugal pump and a two-cylinder, four-cycle, 3-horsepower gasoline engine that powers the pump. The inlet and outlet connections are 2 inches in diameter. The pump has a priming port on the top of the pump casing. The pumping assembly and the engine’s fuel tank are all housed in a tubular aluminum frame.

Filter/Separator. The 100 GPM filter/separator is an aluminum tank with a removable cover. Five filter elements, each in a canister, are set in mounting plate near the bottom of the tank. The filter/separator has an air vent valve, a pressure differential indicator, a water sight glass, and a water drain valve that is turned by hand. The flow rate of the filter/separator is 100 GPM, and its top working pressure is 75 PSI. The filter/separator is mounted in a frame of tubular aluminum.

Discharge hose, suction hose and fittings. The FARE system has two sets of discharge hose, fittings, and nozzles. Each set is mounted in a tubular frame. Two canvas carrying cases hold the suction hose and their fittings.

Fire extinguishers are not components of the FARE system. Providing the extinguishers is a command responsibility. Three fire extinguishers are required for each FARE system used in aircraft refueling--one to be within reach of the pump operator and one for use at each nozzle. The recommended fire extinguisher is the 20-pound Halon 1211.

No fuel source is provided as a component of the FARE system. Generally, 500-gallon collapsible drums are used because they can be airlifted, full, to the FARE point. But the FARE system can also be adapted to use larger fuel reservoirs. The number of drums and tanks, as well as the type of fuel to be used, is determined by the number and type of aircraft the FARE point is to support.

PART B- FARE LAYOUT

Planning. The S3 of the aviation battalion or the operations officer of an aviation company plans the unit operations. As part of these plans, he chooses the general area for a refueling point and specifies the amount and type of refueling support needed. He or a pathfinder team must choose a site that has enough open ground for the aircraft to land and lift off safely. The site must be flat or have only a slight grade. When planning the layout of a FARE system, five factors must be considered.

- **Spacing Between Aircraft:** There must be at least 100 feet of space between these aircraft (center rotor to center rotor).
- **Wind Direction:** Ensure that personnel lay out the FARE system so that the helicopter can land, refuel, and take off into direct head wind or a left or right quartering head wind.
- **Vapor Collection:** By laying out the system at right angles to the wind for helicopter landing and takeoff, the wind will carry the fuel vapors away from the site.
- **Drainage:** Ensure that personnel do not put the equipment in a place where a spill will drain into a stream or river. Choose a part of the site that is firm enough to support the weight of the aircraft and the fuel drums.
- **Camouflage:** Camouflage is the only protection at a FARE point in a combat zone. Site features are depended upon because airlifting in camouflage materials is not practical.

Site Preparation. All sticks, stones, and debris should be cleared from the area. To prevent fires, ensure that personnel clear dry grass, leaves, and brush away from the pumping assembly. In some cases, engineer personnel prepare the site.

Layout. Once all equipment is on-site, ensure that personnel layout the FARE system in the way that is best for the specific situation. Tailor the layout to avoid obstacles, take advantage of terrain features, achieve maximum dispersion, and operate with a restricted amount of space. The only mandatory feature of the FARE system is the spacing between the aircraft (Figure 7-1).

- Position pump and filter/separator.
- Ground pump and filter/separator.
- Assemble discharge hose.
- Assemble discharge hose.
- Assemble dispensing points.
- Connect to two 500-gallon collapsible drums.
- Position fire extinguishers.

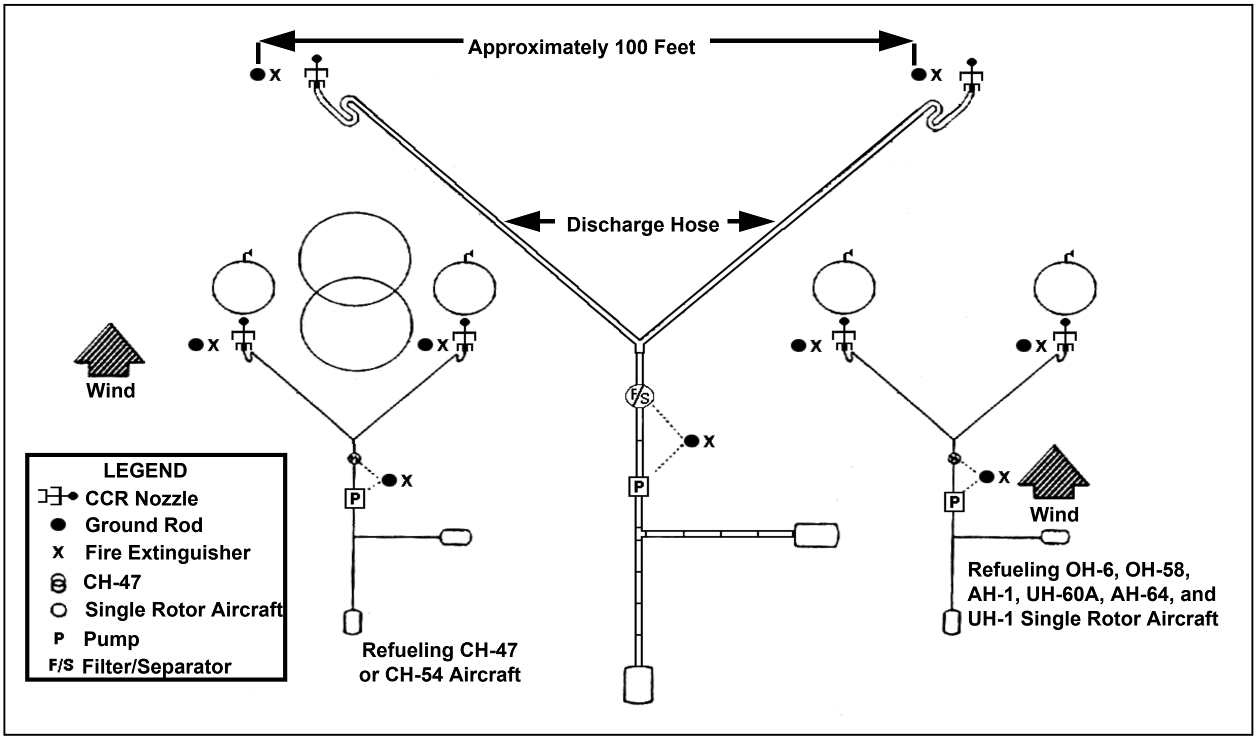

Figure 7-1. Typical FARE layout.

PART C – QUALITY SURVEILLANCE

The quality and cleanliness of turbine fuel are vital to the safety of turbine-engine-powered aircraft. Turbine engines have more stringent cleanliness requirements than do reciprocating engines. Because turbine engines have high fuel consumption rates, contaminants accumulate in them rapidly. Turbine engine filters cannot remove fine sediment, excess amounts of sediment, or water from the fuel. Separating the contaminants from JP-5 and JP-8 is time-consuming and further complicated by their high viscosity and specific gravity. Any unit or organization that has military-owned aviation fuel in its physical possession is responsible for establishing and maintaining an adequate quality surveillance program. Each person involved in aircraft refueling is responsible for ensuring that the fuel pumped into an aircraft is clean, bright, on specification, and does not contain any free water or sediment.

Quality surveillance testing and sampling are used to find common contamination hazards. The hazards that may affect aircraft are sediment, water, microbiological growth, and commingled fuel. Since each aircraft engine is designed to burn one particular type and grade of fuel, the consequences of using a mixture of different fuels can range from small variations in engine performance to total loss of power and engine failure. The consequences of commingling depend on the physical properties of the fuel.

Sampling and Testing. How often aviation fuels are sampled and tested depends on several factors. It depends upon whether the fuel is taken from a fuel source, a system or refueler, or an aircraft tank. Fuel supplies must be tested to confirm their identities (API gravity test) and detect water (Aqua-Glo test) and particulate contaminant by color comparator ratings. Samples of fuel to be dispensed to aircraft should contain no more than 10 fibers when a 1-quart sample is visually examined. The aviation fuel contamination test kit is designed to provide a final check on aviation fuel just before the fueling of an aircraft. It includes the API gravity test, the Aqua-Glo test, and the Millipore test (a test for particulate contaminants). Fuel in aircraft tanks must be checked by the aircraft crew before flight operations begin. Taking a preflight sample is the only way of ensuring that the fuel on board does not contain water or other visible contaminants. Any fuel that fails a visual check should be segregated and held until laboratory test results are received. To check a fuel, choose a clean sample bottle, draw a fresh sample, visually inspect it, and test it for debris, foreign matter, or water. Laboratory testing ensures that the fuel's quality meets specifications, unknown products and existing or potential contaminating causes are identified, unfavorable field test results are corroborated, and off-specification fuels are not used.

PART D - MAINTAINING COMMUNICATIONS

Communication is the single non-equipment-related item which can enable the FARE site to be a major factor in the successful mission. This communication is multi-level. Unless otherwise directed, you are responsible for informing the chain of command of the following:

- When the site becomes operational.
- When the site is shut down for any reason before the scheduled shutdown time.
- Report status of operations and any problems encountered as required by unit policy and procedures.
- When the site is shut down as indicated in the operations orders.

PART E - SUPERVISING THE OPERATION OF THE FARE

The FARE system should be primed and ready for operation as soon as it is laid out and the fuel has been sampled. There should be at least three people in addition to the ATC or pathfinder present during refueling operations. At least two of these people should hold MOS 77F. The proper procedure for refueling an aircraft are as follows:

- Land aircraft. Check to see that the armaments aboard the aircraft have been set to SAFE.
- Deplane crew and passengers. Only the pilot may remain in the aircraft during refueling. If required, a crew member may assist with the refueling by manning the fire extinguisher.
- Position fire extinguisher on the side of the aircraft by the fill port.
- Turn off radios. The pilot may monitor the radio used for air traffic control but must not transmit while actual refueling is taking place. The pilot and crew chief may talk by intercom during refueling.
- Ground and bound the nozzle to the aircraft. It should never be attached to the radio antenna or to a propeller.
- Remove dust cap from the nozzle and remove the plug from the aircraft fill port.
- Begin refueling. Be certain to observe the safety precautions associated with closed-circuit or open-port refueling, as the case may be.
- Replace aircraft fill port plug, and replace nozzle caps/plugs.
- Remove nozzle bond. Carry the nozzle back to its hanger.
- Remove fire extinguisher.
- Board crew and passengers.
- Direct aircraft to lift-off.

Additionally, you are required to monitor fuel stocks and accountability procedures and render status reports as required by unit policy. If any leaks or hazardous conditions are found the system must be shut down and the problem corrected before resuming operations. All spills must be cleaned up and reported as required by unit policies and procedures and applicable environmental laws. Dispose of contaminated fuel and materials in an environmentally safe way in accordance with unit policies and procedures and applicable environmental laws. You must also ensure that during and after PMCS are done and that DA Form 2404 or DA Form

5988-E is annotated with any faults or deficiencies found. The completed DA Form 2404 or DA Form 5988-E is returned to the motor pool with the equipment.

PART F - SAFETY

Switch Fueling. Switch fueling means supplying an aircraft with fuel that has flammability characteristics different from that which is already in the tank. The flammability characteristics of the mixed fuel will be different from the two fuels involved. The danger is that if a spark should occur in the tank, the vapor-air mixture above the fuel may be in the flammable range and an explosion could result. If an aircraft is to be switch fueled, the rate of flow at the nozzle should not exceed 50 percent of the rated flow. Changing to JP-4 after using a kerosene-grade fuel also constitutes switch fueling.

Heat. Aircraft, vehicles, and engine powered equipment generate heat by burning fuel. They also generate static electricity because of friction between moving parts. The engine heat of an idling aircraft turbine engine is in the auto-ignition range of JP-4. Poorly maintained vehicle engines may backfire or discharge sparks. Do not allow any work to be done on an aircraft's batteries while the aircraft is being refueled. Aircraft radios may operate to receive messages during refueling, but radio transmissions from the aircraft are not allowed because of the danger from arcing. Do not use flashlights within 50 feet of the refueling operation unless they are approved explosion-proof type. Do not allow electric handtools to be used in the refueling area. The electric circuits of tools used in refueling operations must be maintained in top condition to prevent short circuits around defects. And in addition, the beam of high-frequency radar equipment can ignite a flammable vapor-air mixture.

Open Flame. The danger of an open flame is that it will ignite fuel or a flammable vapor-air mixture. Do not allow any type of open flame, or any flame-producing device within 50 feet of an aircraft refueling operation.

Static Electricity. There are two ways to prevent static electricity from sparking. The charges on different materials can be equalized by connecting them with a conductor (bonding). Also, a way can be provided for the charges to dissipate harmlessly (grounding). The Army uses both of these methods to control static electricity.

Bonding is the process through which two conductive objects are connected to lessen their potential differences. Bonding does not dissipate the static electricity. It equalizes the charges on two unlike objects (an aircraft and a refueling nozzle) in order to preclude arcing as the two objects are joined. A nozzle-to-aircraft bond is required. This bond is made before the nozzle dust cap or fuel tank cap is removed. Likewise, do not disconnect the bond until refueling is complete and the fuel tank cap and nozzle dust cap are replaced.

Grounding is the process that provides a conductive path into the ground so that a static charge is not trapped on the surface of the equipment where it can discharge as a spark. This conductive path is made by connecting a conductive cable from the piece of equipment to a conductive metal rod that is driven into the earth to reach the level of permanent moisture. Common sources of static electricity are identified as follows:

- Vehicles
- Human body
- Lightning

Air Traffic Control. Air traffic control (ATC) is required for safe refueling operations. An air traffic controller or some other adequately trained person is required at each refueling point that serves more than one aircraft. This person controls and directs refueling traffic and resupply aircraft. He provides flight personnel with information such as wind direction and velocity, remaining fuel supply, enemy activity in the immediate area, hazards or obstructions to landing, and emergency situations. At a fixed airfield, full radio communication equipment is provided for controlling air traffic. At a large semipermanent or temporary refueling point a radio control tower should be used whenever aircraft are being refueled. In forward areas, personnel controlling air traffic should have FM radio suitable for ground-to-air or ground-to-ground communication. Aircraft marshaling signals and landing aids are necessary at semi-permanent and forward refueling points. In marking landing and refueling areas in the field, procedural principles should be followed closely especially in forward tactical areas.

PART G - ENVIRONMENTAL CONSIDERATIONS

You must pay close attention during refueling operations because of the potential for spills and fires. If you take simple precautions you will prevent large pollution problems. During refueling you can protect the environment by doing the following:

- Compliance. Follow your unit SOP concerning the types and quantities of items you can store at a fuel point.
- Prevention. Reduce the amount of soil contaminated during refueling by being careful not to spill fuel. Reuse rags and absorbent materials. Recycle used or contaminated petroleum, oil, and lubricant (POL) products.
- Conservation. Dispose of contaminated soil and absorbents according to the installation's policy and the unit's SOP.

LESSON 7

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check your answers with the answer key. If you answer any items incorrectly, go back to the part of the lesson that contains the information involved and study again.

1. What is the required spacing between aircraft at a FARE point?
   A. 75 feet.
   B. 100 feet.
   C. 150 feet.
   D. 200 feet.

2. Unless otherwise directed, which of the following are you responsible for informing the chain of command of?
   A. When PMCS is performed.
   B. When the site becomes operational.
   C. When fuel fails a visual check.
   D. When contaminated fuel has been disposed of.

3. During operation of the FARE, what are you required to monitor?
   A. Air traffic control transmissions.
   B. That crew and passengers remain on board the plane during refueling.
   C. Fuel stocks and accountability procedures.
   D. That there are at least five people in addition to the ATC or pathfinder present during refueling operations.

4. What is the greatest danger to personnel in refueling operations?
   A. Jet engine exhaust.
   B. Fire.
   C. Live armaments.
   D. Rotor blades.

5. During refueling operations, which of the following can be reused in order to protect the environment?
   A. Rags and absorbent materials.
   B. Contaminated POL products.
   C. Contaminated soil.
   D. Old containers.

LESSON 8

INLAND PETROLEUM DISTRIBUTION SYSTEM

Critical Task:
101-519-4310

OVERVIEW

Knowledge of the lay out, PMCS, and operations of the IPDS is an important skill when directing petroleum pipeline operations.

Lesson Description:
This lesson covers the lay out, PMCS, and operations of the Inland Petroleum Distribution System (IPDS).

Terminal Learning Objective:

Action: The soldier will acquire knowledge on the layout and operation of the IPDS and identify environmental considerations.

Condition: Given subcourse QM 5099.

Standards: The soldier must score a minimum of 70 percent on the end of subcourse examination.

