MEMORANDUM REPORT

M64-18-1

UNITED STATES ARMY

FRANKFORD ARSENAL

49-p $1.25

INVESTIGATION AND ANALYSIS OF STANDARDS FOR USE IN THE SAND AND DUST TESTING OF MILITARY EQUIPMENT

by

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DECEMBER 1963

PHILADELPHIA 37, PA.

MEMORANDUM REPORT M64-18-1

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INVESTIGATION AND ANALYSIS OF STANDARDS FOR USE IN THE SAND & DUST TESTING OF MILITARY EQUIPMENT

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December 1963

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ABSTRACT

An investigative study was made of the state-of-the-art of sand and dust environmental testing. Field and laboratory studies were conducted in order to obtain sufficient realistic data concerning the sand and dust environments for use as guidance in preparation of Military Standards for Sand and Dust Environmental Testing which simulates the degradation and/or damage done by blowing sand or sand and dust in a desert environment.

Due to the lack of sufficiently severe wind storms in the test areas chosen, information collected over a two year period failed to provide all of the field data required. The laboratory data obtained using existing Sand and Dust test chambers were not able to supply all of the answers needed. A new type of test chamber has been designed for this purpose, which when installed, will be used for continuation of the experimental investigations.

This report recommends that two test procedures be established; one for "Dust (Fine Sand)" covering the 10 to 150 micron size range, and the other for "Sand" covering the 150 to 800 micron size range. Some recommendations for inclusion in the "Dust (Fine Sand)" MIL-STD are presented in this report. Recommendations for the "Sand" MIL-STD cannot be made until after additional data is acquired utilizing the new design sand test chamber.

OBJECT

The objectives of the program are.

1. To collate and analyze existing data on airborne sand and dust, up to eight feet above the ground, to collect additional data to bridge the gaps thus unearthed, and to investigate combinations of varying factors such as velocity, particle size, temperature and density, in order to determine those which are most pertinent and eliminate insignificant variables in current sand and dust test procedures, for standardization purposes.

2. To prepare a new sand test specification (MIL-STD) for use by the Department of Defense (DOD), for ground equipment.

3. Based on the results of findings of this program, if warranted, to propose a revision of existing MIL-STD testing procedures for penetration type Dust (Fine Sand) tests, for vehicle-mounted and airborne equipment, in lieu of the present Sand & Dust (S&D) Test.

SAND AND DUST TESTING - BACKGROUND INFORMATION

Over the years the potential damage done by sand and dust has been evaluated in many ways, surface erosion, scouring, interference with moving parts, penetration, blockage of pores and openings, and the fouling of electrical contacts. Each has been used as the basis for establishing a given test, and several general and many detail sand and dust tests are in existence. As many of these as are known to be different, and appropos to military materiel, will be discussed below.

In 1959 the Ordnance Corps, now part of the Army Materiel Command, was assigned the Army responsibility for preparing a new Military Standard for Sand and Dust testing of military materiel. To comply with the several program objectives, several phases were to be investigated by Frankford Arsenal (FA), White Sands Missile Range (WSMR), and a contractor, The Southwest Research Institute (SwRI). FA had and still has the responsibility for coordinating the overall investigation. WSMR had the responsibility for coordinating the technical aspects of the program, but since the reorganization of the Department of the Army, in October 1962, with new assignments for WSMR (and loss of their key man on this program), FA has also assumed the responsibility for coordinating the technical phases of this program, and for completing it.

A complete review of existing specifications and standards dealing with S&D testing appeared to be the natural starting place for this project. This review has been most enlightening -- and discouraging.

SPECIFICATIONS - GENERAL OBSERVATIONS

Specifications fall into two general categories:

The first type is generally referred to as a "detail" specification, and relates to the procurement and testing of a specific item. Those who initially prepare them, spell out the details of the tests which they believe will, if successfully surmounted, assure the successful longevity and utility of the item under all intended storage and use conditions. The detail specification may spell out every test step, or it may reference a "general" specification or standard, which is to be followed as written, or as specially modified. The detail specification normally spells out the goals or test results required.

The "general" specification may take many forms, such as the World War II Joint Army-Navy (JAN) Specifications, Military Specifications, Military Standards, Federal Standards, and standards produced by and for the use of one branch or service. Normally a general specification will cover all types of environmental tests for one complete class of materiel, or it may cover only one specific type of test, in complete detail.

CURRENT ENVIRONMENTAL SAND & DUST TESTING SPECIFICATIONS

In dealing with any test specification or testing standard, we must first ask ourselves what it is we hope to accomplish by its use. Are we attempting to simulate an exact duplication of a natural environment? Or, are we attempting to accelerate the process of degradation caused by a natural environment? In other words, what is the purpose or goal of our tests?

In the mind of the engineer or technician who prepares such a specification or standard, a goal must exist. It may be specifically formulated and take into consideration many varying factors and combinations of factors. On the other hand, since one cannot be an expert in all fields, and the test preparer may not recognize the need of testing expertise which may lie in another organizational area, he may prepare a specification which is incomplete or even valueless, or a specification which accomplishes only one or two of the above-listed goals. He may not even realize that other testing alternatives exist to the ones which he spells out.

Some tests, and even standards, have been approved, and have reached the test engineer couched in such terms as to be impossible to conduct, to be too severe, or to be so mild as to never produce meaningful results for the particular item to which it is applied.

Specifications and tests which have been valid in one field, have often been borrowed intact, or referenced, in an entirely different application where their use is invalid; invalid possibly because the true aim of the borrower requires a different objective or approach than that which formed the basis for the original specification.

Changing a specification or standard is difficult. Once a document is approved and in print, it seems to take on "charismatic authority", which even the experts hesitate to question. Possibly they are afraid of "stepping on the toes" of the specification's unknown originator, in another branch of the service. It seems to be easier and the path of least resistance, that when an existing specification is recognized as invalid, to "waive" or ignore it. This may be easily justified to one's superiors, by merely "proving" that no other test can be readily located. The waiver may continue to be perpetuated to a point where no one recalls why or when it started, and the test engineer hears his customers say: "We never bother with that test at all".

The more conscientious engineer, recognizing the invalidity of a given test, may merely write his own, for local use, and without inter-service coordination. This may or may not be more valid than the one he desires to circumscribe.

Often when a test procedure is followed, and the item fails to comply with the test engineer's interpretation of the test specifications, the vendor or customer will indignantly attack the validity of the tests, and request a waiver.

It is easy to criticize, logically, empirically, or from an engineering point of view, and much disagreement appears as to the interpretation of the results of certain environmental tests. The amount of disagreement varies with the goal that the person criticizing has in mind, and with his own experience in that field.

Before considering the natural environment of sand and dust, let us examine in detail some of the existing simulated test specifications in that area.

MIL-D-13570

MIL-D-13570 (Ord), Military Specification, Dust, Testing by Exposure to, (Ref a, Appendix I), is the only general Ordnance specification in this field. It is dated 1954, replacing a World War II Army Specification dated 1944. The key point of this specification is its requirement for the use of ten pounds of dust for every 27 cubic feet of chamber space, the chemical composition and particle size dispersion of this dust is given, but not its source. A later paragraph in the specification (6.2) refers the reader, viz. "Test apparatus and conditions are comparable to that specified for electrical components by S.A.E.".

S.A.E. is an abbreviation for the Society of Automotive Engineers, and the only listing of "dust" or "sand and dust" in the index of their handbook is to "Lighting Equipment for Motor Vehicles" SAE J575, a standard first approved in May 1942, and brought up to date in June 1961 with only minor editorial changes (Ref (b), and Appendix II). This calls for testing in a 3 feet by 3 feet box, using ten pounds of fine powdered cement, in a test designed to determine whether the light from a vehicle lamp is diminished by dust (sic. powdered cement) adhering to its surface. The cement, according to their referenced American Society for Testing Materials (ASTM) specification (Ref d) does not chemically comply with that called out by MIL-D-13570. One may well speculate at this point as to how many test engineers and designers over the years, have traced this specification back this far, noted these discrepancies, shrugged their shoulders, and left it alone, hallowed and untouched!

Another SAE specification spells out a dust used and distributed by A. C. Spark Plug Co., in Michigan. After some research this was located under the title of "Air Cleaner Test Code - SAE J726" (Ref c and Appendix III). Here the dust size distribution and chemical composition match our specification, and its commercial source is listed as A. C. Spark Plug Company. Its distribution in that test, however, is only 0.025 g/cu. ft. of air, which the filter is supposed to remove at a single pass.

One may now safely surmise that MIL-D-13570, far from being hallowed, is the illegitimate offspring of both of these SAE specifications, and we may further question whether the entwined segments of each which we have to work with are capable of proving anything of value. This specification has not been used in Frankford Arsenal in at least the past decade, although it is referenced by MIL-A-13488B (Ord) (Ref e), and may be used by other installations.

MIL-C-9436A (ASG)

MIL-C-9436A (ASG), Military Specification, Chamber, Sand and Dust Testing (Ref. f, Appendix IV), appears to have made its first appearance in 1954. It will be shown below that it was not quoted in several USAF specifications issued subsequent to that year. It is the only formal chamber design specification which can be located, and requires that the chamber be capable of producing the cycles spelled out in MIL-E-5272. No specific mention is made of the chamber complying with the humidity requirements of MIL-E-5272, but that is implied.

To provide the various detailed requirements of MIL-E-5272, this specification should be more detailed than the form in which it currently appears.

MIL-E-5272

Many specifications bear the instructions that its latest edition supersedes all of its earlier ones, although they remain in effect to cover procurement of previously designed items or materiel.

MIL-E-5272, Environmental Testing of Aeronautical and Associated Equipment, primarily an Air Force Specification, has gone through three revisions (References g, h, i, Appendices V, VI, VII), in each of which there have been changes in the Sand and Dust procedures.

