U.S. Department of Labor

Mine Safety and Health Administration
Pittsburgh Safety and Health Technology Center
626 Cochrans Mill Road
Pittsburgh, PA 15236

February 9, 2026

MEMORANDUM FOR RECORD

THROUGH: J. JARROD DURIG
Acting Chief, Pittsburgh Safety and Health Technology Center

JOHN DURIG Digitally signed by JOHN DURIG Date: 2026.02.10 13:22:38 -05'00'

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FROM: MATTHEW J. PEZZE
Mechanical Engineer, Roof Control Division

MATTHEW PEZZE Digitally signed by MATTHEW PEZZE Date: 2026.02.09 16:56:18 -05'00'

SUBJECT: Laboratory Evaluation of Plywood Underground's Plywood Skin Control Pan at the Pittsburgh Safety and Health Technology Center's Roof Support Laboratory (RCD Control No. 26AB01)

This report documents a Roof Control Division (RCD) laboratory evaluation conducted at the Pittsburgh Safety and Health Technology Center's (PSHTC) Roof Support Laboratory to characterize the mechanical properties of plywood pans supplied by Plywood Underground. The evaluation was initiated after the manufacturer reached out to the Approval and Certification Center's Quality Assurance and Materials Testing Division (QA&MTD) on October 14, 2025. The QA&MTD forwarded the request to the RCD.

A total of 40 specimens were evaluated, consisting of 10 samples each of 16×16-inch and 12×12-inch pans in 3-ply and 4-ply configurations, all of which were untreated plywood. Specimens were tested over either a 14-inch-span or 10-inch-span depending on plate size. Additionally, selected 16×16-inch specimens were tested over a 10-inch-span to verify that observed performance differences between plate sizes were attributable to span length rather than inherent material properties.

Test results demonstrated that face ply orientation relative to the test span was a dominant factor influencing load-deflection response. Specimens with face plies oriented perpendicular to the test span consistently exhibited higher stiffness and higher peak loads compared to specimens with face plies oriented parallel to the span. Span length also significantly influenced measured capacity, with shorter spans sustaining higher loads. Failures were generally governed by

bending with localized cracking and separations at the center of the pan near the applied load, resulting in complete loss of load-carrying capacity.

This document has been digitally signed and provided electronically. If there are any questions regarding this evaluation, please contact Matthew Pezze at 412–386–6315.

Attachment

cc: C. Mark, Acting Director, TS
W. Shumaker, Acting Deputy Director, TS

UNITED STATES DEPARTMENT OF LABOR

MINE SAFETY AND HEALTH ADMINISTRATION

PITTSBURGH SAFETY AND HEALTH TECHNOLOGY CENTER
ROOF CONTROL DIVISION
626 COCHRANS MILL ROAD
PITTSBURGH, PENNSYLVANIA 15236

REPORT NO. 26AB01

LABORATORY EVALUATION OF PLYWOOD SKIN CONTROL PANS PLYWOOD UNDERGROUND ST. LOUIS, MISSOURI

FEBRUARY 9, 2026

BY

MATTHEW J. PEZZE
MECHANICAL ENGINEER

REPORT NO. 26AB01

Background

Plywood pans are not addressed under ASTM F432, “Standard Specification for Roof and Rock Bolt Accessories.” Therefore, the use of such products in underground coal mines requires approval by the District Manager in accordance with 30 CFR §75.204(b) and §75.204(c). Following correspondence and a technical discussion with representatives from Plywood Underground, the RCD offered to conduct a laboratory evaluation. Plywood Underground confirmed that their products are intended for skin control applications and are to be installed with either 6×6-inch or 8×8-inch bearing plates. Additionally, they supply plywood pans in nominal sizes of 12×12-inch and 16×16-inch, with either 3-ply or 4-ply construction, and as treated or untreated wood. All samples provided for this evaluation were untreated.

According to §75.204(c)(4), "Wooden materials that are used between a bearing plate and the mine roof in areas which will exist for three years or more shall be treated to minimize deterioration." This requirement was discussed with Plywood Underground during the December 2, 2025 technical meeting documented under RCD Control No. 26BA03.