INTRODUCTION

Since the days of World War II, petroleum NCOs have grappled with the challenges of moving fuel to the front lines of battle quickly and efficiently. Today's NCOs now have an advantage over their predecessors because they accomplish the task with the Army's inland petroleum distribution system (IPDS). The IPDS is the Army's primary method of receiving, storing, and distributing bulk fuel to support military forces deployed in worldwide contingency operations. The system consists of both commercial and military petroleum equipment made up of three primary subsystems: the tactical petroleum terminal (TPT), pipeline components, and pump stations. By successfully integrating these elements, troops can move fuel from any source forward into the theater of operations.

PART A - COMPONENTS

Inland Petroleum Distribution System (IPDS) is designed as a lightweight, rapidly deployable pipeline and terminal system that can be used in undeveloped and developed theaters of operation. It can interface with an existing host nation fuel source, such as a refinery, or with the Navy's Offshore Petroleum Discharge System (OPDS). The Navy is responsible for delivery of petroleum from offshore tankers to the high water mark. The system is modular in design and can be tailored for any locality or operation.

Pipeline. The pipeline is configured in 5-mile pipeline sets. There are 1,404 sections of 19-foot long IPDS single grooved, aluminum pipe with coupling clamps and gaskets. Pipes are packed in nine 20-foot ISO containers with 156 sections of pipe per container. An allotment of elbows and coupling clamps for directional changes, expansion/contraction devices, and a supply of gate valves, check valves, vent assemblies, pipeline anchors, culverts, overcouplings, and repair clamps are packed in four additional containers.

- 19-foot aluminum pipe sections (Figure 8-1). Used in the main run of the pipeline. The pipes vary in thickness from 0.404 inches to 0.188 inches and are used over long distances. They cannot be cut to different lengths due to the varying wall thickness, but each end may be regrooved once if damaged.
- 9.5-foot aluminum pipe nipples (Figure 8-1). There are 44 pipe sections in each 5-mile set and 10 sections with each pump station. As they are of a constant wall thickness (0.404``), they can be cut to any length required and regrooved using the cutting and grooving tool furnished. They are used to close short gaps in the pipeline. Each section has a black line down the length for easy identification of nipple material.

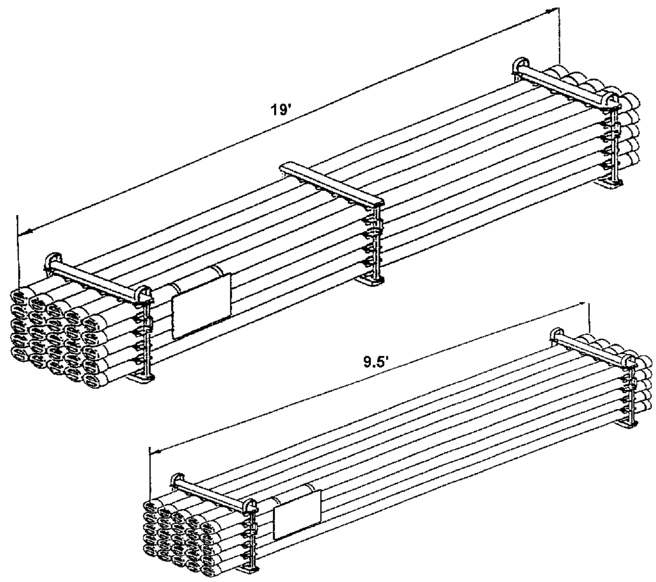

Figure 8-1. 19-foot aluminum pipe sections and 9.5-foot aluminum pipe nipples.

Pump stations. Each pump station has two skid-mounted, diesel engine driven (three stage centrifugal) mainline pumps, with an operational output of 800 GPM at 1,800 feet of head, at 2,100 rpm (Figure 8-2). Only one is operated at a time. Launcher and receiver assemblies, a dual in-line strainer assembly located on the incoming side of the station, and a flood light set are also components of pump stations. Except for the mainline pumps, all pump station equipment will be stored in four 20-foot ISO containers.

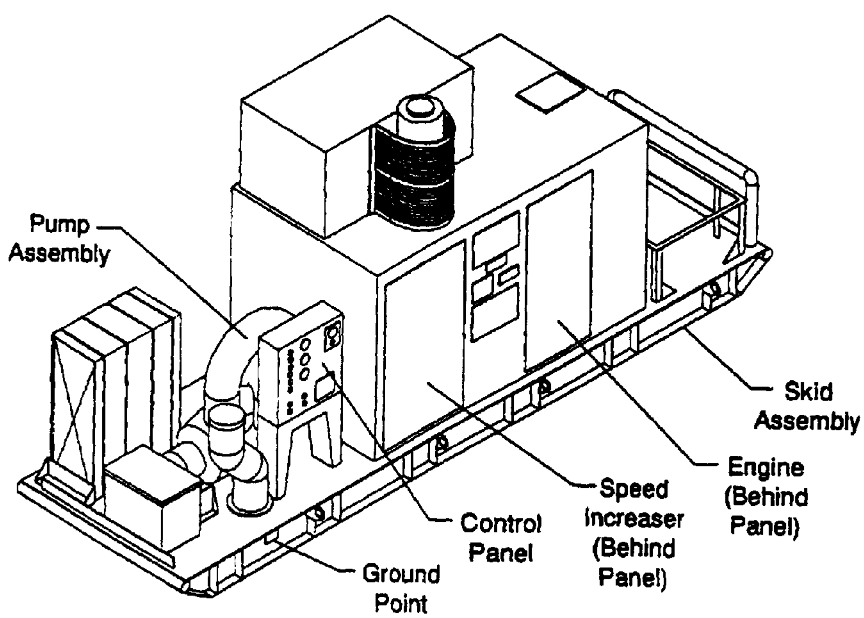

Figure 8-2. 800-GPM mainline pump.

Tactical Petroleum Terminal (TPT). The mission of the TPT is to receive, store, and dispense liquid fuel, specifically diesel, motor gasoline, and aviation jet fuel (Figure 8-3). It serves as a base terminal in an undeveloped theater and can be used in the developed theater to supplement existing facilities that are inadequate or damaged. The TPT was designed to operate at a maximum allowable operating pressure of 150 psi. The standard TPT has a storage capacity of 3,700,000 gallons in eighteen 5,000-barrel (210,000 gallons) collapsible fabric tanks. The TPT is modular with three identical fuel units. Each TPT also has one pipeline connection assembly. The total TPT is stored in 77 ISO containers.

The fuel unit consists of three tank farm assemblies, with two 5,000-barrel fabric tanks each, a tanker-truck receipt manifold, a fuel dispensing assembly, a transfer hoseline assembly, six fire suppression assemblies, a 50,000-gallon optional tank configuration, and a fuel unit support assembly. A total of 24 ISO containers are used to store one fuel unit (min 600’ between units).

- Tank farm assembly. Consists of two 5,000-bbl fabric tanks, a hoseline pump, and associated hose, valves and fittings; a total of three containers for each assembly (at least 400 feet between assemblies).
- Tanker-truck receipt manifold. Consists of a hoseline pump and associated equipment to provide four defueling stations. It is used to receive fuel from fuel tanker-trucks (two containers).
- Fuel dispensing assembly. Dispenses fuel directly to user’s bulk fuel transporters and to 500-gallon collapsible drums. There are six stations for trucks and two for drums (one container).
- Transfer hoseline assembly. Is used to connect the tank farm assemblies, switching manifold, fuel dispensing assembly, and tanker-truck receipt manifold into an operational TPT. There are four transfer hoseline assemblies in a TPT, one in each fuel unit and one in the pipeline connection assembly. Each assembly has fifteen 500-foot by 6-inch hoselines packed in three Tricons (5 hoses per Tricon) to tie the major components into a total system (one ISO container equivalency).
- Fire suppression assembly. The main component is the wheel mounted fire extinguisher. Skid mounted on a two wheeled trailer, the system is designed to apply the dry chemical (Purple K) until fire is under control and then apply the aqueous film forming foam (AFFF) creating a blanketing effect. The chemical should continue to be applied with the AFFF until the solution is exhausted or until there are no existing smoldering pockets remaining that could cause reignition (one container for each of the six assemblies).
- 50,000-gallon tank option. Consists of two 50,000-gallon collapsible fabric tanks, one transfer pump (350 GPM) and one 350 GPM filter separator. This option gives the commander an additional 100,000 gallons of storage space to use as the situation dictates (total option is stored in one container).

The fuel unit support assembly consists of the fuel unit's interim support item list (ISIL), two floodlight sets, one displacement and evacuation kit, one hoseline suspension kit, two hoseline installation and repair kits, and a spare hoseline pump (600 GPM) (four containers to store the assembly).

The floodlight set is trailer-mounted and designed to hold all components. The engine/generator set includes a 6.0 kW, two-cylinder, four-cycle, air-cooled diesel engine and a four-pole brushless, revolving field generator with external voltage regulation. It has an 18-gallon fuel tank with a wide mouth fill cup. Starting power is supplied by a 12-volt, 4D size battery. The telescoping tower assembly, when extended, is stable in gusty winds up to 40 mph. The portable tripod masts are stable in winds up to 15 mph.

The displacement and evacuation kit is used to remove fuel and evacuate the small residual quantity of fuel, vapor, and any air within the hose. The kit consists of a displacement ball, an injector for displacing fluid with the ball, a ball receiver, end caps to seal off the hoseline, and an air ejector, used to evacuate residual fuel and vapor from the hoseline.

The suspension bridge is prefabricated and packed in kits in 100-, 200-, and 400-foot sizes. They are provided for crossing rivers, chasms, or ravines identified in potential areas of operation. The major components are: towers, guy wires, deadpan anchors, main cable suspenders and cross bearers, staging boards, tension cables, wind guys, and hand rope.

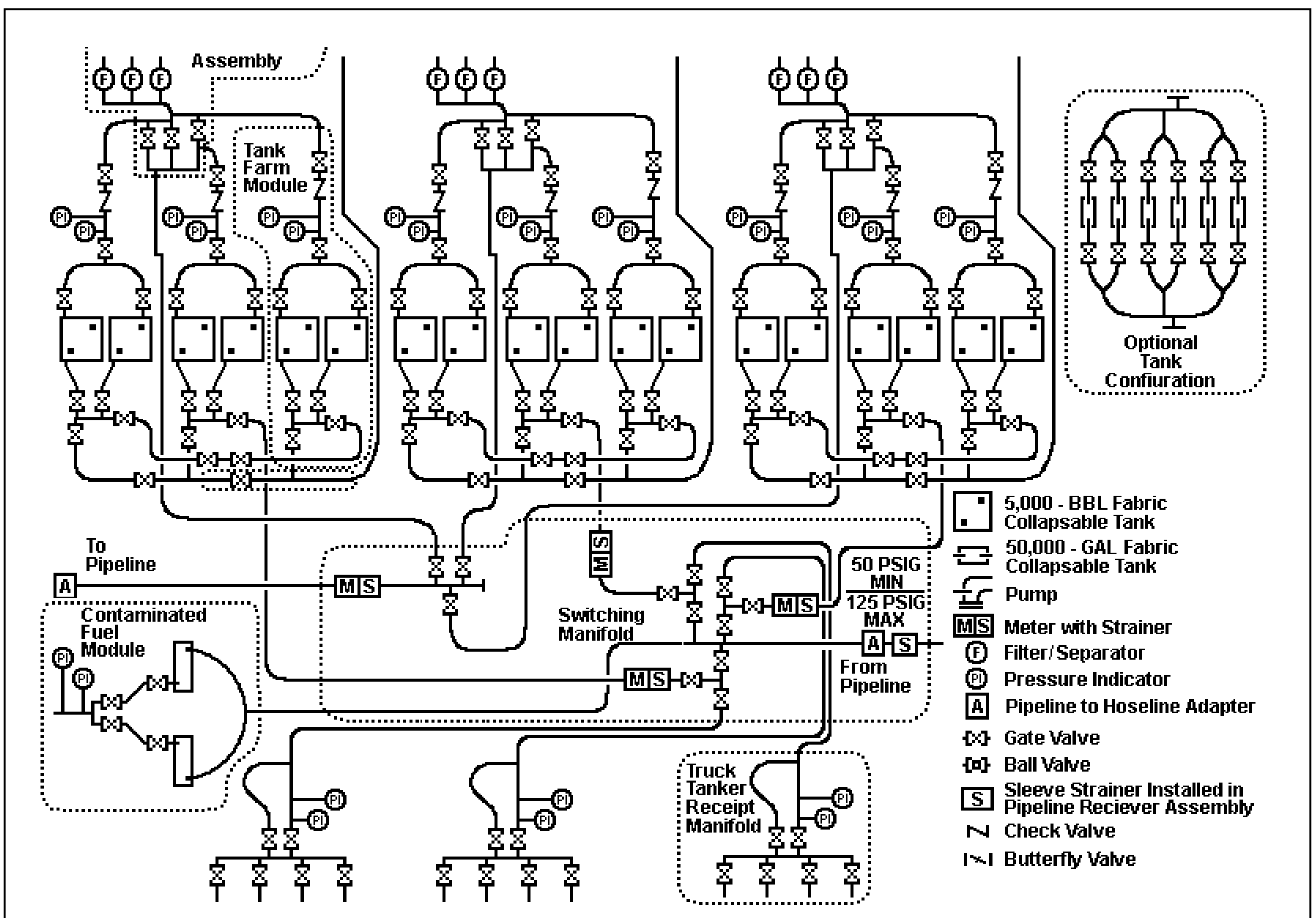

Figure 8-3. Tactical petroleum terminal.

Pipeline connection assembly (PSE). The pipeline connection assembly is required if fuel is to be received from or issued to pipeline. The total assembly is stored in four containers and three Tricons.
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- Switching manifold. Allows the TPT to be connected to the pipeline and controls the fuel flow in, out, and within the TPT (one container).
- Contaminated fuel module. Consists of two 50,000-gallon collapsible fabric tanks used to hold contaminated fuel for blending or disposal and a transfer pump to load tanker-trucks (one container).
- Fire suppression assembly. Main component (one container).
- Pipeline connection support assembly. Contains additional ISIL items, one aviation petroleum test kit, one hoseline suspension kit, one displacement and evacuation kit, and two hoseline installation and repair kits (one container).

Special assemblies are available to aid in the total system construction and interface.

Beach interface. The beach interface is an assembly of adapters to connect IPDS to OPDS. It also allows access to the pipeline for shore-based forces; i.e., U.S. Marines.

Pipeline support equipment. The basis of allocation is one set of pipeline support equipment per 100 miles of pipeline to be installed. The assembly contains those items required to assist in the construction and operation of a pipeline. PSE will accompany each deployed pipeline segment (five containers). Equipment includes:

- Two-wheel mounted hoseline pumps (600 GPM), used as source pumps if the pipeline receives fuel from commercial storage.
- Two cutting and grooving machines for cutting of pipeline and pump station nipples.
- Four hydraulic drive heads for anchor installation.
- Two tapping machines for tapping into a pipeline in order to drain a portion of the line. Usually needed when required to repair a leak.
- A dead weight tester used to calibrate gages.
- Five additional elbow sets.
- Tool kits with pump alignment tools.
- Additional 9.5-foot pipe sections.

PART B - QUALITY SURVEILLANCE

Quality Surveillance includes all procedures used by operators of the TPT to ensure petroleum products received, stored, and dispensed by the IPDS meet the minimum specifications when delivered to the user.

Quality Control (QC) is the inspection performed by refinery personnel to monitor the production of a particular petroleum product. Quality Assurance (QA) is the Army's program to determine if a refinery or other source has fulfilled its contract concerning the quantity and quality of petroleum products. QA is complete when the product is accepted by the Army and becomes Army-owned. Quality Surveillance (QS) consists of the measures taken to ensure that petroleum products, which have been accepted by the Army, are still of the required quality when delivered to the user. QS is the responsibility of the organization having physical possession of the Army owned products.

Sample points. The high-pressure fuel sampling assembly is installed in the pipeline one-half to one mile upstream from the TPT. This assembly is used to spot the interface as it approaches the TPT and to give advance warning of its arrival.

The low-pressure fuel sampling assembly is installed in the header, feeding the TPT switching manifold from the pipeline. The primary use of this fuel sampling assembly is to check incoming fuel and establish the end or last of the interface between batches of different specification fuel. It can also be used to spot sample and check the quality of incoming fuel and to draw samples for laboratory testing.

The water detector kit adapter is in the discharge line of each filter separator. The primary purpose is to check the quality and make sure no water is carried over the dispensing assembly. Samples from the adapter using the aviation fuel contamination test kit are taken downstream of each filter separator to ensure that the filter separators are performing properly and customers are provided quality fuel that meets specification.

- Test once every 4 hours of operation of dispensing assembly.
- Perform three checks at 15-minute intervals after filter separator is first put into operation or whenever the elements are changed.

