

REFLECTIVE SHEETING DETERIORATION  
ON PLYWOOD

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MICHIGAN DEPARTMENT OF STATE HIGHWAYS

**REFLECTIVE SHEETING DETERIORATION  
ON PLYWOOD**

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**Research Laboratory Section  
Testing and Research Division  
Research Project 69 G-170  
Research Report No. R-705**

**State of Michigan  
Department of State Highways  
Lansing, June 1969**

## REFLECTIVE SHEETING DETERIORATION ON PLYWOOD

Loss of nighttime reflectivity and a black daytime appearance was noted on signs made with 3M reflective sheeting on high-density overlay plywood panels. The problem was submitted to this Laboratory by J. C. Brehler on April 17, 1969 with a request to test MDSH warehoused plywood stock and identify the plywood stock with sign failures in the field. This report covers the history, testing, and conclusions of this investigation.

### History

The problem of reflective sheeting deterioration was initially brought to the Laboratory's attention prior to April 17 by A. Lampe, a 3M representative. He noted that the deterioration had been evident for sometime in Michigan, and that 3M had been investigating a similar problem at the request of other States.

The plywood problem was discussed during an April 17 visit with 3M at Minneapolis, and results of the discussion were reported to J. P. Woodford on April 24, 1969. It was noted that MDSH representatives had informed 3M of the sheeting deterioration and that 3M had replied to MDSH stating that the plywood was faulty.

Other detailed information obtained at 3M is as follows:

1. The failure was identified as a corrosion of the reflective sheeting reflector coat (probably aluminum) that renders the sheeting transparent.
2. The corrosion was first noted in Maryland late in 1967.
3. Simpson plywood was involved.
4. Corrosion was most frequently noted along the upper edge of a sign and usually at core gaps.
5. Corrosion occurs only on pressure-sensitive sheeting.
6. The corrosive agent is probably in the high-density overlay--probably an alkaline mold release agent--that has been identified by the American Plywood Association.

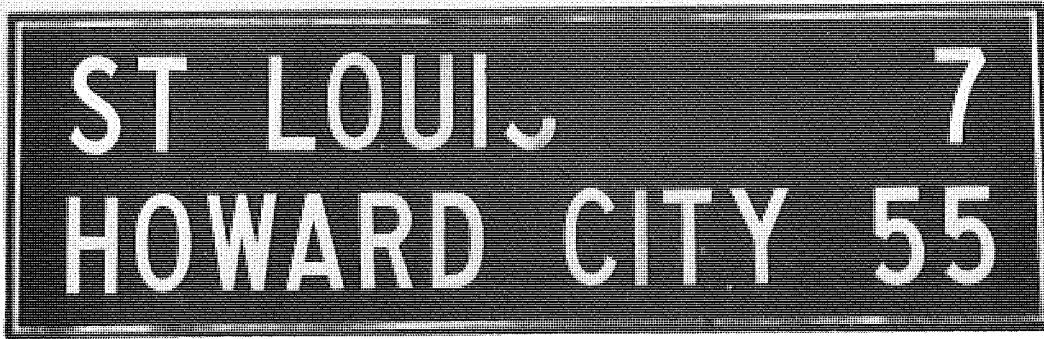


Figure 1. Sign showing reflective sheeting reflector coat corrosion. Note dark areas on top and bottom border.

Figure 2. Portion of barricade bar showing reflective sheeting reflector coat corrosion. Note dark areas showing the plywood grain, indicating sheeting transparency.

