METHODS OF ESTIMATING MILITARY CONSUMPTION OF PETROLEUM IN AXIS EUROPE IN 1943

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METHODS OF ESTIMATING MILITARY CONSUMPTION OF PETROLEUM IN AXIS EUROPE IN 1943

(GROUND FORCE CONSUMPTION)

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1. INTRODUCTION. The Enemy Oil Committee recently released the study No. 59 on "Axis Ground Force Requirements of Petroleum, 1942", which describes the methodology followed for the estimation of 1942 ground force requirements. The present paper, while following in general the outline presented in EOC-59, includes certain modifications and simplifications. It has been assumed that readers of the present paper are fully acquainted with the methodology of EOC 59.

2. SCOPE OF ESTIMATES. Estimates for the 1943 petroleum consumption of Axis ground forces should comprise the requirements of:

I. FIGHTING FRONTS.

A. Eastern Front

1. Finland
2. Northern Russia
3. Central Russia
4. Southern Russia
5. Caucasus

B. North Africa (Libya and Tunisia)

C. Italy (Italian Mainland, Sicily, Sardinia, Corsica, and other Mediterranean Islands).

II. THE OCCUPIED ARMIES OF CONTINENTAL EUROPE.

A. France

B. Low Countries (Holland, Belgium)

C. Denmark, Norway

D. Poland and Baltic States.

E. Yugoslavia, Albania, Greece.

F. Crete and Dodecanese.

III. ARMIES IN TRAINING AND RESERVE IN AXIS COUNTRIES.

A. Germany, including Austria and Protectorate.

B. Slovakia.

C. Hungary.

D. Rumania.

E. Bulgaria.

IV. THE TODT ORGANIZATION.

3. MONTHLY ESTIMATES. Estimates should be prepared on a monthly basis. The study now under preparation has to be completed by the middle of December 1942, and a first draft has to be submitted by December 1, 1942. Thus, detailed calculations can be made only for the first 9 or 10 months of 1943; a summary figure for the remaining 3 or 2 months of 1943 should also be taken to allow a preliminary estimate for total 1943 consumption. More exact data for the last 3 or 2 months will be calculated later as soon as the necessary information becomes available. It may be mentioned that [illegible] monthly estimates should be prepared on a [illegible] published every 3 or 6 months.

4. ESTIMATES FOR FIGHTING FRONT. The estimates of the petroleum requirements at the fighting front have to be based on:

a. The Order of Battle.

b. A campaign analysis indicating the activity by fronts and divisions.

c. Basic data for the monthly petroleum requirements of the various kinds of divisions during the different degrees of activity.

Under "a" the number and kind of divisions stationed month by month at the various fronts should be given. Separate figures should be prepared for German and satellite divisions.

The campaign analysis under "b" should indicate the activity of different kinds of divisions at the various fronts month by month. The following methodology for preparing such an activity index is suggested for discussion and critical examination. The average degree of activity of the various divisions of a particular kind at a certain front during a given month depends on the intensity of fighting of the various divisions where intensity is thought of an an index of the rate of vehicular movement. The intensity index 100 would then be assigned to that kind of fighting which requires the maximum rate of movement. Correspondingly lower index figures -- in linear dependency -- would represent a fighting intensity with lower rates of vehicular movements. It is obvious that a division does not maintain a similar intensity of fighting over a period of one

month, and that not all divisions at a particular front have the same intensity of fighting. The monthly activity index for tho various fronts and divisions is thus really a composite figure calculated on the basis of a daily intensity index for various divisions and fronts. If there are, for instance, 5 motorized German divisions at the Central Russian front in a particular month of 1943 of which two divisions are fighting with an intensity 80 for 8 days, with 40 for 14 days, and with 20 for 9 days, while the intensity index for the remaining 3 divisions is 60 for 19 days and 30 for 21 days, the average activity index for the 5 motorized divisions during this month would be calculated as follows:

$$\frac{2.80.8 + 2.40.14 + 2.20.9 + 3.60.19 + 3.30.21}{5.31}$$ or about 341

If a detailed analysis is not feasible or practical, the average activity for the 5 divisions over the month would have to be estimated directly.