RCD Investigation

Laboratory testing was conducted in the Roof Support Laboratory at the Pittsburgh Safety and Health Technology Center using a Tinius Olsen universal testing machine. A total of 40 specimens were evaluated, consisting of 10 samples each of the following configurations:

- 16×16-inch (3-ply)
- 16×16-inch (4-ply)
- 12×12-inch (3-ply)
- 12×12-inch (4-ply)

Specimens were tested over either a 14-inch span or a 10-inch span, depending on plate size. The samples were delivered without center holes drilled. Prior to testing, RCD personnel contacted Plywood Underground to confirm the intended installation configuration. Plywood Underground indicated the plates were to be installed with a nominal 1⅜-inch center hole, and all specimens were drilled accordingly prior to testing.

The RCD 14-inch-span and 10-inch-span test procedures were used to evaluate the 16- and 12-inch pans, respectively, in accordance with RCD protocol. The test procedures consist of installing a pan centrally over a 14- or 10-inch-span in a universal testing machine. A compressive load of 10 pounds was applied to the pan via a load applicator, and displacement was then zeroed. A load reading was recorded at every quarter inch of deflection from 0.25 inches to 1.5 inches. The peak load achieved over the 1.5 inches of deflection was also recorded. This is because the pans may achieve peak load before reaching 1.5 inches of deflection. There is no requirement to use this test procedure, nor has the RCD established a minimum load-deflection criterion, so this data is only used for comparison purposes. The test setup can be seen below in Figure 1.

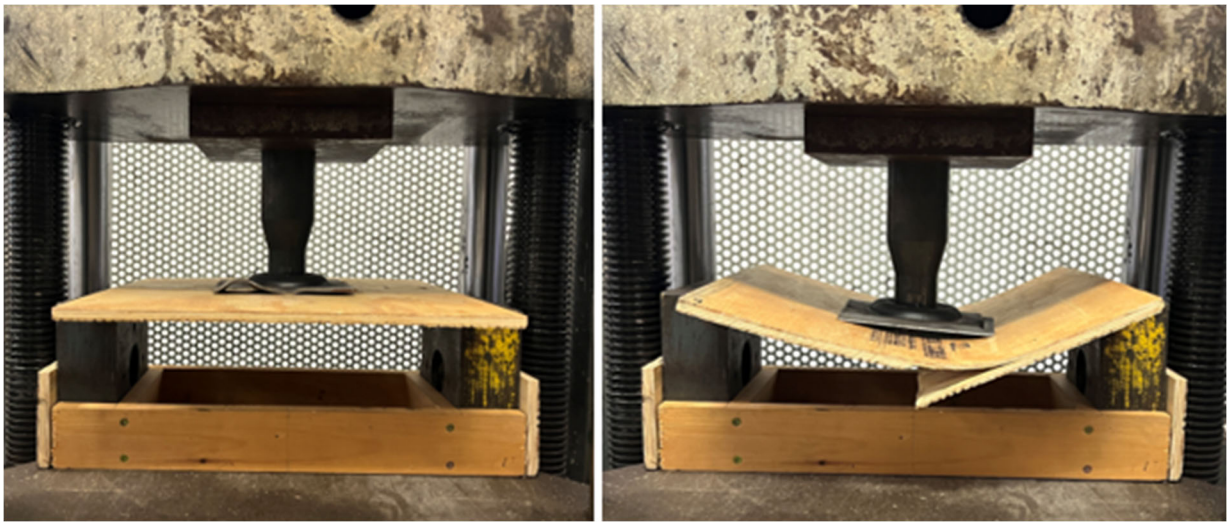

FIGURE 1.—14-inch-span test setup.

For plywood specimens, grain orientation refers to the direction of the outer (face) plies relative to the test span. In 3-ply specimens, the outer plies are oriented in the same direction with the core ply perpendicular. In 4-ply specimens, the two outer plies are oriented in the same direction with the two interior plies oriented perpendicular to the outer plies. Tests were conducted with face plies oriented either parallel to the test span or perpendicular to the test span.

TABLE 1.—Summary of test results.

