

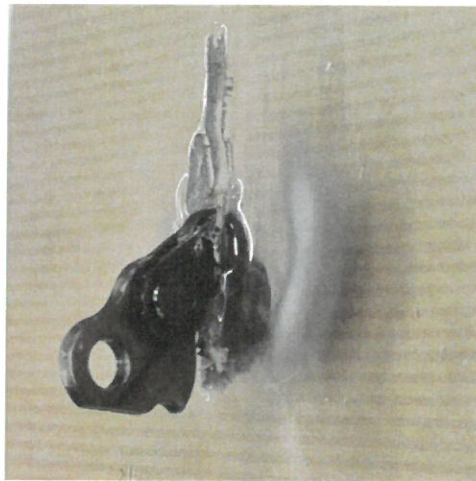


# TEST REPORT

O100185-190970

2022-01-03

**PERFORMANCE TEST OF PROTECTIVE WINDOWS AGAINST  
SAW CHAIN SHOT FROM ROTATING SAW CHAIN  
ISO 21876:2020**



**Aikolon Oy**

**Samples: Aikon, 20.0 mm (3 layers x 6 mm) polycarbonate,  
both outer surfaces coated**

**PERFORMANCE TEST OF PROTECTIVE WINDOWS AGAINST  
SAW CHAIN SHOT FROM ROTATING SAW CHAIN  
ISO 21876:2020**

**SUMMARY**

Window samples were tested against saw chain shots at a sample test temperature of +20°C with a test saw chain speed of 48 m/s. Ten relevant saw chain shots at window samples were tested. None of the tests resulted in a shot through the window test sample by the saw chain shot.

**Test laboratory**

RISE SMP Svensk Maskinprovning AB  
Box 4053  
SE-904 03 Umeå, Sweden.  
Telephone: +46 (0)10-516 64 00

**Test ordered by**

Aikolon Oy  
Posankuja 3  
FI-90620 Oulu, Finland  
Contact persons: Panu Vanninen (panu.vanninen@aikolon.fi)  
Martti Hahtonen (martti.hahtonen@aikolon.fi)

**Test samples**

Samples: One type of polycarbonate window. See identification below.

Identification: Identification/information provided by the client:

- Trademark: Aikon
- 20.0 mm nominal sample thickness with three layers (6 mm + 6 mm + 6 mm) polycarbonate
- Sample size, 355 mm x 1000 mm
- Polycarbonate material: Sabic Lexan ULG1003
- Hard coating on outer surfaces: Momentive AS4000S
- Lamination film between layers: NovoGenio NovoGlass SF1959
- Actual thickness of the tested samples, measured by RISE SMP: 20.0 mm to 20.2 mm

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Dates of arrival: 2021-08-24: saw chains, guide bars and drive sprockets for pre-calibration tests  
2021-12-09 and 2021-12-21: window test samples, saw chains, guide bars and drive sprockets for the window tests

Principle of selection: Window test samples, saw chains, guide bars and sprockets were delivered by the window manufacturer Aikolon Oy, Finland.

### Test information

Test personnel: Joachim Grönlund, Anders Larsson and Peter Tunåker

Test period: 2021-09-07: pre-calibration  
2021-12-21: window tests

Ordered test: Test according to ISO 21876:2020. The test shall be performed using one type of window test sample at a sample test temperature of +20°C. The test saw chain speed shall be 48 m/s. Pre-calibration of the test setup shall be done. For the actual test, ten relevant saw chain shots shall be produced.

Test method: According to ISO 21876:2020.

Test rig: Test rig for ISO 21876:2020 for generating saw chain shots with arrangements for detecting saw chain shots and measuring the saw chain shot speed and angle.

Test temperature: +20°C

Test saw chain speed: 48 m/s (maximum saw chain speed of 40 m/s multiplied by 1.2)

Saw chains: Oregon, 18HX104E (0.404", 2.0 mm, 104 DL)

Guide bar: Oregon Speedmax, 902SMRP149 (90 cm)

Sprocket: CDE-16-404 (0.404", 16 tooth)

Saw chain oil: STIHL SynthPlus

## TEST RESULTS

### General

The test results are valid only for the tested window samples and the parameters given in this test report including test setup, test temperature, saw chain, guide bar and sprocket used and saw chain speed at the test.

