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EVALUATION OF NINE STYLES OF FIBERBOARD BOXES WITH MORE THAN FOUR SIDES

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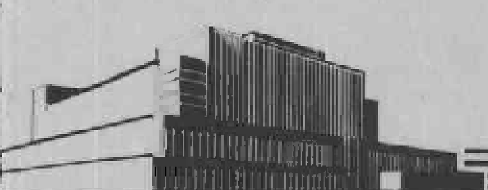

FOREST PRODUCTS LABORATORY
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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

EVALUATION OF NINE STYLES OF FIBERBOARD BOXES WITH MORE THAN FOUR SIDES

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Summary

This report presents the results of tests conducted at the Forest Products Laboratory to evaluate nine styles of hexagonal and octagonal fiberboard boxes by comparing their performance with that of rectangular boxes fabricated according to fiber box specifications. The comparative testing was accomplished by dropping the boxes, containing test loads, from a height of 15 inches, repeatedly, on one edge. Thirty-five rectangular boxes and 121 boxes with more than four sides were tested.

The tests indicated that seven of the nine styles of boxes performed about as well as, or better than, the rectangular control boxes. Two of the styles were inferior to rectangular boxes, and three styles were superior. The boxes that were superior were retested with 50 or 100 percent more load, and still performed adequately.

Introduction

The Bureau of Supplies and Accounts of the Navy Department requested in its letter of authorization dated November 7, 1955, that

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[1] Maintained by the U. S. Department of Agriculture at Madison, Wis., in cooperation with the University of Wisconsin.

the Forest Products Laboratory undertake the preparation of Federal Specification PPP-C-574, "Containers, Fiberboard, More Than Four Sides." It is intended that these containers will be used for the packing of certain household goods, hose, rope, and other materials.

In a letter, November 21, 1955, the Bureau of Supplies and Accounts wrote, "The proposed specification should cover two different styles of both hexagonal and octagonal boxes made of solid and corrugated fiberboard, domestic and overseas type. The size and weight limitations contained in Federal Specification LLL-B-631, and LLL-B-636, "Boxes, Fiber, Corrugated," "Boxes, Fiber, Solid," respectively, and other published specifications for rectangular fiberboard boxes should be used as a guide in preparing PPP-C-574. Results of tests conducted at the Forest Products Laboratory should aid in the final determination of weight limits."

In discussions with the Bureau of Supplies and Accounts and Fibre Box Association personnel, it was decided to conduct rough-handling tests of commercial hexagonal and octagonal boxes and also with comparable rectangular control boxes. All boxes were to be fabricated according to established specifications. The objective of this procedure was to determine the relative performance of hexagonal and octagonal boxes as compared to that of rectangular specification boxes. Then, the results of this test would lead to the establishment of realistic size and load limitations for hexagonal and octagonal boxes.

Fibre Box Association officials requested that nine different styles of boxes be evaluated. These styles are illustrated in figure 1. Since this evaluation of the nine styles of boxes would result in more variables than could be reasonably investigated at one time, it was decided to eliminate other variables during the first phase of the project. Solid fiberboard boxes and overseas boxes were removed from immediate consideration, because there were no commercial examples available. This elimination restricted the first phase to domestic and corrugated fiberboard boxes.

Description of Tests

A free-fall, edge-drop test was chosen for this project rather than a corner drop, because of the difficulty in performing corner drops on hexagonal and octagonal boxes. The type of load and height of drop were decided upon after a preliminary series of drops performed with rectangular boxes. Wood blocks or cylinders were selected for test loads after books were tried and discarded. The books shifted after several drops so that box failure was not progressive. Several heights of drop were tried before 15 inches was chosen. With wooden cylinders as loads, and a 15-inch height of drop, failures of the boxes were progressive and complete after 10 to 40 falls, depending on load and size.

The drops were accomplished on the drop table as shown in figure 2. Each box was oriented by means of a plumb bob, so that the diagonally opposite edge was directly above the drop edge, as shown in the figure. The drops were performed by suddenly removing the support block from under the table leaves so the boxes could fall freely on the steel plate beneath.

Each box was dropped repeatedly until failure occurred, or until the number of drops reached 30. Failure was defined as the fall after which the contents spilled, or when one of the cylinders could be removed easily.

The testing was divided into two parts. Part I was testing of commercially submitted hexagonal and octagonal boxes along with rectangular controls that were prepared at the Laboratory, to conform to existing fiber box specifications, and to be similar in gross weight and size. Part II was testing of hexagonal and rectangular boxes constructed from the same lot of fiberboard, and made to be similar in gross weight and size. Prior to testing each box was conditioned to an equilibrium moisture content of about 8 percent in a room held at 73° F. and 50 percent relative humidity.

Discussion of Results

The results of the 34 tests in part I are presented in table 1. Only six of the nine styles of boxes were sent in by manufacturers, so only six styles are mentioned in the table. The tests representing style A boxes were actually performed by dropping style G boxes on their tops. Failure was characterized by "pulling out" of the staples fastening top to sides (fig. 3). This type of top (or bottom) is inferior in performance to its rectangular control box. The flaps on the top were wide enough to permit only one row of staples in effecting closure.

