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ARMY AIR FORCES HISTORICAL STUDIES: No. 65

AVIATION GASOLINE PRODUCTION AND CONTROL

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AIR HISTORICAL OFFICE
Headquarters, Army Air Forces

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Headquarters, Army Air Forces
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SECURITY INFORMATION

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FOREWORD

This study of the production of aviation gasoline, written by Dr. Charles G. Forbes, is one of a series of historical monographs dealing with the development and production of air materiel during World War II.

The study is focused generally on the problem of increasing the daily output of aviation fuel from 40,000 barrels to 556,000 barrels during the war period. That was approximately a fourteenfold increase which required tremendous efforts on the part of the Government, the Army, and the petroleum industry. The chemical techniques have been passed over, although mention has been made of the several important additives.

Like other Air Historical Office studies, this monograph is subject to revision, and additional information or suggested corrections will be welcomed.

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CONTENTS

Aviation Gasoline Production and Control

Chapter I

FOUNDATIONS LAID FOR PRODUCTION

The fuel that gave the Army Air Forces additional speed, greater range, higher ceilings, and increased lifting power originally was developed in attempts to reduce the size of the automobile motor and at the same time increase its power. The higher the compression of an engine the more power delivery it develops . The fuel which was developed specifically for high-compression engines is generally known as 100-octane gasoline.

Since an understanding of the proolems and achievements in the development of aviation gasoline depends upon knowledge of certain technical factors, it is necessary to present some basic definitions and facts.

The octane number is a performance rating of a fuel which indicates its ability to resist detonation or knock. The first step in the development of this high-test fuel was taken in 1922 when tetraethyl lead was added to reduce the knock or "ping" of motors. The method of determining the octane number of a fuel was devised in 1927. The knock of the fuel being tested was compared with the knock of mixtures of two pure chemicals known as normal heptane and iso-octane. Heptane knocked very badly--more so than any gasoline known--while in those days it seemed as if iso-octane would not knock in any engine. Between these two extremes there was set up an arbitrary scale from 0 to 100,

on which it was possible to measure the anti-knock value of any fuel. By mixing the two reference fuels in various proportions a blend could always be found which just matched the knocking quality of the gasoline being tested. The percentage of iso-octane in this matching blend was called the octane number of the gasoline tested. The octane number, therefore, serves as a measure of the anti-knock value of gasoline. Another way of defining octane rating is to say that it expresses the capacity of a gasoline to be compressed without detonating. Therefore the higher the octane rating of the gasoline which fuel technicians can produce the higher the compression of successful engines which manufacturers can make.

A fuel better than iso-octane may be rated by comparing it with iso-octane containing various concentrations of tetraethyl lead. In this case it is given a "performance number," which indicates the percentage power which can be obtained with the fuel compared with that obtainable using 100-octane fuel, both cases being limited by the knock.[1] For example, a fuel designated grade 130 would develop 130 per cent as much power as would pure octane. Fuels having 100-octane or higher performance numbers are generally given two ratings--one for lean and one for rich mixture conditions.

The first high-test gasoline had an octane number of 73, which was raised to 87 by the addition of tetraethyl lead. Manufacturers improved their engines to take advantage of the increased knock rating of 87-octane fuel, while chemists experimented with other improvements of the gasoline. By 1934 the production of 100-octane gasoline was sufficiently advanced to warrant experiments by the Army. At that time

the cost of iso-octane, which a few years before had been $30 a gallon, had dropped to $2. In 1935, when only 3 per cent of its airplanes could use 100-octane gasoline, the Army purchased 100,000 gallons. Soon afterward more of the high-test fuel was purchased, and by 1937 the Army had established 100-octane as the standard fuel for combat aircraft.[2] With that beginning, the production of 100-octane gasoline in the United States was increased to 20,000 barrels daily by 1939.[3]

The next year, however, it was obvious in some quarters that this production would be inadequate for the demands of an expanded Air Corps. By the summer of 1940 the Army was planning for an operational force of 12,885 tactical airplanes. Those aircraft would require 100-octane grade fuel, although the proposed 8,946 training airplanes might function with only 91-octane gasoline. The rapidity with which the calculations swelled the requirements, however, was shown by the fact that in November 1940 the wartime estimate for the Army and Navy was set at 42,650 barrels a day for 1942. The prediction of consumption for 1943 was estimated at 62,300 barrels a day.[4] At that time the Air Corps was contemplating a strength of 12,000 pilots, or 54 combat groups, while the Navy likewise was laying the foundations of expanded air power. The Petroleum Division of the Advisory Commission to the Council of National Defense estimated optimistically that the existing production of 20,000 barrels of blending agents was equal to a daily output of 40,000 barrels of 100-octane gasoline.[5] But even with that satisfying assumption in mind, the commission suggested that the armed forces purchase and store 7,500,000 barrels of 100-octane gasoline for use in an emergency. Problems of transportation and storage were

deterring factors in acting on such suggestions, however. The best proposal appeared to be that of storing the fuel on Air Corps installations, where it would be convenient for use either in war or peace.[6]

The Defense Supplies Corporation

Storage was only one of the troublesome complications, however, in this period when the predictions of consumption were outrunning all possible production. Contracts could have been signed with the oil industry to induce it to maintain and even expand its refining capacity;[7] but under the existing regulations neither the Army nor the Navy could contract for petroleum for more than six months in advance, and they could not supply the funds for plant expansion.[8] As a solution to the puzzle of finances, storage, transportation, and plant expansion the Defense Supplies Corporation was organized on 19 September 1940 by the Reconstruction Finance Corporation. The Defense Supplies Corporation was to buy, store, and transport aviation gasoline for the Army and Navy at cost plus a carrying fee.[9]

Calculation of Requirements and Production

Another difficulty, which was not resolved satisfactorily for some time, was the manner and method of calculating requirements. In the final months of 1940 the estimates were based on the 18,000 Airplane Program, making imperative a decision as to the percentage of those aircraft which actually would be in combat and the percentage which would remain in reserve at all times. It was important, also, to know the number and length of missions and to establish attrition

rates. Since the United States was not at war, such data obviously had to be theoretical.[10] Vague and speculative as the information may have been, however, the purchase of a war reserve of high-octane fuel sufficient for 100 days was recommended.[11] At a calculated wartime consumption rate of 50,000 barrels daily, 250 days' production would have sufficed for accumulating this estimated 5,000,000-barrel reserve. Half of the supply would remain in storage with the refineries, while a rough distribution was proposed for the remaining 2,500,000 barrels. This storage plan proposed to place 1,000,000 barrels in the northeast part of the United States, 500,000 barrels in the southeast, 200,000 barrels in the northwest, and a total of 800,000 barrels in Hawaii, Puerto Rico, Alaska, and Panama.[12]

Theoretical as those calculations may have been in the light of later events, the petroleum industry at the close of 1940 was confident in its attitude. At that time 15 refineries were making 100-octane gasoline in quantities which a leader in the industry, William S. Parish, president of the Standard Oil Company of New Jersey and chairman of the Defense Policy Committee of the American Petroleum Institute, believed would be more than sufficient for 1941. He considered the time opportune, however, for expanding facilities, since in all probability increased amounts of aviation fuel would be required in 1942. He estimated that the output of 100-octane gasoline could be doubled in about a year at an expense of $30,000,000, and he was confident that the oil industry would meet any demand that might develop.[13]

Office of Petroleum Coordinator

Notwithstanding the optimistic statements of the oil industry, the Aeronautical Board in May 1941 requested the Office of Production Management to provide for a daily productive capacity of 50,000 barrels of aviation gasoline.[14] That production was desired not later than 20 November 1942.[15] Because of the increasing significance of petroleum in international developments, the Secretary of the Interior on 28 May 1941 was designated Petroleum Coordinator for National Defense. The office was named Office of Petroleum Coordinator for War in April of the following year, and the Petroleum Coordinator for War was authorized to coordinate all Federal activities concerned with the production, refining, transporting, and marketing of petroleum, particularly where those functions pertained to defense affairs. This office was abolished by Executive order of 2 December 1942 and its functions transferred to the new Petroleum Administration for War established by the same order. Even though the industry was producing almost double the amount of 100-octane gasoline that was being consumed, in 1941 some officials anticipated the approach of far greater requirements. The Office of Petroleum Coordinator became the agency for expanding the refining capacity.[16] That gasoline was to be placed in commercial storage to prevent the refiners from diverting it to the manufacture of lower grades of fuel. The Army and Navy were eager to encourage expansion of productive capacity also while the military storage facilities were being constructed.[17]

As 1941 passed several elements in the aviation-gasoline situation

were clarified. The Office of Petroleum Coordinator informed the Aeronautical Board that the refining capacity should be 54,200 barrels daily by the summerof 1942. The reply was a request to increase the capacity to 80,000 barrels by that date and to 118,000 barrels by July 1943.[18] Emphasis was given those requests in September 1941 when the daily requirements of Great Britain were raised from 7,500 barrels to 27,650 barrels, while the U.S.S.R. asked for a daily supply of 18,000 barrels. In those particular instances the emergency could be met by increasing the lead content so as to provide an additional 20 per cent in quantity.[19] Thus it became obvious that refining facilities must be expanded rapidly, care being taken meanwhile to gain the most efficient production from the existing plants. This additional productive capacity had to be financed. Equally important was the need to prevent the various military services from competing in the purchase of the aviation gasoline. Consequently, an equitable distribution among the consuming services was organized.[20]

The Office of Petroleum Coordinator foresaw a daily requirement of 106,000 barrels of aviation gasoline by the summer of 1942. That figure was more than double the daily output of the autumn of 1941 and would require the erection of 40 to 50 plants at a total cost of approximately $150,000,000. The refining industry was urged to pay for this construction, but it hesitated because the government could give no assurance of buying the prospective 100-octane gasoline and the previous military method of meeting requirements through bids would not satisfy long-term supply plans.[21] The Office of Petroleum Coordinator sought from the Defense Plant Corporation and the Defense Supplies Corporation

funds for plant expansion. In addition to the financing of construction, it sought to establish a central purchasing and distributing agency for the gasoline. The Defense Supplies Corporation was the logical authority for this centralized function.[22]

Situation in October 1941

A summary in October 1941 of the aviation-gasoline situation gave a less dismal appearance to the future. The existing production amounted to only about 40,000 barrels daily. By July 1942, however, a dozen additional plants were expected to be in operation, bringing an increase of 11,024 barrels to the daily production. Priorities of A-1-a had been authorized for the completion of two other plants with a combined daily capacity of 2,600 barrels, while priorities had been requested for four more plants with a total daily production of 10,406 barrels. The need of funds was delaying the conversion of eight plants having a total daily capacity of 14,487 barrels. Fifteen facilities, capable of manufacturing a total of 21,669 barrels daily, were of a type that could be converted and put into operation after July 1942. According to the summary there was a potential aviation gasoline production of 100,499 barrels daily.[23] This survey tended to produce the erroneous belief that the aviation-gasoline situation was satisfactory.

The situation, however, was far from satisfactory. For example, the fulfillment of hoped-for airplane production would require a daily fuel output of 539,829 barrels.[24] But that represented only a part of the requirements, because both the British and the Russians had requested more fuel from U.S. refineries, thereby aggravating the potential

shortage.[25] Prompt delivery of building materials and supplies was essential so that the plants under construction could be completed at an early date.[26] To relieve the situation somewhat the Aeronautical Board in November 1941 approved an increase of tetraethyl lead content from 3 to 4 cubic centimeters per gallon of gasoline. This increase in the addition of tetraethyl lead would swell the 100-octane production approximately one-fifth. The board also approved the use of 91-octane fuel in pilot training, and thus decreased requirements for the higher grades of fuel. A third saving was effected by restricting the consumption of 100-octane gasoline in experimental activities.[27] In spite of those measures, however, daily production was not considered sufficient at the opening of 1942.[28]

Situation in December 1941

When the United States entered the war in December 1941 the aviation gasoline situation contrasted sharply with that of the previous year, when production capacity had been considered sufficient for future needs. From the British Purchasing Commission came the plea for an increase of 100-octane gasoline in 1942 or "we are sunk." Attention was called to the existing paucity of aviation fuel and to the fact that the estimated 20,000,000 barrels of production for 1942 would be 11,000,000 barrels short of requirements. The British Purchasing Commission also pointed out that the addition of 70,000 barrels to the daily production capacity would necessitate several construction projects, each of which would require separate negotiation and require at least a year for completion.[29] In response to this request, U.S. Army officers

suggested that possibly Great Britain was storing too much fuel.[30] The Office of Petroleum Coordinator surveyed the production facilities of the United Nations, recommending in the meantime that Great Britain expand its refineries on the islands of Curaçao and Trinidad. In addition the British were asked to alter their fuel specifications to meet those of the U.S. Air Corps and Navy.[31]

Two days after the declaration of war the refineries of the United States were asked to bend every effort toward increasing production of 100-octane gasoline.[32] It proved impossible to develop a program of plant expansion at that time because critical construction materials were unavailable. Thus since projected refineries would not be in production as scheduled, the control of aviation gasoline stocks was increasingly important. Consequently the manufacturers were directed to clear all sales of 100-octane gasoline through the Office of Petroleum Coordinator.[33]

By the end of December 1941, 20 refineries were producing 100-octane gasoline at a total rate of 44,008 barrels a day. The status of aviation gasoline plant expansion at that time was as follows:

Status of Plants	No. of Plants	Prospective Barrels per Day
Under construction	10	10,387
In advanced engineering phase	4	6,225
In preliminary engineering phase	7	37,730
In initial development phase	11	24,955
TOTAL	32	79,297

In addition to the 32 projected plants in the United States, a factory of the Anglo-Persian Oil Company at Abadan, Iran, with a capacity of 7,000 barrels per day, was to be completed soon. The total existing and prospective daily output was 130,305 barrels.[34]

It was believed that through improved blending the existing production of 100-octane gasoline could be increased to a daily total of 57,220 barrels. In addition, at certain plants a large supply of raw materials and more efficient operation would result in a total increase of 5,000 barrels. That would make the national daily total output over 62,000 barrels during the first half of 1942. A saving of 8,000 barrels daily was expected from the announcement by the Air Corps that it would use only 91-octane fuel in its pilot training. A careful study of the requirements of the United Kingdom reduced the British needs 2,400 barrels. In addition, a larger output was expected from improved integration of plants both inside and outside the United States.

Added stimulus was given plant expansion in December 1941 when the contract form to provide for government financing was arranged. The contract form provided not only for new construction, but for the purchase of the production as well. This legal instrument, the first one of which was signed by Cities Service Oil Company, provided for 75 per cent government finance of construction, the purchase of the 100-octane product for three years, and an option to purchase for an additional two years. Each contract was to be approved by the War Department, the Navy Department, the Treasury Department, and the Reconstruction Finance Corporation, as well as the oil company involved. Another form

of agreement was arranged for the large companies which needed no monetary assistance, only the assurance of a market for their product.[35]

Thus it was believed that early in 1942 the refineries of the United States could manage to produce more than 57,000 barrels of 100-octane gasoline daily--a great contrast to the 20,000-barrel daily output of 1939. The Defense Supplies Corporation had been organized to help finance the production of aviation gasoline, since the refining industry could not be expected to shoulder so huge and costly a task. The Office of Petroleum Coordinator had been instituted for husbanding this important fuel of warfare, and as the shortage became increasingly acute British allocation was reduced and flying training in the United States was limited to the use of 91-octane gasoline. Despite the scarcity of materials, 32 aviation gasoline plants were in various stages of construction, and financing of those plants was being assumed by the government.