This activity index would replace the campaign analysis as given in Table 3 of the ECC report 50 which distinguished between 6 different kinds of activity. The method suggested above is more elastic than that used in the 1942 study. It is obvious that the activity index by fronts and divisions is liable to a wide margin of error. Such an index is, however, indispensable a

the basis for the calculation of oil requirements; it can also be used for the estimation of military rubber and ammunition expenditure.

The data required under "c" for the monthly rate of petroleum consumption for each kind of German and satellite division for each degree of activity should be established on the basis of:

(1) the average vehicular composition of the various kinds of divisions,

(2) the unit fuel consumption per mile for the various kinds of vehicles in the different divisions, and

(3) the daily average mileage of the various vehicles in the different divisions during the various degrees of intensity of fighting.

The EOC report No. 59 gives in Table 6, 7, and 8 the vehicular composition and unit requirements of the German infantry, motorized and armored division. These data should be checked against all recent information and brought up to date. In particular, it should be ascertained whether the vehicular strength of divisions has been maintained in 1943, whether divisional oil using vehicles have been replaced by generator vehicles, and whether it is necessary to introduce estimates for additional kinds of divisions like mountain divisions etc. Table 4 of the EOC study No. 59 gives

average daily mileage figures of all tactical vehicles in localized fighting for the 3 above named kind of divisions. These figures should be checked. The 1943 intensity and activity index might conceivably be built around this table and Table 5. That would imply that the kind of fighting and the rate of vehicular movement associated in the 1942 study with a major push of an infantry, motorized, and armored division would correspond to the intensity index 100. The index for localized fighting for an infantry division, would then be 66 and for a motorized division, 60.

On the basis of the battle order, the average monthly activity index and the monthly petroleum requirements for the various divisions during the various degrees of activity, it is then possible to calculate the requirements of German divisions at the front by simple multiplication.

5. ESTIMATES FOR SATELLITE DIVISIONS. For the estimates of the petroleum requirements for satellite divisions (Italy, Hungary, Rumania, Slovakia), it is suggested to use a lower basic rate of petroleum consumption per division, probably 65 percent of the corresponding German figure. The use of a lower rate is based on the assumption that satellite divisions are smaller and less motorized. Any more recent information on the comparative vehicular strength and fuel consumption of satellite divisions and German divisions would be

highly desirable.

6. ALLOWANCE FOR WINTER MONTHS. During the winter months -- from mid-November to mid-April -- it is suggested to add 50 percent to the ground force requirements as calculated above to account for higher vehicular unit requirements under conditions of mud and snow. This rate should also be checked against recent experience.

7. ALLOWANCE FOR NON-DIVISIONAL TROOPS. The calculations so far, cover only the requirements of divisional troops. It is suggested to add 66 percent to these figures to account for non-divisional petroleum requirements in rough proportion to the strength of divisional and non-divisional troops. For satellite armies an addition of 50 percent is suggested. The use of these percentage figures should also be checked against all recent information on the size and probable fuel requirements of non-divisional troops.

8. ESTIMATES FOR SUPPLY SERVICES. It is suggested that no separate estimate should be prepared for the requirements of supply services (including self-propelled ordnance) from the rail heads to the fronts. The total requirements for these services at the Eastern Front in 1942 were estimated at about 300,000 tons out of a total consumption of 3.9 million tons. The allocation of one-third of the number of divisional trucks to the supply

services as done in Table 6, 7, and 8 in EOC-59 was somewhat arbitrary. Moreover, an increasing percentage of this transportation is done by substitute fuel-using vehicles. It is thus suggested to include all liquid fuel-using trucks in the calculation of daily divisional petroleum requirements. The estimates calculated on the basis of these figures would then comprise all liquid fuel consumption at the front for fighting and supply.

