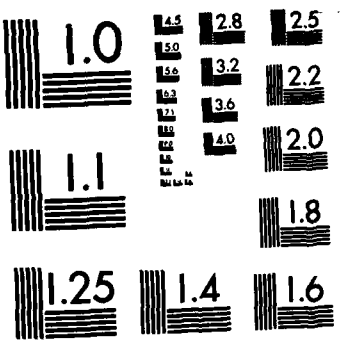
AD-A159 840 EVALUATION OF IRREVERSIBLE HUMIDITY INDICATOR(U) AIR FORCE PACKAGING EVALUATION AGENCY WRIGHT-PATTERSON AFB OH MATERIALS ENGINEERING BRANCH A K LO 14 AUG 85 1/1

UNCLASSIFIED DSTZT-85-R-01 F/G 4/2 NL



DSTZT ~~REPORT~~ NO. 85-R-01
AFPEA PROJECT NO. 83-144

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EVALUATION OF IRREVERSIBLE HUMIDITY INDICATOR

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WRIGHT-PATTERSON AFB OHIO 45433

AUGUST 1985

NOTICE

ABSTRACT

The performance characteristics of Irreversible Humidity Indicators were evaluated in a constant temperature/humidity chamber at various combinations of temperature and humidity conditions. The test results revealed significant information on its actuation threshold value and the degree of influence on the threshold value of both ambient temperature and relative humidity. These data will provide useful guidelines to field personnel who use the indicators and will also be used to establish requirements in procurement specifications.

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PUBLICATION DATE:

14 AUG 1985

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INTRODUCTION Humidity indicators specified in MIL-I-26860 "Indicator, Humidity, Plug, Color Change" have been found to be unrealiable for some applications because of their "reversible" characteristics. When relative humidity (RH) conditions exceed 40 to 50 percent, the indicators change from blue to pink. However, if the humidity falls below this humidity range the indicator will revert to blue. A container inspected during warm daylight hours would show a blue indicator, if the internal humidity was below 40% RH. However, lower temperatures occurring during night time hours, could cause the relative humidity within the container to rise above 40% RH resulting in possible corrosion inducing conditions if the desiccant within the container is at or near saturation. However, since the containers are normally inspected during the warmer daytime hours the occurrence of this potentially damaging humidity condition would probably go undetected since the indicator may again change from pink back to blue. The solution to this deficiency was found to be a color irreversible humidity indicator developed by AGM Container, Inc., of Tucson, Arizona. Extensive field testing of the irreversible humidity indicator has been conducted by this Agency (DSTZ Report No. 83-R-10), with highly satisfactory results.

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OBJECTIVE The purpose of this study was to evaluate the subject indicator under different sets of humidity and temperature conditions to:

(1) Establish the threshold value at ambient conditions.

(2) Determine the effect of temperature and humidity on actuation time.

(3) Develop indicator performance characteristics required to establish procurement specifications requirements.

DESCRIPTION OF IRREVERSIBLE HUMIDITY INDICATOR The indicator is listed in the AGM Container, Inc., catalog as "Delayed Response Maximum Humidity Indicator Element", Model No. TA378-HC-MHI, National Stock Number 6685-01-176-0375. It is comprised of a circular white porous material backing approximately 20mm (0.8 in.) in diameter and 3.3mm (0.13 in.) in thickness. A crystalline material is centered on the backing covering an area approximately 3mm (0.12 in.) in diameter. The crystals dissolve when subjected to a relative humidity above 55%, changing in color permanently, from white to orange. A transparent plastic vapor barrier material is bonded to the front surface of the indicator; its purpose is to delay penetration of moisture to the crystalline material, thereby extending the actuation time of the indicator after exposure to humidities above 55% RH. The indicator element can be installed in the AGM designed TA456, TA356, and TA350 housing or any MIL-I-26860 type humidity indicator plug.