The chemical composition of this sand and dust and its particulate size distribution has remained consistent. Although a source isn't listed, it is well known and readily available.

What has varied, through the revisions, have been the densities, velocities, and duration of exposure, which will be discussed in detail further on in this report. Relative humidity requirements have remained constant throughout.

Although the "B" revision of MIL-E-5272 was issued in 1957, after MIL-C-9436, no specific test chamber design is mentioned. The "C" revision, dated 1959 does reference the chamber specification, but requires that the chamber be vented to the atmosphere. Without going into a technical discussion at this point, it is sufficient to say that a chamber vented to the atmosphere cannot maintain a constant relative humidity, without a very elaborate and expensive generating method and control system. Thus, since 1959 it has been technically impractical to comply exactly with sand and dust tests in the MIL-E-5272 series.

Since there is evidence that neither the "B" nor "C" revisions were approved by the Department of the Army, there may be a question as to which specification has been valid all these years for DOD use. In as much as MIL-E-5272 has been one of the prime standards used for Ordnance Sand and Dust testing, and the most frequently referenced of all environmental testing documents, there may be a question as to whether a design engineer who quoted a Sand and Dust test from the "latest revision" of MIL-E-5272 was wise in doing so.

The Air Force has apparently abandoned the MIL-E-5272 series*, but since there is no specific notice to that effect, the unsuspecting designer or procurement personnel may still quote it. Their new specification, MIL-STD-810, Method 510, Sand and Dust, continues to modify the basic test requirements of the MIL-E-5272 series, eliminates the chamber ventilation and lists a source for the standard dust.

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*Note: MIL-E-5272 has been superseded by MIL-STD-810 (USAF), Military Standards for Aerospace and Ground Equipment, Ref j, Appendix VIII.

MIL-E-4970

The sand and dust test in MIL-E-4970 (USAF) Environmental Testing of Ground Support Equipment (Ref k) is still extant, and is the same as MIL-E-5272.

Federal Test Method Standard No. 141

Method 6191 of this standard, Abrasion Resistance (Falling Sand) (Ref l), is an entirely different type of test, designed only to measure the amount of abrasion caused by sand falling upon a painted surface from a known height. Its sand is specified, and a source for the sand is given. The equipment used is spelled out in detail, and may be construed easily and inexpensively by any laboratory.

MIL-E-5400F (ASG)

This specification: Electronic Equipment, Aircraft, General Specification for, (Ref m), has a simple three-line paragraph appropos to this topic:

3.2.21.7 Sand & Dust - The equipment shall withstand, in both an operating and non-operating condition, exposure to sand and dust particles as encountered in desert areas.

Within environmental testing circles a great deal of discussion has gone into the interpretation of this statement, and many research programs have so far not provided an exact answer as to what we are to simulate, how to do it, and how the results should be interpreted after the testing has been completed.

There are two additional "Proposed" standards worth mentioning at this point: (a) Military Standard, Sand Dust test for use in the Development of Fuzes (Ref n) (NOTE -- not Sand and Dust, but Sand Dust), and (b) Military Standard, Sand & Dust Test for use in the development of Military Equipment (Ref o). Neither reached the approved stage; both worked with the "standard" MIL-E-5272 basic equipment and methods, with minor variations. This current investigative program was promulgated as a result of a tri-service disagreement during the attempted coordination of the last mentioned Proposed MIL-STD (b).

It is believed by many people with expertise in the environmental testing field that these "proposed" procedures never became standards, and that sand and dust testing became unpopular as a whole, because of the apparent lack of correlation between suspected and observed natural phenomena and the proposed simulated tests in a laboratory chamber. Many people in official circles have taken note of this, and several projects have been started as a result --- including this one.

To those who are vitally concerned with the preparation of specifications, and often faced with the necessity of defending each test step they make, a possible respite now appears. AMC Regulation 700-15 (Ref p) states:

"4 - b. Essential factors to be considered in reliability assurance are: (4) The effectiveness of specification criteria in simulating the real environment postulated in the military specification. (When real environment cannot be simulated, quantitative correlation will be required.)

5 - f. To the extentpracticable, tests of increased severity (beyond those environments normally expected in use), and tests to destruction should be performed to establish knowledge of the limitations of the system, the margin of safety inherent in the design of the system, and failure modes."

Discussion, Conclusions

Heretofore, however, the Environmental Engineer and his test personnel have been expected to determine the longevity of a test specimen under this conglomeration of variables by test or tests to which he is bound by firmly fixed parameters --- established by others. More often than not he is the target of the general criticisms that either "he has not complied with the specification", or that the test equipment is faulty or out of calibration. Few people have ever admitted that a test specification of their own creation is faulty, or fails to produce the desired results.

Since a test has been prepared with the acceptance of an end item as its goal, only limited time, money, and engineering talent has been made available for research, study, and evaluation of the correlative factors between the natural environment, and its laboratory "equivalent". We are a long way from being able to say that "x" hours in a chamber equals "y" months or years under a given field exposure condition.

No simple, or single test, will be the answer, but persistent effort can produce meaningful tests, if, as these tests are prepared, one continues to keep asking: "Just what is this test expected to do?"

Now for a moment, let us consider the natural environment with which we are dealing.

THE NATURAL ENVIRONMENT

There can be no argument with the statement that any natural environment selected for consideration will prove to be, in itself, a variable. Minor and major differences for each climatic phenomenon can be determined by measurements made at different locations on the surface of the earth; sometimes even in locations considered close together. Climatic environmental phenomenon are not completely independent, but have interactions which are themselves variables.

The Department of the Army has recognized the need for realistic sand and dust field data, and over the past decade a series of studies have been made by various military agencies and civilian research organizations under their cognizance. References (q) through (z), (arranged chronologically) are typical representatives of the reports resulting from such efforts. These reports include Weather Bureau data, observations by qualified experts, statistical analysis of some of the data collected, and some suggestions as to the form and direction in which the investigation of sand and dust testing should go.

As may be expected, the inconsistencies in nature are reflected in these reports, and there are areas which have not been completely studied. Furthermore, no specific standard or specification has resulted from these reports.

It was the intent of this current project, as stated in its objective, to pull together existing data, collect additional data to bridge the gaps, and to prepare not a single catch-all specification, but several closely related environmental procedures intended to be representative of the desired goal. From these it was hoped that the varied factors of desert degradation could be extrapolated in terms of the utility and life expectancy of military ground material stored or used in a desert area.

THE INVESTIGATIVE PROGRAM

To this end, conferences were held between representatives of cognizant testing and user agencies during 1959-60 as to the goals of this project, and the manner in which it was to be pursued. Additional technical meetings were held between the three afore-mentioned participants (F.A., WSMR and SwRI) as to the procedural method of implementing same. Reports of the technical details of these meetings have been prepared during the past few years. A complete resume of the work, and these reports, will be given here.

Objectives

There were two prime phases of investigational work to be conducted by the project's three participants.

Field Investigations

This phase of the project was undertaken by WSMR, using desert sites in their own range, at Yuma Test Station, Arizona (YTS) and at Dugway Proving Ground, Utah.

Four exposure racks were built from an original design, so constructed as to be self-orientating with the wind. These devices held specimens of exposure samples to various degrees of exposure to the wind (right angle, 30° and 45°) at 4" intervals from ground level to 8.7 feet above the ground. Bags positioned at each 4" level also collected specimens of sand and dust blowing at these levels.

The specimens originally planned for exposure at each location consisted of:

1. * Glass
2. Steel (1020)
3. Steel (1020), not primed, but enamel painted
4. Steel (1020), primed and enamel painted
5. Steel (1020), nickel plated
6. Steel (1020), silver plated
7. Steel (1020), chrome plated
8. Brass
9. * Aluminum Alloy #3003
10. Aluminum Alloy #3003, Anodized
11. Aluminum Alloy #3003, Anodized and Enamel Painted
12. * Stainless Steel, Type 302

Samples prior to, and after exposure, were to be examined by a "metalograph"* at WSMR. Samples, plus bags of collected blowing sand from outlying stations were to be shipped to WSMR for analysis. An elaborate schedule was set up to determine when a new lot was to be exposed, this schedule varying both with time and with wind storm activity.

The materials exposed at each position were later reduced from twelve to three, as indicated by the asterisks (*).

The objective of this phase of the program was to determine:

(a) Normal desert environmental components

(b) Particulate size distribution of blowing sand and dust in the desert, for changes in elevation.

(c) Measurement of damage done to these replicate samples, at each of the three desert locations and at each elevation.

Laboratory Investigations

This phase of the program was to determine the effect of blowing sand and dust over replicate specimens handled under strictly controlled laboratory conditions. To do this the following factors had to be considered:

(a) The type of commercial sand, and its particulate distribution, available for laboratory testing.

(b) Chamber variables and their effect

(1) Density
(2) Temperature
(3) Velocity

(c) Suitable samples available in replicate for exposures, and

(d) Methods of evaluating these samples after exposure to give meaningful or useful correlation information.

Frankford Arsenal and Southwest Research Institute both participated in this phase of the work.

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*Note: A device for observing/photographing the microstructure of a small specimen's surface.

Correlation Studies

The third phase of the program which had to be completed before specifications could be written, was to determine the correlation between field exposure damage, and laboratory simulated damage. In the event that correlation was not readily apparent, it was anticipated that test procedures would have to be modified to more nearly simulate actual field conditions.

Procedures (and Problems Encountered)

Field

Unfortunately, during the normally expected windy seasons of 1961 and 1962, nature failed to cooperate, and wind storm activities were at a minimum; the true meaning of the data thus collected from the exposed samples is open to question, primarily because it is so sparse with respect to higher velocity conditions. Simultaneously, desert rats built nests in the lower collection bags, chewed holes in others, and many of the bags became filled with other flying debris. This might suggest a complete new investigation as to the damage, if any, of non-sand and dust particles blowing through the desert, such as leaves, twigs, etc.