PART C - PIPELINE CONSTRUCTION

Pipeline installation. The aluminum pipe used in the IPDS is highly susceptible to heat. Changes in temperature cause the pipe to expand and to contract. This tendency requires pipeline installation to follow certain rules exactly. The pipeline must be installed as straight and level as possible. Any desired turns or changes in direction must be made using elbows, vertical as well as horizontal directions. Anchors are used to direct expansion and contraction of the pipeline into expansion and contraction devices. Aluminum pipe is subject to thermal expansion that can overstress couplings and cause breaks in the pipeline. Since the pipeline will be installed above ground, the pipe will move as it expands and contracts with temperature variation. In some geographical locations where the pipeline may be used, the temperature can vary by as much as 100 degrees Fahrenheit in 24 hours, which can cause an expansion of up to 20 inches for 50 sections of pipe. Expansion can cause the pipeline to fail at a coupling if side pressure deflects the joint more than 4 degrees. This expansion must be controlled and directed to spots specifically designed to move with pipeline expansion and contraction.

Controlling expansion and contraction. To control this expected expansion/contraction movement, the pipeline must be equipped with anchors and expansion devices. The anchor fixes the pipeline to the ground and directs any expansion towards the expansion device. The flex in the couplings at the elbows allow these devices to move without breaking the integrity of the pipeline. In a desert environment, where the temperature change can be anywhere from 50 to 100 degrees Fahrenheit, there must be a maximum of 50 sections of pipe between expansion/contraction devices, with an anchor in between. In a more temperate environment with an expected temperature change of less than 50 degrees Fahrenheit, the distance between expansion/contraction devices can be extended up to 100 sections of pipe. There still must be an anchor between devices. The pipeline must be laid in an anchor - expansion device - anchor sequence with the anchor just outside of each pump station starting the sequence. Expansion loops on hills should be no more than 15 sections of pipe hanging downhill from an anchor.

There are two types of expansion devices used with the IPDS. The "U" shaped loop and the "Z" shaped offset. Both devices provide required pipeline flexibility and are considered equal from that standpoint. The "Z" shaped offset should be used if sufficient cleared trace (width 30 ft.) is available. If the trace is not available, the "U" shaped loop should be installed. A cleared area of about 30 ft. by 30 ft. is required for each "U" loop.

- "U" shaped loop, will normally be constructed with one pipeline length (19 ft.) on a side and may use 45 or 90 degree elbows or a combination thereof. As elbows are limited, 90 degree elbows should be used whenever possible. The deflection at the loop can be as much as 20 inches from the cold to the hot position.
- "Z" shaped offset will normally be offset one 19-foot pipe length. To allow for proper expansion, the "Z" should be constructed only with 45 degree elbows unless two 19-foot lengths of pipe are used in the offset.

Mandatory anchor points are located:

- Always between expansion loops to direct expansion into the loops.
- On the first or second section of pipe outside pump stations at the launcher and receiver assemblies.
- On the first section of pipe downstream of gate and/or check valves in the pipeline.
- On the first or second section of pipe on both sides of elbows that change the direction of the pipeline (both horizontal and vertical).

Anchors must be located at the bottom of a hill with the expansion loop up the hill. There must be no more than 15 sections of pipe hanging downhill from an anchor.

Pipe support and guides. Must be installed where required to ensure that joint alignment is maintained. Pipe supports and guides may be constructed to pickets, sandbags, or other available materials. Sandbags, if used, should always be stacked in a pyramid to provide support during pipe movement; never stack one on top of the other. Pickets are used to keep the pipeline from slipping downhill when laid along a slope. There are 225 pickets and 2,000 sandbags in each 5-mile set. Obstacle crossings include:

- Road crossing. Ensure that personnel use existing culverts whenever possible. Make sure that the cross sectional area of the culvert is not significantly reduced as this may prevent or restrict the run-off of water. Eighty linear feet (eight 2-foot halves) of 24-inch diameter, nestable, corrugated steel culvert are included in each 5-mile pipeline set.
- Critical gap crossing kit. To aid in crossing gaps along the trace in difficult terrain, a special critical gap crossing kit has been developed and added to the IPDS operational stocks. The kit consists of 4-inch steel pipe, cross beams, braces, and roller assemblies. The steel pipe can be cut/welded to any length required. A kit has enough material to cross up to a 250-foot of gap.

PART D - PUMP STATION OPERATION

Pump stations are located along the pipeline to boost the pressure of the fuels flow. Maintaining adequate pressure is a must. Without adequate pressure, the flow of fuel would decrease to a point that little or no fuel would reach the head terminal.

Information source for pumping order. All users of military fuel in the theater are required to forecast their fuel requirements. These are consolidated at all levels, giving the theater fuel activity estimated fuel requirements at each terminal. The pipeline dispatcher uses this information to schedule fuel flow into each terminal, ensuring that enough fuel is on hand to meet expected demand. The dispatcher sets up a schedule which includes the type and quantity of fuel, flow rate, and the batch number assigned to that fuel shipment. The batch number is a designation given to each fuel shipment. One of the most common ways of assigning batch numbers to fuel shipments is to assign a number to a type of fuel, i.e., 1 = MOGAS, 2 = DF2, 3 = JP4. The second number would be the number of shipments of that type of fuel that have been shipped this fiscal year; i.e., 1st shipment = 1; 2d shipment = 2. Batch 1-14 would be the 14th shipment of MOGAS. Once the dispatcher has set up the schedule, a pumping order is made each day and sent to all pipeline areas.

Daily pumping orders. The dispatcher issues daily pumping orders to pump station and terminal operators. Pumping orders include:

- Type of fuel.
- Batch number.
- Destination of each batch.
- Amount of fuel in batch.
- Estimated size of interface.
- Estimated times of arrival of interface at terminals.
- Starting and stopping times of all pumping operations.
- Type of interface to cut.
- Pipeline pump station pressures and pipeline flow rates.

PART E - SITE SELECTION AND PLANNING

When conducting a site and route reconnaissance, you must have two known points; where the fuel source is or will be located and where the forces will be located requiring support.

Site and route selection. A survey using a topographic map must first be conducted and a profile of the best trace made. Using the profile and the hydraulic limitations of the pumps, mark the pipeline trace and the required locations for pump stations. When conducting the physical reconnaissance on foot or by vehicle, stakes or other marking devices must be used to indicate the actual path of the pipeline. Location of valves, anchors, expansion/contraction devices and any obstacles must be marked on the trace. Actual pump station locations can be adjusted somewhat from the ideal locations selected from the profile and hydraulic analysis. But every effort should be made to locate pump stations within 2,000 feet of their ideal locations.

Plot Plan. After the site has been selected, a preliminary plot plan should be made that shows all the major equipment and system locations, after review and corrections made to the plot plan, roadways and berm construction can begin according to the plan.

- Pump station. A space of 140 feet by 85 feet is ideal, especially if it’s flat. Pumps must be positioned for access in case one needs to be replaced during operation. This requires at least 50 feet to the rear of pumps and should be 10 feet off the road. Stake anticipated location of the inlet and outlet piping about 95 feet from the edge of the road with 140 feet between stakes to align the incoming and the outgoing pipeline.
- Tank farm assembly. Should be located to provide wide spacing between fuel units and to provide fire protection and suppression. Tank farm assemblies within a fuel unit should be at least 400 feet apart. There should be a minimum of 600 feet between fuel units.

- Fuel dispensing assembly (FDA). The FDA should be located on a road capable of supporting heavy vehicle traffic during weather changes and at least 100 feet from the nearest fabric tank. The plot plan requirements for the FDA are approximately 750 feet long by 50 feet wide. An area alongside, 120 feet by 850 feet long should be graded for vehicle traffic and parking while loading.
- Tanker-truck receipt manifold. The most important factor in choosing the exact site is road excess, since heavy traffic will occur in this area of the TPT. A graded area of 120 feet wide by 250 feet long is required per receipt manifold.

PART F - EXTERNAL IDENTIFICATION

- Each ISO container is marked with a large black bordered symbol.
- The pipeline components are represented by a circle.
- The TPT is a triangle. Each container has identification information stenciled on it and is marked as part of a series, i.e., box 1 of 5.
- The pump station is marked by a diamond. Note that a packing list is secured to the outside of each box or crate.

PART G - COMMUNICATIONS

An efficient communication system is a must for the construction, operation, and maintenance of a military pipeline. The system must be separate, continuous, and dependable. Ideally, the chief dispatcher will have direct communication to each pump station operator and to each TPT. Each unit will set up their own communication system along the pipeline with their capability; i.e., teletypewriters, field phone, or radios. No operation will start until there is communication between the issuing and receiving stations. Pipeline patrol will carry radios at all times. Establishing hand signals can be an effective form of communications within small sections such as pump stations and tank farms. All personnel within the communication network must be familiar with all requirements that could be placed on them and what action must be taken in each situation.

LESSON 8

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check your answers with the answer key. If you answer any items incorrectly, go back to the part of the lesson that contains the information involved and study again.

1. The pipeline of the IPDS is configured in what length pipeline sets?
   A. 5-mile.
   B. 10-mile.
   C. 19-foot.
   D. 20-foot.

2. What is the maximum allowable operating pressure that the TPT can operate at?
   A. 150 psi.
   B. 200 psi.
   C. 210 psi.
   D. 350 psi.

3. The beach interface is an assembly of adapters used to connect the IPDS to the.
   A. PSE.
   B. OPDS.
   C. TPT.
   D. AFFF.

4. How often does the water detector kit need to be tested when in operation of dispensing assembly?
   A. Every 2 hours.
   B. Every 3 hours.
   C. Every 4 hours.
   D. Every 5 hours.

5. What is the first step in site and route selection?
   A. Survey using topographic map.
   B. Preliminary plot plan.
   C. Roadway and berm construction.
   D. Mark the pipeline trace.

LESSON 9

COMPUTE BERM REQUIREMENTS

Critical Task:
101-519-4316

OVERVIEW

Knowledge of storage tank capacity and firewalls are important for the petroleum staff NCO to compute berm requirements.

Lesson Description:
This lesson covers storage tank capacity, firewalls, and computing berm requirements.

Terminal Learning Objective:

Action: The soldier will learn to compute the capacity of the tank by referring to the tank capacity tables, using the formula for volume of a cylinder to compute requirements for a tank firewall, and reporting the requirements.

Condition: Given subcourse QM 5099.

Standards: The soldier must score a minimum of 70 percent on the end of subcourse examination.

INTRODUCTION

Firewalls are designed to contain 100 percent of the volume of a storage tank plus one foot of freeboard. These walls are intended to contain fuel spilled when tanks leak, overflow, or burst and to help prevent the spread of fuel or fire to neighboring tanks and other installations. This block of instruction is designed to further your training so that you can better supervise your personnel in terminal operations.

PART A - FIREWALLS

Firewalls should contain 100 percent of the capacity of the storage tank plus one foot freeboard, and in the case of earth firewalls (Figure 9-1), they should be at least 18 inches wide at the top. The exact height of the firewall will depend on the amount of "real estate" or space available in the area in which you are operating. In theaters of operation, it is not uncommon to have "splinter walls" of brick or concrete, 8 or 10 feet high around the tank. These serve as firewalls and protection against low trajectory fire, blast, etc. A sump will be provided at the lowest point inside the firewall, and the rest of the area will be graded or drained to the sump. The sump will connect to the outside of the firewall by a drain line with an elbow (swing point) leg on the outside to drain water from the sump. The crane is closed by elevating the swing joint.

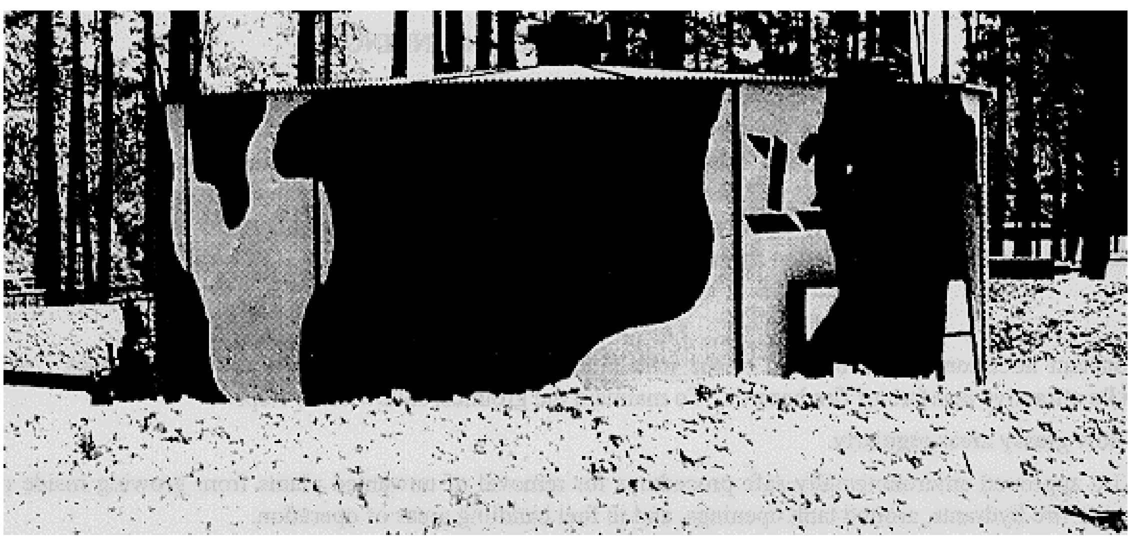

Figure 9-1. Earthen firewall.

PART B - FORMULA

Tank Capacity (Gallons)	Fire Wall Dimensions (Feet)	Inner Dimensions (Feet)
10,000	3 high, 1.5 wide	26 by 26
20,000	4 high, 1.5 wide	31 by 35
50,000	4 high, 1.5 wide	73 by 33
210,000	5.5 high, 1 wide 6.5 wide at bottom	73 by 73

The formula for determining the inside diameter of the firewall is:

$$d = 2.68 \text{ X } \frac{c}{h-1}$$

c = Tank capacity [known, (in barrels)]
h = Height of firewall [known, (in feet)]
d = Diameter of firewall (unknown)

Example: We must construct a six foot berm around a 3000 bbl tank.

$$d = 2.68 \ x \ \frac{3000}{6-1}$$

$$d = 2.68x\frac{3000}{5}$$

$$d = 2.68x600 = 2.68x24.5 = 67.5$$

$$d = 67.5 ft$$

The formula for determining the height of a firewall based on the diameter is:

$$h = \frac{c}{\left(D/2.68\right)^2} + 1$$

Example: Capacity of the storage tank is 3000 bbl, the diameter is 67.5:

$$h = \frac{3000}{\left(67.5/2.68\right)^2} + 1$$

$$h = \frac{3000}{634.36} + 1$$

$$h = 4.73 + 1 = 5.73 or 6 feet$$

LESSON 9

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check your answers with the answer key. If you answer any items incorrectly, go back to the part of the lesson that contains the information involved and study again.

1. How wide should earth firewalls be at the top?
   A. 12 inches.
   B. 16 inches.
   C. 18 inches.
   D. 20 inches.

2. In theaters of operation, how high should "splinter walls" be around the tank?
   A. 6 or 8 feet.
   B. 8 or 10 feet.
   C. 10 or 12 feet.
   D. 18 or 20 feet.

3. What is the formula for determining the inside diameter of the firewall?
   A. d = 4.73 x (h + 1 / c).
   B. d = 2.68 x (c / h - 1).
   C. c = 2.69 x (d / h-1).
   D. d = 2.68. x (c / h + 1).

4. In the formula for determining the inside diameter of a firewall, what does "c" represent?
   A. Height of firewall.
   B. Diameter of firewall.
   C. Percent of capacity.
   D. Tank capacity.

5. What are the fire wall dimensions, in feet, for a tank with a 10,000 gallon capacity?
   A. 3 high, 1 wide.
   B. 4 high, 1.5 wide.
   C. 3 high, 1.5 wide.
   D. 5.5 high, 1 wide.

LESSON 10

RECOMMEND PLACEMENT OF TERMINAL EQUIPMENT AND MANIFOLDS

Critical Task:
101-519-4310

OVERVIEW

In this lesson, you will learn the advantages and disadvantages of different types of pipes, fittings, valves, and pipeline/terminal equipment; how to select the correct pipe and equipment for use in particular pipeline and terminal areas; and how to assign identification markings to valves, tanks, pipelines, and pumps within a terminal.

Lesson Description:
The soldier will supervise the identification, operation, and maintenance of a petroleum pipeline/terminal equipment and Inland Petroleum Distribution System (IPDS) including pipes, valves, and strainers; design a numbering system for manifolds, valves, tanks, and pipelines; recommend and verify placement of valves on the petroleum manifold system and pipeline in preparation for receiving and dispensing product; verify appropriate entries on DA Form 2404, correct deficiencies; and identify environmental considerations.

Terminal Learning Objective:

Action: The soldier will direct petroleum pump station operations; verify flow control procedures are according to the pumping order; interpret pump graph data to determine pump discharge head, brake horsepower, efficiency, and required engine speed; observe proper safety precautions; and identify environmental considerations.