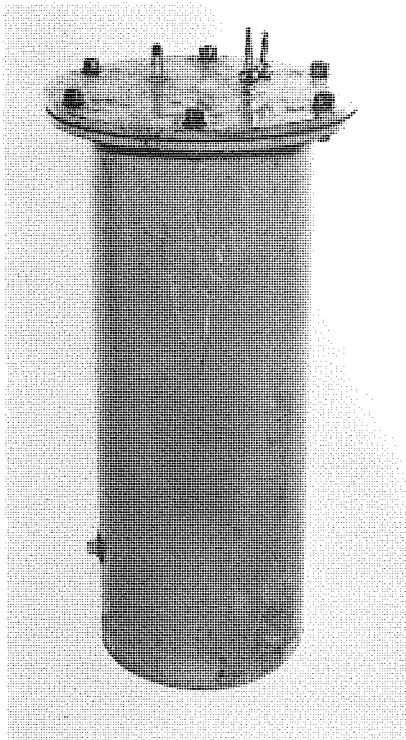
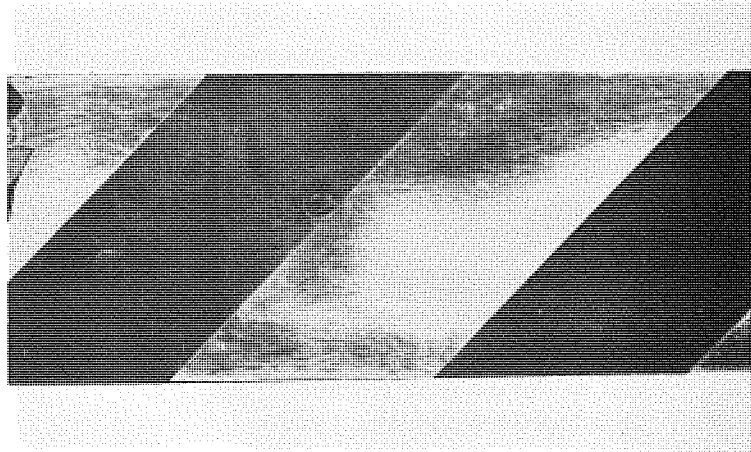
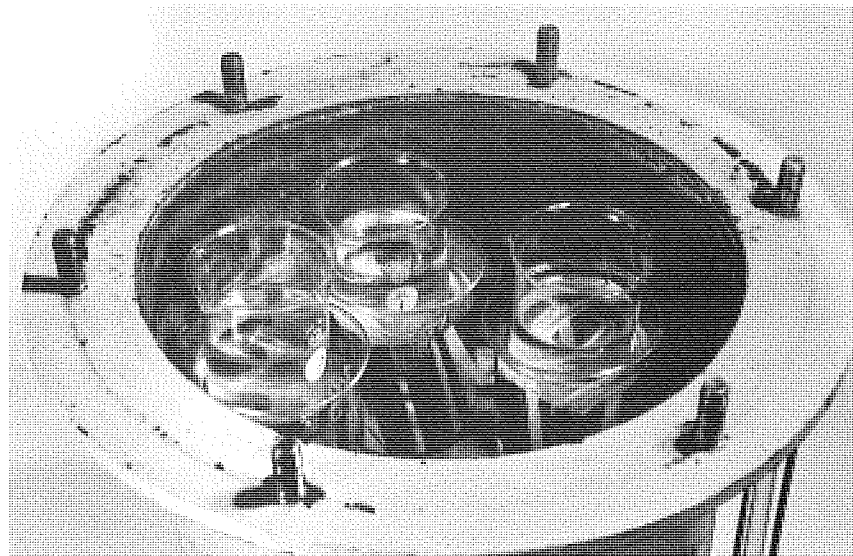


Figure 3. Vacuum/Air-Pressure chamber to water-saturate plywood specimens.



7. The corrosive agent was isolated from Simpson Timber Company production.

8. Simpson has corrected the problem and Simpson plywood edge-branded with an R-2 is satisfactory. The complete edge brand is:  
"Simpson  $\diamond$  GENERAL USE HDO G1-60/60 EXT DFPA 10 PS 1-66 R-2."

9. Other plywood overlays can produce the same corrosive effect but for a different reason.

10. Minnesota Mining (3M) had a method of testing the plywood and had incorporated the test in a suggested specification.

11. Samples of their plywood test panels were inspected, the test procedure was reviewed, and a copy of the method was brought to this Laboratory.

On April 28 a plywood sign was brought to the Laboratory exhibiting loss of nighttime reflectivity (Fig. 1). The plywood had been identified as U. S. Plywood. The sheeting showed corrosion of the reflector coating. One bar from a barricade was received the same date showing a similar sheeting corrosion (Fig. 2).

Department correspondence concerning the problem was not available to this Laboratory and it was suggested that we refrain from contacting the Simpson Timber Company.

### Testing

Samples of plywood were obtained from the warehouse and tested in accordance with the method suggested by 3M. A description of the method is in Appendix A. The samples were water-saturated in the vacuum/air pressure chamber (Fig. 3) and incubated in an oven at 150 F for 24 hours. Table 1 lists the plywood source and edge brand, date tested, and test results.

All specimens (2- by 3-1/2-in. blocks) contained the black high-density overlay on two sides and strips of pressure-sensitive reflective sheeting on two sides. Specimens were tested in triplicate.