9. LUBRICATING OIL REQUIREMENTS. Lubricating oil requirements were calculated in the EOC-59 report as 5 percent of the fuel consumption. This rate may probably be on the high side and should be checked with our own experience. A different rate might be used for the summer and winter months and for gasoline and diesel engined vehicles. However, as the use of a uniform rate for all kinds of vehicles and for all periods of the year would simplify the calculations, a uniform rate should be adopted if it can be done without introducing too great an error. It should also not be ignored that the use of lower quality lubricants would increase requirements.

10. WASTAGE AND LOSSES. An allowance should be made for all kinds of wastage and losses. In the EOC report 59 an overall figure of 10 percent was used under this heading. In the U. S.-London oil meetings it was

agreed to use a figure of 7.5 percent for normal wastage and losses. For the 1943 estimate it should, however, be considered whether a higher figure should not be used for the active fighting fronts, especially as the withdrawal of the enemy in Russia, Africa, and Italy may have been accompanied by an appreciable loss of stocks. Some allowance should also be made for extra-ordinary losses suffered in the supply to the front, as for instance tanker losses in shipments to Africa.

11. LIGHT MOTOR FUEL AND DIESEL OIL REQUIREMENTS. The EOC 59 estimates did not distinguish between light motor fuel and diesel oil requirements, a question of particular importance in view of the strained diesel oil position of the enemy. Separate estimates for these two fuels should be prepared. Such a break-down would be based on information on the number of gasoline and diesel engine vehicles in the various kinds of divisions.

12. ESTIMATES FOR ARMIES OF OCCUPATION, ARMIES IN TRAINING AND IN RESERVE. Estimates for the petroleum requirements of the occupying armies of conquered Europe and of the armies in training and reserve in Axis countries should be based on the number and kind of divisions maintained in the various countries and on an average rate of consumption per division. In the EOC report 59, no distinction was made between the various

kinds of divisions. The monthly average fuel requirements of German divisions in Germany and Eastern Europe, including requirements of all non-divisional troops attached to these divisions and including a small allowance for wastage and losses was put at 390 tons per division per month. The corresponding figure for German divisions in the Low Countries and in Northern Europe and for Axis satellite divisions was 260 tons. Because of special conditions (guerrilla warfare) the monthly requirements of Axis divisions and the Balkans was put at 325 tons.

The figures for the number of Axis divisions stationed in all the European countries, month by month, and their average monthly fuel consumption rates should be checked against all current information. The greater use of generator vehicles and other mode of propulsion in all these countries has probably reduced their petroleum requirements. Lubricating oil requirements will probably be calculated as 5 percent of total fuel demand and the wastage and loss rate may be put at 7.5 percent.

13. THE TODT ORGANIZATION. As much information as possible should be collected on the size, organization and task of the Todt organization to allow an estimate of their petroleum requirements independent from the British figure.

The estimate for the motor fuel requirements of the training and occupying armies and of the Todt organization should also be broken down into light motor fuel and diesel oil.

14. MILITARY USE OF GENERATOR VEHICLES. A final chapter should deal with the use of generator vehicles in the army. It should be calculated how much liquid fuel is used as auxiliary fuel in military generator vehicles (for starting, uphill climbing, in generator vehicles operating partly on generator fuel and partly on diesel oil) and what quantities of lubricants are needed. Finally, the quantities of liquid fuel saved in 1943 by the use of generator vehicles should be estimated and some statement on the probable trend in 1944 should be made.

METHODS OF ESTIMATING MILITARY CONSUMPTION OF PETROLEUM IN AXIS EUROPE IN 1943

(AIR FORCE CONSUMPTION)

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1. INTRODUCTION. The Enemy Oil Committee recently released the study No. 58 on "Axis Air Force Requirements of Petroleum, 1942" which describes the methods followed for the estimation of 1942 air force requirements. The present paper, while following in general the outline presented in EOC-58, includes certain modifications and simplifications. It has been assumed that readers of the present paper are fully acquainted with the methodology of EOC-58.

