

UNCLASSIFIED

AD NUMBER

ADB018178

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited.

FROM:

Distribution authorized to U.S. Gov't. agencies only; Test and Evaluation; DEC 1976. Other requests shall be referred to Air Force Packaging Evaluation Agency, Wright-Patterson AFB, OH 45433.

AUTHORITY

AFALD ltr 27 Jan 1982

THIS PAGE IS UNCLASSIFIED

THIS REPORT HAS BEEN DELIMITED
AND CLEARED FOR PUBLIC RELEASE
UNDER DOD DIRECTIVE 5200.20 AND
NO RESTRICTIONS ARE IMPOSED UPON
ITS USE AND DISCLOSURE.

DISTRIBUTION STATEMENT A

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED.

22 December 1976
DISTRIBUTION LIMITED to U.S. *TLE*
Government agencies only; report
involves evaluation of commercial
products. Other requests for this
document must be referred to
AFALD/PTP, Wright-Patterson AFB OH
45433.

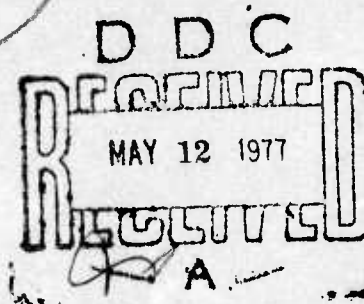
PTPD REPORT NO. 76-32
AFPEA PROJECT NO. 73-P7-15

AD B018178

EDWARD J. KOWALSKI
Mechanical Engineer

AUTOVON 787-3120
Commercial (513) 257-3120

See 1473



EVALUATION OF HUMIDITY INDICATORS

AFALD/PTPD
Air Force Packaging Evaluation Agency
Wright-Patterson AFB OH 45433

December 1976

AU NO. _____
DDC FILE COPY

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 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. This report is not to be used in whole or in part for advertising or sales purposes.

ABSTRACT

Prototype humidity indicators, developed and fabricated by Foster-Miller Associates, Inc., Waltham MA under contract No. F33601-74-C-0815, were tested and evaluated by the contractor simultaneously with humidity indicators presently used or previously considered for packaging applications.

The newly developed humidity indicator is highly shock resistant, has a standard deviation of 2.2 percent RH over its calibrated range, is easily and quickly read on a calibrated scale, and is comparable in cost and mounting characteristics with the color change plug type that adapts into a 1 7/16 - 18 inch threaded hole.

From the tests conducted, some deficiencies have been identified with the newly developed humidity indicators, however, the deficiencies will be corrected prior to fabrication of preproduction prototype units.

ACCESSION for	
NTIS	White Section ☐
ODC	Diff Section ☒
ANNOUNCES	
JUSTIFICATION	
BY	
DISTRIBUTION/AVAILABILITY CODES	
Dist.	AVAIL. and/or SPECIAL
B	

PREPARED BY:

Edward J. Kowalski
EDWARD J. KOWALSKI
Mechanical Engineer
Design Division

PUBLICATION DATE:

December 1976

REVIEWED BY:

Ralph Zynda
RALPH ZYNDA
Chief, Design Division
Air Force Packaging Evaluation Agency

APPROVED BY:

John Thompson
JOHN THOMPSON
Director, Air Force Packaging
Evaluation Agency

TABLE OF CONTENTS

	PAGE
NOTICE	ii
ABSTRACT	ii
TABLE OF CONTENTS	iii-iv
INTRODUCTION	1
Purpose	1
Background.	1
TEST AND EVALUATION.	1
Description of Test Specimens	1
TEST PROCEDURES AND RESULTS.	2
Indicator Accuracy Test	2
Stability Test.	3
Rough Handling Test	3
Resolution Test	4
Response Time Test.	4
Pressurized Container Test.	4
Temperature Compensation Test	4
Mounting Characteristics Test	5
CONCLUSIONS.	5
RECOMMENDATIONS.	6
ILLUSTRATIONS.	8
Figure 1.	8

	PAGE
Figure 2.	8
Figure 3.	9
TABLE I.	10
DISTRIBUTION LIST.	11-12
DD FORM 1473	13-14

INTRODUCTION

PURPOSE:

The intent of this project was to conduct a survey among industrial manufacturers and DoD activities for an economical, self-contained, dial-type, direct read-out humidity indicator to be used as a replacement for the color change card and plug type indicators currently used by the USAF in desiccated military containers. If this type of humidity indicator was not commercially available from production, a work statement was to be written for a contractual development of a new unit.