The Simpson specimens noted in Table 1 as "Received by MDSH April 1968" were given various surface treatments prior to testing either in the MDSH sign shop in Lansing or the Research Laboratory prior to sheeting

TABLE 1  
IDENTIFICATION OF PLYWOOD SAMPLES

Source	Manufacturer's Edge Brand	Date Tested (1969)	Test Results
Simpson Timber Company <sup>1</sup>	Simpson ◇ GENERAL USE HDO B1 - 60/60 EXT DFPA 10 PS 1-66	May 5 and 20	Reflective Sheeting corroded
Simpson Timber Company	Simpson ◇ GENERAL USE HDO G1 - 60/60 EXT DFPA 10 PS 1-66R-2	May 8	Reflective Sheeting not affected
Simpson Timber Company <sup>2</sup>	Simpson ◇ GENERAL USE HDO G1 - 60/60 EXT DFPA 10 PS 1-66	May 20 and 26	Reflective Sheeting not affected
Simpson Timber Company Mill No. 30	Simpson ◇ HDO - G1 EXT - DFPA 30 PS 1-66 TWO SIDES 60-60	May 15 and 26	Reflective Sheeting corroded
Georgia Pacific	GP HIGH DENSITY 60/60 EXT - DFPA B-B8 CS45-60	May 20	Reflective Sheeting not affected
U. S. Plywood	60/60 US PLYWOOD PERMAPLY HDO G1 - EXT - DFPA 28 PS 1-66	May 20	Reflective Sheeting not affected

<sup>1</sup> Received by MDSH, April 1968.

<sup>2</sup> Received by MDSH, November 1968.

application. All specimens showed reflective sheeting corrosion when prepared as follows:

1. Wiped with a naphtha-dampened rag at the sign shop. Immediately after surface treatment, sheeting was applied at the sign shop using vacuum applicator (Fig. 4).

2. Wiped with a naphtha-dampened rag in the Laboratory. Immediately after surface treatment, sheeting was applied in the Laboratory (Fig. 5).

3. Lightly sanded and wiped with a naphtha-dampened rag in the Laboratory. Immediately after surface treatment, sheeting was applied in the Laboratory (Fig. 6).

4. Scrubbed with naphtha-saturated cheesecloth in the Laboratory. Seventy-two hours after surface treatment, sheeting was applied in the Laboratory (Fig. 7).

5. Scrubbed with naphtha-saturated cheesecloth in the Laboratory. Seventy-two hours after surface treatment, sheeting was applied at the sign shop (Fig. 8).

6. Thoroughly sanded and wiped with a naphtha-dampened rag in the Laboratory. Immediately after surface treatment, sheeting was applied in the Laboratory.

7. Swabbed with concentrated hydrochloric acid, rinsed, and wiped dry in the Laboratory. Six hours after surface treatment, sheeting was applied in the Laboratory (Fig. 9). Two specimens shown on the right in Figure 9, from plywood with the Simpson R-2 edge brand, were similarly treated in order to check the effects of the concentrated hydrochloric acid. The untreated Simpson R-2 plywood was tested and showed no corrosion effects.

8. No surface treatment, sheeting applied in the Laboratory (Fig. 10).

Corrosion effects were not as severe when Simpson plywood noted above as "Received by MDSH April 1968" was prepared as follows:

1. One specimen was sanded sufficiently in one spot to remove the high-density overlay. Figure 11 shows removal of the overlay in the center of the specimen before the test and both sides of the specimen after test.

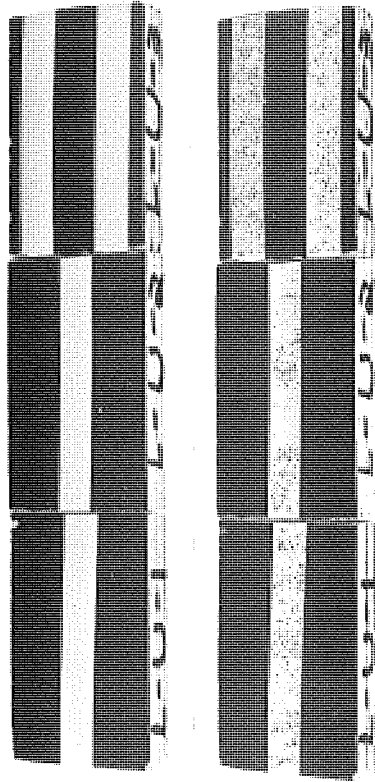


Figure 5. Specimens wiped with naphtha-dampened rag in the Laboratory (sheeting applied in Laboratory). Specimens are shown before test (top) and after test (below).

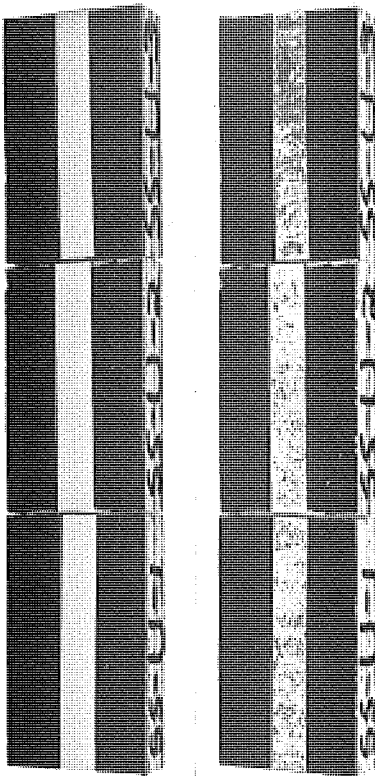


Figure 4. Specimens wiped with naphtha-dampened rag in the Lansing sign shop (sheeting applied in sign shop). Specimens are shown before test (top) and after test (below).