Despite the fact that the number of samples for each exposure were later reduced, the shear physical quantity involved required more metalograph operating man-hours than were available during the working week. It should also be noted that operating this instrument continuously causes eye fatigue which influences the results observed, and that unless the same operator conducts the before and after examination, erroneous data may result.

As one result of the reorganization of the Department of the Army in October 1962, there has been a realignment of missions and work forces at WSMR. and the personnel formerly concerned with this program have other assignments. Furthermore, technicians trained in the use of the metalograph who examined the earlier field specimens are no longer available.

Laboratory

There is a theory, as yet unproven, that erosion by S&D exposure, whether in the laboratory or in the field, is not linear, but follows a type of "S" curve as shown. The sharp change in slope in the "B" area may be due to the breaking off of pieces of the basic metal, or its plating in the case of plated material. This may normally be expected to vary with the type of material, angle of exposure to S&D impact, velocity of impact, particle size of S&D, particle hardness, or a

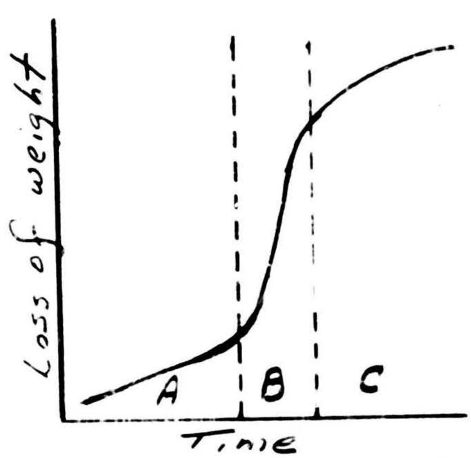

Fig 1

combination of several of these factors. It was hoped to find this sudden change in slope, or "break" in the curve, and make use of it as a criteria for further investigation.

Three distinct laboratory investigations were to be conducted, each with a different set of variables:

(1) Velocity and concentration constant; particle size varied and plotted against erosion. (This required daily chamber cleaning and varying of the type of sand).

(2) Velocity and particle size constant; concentration varied and plotted against erosion. (This required daily varying of sand concentration in chamber).

(3) Concentration and particle size constant; velocity varied and plotted against erosion. (This required daily varying of velocity).

The exposure period for any given set of fixed conditions was four (4) hours. Weight loss, to four decimal places, was to be used as a measure of erosion, and was to be plotted against time; a separate plot for each specimen for each day's exposure. The plot of each, containing five points, followed any one of several configurations. If there was a break in this curve, its value would be used. If there was no break, then the terminal weight loss was to be used to represent the conditions of that exposure. This single point was to be used to develop the curve representing the variable of the particular investigation.

After the specimen for the day's exposure had been selected, their protective coverings were removed from one side. Using extreme care, the samples were weighed, and then inserted in their respective holders. (See fig. [illegible] pg [illegible]). After chamber conditions had been stabilized, the holders and specimen were placed in the chamber.

At the end of one hour of exposure the holders were removed, and blown dry by means of a stream of clean dry compressed air. Each specimen was then immersed in a suitable cleaner* to float away any remaining dust

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* Pressure-sensitive covering was not soluble in the cleaner (alcohol), which was verified in advance.

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particles, air dried and weighed. This process was repeated each hour for the four hour period. It was desirable that the 4 hour exposure be completed in one work-day.

After completing the 4 hour exposure each specimen was to be scribed or engraved along one of the 1½" edges to identify:

Exposure Conditions
Angle of Inclination
Type of Specimen

Since each exposure required one work-day, the total number of exposures which had to be made was the product of: (1) the number of velocities, (2) the number of particle sizes, (3) the number of concentrations, and in the case of F.A., (4) the number of temperatures.

The curves resulting from the first three investigations were to be analyzed to determine breaks or other indications of extreme erosion conditions, and this data used in the preparation of the new specification.

Inasmuch as we were working with materials, and under conditions which were not normally followed in routine S&D tests, we had to consider each action separately, with a view to how such a procedure would appear in the future, if in specification form, they were to be carried out by the regular laboratory technician. It is considered advantageous here to discuss each of these variables in detail.

<u>Availability of Commercial Sand for Laboratory S&D Testing</u>

Particle Size:

With a few negligible exceptions, sand in particle sizes ranging from 10 μ to 800 μ (microns) can be found in many places in nature. Some of this sand and dust is carried aloft by winds under certain conditions, or raised in low clouds by vehicles moving across the desert.

The material (silica flour) presently called for in MIL-E-5272 and MIL-STD-810 has a limited source, and powdered Ottawa River sand dust is generally used. Because of its source, and the consistency of its particle density, sharp edges, etc., there is doubt as to its correlation with the fine particles found in the desert whose characteristics are less uniform.

It was originally thought that to permit repetitive testing, particle sizes which could be separated by standard laboratory type sieves were to be utilized. A fine grade of quartz sand, preferably from the same source location, was sought by both SwRI and FA. FA was to work with particles in the sieve ranges of #70, 60, 50 and 45, comparing to 210, 250, 297, and 350 microns, respectively. SwRI was to use the same size particles as well as larger sizes, above sieve size 45, up to the limit that their equipment would keep such particle sizes in suspension under test conditions (up to 800 μ).

Exhaustive investigation and correspondence between this Arsenal and suppliers of sand elicited the information that the size ranges of sand that we required are not commercially available or are smooth particle sand rather than sharp edged. The most satisfactory sand that we could purchase (Pennsylvania Glass Sand Corp. #22) was obtained in sufficient quantity so that by sieving we would theoretically obtain a sufficient quantity of all particulate sizes that were required.

However, laboratory equipment available or readily obtainable proved to be unsuitable for separation of any but extremely small quantities, inadequate for even preliminary studies of its circulation within the chamber.

Air separation of the sand is possible with expensive commercial equipment such as that used by the manufacturers of sand paper. Contacts with personnel in this industry indicated they could separate our #22 sand, but they refused to do so since they did not want to spend the time necessary to clean their equipment prior to converting from their material to ours, and then back again.

Considerable time was consumed in this problem, unanticipated at the start of the project. Two additional lots of sand were finally secured, the three lots overlapping in particle size but not in distribution. While not entirely satisfactory, it is the best that can be obtained commercially. SwRI encountered the same problem, and made a similar compromise.

It is to be noted that the cost of transporting the sand to the laboratory may exceed the material cost, despite purchasing sand "locally". Lots from one shipment may not contain the exact same distribution of particulate sizes, and orders from the same vendor may come from different quarries, and again have different distributions. Thus from the point of view of good laboratory control of experiments, we started under a basic materials handicap.

The quantity of sand needed to conduct a sand and dust test will vary, depending on whether the test is conducted in a single-pass or re-circulating type of chamber. This will be discussed in detail later.

Chamber Variables and Their Effects

Density:

Originally both FA and SwRI were to use concentrations of sand in four densities: 0.01, 0.05, 0.1 and 0.2 grams/cubic foot.

The Sand and Dust Chamber which we are using for this research was designed to perform routine sand and dust tests utilizing the dust spelled out in Specification MIL-E-5272, and is a closed system. An electronic smoke indicator attached to the chamber was calibrated to indicate the proper density of this dust within the chamber. This smoke indicator will not measure the density of our research type sand, probably because there are less particles in suspension due to the increased volume of each particle.

A second method of measuring density, the removal of a known volume of sand-bearing air by a vacuum pump through a filter, and then weighing the sample removed, also proved unsuccessful. It appeared that a small suction line inserted into the chamber, if faced towards the blowing sand, became clogged. If the suction line faced downstream or across stream, it would not sufficiently divert the moving particles from their original direction of movement.

Knowing the volume of the entire Sand and Dust Chamber closed system, and assuming that the velocity is sufficient to keep all of the sand in suspension, it was thought that it might be possible to introduce the proper weight of sand to produce the density desired. However, this also has proven to be an unreliable method for two reasons: first, the hidden parts of the chamber, cooling coil surfaces, ledges, joints, etc., are capable of entrapping a portion of the circulating sand, thus continually reducing the density of the material in circulation. Secondly, inaccessibility to much of the system prevents thorough cleaning, and operating personnel can never be assured that entrapped material from a previous run will not re-enter the system again and upset the new density.

SwRI also encountered this problem, and solved it by converting their chamber to a one-pass system. It is imperative that we do the same before continuing this project, for two reasons; (1) Recirculating sand particles shatter upon contact with projecting edges of the chamber, and the input particle size distribution becomes changed mere moments after the chamber circulation is started. (2) The recirculating sand abrades the system's circulating fan, picking up metal particles from the fan blades which also strike the exposure specimen.

Our fan ultimately became unbalanced from erosion and had to be replaced. A one pass system can be so designed that sand will not pass through the fan assembly.

Velocity:

To cover the wide range of velocities originally envisaged in the early stages of this project, F.A. was assigned the slower velocities of 1300 ± 200, 2250 ± 200, 3000 ± 300 fpm plus one other point between 1000 - 3000 fpm believed consistent with the design characteristics of our chamber. Any change in velocity required changing a set of pullies, a time consuming and dirty job. The velocities which resulted were not those empirically desired due to the specific limiting characteristics of the fan used in our chamber. Before the fan blade disintegration, it was determined that in the attempt to attain a 3000 fpm velocity we had exceeded the design characteristics of the fan, that velocity was actually being retarded, and top velocities were not reached.

SwRI having a different type of fan utilized velocities intended to overlap those of F.A., from just below 3000 fpm up to a maximum of 5000 fpm.