Chapter II

GROWING DEMANDS ON REFINERIES

The tenseness of the situation in January 1942 proved that the preliminary production steps of 1941 had been taken none too soon. The extraordinary plans for the production of combat aircraft made imperative the projected daily output of 150,000 barrels of aviation gasoline. At that time 22 refineries were producing 44,008 barrels each day, while 14 plants, with a daily capacity of 15,837 barrels, were being constructed and 28 others were in some phase of the engineering stage. That accounted for a total domestic daily output of 143,378 barrels. In addition, four foreign refineries--one each at Abadan, Iran, and at Calgary, Canada; and two in the Netherlands West Indies--were being constructed or planned. Thus a daily grand total of 157,403 barrels of aviation gasoline was expected to be available in the near future. Even that production, however, would still be insufficient for the expanding combat airplane program. As a consequence, contracts were written for additional refining capacity; these contracts generally provided for government aid. By the middle of January 1942, agreements had been signed for the daily production of 32,441 barrels; contracts were under review for 18,720 barrels; and arrangements to build facilities for producing 27,567 barrels were being negotiated. Contracts without government aid had been signed with refiners to provide an additional daily production of 25,117 barrels. Thus, by adding the

contractual total of 103,845 barrels to the actual production and the capacity under construction, the projected daily output of 100-octane grade aviation fuel was 201,348 barrels.[1]

Increased Production Authorized

Contracts were given added significance when the War Production Board on 27 January 1942 authorized an increase in productive capacity to 180,000 barrels daily.[2] By the middle of February, however, the daily requirements had mounted to 200,000 barrels.[3] Hence the supply situation would remain critical until the new facilities were in operation, although domestic production had been increased to 48,487 barrels.[4] The War Department urged that the refining capacity be raised to 200,000 barrels daily, and that change was approved by the War Production Board on 17 February 1942. Then the Aeronautical Board recommended that the Office of Petroleum Coordinator investigate the feasibility of improving the refinery on Bahrein Island in the Persian Gulf as a means of increasing the world supply[5] of aviation gasoline.[6]

The dire seriousness of the aviation gasoline situation was emphasized in March 1942, when a tabulation of production, inventory, and requirements revealed that supply was running far out of balance with anticipated demand. This meant that consumption positively could not continue at the rate indicated by requirements. Through the Japanese conquest of the East Indies the United Nations had lost a daily production of more than 7,000 barrels. The War Production Board had authorized the expansion of refineries, but although the Office of Petroleum Coordinator had requested a priority of A-1-a no steel

had been allocated for this construction during the first two months of 1942. That translated into production meant a delay of 10 weeks and a cost to the gasoline production program of about 8,000,000 barrels. Fundamentally the production of 100-octane gasoline depended on materials, and despite the fact that a projected daily production of about 261,248 barrels was on paper the actual output still was only 48,487 barrels. Causing still greater gloom to the outlook, plans were in process to raise the grade of the gasoline, a change that would amount to a 26 per cent decrease in quantity production.

Aviation Petroleum Products Allocation Committee

Since it was obvious that scrupulous control was imperative, the Munitions Assignments Committee (Air) designated a subcommittee to be known as the Aviation Petroleum Products Allocation Committee. Members of the subcommittee included representatives of the Army Air Forces, the Navy, the Royal Air Force, the British Petroleum Mission, and the Office of Petroleum Coordinator.[7] The committee was charged with the control of all critical grades of aviation gasoline--87-octane and above. It was responsible for the production and distribution of fuel from sources under the control of the United States, while a companion organization at London, the Aviation Petroleum Products London Assignment Committee, performed similar functions for the United Kingdom. Each month the consuming services submitted to the committee their requests for allocation. The Fuels Branch of the Air Service Command submitted the requests of the continental consumers; these were based on estimates of the continental air forces for the three ensuing months. Overseas requests, cabled from the various theaters, were based on consumption estimates and needs for reserves for the same period.

The total was screened at Washington, where allocations were made according to theater priority and the availability of gasoline. Allocation was made each month for the coming 60 days. Fuel produced under United Kingdom control was allocated by the London Assignment Committee to theaters so far as it would go; the remaining requirement was cabled to Washington for assignment from U.S. supplies. The fuel consumed within the United States was allocated to and distributed by the different services. The gasoline for overseas was allocated and shipped to joint pools within the theaters of operation for use by the United Nations. No separate stocks were set up for the individual services. The aviation gasoline for use in the overseas theaters was produced two or three months in advance of the time it would be required.[8]

Difficulties in Manufacture

Essential as were arrangements for the allocation and distribution of aviation gasoline, its manufacture was of first importance. The construction of manufacturing facilities was the prime essential. In March 1942 refineries were forced to get their steel plate where they could find it; not until May of that year did the War Production Board permit the allocation of steel plate to gasoline plants. Another handicap was encountered when the aircraft production program was given a higher priority than fuel manufacturing.[9] That was done despite the estimates which indicated that before the end of 1944 the combined requirements of the United Nations would be 401,000 barrels daily and despite the calculations which showed clearly that a deficiency would exist, probably a shortage of more than 75,000 barrels.[10] Even the

projected producing capacity at that time (April 1942) was only 303,000 barrels--less than enough to meet the anticipated requirements.[11] The War Production Board was told that all expansion projects should be considered on the basis of producing 140-performance-number gasoline. This meant that additional capacity would be necessary. The manufacture of 200,000 barrels of 140-grade[12] fuel, for example, would require a plant capacity capable of making 240,000 barrels of 100-octane. In May 1942 it was believed that daily production of 100-octane would be 200,000 barrels by the end of 1943.[13]

A change in the chemical specifications of aviation gasoline became effective in May 1942, tending to cause a shrinkage in output. This counteracted the increase which had come the preceding November, when the tetraethyl lead content per gallon had been raised from 3 cubic centimeters to 4. The May alteration called for control of the rich knock rating to equal at least 125 performance number. In this case the consequent production shrinkage was largely offset by the use of a newly developed additive called "cumene."[14] This improvement in grade, with its consequent loss in quantity, did not meet with the entire approval of the oil industry because of the increased production costs. An agreement was reached therefore whereby manufacturers would be compensated for losses incurred in the manufacture of aviation fuels of 91-octane grade and higher.[15]

Formula for Computation of Requirements

The urgency of the situation resulted in the adoption in October 1942 of a formula for the computation of requirements. Prior to that

time there had been no uniform method of estimating, but after a conference in England the system of calculating was stabilized by the formula ((I + P) - A) C = R. In applying this formula, the inventory of aircraft on hand (I) plus the airplanes to be produced during the month (P), less those expected to be lost through attrition (A) was multiplied by the monthly gasoline consumption per airplane (C). The monthly gasoline consumption of an airplane was reached by taking 75 per cent of the maximum alternate gasoline load, adding 10 per cent for contingencies such as take-off and climb, and multiplying the total by the number of missions per month. "R" was the monthly amount of gasoline required for a specific type of airplane. As the War Production Board issued airplane production schedules, requirements for aviation fuel were revised accordingly. This procedure continued until February 1943, when there was published the "8-L" airplane production schedule which indicated that the world requirements would be 539,829 barrels daily by July 1944. Flaws in this method of computation, however, became apparent at that time.[16]

In August 1943, when the yearly deficiency was estimated at 3,729,000 barrels,[17] the functions of the Aviation Petroleum Products Allocation Committee were delineated carefully in the interest of improved efficiency.[18] By that time the actual daily production had reached 52,900 barrels, while an additional capacity of 285,700 barrels had been projected at a total cost, private and governmental, of $442,474,663.[19] A step to alleviate the refining situation by reducing operations was taken at a meeting of officials in England; they sought to standardize the oils and greases used by the air arms of the

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two nations.[20] Even so, the daily requirements were fixed in October 1942 at 400,000 barrels.[21] Of that total, sources outside the United States would produce more than 30,000 barrels.[22]

Storage Plans

Plans were formulated in October 1942 for the accumulation of supplies of aviation fuel and lubricants in the different theaters. A minimum of six months' requirements was set as the goal for strategic storage of gasoline, while lubricants were estimated on a basis of 5 per cent of the 130-grade fuel.[23] At that time in the Western Hemisphere 100-octane gasoline was stored at 245 points, 140 of which were in the United States. The other storage points were situated as follows:

Location	No. Storage Points
Alaska	39
Brazil	3
Canada	19
Greenland	3
Hawaii	11
Iceland	1
Newfoundland	4
Panama	12
Puerto Rico	11
Trinidad	7

Of the total storage of 28,000,000 barrels, 6,000,000 were regarded as strategic in the United States, 19,000,000 were called war reserve, and 3,000,000 were held by the oil companies.[24] Considering the possibility of losses through sabotage, enemy action, and shutdowns, it was believed that an additional 40,000 barrels should be added to the projected refining capacity. This meant that production facilities

for 101,818 barrels remained to be constructed.[25] This additional 40,000-barrel capacity would result in a total daily capacity of 406,553 barrels by 1 July 1944.[26] In an effort to approach that figure the War Production Board was asked on 3 November 1942 to approve the construction of an additional 100,000-barrel plant capacity, but action was deferred.[27]

Examination of fuel from certain captured German planes showed the German aviation gas to be 145-grade.[28] This caused some persons in the AAF to argue that the performance number of U.S. fuel should be increased from 130 to 140. They wondered why the United States, which controlled 60 per cent of the world's petroleum resources--crude oil especially adapted to the manufacture of high-octane fuel--merely hoped to have adequate supplies of 130-grade by 1943. The use of 140-grade gasoline in combat aircraft would increase the margin of safety by reducing the hazard caused by detonation. The performance would be improved by increasing the top speed, boosting the take-off power, raising the rate of climb, and enlarging the load of bombers.[29]

Mandatory Construction Directive

Notwithstanding the value of improving the grade, however, the dire need for additional productive capacity still existed. Little assistance in the completion of the new plants had been received by the Office of Petroleum Coordinator. The War Production Board previously had conceded the necessity for augmented productive capacity, but not until December 1942 was a mandatory directive issued to provide for the completion of the plants on the 1 April 1943 schedule.[30] That

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directive came on 4 December 1942, just two days after President Roosevelt had reorganized the controls through the establishment of the Petroleum Administrator for War, which replaced the Office of Petroleum Coordinator.[31] The order from the War Production Board froze delivery dates on all materials needed to complete the urgent 100-octane plants. The estimated daily capacity of these plants was approximately 77,600 barrels, and it was hoped that the directive would effect completion on schedule. In accordance with this plan, the Aviation Petroleum Products Allocation Committee began arranging for an additional capacity of 100,000 barrels of 130-grade gasoline. The possibility of locating the new plants in strategic areas also was considered.[32] Hardly had this increase been approved before the Aeronautical Board announced that the ultimate requirement of the United Nations for 130-grade gasoline would be nearly 540,000 barrels daily.[33]

Interference by Synthetic Rubber Program

The greatest hindrance to the fulfillment of the requirements for both manufacturing facilities and the resulting aviation gasoline was the synthetic rubber production program. The manufacture of rubber was an essential that began interfering with aviation-gasoline production early in 1942. The equipment and some of the processes were identical in the production of aviation gasoline and synthetic rubber. Thus the expansion of oil refineries in the aviation-gasoline program was forced in November 1942 to await the dovetailing of the rubber program.[34] In the summer of 1942 the aircraft production program had been given a higher priority for materials than had the fuel with which

the planes were to be operated. In the autumn of that year the rubber manufacturing program ranked above aviation fuel on the priority list of the War Production Board. The Secretaries of War, Navy, and Interior were unsuccessful in efforts to override the priority of the rubber program.

The problem, however, was more intricate than a simple conflict between the synthetic-rubber and aviation-gasoline programs, because also involved were the manufacture of toluene and the construction of naval escort vessels. All four programs were competing for the same materials. In December 1942 the War Production Board decided to give first preference to the gasoline and rubber plants, intending that they should progress concurrently. The Joint U.S. Staff Planners concluded that the amount of gasoline to be produced from the existing plants would be needed to meet the fuel requirements of the airplanes already in service. If airplane production plans were carried out in 1943, the completion of at least four-fifths of the proposed gasoline plants would be essential for the operation of the aircraft. The Joint Staff Planners submitted a draft of a letter, to be sent by President Roosevelt to Rubber Director Jeffers, ordering that crude rubber stocks be conserved carefully in view of the delay involved in completion of the synthetic plants.[35] The AAF regarded any further delay in the completion of the gasoline plants as most critical. Shortages in the past had been met by reductions in the working inventories and by the reallocation of shipments. While the quality of the aviation gasoline in December 1942 had been increased to 130-performance number, further improvements would be necessary and a decline in output would result

from the alteration of the specifications.[36]

AAF officers flatly contradicted the assertion of the rubber program sponsors that there had been no interference with the production of aviation gasoline. The former contended that the rubber construction had delayed not only gasoline manufacture, but many other programs as well. The conflict with the gasoline program, of course, resulted from the fact that rubber production required similar boilers, heat exchangers, turbo-blowers, pumps, compressors, switchgear, piping, valves, motors, distillation towers, catalyst cases, and instruments. In a brief table the AAF showed statistically that the loss of turbo-blowers, valves, heat exchangers, and boilers to the rubber program had retarded the gasoline production program.[37] Obviously there was serious conflict between the production of aviation gasoline and the production of synthetic rubber.