BACKGROUND:

Contract No. F33601-74-C-0815 was awarded to Foster-Miller Associates, Inc., 135 Second Avenue, Waltham MA 02154 to develop an improved low cost humidity indicator for packaging. The development was programmed into three tasks:

Task I covered the investigation and evaluation of commercial low-cost humidity indicators, and humidity sensing materials.

Task II required a detailed design of the humidity indicator with preliminary test data to indicate that the design will satisfy requirements of the contract statement of work.

Task III required the fabrication and testing by Foster-Miller Associates, Inc, (FMA) of ten prototype humidity indicators, delivery of 110 prototype units to the Air Force Packaging Evaluation Agency (AFPEA) for further testing and evaluation, and a cost analysis for quantity production.

TEST AND EVALUATION

DESCRIPTION OF TEST SPECIMENS:

Humidity indicators used for the investigation and evaluation in Task I were selected for testing because they are presently used, or have been previously considered for packaging applications. The indicators cover the following range of sensing elements and readout types:

<u>SPECIMEN</u>	<u>SENSING ELEMENT</u>	<u>READOUT TYPE</u>
No. 1	Hygroscopic Salt	Color Change
No. 2	Hygroscopic Salt	Color Change
No. 3	Hygroscopic Salt	Color Change
No. 4	Foil-Fiber Element	Pointer & Scale
No. 5	Biplastic Element	Pointer & Scale
No. 6	Human Hair	Pointer & Scale
No. 7	Nylon Cord	Pointer & Scale

TEST PROCEDURES AND RESULTS

Indicator Accuracy Test: The initial accuracy test of the commercial humidity indicators was conducted by mounting the test specimens, one each, on a plexiglass panel which was supported in a vertical position by bracing and was placed in a Tenney, TH-27, environmental chamber. The commercial indicators were tested to determine their performance and accuracy over a 25-90 percent RH range at temperatures from +35°F to +120°F. The humidity and temperature inside the chamber, at any test condition, was monitored with a calibrated electronic humidity indicator accurate to ± 1 percent RH (reference Table I). The probe of this indicator was mounted centrally on the test panel. In addition to a periodic visual readout, a chart recorder was connected to the calibrated instrument to monitor continuously the humidity within the chamber.

To evaluate the performance and accuracy of the commercial humidity indicators the environmental chamber was set at the required dry bulb temperature, the wet bulb temperature was then adjusted to give the required RH level. A preliminary run indicated that one-half hour was sufficient to allow all of the indicators to stabilize. Therefore, the readings at each test condition were taken one-half hour after the chamber adjustments were made.

Further tests were also carried out by mounting the test specimens, six each, in a metal 3' x 3' x 3' exterior shipping/storage container and monitoring the indicator readings for various values of container humidity, ranging from 30 percent to 60 percent RH. As with the initial tests, the temperature and humidity inside the container was also monitored with the calibrated electronic humidity indicator.

Tests were also conducted on the prototype humidity indicators developed by Foster-Miller Associates, Inc. All testing was performed in the same sequence as the tests made on the commercially procured humidity indicators. However, four (4) hours, as opposed to one-half hour for the commercial humidity indicators, were required for the new prototype humidity indicators to stabilize.

Results:

<u>Indicator</u>	<u>Standard Deviation % RH</u>
Hygroscopic Salt	8.0 (Average)
Foil-Fiber Element	10.8
Biplastic Element	10.3
Human Hair	6.2
Nylon Cord	1.9
FMA Prototype	2.2

Based on the results obtained from the initial performance tests, the following humidity indicators were selected for future test and evaluation: Specimen No. 1, Plug Type (Figure 1), Specimen No. 7, Nylon Cord Sensing Element (Figure 2), and the Foster-Miller Associates, Inc., Waltham MA, Prototype Unit (Figure 3).

Stability Test: Long term stability was evaluated by comparing the test data taken at the beginning of the program with that which was obtained at the end of an 18 month period using the same test specimens.

Results: At the end of 18 months the color change indicators showed no detectable difference. The nylon cord hygrometer had an average increase of 13 percent RH in the 30-70 percent RH range. The error was larger at the lower humidities. At the end of 30 days the FMA prototype indicators showed a variation of approximately one percent RH from the standard. Although this is not comparable to an 18 month test, it was felt that the units required a slight refinement to improve their stability. The FMA prototype units were modified, a 30-day stability test was then repeated and no reading variations were observed.

Rough Handling Test: Rough handling tests were conducted in accordance with Federal Test Method Standard No. 101, Methods 5005 and 5008, level A protection, using a drop height of 30 inches. The humidity indicators were mounted in exterior containers and two drops were made on each of the six units that were tested.

