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SOCIETY OF AUTOMOTIVE ENGINEERS, Inc.
485 LEXINGTON AVENUE
NEW YORK 17, N.Y.

AEROSPACE RECOMMENDED PRACTICE

ARP 725

EVALUATING EFFECTIVENESS OF FILTER ELEMENT CLEANING METHODS

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Revised

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

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1. PURPOSE

1.1 The purpose of this Aerospace Recommended Practice is to provide a tool for evaluating methods proposed for cleaning service-contaminated filter elements. The procedure set forth is particularly applicable to the cleaning of metallic filter elements, where the expense of replacement often makes cleanability a desirable consideration. This procedure is applicable only to the evaluation of cleaning methods proposed for removal of service dirt. It is not applicable to cleaning methods for built-in dirt, LOX cleaning, etc.

1.2 This ARP presents a procedure for evaluating filter element cleaning methods with respect to contaminant removal and filter element degradation, and a procedure for checking durability of cleaning equipment. A referee cleaning method is also included.

2. OUTLINE OF METHOD

2.1 The effectiveness of a proposed filter element cleaning method is determined by evaluating the effectiveness of contaminant removal of the proposed method and degradation in performance of the filter element after cleaning. The durability of the cleaning system, where applicable, should be checked before final adoption of any system.

2.2 Effectiveness of contaminant removal is determined by subjecting a known dirty filter element to the cleaning procedure being evaluated and then adding artificial contaminant to the filter element. A comparison of the amount of artificial contaminant retained to the amount of contaminant a known clean filter element will retain is a measure of effectiveness of contaminant removal.

2.3 Because of the comparative difficulty of obtaining service-dirtied filter elements, a preliminary screening procedure using only artificial contaminant is included. It readily eliminates those cleaning methods which have little effectiveness.

2.4 Filter element degradation is checked by subjecting a filter element to the cleaning procedure being evaluated for 10 cleaning cycles, allowing a period of time to elapse in order to permit any corrosive action to take place, and performing a filter element fatigue test.

2.5 Durability is verified by performing an endurance test on the cleaning equipment.

2.6 A discussion of the considerations upon which this ARP is based may be found in section 9.

3. EQUIPMENT

3.1 Equipment for the cleaning procedure being evaluated, including all reagents, solvents, etc.

3.2 Bubble point test equipment, as shown in Figure 1, or equivalent.

3.2.1 Solox* 190 bubble point fluid (or equivalent) - as required.

3.3 Dirt capacity test equipment, as shown in Figure 2.

3.3.1 Standardized Fine Air Cleaner Test Dust (available from AC Spark Plug Division, General Motors Corp.) or other specified contaminant, as required (see 4.3 and 5.5).

3.4 Flow Fatigue test equipment (see 6.4).

3.5 Amplitude, pH, temperature and/or other measuring equipment, as required (see 7.2).

4. PROCEDURE FOR PRELIMINARY SCREENING OF FILTER ELEMENT CLEANING METHODS

4.1 A new filter element should be subjected to a bubble point test as follows:

4.1.1 The test element containing no oil is installed in a setup similar to that shown in Figure 1. Fluid level is maintained 1/2 inch above the top of the test element. The air pressure within the element is raised in small increments and the element is slowly rotated 360 degrees at each pressure increment. The area of greatest porosity is determined by observing the first bubble on the surface of the element, and the manometer reading in inches of water at which this bubble emits from the element is recorded.

4.1.2 This is the Initial Bubble Point. This value should be recorded for comparison with future test results. Dry the element before performing further tests.

4.2 The clean filter element should then be installed in a housing in a test stand plumbed as in Figure 2. Measure the pressure drop across the filter assembly.

4.3 While it is still installed in the test stand of Figure 2, measure the dirt capacity of the filter assembly as prescribed in the filter detail specification, or in accordance with the filter manufacturer's recommended procedure, if a specification does not exist. (Dirt capacity is defined as the amount of a specified standard contaminant which must be added to a filter to cause the pressure drop to reach a certain specified value below relief valve cracking pressure. If a filter relief valve is incorporated in the test stand, it should preferably be blocked for this test.) The dirt capacity measured at this time is the Actual Dirt Capacity, abbreviated ADC (see Table I for a list of definitions of abbreviations).

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*Obtainable from U. S. Industrial Chemicals Division, National Distillers Corp.