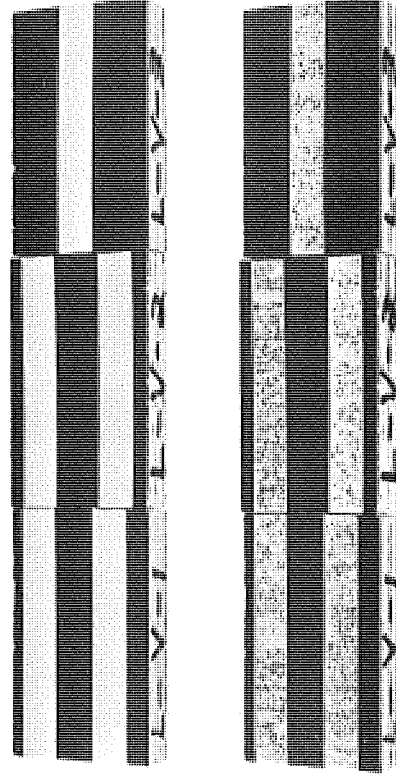


Figure 7. Specimens scrubbed with naphtha-saturated cheesecloth in the Laboratory (sheeting applied in the Laboratory). Specimens are shown before test (top) and after test (below).

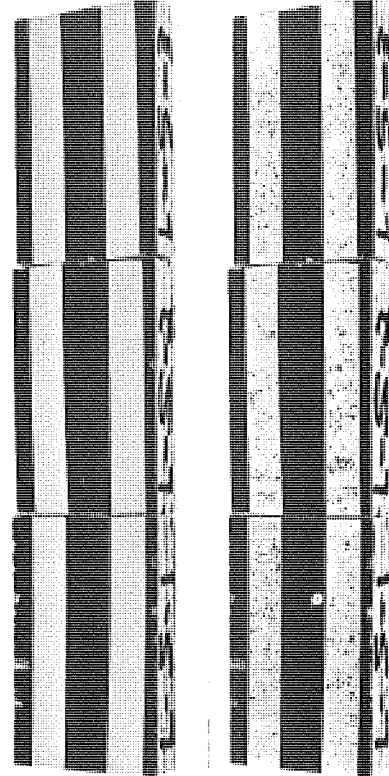


Figure 6. Specimens lightly sanded and wiped with naphtha-dampened rag in the Laboratory (sheeting applied in the Laboratory). Specimens are shown before test (top) and after test (below).



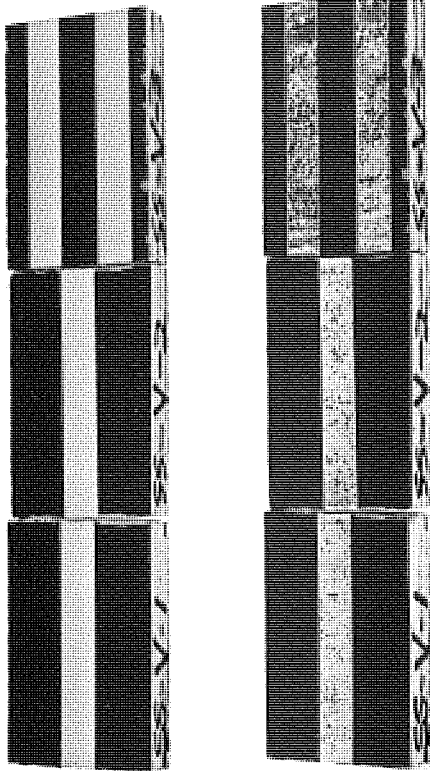


Figure 8. Specimens scrubbed with naphtha-saturated cheesecloth in the Laboratory (sheeting applied in the sign shop). Specimens are shown before test (top) and after test (below).