Exposure Samples

All participants prepared their own exposure samples. WSMR used specimens approximately 1" X 3" X 1/16" since their surfaces were to be microscopically examined. SwRI and FA used approximately 1" X 1½" X 1/16" specimens and weighed their specimens for weight loss. WSMR used twelve specimen (previously listed on page 11); and from their list we used four.

Glass (one-half of a standard microscope slide)
Aluminum, Alloy 3003 (Surface Hardness Rockwell 61±2)
Brass, Hardness Rockwell B 40 or F 79
Mild Steel, Type 302 (18-8), Hardness Rockwell B 80

Frankford Arsenal also exposed three types of plastic specimens.

All metal samples were purchased to have a #7 industrial finish on both sides, and it was specified that they were to be received with an easily removed pressure-sensitive paper protecting each side. Edges were to be free of burrs. However, workmanship of metal suppliers varies. A comparison study of the samples obtained by the three contributors showed ours to have an unsatisfactory surface finish. Also, our specimens had burrs and sharp edges which could conceivably chip off under sand impact, and improperly affect the specimen weight. Attempts made to improve our specimens still fell short of desired conditions.

Specimen Holders

Three (3) specimen holders were constructed to hold one of each type of test specimen by a 1/16 - 3/32 inch grip on opposing edges of the 1½ inch side. The holders were so mounted that upon being placed in the test chamber one was normal to the air stream, and one each at 30° and 45° to the air stream. A sketch showing the design of these holders is shown below:

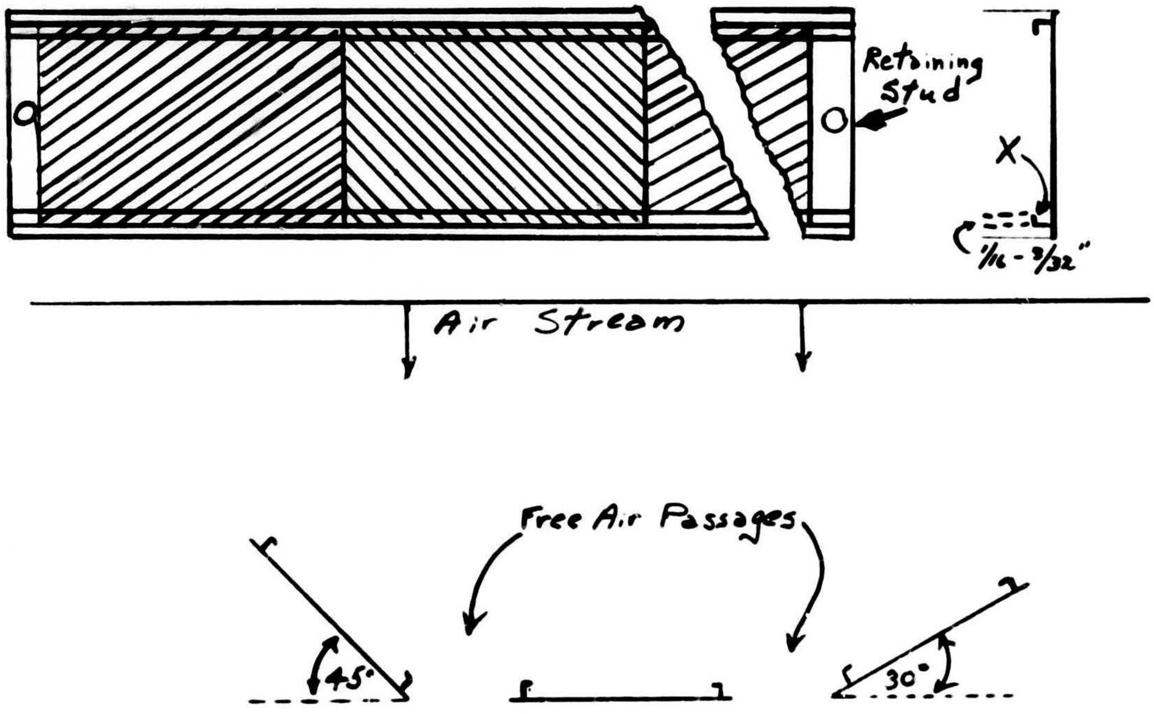

Figure 2

These holders have not been completely satisfactory, and may have been partially responsible for the erratic results obtained. Sand and dust particles which could not be removed by an air blast were able to penetrate between the holder and the specimen at points "X". These were capable of scratching the specimen surface upon removal.

Results

Field Investigations

All of the field data collected during 1961 and 1962 has not yet been analyzed and forwarded to this Arsenal, possibly due to the aforementioned change in WSMR mission responsibility and personnel. Graphed data is available, however, showing the grains impact/sq mm vs. cumulative exposure time on the exposed plates. A partial analysis of the sand collected at various levels is also available. Although this is incomplete, there is sufficient information available to show that particles as large as 840 μ are aloft up to 8.7 feet above the ground in high winds, although the largest particles collected that exceeded 1% by weight was in the 385 - 420 μ range.

Wind velocity data was also only partially analyzed. However, results thus far analyzed showed a peak velocity of 72 mph measured during May 1961. During May, 1961, the following maximum wind velocities and duration of continuous wind activity were recorded.

Duration (Hrs)	Max Vel (MPH)
82 ½	50
11 ½	66
15	43
43 ½	72
20	40

The duration of the maxima are not known, but are interpreted to only be short duration gusts.

Laboratory Investigations

Frankford Arsenal:

No meaningful data could be derived from the limited data obtained at this Arsenal during the eleven (11) runs made prior to equipment failure. As discussed, this may be due to improper preparation of the metal samples, uncertain density of sand in the chamber, and its rapid reduction in particle size with successive passes through the recirculating chamber.

Southwest Research Institute (SwRI):

This Arsenal has received a preliminary rough draft copy of SwRI's laboratory forthcoming report. This document goes into some detail in reporting weight loss in exposed samples, with some secondary observations as to changes in surface roughness, discoloration, surface reflection, and shape. In all, they made forty (40) runs to complete two sets of data, which data includes measurements and calculations of impacts at various velocities and for various particle sizes. Some of their samples did indicate consistent weight loss with time of exposure; others were so erratic that reliable weight loss statistics could not be determined.

The SwRI report pointed out the different trends which could be indicated, depending on which factor was used as a basis for analysis; i.e., exposure angle, sand concentration, velocity, particle size, type of specimen material exposed, variation in surface roughness, etc., and the 149 combinations of groups which were also possible in presenting all of this data statistically.

CONCLUSIONS AND RECOMMENDATIONS

Specifications

Dust (Fine Sand)

There is now available sufficient data to show that maximum air speeds in the desert can reach 72 mph (6336 fpm)* during gust conditions. It therefore would appear to be reasonable to recommend that the velocity of the air in the sand and dust exposure test be increased to at least 6000 fpm. This recommendation will be made to the Ad-Hoc Committee on revision of sand and dust test specifications.

Insufficient new data exists to warrant modification of the concentration of the "dust" used in these tests, and therefore no recommendation is made for varying it. Ultimately this "dust (fine sand)" specification should be orientated towards a particular type of damage/degradation: i.e., penetration, obscuring light passage, plugging a filter, electrostatic conduction, etc., and if necessary, specific sub-sections should be inserted to take care of each of these conditions.

If the chamber specification (Reference a) is still to remain extant, it should be revised to include a positive statement concerning humidity control.

It is further recommended that the proper authorities be alerted to cancel outdated or non-used specifications related to Sand & Dust, and to review, revise, and up-grade those that are still in use to reference the latest approved test methods.

Sand

Although no correlation studies have as yet been made between the field and the laboratory exposures, there is sufficient evidence to justify the recommendation that an entirely new "Sand" exposure specification/standard be prepared. Such a document must take into consideration, among other factors, the aforementioned problems encountered by this investigation:

(a) That the sand specified must have a range of particulate size distribution that is meaningful, testwise, and still be readily available in all parts of the country. Present research results would seem to support selection of particulate sizes ranging from 150 microns to 850 microns.

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*Note: from Research Proposal #3 - Correlation Between Natural Sand and Dust Phenomenon and Chamber Simulation, Army Missile Test Center, WSMR, Sept. 1960

(b) That a new type of chamber (non-recirculating) must be spelled out in this specification, relatively economical to build or purchase, since current Sand and Dust chambers of the re-circulating type will not suffice.

(c) That the density, air velocity, and duration of exposure specified produces degradation which is realistic when compared to extended field exposures, and falls within the purview of Reference p.

No details of such a proposed specification can be given at this state of the investigation.

Program Continuation

It is recommended that this program be continued in order to pursue the investigations started, and to collect additional and more meaningful data. The ultimate goal of this project will remain the issuance of a relsistic "Sand" test specification.

Participants currently funded to continue this work are this Arsenal, WSMR, and Aberdeen Proving Grounds (APG). It is anticipated that SwRI, who did the bulk of the reported laboratory phase of this project to date, will be re-contracted to continue their participation.

This proposed program will consist, fundamentally, of each participant exposing replicate samples of specimens in the same manner, each in his own equipment. It is anticipated that the variables to be investigated will be reduced to sand densities and velocities. The sand particulate size distribution is to be specified and thus become a constant. If time permits, temperature will be introduced as another variable at the end of the program.

Comparisons of degradation done by the various contributors will help evolve a degradation standard. Correlation between this and field damage will also have to be established.

MIL-D-13570(Ord)
9 August 1954
SUPERSEDING
ARMY 60-901-1
3 March 1944

MILITARY SPECIFICATION

DUST, TESTING BY EXPOSURE TO

1 SCOPE

1.1 This specification covers certain test procedures, pertaining to the testing of the resistance of components and their materials to the injurious and otherwise deleterious and undesirable effects caused by exposure to specific test dust, under prescribed conditions.