TEST PROCEDURES A Blue M constant temperature/humidity chamber Model No. FR-256 PCX was used for this test. Conditioned air at the rate of at least 500 ft/min was blown through the chamber to maintain a steady state condition inside the chamber. Indicator samples, each assembled with a housing and disc, were placed inside the chamber once the desired humidity and temperature was attained under stabilized conditions. The effect of temperature on the indicator's actuation threshold was determined by maintaining the relative humidity (RH) constant at 60%, 70% and 80% while varying the temperature between 40 degrees F and 100 degrees F. In a similar manner the effect of relative humidity on the actuation threshold was determined by maintaining the temperature constant at 96 degrees F, 86 degrees F and 72 degrees F while varying the relative humidity between 55% and 96%. At each set of conditions the time was recorded for a complete orange/brown discoloration to occur inside the dark ring on the indicator surface. (See Photo No. 1)

RESULTS/DISCUSSION

The indicator threshold value at ambient temperature (72 degrees F) is approximately 55% RH and it takes approximately 11 hours to actuate the indicator at that condition.

As shown in figure 1, the threshold actuation time decreases as temperature increases. At lower temperatures, the level of the relative humidity can have a significant effect on actuation time. However, at higher temperatures, i.e., between 80 to 100 degrees F, the effect of humidity on actuation time becomes less pronounced. Inspection of the time/temperature curves (Figure 1) at a moderate temperature of 60 degrees F indicates the following comparative effects of humidity on actuation time: at 60% RH the indicator actuates after nearly 7.5 hours, at 70% RH at approximately 4.0 hours and at 80% RH the actuation time decreases to two hours.

The curves in Figure 2 show that the actuation time decreases as relative humidity increases. Near the threshold actuation humidity (55% RH), the effect of temperature has a significant influence on the actuation time, i.e., at 72 degrees F the indicator actuation time is 11 hours, at 86 degrees F it falls to approximately 9 1/2 hours and at 96 degrees F decreases sharply to about 2 3/4 hours. However, at relative humidity values well above 55% RH the curves rapidly converge, i.e., the differences in actuation time as a function of temperature become less, until at 100% RH the actuation time is approximately one hour at 72 degrees F and 1/2 hour at 96 degrees F.

At high temperature and humidity (80 degrees F and 85% RH or above), the indicator will actuate within one hour with the dark orange/brown color extending beyond the dark ring on the indicator surface. This condition is indicative of heavy

moisture penetration. However, high temperature, even 95 degrees F, has no influence on actuation if the relative humidity is at or below 50%. Test results showed no indicator actuated after 90 hours at 85 degrees F and 50% RH, 120 hours at 72 degrees F and 50% RH, and 48 hours at 97 degrees F and 48% RH.

At moderate temperature and humidity, such as 72 degrees F and 60% RH, the discoloration at actuation is light and gradual which is markedly different from the discoloration at high temperature and humidity conditions.

Actuation times are an important consideration in the application of the irreversible humidity indicator. During installation of the indicator in a container and prior to the closure of the container the indicator will be exposed to the prevailing ambient temperature/humidity conditions. After container closure the desiccant will act to draw down the humidity within the container. To prevent premature actuation of an indicator, the time from installation of the indicator to desiccant draw down below 55% RH must not exceed the actuation time for the indicator.

CONCLUSIONS/RECOMMENDATIONS

1. Based on the test data developed, it is apparent that this type of humidity indicator provides positive visually discernable indication of moisture present in the environment above the 55% RH level. Its irreversible characteristic is permanent, not affected by subsequent changes in temperature and humidity.

2. Comparison of the results from a previous desiccant draw down test with the indicator actuation times obtained in this study indicates that even in the worst case situations of high ambient temperature/humidity conditions the indicators can be installed with little danger of premature actuation occurring.

3. Since this test was conducted in a constant humidity/temperature chamber with forced draft circulation, it is anticipated the actuation time will be somewhat longer in actual field applications.