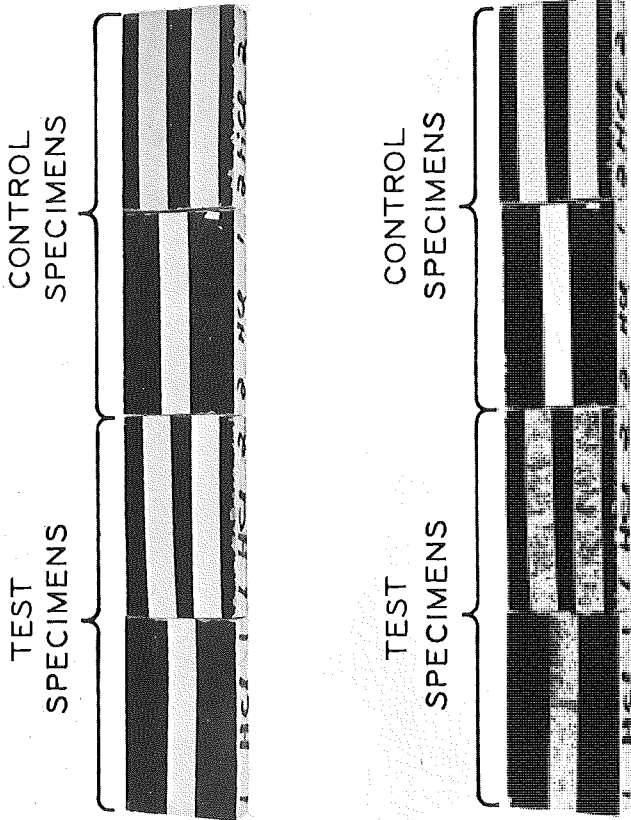


Figure 9. Specimens swabbed with concentrated hydrochloric acid, rinsed, and wiped dry (sheeting applied in the Laboratory). The effects of hydrochloric acid were determined by treating specimens of plywood that had not shown corrosion effects in previous tests. Specimens are shown before test (top) and after test (below).

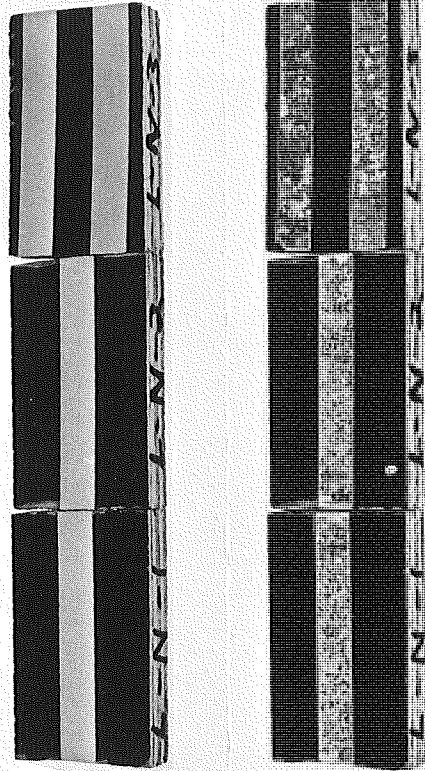


Figure 10. Specimens with no surface treatment (sheeting applied in Laboratory). Specimens are shown before test (top) and after test (below).

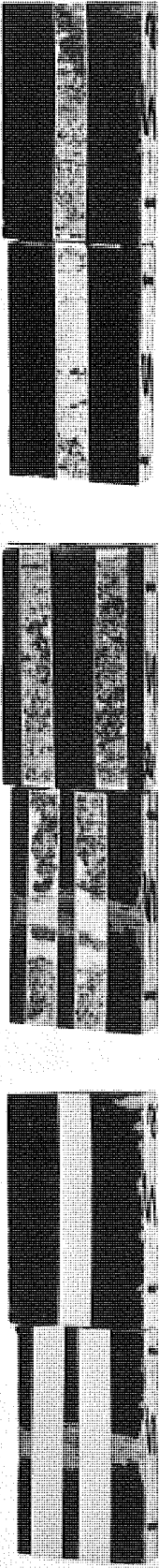


Figure 11. Specimens sanded to remove overlay in one area. Specimens are shown before test (left), and both sides of specimen are shown after test (center and right).

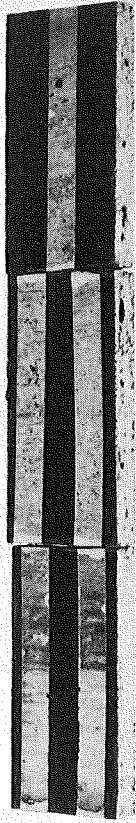


Figure 12. Specimens shown after being water-saturated twice and tested.

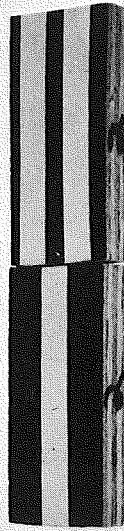


Figure 13. Plywood specimens edge-sealed with one coat of MDSH porch and floor enamel after testing. Note simulated core voids along edge of the specimens on the right.