Condition: Given subcourse QM 5099.

Standards: The soldier must score a minimum of 70 percent on the end of subcourse examination.

INTRODUCTION

As a petroleum manager, you will be required to oversee the minor repair of terminal equipment. It is in your best interest to know the proper procedures and reference material available to you. You will also be responsible for managing the on the job training (OJT) of newly assigned personnel. The more knowledgeable you are in the area of equipment repair, the more effective your training program will be. You will also be responsible for knowing the manifold system within the petroleum terminal. Until bulk petroleum products are issued for consumption from the terminal they must first be received and stored in storage facilities of varying capacities. All facilities have a common feature that allows control of the products entering, leaving and transferring within the system: This control feature is the manifold.

PART A - TYPES OF PIPE AND COUPLINGS

- **Lightweight Steel Tubing** - Lightweight Steel Tubing is made of light gage steel with API STD (standard) 5L pipe nipples welded to each end. This tubing is furnished in 20-foot sections in 4-, 6-, 8-, and 12-inch nominal sizes. Lightweight steel tubing is normally used in long stretches of cross-country pipeline due to greater ease of handling, and because under this condition it will experience only normal operating pressures. Due to its thin wall, the pipe is not to be buried nor is it to be used for submerged stream crossings.
- **API S&D 5L Pipe** - API S&D 5L Pipe has a thicker wall than the lightweight steel tubing pipe and is furnished in 4-, 6-, 8-, 12-, 16-, and 20-inch nominal sizes. It is furnished in 20-foot sections grooved for coupling and is beveled for welding in random lengths. It is used at critical points and high pressure areas such as downhill slopes, manifold areas, and pup joints.
- **"Victaulic" Couplings** - "Victaulic" couplings are used to join the lightweight steel tubing and API S&D 5L pipe sections together. "Victaulic" is a trade name associated with the couplings which consist of two housing segments, two bolts and nuts, and a synthetic-rubber, oil-resistant, self-sealing gasket. The coupling and gasket are designed so that the pipe joint seals under pressure and vacuum. The coupling also provides a sufficient amount of angular deflection and slack adjustment for expansion and contraction of the line between adjacent joints. The gasket used with the coupling should be greased to prevent pinching or sticking of the gasket.
- **Aluminum Pipe** - Aluminum pipe is a new type of pipe being evaluated for future use by the Army. It is lightweight, yet meets static and dynamic pressure requirements of the fuel systems. This pipe has fewer corrosion problems and is available in 19-foot sections. It is used in locations similar to the lightweight steel tubing and API STD 5L pipe. High-pressure situations are corrected by the use of pressure reduction stations. Maximum deflection (4°) is determined using the device shown in the slide.
- **"Labarge" Snap Lock Couplings** - "Labarge" snap lock couplings are one of two types of couplings being evaluated for use with aluminum pipe. "Labarge" is a trade name associated with the couplings. The Labarge

coupling is hinged on one side, clamped around the pipe, and then pinned on the other side. The clamp is pulled tightly shut with the assistance of the tightening handle.

- **Stab Lock Couplings** - Stab lock couplings are the second type of coupling being evaluated for use with aluminum pipe. The pipe sections are stabbed into the coupling where a series of gaskets inside the collar result in a seal being formed. Special pliers are utilized to break apart these sections of pipe in the event that a section needs to be replaced.

Cutting and Grooving Procedures for Steel Pipe. Grooved pipe is used for coupling pipe sections together with the split-ring, groove-type coupling. Due to layout or damage, a section of pipeline must be cut to a nonstandard length and regrooved to allow for proper assembly. A portable cutting, grooving, and beveling machine is used to perform this task. These machines are packaged in a kit and are included in the welded pipeline construction tool set. The kit includes two large suitcases and two pipe stands. The machine is powered by a 250 cubic-foot-per-minute (CFM) air compressor or by a generator. It is used primarily during mainline pump station construction. It takes about 30 minutes to cut and groove each end of the pipe.

Welding of Pipeline. Pipe to be welded will have a beveled edge on it to facilitate making a good weld. Rebeveling, because of damage to the edge, or cutting and beveling are accomplished with the machine described above. The bevel is cleaned of slag with a bevel grinding machine.

PART B - VALVES

- **Gate Valves** - Gate valves have a gate in the form of a disk or wedge, which is raised to permit the flow of fuel and lowered to stop the flow of fuel.
- **Rising-Stem Gate Valves** - Rising-stem gate valves are threaded on the upper end of the stem. The lower end is attached to a disk. When the hand wheel is turned both the stem and disk are raised and lowered. When the valve is fully opened it will allow pipeline scrapers, poly pigs, etc., to pass through. By looking at the valve from a distance you can tell whether or not the valve is open or closed. The stem of the valve is easy to sabotage. The exposed surface of the upper stem on the rising stem gate valve should be protected by placing a split, one-inch hose or some similar device around the stem in the yoke area. A fine film of motor oil can be used to lubricate the thread on the stem. This valve is used in the pipeline at intervals at the bottom of long slopes, on both sides of a stream crossing, and at storage tanks.
- **Nonrising-Stem Gate Valves** - The threaded lower end of the stem on a nonrising-stem gate valve screws into the disk, thereby raising or lowering the disk while the stem is retained in place by a thrust collar. The packing gland must be monitored and replaced as necessary.

- **Globe Valves** - Globe valves are used to throttle the flow of product inside a pipeline. This is the same type of valve used at home on kitchen or bathroom sinks. Packing, disks, and seats will become worn and will need replacing depending on usage. These valves are used in areas where the throttling of product flow is desired.
- **Swing Check Valves** - Swing check valves permit fuel to flow one way only by means of a hinged disk or clapper which is pushed aside by the fuel when it flows in the desired direction. When flow stops and back pressure develops, the clapper is pushed against its seat, stopping back flow. These valves are self-operating and need little maintenance other than tightening the cover nuts regularly. Typically they are used on the discharge sides of pumps and at pump stations between the suction and discharge lines of each pump at the pump station. They are also used at the foot of upgrade slopes in lieu of gate valves, but they must be removed if the line is ever pumped in reverse.
- **Flow Control Valves (Pressure Reducing Valves)** - Flow control valves are activated by pressure. If pressure in the pilot is great enough to overcome the force of the spring, the excess pressure activates the diaphragm to throttle the flow in dynamic situations, and in static conditions it will decrease the head acting against a particular point in the pipeline. These valves require little maintenance beyond checking the pilot strainer at least every 3 months and inspecting the diaphragm once a year. They are used on downhill slopes.
- **Pressure Relief Valves** - Pressure relief valves are set to open at certain pressures and are triggered by a spring. The pipeline is tapped at points which may experience excess pressures under static conditions. If pressures reach the upper limit set on the valve by the operators, the valve activates by opening and bleeding fuel off until safe pressures are again reached and the valve resets itself to the closed position. Typically these valves are used at locations where the pipe is going to a storage tank to bleed-off excess pressures built up in the line because of heating by the sun under shut down conditions. These valves should be tested once a year using a reliable pressure gage.
- **Plug Valves** - Plug valves are small, compact valves activated by turning the head of the valve 1/4-turn. This valve may or may not open to the full diameter of the pipe depending on the type of plug valve used. As a result, plug valves which do not open to the full diameter of the pipe cannot be used in portions of the pipeline through which a scraper is designed to pass. This valve can be lubricated in the open or closed position. Lubrication is done through the lubrication screw at the top by the use of a high pressure grease gun, or the screw can be screwed down. This valve also has rope-type packing which must be periodically replaced. Plug valves are commonly used at tank farm manifolds or in places requiring quick, positive shut-off such as at a scraper launching station.

Additional pipeline components.

Figure Eight Blinds - Figure eight blinds provide a positive shutoff in pipelines and manifold areas. A line blind is comprised of a flanged holder, hand wheel, and figure eight blind. Turning the hand wheel one way causes the holder to spread open wide enough to insert or remove one end of the figure eight blind. Turning it the other way causes the holder to grip the blind tightly. Maintenance involves coating the exposed half of the figure eight blind with a thin film of motor oil every 3 months and inspecting the packing rings in the grooves of the figure eight blind every 6 months for wear. If the packing rings are worn they must be replaced. Grease fittings on the hand wheel must be regularly lubricated.

Spool Pieces - Spool pieces are short sections of pipe into which figure eight blinds are inserted.

Line Strainers - Line strainers catch debris in fuel as it comes down through a basket or strainer and then passes through the discharge side. The basket has a wire-mesh or screen which catches the debris and prevents it from continuing to flow downstream and damaging things like pump impeller blades and meters. The baskets or screens need to be pulled from the devices in which they are installed on a periodic schedule (once a week) to remove the debris. Line strainers are found on the suction side of pumps and meters and on the discharge side of filter separators.

PART C - FITTINGS AND PIPE REPAIR ACCESSORIES

Fittings. Standard, groove-type fittings include elbows, tees, and reducers such as the following:

- **Standard Tee Fittings** - Standard tee fittings provide a splitting of the fuel stream. These fittings have a characteristic "T" shape.
- **Reducing Tee Fittings** - Reducing tee fittings allow reduction in one leg of the branch, either through the tee portion or through the branch portion of the tee.
- **Elbow Fittings** - Provide for the change in the pipeline direction by 45 or 90 degrees.
- **Reducers** - Provide a connection from one diameter of pipe to some smaller diameter of pipe.

Repair clamps. Listed below are some of the more common types of clamps used to repair leaking pipelines.

- **Pit Leak Clamps** - Pit leak clamps are designed to temporarily repair a leak caused by a small hole such as a pit.
- **Split Leak Clamps** - Split leak clamps are designed to temporarily repair a leak caused by a split pipe. This clamp is limited in the size of the split which can be repaired due to its limited length.
- **Over-Coupling Leak Clamps** - Over-coupling leak clamps are designed for placement over the regular split-ring, groove-type coupling when a leak develops from the initial coupling.
- A pipeline leakage report will be completed for all leaks occurring in a pipeline.

PART D - PUMPS

Pipeline pumps consist of one or more impellers mounted on a rapidly rotating shaft. Liquid enters the impeller at its center and is impelled outward by centrifugal force into the volute of the pump casing. The volute catches the discharge and converts peripheral velocity into head pressure while conducting the liquid at a reduced flow rate to the discharge nozzle of the pump casing. Different pumps are used on aluminum and steel pipeline systems.

- **6-inch, Single-Stage Pump** - The 6-inch, single-stage pump is a self-priming, centrifugal pump equipped with a mechanical shaft seal. Suction and discharge connections are grooved pipe. Maximum safe working pressure is 207 PSI or 660 feet of head for fuel with a SG of 0.725.
- **6-inch, Two-Stage Pump** - The 6-inch, two-stage pump is a multi-stage pump fitted for external connection to operate either in series or in parallel. Maximum safe working pressure is 700 PSI or 2,390 feet of head for a fuel with a SG of 0.725.
- **800 GPM Mainline Pump** - The 800 GPM mainline pump is a new pump used for operation in an aluminum pipeline system. It is a skid-mounted, three-stage centrifugal pump.

PART E - PIPELINE SCRAPER OPERATIONS

Scrapers are devices inserted into the pipeline to remove internal scale, rust, or other foreign material. In the petroleum industry, scrapers are often called "pigs" or "go-devils." Two types of scrapers are used:

- **Steel Brush Scraper** - The steel brush scraper is constructed of a tubular shaft on which are mounted two sets of four spring-loaded steel brushes and two synthetic rubber cups. The spring-loaded steel brushes clean the walls of the pipe. The front and rear brush groups are staggered to cover the entire pipe surface. The tubular shaft of the scraper is open at the rear, which permits a fraction of the stream to flow into the scraper and escape through small ports near the front end, thereby agitating and propelling the loosened scale forward. This prevents the scale from accumulating ahead of the scraper, causing the line to become clogged. This type of scraper comes in 6-, 8-, 10-, and 14-inch sizes. The 10- and 14-inch scrapers have three synthetic rubber cups.
- **Poly Pig Scraper Device** - The poly pig scraper device is constructed of foam-type material and wrapped with abrasives to clean the pipeline. They are able to make 90-degree turns in the pipeline and are inexpensive, though they do not clean as thoroughly as steel brush scrapers nor are they as durable.

Military pump station manifolds have two scraper stations; one for launching and another for receiving. Before launching a scraper, lines should be free from sharp bends and valves that do not open the full diameter of the pipe. To provide free passage for scrapers, changes in pipeline direction are made by bending pipe rather than using elbow or tee fittings.

Sandtraps are, in effect, sediment or settling chambers which collect dirt, scale, sludge and floating debris pumped through the pipeline or accumulated during pipeline cleaning. They are installed on the suction side of each pump station. Sandtraps split the flow into two 14-inch barrels, thus reducing the velocity of the flow. This allows sediment to settle out. They must be cleaned periodically and after each scraper run.

PART F - MANIFOLD DESIGN FACTORS

The following factors are affected by the theater support requirements:

- **Number and quantity of products** - The number of and quantity of products depends on theater needs (i.e., troops, equipment, etc.).
- **Number of tanks** - The number of tanks depends on the quantity and type of product stored and the facility size (a minimum of two tanks per product is preferred).
- **Number of incoming lines** - The number of incoming lines entering the facility is determined by the supporting locations.
- **Number of outgoing lines** - The number of lines leaving the facility is determined by the locations supported.
- **Future expansion** - Future expansion is based on the expansion of the theater and an increase in corresponding support requirements.
- **Location** - The location of a facility is given with the manifold centrally located within it.
- **Layout** - The layout requires that the manifold is located at the low point near the center of the tank farm piping network. The minimum distance to any tank should be 250 feet.
- **Construction** - The manifold consists of API standard pipe sections and plug valves. The API pipe will accommodate higher pressures associated with the sharp angles and close proximity to the fuel source. Plug valves provide control in switching products as they require only a 1/4-turn to open or close the valve.
- **Manifold design** - A manifold is designed to support the facility in which it is located. The basic manifold used in a facility is called a switching manifold which is an assembly of pipe, fittings, and valves used for controlling the flow of petroleum products into, out of, and within, a tank farm complex. The manifold is located at the lowest point within the facility to assure positive suction to the transfer/feeder pumps. The manifold connects a number of tanks with incoming and outgoing lines as well as pumps used in transferring products. A single tank connected to a pipeline does not provide the flexibility to accomplish more than a single function. Multiple tanks connected to a pipeline, even while providing increased capacity, can only perform a single function. The manifold system permits simultaneous receipt and delivery of petroleum products by the facility. By adding pipe, fittings, and valves, control of the product to complete multiple tasks can be accomplished. Products can be received into one tank while issues can continue simultaneously.
- **Manifold Identification Markings** - An identification system is essential for control within a facility. The facility commander will establish the identification system where one is not established or if a current system needs changing. Identification systems should be kept simple. The system should identify each tank, pump, line, and valve. A schematic of the facility tanks, pumps, lines, and valves identifying each needs to be available with the facility for reference. Schematic and facility markings are suggested as a method for identification of the system. Whatever method is utilized, the

actual facility schematic must match what is actually in place. The following identification method is suggested:

Valves - Valves located along the main pipeline (ML) are identified by the office of the chief dispatcher, starting at the beginning of the pipeline and ending outside the last facility of the head terminal. These valves are identified by the letter ML, followed by a dash (-), and a number. For example: ML-1, denotes a valve as being the first in the pipeline system.

Tanks - Tanks are identified by numbers. When numbering the tank valves, start with the first valve at the tank and number across the manifold in sequence. Write the tank number down first, followed by a dash, and then the valve number. For example, if identifying Tank 10, all valves starting from the tank would be numbered sequentially beginning with 10-1, then 10-2, then 10-3, etc., to the last valve in the manifold for that particular line.

Pumps - Pumps are identified by numbers. Pump valves may be identified with a letter or numbering system. For example, Pump 1 can have its suction and discharge valves identified individually or in sequence. For example, P-1 or Pump Suction Valve (PSV)-1, and P-2 or Pump Discharge Valve (PDV)-2. An alternative that would identify valves to a specific pump is P-1-1 or PSV-1-1 and P-1-2 or PDV-1-2 for Pump 1, suction and discharge valves.

NOTE: When there is more than one pump, the valve can be numbered in sequence (i.e., P-1 through P-4, two pumps, or in relation to the specific pump).

Pipelines - Pipelines, both incoming from and outgoing to the manifold, are identified by a letter. The incoming lines of a pipeline begin where they enter the facility and end where they connect to the manifold. For example, a line entering the facility is identified with a letter (starting with A). Valves located in the line are identified with the line letter followed by a dash (-), and then in numerical sequence starting with 1. The highest number identifies the valve in the line just prior to its connection to the manifold. If line A has five valves in it, then they would be numbered starting with A-1 (the valve nearest the entry to the facility) and ending with A-5 (the valve closest to the manifold). The outgoing lines begin at the furthest point inside the manifold and are identified with the line letter, a dash, and a number. The last valve in an outgoing line is the one at the point where the line ends in, or exits, the facility.