FIG. 2 - ACTUATION TIME VS RELATIVE HUMIDITY AT SELECTED TEMPERATURES

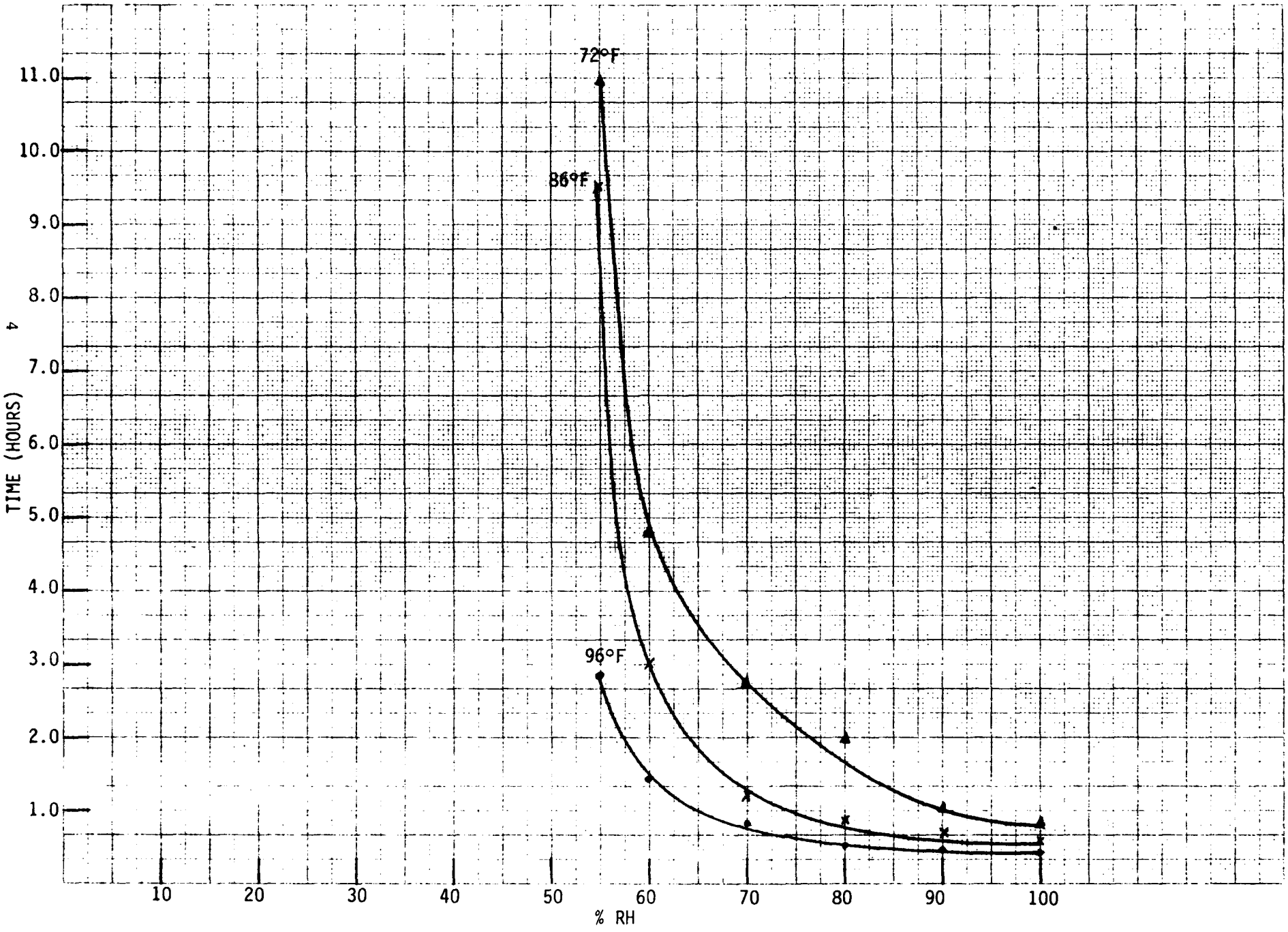
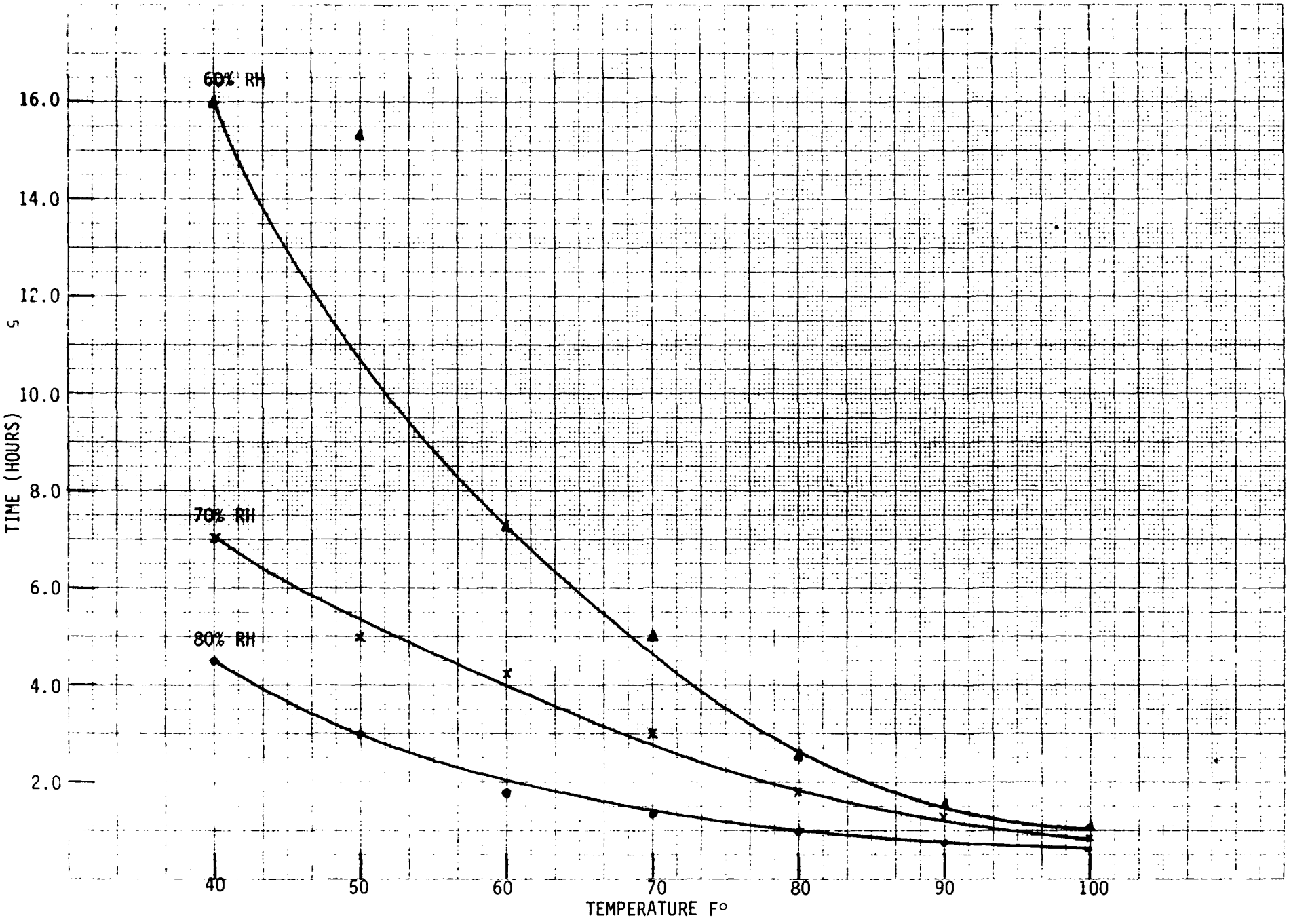