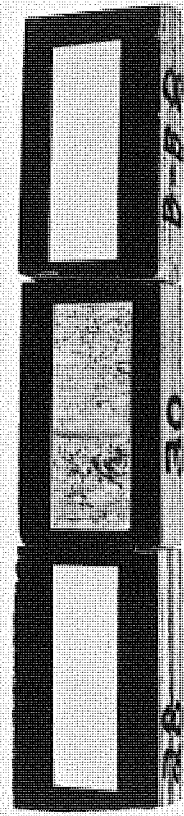


Figure 14. Appearance of specimens after test: U. S. Plywood (left), Simpson Mill No. 30 (center), and Georgia Pacific (right).

2. Two specimens showing little evidence of corrosion effects were water-saturated twice before applying the sheeting and then tested in accordance with the method. The specimens were water-saturated, allowed to dry 24 hours, saturated again, and allowed to dry 96 hours. Sheeting was applied and the specimens tested. Figure 12 shows the specimens after testing.

Core voids were not noticeable in the specimens and the voids were not simulated by drilling holes in the edges as suggested by 3M. The corrosion effects were readily apparent and void simulation was unnecessary.

Specimens were also tested with and without simulated core voids containing either one or two coats of the following edge sealers:

1. Silicone-Alkyd Paint
2. Porch and Floor Enamel (MDSH Warehouse)
3. Hot-Pour Joint Seal, thinned 1:1 with VM&P naphtha
4. Polysulfide-epoxy binder, Type II.

All specimens showed evidence of reflective sheeting corrosion. Appearance of the corroded areas indicated the path of the corrosion agent attack was altered by edge sealing. Figure 13 is typical of specimen appearance after test. These particular specimens were edge-sealed with a single coat of the porch and floor enamel.

Appearances of specimens after testing from Simpson Timber Company Mill No. 30, Georgia Pacific, and U. S. Plywood are shown in Figure 14.

### Conclusions

1. The plywood sign submitted on April 28 was made from plywood manufactured at Shelton, Washington by the Simpson Timber Company. Identification was made from the plywood edge brand as shown in Figure 15 and the knowledge that the numeral "10" following the letters DFPA is an American Plywood Association identifier for the Simpson mill. Simpson has another mill at McCleary, Washington which is identified by the numeral "30."

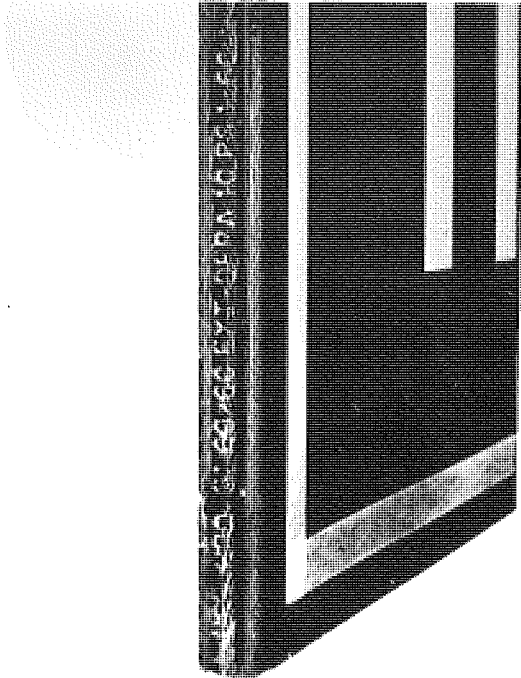


Figure 15. Edge brand of sign (see Fig. 1) submitted as U. S. Plywood. Numeral "10" after "DFPA" identifies plywood as a Simpson Mill No. 10 product.

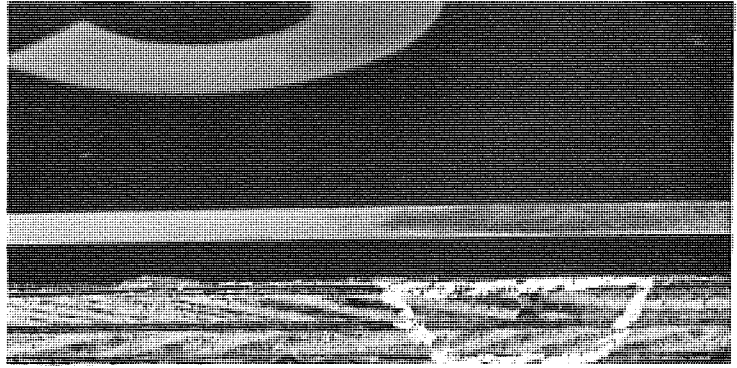


Figure 16. Upper left corner of sign (see Fig. 1) showing core void and associated reflective sheeting corrosion.