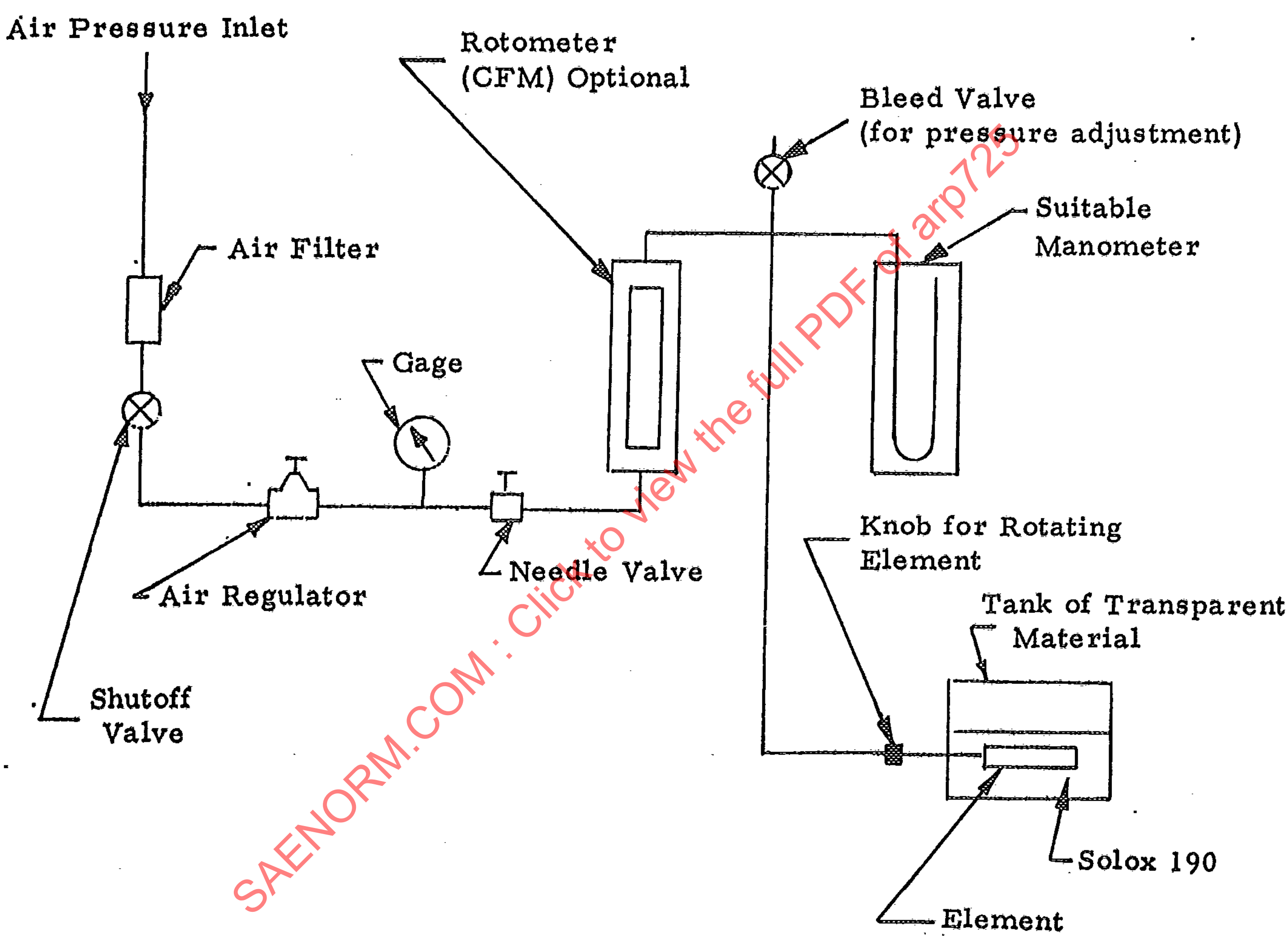


Figure 1. Typical Schematic Diagram for Air Bubble Test

4.4 Clean the filter element by the method being evaluated, insuring that all process variables are at their minimum acceptable value (see section 7).

4.5 Measure the dirt capacity of the filter, following the procedure described in 4.3. The dirt capacity measured at this time is called the Cleaned Dirt Capacity, abbreviated CDC.

4.6 If the cleaning method used in 4.4. is satisfactory, CDC will be at least 90% of ADC. If the CDC is lower, the element is not clean, and either the cleaning method being evaluated is ineffective, or the element has been damaged. If the element is found to be undamaged and CDC is lower than 90% of ADC, the cleaning method should be discarded as ineffective.

4.7 The filter element should be degreased and the procedure of 4.1 should be repeated. The Initial Bubble Point should be recorded and should not vary significantly from the value measured in 4.1. A change of more than ± 10% or ± 0.25 inch of water column, whichever is greater, is a significant change.

4.8 The procedure of paragraphs 4.2 through 4.7 should be repeated until a total of 10 cleaning cycles have been completed. No more than one cycle should be performed per day. CDC at the end of 10 cycles should be at least 85% of ADC. If CDC at the end of 10 cycles is less than 85% of ADC, the cleaning method being evaluated is not capable of repetitively cleaning dirty filter elements to "as new" condition and should be discarded as unsatisfactory.

4.9 The filter element should then be subjected to the procedure of section 6.

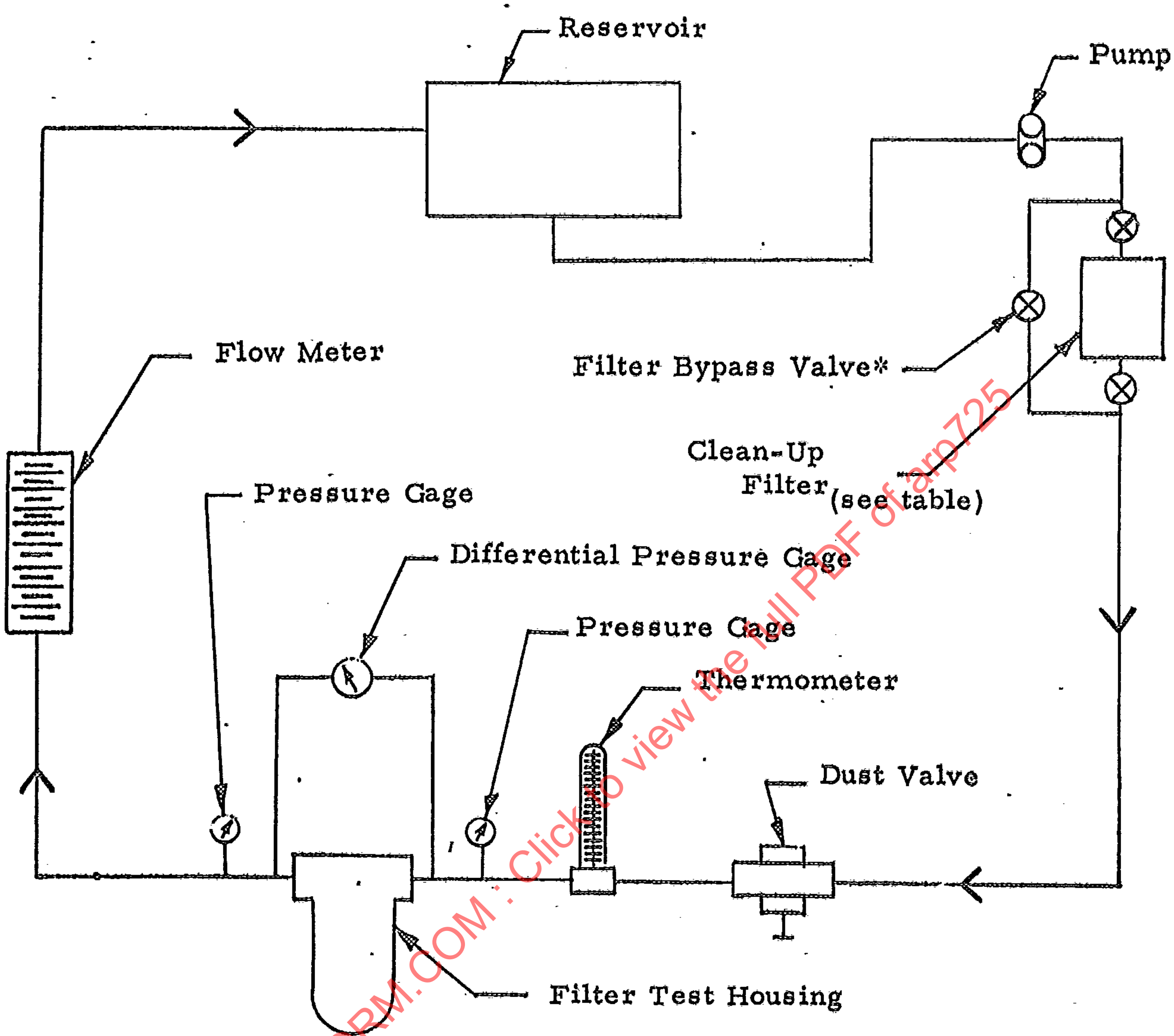
4.10 Cleaning methods which have demonstrated satisfactory performance in the preceding screening should be confirmed in accordance with section 5.