Summary of Plywood Pan Test Results					
Span	**Plate Size**	**Ply**	**Grain Orientation to Span**	**Average Peak Load (lbs.)**	**Average Effective Peak Load (lbs.)**
14-inch-span test	16x16	3-ply	parallel	317	755.6
			perpendicular	1194	
		4-ply	parallel	629	796.7
			perpendicular	964	
10-inch-span test	16x16	3-ply	parallel	401	883.6
			perpendicular	1366	
		4-ply	parallel	1298	1466.5
			perpendicular	1635	
	12x12	3-ply	parallel	547	965.1
			perpendicular	1383	
		4-ply	parallel	1226	1364.5
			perpendicular	1503	

Results and Discussion

Measured specimen dimensions and thicknesses exhibited variability. Nominal 12×12-inch specimens ranged from approximately 11¾ inches to $11^{13}/_{16}$ inches per side, while nominal 16×16-inch specimens ranged from approximately 15¾ inches to 15⅞ inches per side. Thickness measurements also varied within each configuration, with 3-ply generally being slightly thicker than 4-ply. All thickness measurements, as well as complete test results, can be found in Table 1A and 2A of the Appendix.

14-inch-Span Test Results

16×16-inch, 3-ply specimens:

Specimens with face plies perpendicular to the span achieved an average peak load of 1,194 pounds at an average deflection of 0.68 inches. Specimens with face plies parallel to the span achieved an average peak load of 317 pounds at an average deflection of 1.44 inches. This represents a 277% increase in capacity when face plies are oriented perpendicular to the span. The average effective peak load for 3-ply specimens, accounting for both orientations, was 755.6 pounds.

16×16-inch, 4-ply specimens:

Specimens with face plies perpendicular to the span achieved an average peak load of 964 pounds at an average deflection of 0.90 inches. Specimens with face plies parallel to the span achieved an average peak load of 629 pounds at an average deflection of 1.32 inches. This represents a 53% increase in capacity when face plies are oriented perpendicular to the span. The average effective peak load for 4-ply specimens, accounting for both orientations, was 796.7 pounds.

Comparing 4-ply to 3-ply specimens, the 4-ply configuration provided a 5.4% increase in average effective peak load (796.7 vs 755.6 pounds).

10-inch-Span Test Results

16×16-inch, 3-ply specimens:

One specimen with face plies perpendicular to the span achieved a peak load of 1,366 pounds at a deflection of 0.50 inches. One specimen with face plies parallel to the span achieved a peak load of 401 pounds at a deflection of 0.80 inches. The average effective peak load, accounting for both orientations, was 883.6 pounds.

16×16-inch, 4-ply specimens:

One specimen with face plies perpendicular to the span achieved a peak load of 1,635 pounds at a deflection of 0.80 inches. One specimen with face plies parallel to the span achieved a peak load of 1,298 pounds at a deflection of 1.20 inches. The average effective peak load, accounting for both orientations, was 1,466.5 pounds.

Comparing 4-ply to 3-ply 16×16 specimens tested at 10-inch span, the 4-ply configuration provided a 66% increase in average effective peak load (1,466.5 vs 883.6 pounds).

12×12-inch, 3-ply specimens:
Specimens with face plies perpendicular to the span achieved an average peak load of 1,383 pounds at an average deflection of 0.43 inches. Specimens with face plies parallel to the span achieved an average peak load of 547 pounds at an average deflection of 1.03 inches. This represents a 153% increase in capacity when face plies are oriented perpendicular to the span. The average effective peak load for 3-ply specimens, accounting for both orientations, was 965.1 pounds.

12×12-inch, 4-ply specimens:
Specimens with face plies perpendicular to the span achieved an average peak load of 1,503 pounds at an average deflection of 0.57 inches. Specimens with face plies parallel to the span achieved an average peak load of 1,226 pounds at an average deflection of 1.06 inches. This represents a 23% increase in capacity when face plies are oriented perpendicular to the span. The average effective peak load for 4-ply specimens, accounting for both orientations, was 1,364.5 pounds.

Comparing 4-ply to 3-ply 12×12-inch specimens, the 4-ply configuration provided a 41% increase in average effective peak load (1,364.5 vs 965.1 pounds).

Comparison of 16×16-inch and 12×12-inch Plates at 10-inch Span
When tested over the same 10-inch span, the comparison between plate sizes reveals important findings. For 3-ply specimens, the 16×16-inch plates achieved an average effective peak load of 883.6 pounds compared to 965.1 pounds for the 12×12-inch plates. For 4-ply specimens, the 16×16-inch plates achieved an average effective peak load of 1,466.5 pounds compared to 1,364.5 pounds for the 12×12-inch plates.