Results: As expected, the color change indicators showed no difference in readings after the rough handling tests were completed. The FMA prototypes also showed no change in readings. The nylon-cord hygrometers showed a significant shock-induced change. One unit became inoperative while the others showed an error increase of five percent RH.

Resolution Test: To test resolution, reading ease and accuracy, observations were made by various observers by reading the units from different distances and under different light conditions.

Results: The results for reading accuracy indicated that observers can estimate within 10 percent RH the color change indicators. By contrast, readings of both the nylon-cord hygrometer and FMA prototypes were less than one percent RH.

Response Time Test: Response time of the humidity indicators was evaluated by monitoring the readings of the indicators after a sudden drop in humidity. This was accomplished by initially conditioning the test indicators in a sealed container for 24 hours at 45 percent RH. The container was then opened and the indicators were exposed to an ambient humidity level of 30 percent RH. Readings were taken at five minute intervals until the 30 percent RH level was recorded for each indicator.

Results:

<u>Indicator Type</u>	<u>Response Time</u>
Color Change Plug	15-30 Minutes
Nylon-Cord Hygrometer	15 Minutes
FMA Prototype	4 Hours

Pressurized Container Test: Pressure testing of humidity indicators was accomplished by mounting the indicators in an exterior container, which was sealed and pressurized with air to five psi. This test was conducted to determine: (1) indicator fluid leakage, (2) seal leakage, and (3) reading error caused by the internal pressure.

Results: None of the indicators showed any air leakage through the seals, and no change was observed in any of the readings.

Temperature Compensation Test: Temperature compensation tests were performed by mounting the indicators in exterior containers and exposing the containers to ambient indoor and outdoor conditions and also to

temperature extremes within an environmental chamber. The test temperature of the environmental chamber ranged from +40°F to +110°F. The temperature and humidity were monitored with the calibrated instrument of Table I.

Results:

<u>Indicator Type</u>	<u>Deviation</u>
Color Change	5 percent RH per 10°F
Nylon Cord Hygrometer	1/2 percent RH per 10°F
FMA Prototype	2/3 percent RH per 10°F

Mounting Characteristic Test: Humidity indicators were mounted in exterior containers to study the advantages and disadvantages of the mounting characteristics.

Results: The color change plug and the FMA prototype indicators have an identical mounting arrangement. These indicators can be mounted from the outside of the container into a threaded hole or can be fastened by means of a backup nut. The nylon cord hygrometer must be mounted from the inside of the container and must be locked in place by means of a nut from the outside. For large containers where the mounting location is not easily accessible from the inside, this mounting arrangement is inconvenient. Also, the protective cover for the scale and pointer must be removed, thus exposing the delicate parts to accidental impact, when the indicator is being mounted.

CONCLUSION

The survey conducted among industrial manufacturers and DOD activities revealed a nonavailability of a replacement of an economical, self-contained and direct readout type of humidity indicator for USAF use.

The performance of the FMA prototype unit indicates the following advantages:

- a. The standard of deviation for the FMA prototype humidity indicator, at 2.2 percent RH over its calibrated range, was slightly higher than the 1.9 percent RH for the nylon cord hygrometer. However, at 2.2 percent RH it is within the range as specified in the Statement of Work.

b. When mounted and tested in exterior shipping/storage containers the nylon cord hygrometer failed during the stability and rough handling tests. The FMA prototype has no moving links or pivots, has ten component parts compared to forty-five parts on the nylon cord hygrometer, resulting in a design that is highly shock resistant.

c. Graduated scale is read easier, quicker, and more accurately than the color change type.

d. Response time, pressurization, and temperature compensation were within the range as specified in the Statement of Work.

e. Mounting characteristics are compatible with the present system used within the USAF distribution system.

f. Production cost computed at \$6.62 for each unit (1975 prices) is comparable to the plug type presently used in the USAF distribution system and approximately four times less than the cost of the nylon cord hygrometer.

The following are disadvantages noted in the FMA prototype humidity indicator:

a. Sensing unit is exposed to accidental impact.

b. Requirement exists for percent RH read-out below the 30-70 scale calibration.

c. Although pressure tests of five psi are within the Statement of Work unit cannot survive shipment in unpressurized aircraft.

RECOMMENDATIONS

As a result of work conducted thus far, it is recommended that:

a. Some additional features be incorporated in the present design of the humidity indicators including:

(1) Protect unit against mishandling by inclusion of guard disc over the sensing unit.