4.11 If the proposed cleaning method is partially or principally dependent on operation of cleaning equipment, chemical reagents, or other process variables which are subject to change, evaluation of the process should show that suitable limits on all governing variables are in effect. Test or analysis as appropriate should be conducted. See section 7 for further information.

5. <u>PROCEDURE FOR EVALUATING EFFECTIVENESS OF FILTER ELEMENT CLEANING METHODS ON SERVICE-DIRTIED ELEMENTS</u>

5.1 The following procedure is intended only for use with filter elements returned from service. It is suggested that the procedure of section 4 be used to screen proposed cleaning methods.

5.2 The following data should be submitted with all elements returned from field service for evaluation. Elements should be separately tagged or marked for identification. Similar information should be given for non-aircraft applications.



*To be left closed unless otherwise directed in the filter detail specification

Nominal Rating of Filter under Test, Microns	Absolute Rating of Filter under Test, Microns	Absolute Rating of Clean-up Filter, Microns	
		Preferred	Acceptable
2	15	3	
5	18 and up	3	
10	25 and up	3	15
17 to 74	33 and 110	15	25
over 74	over 110	25	70

Figure 2. Typical Setup for Dirt Capacity Tests

Table I. Definition of Abbreviations

Abbreviation	Meaning	Reference Paragraph
ADC	Actual Dirt Capacity	4.3, 5.12
CDC	Cleaned Dirt Capacity	4.5, 5.8
EDC	Estimated Dirt Capacity	5.3
RDC	Residual Dirt Capacity	5.5

5.2.1 Type or model aircraft or other vehicle on which used, and serial number, if known.

5.2.2 Fluid service (e.g., MIL-H-5606, Skydrol 500, JP5, compressed air, etc.).

5.2.3 Number of hours of operation.

5.2.4 Estimated number of hours of ground service (if possible).

5.2.5 Location in system (e.g., primary hydraulic reservoir filter, etc.).

5.2.6 Any abnormal operating conditions or system failures during operating period (e.g., overheating hydraulic system, main pump failure, etc.).

5.2.7 Climatic conditions and season in which operated (e.g., arctic, winter, etc.).

5.2.8 Any other factors which may be of significance.

5.3 Obtain an estimate from the filter element manufacturer of the typical dirt holding capacity of production units when tested in a system conforming to Figure 2. This is the Estimated Dirt Capacity and will be referred to as EDC throughout this procedure. An average of the dirt capacities obtained in section 4 may also be utilized as the EDC (see Table I for definitions of abbreviations).

5.4 Install a service-dirtied filter element in a housing in a test stand plumbed as in Figure 2. Measure the pressure drop across the filter assembly.

5.5 While it is still installed in the test stand of Figure 2, measure the dirt capacity of the filter assembly as prescribed in the filter detail specification, or in accordance with the filter manufacturer's recommended procedure, if a specification does not exist. (Dirt capacity is defined as the amount of a specified standard contaminant which must be added to a filter to cause the pressure drop to reach a certain specified value below relief valve cracking pressure. If a filter relief valve is incorporated in the test stand, it should preferably be blocked for this test.) The dirt capacity measured at this time is the Residual Dirt Capacity, abbreviated RDC.

5.6 Any element with an RDC more than 50% of the EDC should be considered too clean to provide a satisfactory specimen for evaluation of cleaning methods. These elements will be readily cleaned by most cleaning methods, and can serve only to eliminate the most ineffectual of these methods.

5.7 Clean the filter element by the method being evaluated, insuring that all process variables are at their minimum acceptable value (see section 7).

5.8 Measure the dirt capacity of the filter, following the procedure described in 5.5. The dirt capacity measured at this time is called the Cleaned Dirt Capacity, abbreviated CDC.

5.9 If the cleaning method used in 5.7 is satisfactory, CDC will be at least 85% of EDC. If the CDC is lower, the element is not clean, and either the cleaning method being evaluated is ineffective, or an abnormal condition may exist. Also check to insure that filter elements have not been damaged by differential pressure in such a way that dirt capacity is reduced. For instance, the pleats of poorly supported corrugated elements may have been found collapsed so that the flow space was eliminated on the downstream side of each pleat. This increases the pressure drop and reduces (often markedly) the dirt capacity.