These results demonstrate that when tested over the same span, plate performance is generally comparable between the two sizes. However, the 16×16-inch plates provide significantly greater surface area. The 16×16-inch plates offer 256 square inches of coverage compared to 144 square inches for the 12×12-inch plates, which is a 78% increase in surface area. When used underground, this increased surface area may improve the ability to control detached draw rock and fractured roof or rib material.

Span Length Effects
Comparing equivalent 16×16-inch configurations tested over different spans reveals the significant effect of span length on load capacity. For 3-ply specimens, the average effective peak load increased from 755.6 pounds at 14-inch-span to 883.6 pounds at 10-inch span, a 17% increase. For 4-ply specimens, the average effective peak load increased from 796.7 pounds at 14-inch span to 1,466.5 pounds at 10-inch span, an 84% increase.

Comparing the 16×16-inch plates tested at 14-inch-span to the 12×12-inch plates tested at 10-inch-span further demonstrates the span effect. For 3-ply specimens, the average effective peak load increased from 755.6 pounds to 965.1 pounds, a 28% increase. For 4-ply specimens, the average effective peak load increased from 796.7 pounds to 1,364.5 pounds, a 71% increase.

Failure Modes

Failures were generally governed by bending with localized cracking and separations at the center of the plate near the applied load (Figure 2 below). Upon reaching peak load, specimens experienced a sudden and complete loss of load-carrying capacity, as evidenced by the abrupt drop in force recorded in the test data (see Tables 1A and 2A in the Appendix). Failure typically initiated at the center of the plate where stress concentration was highest, propagating rapidly through the face ply and resulting in structural collapse. This brittle failure characteristic is typical of plywood subjected to concentrated bending loads.

The observed trends in stiffness and grain orientation effects are consistent with published literature describing plywood as an orthotropic material whose bending behavior is strongly influenced by face ply orientation.

Variability in load-deflection response was observed within identical configurations, consistent with the inherent material variability of untreated plywood products. Natural variations in wood density, grain characteristics, knots, and veneer quality contribute to performance differences between individual specimens.

