SUMMARY OF A STUDY OF TEMPERATURES ATTAINED IN A DUMMY AIRCRAFT WING DURING THE SUMMER AT MADISON, WISCONSIN

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UNITED STATES DEPARTMENT OF AGRICULTURE
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Madison, Wisconsin

In Cooperation with the University of Wisconsin
SUMMARY OF
A STUDY OF TEMPERATURES ATTAINED IN A DUMMY
AIRCRAFT WING DURING THE SUMMER
AT MADISON, WISCONSIN

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The material herewith presented comprises a summary of the principal results of a more extensive report issued by the Forest Products Laboratory as Mimeograph No. 1343B. Reference should be made to the extensive report for details of test procedure and results.

Because of the poor ventilation of the enclosed air spaces and the dark camouflage paints with which military aircraft are painted, some of the woodwork becomes heated to temperatures far above those of the surrounding air when the aircraft are on the ground in bright sunshine. The experiments discussed here were made to give an indication of the magnitude of the temperatures that may be attained and some of their consequent effects on the moisture content of the woodwork.

Phases of the study included (1) the effect of weather upon internal wing temperatures; (2) the effect of temperatures upon the glue used to construct the plywood; (3) the relation between temperature and moisture content of the wing interior; and (4) the effect of the reflective power of different finishes upon the internal temperatures attained.

1. Dummy aircraft wings consisting of wood framework covered with 3/32-inch aircraft plywood were constructed and exposed at Madison, Wis., in such a way as to permit the sun to shine directly on the upper surfaces. Thermocouples suitably placed permitted readings of the temperatures reached at various times throughout the daylight hours during July and August, 1942. When exterior surfaces were finished with a typical olive drab camouflage

1This mimeograph is one of a series of progress reports issued by the Forest Products Laboratory to further the Nation's war effort. Results here reported are preliminary and may be revised as additional data becomes available.
finishing system, it was found that the upper painted surface and the cuter
glue line in the plywood sometimes reached 180°F. or slightly more at times
when the temperature of the outside air was no higher than 85°F. The tem-
perature of the air proved to be a much less important factor than the angle
of incidence of the sun's rays, which changes with the time of day and the
season of the year, the velocity of the wind, or the presence or absence of
clouds to dull the sun's rays. As a rule, maximum surface and glue-line tem-
peratures occurred when the sun reached meridian, although the maximum out-
side air temperature might not be reached for another hour or two, by which
time the surface and glue line had begun to cool off noticeably. Mere pas-
sage of a cloud over the sun promptly cooled both surface and glue line,
although the air temperature remained essentially unchanged. Windy days
never produced surface and glue-line temperatures as high as those observed
when there was little or no wind, even though the windy days were often fully
as warm as the still days.

Temperatures in the enclosed air spaces within the dummy wings followed
not far behind those at the upper surface, reaching temperatures as high as
170°F. when the outside temperature was 90°F. Glue lines in the plywood on
the bottom of the dummy wing reached temperatures as high as 135°F.

Presumably still higher temperatures are attainable in other parts of
the world where the intensity of sunlight is greater than it is at Madison,
Wis. Even at Madison, higher temperatures might have been observed if the
tests had been started by the middle of June, when the sun reaches its maximum
angle.

2.—The temperatures reached in the glue lines of the upper plywood
under the conditions of the test apparently were high enough to soften the
thermoplastic glue used, because opening of joints and delamination attribut-
able to "creep" of the glue were observed. Where thermosetting phenolic-
resin glue was used in making the plywood a few slight cracks developed at
joints, but there was no evidence of "creep" or delamination.

3.—To study changes in moisture content in woodwork within the dummy
wing resulting from the marked rises in temperature during sunny days, two
spruce specimens representative of small braces in ribs were inserted in one
of the air spaces in such manner as to permit quick removal for weighing and
reinsertion. One specimen was left unfinished and the other was protected
with a very generous coating of a typical aircraft sealer. Starting with the
specimens in the oven-dry condition, it was found that the unfinished specimen
came to approximate equilibrium with the environment within 2 days but the
finished specimen required approximately one week. Subsequently, the unfin-
ished specimen fluctuated in moisture content as much as 1.3 percent within a
single day, whereas the finished specimen experienced daily fluctuations of
no more than 0.6 percent. During August the unfinished specimen fluctuated
between 7.6 and 5.4 percent, the finished specimen between 6.8 and 5.7 percent
moisture content. For both specimens, the over-all average moisture content
for the mid-summer season seemed to be about the same, roughly 6.5 percent.
For the period under consideration, the spread from maximum to minimum mois-
ture content was 2.2 percent for the unfinished and 1.1 percent for the fin-
ished specimen. In stretches of bright, sunny days, the finished specimen

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usually contained more moisture, and in stretches of cloudy days it contained less moisture than the unfinished specimen. (Although this report is concerned with the summer season only, the observations have been continued. With the passing of summer weather, both specimens slowly increased in moisture content until by the middle of December they attained approximately 15 percent moisture content.)

4. --Experiments were made in a second dummy wing, in which the neighboring sections between ribs were finished with exterior paints differing in color and reflective power for infrared radiation. It was found that higher surface, glue-line, and interior air space temperatures were developed, the lower the infrared reflectance of the paint. Highest temperatures were obtained under a blue camouflage paint of 5 percent reflectance, and lowest temperatures were recorded with a glossy yellow enamel of 80 percent reflectance. The order of difference in temperature at 1:30 p.m. on August 28, when the outside temperature was 90° F., is indicated in the following table:

<table>
<thead>
<tr>
<th>Location of thermocouple</th>
<th>Temperature in degrees F, in section painted with--</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glue line in upper plywood</td>
<td>-- 157 10% 50% -- --</td>
</tr>
<tr>
<td>Glue line between upper plywood and rib cap</td>
<td>159 156 145 136</td>
</tr>
<tr>
<td>Enclosed air space</td>
<td>146 138 133 129</td>
</tr>
<tr>
<td>Glue line between lower plywood and rib cap</td>
<td>128 123 120 116</td>
</tr>
</tbody>
</table>

Variations in temperature with different finishes

Mimeo. No. 1343A -3-
Figure 1.--The dummy wing partly assembled, showing some of the wiring for the thermocouples.