5.10 Measure and record the Initial Bubble Point of the filter element, following the procedure outlined in 4.1. If the bubble point is below the requirement for a new filter, this indicates an oversized hole in the filter element. If there is an oversized hole, and the data obtained in paragraphs 5.7 through 5.9 indicate that the filter cleaning method is unsatisfactory, the oversized hole may be ignored. However, if there is an oversized hole, and the data obtained in paragraphs 5.7 through 5.9 indicate a satisfactory cleaning method (i.e. a CDC at least 85% of EDC), part of the high CDC may be due to the hole. The filter element should therefore be repaired to meet the bubble point requirements for a new filter. If the extent of repair required is less than 10% of the effective filter area, the repaired filter element should be retested commencing with the procedure of 5.7. If the extent of repair required exceeds 10% of the effective filter area, the filter element should be discarded and the procedure of section 5 should be performed on a new element.

5.11 If an element fails in 5.8, other cleaning methods should be attempted. Satisfactory performance by another method usually indicates that the first method was ineffective and that an abnormal condition was not present.

5.12 If the filter element cannot be cleaned by any other method, the procedure of section 8 should be attempted as a control. Note that this method will destroy aluminum and other materials affected by caustic soda, so that filter elements containing these materials will be damaged if subjected to this procedure. After completion of this procedure, the dirt capacity test of 5.5 should be rerun.

5.13 The procedure of section 8, followed by a dirt capacity test, may be run to corroborate the EDC and establish the Actual Dirt Capacity (ADC) of the filter. An effective cleaning method will produce a CDC of at least 85% of the ADC.

5.14 Satisfactory performance of a cleaning method cannot be proved by cleaning only one element. Because of the variety of conditions under which filter contamination occurs, a large quantity of filters should be cleaned to establish a reliable method. See section 9 for further information.

5.15 If the proposed cleaning method is partially or principally dependent on operation of cleaning equipment, chemical reagents, or other process variables which are subject to change, evaluation of the process should show that suitable limits on all governing variables are in effect. Test or analysis as appropriate should be conducted. See section 7 for further information.

5.16 If the proposed cleaning method has not previously been screened by the procedures of sections 4 and 6, the filter element should be subjected to the procedure of 4.8. The procedure of section 5 which has just been completed should be considered the first cleaning cycle. The filter element should then be subjected to the procedure of section 6.

6. PROCEDURE FOR EVALUATING DEGRADATION OF FILTER ELEMENTS DUE TO CLEANING

6.1 Filter elements which have been subjected to the procedure of section 4 should be sealed in a plastic bag and stored for 3 months. These elements are referred to as "element 4" in this procedure. A brand new filter element, preferably manufactured in the same lot as element 4, should be subjected to the bubble point test of 4.1 and then sealed in a plastic bag and stored concurrently with element 4. This element is referred to as the "control element" throughout this procedure.

6.2 At the completion of the 3-month storage period, the filter elements should be removed from the plastic bags, vigorously scrubbed with an extra firm toothbrush, and carefully examined. Any evidence of deterioration found only on element 4 indicates that the cleaning method utilized is harmful to filter elements and should be rejected. Deterioration common to both element 4 and the control element indicates that the storage conditions were unsatisfactory.

6.3 The filter elements should be subjected to the bubble point test of 4.1. The initial bubble points should not vary significantly from the values measured immediately prior to storage. A change of more than ± 10% or 0.25 inch of water column, whichever is greater, is a significant change. Any change of bubble point on element 4 only is evidence of deterioration caused by the cleaning method.

6.4 Both filter elements should be subjected to the flow fatigue test of the filter detail specification. If the filter detail specification does not include a flow fatigue test, a test procedure should be developed by the testing agency and the filter element manufacturer.

6.5 The filter elements should be subjected to the bubble point test of 4.1. Any evidence of gross failure found only on element 4 indicates either that the cleaning method causes degradation of filter elements and should be rejected, or that the element was sensitized to corrosion before cleaning. The failed element should be metallurgically examined to determine the cause of failure and if sensitization is suspected, the procedure should be repeated with elements known to be sound.

6.5.1 A gross failure is indicated by a large drop in Initial Bubble Point. Failure of both elements indicates that the element design was insufficient for the test requirements. If there is no evidence of failure, the cleaning method may be considered satisfactory from the viewpoint of element degradation. Satisfactory performance in the procedure of section 5, and evaluation following the considerations of section 7 should also be required before final approval is granted to any cleaning method.

7. PROCEDURE FOR EVALUATING CLEANING SYSTEM DURABILITY

7.1 It is desirable to perform quality control directly on filter elements after cleaning, in order to insure that elements have been properly cleaned. However, a quality control procedure with the desired degree of sensitivity may not be attainable or economical. It may therefore be necessary to control the cleaning process to insure that clean filter elements are obtained. In addition, cleaning equipment and control are of interest from the viewpoint of productivity and practicality. This section is a guide to some of the considerations frequently encountered.

7.2 The prime considerations in process control are the durability and dependability of performance of cleaning systems. In order to evaluate both items, it is necessary to measure the performance of the cleaning system to check for deterioration. The following procedures, relating to sonic and chemical cleaning systems may be used. Since it is not possible to describe all variations in cleaning systems in this procedure, the procedure should be used as a guide in the evaluation of systems not specifically covered.

7.2.1 Chemical - The concentration, specific gravity, pH, temperature and other pertinent characteristics of chemical cleaning solutions should be measured and recorded as an indication of consistency of performance.

7.2.2 Sonic - The following methods may be utilized to measure performance of sonic cleaning systems. They are listed in order of preference.