2. APPLICABLE DOCUMENTS

2.1 The following specifications, of the issue in effect on date of application of this specification, shall form a part of this specification.

SPECIFICATIONS
Military
MIL-V-3329 - Vehicles, Combat, Self-Propelled and Towed; General Requirements For.
MIL-V-3798 - Vehicles, General Purpose and Special Equipment, Self ropelled and Towed, General Requirements For.

(Copies of specifications required by the contractor in connection with specific procurement functions should be obtained from the procuring agency or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Materials. - Materials used in tests shall conform to analysis as specified in paragraphs 4.5.1.2 and 4.5.1.3.

3.2 Tests. - Tests shall be accomplished to determine the effect of exposure to dust on the components and materials being tested. Tests shall be accomplished wholly or in part by the use of suitable equipment (see 4.6).

3.2.1 Test result determination. - The result as to the extent of injurious and undesirable effects caused by exposure to specified test dust conditions, with relation to the operation and function of the component, shall be determined in accordance with the detail specification applicable to the component or material under test.

3.3 Workmanship. - Tests herein specified shall be made by, or under the direction of, a person or persons well qualified by experience and knowledge to conduct tests in conformance with this and pertaining specifications.

4. QUALITY ASSURANCE PROVISIONS

4.1 Inspection. - Government inspection and tests shall be conducted in accordance with this and the detail specification of the component or material under test and in accordance with the applicable requirements of Specifications MIL-V-3329 and MIL-V-3798.

4.2 Place of inspection. - Unless otherwise specified, the inspection and tests of components and materials as prescribed herein shall be made at a place designated by the contracting officer.

4.3 Lot size. - A lot shall consist of all components of a type or a kind submitted for inspection at the same time by one manufacturer, or as specified in the detail specification for the component. Specimen for test shall be selected by the inspector from the lot represented. The lot and test specimens selected shall be in conformance with the requirements of the detail specification for the component.

4.4 Visual and gaging inspection.

4.4.1 Visual inspection. - Each specimen shall be given a complete visual inspection before testing, to ascertain that appearance and manufacturing processes have been satisfactorily completed.

4.4.1.2 Gaging inspection. - Each specimen shall be gaged and checked for hardness, weight, dimensions, and chemical and physical characteristics. When necessary due to conformance to requirements of detail specifications, an inspection of each part or component shall be made prior to the test. Individual parts or component shall be made prior to the test. Individual parts or components shall be inspected prior to assembly. Complete specimen shall be disassembled and inspected. The results of the inspection of parts in new condition shall be recorded for the purpose of comparison to determine if there has been any change in dimensions, physical, or chemical characteristics, due to wear or abrasion, or chemical action of the tests.

4.5 Test dust. - Unless otherwise specified, dust used in the tests shall have the following characteristics:

4.5.1 Screening requirements. - There shall be no residual matter evident after screening test dust through a 200 mesh screen.

4.5.1.2 Particle size analysis. - Particle size analysis of the test dust shall be as follows:

Size in microns:	Percent of total weight:
0 to 5	39 ± 2
5 to 10	18 ± 3
10 to 20	16 ± 3
20 to 40	18 ± 3
40 to 80	9 ± 3

4.5.1.3 Chemical analysis. - Chemical analysis of the test dust shall be as follows:

Substance	Percent of total weight
SiO_2	67 to 69
Fe_2O_3	3 to 5
Al_2O_3	15 to 17
CaO	2 to 4
MgO	0.5 to 1.5
Total Alkalis as (Na_2O)	3 to 5
Ignition losses	2 to 3

4.6 Test apparatus and conditions. - Unless otherwise specified, and when not in conflict with detail specification, test apparatus and conditions shall be as specified in 4.6.1 through 4.9 (see 6.2).

4.6.1 Testing chamber. - Testing chamber shall be of adequate size to accomodate the specimen to be tested and permit mounting as specified in 4.10.

4.6.2 Dust quantity. - Ten pounds of dust shall be placed in the testing chamber for each 27 cubic feet thereof.

4.6.2.1 Density of dust. - Dust shall be completely and uniformly diffused throughout the cube of the chamber when agitated as specified in 4.6.2.2.

4.6.2.2 Dust agitation. - Air blast shall be in a downward direction into the dust in a manner that will diffuse the test dust as specified (see 4.6.1.1). The dust agitation cycle shall be 2 seconds of air blast at 15 minute intervals. Test shall be conducted for a minimum of 8 hours.

4.7 Air temperature. - Regardless of ambient air conditions, temperature in the testing chamber shall be uniform throughout and not less than 70°F. nor more than 100°F.

4.8 Air pressure. - The absolute air pressure in the testing chamber shall not exceed the absolute pressure of the ambient air by more than one percent, unless otherwise specified.

4.9 Moisture. - The relative humidity shall not exceed 30 percent at any time during the test.

4.10 Method of mounting. - The specimen to be tested shall be mounted in the same manner as approved for the actual installation and application or as specified in the detail specification.

4.11 Operation of electrical units. - Unless otherwise specified in the detail specification, each electrical terminal or connection normally attached to an electrically energized part, that in the actual installation and application, will be operated electrically, under electrical load or in an electric circuit or circuits shall be included in the test.

4.12 Adjustment and inspection. - Adjustment and inspection of the specimen during the test shall be made as required in the detail specification.

4.13 Operation during test. - Unless otherwise specified in the detail specification, specimens that will be electrically, pneumatically, hydraulically, or mechanically operated in their actual installations and applications shall be operated during tests in the same manner as in their actual installation and application.

4.14 Operation after test - When additional tests are necessary due to conformance to requirements of the detail specification, the specimen shall be carefully removed from dust chamber, so as not to disturb any accumulation of dust on the specimen. Tests shall then be conducted as specified in detail specification

4.15 Rejection. - Dimensional changes, (see paragraph 4.4.1.2) or changes in physical or chemical characteristics exceeding the limits specified in detail specification, or the leakage of current to ground or short circuits of electrical components, as a result of this test, shall be cause for rejection.

4.16 Retests. - Retests shall be conducted as required in the detail specification.

5. PREPARATION FOR DELIVERY

Not applicable.

6. NOTES

6.1 The tests and procedures covered in this specification pertain to automotive-type vehicles and trailers and the components parts thereof.

6.2 Test apparatus and conditions (4.6) are comparable to that specified for electrical components by S. A. E.

Patent notice: When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Custodian

Army - Ordnance Corps

GPO 880340

APPENDIX II

SAE Standard J575

Lighting Equipment for Motor Vehicles

Excerpt from 1962 SAE Handbook

This specification is a report of Lighting Division approved May 1942, and last revised by Lighting Committee April 1960. Editorial change, June 1961. Scope covers 19 varieties of headlamp units, passing lamps, special identification lights, etc.

G. DUST TEST

A sample unit with an drain hole closed shall be mounted in a normal operating position, at least 6 inches from the wall in a box measuring 3 feet in all directions, containing 10 pounds of fine powdered cement in accordance with ASTM C 150-56 Specification for Portland Cement. At intervals of 15 minutes this dust shall be agitated by compressed air or fan blower by projecting blasts of air for a 2 second period in a downward direction into the dust in such a way that the dust is completely and uniformly diffused throughout the entire cube. The dust is then allowed to settle. This test shall be continued for 5 hours.

After the dust test the exterior surface shall be cleaned; and if the maximum candlepower is within 10% of the maximum as compared with the condition after the unit is cleaned inside and out, shall be considered adequately dust tight. Where sealed units are used, the dust test shall not be required.

APPENDIX III

STANDARD SAE J726

AIR CLEANER TEST CODE

Excerpts from

1.0 SCOPE

This test code is for laboratory use in determining the operating characteristics of air cleaners. It refers specifically to laboratory testing of oil bath, oil wetted, dry and multistage air cleaners. Other types should follow this recommended practice wherever applicable. Multistage types should be evaluated as a complete assembly although, if desired, a component stage can be tested separately in accordance with its individual type.

This code contains alternate procedures and permits prescribing certain specific conditions of a test. Therefore reported results of tests are not complete unless accompanied by statements, where applicable, of the specific conditions such as: (1) rated air flow, (2) prescribed air flow, (3) steady or variable airflow, (4) fine or coarse dust, (5) amount of dust, and (6) maximum permissible restriction.

2.0 MATERIAL AND APPARATUS

Test oil for oil bath types shall be of two grades: (a) light, SAE 10; (b) heavy, SAE 30.

Test dust* shall be standardized and shall be of two grades (labeled "fine" and "coarse"). The following chemical analysis is typical:

Chemical	% by Weight
SiO_2	67 to 69
Fe_2O_3	3 to 5
Al_2O_3	15 to 17
CaO	2 to 4
MgO	0.5 to 1.5
Total Alkalis	3 to 5
Ignition Loss	2 to 3

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* Obtainable from AC Division, General Motors Corporation, Flint, Michigan

The particle size distribution by weight as measured with a Roller analyzer shall be as follows:

Size, Microns	Fine Grade	Coarse Grade
0-5	39 ± 2	12 ± 2
5-10	18 ± 3	12 ± 3
10-20	16 ± 3	14 ± 3
20-40	18 ± 3	23 ± 3
40-80	9 ± 3	30 ± 3
80-200	------	9 ± 3

The dust feeding mechanism should feed the desired grade of dust at a steady rate to disperse a continuously uniform particle-size distribution in the air stream before reaching the air cleaner. The particle size shall not be changed by the dust feeding mechanism.

8.0 DETERMINATION OF EFFICIENCY

(b) The dust feed rate should be calculated using the dust concentration of 0.025 g per cu ft of air (1.5 g per hr per cfm). Either fine or coarse test dust may be prescribed.