Four Party Agreement

Probably the most significant event of the year was the arrangement made in December 1942 for the improvement of aviation-gasoline distribution. Known as the Four Party Agreement, this arrangement was participated in by the War Department, the Navy Department, the Defense Supplies Corporation, and the Petroleum Administration for War. The four parties contracted with the refineries to purchase all the 100-octane gasoline produced, with the Defense Supplies Corporation placing virtually the entire output under contract. The gasoline was to be distributed through the Aviation Petroleum Products Allocation Committee, and only to the Army, the Navy, and Lend-Lease users. It was agreed that the War Department would advance $34,000,000 and the Navy

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Department $66,000,000--about half the cost for the first six months of 1943. The Four Party Agreement became effective 1 January 1943.[38] Among the virtues of this arrangement was the elimination of bids and competition among the purchasers of all fuel above 96-octane.[39]

Conservation and Improvement of High-test Gasoline

Despite the fact that by the close of 1942 the 22 refineries of the United States were producing daily 124,350 barrels of aviation gasoline, or its equivalent,[40] action was taken to gain the maximum use from the high-test gasoline. Manufacturers were directed to use 87- and 91-octane fuel for their run-in schedules, and 87-octane was ordered for training.[41] In addition to the U.S. production, three refineries in the Caribbean, one in the Persian Gulf, and plants in the United Kingdom produced 24,440 barrels. Thus the total 100-octane, or equivalent, production for the United Nations[42] was 148,790 barrels daily.[43] General Arnold urged that the projected new facilities be erected as near AAF installations as possible to prevent delay in transportation.[44]

In spite of handicaps, hindrances, and delays, the actual production of aviation gasoline by January 1943 was in excess of the estimated possibilities of eight months earlier. It was estimated, however, that the rubber program alone had been responsible for a loss of at least 4,000,000 barrels of gasoline.[45] The change in specifications, raising the performance number to 130, did not affect production materially, although it had been expected to have that result.[46] Technically trained AAF inspectors were stationed at each of the refineries to check the quality of the gasoline, since it was impossible to

test the fuel at the numerous consuming installations.[47]

For the sake of efficiency in distributing the insufficient supply, it was decided to allocate to the AAF the output of the Curaçao and Trinidad refineries. This production was considered as a unit with the U.S. Gulf Coast plants so as to relieve tankers for the Atlantic and Pacific ocean transportation.[48] Thus arrangements were made to supply the AAF at Ponce, in Puerto Rico, and Jamaica from Curaçao.[49] While the Aeronautical Board estimated a daily requirement of nearly 540,000 barrels on the basis of scheduled airplane production,[50] an attempt was made to collect more accurate data on the consumption of aviation gasoline. The purpose was to determine a basis for calculating over-all requirements for 1943 and 1944, bearing in mind allocations to the various theaters and transportation requirements. Fundamental factors in the calculations were the number of missions to be flown in the various theaters.[51]

Aviation Petroleum Branch

When the daily requirements approached 540,000 barrels early in 1943 and the existing and authorized facilities had a capacity of only 506,000, it was obviously imperative to seek a balance between potential consumption and production. To avoid unnecessary construction, realism in calculating the requirements was particularly important. At the direction of the Secretary of War, the Aviation Petroleum Branch was established in February 1943 under the Air Services Division of Headquarters, AAF. One of the prime duties of the Aviation Petroleum Branch was the analysis of the method used by the Aeronautical Board

in estimating requirements. Important factors were both the need for realistic long-range estimates and for a system by which to check the calculations. In March 1943, when the Aviation Petroleum Branch began its studies, a significant error in the previous estimating formula soon became apparent. That error was the application of a 20 per cent attrition rate to all tactical-type aircraft, both in the continental United States and on a reserve status overseas. Actually such a high attrition rate could apply only to those airplanes in the active theaters, while a far lower rate was applicable in the inactive theaters and in the United States.

New Method of Calculating Requirements

A revised method of calculating requirements, based not on the number of aircraft produced but on the AAF planned air strength, was developed. This was known as the Tactical Group Plan. The importance of this change was demonstrated by the fact that the airplane production programs would manufacture more aircraft than would be required by the AAF. Approximately one-third of the total aircraft in the active theaters remained on the ground in reserve, consuming no gasoline. Consequently the fuel requirements of only two-thirds of the airplanes deployed to the theaters needed to be met. In computing the revised requirements of 130-grade fuel five types of aircraft were considered: heavy, medium, and light bombers; fighters; and transports. An average consumption figure was reached by carefully weighting each model according to the relative number that would be available during any particular period. The requirements were estimated for overseas,

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for the continental United States, and for the Zone of the Interior.[52] Since this system involved several new factors, there was delay in assembling the actual data. By May 1943 it was known that realistic consumption calculations could be made, but that such calculations would require access to operational records. The necessary information was collected by the Air Service Command and the Statistical Control Office.

It was discovered that the fuel consumption of a specific model of airplane might vary with the different theaters. Then, too, as control of the enemy skyways was gained the attrition rates declined. As all of this information became available for the different theaters, it was possible to establish reasonably accurate trends of future operations. The procedure for estimating fuel requirements gradually was simplified. Flying hours ultimately were established as the basis of calculating fuel requirements. The estimates of flying hours were based on official AAF programs for the deployment of groups to overseas bases, combat crew training loads, and individual training loads. The realistic long-range estimates were important as a means of determining in advance the necessity for construction of facilities, in the estimation of tanker requirements, and in establishing the need for storage facilities.[53]

In March 1943 the production of aviation gasoline was considered one of the most difficult problems faced by the United States at war. Fighter airplanes needed 140-grade fuel,[54] and it was argued that there was little value in manufacturing high-output aircraft engines unless the proper gasoline was available for them.[55] On the other hand, strict economy in the use of aviation gasoline was necessary to meet

the world requirements.[56] The 100-grade fuels were limited to those functions where lower quality would not suffice. A conference of supply officials of the continental consuming agencies stressed the urgency of the situation.[57] With the scarcity of the fuel under consideration, the flying training commands were directed to use 100-octane gasoline only on missions directly concerned with combat training. Landings for gasoline service were limited to home fields and stations of the flying training commands. The directors of training were warned that their allocations could not be increased.[58]

Delays in Production and Distribution

Several difficulties had hindered the production of aviation gasoline, and by April 1943 a strenuous effort was being made to overcome them. Much time had been lost through waiting for official requirements figures, although little in the way of materials had been saved by this precaution. Another inhibiting factor had been the limited authority to develop plans and erect facilities. Delays were inherent in the existing system of processing priority and allotment papers, which required 14 steps. Not the smallest difficulty was that of scheduling the deliveries of component parts for the refining units. This factor of delay had been recognized for months, but in the absence of a mandatory scheduling plan construction projects continued to be neglected.

Adding to the difficulties of producing aviation gasoline was the fact that by this date there was a need for a higher-performance number. By April 1943 the air services wanted the fuel raised to 140-

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grade as soon as possible, despite the fact that originally this goal had been planned for July 1944. Although the Petroleum Administrator hoped that technological changes eventually would facilitate this improvement in the gasoline, in the spring of 1943 the change would effect a 25 per cent reduction in quantity. That decline in quantity would result because the poorer base stocks, adequate for the manufacture of 130-grade, could not be used in the manufacture of 140-grade fuel. Since the anticipated quantity was approximately 540,000 barrels daily, the production of sufficient 140-grade would require a facility capacity equal to 720,000 barrels daily of 130-grade. The facilities then in existence, in process of construction, and authorized had an estimated capacity of 442,390 barrels; but with the estimated requirements increasing, an output of less than 600,000 barrels of 130-grade would be insufficient.

Several specific remedial measures were proposed. The most important suggestion was that the Petroleum Administrator be given definite and unqualified authorization to make available to the United States and its allies a world-wide capacity sufficient to produce at least 600,000 barrels of 130-grade fuel. A complete revision of the method of granting priorities was proposed, with the intention of giving the Petroleum Administration for War (PAW) wider authority. Finally, the Petroleum Administrator wanted a mandatory schedule for the delivery of component parts to the unfinished plants of the gasoline program.[59]

Those remedial suggestions were especially valuable at that time, April 1943, since a rising shortage in terms of stock-level requirements was anticipated. This shortage could be lessened only through the

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substitution of 91-grade fuel for the higher-grade fuel until sufficient production of the latter became available.[60] Training was seriously curtailed, and by the close of the month only a few days' supply of 100-octane was accessible in the Southeast and the Gulf Coast Training Centers.[61] Because of the time necessary for the expansion of facilities, this critical situation promised to continue at least through 1943.[62] For example, an average of three weeks elapsed between the filing of a builder's application and its approval by the Petroleum Administration for War. The time which elapsed between that approval and the granting of the initial priority by the War Production Board was usually as much as 10 days. Originally the average completion time for the plants was 16 months; but miscalculations and delays extended that construction period to nearly two years.[63] As a part of the campaign to increase the fuel supply a new additive, xylidine, was tested. Experiments were begun in April 1943 at Wright Field to discover its effectiveness as a blending agent.[64]

Not only were the plants in the United States required to provide fuel for the active theaters of combat, but reserve supplies in large quantities were stored at strategic points outside the United States proper. The amount of this storage in April 1943 is shown in the following table:[65]

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RESERVE SUPPLY OF AIRCRAFT FUEL AND OIL STOCKS
OUTSIDE THE UNITED STATES PROPER
(April 1943)

Location	No. stations	100-octane gasoline (gals.)	Oil (gals.)
Alaska	26	20,241,838	1,094,905
Canada	7	215,640	49,283
Greenland	2	5,378,549	150,605
Hawaii	21	18,108,816	996,111
Iceland	1	1,375,755	56,858
Newfoundland	4	2,035,696	77,348
Panama	12	10,550,116	2,269,547
Puerto Rico	14	5,708,208	972,231
Trinidad	7	2,878,535	1,708,965

The great handicap in the production of 100-octane aviation gasoline was the synthetic rubber program, and one of the points where the shortage was felt seriously was in the training of pilots. In the early stages of the training 91-octane fuel was satisfactory, but for transitional and operational instruction the higher grades were required. The ways in which flying was affected by higher-grade fuel included quicker take-off, greater speed, steeper climb, higher ceiling, and longer range. In the final phases of pilot training it was important to have flying conditions as nearly as possible identical with combat operations. The competition with rubber in production of the needed gasoline arose from the fact that aviation fuel was given the lower priority.[66] Under Secretary of War Patterson approved the efforts of the Petroleum Administration for War to enlarge the production of 130-grade gasoline to a daily capacity of 600,000 barrels.[67]

For the purpose of conserving 100-octane gasoline, the Materiel Command tested the various grades in the different types of combat aircraft. This resulted in the restriction of 91-grade fuel to specific aircraft, since that particular gasoline was found to be a definite hazard when engines were not designed for it or when the carburetor was not especially set. It was found that the P-47 airplane, for example, when operated on fuel of less than 130-grade was faced with such malfunctioning as the burning of pistons. At one time forced landings resulted when an attempt was made to operate the B-24 with 91-octane gasoline.[68] Another test was ordered, however, in an attempt to determine whether it would be feasible to use 91-octane gasoline in heavy bombers.[69]

The difficulties connected with aviation gasoline were not entirely those of production, but included transportation as well. The Second Air Force, for example, was limited by excessive hauls. In May 1943 this air force consumed 26,000,000 gallons of 100-octane gasoline; but that was only a part of the requirements, and training was hindered by the shortage. When the peak of the anticipated training load was reached the Second Air Force would require 63,000,000 gallons monthly. The situation then would be aggravated by the weather, because that peak load would come in the winter months when ice would interfere with distribution.[70] The problem of distributing 100-octane fuel remained troublesome so long as production prevented the accumulation of stocks near the airfields. The Second Air Force surveyed the stations on the Pacific Coast to learn the source of supply and the availability of storage at each post.[71] Overland transportation was only one of the

distribution problems. Toward the close of May 1943 nearly 800,000 barrels of aviation gasoline had been accumulated on the Gulf Coast, awaiting distribution by tanker to ports in Georgia and Florida.[72] The Petroleum Administrator, meanwhile, desired to augment existing facilities with a productive capacity of 43,325 barrels a day. That increase, which included 27 projects and would make the ultimate output about 514,000 barrels, was authorized by the War Production Board.[73]

The total daily production was reported as 304,000 barrels by June 1943. It was believed, however, that a year later the daily output would be 455,000 barrels, while requirements for that period were projected at only 441,000 barrels. Sixteen additional production projects were requested before the end of June, with the hope of boosting the daily production 940 barrels. Half of these projects were looked on as necessary to sustain the output already in prospect.[74]

Since the requirements for 130-grade fuel in July 1943 exceeded production, it was necessary to limit final training phases to the use of 96-octane so that the higher-quality gasoline could be sent overseas.[75] The training programs were surveyed to determine just exactly how much of the flying time required 100-octane fuel in preparing pilot and crew for combat operations.[76] It was decided to use 73-octane in primary training, 87-octane in basic training, and 91-octane in advanced training.[77] Before the end of July it was estimated that because of the shortage of 100-octane gasoline many flying hours had been lost. Because of insufficient fuel 147 pilots and 81 bomber crews had been unable to complete their training.[78] The War Production

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Board was requested to approve the construction of 13 more small projects, with a calculated increase in output of 11,777 barrels daily of 130-grade gasoline.[79] It was more necessary than ever to increase production, since the change to lower grades of fuel for training resulted in a shortage of 91-octane gasoline.[80]

Attempts to Speed Up Production

The War Department in August 1943 supported a campaign of morale building for the purpose of stimulating both the construction of plants and the production of aviation gasoline.[81] In September representatives of construction firms and oil companies met with officers of the Petroleum Administration for War to discuss gasoline requirements, progress of construction, and methods of improving the morale of workers. An illustrated booklet on the vital importance of 100-octane gasoline in winning the war was prepared for distribution among construction workers. Combat crews back from war theaters made personal appearances before groups of workers. The public relations officers in the five PAW districts of the United States were instructed and supplied with press releases. Official war films, of which there were then eight, were put at the disposal of the Petroleum Administration for War. Construction firms and oil companies were given a list of the films and told how to order them for showings before their workmen. It was suggested that every man on a refinery construction job be given a special "100 Octane" badge to wear. Other proposals included "pep" dinners for the foremen, photograph contests, and a steady stream of publicity.[82]

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Efforts to step up the production of aviation gasoline continued to take the form of the addition of more lead and other blending agents. In September 1943 the United Kingdom was requested to divert 200,000 barrels of its 100-octane grade for use in the United States; requirements of the active theaters were reestimated; and the possibility of reducing the distribution time was studied. The Petroleum Administration for War was asked to revise its estimates, and still more publicity on the necessity for aviation gasoline was sought.[83] By the end of September the dollar value of the 1943 aviation gasoline program amounted to $571,235,000. In addition the United States had sent material and plants to the U.S.S.R. valued at $426,733,000.[84]

The War Department felt that the failure of the 100-octane production program to meet all requirements had become a serious obstruction. The output for each month since January 1943 fell short of estimates by the Petroleum Administration for War. The shortage had compelled the use of lower-grade fuels, with consequent increase in flying hazards to both the combat pilots and the training crews. The production program was looked on as unsatisfactory, and new construction projects were lagging. Robert A. Lovett, Assistant Secretary of War for Air, believed the trouble to be with the men who were directing the program and sought their replacement.[85]

With the intention of speeding up the increase of 100-octane production, the Petroleum Administration for War on 7 October 1943 requested authority to allot controlled materials to the value of $2,000,000 for the construction of small plants. These plants were

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intended to increase the production of butylene, isobutane, and base stock. This production was to be used in the elimination of bottlenecks, which were arising constantly in the manufacturing processes.[86] The $2,000,000 was authorized in November, when it was announced that nine additional plants had been completed since 10 October. Five of those plants had started operating, and tests were being made at the other four.[87]

In July 1943, after five months of experimentation, the unlimited use of xylidine as a blending agent for aviation gasoline had been approved. More than 1,000,000 gallons of the blended fuel were used in test flights before the new additive was authorized for general use.[88] The approval of xylidine came at an opportune time because the substitution of 91-octane for 100-grade in the training program had been damaging.[89] At the flying training fields the lower-grade fuel had caused the curtailment of high-altitude missions, maximum load take-offs, and 10-hour cross-country hops, aggregating a loss of 1,231 missions. In addition 160 pilot trainees and 29 bomber crews were diverted to other training because of the curtailment of high-grade fuel.[90] The approval of xylidine as an additive was a means of increasing the quantity of available aviation gasoline.