7.2.2.1 One method of measuring the output of a sonic system is to measure the amplitude of motion of the radiating surface. This value may range from 1 micron or less for a typical 40 KC piezoelectric unit to 20 microns for a hyperintense proximal unit. Some sonic cleaners come equipped with a device which continually measures this amplitude, but most cleaners are not so equipped. For these units, a probe is available which may be touched to the radiating surface and will read the amplitude directly. Use of this probe is shown in Figure 3. Alternate measurement procedures, such as microscopic, may be used where practical.

NOTE: Many sonic cleaners have meters which measure the power or current input to the output stage of the generator. The reading of these meters bears no relation to the actual amplitude of motion of the transducer radiating surface. Unless a sonic cleaner is equipped with a meter which is clearly labelled amplitude or calibrated in amplitude, the reading of any built-in meters should be disregarded and external means used to check performance.

7.2.2.2 An erosion test as described in ARP 599 will detect large degradation in performance. A strip of aluminum foil approximately 1 inch wide and extending from the top to the bottom of the fluid in the tank should be placed in the cleaner at a specific position (near the center of the tank). The transducer is actuated for 60 seconds. The foil is then removed and examined. Erosion may be evaluated by comparison with foils from previous tests. Figure 4 shows a typical foil sample. The same thickness and grade of foil should be used for comparative tests. The thickness should be noted in any reports.

If the fluid used in the sonic cleaner attacks aluminum rapidly, a beaker containing water may be placed in the tank and the foil placed in the beaker. There will be little or no attenuation of sonic energy by this procedure. Since evaluation is by comparison with previous foils from the same setup, any effects will cancel out. If attack of the aluminum by the fluid is slow, as with detergents, the test may be performed in the basic fluid.

NOTE: The location of the beaker, if one is used, and the fluid height in the beaker and in the tank must be identical for all tests. Erosion is usually much more apparent in water solutions than in solvents.

7.2.2.3 A test in which the temperature rise of the tank is measured as a function of time will serve as an indication of system output. For this test, a thermometer is placed in the tank at a known point, for instance in the center of the tank, approximately 2 inches from the bottom. The temperature of the fluid is noted and then the transducer is turned on for 30 minutes. Temperature is measured every 5 minutes. A curve of temperature vs. time is plotted to verify that measurements fall very close to a straight line, such as that shown in Figure 5. The acoustic power input to the tank may then be calculated by the formula:

Figure 3. Probe Being Used to Measure Amplitude of Tank Sonic Cleaner

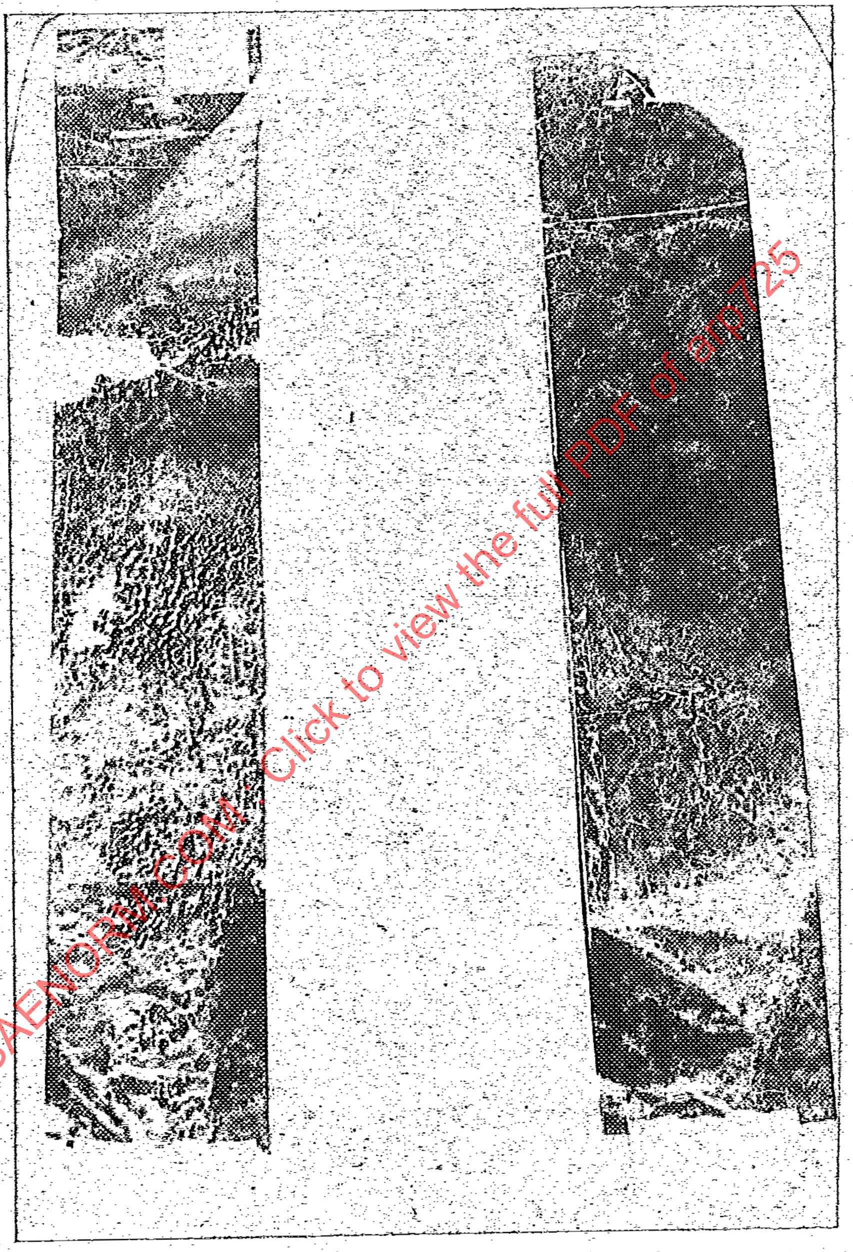


Figure 4. Typical Foil Erosion Specimens from Two Sonic Systems

$$P = \frac{.07mC\Delta T}{t}$$

P = power, watts
m = mass of fluid in tank, gms
C = specific heat of fluid, cal/gm^{o} C
ΔT = temperature change, ^{o}C
t = time, minutes

This formula assumes that no heat transfer into or out of the tank has taken place. In practice, the heat generated in the transducer, particularly in piezoelectric transducers where no cooling is provided, will also be conducted into the tank, causing this figure to be high. The calculations may be used for purposes of day to day comparison of the same unit. They will not serve to compare different units because of uncontrolled heat transfer effects.