9.0 DETERMINATION OF DUST CAPACITY

9.1 Steady Airflow -

( ) The dust feed rate should be calculated using the dust concentration of 0.025 g per cu ft of air (1.5 g per hr per cfm). Either fine or coarse test dust may be prescribed.

MIL-C-9436A (ASG)
5 MAY 1955

Superseding
MIL-C-9436(USAF)
2 February 1954

MILITARY SPECIFICATION

CHAMBER, SAND AND DUST TESTING

This specification has been approved by the Department of the Air Force and by the Navy Bureau of Aeronautics.

1. SCOPE

1.1 Scope.- This specification covers sand and dust chambers to be used for environmental testing of aircraft equipment.

1.2 Classification.- The environmental test chambers shall be one of the following types shown in table I, as specified (see 6.2):

TABLE I

Test compartment sizes (inches)

Type	Width	Height	Depth
I	36	24	18
II	48	48	48

2. APPLICABLE DOCUMENTS

2.1 The following specifications and standards, of the issue in effect on date of invitation for bids, form a part of this specification to the extent specified herein:

SPECIFICATIONS

Military

MIL-E-5272	Environmental Testing, Aeronautical and Associated Equipment, General Specification for
MIL-P-116	Preservation, Methods of
JAN-P-100	Packaging and Packing for Overseas Shipment - General Specification
JAN-P-104	Packaging and Packing for Overseas Shipment - Crates, Sheathed, Wood, Nailed

STANDARDS

MIL-STD-129	Marking for Shipment and Storage
MIL-STD-130	Identification Marking of U. S. Military Property

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.

3. REQUIREMENTS

3.1 Materials.- The materials, component parts, and mechanical assemblies, used in the construction of this chamber shall be of the best commercial quality consistent with the performance requirements of this specification. Materials which will resist erosion and insure a satisfactory operating life will be used for the ducting and fan blades. All protective features normally incorporated in electrical and mechanical apparatus of this type shall conform to the standards of the National Electric Manufacturers Association and the best practice in industry.

3.2 Design and construction.-

3.2.1 General.- This sand and dust testing facility shall be a self-contained unit capable of establishing, maintaining, and withstanding the environmental conditions specified under paragraph titled "Sand and dust tests," of Specification MIL-E-5272. The facility shall consist primarily of a dusttight chamber with a blower and necessary ducting installed to produce the conditions specified. A desiccant may be used for controlling the relative humidity. The facility shall be well lighted and, if necessary, a vibrator shall be installed on the dust hoppers to assure proper dust flow. The door shall include a large glass panel with an effective means, such as a wiper, for keeping the glass clear for visual inspection of the test specimen. Sufficient heaters to maintain the test chamber at 160°F (71°C) shall be provided.

3.2.2 The facility shall be designed to meet the performance requirements outlined in 3.3.

3.2.3 Figures 1 and 2 are for reference only and in no way limit or restrict the freedom of the contractor in designing a facility to meet the requirements specified herein. The facility shall, however, generally conform to figures 1 and 2 and provide, by some approved means, all the features indicated thereon.

3.2.4 Chamber.- The chamber shall consist of a dusttight cabinet, with the floor designed to permit the dust to fall into the hoppers for recirculation and capable of supporting 100 pounds per square foot. The door shall provide full front area clearance and shall close tightly, in order to prevent the escape of dust from the chamber. The door shall include a glass panel and shall be of sufficient size as to expose the complete interior of the facility. The chamber shall be adequately lighted.

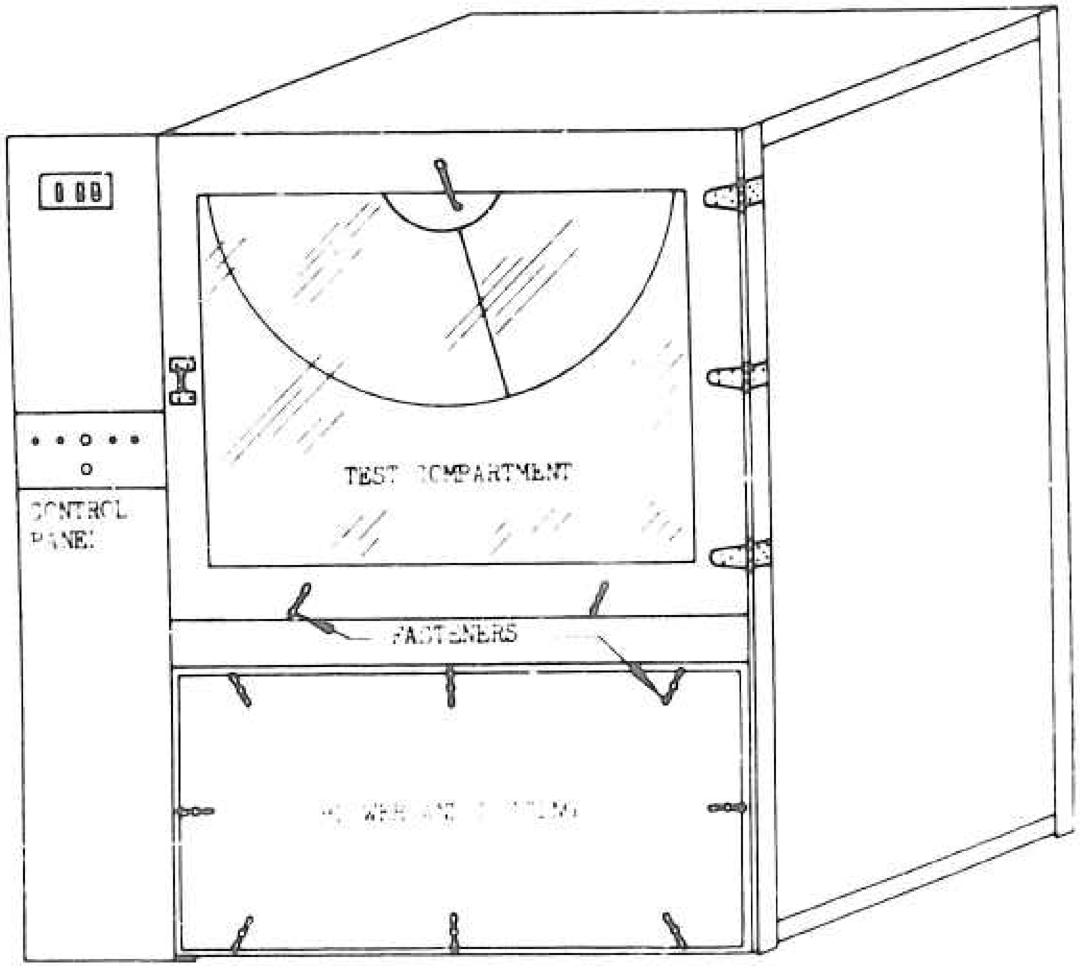
3.2.5 Controls.- The facility shall be automatically time-cycle-controlled to accomplish the exposure and shutdown required in:

> Procedure I, under paragraph titled "Sand and dust tests," of Specification MIL-E-5272
>
> Procedure II, under paragraph titled "Sand and dust tests," of Specification MIL-E-5272

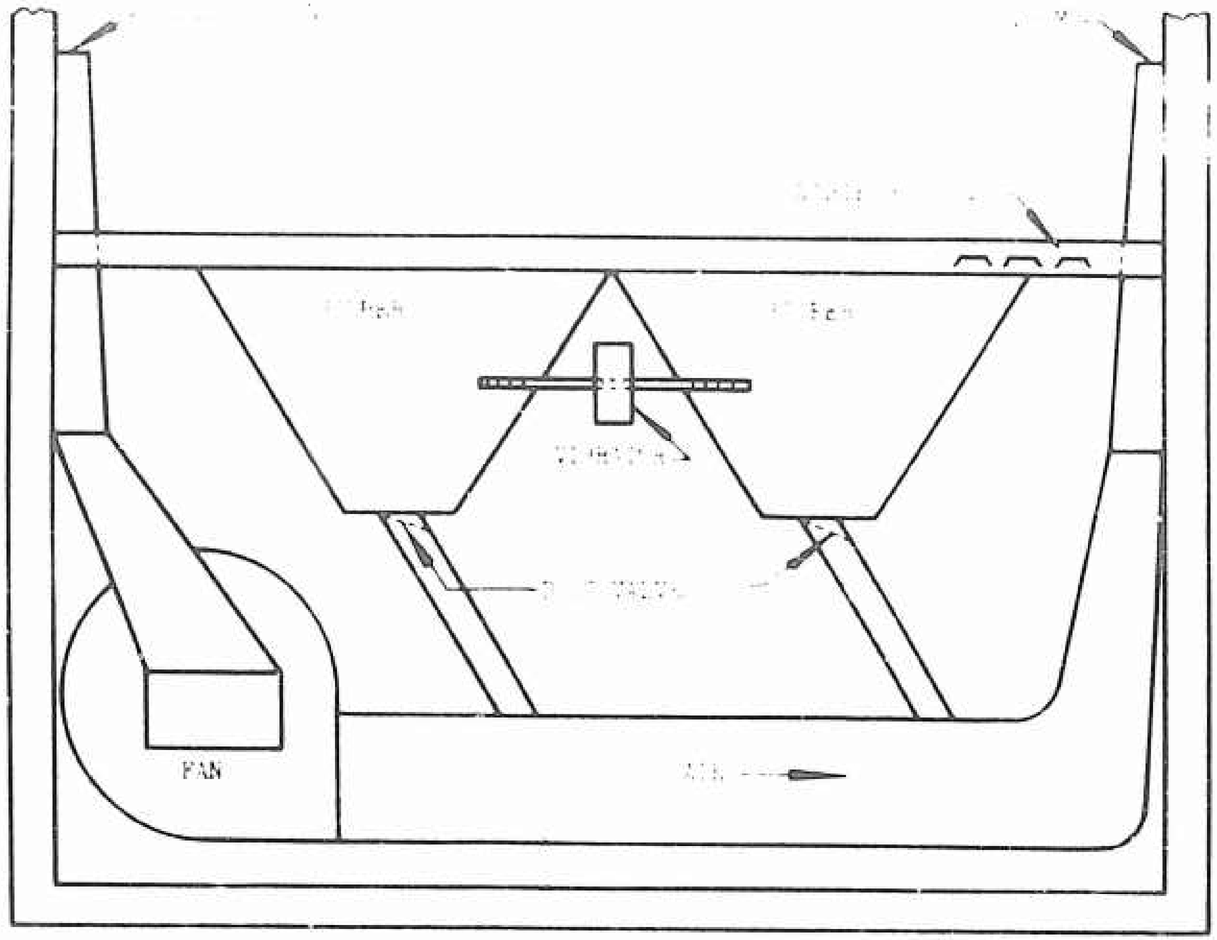
Manual choice of either Procedure I or II shall be possible by means of a single switch on the control panel. Convenient manual setting of the cycling control to "start" shall be possible. The thermostat control shall be located for convenient manual adjustment. Specification MIL-E-5272 temperature requirement for 77°F (25°C) shall mean room-temperature operation between 77°F (25°C) and 89.6°F (32°C), and the 159.8°F (71°C) requirement shall have a ±4°F (±2°C) tolerance.