Style B boxes failed at either a top-to-side or bottom-to-side edge (figs. 4 and 5), and generally failed after fewer falls than the corresponding control boxes. Some of these results were inconclusive, however, which justified a retest in part II.

Style D boxes performed exceptionally well, and were superior in all but one instance to the control boxes. Style D boxes were evaluated with steel strap (3/8 inch), filament-reinforced tape (1/2 inch), and hemp twine. The twine failed after 10 drops, and the contents spilled. Failure of the other boxes was characterized by a tearing-off of flaps which released the strap or tape, and allowed easy removal of the loads (fig. 6).

Style E boxes also exhibited superior performance. Boxes were tested both with 3/8-inch steel strapping, and a 1/2-inch filament-reinforced tape. Typical failure is illustrated in figure 7. The bottoms tore through at an edge away from the drop edge.

Style G boxes, with their multiple-layer bottoms, resisted 30 falls easily. The bottoms, after a few falls, became soft and spongy, and served well as a cushion or shock absorber for subsequent falls.

The design of style H boxes is not adequate to resist falls on either tops or bottoms. The little tabs on the sides that key into the top (or bottom) soon disengage, and permit the top (or bottom) to loosen, and spill the contents (fig. 8).

The results of the 122 tests in part II are presented in table 2. Styles A, B, C, D, E, and G are included. Style K was not included because of its similarity to style C. Style G was not included because its bottom proved adequate in part I, and its top is identical to style A. Style H was not included because of its poor performance demonstrated in part I.

Style A boxes, in groups 20, 30, and 40 failed much the same as they did in part I, by "pulling out" of the staples which fastened top and bottom to sides. In all cases, the test boxes always failed before the control boxes. However, in group 50, the flaps were increased from 1 inch to 1-1/2 inches in width, and two rows of staples were used instead of one. This increased the performance level of style A boxes and made them somewhat better than the rectangular control boxes.

Style B boxes resisted more falls in groups 30 and 40 than did the control boxes. In group 20, their performance was slightly inferior. In general, considering both parts I and II, the results of testing style B boxes are rather inconclusive. However, if all the falls are totaled for style B boxes, and for the control boxes, the control boxes resisted 147 falls and the style B boxes 112 falls.

All of the style C boxes in groups 20, 30, and 40 resisted about as many or more falls than the rectangular control boxes. Failures were characterized by tearing of the top edge opposite the bottom edge being dropped. Style K boxes were considered so similar to style C boxes that it wasn't necessary to test both. The top and bottom inserts were deemed necessary to provide a surface for attaching the overlapping flaps.

The performance of style D boxes in groups 20, 30, and 40 as a whole was not as good as their rectangular controls. These boxes were closed without the top and bottom inserts required in figure 1. In group 50, when the inserts were included, the performance was so much improved that it was decided to test with loads 50 percent greater. The performance of the overloaded style D boxes, in group 60, was still substantially better than the control boxes.

Style E boxes, in groups 20, 30, and 40 performed so much better than the rectangular boxes that it was also decided to try 50 percent overloads in group 50. The results of style E box tests in group 50 showed such superior performance, even when overloaded, that group 60 tests included style E boxes containing 100 percent overloads. Even when 100 percent overloaded, the style E boxes performed satisfactorily.

The five style F boxes in group 50 performed much better than the rectangular boxes. This style was similar to style B, but had flaps on top and bottom for strapping to the body, which increased the performance considerably. The performance of style F boxes in group 60, when 50 percent overloaded, was still far superior to the control boxes.

Conclusions

The tests indicated that three styles (D, E, and F) of the nine styles of fiberboard boxes tested were superior in performance to rectangular fiberboard boxes and are suitable in domestic shipments for loads that are 100 percent in excess of those permitted in the fiber box specifications. Four styles (A, B, C, and G) were about equal, performancewise, to rectangular fiberboard boxes and are satisfactory in domestic shipments for the same load and size limitations. Two styles (K and H) were inferior in performance to rectangular fiberboard boxes and are therefore not suitable for general domestic shipments.

Table 1.--Results of drop tests of hexagonal, octagonal, and rectangular fiberboard boxes in part I of evaluation

Box No.	Style	Shape	Gross weight	Perimeter/2 + depth	Mullen test	Falls	Length + width + depth	Mullen test	Falls
Boxes with more than four sides							Controls		
			Pounds	Inches	P.s.i.		Inches	P.s.i.	
1	A	Hexagonal	97	61-1/2	335	3	66	362	21
2	A	....do.....	97	61-1/2	335	6	66	362	12
3	B	Octagonal	64	30-3/4	327	5	32	300	4
4	B	....do.....	64	30-3/4	327	4	32	300	10
5	B	....do.....	64	30-3/4	327	6	32	300	6
6	B	Hexagonal	59	33-3/4	317	6	36	337	25
7	B	....do.....	32	38	317	21	41	337	30
8	D	Octagonal	121	66	430	30	72	484	14
9	D	....do.....	142	66	430	[1]10	68	484	7
10	D	....do.....	142	66	430	30	68	484	18
11	D	....do.....	142	66	430	30	68	484	18
12	E	Octagonal	145	66-1/2	450	29	70	410	3
13	E	....do.....	145	66-1/2	450	20	70	410	3
14	E	....do.....	145	66-1/2	450	25			
15	G	Hexagonal	97	61-1/2	298	30	66	362	21
16	H	Octagonal	121	61	344	1	67	456	7
17	H	....do.....	121	61	344	2	67	456	5
							67	456	7

[1] This box was closed with twine which failed at 10 falls. One-half inch pressure-sensitive filament tape and 3/8-inch steel strapping resisted 30 falls.