All possible steps should be taken to minimize heat transfer into or out of the tank by conducting or convection. Any pumping systems should be turned off. A cover should be placed over the tank. Fluid in the tank should initially be at room temperature. Units with water cooled transducers should always be checked at the same cooling rate using water at a constant input temperature.

Wide variations in heat rise measurements may be expected in practice. However, if the general trend of the measurements is downward, this is a definite indication of degradation of the sonic system.

Because of uncertainties in experimental results, the heat rise test is the least reliable of the three proposed and is recommended as last choice. Despite its drawbacks, this procedure is still more reliable than any attempt to judge decay by eye, ear, or feel, since this procedure will be sensitive to changes in performance which are not obvious to the senses. In the event that a decay in performance is sensed by the operator, the above procedure should be used to verify the performance level.

7.2.2.4 For correlation with the results of 7.2.2.1, 7.2.2.2, and 7.2.2.3, the sonic system manufacturer should be asked to state the amplitude of the radiating surface and the acoustic power output (not input) of the transducer in watts.

7.3 ENDURANCE TEST

7.3.1 Short Term Endurance Test - The following procedure should be conducted to determine the durability and dependability of cleaning systems.

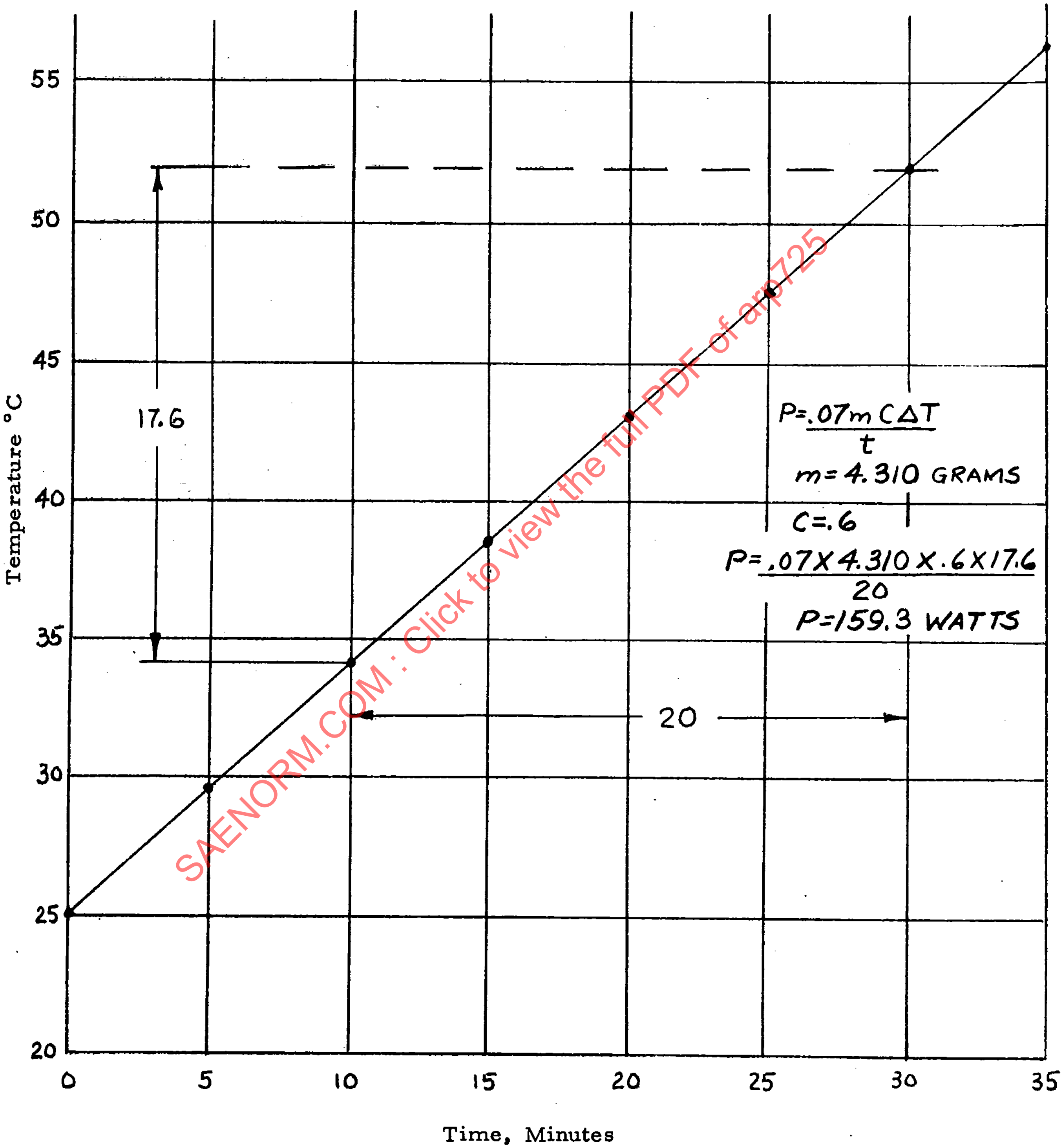


Figure 5. Typical Heat Rise Curve with Sample Calculation

7.3.1.1 The cleaning system should be run a minimum of 4 weeks. If it is a sonic system, the cleaning system should include operation of the transducer. In addition, the unit should be run continuously overnight at least once each week, resulting in a total operating time of not less than 56 hours per week. Electrical power, water, etc. available for the equipment should be of no better quality than will be expected in service. Line voltage variations, to be expected in any industrial plant, should be present during test. Any unit into which a Line Voltage Regulator is not built, but is furnished as a separate part, should be run without the regulator, since this component will generally be omitted in field installations.