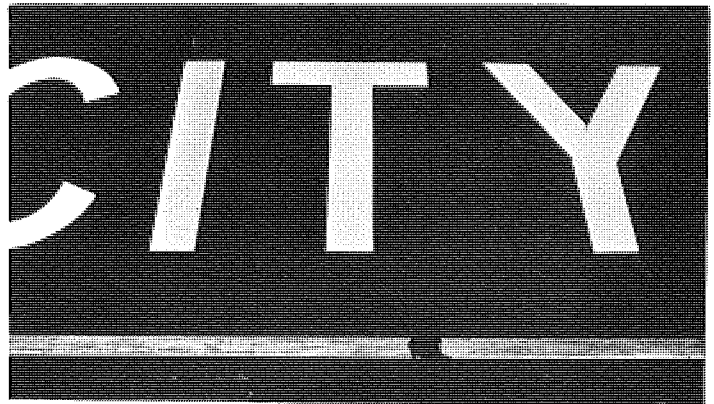


Figure 17. Corrosion of lower portion of sign (see Fig. 1).

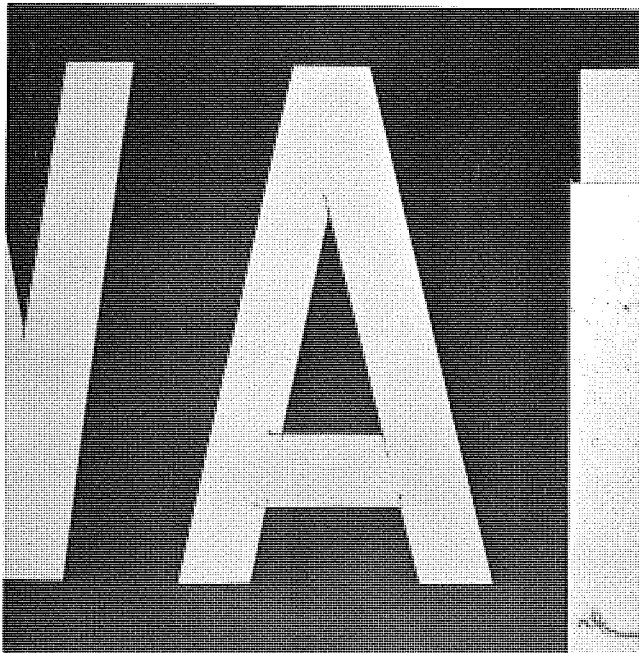


Figure 18. Inside corners of letters from sign showing knife cuts and early stages of corrosion of cuts. Detail view shows the lower portion of the letter "A."

Reflective sheeting corrosion was most severe on the upper portion of the sign and especially near core voids as shown in Figure 16. This was expected on the basis of 3M information. Corrosion noted along the lower edge as shown in Figure 17 was probably promoted by the rough-sawed edge which retained surface run-off. Figure 18, also of the lower portion of the sign, shows another type of corrosion typically found on cut-out letters. The inside corners of the letters show the extension of knife cuts and small areas of corrosion on either side of the cut.

2. The barricade-bar plywood could not be identified.

3. The black high-density overlays on some Simpson Timber Company plywoods currently stocked in the MDSH Warehouse contain a compound that will corrode the reflector coating on 3M pressure-sensitive reflective sheeting. This was verified by a representative of the Simpson Timber Company. The corroding agent has been a part of the resin-impregnated overlay paper supplied to Simpson by the Reichhold Chemical Company for a number of years. Corrosion reactions were not noted until 3M changed their reflective sheeting structure. The overlay papers used by Simpson have been changed. Currently, plywoods edge-branded R-2 contain a different Reichhold paper and plywoods edge-branded F-4 a Simpson Timber Company paper both of which are satisfactory for highway signs.

4. Black high-density overlays on plywood are permeable to water and water appears necessary to transport the corroding agent to the reflective sheeting in the case of the Simpson plywoods.

5. Samples of Simpson plywood tentatively identified as an April 1968 shipment showed reflective sheeting corrosion. It was learned that on March 6, 1968, Purchase Order No. 31465 was issued to the Burt Forest Products Company for plywood which was received by MDSH on April 11, 15, and 16, 1968. It could neither be determined that the plywood received on the three dates was from a particular lot at Burt Forest Products nor that the plywood was from a particular Simpson Timber mill production.