Table 2.--Results of drop tests of hexagonal and rectangular fiberboard boxes in part II of evaluation

Box group No.	Style	Shape	Gross weight	Perimeter/2 + depth	Mullen test	Falls	Controls: Length + width + depth	Controls: Mullen test	Controls: Falls
			Pounds	Inches	P.s.i.		Inches	P.s.i.	
20	A	Hexagonal	65	52-1/2	245	6,5,5,5,5	55	245	3,8,8,7,6
20	B	...do....	65	52-1/2	245	4,4,6,4,4	55	245	3,8,8,7,6
20	C	...do....	65	52-1/2	245	9,6,5,5,30	55	245	3,8,8,7,6
20	D	...do....	65	52-1/2	245	4,12,3,10,3	55	245	3,8,8,7,6
20	E	...do....	65	52-1/2	245	30,30,30,30,30	55	245	3,8,8,7,6
30	A	Hexagonal	120	52-1/2	417	4,6,5,4,6	55	417	6,7,4,6,4
30	B	...do....	120	52-1/2	417	4,5,6,7,6	55	417	6,7,4,6,4
30	C	...do....	120	52-1/2	417	18,20,24,30,14	55	417	6,7,4,6,4
30	D	...do....	120	52-1/2	417	2,6,2,3,12	55	417	6,7,4,6,4
30	E	...do....	120	52-1/2	417	30,30,30,30,30	55	417	6,7,4,6,4
40	A	Hexagonal	120	60-1/4	417	3,3,3	62-3/4	417	5,4,4
40	B	...do....	120	60-1/4	417	4,7,9	62-3/4	417	5,4,4
40	C	...do....	120	60-1/4	417	15,11,10	62-3/4	417	5,4,4
40	D	...do....	120	60-1/4	417	4,2,5,2,3	62-3/4	417	5,4,4
40	E	...do....	120	60-1/4	417	30,30,30,30,30	62-3/4	417	5,4,4
50	A	Hexagonal	65	52-1/2	200	8,10,17,13,30	55	200	11,7,13,7,8
50	D	...do....	65	52-1/2	200	30,30,30,30,30	55	200	11,7,13,7,8
50	E	...do....	97.5	52-1/2	200	30,30,24,20,28	55	200	11,7,13,7,8
50	F	...do....	65	52-1/2	200	30,30,30,30,30	55	200	11,7,13,7,8
60	D	Hexagonal	97.5	52-1/2	200	30,30,26,24,20	55	200	11,7,13,7,8
60	E	...do....	130	52-1/2	200	17,14,30,14,23	55	200	11,7,13,7,8
60	F	...do....	97.5	52-1/2	200	30,22,29,30,30	55	200	11,7,13,7,8