The second year of warfare for the United States, 1943, drew to a close with great accomplishments in the production of aviation fuel on record. During the two-year period 32 major manufacturing plants had been built, and as the year closed 40,000 men were constructing

an even larger number. In this war effort the government was represented by the Petroleum Administration for War, while 72 men known as the Petroleum Industry War Council represented the oil industry. Through cooperation of the government and the industry, contributions to the production of 100-octane gasoline were being made by a total of 161 refineries. The estimates of requirements had been raised steadily from 24,000 barrels in the spring of 1941 to approximately 600,000 barrels by the end of 1943.

Progress in Chemical Processes

The increase in production of aviation gasoline had by no means all come from the construction of new plants; much of the enlarged output had resulted from technical changes in the chemical processes. Five significant changes had been made:[91]

(1) A new blending agent called cumene had been adopted, the production of which by September 1942 had reached 6,000 barrels daily.

(2) Catalytic cracking had been converted from the manufacture of automotive fuel to the production of 100-octane gasoline. Early in 1942, 14 catalytic plants through minor alterations had been converted to the manufacture of aviation fuel.

(3) Refining plants which had been making polymer for automotive gasoline were changed to manufacture codimer for aviation gasoline. By the close of 1943 codimer was being produced at 72 plants.

(4) Inter-plant movement of the component parts of 100-octane was expedited through improved distribution.

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(5) Technical production changes in many refineries increased the production of aviation gasoline generally.

The construction of additional plants was complicated by the need to build destroyers, merchant vessels, and factories for making synthetic rubber. The question of whether to use a specific lot of material in this or that construction program, however, was being solved by the close of 1943 through coordination of the Petroleum Administration for War and the War Production Board. At times synthetic rubber appeared to have a preferential rating, but by the end of 1943 there were 107 producers of 100-octane gasoline or its major components. In addition, 40 plants were producing other aviation gasoline or base stocks, while another 14 were expected to be contributing their output in the spring of 1944.[92]

Several significant problems awaited solution when the year closed. Among them was the necessity for changing the specifications of aviation gasoline; the question of when and how the different fuels would be available; and determination of the course that research should follow in the future. A full-scale testing program was urged.[93] The world-wide requirements continued to exceed the supply, and stocks in the active theaters were being depleted. The full-scale production of xylidine had resulted in an increase in 130-grade fuel, but methods of gaining additional supplies were sought.[94] The intention was to eliminate the production of 91-octane gasoline entirely, with xylidine available for blending more than 80,000 barrels of 130-grade daily.[95]

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Chapter III

STRENUOUS YEARS OF 1944 AND 1945

Improved quality, the construction of additional manufacturing facilities, and world-wide distribution occupied those officials concerned with the production of aviation gasoline during 1944 and 1945. A definite procedure was developed for handling the global distribution of the high-octane fuel. Beginning in February 1944, monthly fuel requirement reports were assembled at Headquarters, AAF by the Statistical Control Division. These reports were based on aircraft availability and anticipated flying hours.[1] The estimate of world-wide petroleum needs was supplemented by information from the refinery areas regarding the amount of aviation fuel available. This requirement and supply data was then broken down so as to indicate the amount for distribution by pipe line, tank truck, railroad, and tanker.[2]

Better Fuel, Improved Engines

Although by January 1944 the United States had supplied more than 60 per cent of the aviation fuel of the United Nations, engine manufacturers objected that attention had been given to quantity rather than to quality. The engine, said they, must be the ultimate judge of the fuel.[3] Before the middle of February a program for the improvement of aviation gasoline had been arranged,[4] with fuel designated as 104/150[5] and containing 3 per cent xylidine and 6 cubic centimeters of tetraethyl lead being that decided upon.[6] Two tests of 150-

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performance number gasoline were conducted--at Wright Field, Ohio, in the power plant laboratory of the Materiel Command, and at Eglin Field, Fla., by the Proving Ground Command. Nine airplanes were used in the experiments, three each of P-47, P-51, and P-38 types, and each plane was flown 100 hours. At the conclusion of the tests it was found that 150-grade fuel permitted a higher-power operation and resulted in improved airplane performance. Some disadvantages were noted, however. These included deterioration of synthetic rubber parts in contact with the gasoline, shorter spark-plug life, increase in spark-plug fouling under low-power cruise conditions, increase in ring-sticking tendencies, and increase in flight-line maintenance generally. Higher toxicity necessitated more care in handling the 150-grade gasoline.[7]

Two Improved Fuels--130/150- and 110/142-Grades

By March 1944 the War Production Board had approved the construction of facilities to produce 540,000 barrels daily of 130-grade fuel with 4 cubic centimeters of tetraethyl lead per gallon, but by increasing the tetraethyl content to 4.6 cubic centimeters the output would be raised to 598,000 barrels daily. The Joint Chiefs of Staff urged that the program of fuel improvement be pushed only so far as would not interfere unduly with quantitative production.[8]

Both the Army and the Navy were anxious to use 150-grade gasoline in operations, but making that grade of fuel general would require a large increase in facilities. It was planned, therefore, to fit the demand for 150-grade gasoline into the program of facilities and production already planned.[9] In an effort to prevent reducing over-all

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production, the Industrial Planning Committee of the Aeronautical Board prepared specifications in March 1944 for two improved fuels--grades 120/150 and 110/142.[10] A cheering note, however, came from the report of the Petroleum Administrator on 1 April 1944 that the supply of 130-grade gasoline soon would exceed the requirements.[11]

The Best Compromise Fuel--115/145-Grade

In June 1944 the Industrial Planning Committee of the Aeronautical Board issued its compromise proposal for improved aviation fuel. This proposal was based on engine performance, production capacity, requirements, and logistics. All factors considered, the best compromise grade was 115/145, although the future availability of 120/150-grade was desired. It was proposed to continue the production of 130-grade as the primary tactical fuel, and to substitute that gasoline for 91/96 grade in training and transport consumption. The remaining planned manufacturing capacity would be used to develop 115/145-grade gasoline. The Petroleum Administration for War was requested to prepare 75,000 barrels of 115/145-grade for use in engine development experiments.[12] The War and Navy Departments, however, interposed an objection. They agreed that the improvement of the fuel was eminently desirable, but the Secretaries bluntly called attention to the fact that the requirements for 130-grade thus far had not been met.[13] During the next month, July, the aviation-gasoline situation became more critical than ever because of the acceleration of the war in Europe and the effort to acquire sufficient fuel for training.[14]

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Increased Efforts to Meet Demands

It soon became evident that despite all efforts to the contrary sufficient quantities of 115/145-grade gasoline would not be available for immediate operational purposes. The calculations of the consuming services indicated that from November 1944 to June 1945 requirements might increase as much as 50,000 barrels a day. Extraordinary measures therefore were necessary to meet the growing demands, and one of the first steps was the diversion of butylenes from the manufacture of synthetic rubber for use in the blending of aviation fuel. The Army and Navy granted exceptions in the distillation specifications for 130-grade, while new chemical details were issued to reduce manufacturing operations through the use of additives. The consuming services agreed in August 1944 that in the United States they would use some 130-grade fuel to which 6 cubic centimeters of tetraethyl lead per gallon had been added. These extraordinary measures resulted in 18,000 additional barrels of aviation gasoline daily, so that during September it was possible to discontinue the use of 6 cubic centimeters of tetraethyl lead and return to the preferred 4.6 mixture. In September, October, and November five additional manufacturing units were completed with a total daily capacity of 13,350 barrels. Seven plants, four in the United States and three abroad, with a total daily capacity of 29,320 barrels, remained to be completed from the 1943 construction program. In addition the War Production Board had been asked to grant priorities for the construction of two cracking units which would need no government aid.[15]

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In November 1944 a plant-by-plant production survey showed that the aviation gasoline output would not reach the anticipated amount. A month earlier the production had been considered in balance, which may have been the reason that several refineries closed down for cleaning and overhauling. The refiners found a great deal of work to be done and labor scarce. The War Manpower Commission had reported a surplus of production, and this made the recruiting of workers even more difficult. The Production Executive Committee of the War Production Board had deleted the 100-octane program from the Production Urgency List early in October, but had not informed the Petroleum Administration for War of that fact before the end of the month. As a result, the War Manpower Commission had been prohibited from referring men to the refineries. It was not until past the middle of November that the 100-octane program was restored to the Production Urgency List. Continuous use of the refining equipment, much of which had been constructed from inferior materials, and insufficient maintenance combined to lengthen the overhaul periods of the refineries. To make the situation even more critical, production in the plants abroad had declined. These plants had experienced mechanical trouble with their equipment and were unable to get new parts. Also, in the United Kingdom the hydrogenation equipment had been diverted to the production of ammonia. To make bad matters worse, at Abadan a fire in the refinery caused a loss of 5,000 barrels a day. A bright spot in the picture, however, was the elimination of 87-octane from the fuels consumed by the aviation services. Also, the substitution of 96-octane

for 100-grade in flying training was discontinued, and this left a surplus that could be absorbed in the production of high-test aviation gasoline.[16]

Requirements versus Production

By the close of 1944 the production of aviation gasoline had reached eight times the quantity being manufactured in 1940, but the demand for high-test fuel continued to outstrip the refining capacity.[17] The comparison of anticipated requirements with prospective production foreshadowed an appreciable deficiency in 130-grade gasoline. The schedule of requirements following victory in Europe did not indicate any considerable surplus, since the demands were expected to increase to approximately 560,000 barrels a day by December 1945. The Petroleum Administration for War, furthermore, anticipated a decline in the production of aviation gasoline. Another disturbing element was the fact that the Navy was purchasing aircraft that required 145-grade gasoline. With those facts in mind, a special military committee on gasoline declared that the Army-Navy Petroleum Board should be empowered to control the quality and quantity questions of the production program. Technicians of the armed services were convinced that the future use of large quantities of 145-grade fuel was certain. Several methods of increasing production were examined, including the improvement of efficiency in the existing plants and the construction of additional facilities. In fact, plans had been completed for the erection of plants by five companies, which would augment the daily production nearly 40,000 barrels. On the assumption that at its height the

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campaign in the Pacific would require 550,000 barrels of gasoline daily, of which one-half would be 145-grade, a manufacturing capacity equivalent to 700,000 barrels of 130-grade would be necessary. Those calculations required a daily productive increase in plant capacity of 100,000 barrels of 130-grade gasoline, or a total of $300,000,000 in new construction. In addition to the building of new facilities, it was urged that strategic storage for 15,000,000 barrels of aviation gasoline be constructed to hold the 145-grade as rapidly as it was manufactured. To both the Army and Navy the maximum use of 96-octane gasoline for training within the United States was recommended.

Manpower deficiency in the operation and maintenance of refineries was an increasingly serious problem by the close of 1944. The armed services were urged to provide more accurate predictions of their requirements, especially their needs for 145-grade gasoline.[18] A higher priority rating was sought for an 8,000-barrel plant under construction at Philadelphia, which had been scheduled for completion in August 1945.[19] Yet at the close of the year the officers directing the production of aviation gasoline remained more interested in the manufacture of 130-grade gasoline than in the improvement of quality.[20] The total actual production of grade-130 equivalent in 1944 in the United States was 143,178,370 barrels, a figure that was increased to 164,534,670 by the output of refineries abroad.[21]

Additional Plants

In January 1945, nine gasoline manufacturing plants were in the process of construction to augment the [redacted] United

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Nations.[22] Three of those plants, designed to add 13,540 barrels to the daily production, were in the United States while the remaining six were abroad.[23] Three plants, with a combined capacity of 13,680 barrels of 130-grade had been completed a short time before and were already in operation. A campaign was being conducted for the removal of bottlenecks in the production system, but no definite plans had been made to manufacture 145-grade gasoline for operational purposes. About 75,000 barrels had been produced for development purposes in December 1944, but the requirements for 130-grade continued to exceed production.[24]

By March 1945 a dozen gasoline manufacturing plants were in some stage of construction, ultimately to add a total of 65,630 barrels to the world-wide daily output of aviation gasoline.[25] A critical storage situation had developed in the United States by that time because of a shortage of tankers. In the first two months of 1944 about 3,000,000 barrels of 130-grade had accumulated in refinery tanks. Since most of the facilities had been completed and put into operation, the production figures now became a matter of practical knowledge and experience. The daily March production, only a small part of which was estimated, was 625,000 barrels of 130-grade gasoline, but the requirements amounted to 666,000 barrels.[26]

The arrival of a one-front war removed the strain in the aviation gasoline production program. In March 1945 arrangements had been made to put a new substitution plan into effect so as to conserve supplies of 130-grade fuel. Those changes never were made, however, because tremendous transportation problems and the re-deployment of major

training facilities would have been required. Moreover, the change might have endangered the steady flow of fuel to the fighting fronts. By May, however, it was believed unlikely that the substitution ever would be undertaken. The critical storage situation, resulting from a shortage of tanker transportation, was relieved. The diversion of butylenes from the synthetic rubber to the aviation gasoline program also was reduced somewhat. In May only 16 minor projects for the removal of bottlenecks in manufacturing plants required approval by the War Production Board. One major project, involving alkylation and isomerization facilities, was approved by the War Production Board. It was expected to add 6,500 barrels in the daily production of one company. Between March and May 1944 one domestic and two foreign aviation-fuel plants were completed with a capacity increase of 10,740 barrels in world-wide production.[27]

On the basis of a one-front war, the estimates for 1946 amounted to a total of 63,000,000 barrels, of which the Navy would require 15,000,000 and the AAF 48,000,000.[28] Strategic storage of 5,000,000 barrels was arranged by the Pacific Petroleum Pool for supplying the campaign against the Japanese. The Gulf Coast and the inland storage approached 10,000,000 barrels, making a total of 15,000,000 barrels in the United States. Transportation was handled with tankers, tank cars, and pipe lines as the scene of conflict shifted away from Europe.[29]

Thus in the final stages of the war, the production of combat aviation gasoline continued to be an incessant struggle. During the months of the two-front conflict one of the important considerations was global distribution. At the same time that the improvement of

both engines and gasoline was stimulated, the acceleration of the war in the European theater increased the demands of the aircraft in that area. Hence requirements continued to outstrip production, while the need for 145-grade gasoline became more intense. A large quantity of 145-grade fuel was manufactured for experimental purposes, but operational quantities were not available before the close of the war. As late as March 1945 the daily production of 625,000 barrels of 130-grade failed to meet the requirements. Then with the arrival of the one-front war sufficient high-test aviation gasoline was available, and storage was arranged for its rapid movement to the Pacific theater.