Additional markings used in a system for identification include the following:

Direction of Flow - The direction of flow in a line is indicated with an arrow physically placed/painted on the line. The direction can be in one direction only or in both directions.

Product Identification for Products - The product identification for products should relate to the product in the line (i.e., tank lines immediately outside the manifold should show the product).

Product Identification for Facilities - The product identification for a facility will be applied where practical depending on the tactical situation and the commander's guidance.

LESSON 10

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check your answers with the answer key. If you answer any items incorrectly, go back to the part of the lesson that contains the information involved and study again.

1. What valve types are used at the foot of upgrade slopes to allow fuel to flow in one direction only by means of a hinged disk or clapper?
   A. Rising-stem gate valves.
   B. Swing check valves.
   C. Gate valves.
   D. Beveled valves.

2. What action should you take if the packing rings in the figure eight blinds are worn?
   A. Shut them off.
   B. Separate them.
   C. Lubricate them.
   D. Replace them.

3. Which of the following fittings provides a connection from one diameter of pipe to some smaller diameter of pipe?
   A. Reducers.
   B. Elbows.
   C. Standard tees.
   D. Reducing tees.

4. A split leak clamp is designed to temporarily repair a leak caused by
   A. A small hole in the pipe.
   B. A split in the pipe.
   C. The initial coupling.
   D. Too much pipe.

5. Sandtraps are in effect sediment or settling chambers which collect dirt, scale, sludge, and floating debris pumped through the pipeline or that are accumulated in the pipeline during
   A. Pumping.
   B. Bending.
   C. Cleaning.
   D. Expansion.

LESSON 11

DIRECT USE OF PUMPS

Critical Task:
101-519-4260

OVERVIEW

The correct operation of pumps and the adherence to the pump order will enable the pipeline to be operated at maximum efficiency. This lesson will provide you with information that will allow you to direct such operations.

Lesson Description:
To effectively utilize the pumps available to you and supply the maximum amount of fuel to be transported to the forward areas, it is imperative that you be able to accurately interpret pump graphs.

Terminal Learning Objective:

Action: The soldier will direct a petroleum pump station operation including verifying flow control procedures, interpreting pump graph data to determine pump discharge head, brake horsepower, efficiency, and required engine speed.

Condition: Given subcourse QM 5099.

Standards: The soldier must score a minimum of 70 percent on the end of subcourse examination.

INTRODUCTION

Pumps can be operated at a wide range of speeds in order to compensate for variations in the pumped product's specific gravity, temperature, and the pipeline topology. The speed at which the pump is operated also determines the efficiency and therefore the cost of operation. To effectively direct a pumping operation you must be able to balance all the operating parameters of the pumps which is accomplished by the use of pump graphs.

PART A - FEET OF HEAD AND POUNDS PER SQUARE INCH

A pump graph is constructed to show feet of head, flow rate in gallons per minute (GPM), and barrels per hour. Pumps are equipped with gauges that register the suction and discharge pressure in pounds per square inch (PSI). Therefore the operator must be able to convert PSI to feet of head to determine the flow rate and efficiency of the pump.

The equation for converting PSI to feet of head is $H = \frac{2.31xPSI}{SPGR}$.

2.31 is a constant based on a column of water at 60 degrees Fahrenheit, 2.31 feet high and measuring 1 inch by 1 inch. 2.31 feet of head of water at 60 degrees Fahrenheit equals 1 PSI. One foot of head is equal to 0.433 PSI (1 divided by 2.31). By using the specific gravity of different fuels in the equation the operator can determine the difference in PSI.

EXAMPLE: The fuel being pumped (DF) has a specific gravity of 0.8254. The pressure at which it is being pumped is 325 PSI. Using the following equation, it is calculated that the feet of head is 909:

$$H = \frac{2.31x325}{0.8254}.$$

The operator knows the pump can overcome 909 feet of head.

The equation for changing feet of head to pressure is $P = \frac{HxSPGR}{2.31}$.

EXAMPLE: A pump operator must overcome 909 feet of head while pumping DF with a specific gravity of 0.8254 and needs to know the pressure which must be maintained. Using the equation:

P = pump
H = Head
2.31 = constant
SPUR = specific gravity

$$P = \frac{909x.8254}{2.31} = 325PSI.$$

PART B - EFFECT OF PUMP STATION OPERATION ON HEAD CAPACITY AND FLOW RATE

The normal head capacity of a pump station is the total head against which it will pump at the most efficient operating point for example, the design speed of the pumping units. Revolutions per minute (RPM) must be considered, together with the required head and desired throughput (GPM or BPH), to establish maximum efficiency in design. The maximum head capacity of a pump station is the total head against which it will pump to provide maximum pipeline capacity. Maximum head capacities are only for use in emergency operations and are never used in normal operations. Pump stations should not be operated at maximum capacity except for emergencies. Operation under emergency conditions should not exceed 24 consecutive hours.

PART C - PARALLEL AND SERIES INSTALLATION OF PUMPS

Electrical storage batteries are described in terms of series or parallel hook-up. In order to get 12 volts of electricity, two 6-volt batteries may be connected in series. The two 6-volt batteries connected in parallel provide 6-volts of electricity, but the current is doubled. A hydraulic system is very similar to an electrical system because the head capacity resembles voltage and the flow rate resembles the current.

Two pumps connected in series double the head capacity of a single pump while the flow rate in GPM or brake horse power (BHP) remains the same as for one pump. Two pumps connected in parallel double the flow rate, while the head capacity remains the same as for one pump.

Parallel operation is not normally used on petroleum pipelines. Pump stations are costly to operate and require man power. The objective in pipeline design is to use as few pump stations as possible. The size of the pipeline maintains the required volume. Pump stations are designed to push fuel products as far as possible down the line. As a result, pump stations are connected in series.

PART D - PUMP GRAPHS

Observe how the pump graph is constructed (Figure 11-1). The graph consists of a coordinate system. It is a uniform scale which means there is an equal space between all units on the graph in both directions. Rate of flow is plotted along the X or horizontal axis increasing from left to right in GPM on the bottom and BPH on top. The remaining variables are plotted along the Y or vertical axis. The RPM curve defines what is referred to as the operating speed of the pump.

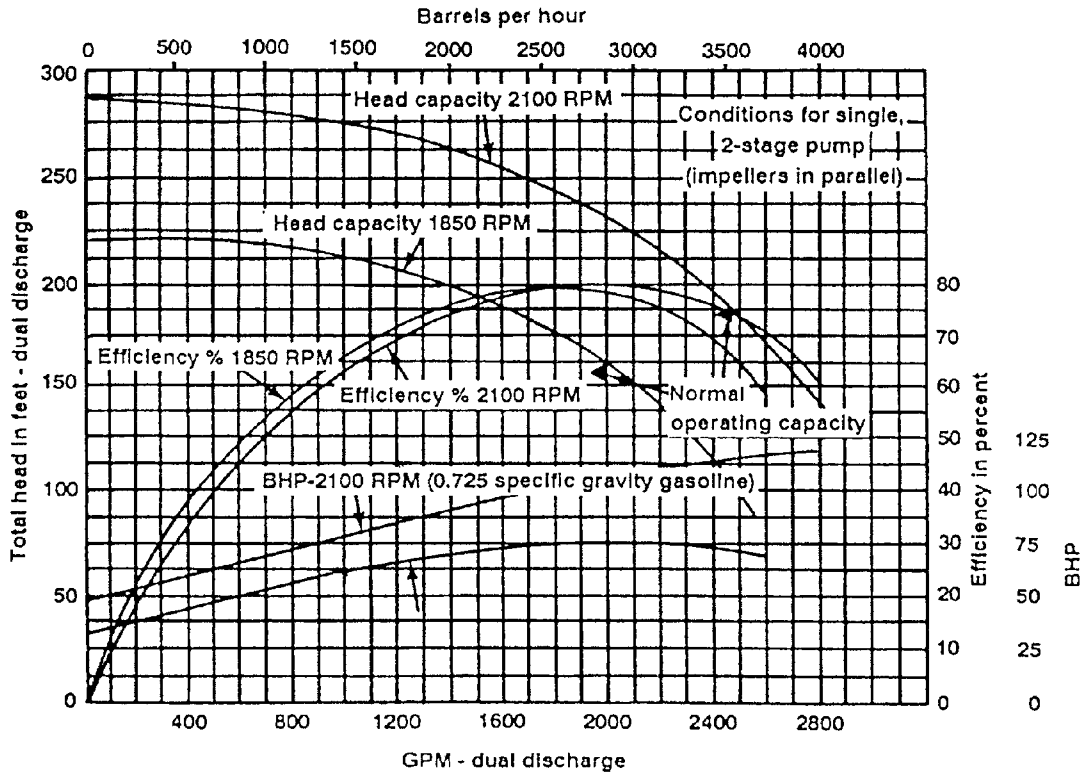

Figure 11-1. Pump graph.

Pump graph application. A common application of a pump graph (Figure 11-1) is its use in determining the rate of flow, efficiency, and BHP, given the total dynamic head in feet and operating speed of the engine in RPM. Recall the definition of dynamic head--the height to which a pump can push a column of liquid. Rate of flow is the most commonly desired variable on the graph, and can be expressed in either GPM or barrels per hour. At an engine speed of 1,800 RPM and total dynamic head of 160 feet, determine the following:

- Rate of flow (GPM).
- Efficiency (percent).
- Brake horsepower (BHP).

To solve this problem, enter the graph on the Y axis at 160 feet of head. Follow this line to the right until it intersects the head capacity curve for 1,800 GPM. At this point, all answers are determined vertically up and down.

- To read rate of flow in GPM, drop down to the X axis and read the answer 850 GPM.
- To determine the efficiency, drop down to the efficiency curve and read the percent efficiency in the right-hand margin (70 percent).
- The BHP is similarly read. Drop down to the BHP curve for gasoline and read the answer (35 BHP).

NOTE: BHP is expressed with a given specific gravity fuel. For design purposes, we use 0.8524 specific gravity diesel fuel.

PART E - DETERMINATION OF PUMP SPEED

Individual pump stations must regulate pump speed to keep suction pressures at the next pump station downstream above the minimum. The normal suction pressure at a pump station is 20 PSI for elevations less than 5,000 feet and where temperatures are below 100 degrees F (20 PSI is equivalent to 64 feet of head of Mogas). The minimum suction pressure at a pump station must be 5 PSI because of pump entrance friction losses and the possibility of vapor lock in the pump. 5 PSI is equivalent to 16 feet of head of Mogas. To determine flow rate, efficiency, and BHP in pump station operations the total pressure produced on the discharge side of the pump station must be determined first.

EXAMPLE: There are three pumps on line connected in series operating at 1800 RPM with a discharge pressure of 480 PSI and a suction pressure of 20 PSI. They are pumping a product which has a SP/GR 0.8254.

480 PSI minus 20 PSI = 460 PSI.

$$H = \frac{2.31x460}{0.8254} = 1,287$$

In order to use the pump graph, divide 1,287 ft/hd by three because there are three pumps on line (429 ft/hd). Locate 429 feet of head on the graph, read to the right of the head curve (1,800 RPM). Read down to 600 GPM. At that flow rate, read up the graph until the line intersects the brake horsepower curve at 1,800 and read 68 BHP. This represents one pump and there are three on line. Multiply by three, 204 BHP for the station. In the same manner, read up to the efficiency curve and read 74 percent. As shown, the graphs can be used for pump stations as well as individual pumps.

800 GPM main line pump graph. This pump graph (Figure 11-2) looks different but is constructed and interpreted the same as the other pump graphs used. It shows total dynamic heads in PSI, feet of head, and flow rate for water (1.0 sp/gr), DF-2 (0.8254 sp/gr), and Mogas (0.7254 sp/gr) from 770 RPM to 2,100 RPM.

For example, at a flow rate of 500 GPM and 1,800 RPM pumping DF-2, the pressure and feet of head can be determined. Locate 500 GPM and read up to the 1,800 RPM curve. Read to the left 1,359 ft/hd 500 PSI.

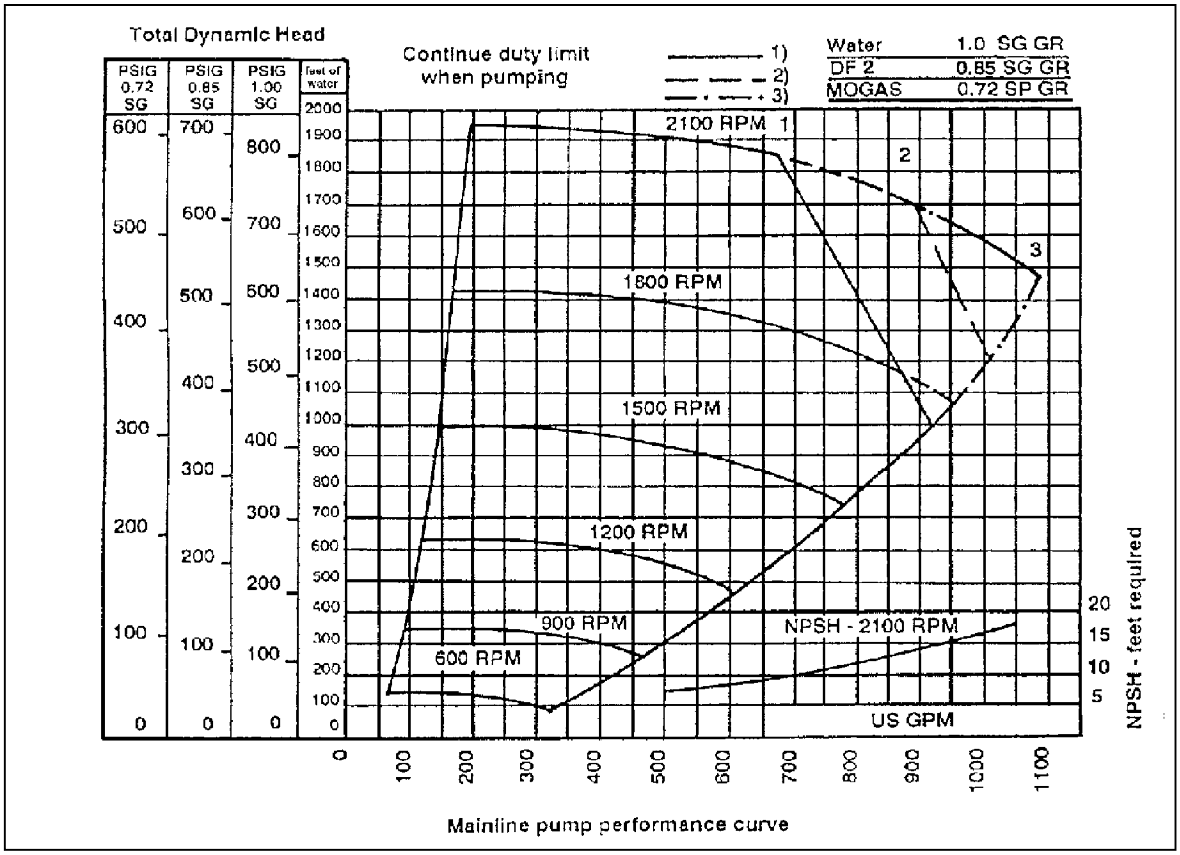

Figure 11-2. 800 GPM main line pump graph.

LESSON 11

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check your answers with the answer key. If you answer any items incorrectly, go back to the part of the lesson that contains the information involved and study again.

1. A hydraulic system is similar to an electrical system in two ways. In one way head capacity resembles voltage, and in the other the flow rate resembles

   A. Batteries.

   B. Pumping.

   C. Current.

   D. Pressure.

2. Choose the best answer to the following sentence: In pipeline design, the size of the pipeline determines the

   A. Cost of operation.

   B. Manpower requirement.

   C. Pump station connections.

   D. Volume of fuel moved.

3. What is the most commonly desired variable on the pump graph, which can be expressed in either gallons per minute or barrels per hour?

   A. Rate of flow.

   B. Brake horsepower.

   C. Efficiency.

   D. Vertical slope.

4. The normal head capacity of a pump station is the total head against which it will pump at the most efficient operating point, i.e.,

   A. The optimum standard pipeline capacity.

   B. The design speed of the pumping units.

   C. The maximum head rating.

.
D The suction pressure operating level.
.

5. The minimum suction pressure at a pump station must be _______ because of pump entrance friction losses and the possibility of vapor lock in the pump.
This measurement is equal to 16 feet head of MOGAS.
A 5 PSI.
.
B 6 PSI.
.
C 10 PSI
.
D 12 PSI.
.