7.3.1.2 During this period, chemicals, operating fluids, etc., should be replenished or replaced as required by the operating procedure. Concentration, pH, etc., for chemical systems or amplitude, erosion, or heat rise, for sonic systems, should be measured daily, both at the start and end of the operating period. Small variations may be ignored. A steady change in any of these tests is indicative of a change in performance.

7.3.1.3 Equipment which has no significant change in performance during this test should be dependable and durable in service. If equipment performance does change during this test, it is necessary to determine the minimum acceptable level of performance. This level should be the same level at which the procedures of sections 4 and 5 were conducted. If equipment changes in performance during this test and levels off at a satisfactory level of performance, this equipment should also be considered dependable. If equipment continues to change in performance during this test and does not show any signs of leveling off, or goes out of acceptable limits during the test period, the dependability of the equipment is subject to question. Acceptability of the equipment will then be subject to an evaluation considering the rate of change of performance, cause, anticipated usage, and cost of replacement parts.

7.3.2 In-Service Process Control - Since proper cleaning of filter elements may depend on process control, and variation in certain process performance may not be obvious to the operator, it will be necessary to provide process control inspection for in-service cleaning equipment. Process control should be established by measuring the same performance characteristics as were measured in the short term endurance test of 7.3.1. These characteristics should be checked either continuously or at periodic intervals, depending on method of check and schedule of usage, to insure that satisfactory performance limits are being maintained.

8. REFEREE CHEMICAL CLEANING PROCEDURE FOR FILTER ELEMENTS WITHOUT ALUMINUM PARTS

8.1 Degrease the filter element with petroleum ether, trichloroethylene, or other suitable completely volatile solvent.

8.2 Dry the filter element.

8.3 Boil in Turco 4008 cleaning fluid for 2 hours. The cleaner should be pre-filtered through an absolute 25-micron or finer filter before use.

CAUTION: a. A reflux condenser or other means for preventing loss of water must be used.

b. Remove any aluminum parts from elements containing integral relief valves.

8.4 Rinse by immersing in filtered water for 30 seconds or more; then dip in Turco WO1 cleaner neutralizer for 5 to 15 minutes.

8.5 Wash while immersed in a tank through which filtered water is run for a minimum of 4 hours.

8.6 Dry element in clean, dust limited area, or by using warm filtered air.

NOTE: Lacking Turco 4008 cleaner, a 20% solution of reagent grade caustic soda may be used for a period of 6 hours. However, cleaning may not be as effective. A 1:6 solution of nitric acid may then be used as a neutralizer, for a period of 3 to 5 minutes.

9. <u>SUPPORTING INFORMATION FOR USE WITH THIS ARP</u>

9.1 The purpose of this ARP is to provide a recommended procedure for the evaluation of filter element cleaning methods to determine which methods, if any, may be developed for use by filter element users. The evaluation procedure must therefore consider all those aspects of cleaning procedures which may affect their acceptability for use. These aspects may best be summarized by the following questions.

9.1.1 Will the proposed cleaning method take out the dirt that is plugging the filter element?

9.1.1.1 A filter element removes contaminant from a system by passing the system fluid through pores, thus preventing particles larger than these pores from continuing further into the system. As the filter operates, more and more of the pores will become plugged by these particles until the few remaining unplugged pores provide too much of a restriction to flow to permit continued operation of the system. In order to return the filter to usable condition, it is necessary to remove the dirt from these pores. The first criterion of evaluation of a filter element cleaning system is the effectiveness with which it will remove actual system dirt from the filter element pores.

9.1.1.2 It has been found in laboratory tests that AC fine test dust, widely used as a standard contaminant in filter evaluation, is much easier to clean from a filter element than the dirt which is found in service. Therefore, a cleaning procedure may effectively remove AC test dust and still be ineffective on filter elements dirtied in field use. For this reason, the cleaning method effectiveness is evaluated in section 5 using only service-dirtied elements. It is important that only service-dirtied elements be utilized in the procedure of section 5 if an effective cleaning procedure is to be obtained.

9.1.1.3 To be effective, a cleaning method should consistently remove all contaminants, of any type that may reasonably be encountered, from a filter clogged-to-close to the maximum differential pressure expected in service. There are several possible ways to check efficiency of contaminant removal. It can be checked visually using a microscope, but this is very tiring and time consuming, and is very difficult with the finer filter elements. The next most obvious method is to check pressure drop before and after cleaning. Unfortunately, even though a pressure drop reduction does indicate that some contaminant has been removed, it does not provide a sufficiently accurate indication of the amount of contaminant removed, or of how much contaminant is left. This is because the pressure drop of a filter element is approximately inversely proportional to the dirt capacity remaining in the filter element. Thus, an element which is 25% plugged will only show about 1/3 higher pressure drop across the filter medium than a clean unit shows. This difference is usually less than 1 psi for most filter elements, and is of the same order of magnitude as variations in pressure drop between different filter elements of the same design due to minor tolerances, etc. Furthermore, depending upon the method in which a pressure drop test is instrumented, extraneous pressure variations may completely mask any changes due to contamination. Therefore, pressure drop cannot be relied upon as a test of cleaning effectiveness for purposes of evaluation.

9.1.1.4 It should be noted that a properly instrumented pressure drop test may usually be relied upon to detect filters which are more than half dirty once a reliable cleaning procedure has been established. This does not apply to coarse filters, where a visual check is the preferred procedure.