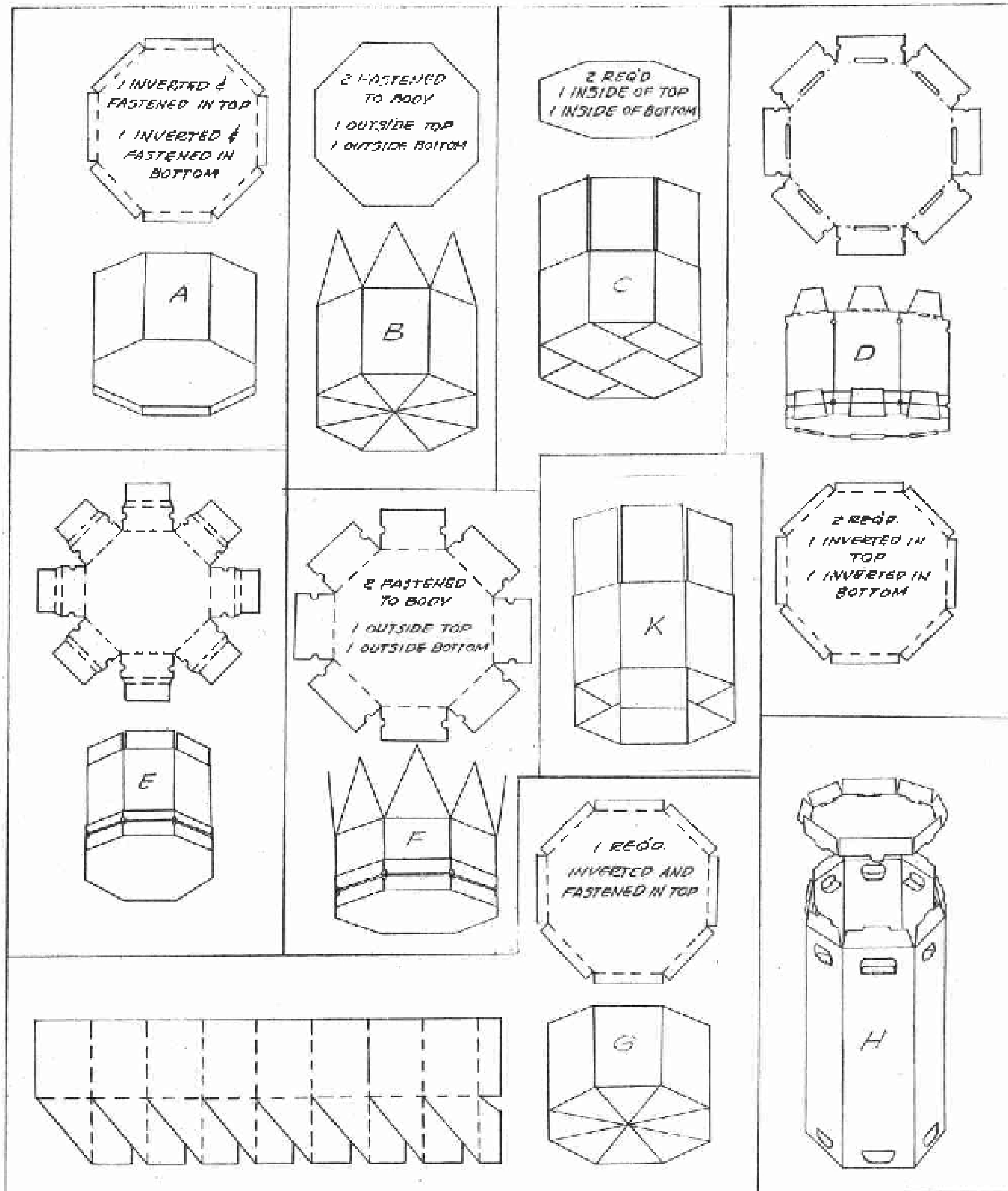

Figure 1.--Nine styles of fiberboard boxes with more than four sides.

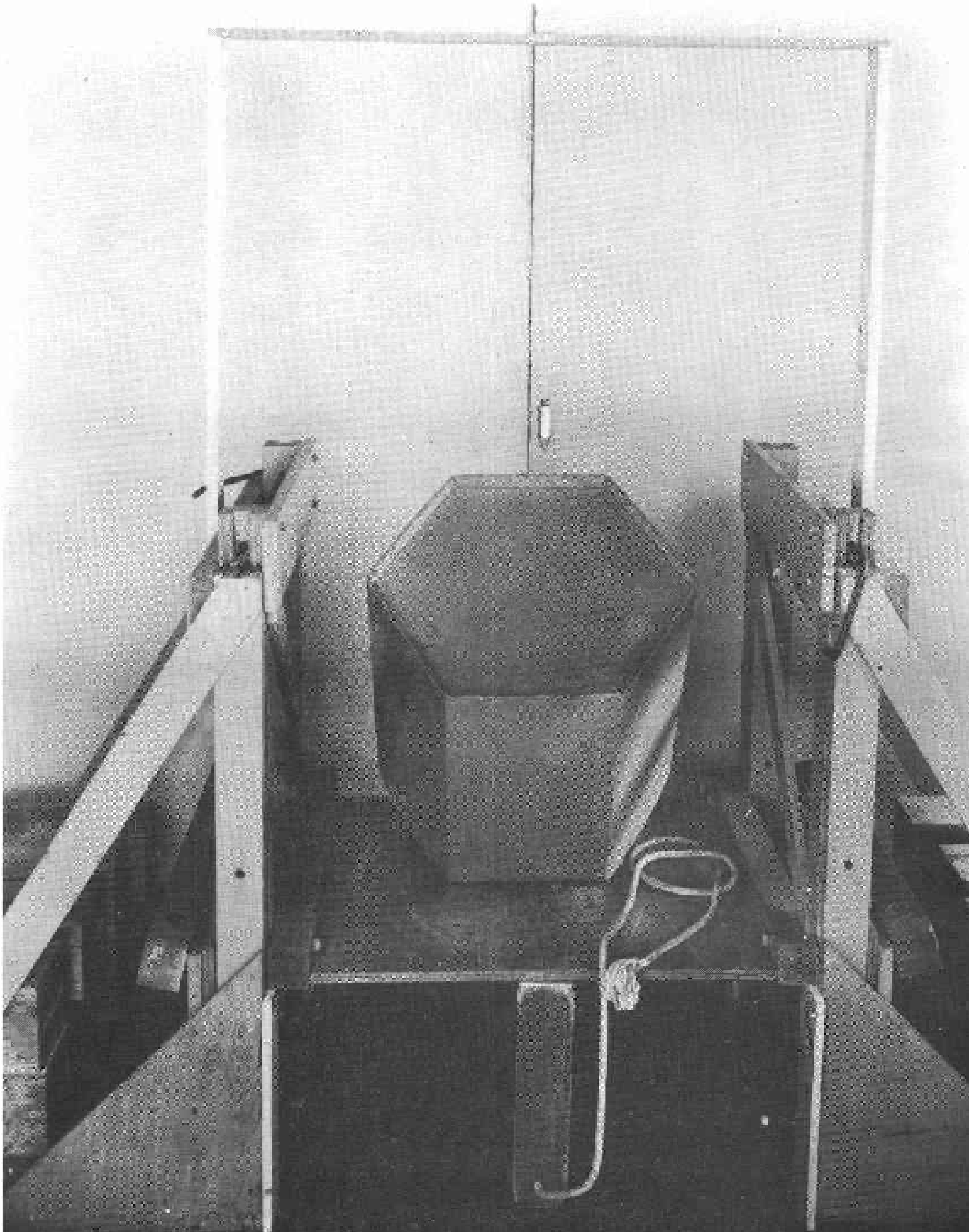

Figure 2.--Setup for drop test of a hexagonal, fiberboard box. The plumb bob used is for positioning the box so that diagonally opposite edges are in a vertical plane.