LESSON 12

Pressure Testing Hose and Pipeline

Critical Task:
101-519-4310

OVERVIEW

Knowledge of the kinds of internal and external corrosion of pipeline help the petroleum staff NCO when directing the pressure testing of petroleum pipeline and hoseline to locate leaks.

Lesson Description:
This lesson covers the external corrosion of pipeline, pressure testing of petroleum pipeline and hoseline to locate leaks, and safety precautions.

Terminal Learning Objective:

Action: The soldier will acquire knowledge on the external corrosion of pipeline, pressure testing of petroleum pipeline and hoseline to locate leaks, safety precautions, and environmental considerations.

Condition: Given subcourse QM 5099.

Standards: The soldier must score a minimum of 70 percent on the end of subcourse examination.

INTRODUCTION

Periodically, due to corrosion and/or erosion leaks and cracks occur which must be corrected immediately.

PART A - CORROSION

Corrosion is the process of any refined metal returning to its natural form. What happens during corrosion is similar to the chemical actions that takes place in a battery. Negatively charged atomic particles called electrons are given up by a metal called an anode. These particles form an electrical current which passes through an electrical conductor called an electrolyte. The electrons are attracted to another metal called a cathode. The circuit is completed when current returns to the anode by way of a metal connection. During this process the metal acting as the anode breaks down and deteriorates. The metal acting as a cathode is protected and suffers no damage.

Different and Same Metals. Corrosion can involve two different metals. Also, it can occur when the anode and cathode are the same metal. For example, a newly cast metal will act as an anode to an older similar metal. A metal in acidic surroundings will act as an anode to the same metal in less acidic surroundings. A metal in an area lacking in oxygen will act as an anode to the same metal in an oxygen rich atmosphere.

Causes of Pipeline Corrosion. For corrosion to take place, there must be an anode, a cathode, an electrolyte, and some metallic connection between the anode and the cathode. Corrosion can occur in a pipeline under the following conditions:

- Different metals come in contact. This occurs where sections of pipe are joined by couplings and where fittings and valves are used. Moisture and chemicals in the surrounding ground and air act as the electrolyte. The pipeline provides the necessary metallic connection between the anode and cathode.
- A new section of pipe is put in the place of an old one. The new pipe acts as an anode to the neighboring old pipe.
- The pipeline passes through different kinds of soil. Electrons will move from pipe sections laid in high acidic soil to sections in low acidic soil and from pipe sections in high alkaline areas to sections in low alkaline areas. (A swamp is an example of an acidic area. Ground made up of moist clay is alkaline.)
- The pipeline moves from under ground to above ground, and it moves from under water to above water.
- The pipeline passes through fine soil. Fine soil holds more water and dissolved minerals and acts as a better electrolyte than coarse sand and earth.
- Stray electrical currents from outside power sources flow into the pipeline. They are carried along and then leave the pipeline to reenter the soil. The area of the pipe where the stray current enters will act as a cathode, and the area where it leaves will act as an anode. An example of a possible source of stray currents is the

ground wire of an electrical device such as an electrically powered pump.

Prevention of External Corrosion. Several techniques are used to prevent external corrosion. None is perfect, so a combination of several methods is usually used to cut down on corrosion as much as possible.

- Design. Corrosion control is considered before the pipeline is built. Soil studies are made and the planners try to avoid high acidic areas such as swamps and high alkaline areas such as clay deposits.
- Protective coverings. Pipe sections are coated at the factory or at the construction site with coal tar enamel. Protective wrappings are put around the pipeline before it is buried. The enamel and wrappings are waterproof. They act as a barrier between the pipeline and surrounding ground and atmosphere, and they prevent current from leaving the pipeline. When a pipeline is repaired it is important that these protective coverings be restored to their original condition.
- Sacrificial anodes. Another way to protect the pipeline is to use sacrificial anodes. One type of sacrificial anode is magnesium. Bars of magnesium are buried in ground beds that are located away from the pipeline. The anodes are connected to the pipeline with insulated copper wires. In this way, the pipeline becomes the cathode and the magnesium anode is sacrificed to protect the pipeline. Corrosion is not stopped; it is only directed to a less important surface.
- Mitigation bonds. Mitigation bonds are used to protect the pipeline from stray electrical current. These bonds are insulated grounding cables that serve as paths of least resistance to stray electrical currents. Stray current will tend to flow through these cables instead of the pipeline.

PART B - PIPELINE TESTING

A new coupled or welded pipeline should be tested before it is accepted for service by the using organization. Testing is done to locate leaks, blockages in the line, and flaws in construction. Testing may be done with water, fuel, or compressed air.

Water. Although testing with water is safer than testing with fuel, there are disadvantages to using water. Water may be scarce in some area. It may not be practical or possible to pack the line with water. Water expands as it freezes. It should not be used to test a line if there is any chance of the temperature falling low enough to freeze the line. All water should be removed or displaced entirely form the line before it is packed with fuel. In a combat situation this process could use valuable time.

Fuel. Since there are problems testing with water testing is usually done with fuel. Several conditions should be met when fuel is used.

- The test section should be outside of a city or heavily populated area.

- Each building within 300 feet of the test section should be empty of people.
- The test section should be watched by a patrol during the test.
- The people running the test should be in constant contact with the patrol.
- The fuel used should be a low grade, noncritical fuel that does not vaporize quickly.

Compressed Air. If the test section is in an area with many people, the line should be tested with compressed air. Compressed air should also be used to test a section of line that crosses a river. Compressed air can only be used on clean, vapor free lines. To test coupled and welded pipelines with compressed air, ensure that personnel:

- Divide the pipeline into smaller sections than those used in testing with fuel or water. Consider the size of the pipe and air compressor before deciding how long of a section should be tested. Do not try to test more than 5 miles at a time. Use the gate valves placed 1 mile apart in the pipeline to break the test section into 1 mile pieces. If the pipeline must be tested quickly test the line mile by mile instead of by 5 mile sections. Break the line at each gate valve. Uncouple and move the air compressor forward for each test. This method cuts down on the time it takes to empty a line of air.
- Uncouple the beginning of the test section from the rest of the pipeline.
- Cap off this section with a coupling made from a blank end. (To make this coupling, cut a hole in a blank end and weld an air hose coupling to the blank end over the hole.)
- Attach the air line from the air compressor to the blank end.
- Close the gate valve at the end of the first mile of test section.
- Pressurize the line at 90 pounds per square inch to the closed gate valve.
- Patrol the line and swab the couplings with soapy water. Look for bubbles caused by air escaping at a leak. Listen for the hissing sound of air escaping.
- If a leak must be repaired: close the gate valve at the end of the next mile of the test section, open the gate valve at the end of the first mile to relieve pressure, repair the leak, close the gate valve at the end of the first mile, pressurize the first mile of pipeline, and patrol again to look and listen for leaks.
- If the first mile checks out all right, close the gate valve at the end of the second mile of the test section and open the gate valve at the end of the first mile.
- Pressurize the first 2 miles of pipeline.
- Patrol for leaks in the second mile.
- If there are leaks: close the gate valve at the end of the first mile of pipeline to prevent loss of air pressure, open the gate valve at the end of the second mile to relieve pressure in the section to be repaired, repair leaks, close the gate valve at the end of the second mile, open the gate valve at the end of the first mile, pressurize the first 2 miles of the pipeline, and patrol again to look and listen for leaks.

- Repeat the above steps until the 5-mile section of pipeline has be tested and all leaks repaired.
- Pressurize the whole 5-mile section for a 24-hour test if there is enough time.
- Anchor the end of the pipeline after the test is over or hold it down with heavy equipment so that it cannot whip around. Warn everyone in the area to stand clear of the line. Then empty the air from the line by opening the gate valve at the end of the test section. Open the gate valve as quickly as possible.

Preparations for Testing. Before the test begins several actions should be taken. To ensure that the test runs smoothly, personnel should:

- Test all radios and telephones.
- Check the accuracy of all gages.
- Make sure enough repair clamps are on hand.
- Move in fire fighting equipment.
- Make sure a tank vehicle and drums are nearby in case a section of line has to be drained.
- See that shovels and material to dig and line a pipe are at the test site in case there is a spill.

The pipeline should be divided into test sections. The usual test length is the distance between pump stations (about 15 miles). Shorter distances can be tested by using gate valves to divide the pipeline into smaller segments.

During testing, line pressure in welded pipelines is measured by gages at pump stations and at line taps between pump stations. Before the test begins, over coupling leak clamps with pressure gages are mounted on coupled pipelines to measure line pressure. The clamps are mounted every one third mile, if practical. If not, they are used at least every mile. To mount an over coupling leak clamp for a pressure test, personnel should:

- Remove the vent plug and put a pressure gage in the vent plug hole.
- Loosen the split ring coupling on the pipeline.
- Remove the gasket or push a nail under the gasket to make a small leak. (The nail should not damage the gasket and should not get in the way of the over-coupling leak clamp.)
- Remove nuts and bolts from the over coupling leak clamp.
- Fit the two halves of the leak clamp and the two part gaskets over and around the split ring coupling.
- Put the large side bolts back in on each side of the clamp and tighten them.
- Tighten smaller packing bolts around the housing on the leak clamp to form seal between the gaskets and the pipe.

PART C - PIPELINE PATROLLING

When put into service, pipelines are patrolled by at least two people. The patrols look for leaks and signs of a leak such as an oil slick on a stream and/or dead or wilted plant life nearby. They report all leaks on a DA Form 5456-R. Patrols also prevent or hinder sabotage or theft. They are sent out often and at different times each day so that no one can predict when a patrol may be in a specific area. Usually, patrols are not sent out during the night because leaks are hard to spot when flashlights must be used. Patrols can be made on foot, by using a jeep or truck, or by using a small airplane or helicopter.

Foot and Motor Patrols. Foot and motor patrols are equipped with radios or telephones, coupling wrenches, grease, gaskets, and repair clamps to make minor on the spot repairs. Motor patrols can carry more equipment and cover more territory than foot patrols, but they are limited to areas where the pipelines runs alongside a road. Foot and motor patrols report major leaks to the pump operator as soon as possible.

Air Patrols. Air patrols are used only when there is a need to check out the pipeline quickly. They are also used in areas where foot and motor patrols are difficult or impossible to use because of the rough terrain. This is especially true in mountainous areas. Air patrols require fewer persons to patrol more pipeline than do foot and motor patrols. However, air patrols may be limited because of bad weather. Air patrols report all problems by radio so that repair crews can be sent to work on the pipeline.

LESSON 12

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check your answers with the answer key. If you answer any items incorrectly, go back to the part of the lesson that contains the information involved and study again.

1. What does a newly cast metal act as to an older similar metal?
   A. Acid.
   B. Cathode.
   C. Electrolyte.
   D. Anode.

2. What could you use to prevent material from building up in the pipeline?
   A. Corrosion inhibitor.
   B. Scraper.
   C. Electrical currents.
   D. Sacrificial anodes.

3. What is used to protect the pipeline from stray electrical current?
   A. Mitigation bonds.
   B. Sacrificial anodes.
   C. Protective coverings.
   D. Corrosion inhibitors.

4. When testing coupled and welded pipelines with compressed air, what do personnel pressurize the line at to the closed gate?
   A. 75 lbs per square inch.
   B. 80 lbs per square inch.
   C. 85 lbs per square inch.
   D. 90 lbs per square inch.

5. What form is used for reporting all leaks when patrolling the pipeline?
   A. DA Form 2404.
   B. DA Form 5456-R.
   C. DA Form 1712-R.
   D. DA Form 1714

LESSON 13

Slating

OVERVIEW

Having a current knowledge of bulk petroleum shipments is essential for planning petroleum requirements. A petroleum slate is the document used to track and plan for future petroleum requirements. The fuel requirements at ocean terminals are resupplied by ocean tankers via a program called slating.

Lesson Description:
This lesson covers the procedures required to accurately prepare and review petroleum slates.

Terminal Learning Objective:

Action: The soldier will acquire knowledge on preparing a petroleum slate, as well as identifying and correcting errors on previously prepared slates.

Condition: Given subcourse QM 5099.

Standards: The soldier must score a minimum of 70 percent on the end of subcourse examination.

PART A. INTRODUCTION

A slate is a request for a quantity of fuel, by product type, to be delivered by a specified means (MSC-tanker, commercial tanker), at a specified period. A slate also projects future requirements. From the slate, a Weekly Arrival Schedule (WAS) is developed to meet the requirements. This schedule projects what tankers will arrive at what ocean terminal on what date. A slate projects requirements for four months (current plus three months). The first and second month requirements must be firm, subject to minimal change, since shipping arrangements are made 30 to 60 days in advance:

- The requirements for later months are future projections and these requirements become refined/perfected as their time period gets closer. Therefore the slate establishes requirements for products and tankers.
- The early months are accurate requirements and the later months are a "heads up" notice.
- Efficient Tanker Distribution - As mentioned earlier, the early months of the slate are accurate requirements. Shipping arrangements are made 30 to 60 days in advance of the delivery date, thereby dedicating vessels to meet the requirements. The later months are used to schedule tankers the 30 to 60 days in advance for the requirement.

PART B. TYPES OF SLATES

CONUS Slate.
Use - CONUS slates are used to schedule the movement of bulk products to ocean terminals within CONUS.
Four Month Requirement - The CONUS slate establishes requirements for the current plus three (3) subsequent months.
DESC Fuel Regions - There are five (5) fuel regions in CONUS. They are: DFR's Northeast, Southwest, Central Southwest, and West (Alaska and Hawaii are considered overseas DFR's).
Tanker Movements of Product to CONUS Terminals - DESC consolidates requirements from all CONUS DFR's. Tanker movements to all water terminals are developed from these slates.
Format - CONUS slates have no universal format. The slates are prepared IAW established fuel region operating procedures.

Overseas Slate.
Use - Overseas slates are used to schedule the movement of bulk petroleum products to ocean terminals outside of CONUS.
Five Month Requirement - The overseas slate establishes requirements for the current plus four (4) subsequent months.
JPO - The JPO is normally located at the theater J-4 office. The JPO consolidates requirements from each of the theater services. The requirements of the terminals are used to prepare the slate.
Receive at DESC - the slate must be received at DESC NLT the tenth (10th) calendar day of each month. In order for this to be accomplished, JPO's transmit the slate via AUTODIN. AUTODIN is Automatic Data Information

Network, a punch card system for communication centers to transmit information.

Format - The format for the overseas slate is explained in DOD Manual 4140.25M. There are three types of punch cards that are required to be filled out. The three types are:

- The Header Card
- The Bulk Requirements Card
- The Requirements Footnote Card

PART C. SLATE PREPARATION

Preparation of the Overseas Slate.

Header Card - The header should never change except for the slate number (card column [cc] 51 thru 55) and any change number (cc 56 thru 58).

cc 1-3	ZRH (Document Identifier Code)
cc 4	Destination Area Code
cc 5-50	Blank
cc 51-52	Month - two characters, i.e. 01 will represent the month of OCT, 02 - NOV, thru 12 - SEP.
cc 53	(a dash)
cc 54-55	Last two digits of the fiscal year.
cc 56	(a dash) if change submitted, otherwise blank.
cc 57-58	Change Number - (01 - first change etc., otherwise leave blank)
cc 59-80	blank

Bulk Requirements Card - Reflects the type of product required, by quantity, during a specific period, at a specific location, and by a specific delivery method. At least one card for each month is prepared. Up to four types of product or four locations can be put on each card. There will always be at least five bulk requirements cards prepared with each slate.

cc 1-3	ZRQ (Document Identifier Code)
cc 4	Destination Area Code (DESC 4705.1, PG. 72)
cc 5-7	Month - three letters (i.e. JAN-January, OCT-October, etc.).
cc 8-22	First Product, Delivery, Quantity, Destination and Period, for up to four products.
cc 8-10	Product Type - three characters (MG2, DFM, etc.(DESCH 4705.1, pg. 32))
cc 11	Method of delivery. -Code: 1 - MSC controlled tankers/barge. -Code: 2 - Commercially controlled tankers making FOB destination shipments. -Code: 3 - Pipeline, tank-car, tank-truck, barge deliveries arranged by other than MSC.
cc 12-16	Quantity - expressed in hundreds of barrels, zeros will precede the numerical quantity (i.e., 50,000 bbl are shown as 00500).
cc 17-21	Destination Terminal Code. (DESCH 4705.1)

cc 22	Period - delivery desired. -Code: 1 - 1st thru 10th day of month. -Code: 2 - 11th thru 20th day of month. -Code: 3 - 21st thru end of month. -Blank - No preference.
cc 23-37	Second Product - same as (d) above.
cc 38-52	Third Product - same as (d) above.
cc 52-67	Fourth Product - same as (d) above.
	a. Code: A - The initial submission each month will contain code **"A"**. b. To add a new requirement where no previous entry appeared on the original slate. c. To change a quantity and or particular period and method. **NOTE:** Action code 3, report only quantities increase or decrease coded IAW DOD 4140.25m. d. To delete a specific requirement (product, quantity, terminal). e. To delete all data for a product an given month pertaining to a terminal.
cc 69-80	blank

Requirements Footnote Card - Footnotes will be used to convey information not included in the slate format:
- Changes in storage capacities resulting from such factors as removal of tankage for tank cleaning, maintenance, repair, or abandonment.
- Significant changes in requirements. Footnote should fully explain for revised estimate.
- Special requirements, restrictions, or limitations relative to ullage, storage facilities, pipeline distribution schedules, draft, safety regulations, port congestion which affect tanker operations.

cc 1-3	ZRF
cc 4	Destination Code
cc 5-6	Footnote Card Number (i.e.; 01 - 1st footnote; 02 - 2nd footnote; etc.)
cc 7-9	Month - first three letters
cc 10-12	Product type
cc 13	Methods of Delivery
cc 14-18	Destination
cc 19	Period
cc 20-67	Written Footnotes
cc 68-80	Blank

NOTE: cc 7-19 are filled out on the first (1st) footnote card referring to all the areas mentioned. Where footnote comments exceed card column 67 they are continued on additional cards starting in cc 20. Card column 1-6 will be filled in with required data.