9.1.1.5 A filter element has the ability to collect a certain amount of contaminant before it will excessively limit flow. When a test of this ability is run under constant conditions with a known contaminant, it is known as a Dirt Capacity Test, and the amount of contaminant used in the test is known as the Dirt Capacity. In operation, as a filter collects contaminant, the dirt capacity is used up. Cleaning of the filter is the process of restoring the dirt capacity to essentially that of a new filter. Therefore, the most realistic test of cleaning effectiveness is a Dirt Capacity Test. This is also the most practical procedure since, as cited above, pressure drop testing is not a satisfactory method.

9.1.1.6 An illustration of the inadequacy of the pressure drop test as a cleanliness indicator is shown in Figure 6, which contains dirt capacity curves measured on fuel filters returned from field service. Note that the element with the highest as-received pressure drop also has the highest dirt capacity. This case is typical of coarse filters, but fine filters may behave similarly, to a lesser extent.

9.1.2 Will the proposed cleaning method damage the filter element?

9.1.2.1 If a cleaning method alters the performance of a filter element, it is obviously not acceptable for use. Corrosion is widely recognized as a potential danger and should be considered carefully before a procedure is attempted. In addition, there are many other ways that must be considered in which a cleaning method may alter a filter's performance. Some more subtle forms of damage may result from heat distortion or heat treatment of parts, alloying, sensitization of normally corrosion resistant materials, etc. It should be recognized that many filter media contain extremely small wires or bonding points so that an amount of corrosion that would be considered insignificant in more bulky parts can be quite serious in a filter element.

9.1.2.2 Unfortunately, the above phenomena are not always visible to the eye and a test must therefore be utilized. It is also noted that time will be a factor where sensitization and slight corrosion are concerned, so that a waiting period is required. An example of the value of the waiting period is shown in Figure 7. The corrosion of this filter did not appear until 2 to 3 months after the filter element was subjected to the proposed cleaning procedure.

9.2 In addition to the two questions stated above, certain other factors must be considered in the evaluation of any cleaning procedure. Of major importance are the following questions.

9.2.1 Is the filter element adversely affected in normal use, and is it capable of withstanding use (assuming a satisfactory cleaning procedure) for a number of service intervals?

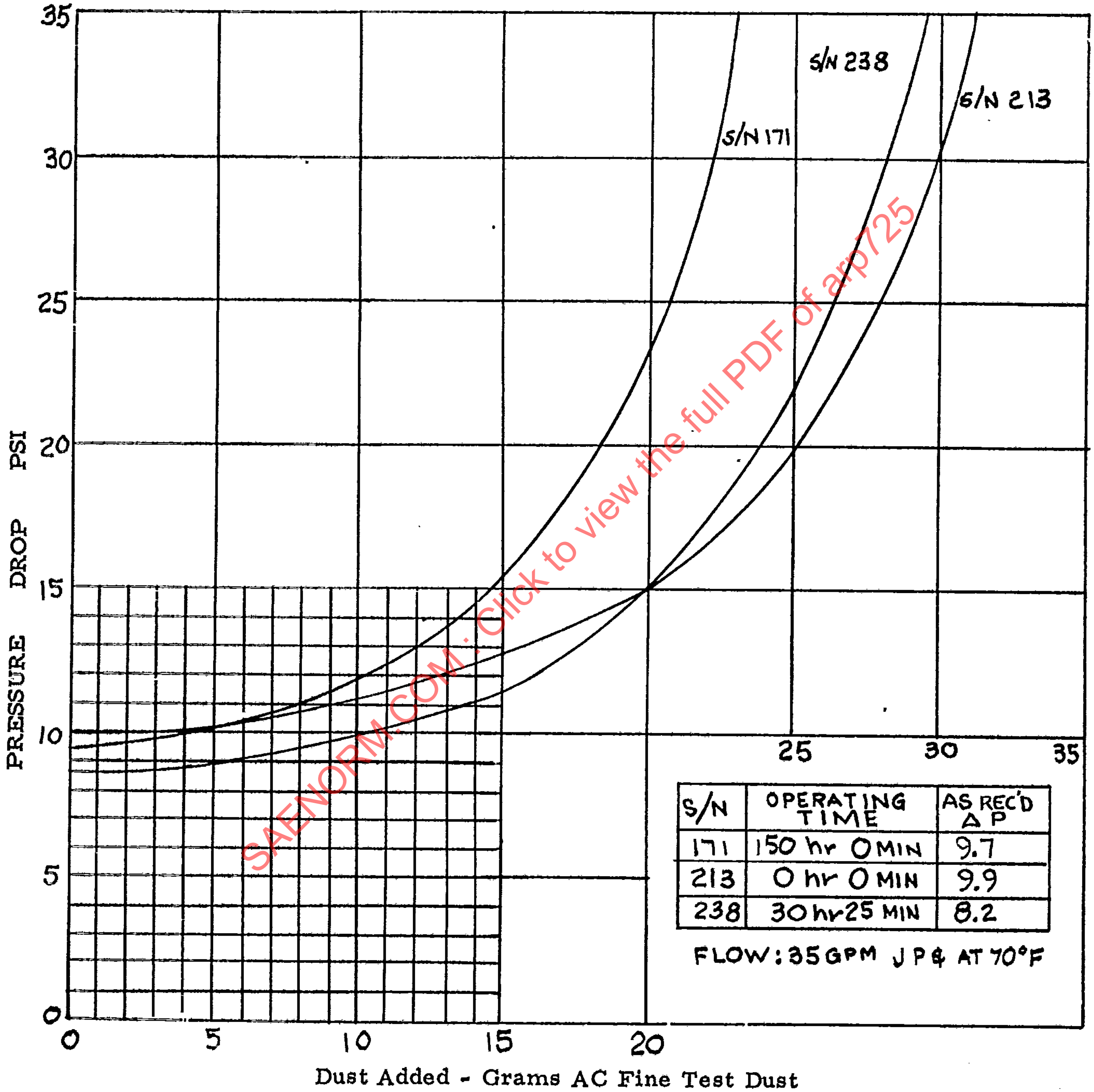


Figure 6. Dirt Capacity Curves for Fuel Filters Returned from Field Use