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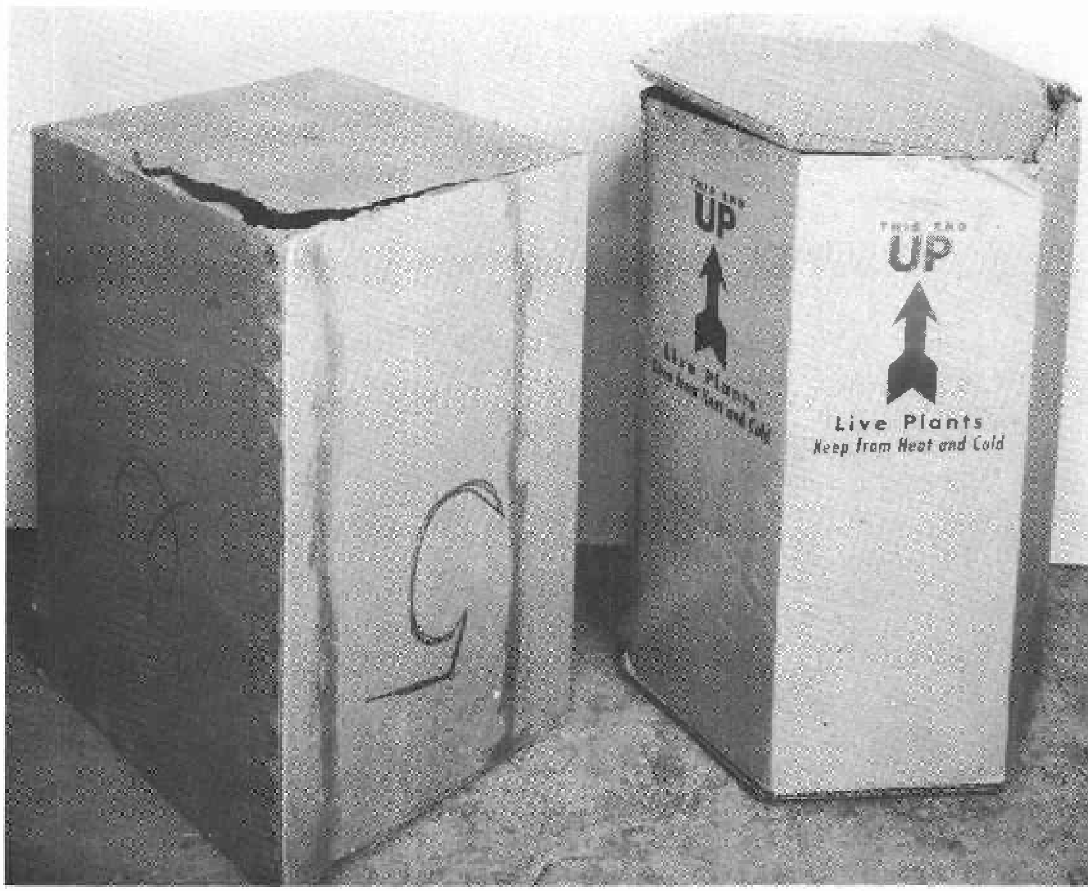

Figure 3.--Typical failure of a style A box and its corresponding rectangular control box. The hexagonal box is a style G box, but it was dropped on its top which is identical to style A construction.

