

3685

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT
1003-20-4838

July 1 to Sept. 30, 1954

NBS REPORT
3685

PROGRESS REPORT ON ENGINE AIR CLEANING

by
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to

Office of the Chief of Transportation
Department of the Army

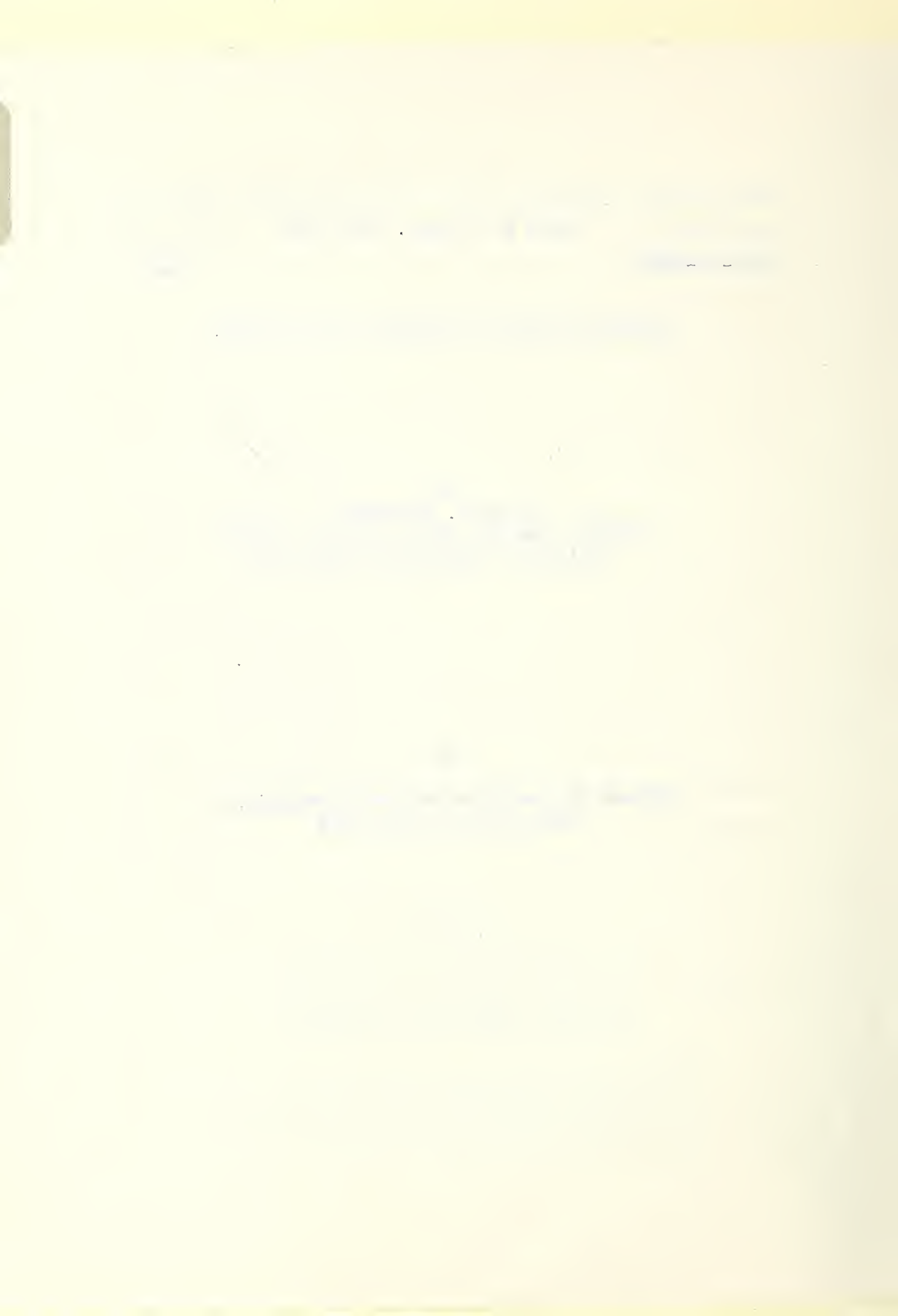
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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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FEDERAL BUREAU OF INVESTIGATION

A visit was made to the Cadillac Motor Car Division, GM at Detroit, Michigan, to discuss and abstract the report on their investigation of engine wear using two dusts of 0 to 2-1/2 micron and 0 to 40 micron size respectively. This report had not been published and no copies were available but the company consented to having it examined and abstracted.