2. SCOPE OF ESTIMATES. Estimates for the 1943 petroleum consumption of Axis air forces should comprise the requirements of the German air force, of the Italian air force (for the first 8 months of the year), and of the air forces of Axis satellite countries (Finland, Hungary, Rumania, Bulgaria, Croatia, France). Separate estimates should be provided for the petroleum requirements for actual flying and those for supply and ground services. All estimates should be prepared on a monthly basis. As the completion date for this study is December 1943, detailed calculations can only be made for the first 9 or 10 months of the year. For the remaining

3 or 2 months of 1943 summary figures should be given to allow a preliminary estimate of 1943 consumption. More exact data for the last 3 or 2 months will be calculated as soon as the necessary information becomes available. It may be mentioned that from now on military estimates should be prepared on a current basis and published every 3 or 6 months.

3. FUNCTIONAL BREAKDOWN OF ESTIMATE FOR GAF. The estimate for the petroleum consumption of the German air force should be broken down into requirements for operational flying, air transport and training, and for the motor transport needed by the supply and ground services (including AA. establishments).

4. GEOGRAPHICAL BREAKDOWN OF ESTIMATE FOR GAF. A broad geographical breakdown of these estimates should also be provided. It is suggested to follow the division made in Table 3 of the EOC study 58. This table gives separate estimates for Western and Central Europe (France, Holland, Belgium, Denmark, Norway, and Germany), Eastern Europe (Eastern Front, occupied Russia, and Poland), and the Mediterranean (Italy, the Balkans, and Africa).

5. ESTIMATE FOR OPERATIONAL FLYING. The operational petroleum requirements should be estimated on the basis of sortie estimates for the various types of planes. These sortie estimates are in turn based on the monthly

plane losses suffered by the German air force during 1943 and on the estimated number of sorties per plane lost. This ratio varies for different types of planes. In the EOC report 58 it was estimated that long range bombers perform (with certain exceptions) 15 sorties for each plane lost, reconnaissance bombers 50 sorties, dive bombers 30 sorties (except at the Eastern front where they perform 40 sorties), single-engine fighters 40 sorties (at the Eastern front 50 sorties), twin-engine fighters 35 sorties (at the Eastern front and the Mediterranean 45 sorties), army cooperation planes 25 sorties (Eastern front 35 sorties) and coastal planes 50 sorties. For the 1945 estimates most recent information on monthly plane losses by type of plane and on the sortie ratio per plane lost would be needed. (See also under 6).

The total number of sorties for the various types of planes is then broken down into sorties by models according to the average percentage share of the various models in the first-line strength of the enemy. In EOC-58 it was assumed that the average gasoline consumption per sortie was 75 percent of the average tankage capacity of this particular model. For models which are provided with excess tankage capacity it was estimated that the average gasoline consumption

for three-fourths of the total number of sorties amounted to 75 percent of the normal tankage capacity and that for the remaining quarter of the sorties to 75 percent of the maximum tankage capacity. In the case of long range reconnaissance bombers it was assumed that 75 percent of the normal tankage capacity was used in one quarter of the total sorties and 75 percent of the maximum tankage in the remaining three quarters. For the 1943 study the following changes are suggested. The average fuel consumption per sortie will, in general, be put at 75 percent of the tankage capacity calculated as described above, except for fighters where a rate of 85 percent will be used. Information on the percentage share of the various models in the first-line strength during the different months of 1943 and on the tankage capacity of these models should thus be procured.

6. ESTIMATE FOR NON-OPERATIONAL FLYING BY OPERATIONAL PLANES. In addition to the sorties flown, the operational planes will be active for a certain number of non-operational hours per month, e.g., for shifting of planes, ferrying, etc. In the 1942 estimates ferrying requirements were calculated separately. The other kinds of non-operational flying were accounted for partly by increasing the sorties and partly by using a high overall wastage and loss rate (20 percent as against 10 percent

for the ground forces).