Chapter IV

CONCLUSION

Almost immediately after hostilities ceased on 14 August 1945 restrictions were removed from the allocation of 87- and 91-grade aviation gasoline, and the Aviation Petroleum Products Allocation Committee issued a statement of general thanks to consumers and manufacturers for their cooperation during the war.[1] A few days later emergency action was taken to cancel aviation fuel shipments scheduled for overseas.[2] The Petroleum Administrator advised all manufacturers of 100-octane gasoline to discontinue production as rapidly as possible, and in no case to extend beyond a 30-day run-out period.

The war closed with prodigious accomplishments in the production of aviation gasoline. The world-wide daily output of 100-octane gasoline[3] was about 73,000 barrels as of 1 January 1942, whereas at the close of the conflict daily production surpassed 600,000 barrels. This vast increase in daily production was attained in various ways.

Soon after the United States entered the war, production of aviation gasoline was swelled by the addition of 4 cubic centimeters of tetraethyl lead to each gallon. This accomplished a 20 per cent increase. Although production from new facilities was more or less negligible until 1943, the greatest single factor in the over-all production picture was construction of new facilities, which by July 1945 were manufacturing about 360,000 barrels a day. Throughout the war period a steady flow of aviation fuel was gained from the conversion of

catalytic plants, a factor which by 1945 accounted for about 14,000 barrels daily. Another important feature of the production program was the elimination of minor bottlenecks in the individual refineries. This factor was credited with the addition of approximately 30,000 barrels daily by 1945. An additional boost was given the total output when the percentage of tetraethyl lead was increased from 4 to 4.6 cubic centimeters per gallon; for a time in 1943 and 1944 the output of high-grade aviation fuel was pushed upward through the addition of as much as 6 cubic centimeters of tetraethyl lead to each gallon. The use of codimer and cumene in blending the gasoline served to increase daily production nearly 30,000 barrels. By the diversion of part of the synthetic rubber program to the manufacture of gasoline, another 10,000 barrels of gasoline was added daily.

Throughout the entire three and one-half years, foreign production[4] was a considerable factor in the aviation-gasoline program. This production increased from about 20,000 barrels daily in 1942 to approximately four times that quantity in 1945. The foreign refineries, however, produced only a total of 62,000,000 barrels during the war, or 15 per cent of the total world-wide production. This total amounted to 411,000,000 barrels, of which 37,000,000 barrels were manufactured in 1942; 76,000,000 in 1943; 164,000,000 in 1944; and 134,000,000 in 1945. On a percentage basis, this production was achieved as follows:

Method	Per cent of Total World-wide Production[5]
New Facilities	41.4
Prewar Plants	18.3
Foreign Plants	15.0
Use of cumene as blending agent	6.1
Use of blending agent called "C-S"	1.1
Use of codimer as blending agent	2.9
Addition of increased amounts of tetraethyl lead	4.2
Conversion of catalytic cracking units to aviation fuel production	4.0
Ordnance and rubber	2.5
Miscellaneous	4.5
	100.0

The importance of blending agents is indicated by the fact that 347,000,000 barrels were blended.[6]

An important aspect of the aviation gasoline production was the phase which resulted in July 1944, when requirements greatly exceeded output. In order to supply the active theaters and at the same time maintain training operations, the 91/96 grades of fuel were substituted for 130-grade where possible, chiefly in training operations. The amount of this substitution varied from a total of 700,000 barrels in July 1943 to the peak total of 2,140,000 barrels in August 1944.[7] The substitution was relaxed in November 1944 because of the increase in 130-grade production as well as because of the anticipation of victory in Europe.

Distribution of aviation gasoline produced in American and British spheres was handled by two organizations, the Aviation Petroleum Products Allocation Committee at Washington and the Aviation Petroleum Products London Assignment Committee. In the theater itself allocations were made by a local Aviation Petroleum Coordinating Supply Committee, when such a committee existed. In theaters where such a committee did not exist, aviation gasoline was distributed to major terminals and from there by the theater commander within his theater.[8] Stocks were established and targets of quantity were set in the different theaters. From an over-all standpoint these fuel targets were approached during 1944 and exceeded in 1945, but at specific theaters--North Africa, Southwest Pacific, Central and South Pacific, and China-Burma-India--the recommended stocks were not reached.[9]

The production of aviation gasoline in the United States during the war was greatly aided by the strict control exercised by military and civilian divisions of the government. The refining industry at the outbreak of the war was a highly developed industry which had been supplying products of constantly improving quality to the public. It was an industry which, because of the demand for ever-improved product quality, was building bigger and more complicated processing units. It was a virile industry and, fortunately for the nation, one which was able and willing to meet the demands thrust upon it by the war. The tremendous increase in 100-octane production was primarily the result of excellent industry-Government cooperation.

Production of 100-octane aviation gasoline required the manufacture of such highly technical components as alkylate, isopentane, cumene,

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and base stock; the blending of these components in the correct proportions; and the addition of the proper quantity of tetraethyl lead. For 100-octane is not truly a gasoline at all but a carefully adjusted blend of synthetic ingredients. The manufacture of the components in most cases required complicated and expensive refinery processing units, few of which were in existence prior to the war. Industry and government spent a total of nearly a billion dollars in the construction of such facilities during the war years. All refineries producing 100-octane gas or its components were considered as parts of one gigantic refinery. Components were shipped from one refinery to another, and each refinery was operated in such a manner that its production of 100-octane components fitted into the over-all plan without regard to the effect on its individual production. If various components of 100-octane gasoline were blended in the plant best able to utilize them, more fuel could be made. Hence the Petroleum Administration for War was authorized to cut freely across company lines and make whatever shifts were necessary to get the most 100-octane gasoline from whatever components were available anywhere in the United States.

During the war years $864,000,000 was spent on facilities for the production of 100-octane aviation gasoline. Of this amount, approximately $694,000,000, or 75 per cent, was spent by industry for facilities which it owned and operated, while $233,000,000, or 27 per cent, was spent by the government for government-owned and industry-operated facilities. Government loans amounted to $245,000,000. In addition, the government paid $7,296,379 to compensate for extraordinary

construction expense.

Only by the closest cooperation of everybody concerned could the wartime demands for refined petroleum products be met. It was the function of the Petroleum Administration for War to coordinate the job, and it was industry's responsibility to carry it out, with government financial assistance. Both sides fulfilled their responsibilities so well that aviation gasoline was produced in quantities which, though not satisfying every demand of war, would have been considered miraculous a few years before.

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G L O S S A R Y

AAFFTC	Army Air Forces Flying Training Command
AAG	Air Adjutant General
AC/AS	Assistant Chief, Air Staff
AFDMR	Director of Military Requirements
AFTRC	Army Air Forces Training Command
AFRBS	Director of Base Services
Avn Petroleum Br	Aviation Petroleum Branch
C/AC	Chief of the Air Corps
CG	Commanding General
C/S	Chief of Staff
Comm	Committee
DPC	Defense Plant Corporation
Dir	Director
Div	Division
M&S	Materiel and Services.
MM&D	Materiel, Maintenance, and Distribution
OC&R	Operations, Commitments, and Requirements
PAW	Petroleum Administration for War
R&R	Routing and record sheet
S/W	Secretary of War
WPB	War Production Board

[redacted]

N O T E S

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12. This figure is the performance number of the fuel under rich-mixture conditions.

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28. Under rich-mixture conditions.

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42. "Production for the United Nations" refers only to aviation gasoline produced under the control of the United States and the United Kingdom.

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44. Ltr, Lt Gen H.H. Arnold to Ralph K. Davies, 29 Dec 42, in AAG 463.7-A, Gasoline and Motor Oil.

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52. The sources of data for determining these requirements included the Office of Assistant Chief of Air Staff, Plans, Aircraft Scheduling Unit; Office of Chief of Air Staff; Management Control; Statistical Control; the various aviation petroleum products allocation committees; Combined Chiefs of Staff; Air Transport Command; Air Service Command; and Navy Department. These offices supplied detailed information on fuel consumption, flying hours, strength of units, and attrition rates.

53. Avn Petroleum Br, Report, 1941-45.

54. This figure is the performance number of the fuel under rich-mixture conditions.

55. Ltr, H. LeRoy Whitney to Charles E. Wilson, [illegible] Mar 43, in Avn Petroleum Br files.

56. The term "world requirements" refers only to aviation gasoline to be produced and allocated under control of the United States and the United Kingdom.

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4. R&R, Maj Gen O.P. Echols to AC/AS MM&D, 12 Feb 44, in AAG 463.7-I, Gasoline and Motor Oil.

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27. Petroleum Administration for War, Aviation Gasoline Report, 10 May 45, in Avn Petroleum Br files. See also meaning of "world-wide" in n. 25.

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4. This term means only that production outside the continental United States under control of the United States or the United Kingdom.
5. This term means aviation gasoline produced and allocated under control of the United States or the United Kingdom.
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7. For world-wide consumption of high-test aviation gasoline, including the share used by the AAF, see Apps. 9 and 10, this study.
8. For world-wide theaters of distribution, see App. 8, this study.
9. See Apps. 11-16, this study.

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[redacted] SECURITY INFORMATION

"Plan Suggested to Double Output of 100 Octane and High Octane Fuel," Oildom, 31 December 1940

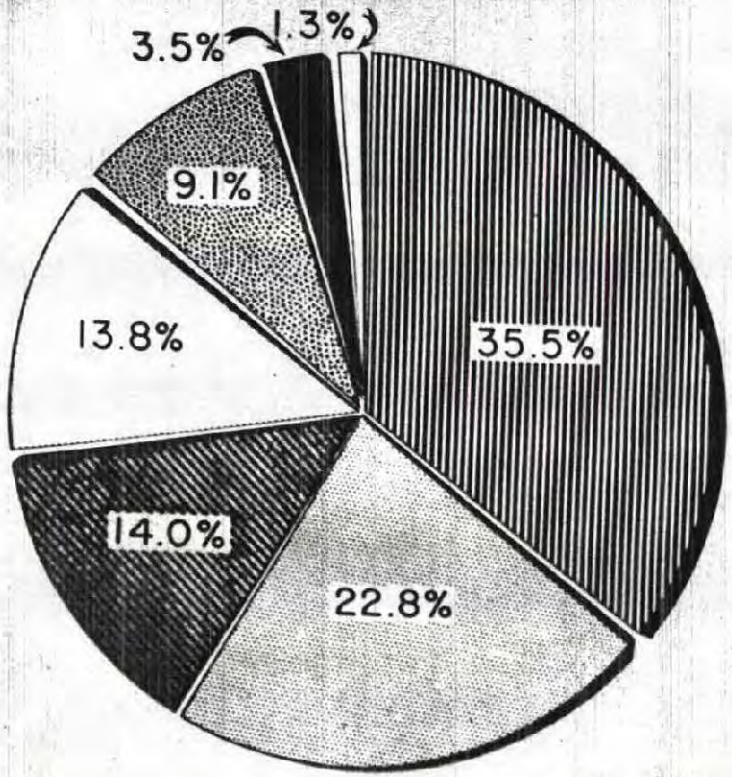
Statement by Secretary Robert P. Patterson on 100 Octane Gasoline before Truman Senate Committee, 3 May 1943

Statement of Secretary Harold L. Ickes on 100 Octane Gasoline before Truman Senate Committee, 28 April 1943

Technical Advisory Committee of Petroleum Industry War Council, Round Table Discussion on 100 Octane Gasoline, 28 August 1943

Appendix 1

100 OCTANE AVIATION FUEL
SOURCES OF INCREASED PRODUCTION *



NEW FACILITIES	35.5 %
USE OF CUMENE AS BLENDING AGENT	22.8 %
MECHANICAL AND OTHER IMPROVEMENTS	14.0 %
CONVERSION OF CATALYTIC CRACKING UNITS TO PRODUCTION OF AVIATION FUEL	13.8 %
USE OF CODIMER AS BLENDING AGENT	9.1 %
ADDITION OF 0.6 cc. OF TETRAETHYL LEAD	3.5 %
USE OF TOLUENE AND OTHER BLENDING AGENTS	1.3 %
	100.0 %

* FROM JANUARY 1, 1942 - DECEMBER 31, 1943

PETROLEUM ADMINISTRATION FOR WAR

MARCH 1, 1944

Poor Original

Appendix 2

AVIATION GASOLINE GRADE 100/130[a]
REPORTED ISSUES[b] BY THEATERS
Yearly 1943 - August 1945

000's of Barrels (42 U. S. Gals.)

THEATER	JAN-DEC 1943	JAN-DEC 1944	JAN-JUL 1945
INDIA CHINA	1985	8509	9993
CEYLON	69	289	242
UNITED KINGDOM incl. ICELAND	14236	41063	24095
MIDDLE EAST GROUP I	3374	2413	1223
MIDDLE EAST GROUP II	261	399	315
MIDDLE EAST GROUP III	109	96	80
MEDITERRANEAN	6923	16418	9832
WEST AFRICA AND DAKAR	697	878	451
SOUTH AFRICA	162	128	127
BRAZILIAN AREA	1537	2099	1422
BWI, IL AND ASCENSION	1074	1569	755
SOUTH PACIFIC	4653	12038	13809
NORTH PACIFIC	194	202	127
SOUTHEAST PACIFIC	2839	7516	7810
ATLANTIC BASES	1159	1453	998
ALASKA	564	961	683
[illegible]	2912	11879	9459
TOTAL OVERSEAS	45748	107910	77412
CONTINENTAL STATIONS - ARMY	15890	26226	17666
CONTINENTAL STATIONS - NAVY	4680	9343	7934
TRAINING AND FERRY	4109	5731	3869
CANAL	1000	1073	626
TOTAL NORTH AMERICAN	25669	45376	30038
[illegible]	[illegible]	153256	[illegible]

a. [illegible] Aviation Petroleum Branch, ASNC-4, 1941-1945, p. 20.
b. [illegible]