The tests were conducted on an 8-cylinder tank engine with a standard W-5 oil-bath air cleaner, with and without using a precleaner. It was found that only dust particles of less than 2-1/2 micron size would pass the oil-bath air cleaner. It was found that the efficiency of the standard oil-bath air cleaner alone averaged 97.5% but with the addition of a 67% efficient precleaner the overall efficiency dropped to 98.8% while lengthening the service period of the oil-bath cleaner about three times. The theory was advanced that the precleaner breaks up the larger dust particles giving the oil-bath cleaner more fine dust to handle. It is the fine dust particles that pass the oil-bath cleaner, thus decreasing the overall efficiency.

In order to obtain a supply of dust similar to that found in the absolute filter cloth used during the air cleaner tests a 0 to 2-1/2 micron dust from the Phoenix, Arizona area was specially prepared by the A. G. Spark Plug Division,

REPORT ON THE PROGRESS OF THE WORK

The first part of the report deals with the progress of the work done during the year. It is divided into two main sections, the first of which deals with the work done in the laboratory and the second with the work done in the field. The first section is divided into three parts, the first of which deals with the work done in the laboratory during the year, the second with the work done in the laboratory during the year, and the third with the work done in the laboratory during the year. The second section is divided into two parts, the first of which deals with the work done in the field during the year, and the second with the work done in the field during the year.

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OWC. For equal masses and concentrations of dust in the inlet air this very fine dust was found to cause 32% less top cylinder wear and 63% less top piston ring wear than 0 to 40 micron dust of the same origin.

It was also found that dust entering the crankcase affected the bearings, piston skirts and oil rings more than the dust entering the induction system. The latter is responsible for more wear at the top of the cylinders and pistons above the compression rings.

A chrome-plated compression ring in the upper groove decreased the wear at the top of the cylinder sufficiently to eliminate the taper ordinarily encountered in the top inch of piston travel. The wear with the chrome-plated compression ring ranged from 10 to 22 percent of that observed with conventional rings. The wear of the second compression ring and the oil ring was not affected by chrome-plating the top ring. A chrome-plated oil ring resulted in increased wear by this ring. Manufacturing difficulties make it too difficult to control the accuracy of the chrome-plated oil ring, resulting in high oil consumption. The higher oil consumption results in a heavier oil film on the cylinder walls which carries more abrasive and results in greater wear.

When dust was fed directly into the crankcase the cylinder wear was much more uniform from top to bottom; there was

The first thing I noticed when I stepped out of the car was the cold, crisp air. It felt like a blanket, wrapping around me and filling my lungs. The sun was just starting to rise, painting the sky in soft, pastel hues of pink and orange. The world was still quiet, with only the occasional chirp of a bird or the rustle of leaves breaking the silence.

I took a deep breath, savoring the freshness of the morning. The dew on the grass glistened in the low light, and the scent of earth and flowers filled the air. It was a perfect moment, a fleeting glimpse of peace in a busy world. I closed my eyes for a moment, letting the tranquility wash over me.

When I opened my eyes, I saw a small stream flowing through the woods. The water was crystal clear, reflecting the surrounding trees and the bright sky. A small bridge made of logs spanned across it, leading to a clearing where a few deer were grazing. The scene was idyllic, a true slice of nature's beauty.

I walked towards the stream, my feet crunching on the fallen leaves. The water was so clear that I could see the small fish swimming beneath the surface. The sound of the water flowing was soothing, a natural melody that had been playing since the beginning of time.

I stood by the stream for a while, watching the world around me. The trees were tall and majestic, their branches reaching towards the sky. The air was so clean and fresh, a stark contrast to the smoggy air of the city. It felt like I had found a hidden gem, a place where time stood still and the worries of the world were left behind.

As the sun rose higher, the colors of the sky grew more vibrant. The birds were now singing, their voices filling the air with a sense of joy and freedom. The world was coming to life, and I felt a part of it. I took another deep breath, feeling a sense of renewal and hope.