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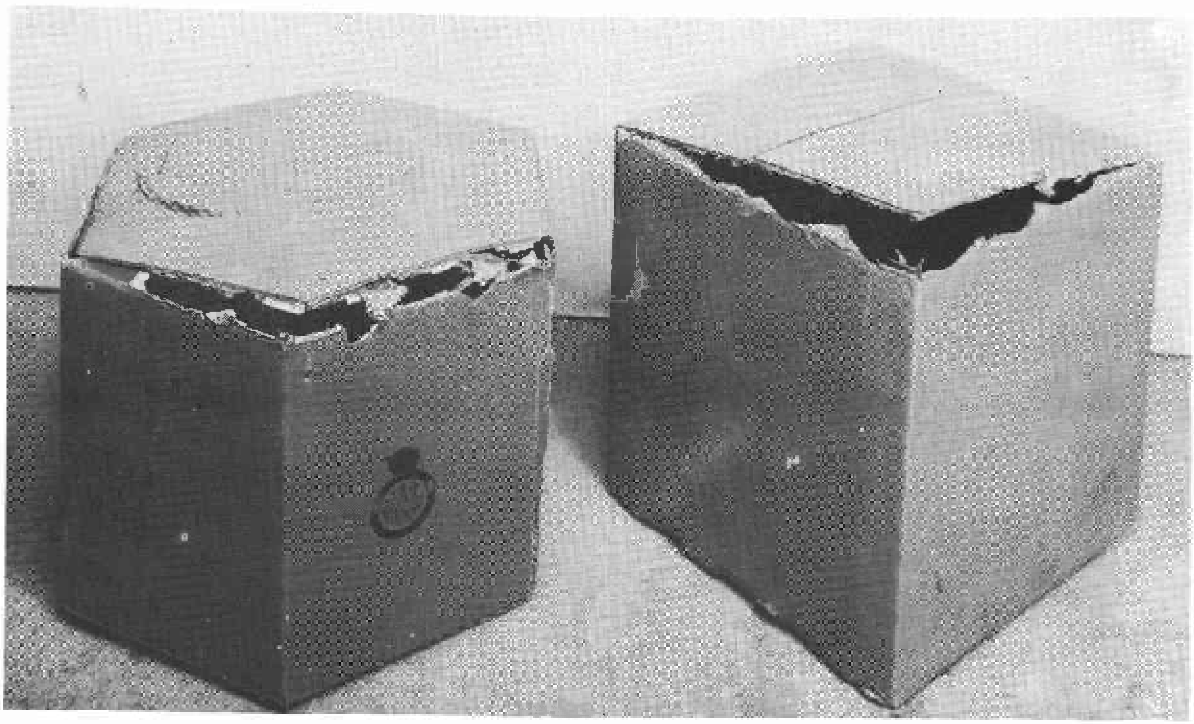

Figure 4.--Typical failure of a style B, hexagonal box and its corresponding rectangular control box.

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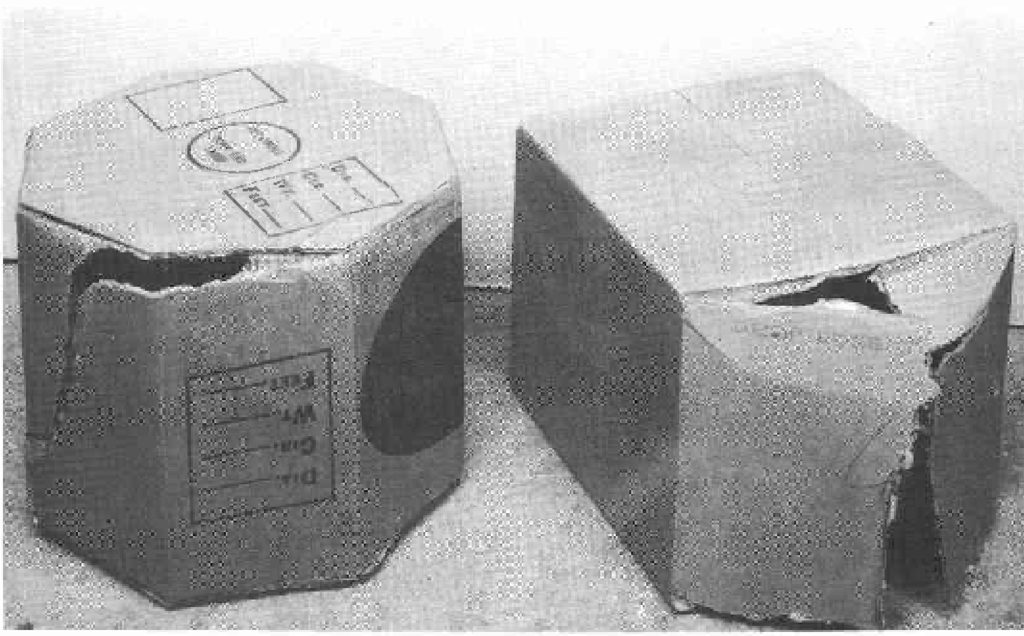

Figure 5.--Typical failure of a style B, octagonal box and its corresponding rectangular control box.