Appendix 3

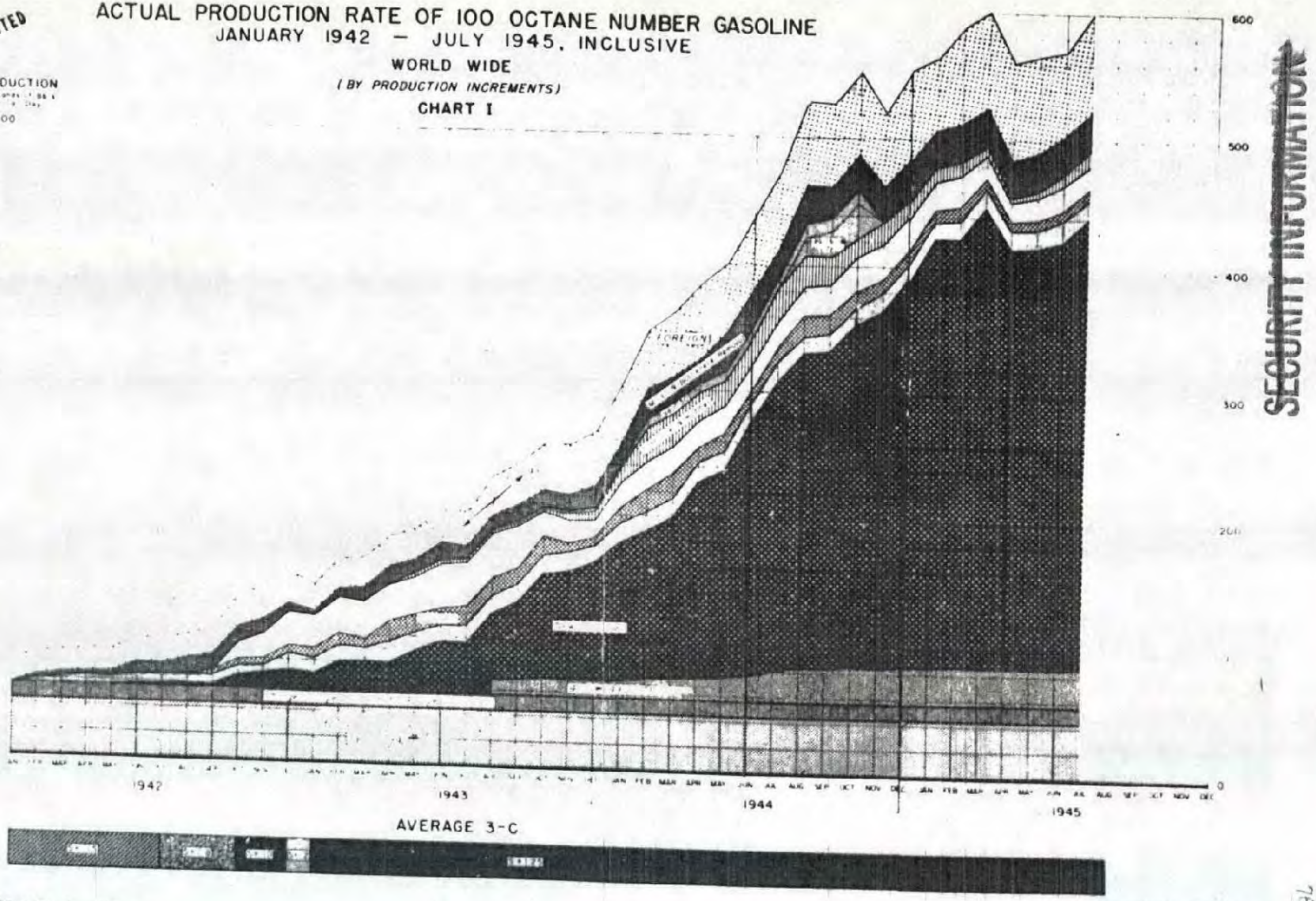
RESTRICTED

ACTUAL PRODUCTION RATE OF 100 OCTANE NUMBER GASOLINE
JANUARY 1942 – JULY 1945, INCLUSIVE

WORLD WIDE

(BY PRODUCTION INCREMENTS)

CHART I



SECURITY INFORMATION

SEPTEMBER 1945

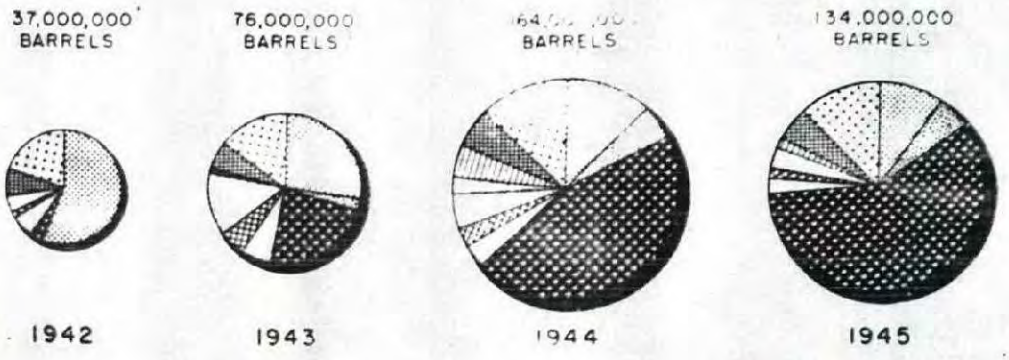
Prepared By
GRAPHICS" – REFINING DIVISION
PETROLEUM ADMINISTRATION FOR WAR

CHART I

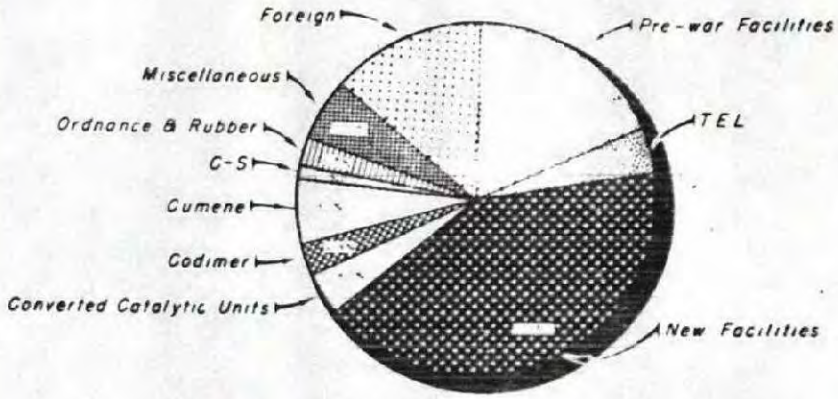
GRADE 130 AVIATION GASOLINE

1942 — 1943 - 1944 — 1945

PRODUCTION BREAKDOWN



411,000,000 BARRELS



1942 — 1943 — 1944 — 1945

Poor Original

SECURITY INFORMATION

Appendix 5

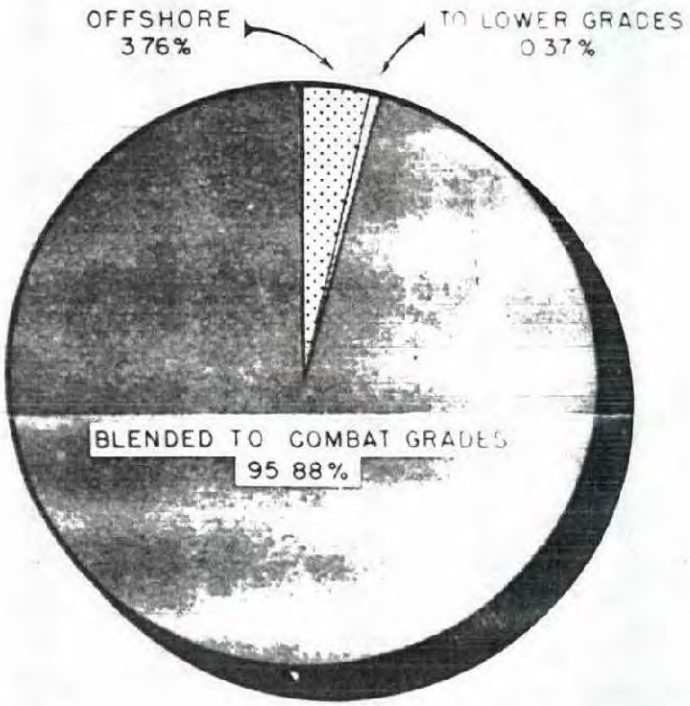
CHART III

HIGH QUALITY AVIATION GASOLINE

RELATIONSHIP BETWEEN PRODUCTION AND BLENDING

UNITED STATES

JANUARY 1942 TO AUGUST 1945 INCLUSIVE



Combat Grade Blended	*347,000,000 Barrels*
Equivalent Grade 130 Offshore	*13,000,000*
Equivalent Grade 130 to lower Grade	*1,000,000*
Total Production	*361,000,000 Barrels*

RESTRICTED

Appendix 6

CHART IV

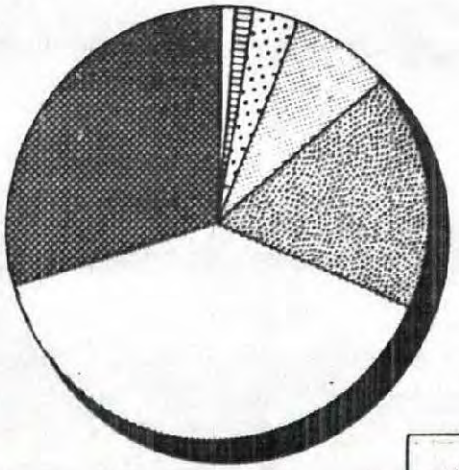
PRODUCTION OF 100 OCTANE AVIATION GASOLINE

UNITED STATES AND FOREIGN

BY YEARS

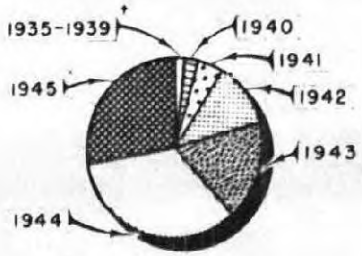
UNITED STATES

377,000,000 BARRELS[A]



FOREIGN

62,000,000 BARRELS[A]



UNITED STATES PRODUCTION HAS BEEN 6 TIMES THAT OF FOREIGN PRODUCTION

A Total Equivalent Production - 1935 through August 1945

† Estimated

January through August only

SEPTEMBER 2, 1945

RESTRICTED

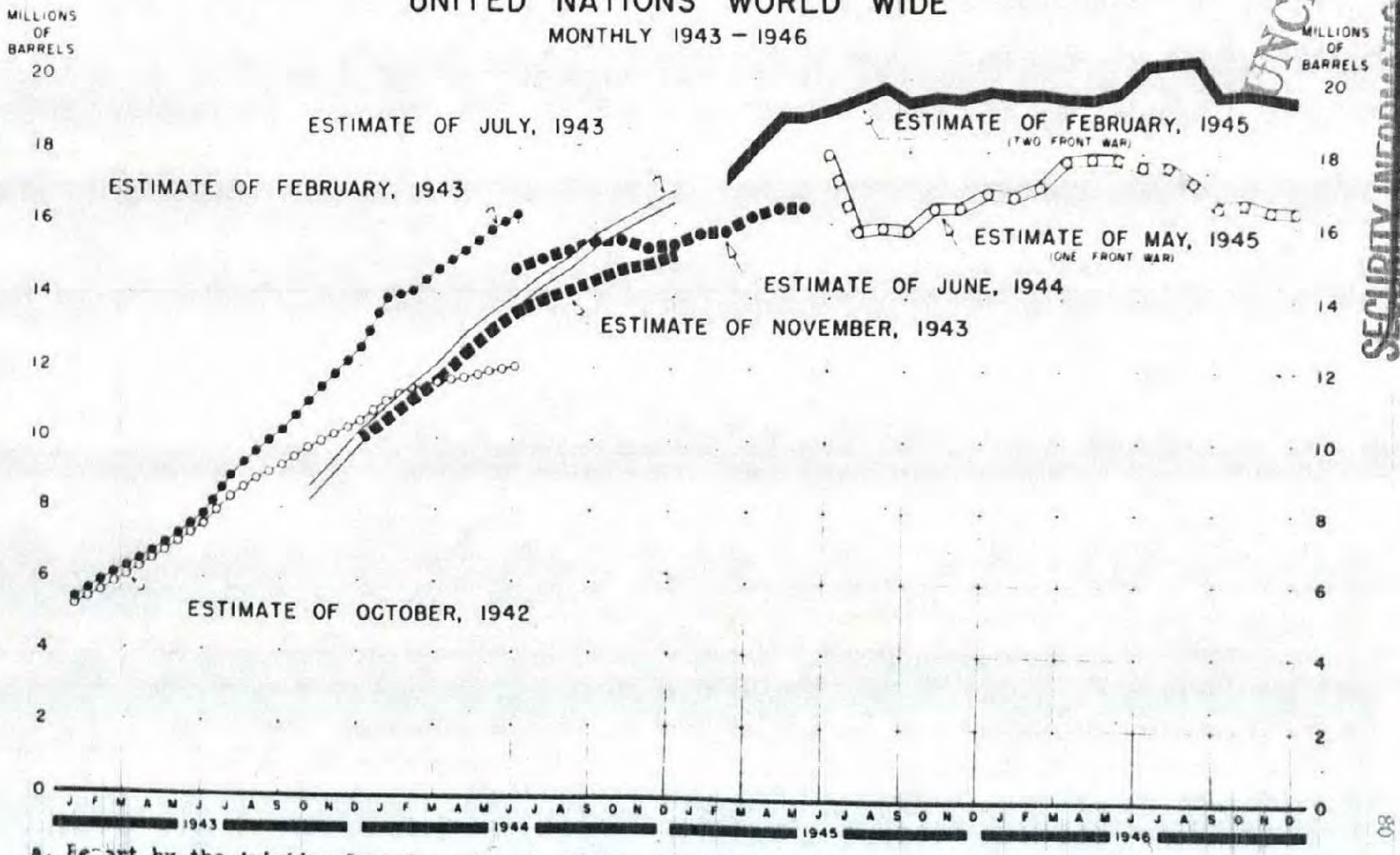
Prepared By
"REFINING GRAPHICS" - REFINING DIVISION
PETROLEUM ADMINISTRATION FOR WAR

Appendix 7

AVIATION GASOLINE GRADE 100/130[a]

COMPARISON BETWEEN LONG RANGE ESTIMATED REQUIREMENTS UNITED NATIONS WORLD WIDE

MONTHLY 1943 – 1946



a. Report by the Aviation Petroleum Branch, ACAS-4, 1941-1945, p. 14.