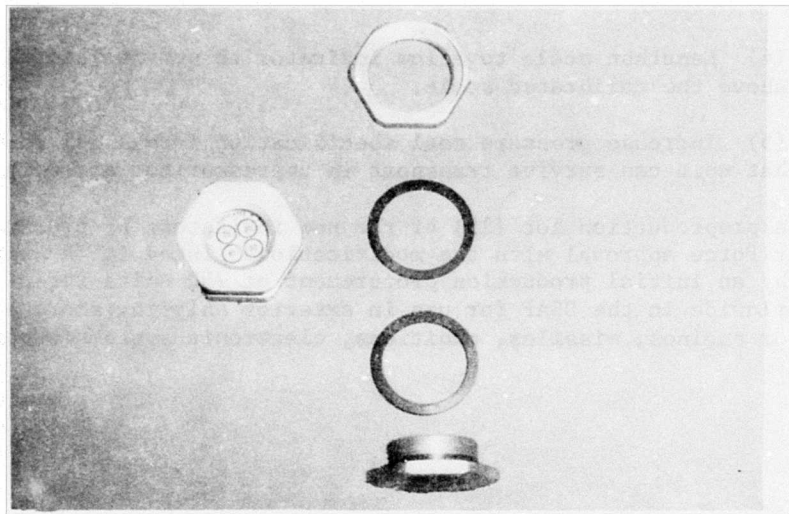
(2) Change scale calibration from 30-70 percent RH to 20-60 percent RH.

(3) Standard of deviation over the calibrated scale of 20-60 shall be 2.0 percent RH.

(4) Lengthen scale to allow indicator to survive humidity exposure above the calibrated scale.

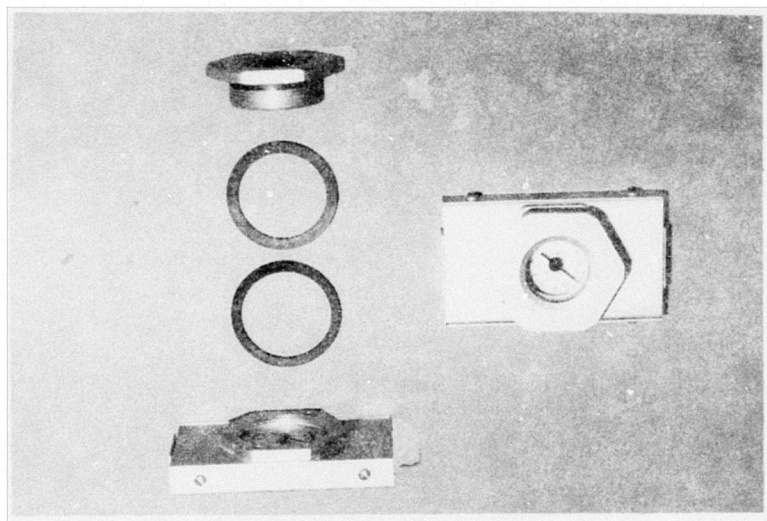
(5) Increase pressure seal specification from 4 psi to 19 psi, so that unit can survive transport in unpressurized aircraft.

b. A preproduction lot (25) of the new indicators be procured for US Air Force approval with the modifications listed in "a" above, followed by an initial production procurement of 750 units for distribution worldwide in the USAF for use in exterior shipping/storage containers for engines, missiles, munitions, electronic systems/components, etc.



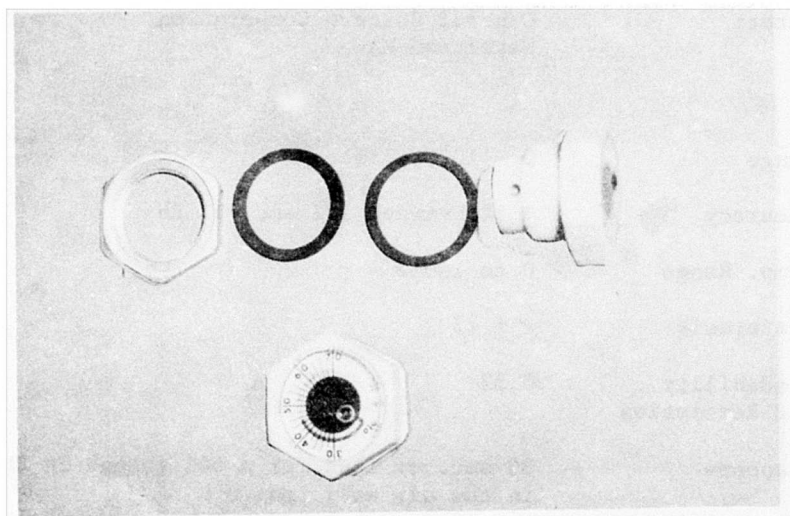
SPECIMEN NO. 1 - PLUG TYPE

FIGURE 1



SPECIMEN NO. 7 - NYLON CORD SENSING ELEMENT

FIGURE 2



FOSTER-MILLER ASSOCIATES, INC. - PROTOTYPE UNIT

FIGURE 3

TABLE I

REFERENCE INDICATOR SPECIFICATIONS

Indicator:	Model 400C, Temperature Compensated Analog Indicator
Probe:	Model 411, RH and Temperature Sensor
Manufacturer:	General Eastern Corporation Watertown MA