Reporting. Slates will be reported on a monthly basis calculated to ensure its arrival at DESC on or before the 10th calendar day of each month, IAW the Bulk Petroleum Slate RCS DLA(M) 1881-(DESC). Detailed procedures for reporting slates are contained in DOD 4140, Volume V, Appendix A27.

Bulk Requirements Report - Reflects the type of product required, by quantity, during a specific period, at a specific location, and by a specific delivery method. At least one card for each month is prepared. Up to four types of product or four locations can be put on each card. There will always be at least five bulk requirements cards prepared with each slate.

PART D. DELIVERY REQUIREMENTS

The delivery requirements for each ocean terminal will be by product code for each of the months reported. Each months requirement may be further refined by requesting delivery during: (1) the first through the tenth of the month; (2) the 11th thru the 20th of the month; (3) the 21st thru the end of the month. These refinements should only be used if delivery is required in a specific period of the month. Due to the many variables involved in resupply of bulk fuel by ocean tankers, the quantities and times of deliveries may not always match the slate. Any requirement that that has priority for firm delivery of quantity or date, must be highlighted by footnotes to the slate card.

PART E. REQUIREMENT BALANCES

Requirements Balance. Some variations can be expected between the quantity slated and the quantity actually delivered during a calendar month by tankers with DESC cargo number designations.

The quantity on the tanker may not equal the quantity requested on the slate. The difference between ordered and received is reported as a "PLUS, MINUS, or ZERO", in cc 20-67.

If the quantity delivered is less then the quantity slated, the requirements balance would be a MINUS.

- If the quantity delivered is greater than the quantity slated, the requirements balance would be a PLUS.
- If the quantity delivered is the same as slated, the requirements balance would be a ZERO.
- The requirements balance must be considered when preparing the slate.
- If a MINUS quantity is reflected then the slating activity considers that negative quantity to be a requirement. DESC will schedule and no further action needs to be taken.
- Storage must be available to accept the product.
- (7) If storage is not available, the requirements balance on the slate must be adjusted to meet the storage and an explanation in the footnotes is required.
- If a PLUS quantity is reflected then DESC will count that plus quantity as already having been delivered against the next slated requirement for that product.
- (9)If the quantity delivered equals the quantity slated, the requirements balance would be ZERO.

The following is an example of the requirements balance.

Terminal X (JP4)

Month	JUN	JUL	AUG	SEP	OCT
	100	120	90	125	100

Slated Qty				
Delivered	100	100	120	115
Req. Bal.	0	-20	+10	0

JUN The slated quantity was quantity was equaled by the delivery quantity. Assuming the previous months' requirements balance was zero, the slate for July would reflect a requirements balance of ZERO for JP4 at ocean terminal X.

JUL The slated quantity was 120 Mbbl but only 100 Mbbl were delivered. This leaves terminal x, 20 Mbbl short. June requirements balance was ZERO, the slate for August will reflect a requirements balance (minus) 20 Mbbl of JP4 at ocean terminal X, providing storage (ullage) is available.

AUG The slated quantity was 90 Mbbl, but 120 mbbl were delivered. This difference, 30 Mbbl brings the requirements balance to (plus) 10 Mbbl. The slate for September will reflect a requirements balance of (plus) 10 Mbbl. Note: The slate for September did not reflect a requirements balance of 30 Mbbl because July's requirements balance of (minus) 20 Mbbl was considered in determining August requirements balance (i.e.: 20 + 30 = +10).

SEP The slated quantity was 12 Mbbl, and 115 Mbbl were actually delivered. The delivery is 10 Mbbl short, but this evens out the requirements balance. The August requirements balance was (plus) 10 Mbbl, the September slated and delivered quantity was (minus) 10 Mbbl which leaves the requirements balance in September as ZERO for JP4 at terminal X.

PART F. UNFORESEEN CHANGES

Changes can have an impact on delivery requirements. These unforeseen changes in the storage capacity, consumption, and receipt capability etc. will require a change in the delivery requirements. If the changes affect the third and latter months the following months slate can reflect corrections. If a change affects delivery requirements during the first two (2) months of the current slate, a follow-up submission of a slate change, and explanation of the change will be in the footnotes section to DESC using the quickest means possible.

PART G. WEEKLY ARRIVAL SCHEDULE (WAS)

The WAS provides the JPO and SAPO with tanker arrival information. The WAS is sent out the first Tuesday after the monthly slates have been processed. The WAS will reflect all cargoes destined to fill slated requirements at all terminals from the date the WAS is sent out through the last day of the five month slating period. On all other Tuesdays a WAS is sent out listing all deliveries scheduled for the next 60 days. Changes other than previously mentioned will be updated by message traffic. The JPO's will review all WAS and update message traffic.

LESSON 13

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check your answers with the answer key. If you answer any items incorrectly, go back to the part of the lesson that contains the information involved and study again.

1. The WAS projects which of the following types of information?
   A. Terminal and tanker arrival date.
   B. Four month petroleum requirements.
   C. Tanker distribution.
   D. None of the above.

2. Which of the following is a type of slate?
   A. SAPO.
   B. CONUS.
   C. JPO.
   D. DESC.

3. Footnotes are used to reflect which of the following?
   A. Specific product requirements.
   B. Type of product.
   C. Destination information.
   D. Information not included in the slate format.

4. If the quantity delivered equals the quantity slated, the requirements balance would be which of the following designations?
   A. Plus.
   B. Minus.
   C. Zero.
   D. None of the above.

5. Unforeseen changes in storage capacity, consumption, and which of the following other factors will require a change in delivery requirements?
   A. Receipt capability.
   B. Product pricing.
   C. Tanker traffic.
   D. Military actions.

LESSON 14

Preparing Terminal Operating Reports

OVERVIEW

Terminal operating report are necessary in determining the quantities of petroleum products on hand, received, and issued during the reporting period. This lesson outlines your duties as a supervisor/manager relating to preparation and review of these reports.

Lesson Description:
This lesson covers the procedures required to accurately prepare and review petroleum terminal operating reports.

Terminal Learning Objective:

Action: The soldier will acquire knowledge on preparing, reviewing, and using petroleum terminal operating reports..

Condition: Given subcourse QM 5099.

Standards: The soldier must score a minimum of 70 percent on the end of subcourse examination.

PART A. INTRODUCTION

The bulk petroleum facilities report provides data on all bulk petroleum storage facilities of 500 barrel capacity or more, either alone or in manifold configurations. Defense Energy Supply Center (DESC) sends current storage data on record to each of the military services; for the Army this agency is US Army General Material & Petroleum Activity (USAGMPA). DESC established a three year update schedule for this report. The report is provided to the military services by 1 June, for review and updating with appropriate additions, changes, or deletions. The report is due to DESC via USAGMPA by 15 August.

PART B. FORMAT AND CONTENT

The report consists of six (6) sections which includes the following data:

Section I -	Activity Information. Includes command, location, operating hours etc.
Section II -	**T**ankage Information. Includes product, number of tanks by product, shell capacity in barrels, tank characteristics (type of construction and type of protection), tanks in/out of service and product/tank owner etc.
Section III -	Manifold Information. Includes product code (a three digit code identifying a specific product, for multi-product manifolds "MLT" is used), capacity (in barrels) etc.
Section IV -	Vessel Berth Information. Includes type, draft, size, channel, tonnage, status (for ship, pier size and design) etc.
Section V -	Receipt and Issue Capability Information. Includes data on products, pumping hourly rate in barrels (for issuing and receiving) and accommodations. Note: This section is divided into five (5) parts: Part 1 - Barge Part 2 - Tanker Part 3 - Tank Truck Part 4 - Rail Part 5 - Pipeline
Section VI -	Bulk Petroleum Storage Review Planning Data. Includes data on all changes i.e. construction, repair, additions, deletions and use etc.

All changes in bulk petroleum storage facilities which take place other than at the time of the scheduled review and update will be reported to DESC via USAGMPA when the change takes place. Changes will include:

- Storage capacities, including product allocation which exceed 10,000 bbl at any location.
- Berthing capacities that affect the size of a tanker or barge that can be accommodated.
- Shipping or receiving facilities, increases or decreases.

Report Transmission. Transmission of data through USAGMPA after updating the report is by the mail system. Optional data submission is by the AUTODIN system or punch card format. The AUTODIN use through the Defense Automatic Addressing System (DAAS) is contained in DOD 4140.29M. The keypunch format is obtained through the local data service element and transmitted via mail.

PART C. BULK PETROLEUM STORAGE FACILITIES REPORT (DA FORM 5411-R)

This report form is submitted by CONUS Army commanders to USAGMPA upon request. The report provides data on fixed petroleum storage facilities with individual or manifold configured tankage ranging in capacity from 200 to 21,000 gallons. This report, coupled with the 506 report (which reflects quantities of 21,000 gallons [500 bbl) and up]), allows GMPA the capability of determining the total CONUS petroleum storage capacity.

PART D. BULK PETROLEUM TERMINAL MESSAGE REPORT-RCS 1884

This report is a weekly operational report submitted by each DLA terminal or terminal complex. This report is prepared by locations that in the past also submitted the DD Form 1788 monthly report. The DD Form 1788 has been discontinued per DESC and has been replaced by the Defense Fuel Automated Management System (DFAMS). The report is prepared as of 0800 hours local time each Friday. The message is to arrive at DESC-OD/FM no later than 0800 hours the following Monday, Washington D.C. time, with an information copy to the appropriate JPO and Defense Fuel Region.

Bulk petroleum message report format:
Heading - Name of activity, Julian date, phone number, name of person who prepared the report, terminal name and DODAAC.

Section I - (Submitted by all terminals) Grade of product (code), receipts, sales, inventory, capacity, totals (all quantities are to the nearest thousand barrels).

Section II - (Reported by ocean terminals only) Product, cargo number, vessel name, quantity (quantities will be to the nearest thousand barrels).

Section III - (Remarks) To be reported by all activities as applicable.

PART E. MISCELLANEOUS REPORTS

The following reports are only reviewed/updated and maintained by a limited number of locations/duty positions:

Prepositioned War Reserve Requirements for Terminal Storage (RCS 1887) (DD Form 1887). For the Army; USAGMPA will compute bulk petroleum (Prepositioned War Reserve Requirements (PWRR)), by grade of product based on approved force structure, and prescribed combat days of supply. The Army will store Prepositioned War Reserve Stock (PWRS)/(Propositioned War Reserve Material Stock (PWRMS), at or near the location of ultimate use to the maximum extent possible. USAGMPA will provide to the Theater Army commands partially completed DD Form 1887. The Theater Army Staff agencies responsible (i.e. 200th TAMMC) will complete the form identifying requirements that are equal to or exceed 150 barrels (nominal tank truck cargo) for terminal prepositioning. The following categories of petroleum supplies will not be counted as PWRMS:

- Peacetime operating stocks.
- Military Stocks intransit i.e. Seagoing tankers, pipelines etc.
- Non-dedicated commercial stocks.
- Refinery production capacity.

- Fuel dispensed to using organizations or field activities.

Upon completing the form, the theater staff agencies will coordinate with the appropriate joint or unified commands JPO, and return the form to USAGMPA. GMPA will consolidate all information and forward the terminal storage requirements to DESC for inclusion in the Inventory Management Plan (IMP). The Inventory Management Plan (IMP) is a two-volume publication that provides data on storage availability and product inventory which is to be positioned geographically in support of peacetime operations and pre-positioned war reserve materiel requirements. As requirements and military force structure change, inventory is pre-positioned to support those changes.

PART F. SOURCE IDENTIFICATION AND ORDERING AUTHORIZATION (SIOATH)

Activities that receive authorization Source Identification & Ordering Authorization (SIOATH) to order fuels from an industry source are required to submit an on-order, but not delivered report, DD Form 1886, each month. The activities authorized to order petroleum products from DESC contracts will maintain a DD Form 1886 for each contract line item for which a SIOATH authorization has been received. Ordering activities must place orders under SIOATH in advance of required deliveries IAW limits established by the contracts. The SIOATH will provide details when ordering limits are other than the following standards:

- Tanker - 20 days
- Pipeline - 15 days
- Barge - 15 days
- Tank car/tank truck - 2 days (48 hours)

PART G. DEFENSE ENERGY INFORMATION SYSTEM (DEIS)

The DEIS currently consists of the DEIS-I (Bulk Petroleum Products Report), and the DEIS-II (Utility Energy Report). The Defense Energy Information System (DEIS) - DEIS-I provides information on inventory, consumption, resupply, and sale of bulk petroleum throughout the Department of Defense. The DEIS-II identifies inventory for coal, propane, wood, and LPG only, and the consumption of purchased utility energy. The DEIS reports are as of the last day of each month and provided to Defense Logistic Agency.

LESSON 14

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check your answers with the answer key. If you answer any items incorrectly, go back to the part of the lesson that contains the information involved and study again.

1. The Bulk Petroleum Facilities Report provides data on petroleum storage facilities of at least_______ barrels?
   A. 500.
   B. 5,000.
   C. 50,000.
   D. 500,000.

2. Which of the following is the three-digit code that identifies muti-product manifolds in the Terminal operating reports?
   A. MPM
   .
   B. MLT.
   C. MP.
   D. None of the above.

3. The bulk petroleum message format is made up of how many sections?
   A. One.
   B. Two.
   C. Three.
   D. Four.

4. As requirements and force structure change, which of the following is prepositioned under the PWRS?
   A. Tankers.
   B. Inventory.
   C. Storage facilities.
   D. Petroleum personnel.

5. DEIS reports are provided to which of the following agencies?
   A. GPMA.
   B. DESC.
   C. DLA.
   D. DFAMS .

LESSON 15

Schedule And Evaluate Meter Verification

OVERVIEW

Knowledge of positive displacement, turbine, and inferential meters; using protective devices; calculating meter correction factors; and using a prover tank are essential skills for the petroleum staff NCO when scheduling and evaluating meter verification.

Lesson Description:
This lesson covers positive displacement, turbine, and inferential meters; using protective devices; calculating meter correction factors; and using a prover tank.

Terminal Learning Objective:

Action: the soldier will acquire knowledge on calculating meter correction factors based on the volume recorded by a meter and prover tank, and calculating the quantity of fuel issued using the meter correction factor when given a meter reading.

Condition: Given subcourse QM 5099.

Standards: The soldier must score a minimum of 70 percent on the end of subcourse examination.

INTRODUCTION

Accounting for fuel is one of the most important aspects of operations in the field. If you are using meters for accountability, then you must understand how they work in order to properly protect the meter and ensure that they are properly calibrated.

PART A - TYPES OF METERS

Positive Displacement (PD) Meters. As the name implies, a positive displacement meter measures the flow by separating the flowing stream into volumetric segments and counting them. There are typically three basic subassemblies in a PD meter.

- External housing. This is the pressure vessel with inlet and outlet connections. Meters may be of single or double case construction. The single case acts as a pressure vessel and as the outer wall of the measuring element. Small meters (less than 6 inches) are normally single case. Double case construction is used on meters over 6 inches. The advantage of double case construction is that the piping stress or pressure is not transmitted to the measuring element.
- Internal measuring element. Measures the volumetric flow by continuously separating a flow stream into discrete volumetric segments and counting them. It is also used to drive the counter.
- Counter drive train (counter or totalizer). The gear ratio of the drive train is designed to convert the fixed volume per revolution to the number of gallons or barrels and transmit it to the counter. The calibrator (adjuster) is used to adjust the counter for slippage through the meter. It may be used if the meter is outside the authorized tolerance.

Because of the design of the PD meter it must be protected from dirt and trash. Any solid material passing through the meter will cause it to malfunction. The meter will also register any air passing through the housing. The clearance between the housing and the van is usually .004 inches to .005 inches. Because of their simplicity, positive displacement meters are the most commonly used in petroleum operations and are used as master meters in the place of provers.