6. Samples of Simpson plywood tentatively identified as a November 1968 shipment showed no corrosion effect on reflective sheeting. Again, it was learned that on September 17, 1968, Purchase Order No. 30437 was issued to the Burt Forest Products Company for plywood which was received by MDSH on November 12, 21, and 25, and December 9, 11, 18, and 19, 1968. Continuity from Simpson Timber to MDSH could not be established with these shipments, as noted above. A Simpson representative noted that

a shipping certificate accompanies each railroad car of plywood and this certificate is the only means of identifying mill productions.

7. Simpson Timber Company plywood in the MDSH Warehouse is bundled approximately 20 sheets per bundle. Identification of plywood showing corrosion effects or no corrosion effects on reflective sheeting is limited to the bundle sampled. The exception obviously is that plywood carrying the R-2 edge brand. Throughout the testing program possible accelerated tests or non-destructive tests were investigated. One method which was most promising involved sampling only the high-density overlay from a corner of the plywood, applying sheeting, and incubating the water-immersed sample at 150 F for 24 hours.

8. Other plywoods (Georgia Pacific and U. S. Plywood) did not show corrosion effects according to the test procedure but this does not guarantee the plywoods will perform satisfactorily in the field.

9. Signs fabricated since May 1, 1968 and fabricated of black high-density overlay plywood sheets of either 4- by 8-ft or 4- by 10-ft signs will probably show evidence of failure from reflective sheeting reflector coat corrosion by the end of this year. Signs fabricated since March 1, 1967 from 5- by 12-ft plywood will also show corrosion failure. The 5- by 12-ft plywood was identified as a Simpson Mill No. 30 product which showed the corrosion effects during the test.

10. Edge-sealing the plywoods containing the corrosive agent may be successful in controlling corrosion in the field. Even though the laboratory test results showed corroding action after edge-sealing, the test conditions were very severe and would not be duplicated under field exposure conditions. According to the Simpson Timber Company, a moisture curing polyurethane paint might successfully seal the plywood edges to prevent corrosion. During the laboratory testing of edge sealers it was noted that corrosion did not take place in those areas where the overlay had inadvertently been coated with the edge sealer.

11. Specimens taken from weathered signs will probably not show the corrosion effects because specimens water-saturated more than once showed very limited effects.

12. Differences in test results were not noted between specimens prepared in the sign shop and the Research Laboratory.

13. The corrosion agent is not removed from Simpson overlays by

naphtha nor is it affected by a practical application of concentrated hydrochloric acid.

### Recommendations

1. Isolate the Simpson Timber Company plywoods in all sign shops and the central warehouse containing the Simpson edge brands noted in Table 1. The Simpson edge brand containing the R-2 is excepted.

2. Prohibit use of the isolated plywoods for sign fabrication. Sampling and testing of individual plywood bundles may be satisfactory in culling the isolated plywoods.

3. Inventory plywood signs fabricated since May 1, 1968 with Simpson edge brands as noted in Table 1 and consider replacement of such signs. Again the R-2 is excepted and note that the mill numbers 10 and 30 identify Simpson.

4. Revise procurement procedures by requiring plywood to conform with MDSH specifications.

5. Review and revise MDSH specifications with the following considerations:

(a) Consider requirements that may preclude receipt of black high-density overlays that weather to a brown color.

(b) Consider requirements that may preclude receipt of black high-density overlays that corrode reflective sheeting.

(c) Consider requirements that would upgrade the plywood and/or overlay quality by requiring mill certification that the material is of sign grade.

(d) Initiate procedures to test specification requirements.

## APPENDIX A

### SECTION III - TESTING OF THE PLYWOOD

- A. Where compliance to Section II, paragraph B is not assured by the plywood manufacturer, the following tests shall be conducted:

. . .

#### 2. Plywood Contamination Test

Panels of the plywood to be tested shall be cut 3 inches long and 2 inches wide. The panels shall be wiped with a tack rag to remove any dust or loose particles and reflective sheeting of the type or types to be used shall be applied to both faces of the test panels. Following conditioning for 24 hours at room temperature (75<sup>o</sup> F.), the test panels shall be placed in a pressure vessel and held submerged in cold tap water. A vacuum of 24 inches of mercury shall be drawn and maintained for 45 minutes. This will be followed immediately by the application of 40-50 psi of water pressure for 45 minutes. Proper test procedures are assured if the panel does not float after the above treatment. Test panels shall then be removed and each shall be placed in a glass container (400 ml beaker) filled with approximately 50 ml of water. Cover the container with a glass lid such as a petri dish and place in an oven at 150<sup>o</sup> F. for 24 hours. Remove panel and wipe the sheeting surface to remove any residue. Upon examination, any evidence of staining, discoloration or other degradation of the applied sheeting shall constitute failure of the plywood to meet the specification. Some bubbling of the applied sheeting shall be permissible

[3M - SAE 3(3.9.8)]