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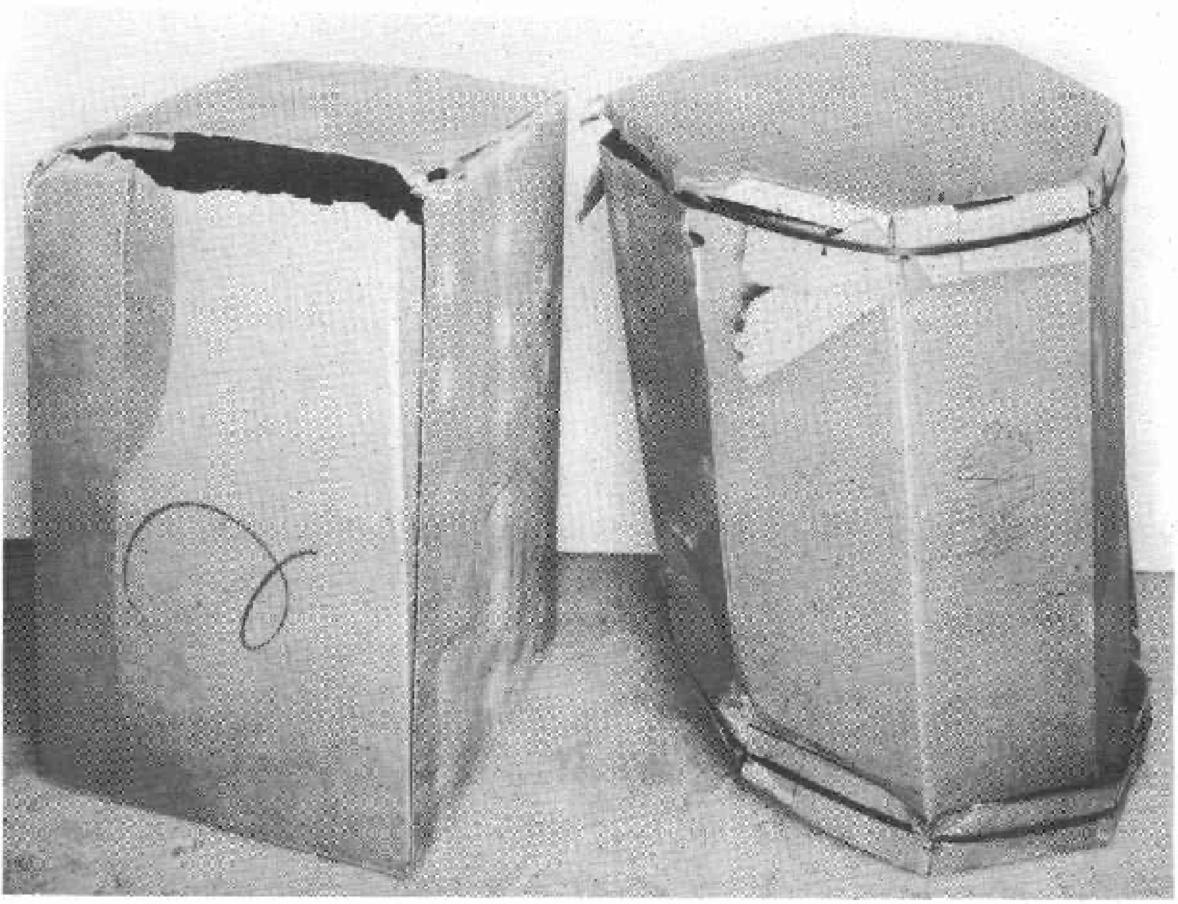

Figure 6.--Typical failure of a style D, octagonal box and its corresponding rectangular control box.

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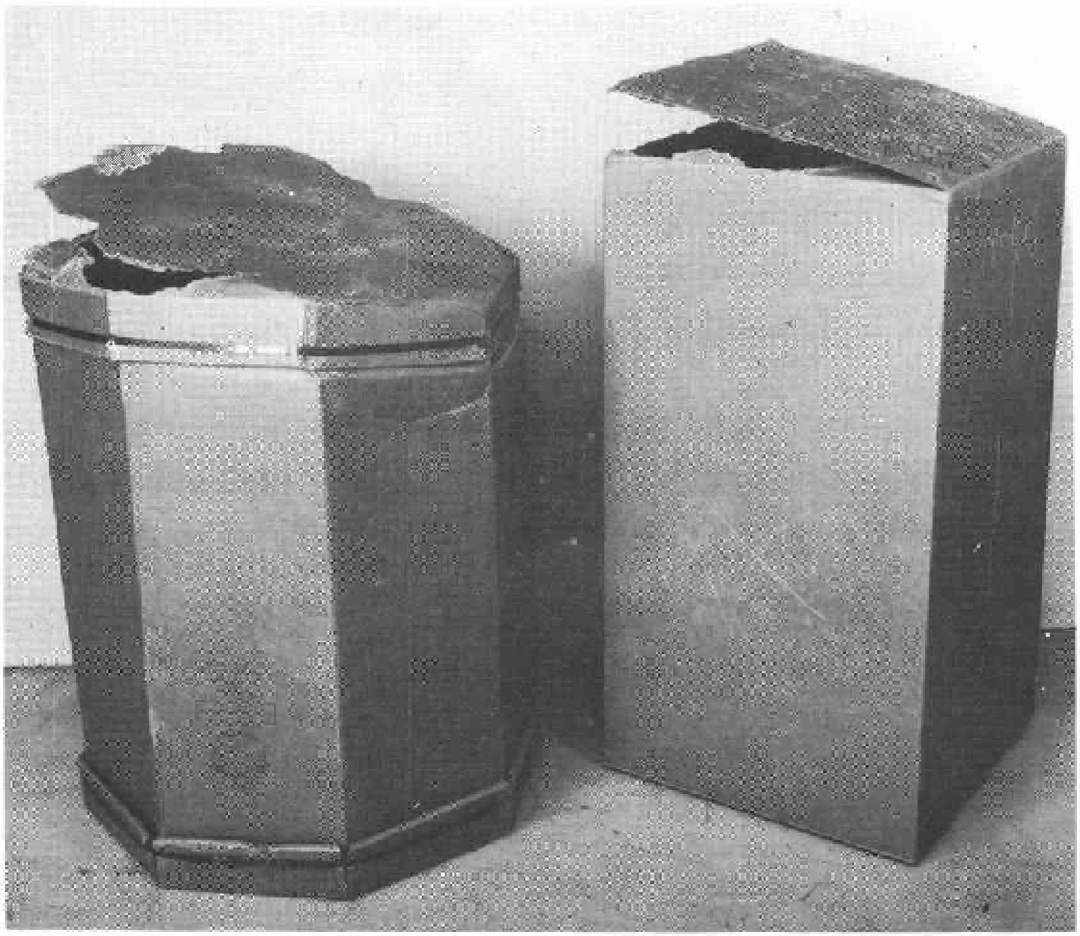

Figure 7.--Typical failure of style E, octagonal box and its corresponding rectangular control box.