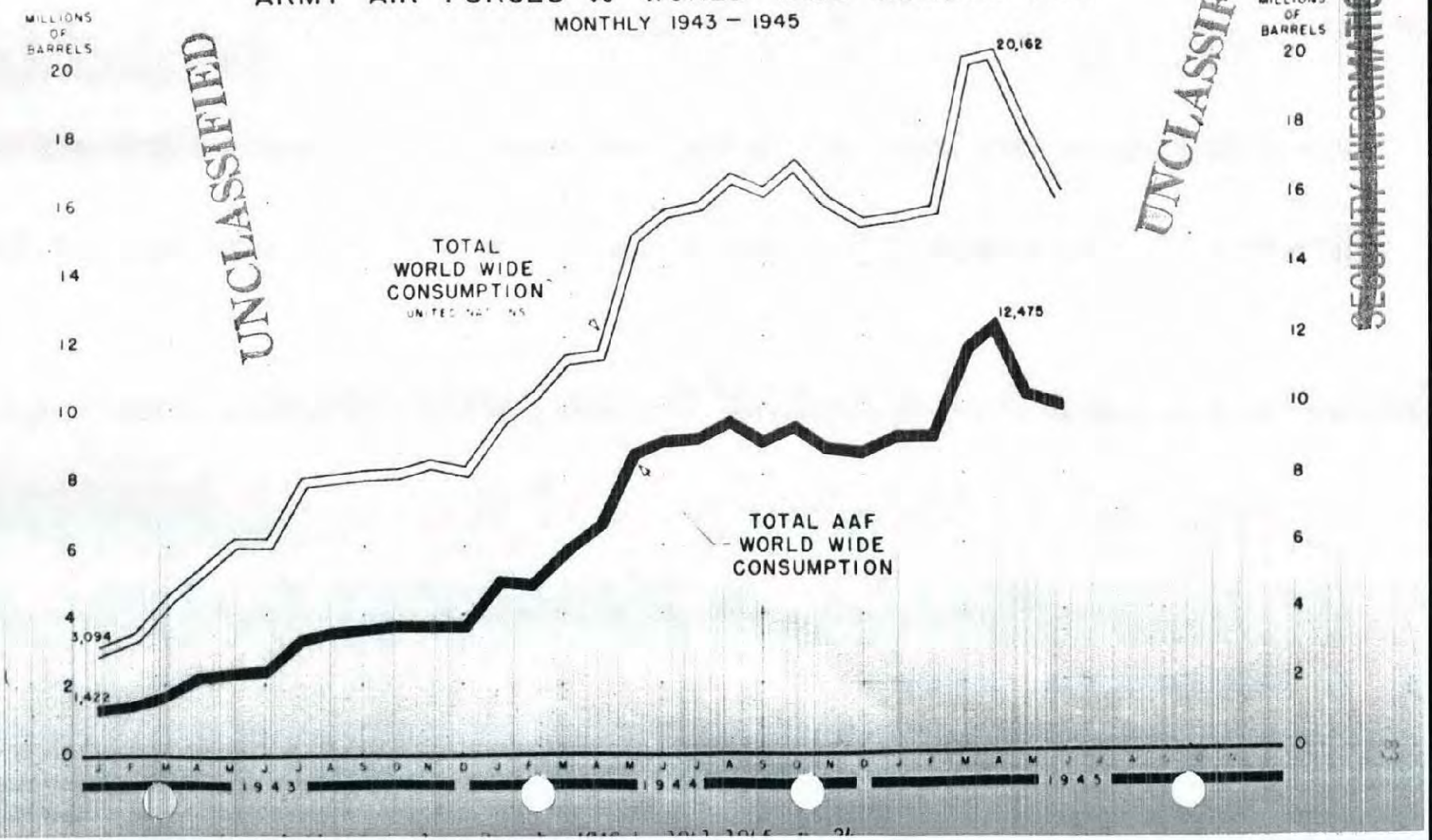
Appendix 10

AVIATION GASOLINE GRADE 100/130

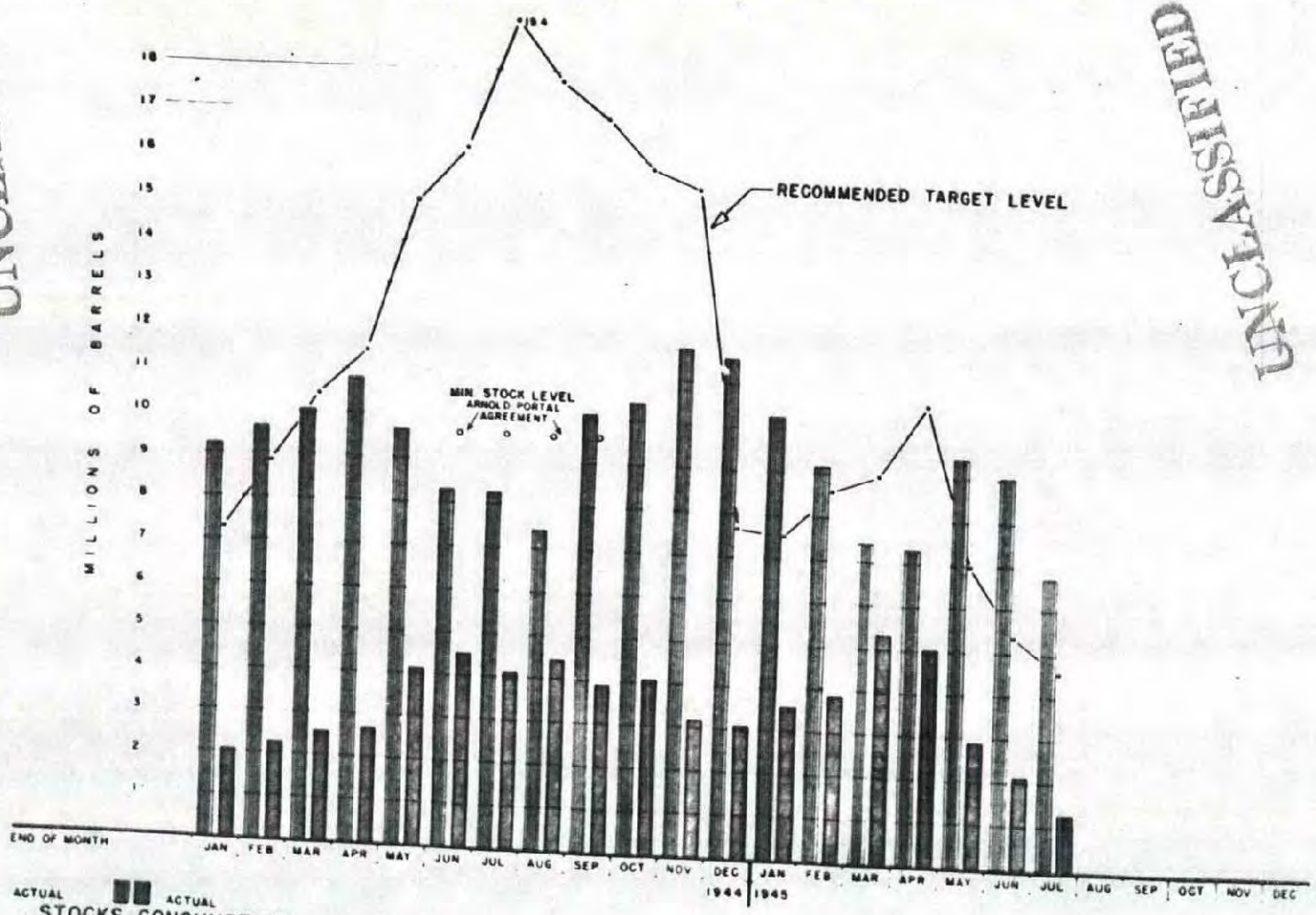
INCLUDING SUBSTITUTION OF GRADE 91/96 IN ZONE OF INTERIOR ACTIVITIES

ARMY AIR FORCES vs WORLD WIDE CONSUMPTION

MONTHLY 1943 – 1945



Appendix 11



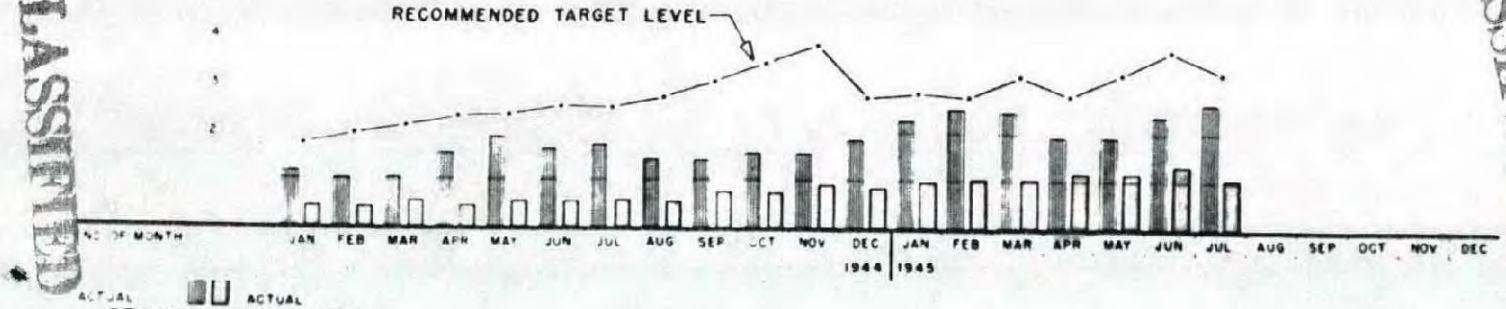
STOCK POSITION, CONSUMPTION AND TARGET LEVEL
EUROPEAN THEATER
INCLUDING ICELAND

1. Report by the Aviation Petrole Branch, ACAS-4, 1941-1945 . 26.

Appendix 12

STOCK POSITION, CONSUMPTION AND TARGET LEVEL NORTH AFRICA

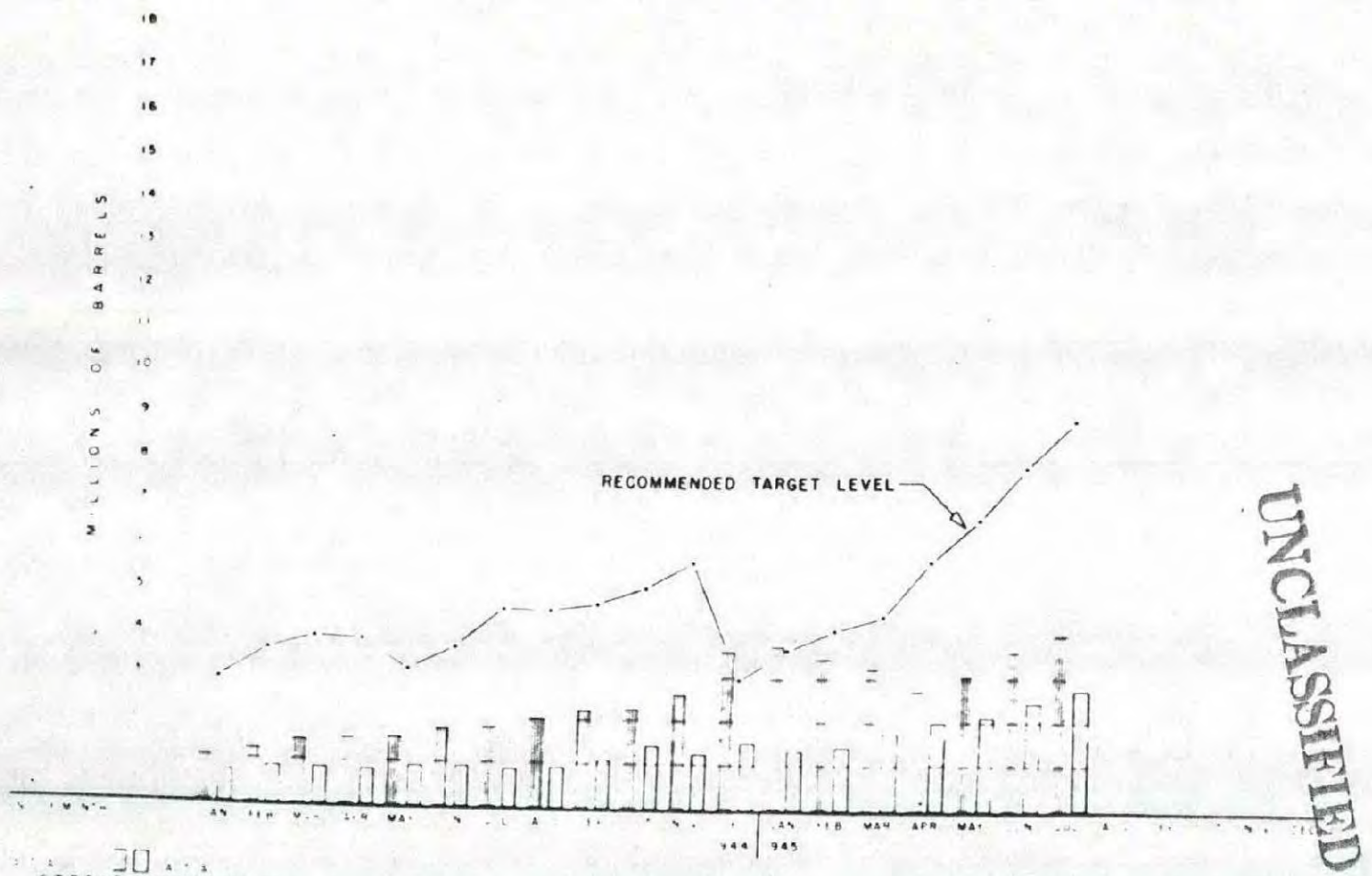
Appendix 13



STOCK POSITION, CONSUMPTION AND TARGET LEVEL SOUTHWEST PACIFIC [a]

a. Report by the Aviation Petroleum Branch, ACAS-4, 1941-1945, p. 28.

Appendix 1/4



STOCK POSITION, CONSUMPTION AND TARGET LEVEL
CENTRAL & SOUTH PACIFIC

UNCLASSIFIED

SECURITY INFORMATION

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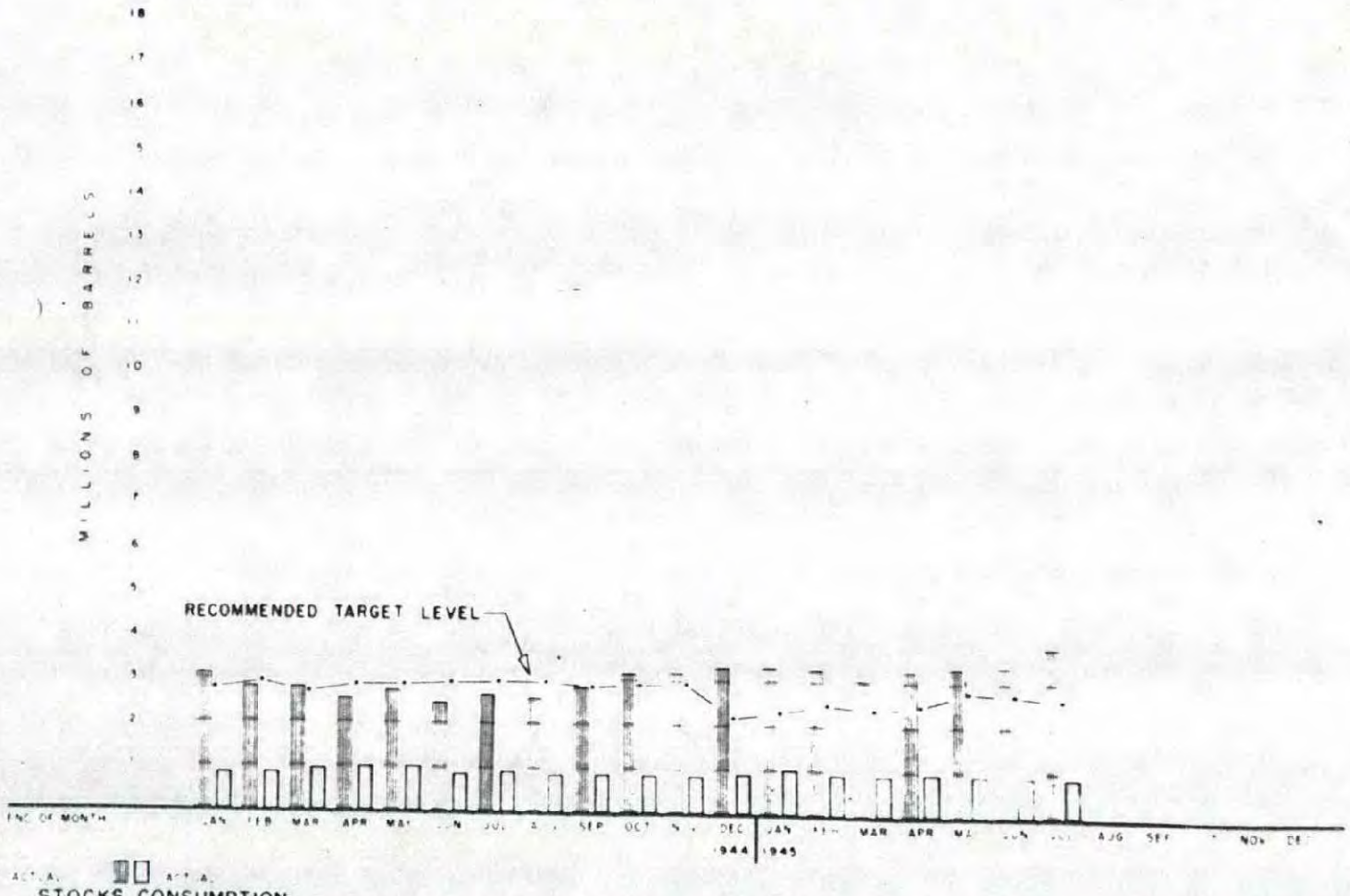
STOCK POSITION, CONSUMPTION AND TARGET LEVEL
CHINA · BURMA · INDIA[a]

a. Report by the Aviation Petroleum Branch, A-3-4, 1941-1945, p. 30.