The day was just beginning, and I knew that this was a special day. I had found a place where I could truly relax and recharge. I smiled, feeling a sense of peace and contentment. The world was beautiful, and I was grateful to be here, in this moment, with nature.

less wear at the top of the ring travel and more at the bottom. The piston wear was much greater, particularly at the bottom of the skirt end, while the piston ring wear was better, the oil ring had worn much more than the top compression ring. The bearing wear was extremely high. Whereas the blow-by was excessive when the dust was fed into the induction system because of the top ring and cylinder wear, it remained reasonable when the dust was fed into the crankcase. The oil consumption was higher in latter case, probably because of the piston and bearing clearances. The difference in wearing characteristics resulting from dust entering the crankcase and the intake manifold should provide a very useful basis for analyzing the causes of wear in a badly worn engine.

While in Detroit, it was considered advantageous to visit the A. E. Spark Plug Division, GEC in Flint, Michigan, since this Division builds and tests all air cleaners for the General Motors Corporation. The Division has recently concluded a contract with the Continental Motor Corporation to develop an air cleaner for helicopters. They were, therefore, reluctant to discuss this problem.

However, they showed the National Bureau of Standards representative an air filter presently used for helicopters consisting of a wire mesh panel one inch thick which they had received from Continental Motor Corporation. They considered it is

filter inadequate in efficiency as well as dust holding capacity.

Tests of the standard automotive oil-bath air cleaners at the A. C. Spark Plug Division, GPO were said to show 100% efficiency on dust particles greater than 100 microns in diameter. However, they were trying to improve the filtering efficiency for very small particles.

The air cleaner test apparatus used by this Division generally conformed to that described in Army Specification 93-21. Inquiries regarding the effectiveness of a flannel cloth as an absolute filter for air cleaner tests were answered with the information that this cloth did retain about 95% of all dust that passed through the test filter and that they did not know of any better material for the purpose. The engineer who operated this test apparatus recommended that at least three tests under each condition should be made to obtain a good average value. The Division was setting up a test to determine the features of a Farr-Rotomatic cyclonic type filter as a preclearer with a flannel cloth after filter.

Findings of Other Investigations on Engine Wear

The test results of the only two other investigations made on the subject of engine wear are summarized in the following pages.

These findings are being reported to the Board of Directors.

It is noted that the Board of Directors has not yet received a copy of the report of the Committee on the subject of the proposed merger of the two companies.

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Mr. G. T. O'Harrow of the Allis-Chalmers Mfg. Co. investigated the wear of an engine with wet cylinder sleeves due to dusts of three size classifications and from three different sources. Although the chemical analysis of the dusts collected from the Allis-Chalmers' Test Field, from Phoenix, Arizona, and from St. Anthony, Idaho, varied widely as to their content of silica, alumina and ferric oxide and also in loss on ignition, Mr. O'Harrow was unable to detect any correlation between the chemical composition of the dusts and the rate at which they caused wear to the engine.

There was some difference in wear produced by dusts of the same size classification, but of different origins. The dust collected at Test Allis and at St. Anthony, Idaho, produced generally higher rates of wear than dust originating in the Phoenix, Arizona area, in spite of the fact that higher rates of engine wear are often encountered in the Phoenix area during actual use of engines. These tests indicated that this is not because the Phoenix dust is more abrasive, but apparently because the air around Phoenix contains more of the fine dust particles that are not effectively caught by the air cleaners.

Mr. E. A. Davis of the Australian Aeronautical Research Laboratories drew the following conclusions from his tests;

THE U. S. DEPARTMENT OF THE INTERIOR

Geological Survey

Washington, D. C.

Report of the Director

for the year 1900

and for the first six months of 1901

by

W. H. Diller, Director

and

W. M. Galloway, Chief of Division

Washington

1901

Published by the Government Printing Office

Washington, D. C.

1901

Price 10 cents

Per copy 5 cents

By mail 10 cents

By express 15 cents

By air mail 20 cents

By registered mail 25 cents

By special delivery 30 cents

By registered mail and special delivery 35 cents

By registered mail and special delivery and express 40 cents

a. When dust is fed to an engine constantly at a moderate rate the wear at the top of the cylinder and the average cylinder wear are proportional to the amount of dust fed. The wear of the top compression rings is also proportional to the dust fed, but with alloy pistons, a preliminary growth takes place so that the final change in dimensions is not indicative of the wear. The total weight of metal worn from the cylinder walls, piston and rings is proportional to the weight of dust fed for a wide range of wear.

b. The higher the dust feed rate the less wear is produced per unit weight of dust. Under the conditions of the tests the ratio of the total metal wear to the amount of dust fed decreased from 1.6 to 1.0 when the dust concentration was increased from 1 mg per cu.ft. to 6 mg per cu.ft.

c. Other factors being equal, the wear produced by a given weight of dust depends on the size of the dust. The maximum wear occurs with a dust size of about 15 microns, the wear with 100 micron dust being about half that of 15 micron dust.