It is suggested to follow a slightly different method for the 1943 estimates. The sortie figure used should be all comprehensive and should include all sorties proper and all other flying activity by operational planes translated into sorties. The loss figures on which the sortie estimates are based (see under 5) include losses suffered in non-operational flying by operational planes. The loss ratio for such flying is obviously smaller than that for operational sorties. The 1943 estimates for the number of sorties per plane lost should take cognizance of this fact (see under 5).

7. ESTIMATE FOR TRANSPORT PLANES. Estimates for the petroleum requirements of transport planes should be based on sortie estimates derived from the losses suffered by transport planes during the various months of 1943. In the 1942 estimates it was assumed that the ratio of transport sorties per plane lost was 75 to 1. This ratio should be checked against latest intelligence. Information on the different models used for transport flying, on their share in the total number of transport planes and on their tankage capacity is needed.

8. LUBRICATING OIL REQUIREMENTS. In the EOC-58 lubricating oil consumption was calculated at 5 percent throughout. This rate may be on the high side and should be checked by technical experts. If possible,

however, a uniform rate should be used for summer and winter requirements, and ground and air force consumption. It should also be kept in mind that lower quality oils have a shorter life than high quality products, and that this fact may justify the use of a relatively high rate.

9. WASTAGE AND LOSSES. The allowance for genuine wastage and losses should be reduced from the 20 percent used in the EOC report 58 to probably 10 percent. This percentage is somewhat higher than that suggested for the ground forces (7.5 percent); the higher rate has been chosen because of the fuel losses suffered at airdromes, which are usually the target of most intensive air attacks, and because of the losses suffered in the tanks of shot down planes. In addition to these 10 percent, however, an allowance of probably 5 percent should be made for the losses sustained during the withdrawal in Russia, Italy, and Africa and during the tanker transport of supplies to Africa and the Eastern Mediterranean.

10. ESTIMATE FOR TRAINING. The requirements for training should be calculated in a similar way as done in EOC 58. The information needed for the 1943 estimates on basic training would consist first of all in data on the average number of basic training planes used. It should then be checked whether the assumptions stated in EOC 58 correspond to most recent experience and intelligence; in particular whether the average number

of engines per training plane is one and one-fourth with 200 horsepowers per engine and whether each plane flies on the average 30 hours per month and needs 0.3 pounds of aviation gasoline per horse power. The wastage and loss rate should probably be put at 10 percent.

The number of bombers and fighters available in 1943 for advanced and operational training would also have to be estimated. The assumptions on the average fuel consumption per hour of flightiand on the average number of hours flown per month made in EOC-58 should be checked against more recent intelligence. The estimates made in the EOC 58 study concerning the number of planes and the fuel requirements of Reserve Training Units should also be brought up to date. Again, it is suggested to use an overall ratio of 10 percent for wastage and losses.

11. ESTIMATE FOR THE IAF. Similar, though somewhat simplified, methods are suggested for the calculation of the fuel requirements of the Italian air force in the first 8 months of 1943 during which it was active on the side of the enemy. Estimates for the total number of sorties by bombers and fighters should be provided. The requirements for operational planes should then be calculated similarly as described in the case of the German air force. Such a calculation would require information on the average percentage of the

various Italian models in 1943 Italian first-line strength and on their tankage capacity.

To calculate fuel requirements for Italian transport planes, information would have to be provided on the number of transport sorties and on the tankage capacity of the models used in 1943. The procedure and basic data used for the 1942 estimates of fuel requirements for training purposes should be checked and brought up to date.

The basic wastage and loss rate for the Italian air force should again be 10 percent. In addition, the Italian air force will most likely have lost stocks to the advancing enemy. Tentatively it is suggested to use a figure of 5 percent under this heading.

12. ESTIMATE FOR THE AIRFORCES OF OTHER AXIS SATELLITES. For lack of more specific information the petroleum requirements of other Axis satellite air forces were calculated in EOC 58 in a summary fashion. If no more detailed information should be available for the 1943 estimates it is suggested to use the same methodology. Information should thus be procured on the number of sorties for the various satellite countries and on the average fuel consumption per bomber and per fighter sortie. In EOC 58, requirements for training and transport planes were put at 20 and 15 percent of operational requirements respectively. It should be checked whether the same rate should be used for the 1943 estimates.