Turbine Meters. Turbine meters are precise measuring devices, even though they are classified as inferred rate meters. They go from simple measuring devices to very complex instruments, and they are much smaller than PD meters. There are three basic subassemblies in a conventional turbine meter.

- Meter housing. The meter housing assembly is constructed of a flanged pipe spool and houses the internal parts.
- Internal parts. The heart of the internal parts subassembly is the rotor blade suspended in the flowing stream on the platform bearing and rotor shaft.
- Detector subassembly. In the more complicated meters you have the viscosity compensator and the magnetic reed switch. In this kind of meter the flow is corrected to 60 degrees Fahrenheit.

When the meter is installed it must have straightening vanes upstream and downstream of the meter. The pipes are usually 5 pipe diameters long downstream and 10 pipe diameters upstream. This prevents fluid swirl and cavitation due to back pressure, which will cause the thermometer to lose accuracy. The meter is accurate up to 1/10th of 1 percent and is used for custody transfer. However, the meter requires a lot of maintenance and expertise. (They are generally not used by the military.)

Turbine meters, like the PD meters, will register air and any obstructions from trash which can effect the flow (the meter must be protected while in operation). Protective devices consist of air eliminators and basket type strainers.

Inferential Rate Meters. The inferential rate meter is an instrument whose primary element (orifice plate), when placed in a flowing stream, infers the flow rate by known physical laws (pressure drop based on the viscosity of the fuels). The orifice plate is machined to exact tolerances.

The secondary element is used to record the quantity of fuel passing through the meter. It consists of piping, high- and low-pressure sealing pots, and a 24-hour recording chart. The 24-hour chart registers the viscosity of the fuel (based on pressure drop) and the flow rate in barrels over a 24-hour period.

When the meter is installed it must have straightening vanes upstream and downstream. The length of the pipe depends on the size and type of valves used. The meter also requires protection from trash in the flowing stream (line strainers). The meter itself requires a great deal of maintenance and expertise to keep it in proper operating condition. Orifice meters are used in pipelines where the interface passage needs to be monitored.

PART B - METER INSTALLATION AND PROTECTIVE DEVICES

Meter Installation. A typical meter installation would be set up as follows:

DIRECTION OF FLOW→→→Filter separator→ Strainer→ Air eliminator→ Meter.

The strainer is downstream of the filter separator in case you have a ruptured element. The strainer will catch any fiberglass or filter paper that might get into the meter and cause it to hang up. There is also a strainer in the system on the suction side of the pump. This would prevent any trash from entering the filter separator.

Line Strainers. Line strainers consist of a metal housing which holds a canister-shaped wire mesh strainer. The mesh is usually 25 mesh or more.

- Uses. Line strainers are used in the suction side of pumps and on the inlet side of meters preventing debris from entering the pump and damaging the impeller or meter.
- Maintenance. Line strainers should be inspected and cleaned on a periodic basis (recommended at once a week). The gaskets are checked for damage, cleaned, and returned to use.

Air Eliminators. Air eliminators are placed in the line on the intake side of the meters. It consists of a cylinder usually 14 inches to 20 inches in diameter, containing baffles that are designed to force the flow of fuel to the bottom of the cylinder and to force air to the top. On the top of the cylinder is a diaphragm float-activated valve. The float holds the valve open, allowing air and vapors to escape to the atmosphere; when all air is removed, the float rises in the product and closes the valve.

The flange gaskets should be checked daily for leaks. The diaphragm valve should be checked daily to ensure it is working properly or to be replaced if needed. Remove any rust and paint.

PART C - PROVING DEVICES

- Prover tanks. There are several types of provers available for proving meters. They are primarily tanks or piping of a known volume. When they are filled, the known volume is compared to the metered volume (unknown). Prover tanks normally range in size up to 600 gallon capacity.
- Five gallon prover. The 5-gallon prover is used for proving small meters on tank trucks and at service station type installations.
- Mechanical displacement provers. These provers have a calibrated continuous loop and a spheroid. The sphere displaces a known volume from the number one sensor to the number two sensor, and the amount displaced is compared to the meter reading. You will find this kind of meter in fixed installations, or they may be trailer-mounted.
- Open volumetric prover. Open provers can be trailer-mounted or in a fixed installation. They consist of the tank, the neck of the prover, a splash dome, overlapping site gage glasses, and a gage glass scale in the neck of the prover. Thermometers are at the top and bottom. Provers are used in any installation where you have to calibrate meters in pipelines, loading docks, and dispensing areas. The maintenance of meters is very limited. Check for dents or distortions, and make sure the sight gages are in good working order. Make sure the thermometers are certified.

PART D - VERIFICATION REQUIREMENTS

Meters must be verified based on the following factors:

Size of Meters (GPM)	Total Gallons Measured
10-99	200,000
100-299	800,000
300-599	1,200,000
600 and over	2,000,000

Meters will be calibrated at least every 12 months or whenever the meter is suspect, whichever comes first. The meter must be within .0025 (1/4 gallon) for every 100 gallons registered by the master meter. If the meter is out of tolerance by more than .0025, then it must be adjusted or taken out of service. If this cannot be done, then you may use the meter factor or meter percent error to adjust the meters registered reading on the gallons pumped. The instructions for adjusting the meter are normally placed inside the top cover or in the manufacturer's manual.

Preparation.

- Meters must be checked under normal operating pressure and flow rate.
- The prover must have the capacity for no less than the volume delivered through the meter in one minute.
- Fill the prover and then empty to the zero mark (dry run). This removes air pockets in the line and warms up the meter.
- During the dry run, the time and flow rate can be determined.
- All gages and thermometers will be checked for accuracy.
- All fittings and valves must be checked for leaks.

Verification Records and Reports.

Meter test results. The following information will need to be included on all meter verification reports and records in order to obtain reliable meter performance rating:

- Closing meter reading, after the prover is full.
- Opening meter reading; this is for meters that cannot be set to zero.
- Registration; quantity recorded by the meter.
  Example:
  * Closing meter reading = 2,762
  * Opening meter reading = 1,920
  * Quantity Recorded = 2,762 - 1,920 = 842 gallons
- Temperature of metered stream.
- Temperature correction factor.
- Registration corrected to 60 degrees Fahrenheit equals amount pumped times the correction factor.
- Elapsed time. Elapsed time for test in seconds. (It will usually take less than a minute to fill the prover.) Elapsed time for test in minutes. (The flow rate is in GPM, so seconds must be corrected to minutes.)
- Rate of flow. The total register reading corrected to 60 degrees Fahrenheit divided by the elapsed time for the test equals the rate of flow. (This tells you whether the meter is running at its prescribed flow rate in one minute.)
- Closing prover tank reading (percent). The prover is allowed to be in excess of the rated capacity by +1percent or -1percent. (The graduations are in 10ths.) If the prover is rated at 840 gallons and the closing percent is +2, then change the percent to a decimal (for example 2percent is changed to .002); multiply the prover capacity (840) by .002 = 1.68 gallons. (Note: You pumped 841.68 gallons).
- Closing prover tank readings (gallons). 841.68 gallons.
- Opening prover tank reading is always 0.
- Delivery. The closing prover tank reading minus the opening reading equals the delivered amount.
- Prover temperature. If the prover has an upper and lower thermometer this would be the average of the two.

- Temperature correction factor.
- Delivery correction to 60 degrees Fahrenheit.
- Meter factor. The meter factor equals the prover quantity at 60 degrees Fahrenheit divided by the meter quantity at 60 degrees Fahrenheit divided by the meter quantity at 60 degrees Fahrenheit. The factor is carried out to four (4) decimal places.

Meter certification record. The meter certification record in conjunction with the meter test results is your proof that the meter has been properly calibrated. The following items will be included in the meter certification and recorded to ensure that the meter has been properly tested and calibrated when required:

- Date meter was verified.
- Meter factor.
- Was meter factor within .0025.
- Verification adjustment:

Not Required___________	Performed Date__________
Required but Not Performed	______________________

- If adjustment is required but not performed, the meter factor should be used to adjust all issues or receipts through the meter.
- Use of the meter verification record.
- Remarks: Any repairs or adjustments to the meter should be recorded.

LESSON 15

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check your answers with the answer key. If you answer any items incorrectly, go back to the part of the lesson that contains the information involved and study again.

1. Which type of instrument measures the flow by separating the flowing stream into volumetric segments and counting them?
   A. Turbine meter.
   B. Inferential rate meter.
   C. Positive displacement meter.
   D. Prover.

2. What type of mesh is used for a line strainer?
   A. 5 mesh or more.
   B. 15 mesh or more.
   C. 20 mesh or more.
   D. 25 mesh or more.

3. How often should the diaphragm valve on an air eliminator be checked?
   A. Daily.
   B. Weekly.
   C. Monthly.
   D. Never.

4. What type of prover is used for proving small meters on tank trucks and at service station type installations?
   A. Mechanical displacement prover.
   B. Five-gallon prover.
   C. Open volumetric prover.
   D. Closed volumetric prover.

5. If a meter is out of tolerance by more than _________ for every 100 gallons registered then it must be adjusted or taken out of service.
   A. .0025
   B. .025
   C. 2.5
   D. 25

GLOSSARY

Section 1. Acronyms and Abbreviations

ADC	Area damage control
API	American Petroleum Institute
ATC	air traffic control, air traffic controller
COSCOM	Corps support command
DA	Department of the Army
DD	Department of Defense
DISCOM	Division support command
F	Fahrenheit
FARE	Forward Area Refueling Equipment
FSSP	Fuel System Supply Point
GPM	gallons per minute
GPS	Global Positioning System
HM	hazardous material
HW	hazardous waste
ISO	International Organization for Standardization
IPDS	Inland Petroleum Distribution System
MPH	mile per hour
MSDS	Material Safety Data Sheet
NBC	Nuclear, biological, chemical
NCO	noncommissioned officer
NCOIC	noncommissioned officer in charge
Para	Paragraph
PMCS	preventive maintenance checks and Services
POL	petroleum, oils, lubricants
RAOC	Rear Area Operations center
RAP	Rear area protection
PSE	Pipeline support equipment
PSI	pounds per square inch
S3	Operations
SLGR	Small Lightweight Global Positioning Receiver
SOP	Standing operating procedure
TAACOM	Theater area command

American Petroleum Institute (API) The institute represents and is supported by the petroleum industry. It standardizes the tools and equipment used by the industry and promotes the advancement of research in the petroleum field.

API Gravity An arbitrary scale expressing the gravity or density of liquid petroleum products. The measuring scale is calibrated in terms of degrees API. The gravity of any petroleum product is corrected to 60'F (16'C). *(See Specific Gravity.)*

API gravity test A test to confirm the identities of fuel supplies.

Aqua-Glo test A test to detect water in fuel supplies.

bulk petroleum products Those petroleum products (fuels, lubricants) which are normally transported by pipeline, rail tank car, tank truck, barge, or tanker and stored in tanks or containers having a capacity of more than 55 gallons, except fuels in 500-gallon collapsible containers, which are considered to be packaged.

Class III (POL) Petroleum fuels: lubricants, hydraulic and insulating oils, preservatives, liquid and compressed gases, chemical products, coolants, deicing and antifreeze compounds, together with components and additives of such products and coal.

contaminant A foreign substance in a product.

contaminated product A product in which one or more grades or types of products have been inadvertently mixed, or a product containing foreign matter, such as dust, dirt, rust water, or emulsions.

contamination The addition to a petroleum product of some material not normally present. Common contaminants are water, dirt, sand, rust, mill scale, and other petroleum products.

diesel fuel A hydrocarbon fuel used in diesel engines. Diesel fuels used by the Armed Forces are manufactured under two specifications: W-F-800 and MIL-F16884.

filter/separator A device used to separate both solid contaminants and water from a petroleum fuel.

flammable A term describing any combustible material which can be ignited easily and which will burn rapidly. Petroleum products which have flash points of 100° F (37.80C) or lower are classed as flammable.

flash point The lowest temperature at which a liquid petroleum product gives off vapor in sufficient concentration to ignite (that is, flash) on application of a flame under specified conditions.

jet fuel Fuel meeting the required properties for use in jet engines and aircraft turbine engines. Jet fuels are procured for the Armed Forces in several grades. The most important grades are JP-4 (low vapor pressure) and JP-5 (high flash point), and JP-8.

kerosene A refined petroleum distillate used in space heating units, in wick-fed lamps, bomb-type flares, for cleaning certain machinery and tools, and as a base for liquid insecticide sprays. A single multiple-use type is procured under Federal Specification VV-K-21 1. A deodorized type, which is used as a base for insecticide sprays, is procured under Specification VV-K-220.

Millipore test A test for particulate contaminants in fuel supplies.

petroleum Crude oil. Petroleum is a mixture of gaseous, liquid, and semisolid hydrocarbons varying widely in gravity and complexity. Petroleum can be removed as a liquid from underground reservoirs, and it can be separated into various fractions by distillation and recovery. Petroleum is a general term that includes all petroleum fuels, lubricants. and specialties.

POL Petroleum, Oils, and Lubricants. Included are petroleum fuels, lubricants, hydraulic and insulating oils, temporary protectives, liquid and compressed gases, chemical products, liquid coolants, deicing and antifreeze compounds, together with components and additives of such products.

specific gravity The ratio of the weight of any quantity of matter, a petroleum product for example, to the weight of an equal quantity of water; usually determined by use of a hydrometer.

static electricity Electricity generated by friction between unlike substances and in the atmosphere; contrasted with voltaic or current electricity.

vapor Any gas-like form of a substance that is normally a solid or a liquid; any gaseous substance that can be condensed by cooling or compression.

Lesson 1 Practice Exercise
Answer Key and Feedback

Item	Correct Answer and Feedback
1.	D. Part A
2.	D. Part A
3.	C. Part A
4.	A. Part A
5.	D. Part B

Lesson 2 Practice Exercise
Answer Key and Feedback

Item	Correct Answer and Feedback
1.	B. Part A
2.	B. Part B
3.	B. Part B
4.	B. Part B
5.	B. Part B

Lesson 3 Practice Exercise
Answer Key and Feedback

Item	Correct Answer and Feedback
1.	C. Part A
2.	B. Part B
3.	A. Part B
4.	B. Part A
5.	D. Part A

Lesson 4 Practice Exercise
Answer Key and Feedback

Item	Correct Answer and Feedback
1.	B. Part C
2.	D. Part D
3.	D. Part C
4.	B. Part A
5.	B. Part D

Lesson 5 Practice Exercise
Answer Key and Feedback

Item	Correct Answer and Feedback
1.	C. Part A
2.	B. Part A
3.	C. Part B
4.	A. Part C
5.	C. Part D

Lesson 6 Practice Exercise

Answer Key and Feedback

Item	Correct Answer and Feedback
1.	A. Part A
2.	C. Part A
3.	B. Part D
4.	D. Part C
5.	C. Part E

Lesson 7 Practice Exercise
Answer Key and Feedback

Item	Correct Answer and Feedback
1.	B. Part B
2.	B. Part D
3.	C. Part E
4.	B. Part F
5.	A. Part G

Lesson 8 Practice Exercise
Answer Key and Feedback

Item	Correct Answer and Feedback
1.	A. Part A
2.	A. Part A
3.	B. Part A
4.	C. Part B
5.	A. Part E

Lesson 9 Practice Exercise
Answer Key and Feedback

Item	Correct Answer and Feedback
1.	C. Part A
2.	B. Part A
3.	B. Part B
4.	D. Part B
5.	C. Part B

Lesson 10 Practice Exercise
Answer Key and Feedback

Item	Correct Answer and Feedback
1.	B. Part B
2.	D. Part B
3.	A. Part C
4.	B. Part C
5.	C. Part E

Lesson 11 Practice Exercise
Answer Key and Feedback

Item	Correct Answer and Feedback
1. C.	Part C
2. D.	Part C
3. A.	Part D
4. B.	Part B
5. A.	Part E

Lesson 12 Practice Exercise
Answer Key and Feedback

Item	Correct Answer and Feedback
1. D.	Part A
2. B.	Part A
3. A.	Part A
4. D.	Part B
5. B.	Part C

Lesson 13 Practice Exercise
Answer Key and Feedback

Item	Correct Answer and Feedback
1. A.	Part A
2. B.	Part B
3. D.	Part C
4. C.	Part E
5. A.	Part F

Lesson 14 Practice Exercise
Answer Key and Feedback

Item	Correct Answer and Feedback
1. A.	Part A
2. B.	Part B
3. C.	Part D
4. B.	Part E
5. C.	Part G

Lesson 15 Practice Exercise
Answer Key and Feedback

Item	Correct Answer and Feedback
1. C.	Part A
2. D.	Part B
3. A.	Part B
4. B.	Part C
5. A.	Part D