3.2.6 Blowers and ducting.- A blower and ducting shall be provided to circulate the dust throughout the test chamber with the velocity and concentration as outlined in paragraph titled "Sand and dust tests," of Specification MIL-E-5272.

3.2.6.1 Auxiliary blowers or fans shall be provided to generate velocities of 2,300 ±500 ft/min through a minimum area of 1 square foot in the test space.



TEST COMPARTMENT
FASTENERS
CONTROL
PANEL



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3.2.7 Terminal board.- An electrical terminal board shall be provided on the control panel, with connections being of the "jack-plug" types and electrically connected to an exposed terminal strip inside the chamber through a dustproof penetration. The following electrical power connections shall be provided:

4 - 150 amp, jack and plug terminals
4 - 75 amp, jack and plug terminals
4 - 40 amp, jack and plug terminals
4 - 10 amp, jack and plug terminals

Studs may be used through the chamber walls, provided they are wired to jacks located on a panel mounted on the facility. Jacks and plugs shall be similar to and interchangeable with existing laboratory equipment and must be approved by the procuring activity.

3.2.8 A 2-inch diameter opening shall be provided at one side of the chamber to accommodate rotating shaft drives for test equipment. The opening shall be provided with a cover plate for proper sealing when the opening is not utilized.

3.2.9 Two threaded plugs in the back or sides of the facility shall be provided to accommodate electrical cables. The plugs shall be dustproof and shall be of 1-1/2 and 2-inch size (internal diameter).

3.2.10 Instruments.- Temperature-indicating instruments shall be provided to show the temperature of the chamber.

3.3 Performance.- The facility shall be capable of establishing, maintaining, and withstanding all environmental conditions specified under paragraph titled "Sand and dust tests," of Specification MIL-E-5272.

3.4 Identification of product.- Equipment, assemblies, and parts shall be marked for identification in accordance with Standard MIL-STD-130.

3.5 Workmanship.- All details of workmanship shall be in accordance with best commercial practice consistent with the performance requirements of this specification.

4. QUALITY ASSURANCE PROVISIONS

4.1 Inspection.- Each chamber shall be inspected to determine compliance with the requirements of this specification.

4.2 All parts, specimens, or assemblies destroyed in making tests required by this specification or drawings, to determine compliance with the specification or drawings, shall be in addition to the quantity specified in the contract or purchase order and shall be furnished without increasing the cost of the contract or order.

5. PREPARATION FOR DELIVERY

5.1 Application.- The requirements of Section 5 apply only to direct purchase by or direct shipments to the Government.

5.2 Preservation and packaging.- The chamber shall be protected from corrosion and deterioration during shipment or storage in accordance with Specification MIL-P-116, Method IIa.

5.3 Cushioning, blocking, and bracing.- Cushioning, blocking, and bracing shall be in accordance with the applicable paragraphs of Specification JAN-P-100.

5.4 Domestic and overseas shipment.- Chambers shall be packed in a container conforming to Specification JAN-P-104. Requirements on seal case liner are waived.

5.5 Marking of shipments.- Interior packages and exterior shipping containers shall be marked in accordance with Standard MIL-STD-129. The nomenclature shall be as follows: Chamber, Sand and Dust Testing, Type (I or II, as applicable) Specification MIL-C-9436A, Manufacturer's Part No. _*_, Stock No. _*_, (Federal, USAF, or Navy, as applicable).

* Applicable data to be entered by the contractor. If the Federal Stock No. is available (either stated in the purchase order or furnished by the procuring activity), omit the USAF or Navy Stock No. If the Federal Stock No. is not available, insert the USAF or Navy Stock No., and leave a space for subsequent placement of the Federal Stock No.

6. NOTES

6.1 Intended use.- The chambers covered by this specification are intended for use in accomplishing sand and dust tests in accordance with Specification MIL-E-5272.

6.2 Ordering data.- Requisitions, contracts, and purchase orders should specify the following:

(a) Title, number, and date of this specification.
(b) Type of chamber required. (See 1.2.)

6.3 Instruction manual.- An instruction manual shall be furnished which provides the following information:

Operating instructions
Maintenance instructions
Assembly and disassembly procedure
List and description of all replaceable parts
Detailed assembly drawing

Custodians:
Navy - Bureau of Aeronautics
Air Force

APPENDIX V

MIL-E-5272A

16 September 1952

ENVIRONMENTAL TESTING, AERONAUTICAL AND ASSOCIATED EQUIPMENT, GENERAL SPECIFICATION FOR

Excerpt from

4.11 Sand and Dust Tests.-

4.11.1 Procedure I.- The equipment shall be placed within the test chamber and the sand and dust density raised and maintained at 0.1 to 0.5 grams per cubic foot within the test space. The relative humidity shall not exceed 30 percent at any time during the test. Sand and dust used in the test shall be of angular structure and shall have characteristics as follows:

(a) 100 percent of the sand and dust shall pass through a 100-mesh screen, U S Standard Sieve Series.

(b) 98 ±2 percent of the sand and dust shall pass through a 140-mesh screen, U S Standard Sieve Series.

(c) 90 ±2 percent of the sand and dust shall pass through a 200-mesh screen U S Standard Sieve Series.

(d) 75 ±2 percent of the sand and dust shall pass through a 325-mesh screen, U S Standard Sieve Series.

(e) Chemical analysis of the dust shall be as follows:

Substance	Percent by Weight
SiO_2	97 to 99
Fe_2O_3	0 to 2
Al_2O_3	0 to 1
TiO_2	0 to 2
MgO	0 to 1
Ign Losses	0 to 2

The internal temperature of the test chamber shall be maintained at 25°C (77°F) for a period of 6 hours with sand and dust velocity through the test chamber between 200 ±100 feet per minute, (2,300 ±500 feet per minute if specified by the detail specification). After 6 hours at above conditions, the temperature shall be raised to and maintained at 71°C (160°F). These conditions shall be maintained for 6 hours. At the end of this test period, the equipment shall be removed and allowed to cool to room temperature and shall be operated and the results compared to those obtained in paragraph 3.6 and examined in accordance with paragraph 3.7.

4.11.2 Procedure II.- This test shall be the same as Procedure I except that the test at 25°C shall be of 8 hours duration, and the test at 71°C shall be deleted.

APPENDIX VI

MIL-E-005272B (USAF)

5 June 1957

Used in Lieu of MIL-E-5272A 16 Sept 1957

ENVIRONMENTAL TESTING, AERONAUTICAL AND ASSOCIATED
EQUIPMENT, GENERAL SPECIFICATION FOR

Excerpts from

4.11 SAND AND DUST TESTS

4.11.1 Procedure I.- The equipment shall be placed within the test chamber and the sand and dust density raised and maintained at 0.1 to 0.5 grams per cubic foot within the test space. The relative humidity shall not exceed 30 percent at any time during the test. Sand and dust used in the test shall be of angular structure and shall have characteristics as follows:

(a) 100 percent of the sand and dust shall pass through a 100-mesh screen, U S Standard Sieve Series.

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(d) 75 ±2 percent of the sand and dust shall pass through a 325-mesh screen, U S Standard Sieve Series.

(e) Chemical analysis of the dust shall be as follows:

Substance	Percent by Weight
SiO_2	97 to 99
Fe_2O_3	0 to 2
Al_2O_3	0 to 1
TiO_2	0 to 2
MgO	0 to 1
Ign Losses	0 to 2

The internal temperature of the test chamber shall be maintained at 25°C (77°F) for a period of 6 hours with sand and dust velocity through the test chamber between 100 to 500 feet per minute (2.300 ±500 feet per minute if specified by the detail specification). After 6 hours at above conditions, the temperature shall be raised to and maintained at 71°C (160°F, 200°F for any CAD items). These conditions shall be maintained for 6 hours. At the end of this test period, the equipment shall be removed and allowed to cool to room temperature and shall be operated and the results compared to those obtained in 3.6 and examined in accordance with 3.7.

4.11.2 Procedure II.- This test shall be the same as Procedure I except that the test at 25°C shall be of 8 hours duration, and the test at 71°C shall be deleted.