Whereas, EOC-58 assumes a wastage rate of 20 percent, it is now suggested to reduce this rate to 10 percent. For the air forces of Hungary and Rumania which took part in the retreat at the Southern and Central Eastern Front, another 5 percent might probably be added to account for losses sustained during the withdrawal.

13. ESTIMATE FOR GROUND AND SUPPLY SERVICES. The estimate presented in EOC-58 for the motor transport of the supply and ground services, including requirements for AA establishments and self-propelled guns, should be checked against latest intelligence. The actual vehicular strength of the air force units may, however, at present, fall well below the established strength. Substitute fuel driven vehicles may also be used to an increasing extent, especially behind the front lines. The average figure for fuel requirements per vehicle per day used in EOC-58 should be checked against recent intelligence and our own experience.

A broad geographical breakdown of these requirements and a statement on the estimated share of light motor fuel and diesel oil in total fuel requirements is also needed. Lubricating oil requirements should be put at 5 percent of the fuel demand if this percentage should be accepted as a reasonable rate.

It is suggested to use a wastage rate of 10 percent. Some additional allowance of probably 5 percent of total requirements for the loss of stocks suffered during the withdrawal in Russia, Italy, and Africa should be made.

CONFIDENTIAL

METHODS OF ESTIMATING MILITARY CONSUMPTION OF PETROLEUM IN AXIS EUROPE IN 1943

(NAVAL CONSUMPTION)

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1. SCOPE OF REPORT. Separate estimates for Axis naval petroleum requirements in 1943 should be prepared for the consumption in Northern Waters (Atlantic Ocean, English Channel, North Sea, Norwegian Sea, and Baltic Sea) and in the Mediterranean (including the Black Sea). These estimates should in turn be subdivided into the consumption of the German Navy (including that of incorporated French and other naval units) and of the Italian navy during the first 8 months of 1943. For the last 4 months of the year estimates would refer to the German Navy only including also those Italian units now serving under the Nazis.

The estimates refer to the consumption of all naval vessels, including auxiliary ships, like naval tankers, supply ships, troop ships and raiders, which have been requisitioned by the navy and which are predominantly manned by naval personnel.

The petroleum requirements for motor transport used in shore establishments, harbor defenses, and similar services which are performed by the navy should also be included with the present estimates.

Estimates should be broken down into light

motor fuel, diesel oil, fuel oil and lubricating oil requirements.

2. MONTHLY ESTIMATES. Estimates should be prepared on a monthly basis. As the present study has to be completed by December 1943 (a preliminary draft has to be ready by November 1), detailed estimates for the first 9 or 10 months only can be presented by that date. However, for the remaining 3 or 2 months of the year summary figures should be given to allow the preparation of a preliminary estimate for the whole of 1943; more detailed calculation for the last months of 1943 will be submitted later.

It is suggested that estimates should from now on be prepared on a current basis and be submitted every 3 or 6 months.

3. ESTIMATES FOR MAIN GERMAN NAVAL UNITS. Estimates for the petroleum requirements of the German Navy should be prepared as follows: for the main units of the German fleet, including all battle ships, aircraft carriers, heavy cruisers, light cruisers, and destroyers -- information on the number of days spent each month at sea and in port should be procured. Such information will be based largely on actual observations. The fuel consumption of these units per day at sea and per day in port should then be estimated. For many of the larger

units information on their tankage, horse power, cruising speed, endurance rates, fuel stowage, and mode of propulsion is available here. But this information alone is not sufficient to estimate their average fuel requirements at sea and in port. Certain assumptions must be made on the time which a ship runs at maximum speed and at cruising speed and what, under different sets of conditions, its fuel requirements in port are likely to be. In some cases the average speed at sea can probably be ascertained from intelligence, e.g., on the basis of the distance moved during a certain period, or from reports on actual engagements. In general, however, all these assumptions have to be based on our experience under comparable conditions. Different sets of assumptions must be made for different classes of ships and probably also for the different months of the year and the different theaters of operation.