Humidity

Range	0 - 100%, linear
Accuracy	$\pm 1\%$ between 15% and 95% RH
Temp. Range	0 to 140°F
Hysteresis	$< \pm 2\%$
Readability and Resolution	0.5%
Response	30 sec. or less for a 64% change in RH in the air at 1 fps.

Temperature

Range	- 50 to + 150°F
Accuracy	$\pm 2^\circ\text{F}$
Readability	0.5°F

DISTRIBUTION LIST

Defense Documentation Center	12
AFALD/PTP Library	10
AFALD/PT	1
USAF/LGTN Washington DC 20330	2
AFSC/LGT	2
ASD/4950/SUP	2
ADTC/SDMT Eglin AFB FL 32541	2
DESC/LQP 1570 Wilmington Pike Dayton OH 45444	2
OO-ALC/DSP Hill AFB UT 84406	2
OC-ALC/DSP Tinker AFB OK 73145	2
SA-ALC/DSP Kelly AFB TX 78241	2
SM-ALC/DSP McClellan AFB CA 95652	2
WR-ALC/DSP Robins AFB GA 31098	2
JMPTC Aberdeen Proving Ground MD 21005	2
Tobyhanna Army Depot/DRXTO-TP-S Tobyhanna PA 18466	2
Picatinney Arsenal, SARPA-AD-D-P Dover NJ 07810	2

US Army Natick Research & Development Ctr/DRXNM-EPS Natick MA 01760	2
US Army Mobility Equipment Research & Development Ctr/SMEFB-RDE-DX Fort Belvoir VA 22060	2
US Army Missile Command/AMSMI-IDD Redstone Arsenal AL 35809	2
US Army Tank Automotive Command/AMSTA-TS Warren MI 48909	2
Naval Supply Systems Command, Code 0321B Washington DC 02376	2
Naval Logistics Engineer Group Cheatham Annex Williamsburg VA 23185	2
Naval Ship R & D Center, Code 2841 Annapolis MD 21402	2
Naval Ship Engineer Center Sec 6101E2, Prince George's Center Hyattsville MD 20782	2
Foster Miller Associates, Inc. Waltham MA 02154	2
HQ RADC/IRAQ Griffis AFB NY 1344C	2

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER PTPD Report No. 76-32	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EVALUATION OF HUMIDITY INDICATORS	5. TYPE OF REPORT & PERIOD COVERED Engineering Test Data rept. July 1974 - October 1976	6. PERFORMING ORG. REPORT NUMBER 76-32
7. AUTHOR(s) Edward J. Kowalski	8. CONTRACT OR GRANT NUMBER(s)	
9. PERFORMING ORGANIZATION NAME AND ADDRESS AFALD/PTPD WPAFB OH 45433	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AFPEA Project No. 73-P7-15	
11. CONTROLLING OFFICE NAME AND ADDRESS AFALD/PTPD WPAFB OH 45433	12. REPORT DATE December 1976	13. NUMBER OF PAGES 14
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 12 16p	15. SECURITY CLASS. (of this report) Unclassified	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) DISTRIBUTION LIMITED to U.S. Government agencies only; evaluation of commercial products Other requests for this document must be referred to AFALD/PTP, Wright-Patterson AFB OH 45433. TVE 22 DEC 76		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Exterior container Humidity indicator Test and evaluation		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Prototype humidity indicators, developed and fabricated by Foster-Miller Associates, Inc., Waltham MA under contract No. F33601-74-C-0815, were tested and evaluated by the contractor simultaneously with humidity indicators presently used or previously considered for packaging applications. → next page		

Continued

DD FORM 1473
1 JAN 73

EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

13 SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

403 519

1B

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

#20. ABSTRACT (Cont'd)

The newly developed humidity indicator is highly shock resistant, has a standard deviation of 2.2 percent RH over its calibrated range, is easily and quickly read on a calibrated scale, and is comparable in cost and mounting characteristics with the color change plug type that adapts into a 1 7/16 - 18 inch threaded hole.

From the tests conducted, some deficiencies have been identified with the newly developed humidity indicators, however, the deficiencies will be corrected prior to fabrication of preproduction prototype units.

Unclassified