APPENDIX VII

MIL-E-5272C(ASG)

13 April 1959

Superseding MIL-E-005272B(USAF)

ENVIRONMENTAL TESTING, AERONAUTICAL AND ASSOCIATED EQUIPMENT, GENERAL SPECIFICATION FOR

Excerpts from

4.11 Sand and dust tests.-

4.11.1 Procedure I.- The equipment shall be placed in a test chamber equal to MIL-C-9436 and the sand and dust density raised and maintained at 0.1 to 0.5 grams per cubic foot within the test space. The test chamber shall be vented to the atmosphere. The relative humidity shall not exceed 30 percent at any time during the test. Sand and dust used in the test shall be of angular structure and shall have characteristics as follows: (same as Appendix V).

Part I: The internal temperature of the test chamber shall be maintained at 25°C (77°F) for a period of 6 hours with sand and dust velocity through the test chamber between 100 and 500 feet per minute, (2,500 ± 500 feet per minute if so required by the applicable equipment specification).

Part II: After 6 hours at the above conditions, the temperature shall be raised to and maintained at 71°C (160°F). These conditions shall be maintained for 6 hours. At the end of this exposure period, the equipment shall be removed and allowed to cool to room temperature. Accumulated dust shall be removed by brushing, wiping, or shaking, care being taken to avoid introduction of additional dust into the equipment. Under no circumstances shall dust be removed by either blast or vacuum cleaning. The equipment shall be operated and inspected as directed in 3.8.

4.11.2 Procedure II.- Discontinued, use Procedure I, Part I, 4.11.1.

4.11.3 Procedure III.- The general procedure and the sand and dust used shall be the same as Procedure I, but the dust concentration shall be 0.1 to 0.25 grams per cubic foot, the temperature shall be 25°C (77°F), the air velocity shall be 2,500 ± 500 feet per minute and the duration of the test shall be 3 hours.

5.4.3 Sand and dust.- The sand and dust specified for use in Procedures I and III is commercially known as "140-mesh silica flour". Sand and dust (140-mesh silica flour) produced by the Fenton Foundry Supply Company, Dayton, Ohio, and Ottawa Silica Company, Ottawa, Illinois, or equal, is satisfactory for use in the performance of these tests.

APPENDIX VIII

MIL-STD-810 (USAF)

METHOD 510

14 June 1962

SAND AND DUST

Excerpts from

1. PURPOSE

The sand and dust test is conducted to determine the resistance of aerospace and ground equipment to blowing fine sand and dust particles. Because of its abrasive character, sand and dust may affect items having moving parts where sand may enter. It may also cause the parts to bind, and may interfere with electrical contacts. Dust particles may also form nuclei for condensation of moisture, thus aiding in corrosion. Equipment may malfunction due to clogging of air filters.

2. CHARACTERISTICS OF SAND AND DUST

Sand and dust used in the test shall be of angular structure and shall have characteristics as follows:

(a) 100 percent of the sand and dust shall pass through a 100-mesh screen, U.S. Standard Sieve Series.

(b) 98 ± 2 percent of the sand and dust shall pass through a 140-mesh screen, U.S. Standard Sieve Series.

(c) 90 ± 2 percent of the sand and dust shall pass through a 200-mesh screen, U.S. Standard Sieve Series.

(d) 75 ± 2 percent of the sand and dust shall pass through a 325-mesh screen, U.S. Standard Sieve Series.

(e) Chemical analysis of the dust shall be as follows:

Substance	Percent by Weight
SiO_2	97 to 99
Fe_2O_3	0 to 2
Al_2O_3	0 to 2
TiO_2	0 to 2
MgO	0 to 1
Ign Losses	0 to 1

The sand and dust is commercially known as "140-mesh silica flour." Sand and dust (140-mesh silica flour) produced by the Fenton Foundry Supply Company, Dayton, Ohio, and Ottawa Silica Company, Ottawa, Illinois, or equal, is satisfactory for use in the performance of these tests.

3. PROCEDURE

Procedure 1. The test item shall be placed in a test chamber equal to that specified in MIL-C-3436, in accordance with section 3.2.2. The sand and dust density shall be raised and maintained at 0.1 to 0.25 gram per cubic foot as measured at least three different locations withing the test area utilizing approved collection devices. The relative humidity shall not exceed 30 percent at any time during the test. The internal temperature of the test chamber shall be maintained at 25°C (77°F) for a period of not less than 2 hours with the air velocity through the test chamber at 100 to 500 feet per minute. Following this 2 hour period the temperature shall be raised to and maintained at 71°C (160°F). These conditions shall be maintained for not less than 2 hours. At the end of this exposure period, the test item shall be removed from the test chamber and allowed to cool to room temperature. Accumulated dust shall be removed from the test item by brushing, wiping, or shaking, care being taken to avoid introduction of additional dust into the test item. Under no circumstances shall dust be removed by either air blast or vacuum cleaning. The test item shall then be operated, the results compared with those obtained in accordance with section 3.2.1, and inspected in accordance with section 3.2.4. In the performance of this inspection, test items containing bearings, grease seals, lubricants, etc., shall be carefully examined for the presence of sand and dust deposits.

REFERENCES

a. MIL-D-13570 (Ord), Military Specification, Dust, Testing by Exposure to: dated 9 Aug 1954, superseding Army tC-901-1, dated 3 March 1944.

b. SAE J575, Lighting Equipment for Motor Vehicles, June 1961 revision of a May 1940 approved document.

c. SAE J726, Society of Automotive Engineers Air Cleaner Test Code 1960 Revision of Jan 1941 approved document.

d. ASTM C150-61, American Society for Testing Materials Standard Specifications for Portland Cement; a 1961 revision of a document adopted in 1941.

e. MIL-A-13488B (Ord), Military Specification, Air Cleaner, Engine; Heavy Duty, Oil-Bath Type (for internal-combustion engines); dated 24 Feb 1960, superseding MIL-A-13488A (Ord) dated 22 Dec 55 - Section 4.5.1.4, Test Dust, and 4.5.3.6, Efficiency.

f. MIL-C-9436A (ASG), Military Specification, Chamber, Sand and Dust Testing, dated 5 May 1955, superseding MIL-C-9436 (USAF), dated 2 Feb 1954.

g. Military Specification, MIL-E-5272A, Environmental Testing, Aeronautical and Associated Equipment, General Specifications for. Dated 16 Sep 1962, superseding MIL-E-5272 (USAF) dated 16 Aug 1950; Section 4.11, Sand & Dust Tests.

h. MIL-E-005272B, same title as above, dated 5 Jun 1957, to be used in lieu of MIL-E-5272A; (This bears a notation that it has not been approved for promulgation as a revision of MIL-E-5272A).

i. MIL-E-5272C, same title as above, dated 13 Apr 1959, and superseding MIL-E-005272B.

j. Military Standard, MIL-STD-810 (USAF), Environmental Test Methods for Aerospace and Ground Equipment, dated 14 June 1962; Method 510, Sand and Dust.

k. MIL-E-4970-A (USAF). Military Specification, Environmental Testing, Ground Support Equipment, General Specifications for, dated 3 Mar 1959, superseding MIL-E-4970 (USAF), dated 1 Jun 1955, Section 4.10, Sand and Dust Tests.

REFERENCES (contd)

l. Federal Test Method Standard No. 141, Paints, Varnish, Lacquer, and Related Materials; Methods of Inspection, Sampling, and Testing, dated May 15, 1958, superseding Fed. Spec. TT-P-141b dated Jan 15, 1949; Method 6191, Abrasion Resistance (Falling Sand).

m. MIL-E-5400F (ASG), Military Specification, Electronic Equipment, Aircraft, General Specifications for (Approved by Air Force and Bureau of Naval Weapons) dated 1 June 1962: Section 3.2.21.7, Sand and Dust.

n. Proposed MIL-STD _____, Military Standard, Sand Dust Test for Use in Development of Fuzes, dated (1) 10 Dec 57, (2) 8 Jan 58.

o. Proposed MIL-STD, Military Standard, Sand and Dust Tests for Use in Development of Military Equipment, dated 4 Nov 58.

p. AMC Regulation No. 700-15, Logistics, Reliability Program for AMC Materiel, dated 26 Aug 1963.

q. A Laboratory-Type Sand and Dust Test Procedure, WADC Technical Note 56 (An information copy only) Contract AF 33(616)-3280, James Pauly, Southwest Research Institute.

r. A Study of the Effects of Dust on Ordnance Automotive Materiel, Final Report on OCO Contract DA-23-072-ORD-836, dated Feb 1956 by Southwest Research Institute.

s. The Dust Environment and Its Effect on Dust Penetration, WADC Technical Report 56-336, ASTIA Document No. AD 110472 by James Pauley, Southwest Research Institute, September 1956.

t. A Study of Desert Surface Conditions, Quartermaster Research & Development, Technical Report EP-53, dated April 1957.

u. A Survey of the Factors which Affect the Dust Environment Created by a Vehicle Operating Over Unsurfaced Terrain, Prepared for the Office Chief of Ordnance, Project #TB5-1401, Department of the Army Project 598-09-004, dated September 1958 by Carl Kafer, Southwest Research Institute.

REFERENCES (contd)

v. Survey of Dust Problems in Tank Automotive Equipment, Detroit Arsenal, Report No. 4242 (Final), dated 11 Nov 58.

w. The Necessity for Subjecting Equipment to a Sand & Dust Test, Paper delivered at the Institute of Environmental Engineering Annual Meeting, April 1958, by James Pauly, Southwest Research Institute.

x. Development of a Soil Sampling Technique and Measurement of Deglomeration of Six Soils to Determine Dust Producing Capability, Contract No. DA-23-072-ORD-1375, dated Oct 1960 by Carl Hafer, Southwest Research Institute.

y. What's Typical About a Typical Dust Environment?, Paper delivered at the 1961 Annual Meeting of the Institute of Environmental Sciences, by Robert Engelhardt, Southwest Research Institute.

z. A Study of Windborne Sand and Dust in Desert Areas, U. S. Army Natick Laboratories, Earth Sciences Division Technical Report ES-8, dated August 1963.