FIG. 1 - ACTUATION TIME VS TEMPERATURE AT SELECTED RELATIVE HUMIDITIES



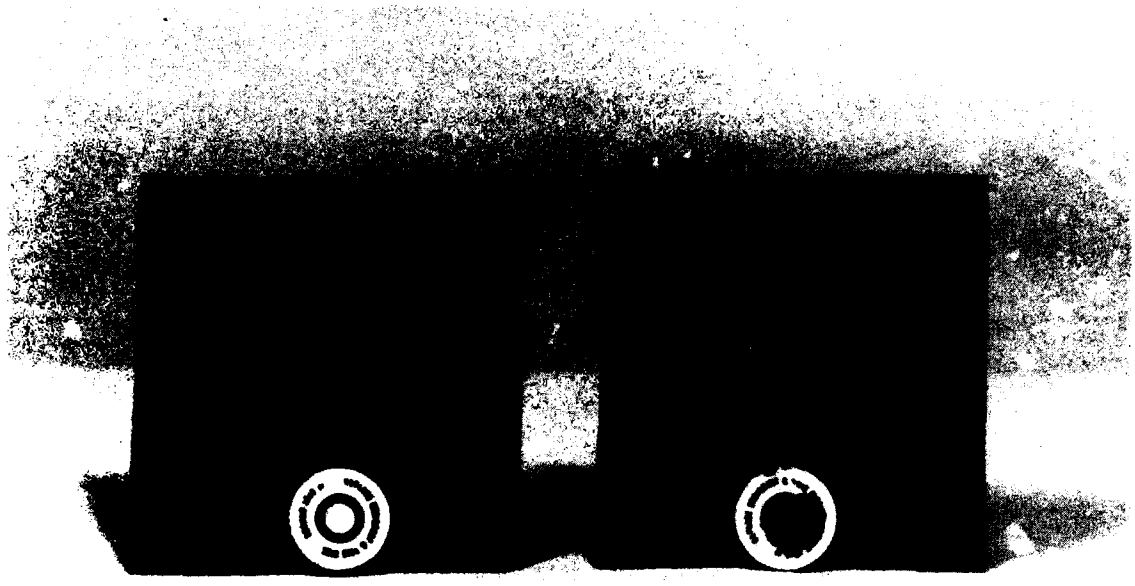


PHOTO NO. 1 UNACTUATED (LEFT) VS ACTUATED (RIGHT)

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SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY None	3. DISTRIBUTION/AVAILABILITY OF REPORT APPROVED FOR PUBLIC RELEASE DISTRIBUTION UNLIMITED
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) DSTZ 83-144	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Air Force Packaging Evaluation Agency 6b. OFFICE SYMBOL (If applicable) HQ AFLC/DSTZT	7a. NAME OF MONITORING ORGANIZATION Same
6c. ADDRESS (City, State and ZIP Code) Wright-Patterson AFB OH 45433-5999	7b. ADDRESS (City, State and ZIP Code) Same
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State and ZIP Code)	10. SOURCE OF FUNDING NOS. PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT NO.
11. TITLE (Include Security Classification) (U) Evaluation of Irreversible Humidity Indicator	
12. PERSONAL AUTHOR(S) Lo, Augustus K.	
13a. TYPE OF REPORT Final 13b. TIME COVERED FROM 84 Oct. TO 85 May	14. DATE OF REPORT (Yr., Mo., Day) 85-Aug-15 14
15. PAGE COUNT 0	
16. SUPPLEMENTARY NOTATION	

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB. GR.	
04	02		Humidity Indicators, Packaging

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

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1

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL Augustus K. Lo	22b. TELEPHONE NUMBER (Include Area Code) (513) 257-4234 22c. OFFICE SYMBOL DSTZT

DD FORM 1473, 83 APR EDITION OF 1 JAN 73 IS OBSOLETE.

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