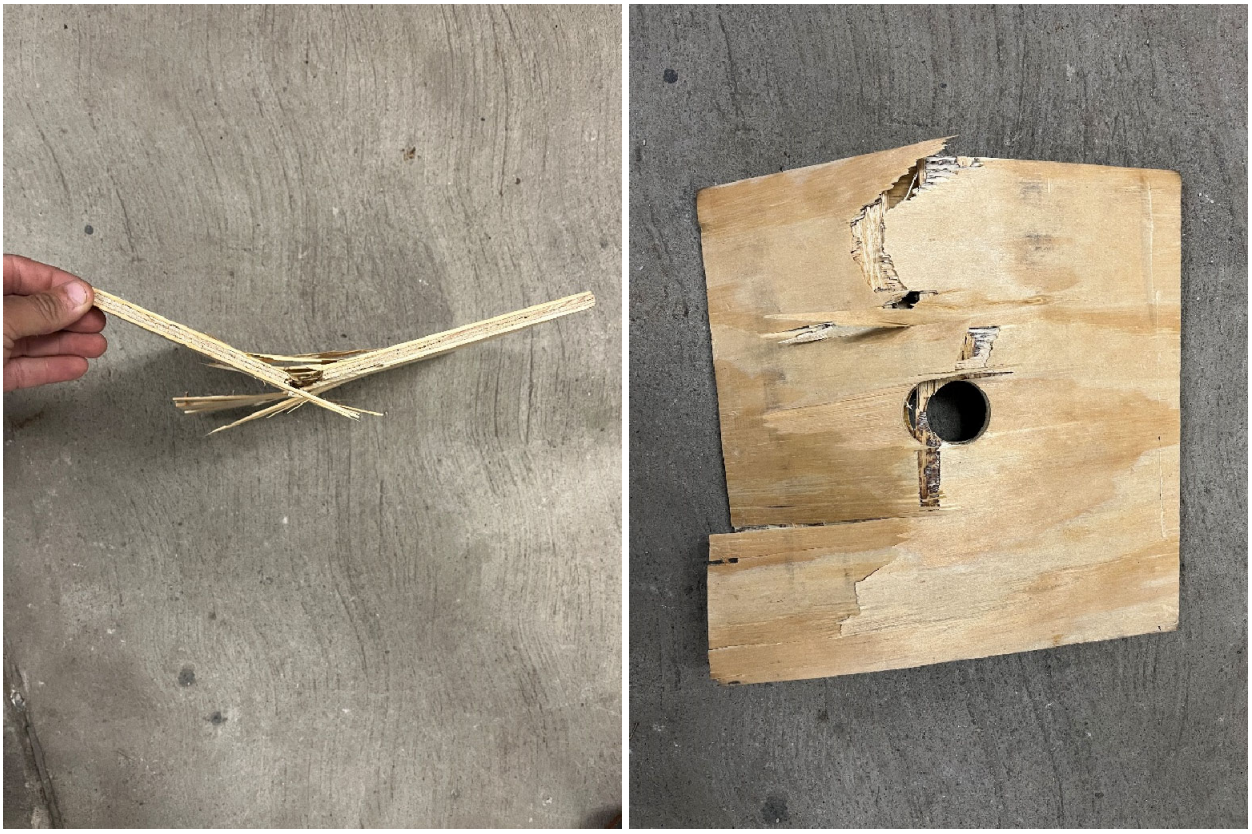

FIGURE 2.—Typical failure governed by bending with localized cracking and separations at the center of the plate near the applied load.

Conclusion

This laboratory evaluation provides comparative load-deflection data for untreated plywood roof pans supplied by Plywood Underground. The results demonstrate that grain orientation and span length significantly influence measured performance, and that failure occurs through sudden structural collapse following localized cracking at the center of the plate. Key findings include:

- Face ply orientation is a dominant factor affecting load-deflection response. Specimens with face plies perpendicular to the test span consistently exhibited significantly higher peak loads compared to specimens with parallel orientation, with improvements ranging from 23% to 277% depending on configuration.

- Span length significantly affects measured capacity. Comparing plates tested at different spans, the 10-inch-span configuration produced substantially higher average effective peak loads than the 14-inch-span configuration, with increases of 17% to 84% depending on ply count.

- When tested over the same 10-inch-span, 16×16-inch and 12×12-inch pans demonstrated comparable performance. However, the 16×16-inch plates offer superior coverage for underground applications, providing 78% more surface area than 12×12-inch pans (256 vs 144-square-inches), which may improve the ability to control detached roof material.

- Ply count effects varied by configuration. For plates tested at 14-inch-span, 4-ply provided modest improvement (5.4% increase in average effective peak load). For 16×16-inch pans tested at 10-inch span, 4-ply provided substantial improvement (66% increase). For 12×12-inch pans tested at 10-inch span, 4-ply provided moderate improvement (41% increase).

- All specimens experienced sudden and complete loss of load-carrying capacity upon failure, as evidenced by the abrupt force drop recorded in test data.

The results of this evaluation are intended to support technical review and do not constitute approval or endorsement of the tested products. The RCD recommends that any proposed use of plywood pans be evaluated by the appropriate District Manager in accordance with 30 CFR §75.204, and that consideration be given to installation orientation, plate size, and intended function as part of a mine's approved Roof Control Plan.

If you have any questions, or if we can be of further assistance, please contact Matthew Pezze at 412–386–6315.

APPENDIX

TABLE 1A.—Results for 14-inch-span test.