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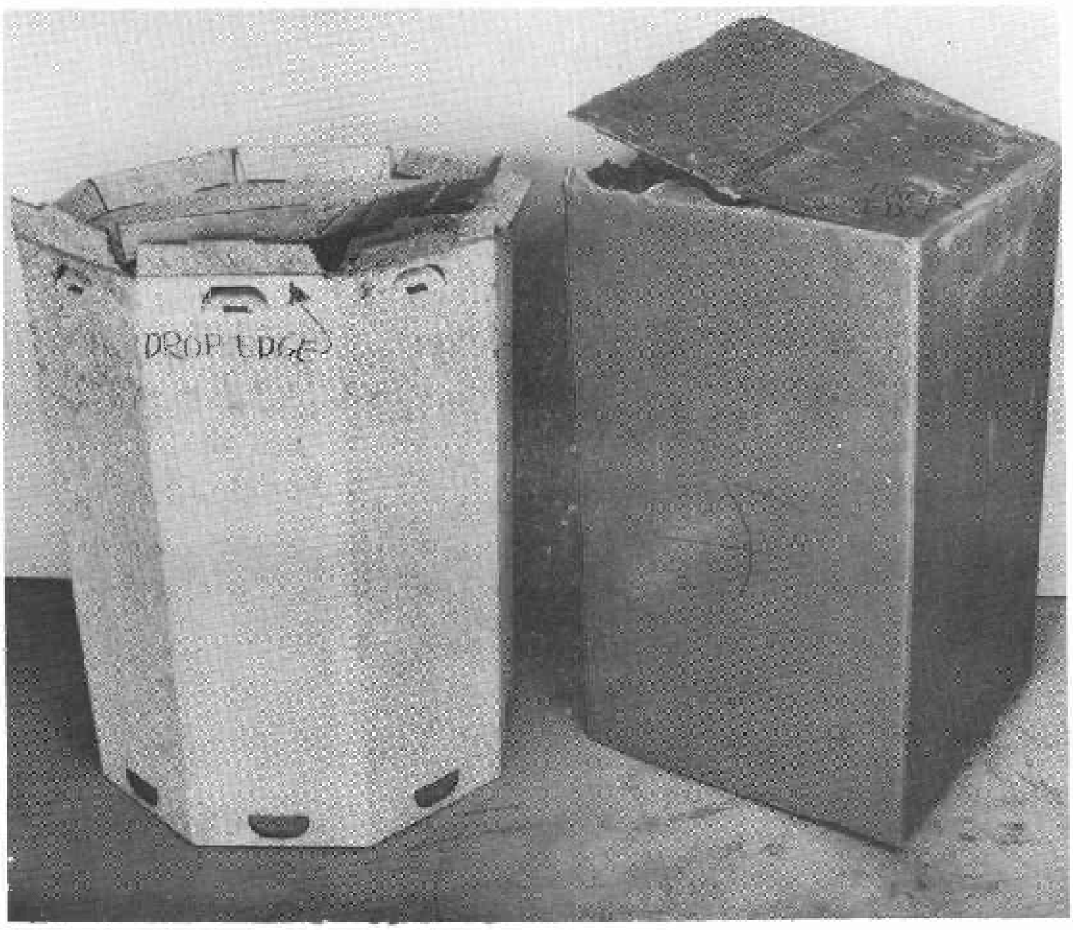

Figure 8.--Typical failure of style H, octagonal box and its corresponding rectangular control box.

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SUBJECT LISTS OF PUBLICATIONS ISSUED BY THE

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The following are obtainable free on request from the Director, Forest Products Laboratory, Madison 5, Wisconsin:

List of publications on Box and Crate Construction and Packaging Data

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List of publications on Fungus Defects in Forest Products and Decay in Trees

List of publications on Glue, Glued Products, and Veneer

List of publications on Growth, Structure, and Identification of Wood

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List of publications on Structural Sandwich, Plastic Laminates, and Wood-Base Aircraft Components

List of publications on Wood Finishing

List of publications on Wood Preservation

Partial list of publications for Furniture Manufacturers, Woodworkers and Teachers of Woodshop Practice

Note: Since Forest Products Laboratory publications are so varied in subject no single list is issued. Instead a list is made up for each Laboratory division. Twice a year, December 31 and June 30, a list is made up showing new reports for the previous six months. This is the only item sent regularly to the Laboratory's mailing list. Anyone who has asked for and received the proper subject lists and who has had his name placed on the mailing list can keep up to date on Forest Products Laboratory publications. Each subject list carries descriptions of all other subject lists.