Course dust particles larger than 100 microns are easily removed aerodynamically. The less easily retained fine particles, down to less than one micron size, should be prevented from entering the engine if wear is to be kept to a minimum.

The first part of the report is devoted to a description of the
 experimental apparatus and the method of observation. The
 apparatus consists of a glass vessel containing a liquid,
 in which a small amount of a solid substance is suspended.
 The vessel is placed on a platform scale, and the weight
 of the vessel and its contents is measured at regular
 intervals. The weight of the vessel and its contents
 is found to decrease steadily with time, and it is
 concluded that the solid substance is being dissolved
 in the liquid. The rate of dissolution is found to
 depend on the surface area of the solid, the nature
 of the liquid, and the temperature. The results are
 compared with those obtained by other investigators,
 and it is shown that they are in good agreement.

Conclusions

The three investigations on engine wear, due to dust, which have been summarized above and which are the only ones known to have been made on this subject, to date, cover only a few of the possible variables. Therefore, the total knowledge of the effect of dust particle sizes and concentration on the engine wear is rather limited. It might seem obvious that the larger the particles and the greater the concentration the heavier the wear. On the other hand, it is quite likely that large particles in excess of 100 micron size will not force their way into the interstices between piston and cylinder and are ejected through the exhaust without causing much wear; and particles below 1 micron size, or so, do not bridge the oil film and thus produce a lapping effect rather than an abrasive one, but even so it has been shown that the presence of small particles weakens the oil film.

The removal of the large dust particles from the induction air can be accomplished with practically 100% efficiency with moderate difficulty whereas the fine particles which still cause considerable wear are hard to collect in a simple filter.

State of Laboratory Work

The assembly of the test apparatus was completed about Sept. 1st. Tests are now being conducted to determine the

Introduction

The first consideration in making any plan is that of the nature of the work to be done. It is necessary to have a clear idea of the scope and extent of the project, and of the resources available for its execution. This involves a study of the organization, its personnel, and its financial position. It is also necessary to have a clear idea of the objectives of the project, and of the methods to be used for its accomplishment. The plan should be based on a realistic assessment of the situation, and should be flexible enough to allow for changes in circumstances. It should also be simple and concise, and should be communicated to all those concerned with its execution. The plan should be a living document, and should be revised as necessary. It should be a guide to action, and should be used to measure progress and to control costs. It should be a tool for management, and should be used to achieve the best possible results.

Statement of Objectives

The primary objective of this plan is to provide a clear and concise statement of the objectives of the project, and to outline the methods to be used for their accomplishment. It is also intended to provide a framework for the organization of the project, and to serve as a guide to action for all those concerned with its execution. The plan is based on a realistic assessment of the situation, and is designed to be flexible enough to allow for changes in circumstances. It is intended to be a living document, and should be revised as necessary. It is intended to be a tool for management, and should be used to achieve the best possible results.

operational characteristics of a standard 300 cfm squirrel cage blower that has been modified to work as a rotating filter or precleaner in accordance with the experience obtained with a small pilot model. Besides the possible desirability for some additional structural changes, the present tests will furnish information as to the efficiency of the filter at different rotor speeds, blow-down ratios, air flow rates, dust concentrations and the effect of dusts of different fineness. The observations made to date are incomplete, but the efficiency of the rotating filter appears to be somewhat better than that reported in the literature for other precleaners and the pressure drop is considerably less than for the cyclonic type filter. The results will be presented in the next progress report.

After the tests with the rotating filter are completed the helicopter engine, which just arrived here from Ft. Hill, Oklahoma, will be analyzed for causes of excess wear.

The procurement of a good commercial air cleaner applicable to helicopter use has been postponed until information is obtained regarding the specifications contemplated for such equipment. It is considered desirable that a commercial air cleaner be tested here to compare its performance with the present concepts of the duty expected of helicopter air cleaners.