14-inch-span Test													
Plate Size	Ply	Grain Orientation to Span	Test	Thickness	Force at (lbs.)						Peak Load (lbs.)	Deflection at Peak Load (inch)	Average Peak Load (lbs.)	Average Deflection at Peak Load (inch)
					0.25"	0.5"	0.75"	1"	1.25"	1.5"				
16x16	3-ply	parallel	6	0.46	90.7	148.2	205.2	269.9	333.9	324.4	339.8	1.27	317.1	1.44
			7	0.47	99.2	166	231.2	289.3	341.2	397.1	397.1	1.5		
			15	0.42	60.72	99.69	136	173.5	213	247.5	247.5	1.5		
			16	0.39	66.58	105.8	145.7	187.7	235.9	283.9	283.9	1.5		
16x16	3-ply	perpendicular	8	0.45	484.3	1009	292.8	283.2	286.7	239.3	1215	0.6	1194.2	0.68
			9	0.47	450.2	917.1	1507	337.7	183.3	143.6	1769	0.9		
			13	0.41	289.4	416.7	272	28.4	38	30.8	464.6	0.4		
			14	0.45	421.5	832.2	1300	1259	1097	129.3	1328	0.8		
16x16	4-ply	parallel	1	0.44	117.5	273.2	455.7	622	511.7	552.6	721.1	1.2	629.2	1.32
			2	0.44	138.2	281.4	418	539	613.3	434.9	652.2	1.4		
			3	0.42	140.1	257	369.9	471.5	546.6	617.7	620.6	1.45		
			4	0.42	153.1	286.3	390.1	467.3	310	199.1	523	1.21		
16x16	4-ply	perpendicular	5	0.42	174	321.1	472.7	614.5	739.7	843.4	846.6	1.48	964.2	0.90
			10	0.42	321.9	710.6	1092	156.5	150.7	124.1	1244	0.8		
			11	0.43	347.5	628.3	943.5	473.7	24.8	42.6	995	0.8		
			12	0.43	380	711	695.8	731.3	252	164.8	771.3	0.5		

TABLE 2A.—Results for 10-inch-span test.

10-inch-span Test														
Plate Size	Ply	Grain Orientation to Span	Test	Thickness	Force at (lbs.)						Peak Load (lbs.)	Deflection at Peak Load (inch)	Average Peak Load (lbs.)	Average Deflection at Peak Load (inch)
					0.25"	0.5"	0.75"	1"	1.25"	1.5"				
16x16	3-ply	parallel	40	0.41	151.1	264.9	379.3	146.8	114.8	35	401.2	0.8	401.2	0.80
		perpendicular	39	0.46	698.8	1221	858.4	104.4	305.8	421	1366	0.5	1366.0	0.50
16x16	4-ply	parallel	38	0.43	393.2	748.5	1135	1081	1056	978.1	1298	1.2	1298.0	1.20
		perpendicular	37	0.47	549.7	1110	1588	701.8	778.4	732.5	1635	0.8	1635.0	0.80
12x12	3-ply	parallel	32	0.46	148.5	269.5	405	453.5	159.2	7.45	522.2	1	547.3	1.03
			33	0.46	146.7	269.3	381.1	2.7	3.4	4.5	460.6	1.2		
			34	0.47	185.9	312.5	441.6	409.9	84.5	6	460.5	0.78		
			35	0.46	149.3	248.5	314.8	326.6	5	5.8	335.7	0.8		
			36	0.45	229.4	438.6	590.8	749.5	906.7	733.5	957.3	1.35		
12x12	3-ply	perpendicular	27	0.46	699.3	1293	846.8	402.3	179.8	142	1651	0.5	1383.0	0.43
			28	0.46	704.5	998.8	445	334.8	257.7	181.3	1221	0.37		
			29	0.46	691.5	1192	345.6	292.7	193.3	151.6	1239	0.4		
			30	0.45	671.7	1285	680.1	293.4	106.5	5.6	1509	0.45		
			31	0.45	654.6	972	511.6	216.1	134.6	120.5	1295	0.41		
12x12	4-ply	parallel	22	0.41	412.1	774.9	1233	1536	1561	1176	1607	1.1	1225.6	1.06
			23	0.41	347.8	657.8	944	924.8	670	6.5	1032	0.83		
			24	0.41	317.4	595.7	882.9	948.4	667	419.5	1144	1.2		
			25	0.4	313.3	584.2	826.8	1081	1194	389.4	1201	1.25		
			26	0.4	339.7	661.8	992.8	1087	1010	1320	1144	0.9		
12x12	4-ply	perpendicular	17	0.39	553.2	1213	339.8	31.1	23.4	20.6	1262	0.6	1503.4	0.57
			18	0.41	661	1574	374.8	429.4	128.4	62.7	1848	0.58		
			19	0.4	624.4	1355	197.8	229.2	185.9	9.3	1543	0.55		
			20	0.4	625.5	1175	352.7	258	190.5	10.3	1276	0.45		
			21	0.41	595.2	1369	240.3	176.4	123.9	84.4	1588	0.67		