Appendix 16



STOCK POSITION, CONSUMPTION AND TARGET LEVEL
ALL OTHER THEATERS[a]

a. Report by the Aviation Petroleum Branch, [illegible], 1941-1945, p. 31.

Poor Original

Appendix 17

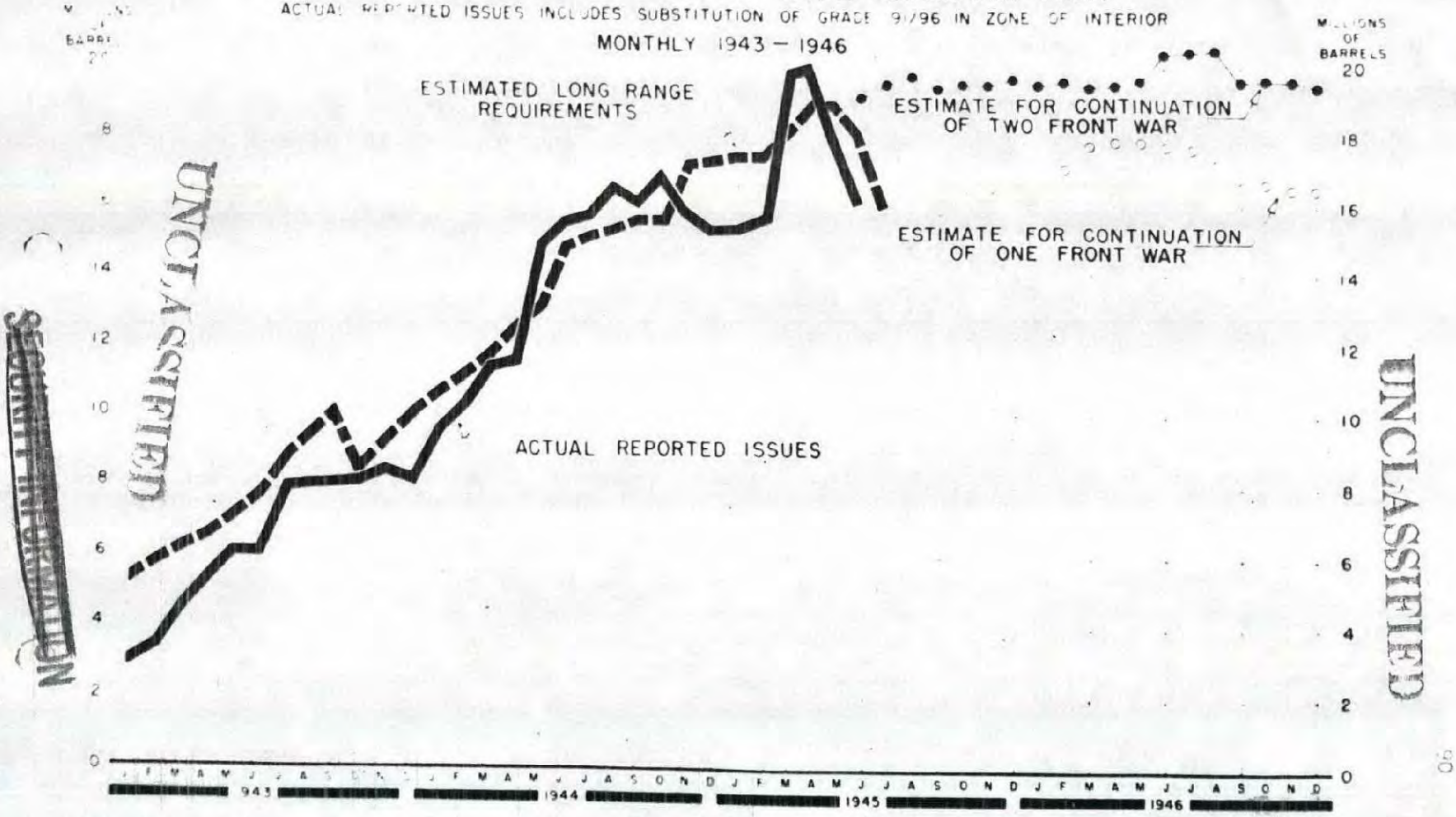
AVIATION GASOLINE GRADE 100/130[a]

ESTIMATED LONG RANGE REQUIREMENTS vs ACTUAL REPORTED ISSUES

UNITED NATIONS WORLD WIDE CONSUMPTION

ACTUAL REPORTED ISSUES INCLUDES SUBSTITUTION OF GRADE 91/96 IN ZONE OF INTERIOR

MONTHLY 1943 – 1946



UNCLASSIFIED

SECURITY INFORMATION

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a. Report by the Aviation Petroleum Branch, ACA3-4, 1941-1945, p. 32.

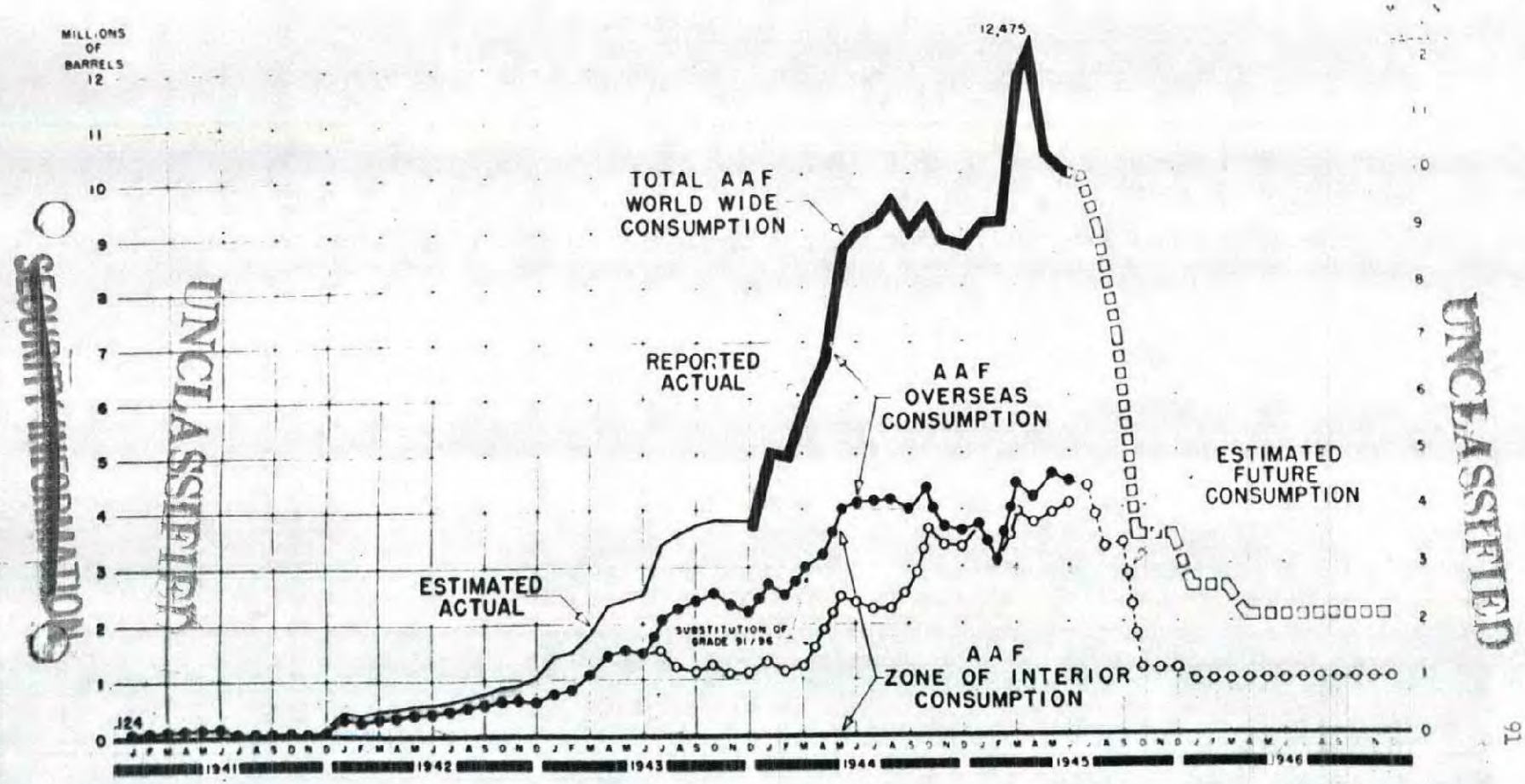
Appendix 18

AVIATION GASOLINE GRADE 100/130[a]

INCLUDING SUBSTITUTION OF GRADE 91/96 IN ZONE OF INTERIOR ACTIVITIES

CONSUMPTION BY ARMY AIR FORCES WORLD WIDE

MONTHLY 1941 – 1946



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SECURITY INFORMATION

UNCLASSIFIED

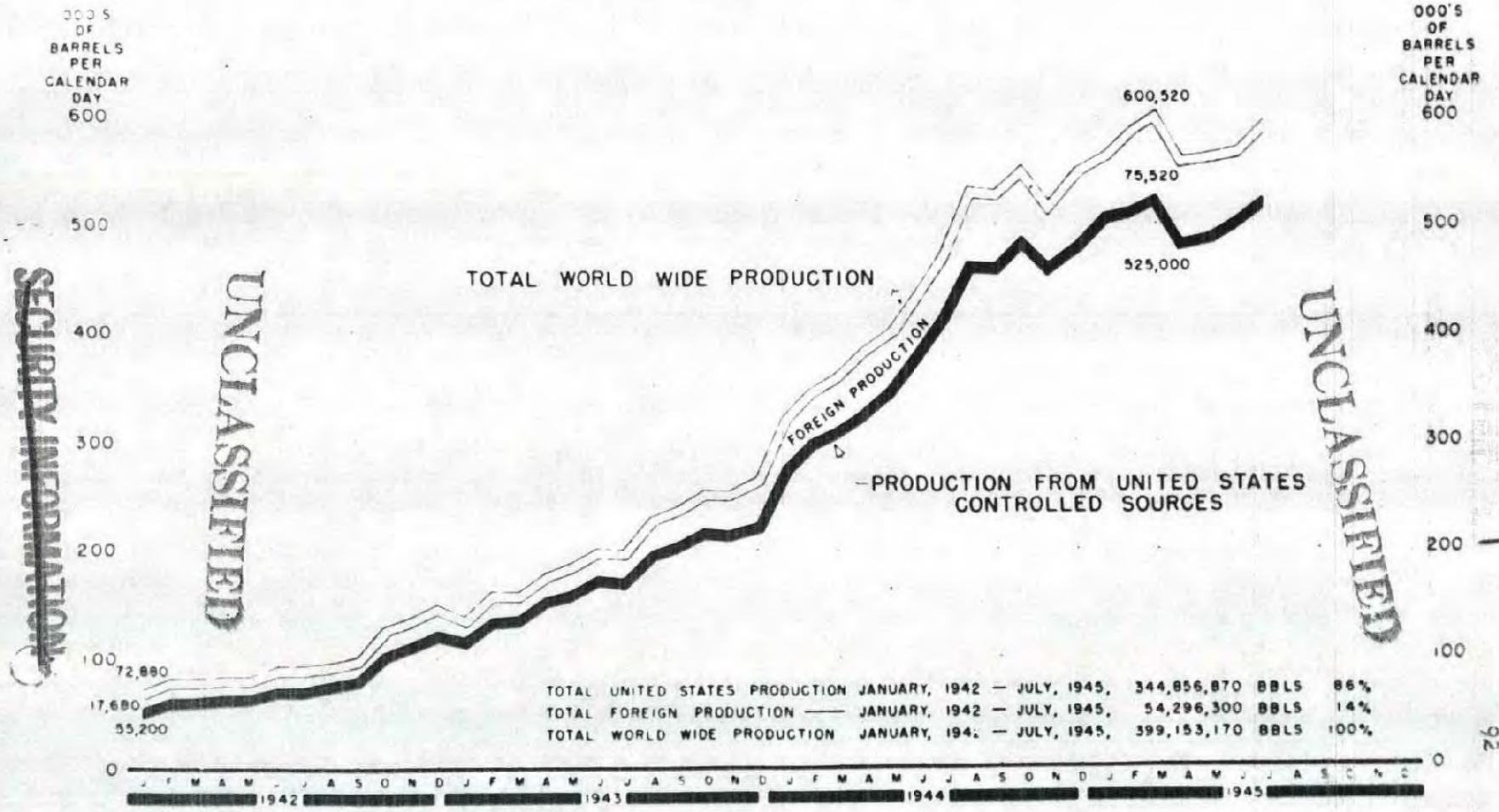
91

Appendix 19

AVIATION GASOLINE 100 OCTANE NUMBER [a]

ACTUAL PRODUCTION RATE

JANUARY, 1942 — JULY, 1945 INCLUSIVE



TOTAL UNITED STATES PRODUCTION	JANUARY, 1942 — JULY, 1945,	344,856,870 BBLS	86%
TOTAL FOREIGN PRODUCTION ——	JANUARY, 1942 — JULY, 1945,	54,296,300 BBLS	14%
TOTAL WORLD WIDE PRODUCTION	JANUARY, 194. — JULY, 1945,	399,153,170 BBLS	100%

a. Report by the Aviation Petroleum Branch, ACAS-4, 1941-1945, p. 35.

INDEX

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