The estimates for the fuel requirements at sea and in port should also include fuel consumption for training for trial runs, etc.

4. ESTIMATES FOR SUBMARINES. Separate estimates should be made for the fuel requirements of submarines. The following information is needed to calculate these requirements:

a. the number and size of submarines in active operation, at home, and in training, and

b. the average daily consumption of submarines of various size in active operation, at home, and in training. If no other information should be available, fuel consumption should be estimated on the basis of our own experience under comparable conditions.

5. ESTIMATES FOR SMALL CRAFTS. The fuel requirements of small naval ships (mine sweepers, mine layers, harbor defense crafts, torpedo boats, patrol boats, etc.) constitute a most important item in the total estimates virtually exceeding the requirements of all other naval ships put together. It is unlikely that complete or even satisfactory intelligence on the activity of such boats can be procured. However, information is probably available on the number, size, horse power, endurance, and mode of propulsion of such ships. Estimates on the rate of activity and on their fuel requirements during such activity and during their stay in port have thus to be based on comparable experience. The rate of activity will most likely vary for the different kinds of ships, during the various months of the year and in the different theaters of operation. The best way to prepare the estimates would probably be to establish first of all the number of ships in the various classes; secondly, the average number of days at sea and in port for the different classes of ships during the various

months of the year and in the various theaters of operation; and thirdly, the average fuel consumption per class of ship at sea and in port. Separate estimates should be prepared for their diesel and fuel oil requirements. Special attention should be paid to the fact that an increasing number of these ships use coal instead of oil. However, it should not be ignored that coal using vessels still need lubricants.

6. ESTIMATES FOR NAVAL AUXILIARIES. Estimates should also be made for the liquid fuel requirements of troop ships, naval tankers, supply ships, and raiders. Some information on the number and size of these ships and on their activity is available. These data should be used for the preparation of summary estimates for their monthly diesel oil, fuel oil, and lubricating oil requirements, based on the number of days spent at sea and the average fuel requirements at sea and in port.

7. ESTIMATES FOR SHORE ESTABLISHMENTS. Shore establishments for supply, training, harbor defense, and similar naval services obviously require some motor transportation. The quantities of liquid fuel needed for these services are most likely drawn from naval stocks and should be included with our estimates. Only very little intelligence is probably available on the number of motor vehicles used by the navy; some information on the initially established vehicular

strength is probably contained in German naval manuals and tables of organization. However, actual vehicular strength at present may very well differ considerably from the initial establishment. Some of the vehicles have most likely been converted to substitute fuels. Summary estimates for the motor fuel requirements of naval shore establishments should probably be made on the basis of an estimated number of naval motor vehicles and an average consumption per vehicle per day.

8. PRODUCT BREAKDOWN OF ESTIMATES. As mentioned under 1, estimates should be broken down into light motor fuel, diesel oil, fuel oil and lubricating oil consumption. In the case of most of the main naval units it is known whether they use diesel oil or fuel oil. For small crafts and auxiliary ships somewhat arbitrary assumptions will have to be made if specific intelligence should be lacking. The motor fuel requirements of shore establishments must also be divided into light motor fuel and diesel oil consumption, in a somewhat arbitrary fashion.

Lubricating oil consumption will in general be calculated as a percentage of liquid fuel requirements. The following rates are submitted for criticism by technical experts: for fuel oil burning ships 1 percent, for diesel ships 4 percent, and for motor vehicles 5 percent. In addition, special allowance has to be

made for the lubricating oil requirements of coal burning naval ships.

9. WASTAGE AND LOSSES. To account for all wastage and losses including losses suffered through the sinking of naval ships, it is suggested to apply an overall wastage and loss rate of 10 percent.