### Pre-calibration

Pre-calibration was done with the test equipment to verify that saw chain shots were produced and to establish the correct angle for the tests on the window test samples. The blocking mechanism was positioned at 764 mm from the sprocket centre ( $0.8 \cdot X_S$ , where  $X_S$  is 955 mm). Ten out of ten test runs resulted in saw chain shots. One of the test runs resulted in a saw chain shot consisting of several pieces and one of the test runs resulted in a saw chain shot with shot angle outside the criteria (i.e. more than  $\pm 10^\circ$  from the average shot angle).

See detailed results from the pre-calibration in Table 1 in Enclosure 1.

### Test on windows

The tests were done at a sample test temperature of  $+20^\circ\text{C}$ . The test saw chain speed was 48 m/s. The position of the blocking mechanism was kept at 764 mm based on the pre-calibration. Ten relevant shots were produced.

None of the tests resulted in a shot through the window test sample by the saw chain shot as defined by ISO 21876:2020. All results from the saw chain shot tests are found in Table 2 in Enclosure 1. A summary of the main test results:

- Saw chain shot types: Five different types of saw chains shots were created among the ten relevant main shots. The shots varied in size from one drive link to pieces with up to two rivets.
- Saw chain shot angles:  $-8^\circ$  to  $+7^\circ$  from a perpendicular hit to the window sample for the relevant saw chain shots.
- Saw chain shot speeds: 311 m/s to 394 m/s with an average of 328 m/s for the relevant saw chain shots.

Photos of the tested window samples and used saw chains are found in Enclosure 2.

### Relevant saw chain shot speeds

The minimum acceptable saw chain shot speed,  $X_{\min}$ , is calculated according to ISO 21876:2020, clause 10.

For the test series:  $X_{\min} = \mu - 1.96\sigma = 328 - 1.96 \cdot 22.7 = 284 \text{ m/s}$

This means that all saw chain shot speeds are above the minimum limit.

### Statement of uncertainty of measurement

All uncertainty values are written between two notch parentheses [ $\pm xxx$ ]. The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor  $k=2$ , which for a normal distribution provides a level of confidence of approximately 95%. The standard uncertainty has been determined in accordance with EA Publication EA-4/16:2003. Unless otherwise stated, decisions are ruled without considering the uncertainty.

Saw chain speed, [ $\pm 2 \text{ m/s}$ ]  
Thickness, [ $\pm 0.2 \text{ mm}$ ]  
Angle, [ $\pm 1^\circ$ ]  
Temperature, [ $\pm 2^\circ\text{C}$ ]  
Calculated saw chain shot speed, [ $\pm 3\%$ ]

Enclosure 1. Test results from the pre-calibration and the window tests  
Enclosure 2. Photos of broken saw chains and saw chain shots in the test samples

**RISE SMP Svensk Maskinprovning AB**  
Machine Safety, Umeå



Stefan Frisk  
Senior Testing Officer



Anders Larsson  
Testing Officer

Table 1. Results from the pre-calibration

Test ID.	Saw chain speed (m/s)	Position, X (mm)	Saw chain shot created (Yes/No)	Saw chain shot type	Saw chain shot angle to horizontal (°)	Saw chain shot speed (m/s)	Comments
PC, Test #1	48	764	Yes	DL+2SL+DL	48	323	
PC, Test #2	48	764	Yes	DL+SL/CL	51	333	Secondary pieces: SL, SL, DL
PC, Test #3	48	764	Yes	DL+SL/CL	51	338	Secondary pieces: SL, SL, DL
PC, Test #4	48	764	Yes	SL/CL+DL	48	334	Secondary pieces: SL, SL
PC, Test #5	48	764	Yes	DL+2SL+DL	44	310	
PC, Test #6	48	764	(Yes)	Splitter shot	45	N/A	Several pieces: CL, SL, DL, SL, SL
PC, Test #7	48	764	Yes	DL+2SL+DL	41	338	
PC, Test #8	48	764	Yes	DL+2SL+DL	52	311	Secondary pieces:: SL, CL
PC, Test #9	48	764	Yes	DL+2SL+DL	46	313	
PC, Test #10	48	764	(Yes)	DL	29	436	Angle outside criteria. Secondary pieces: SL, CL

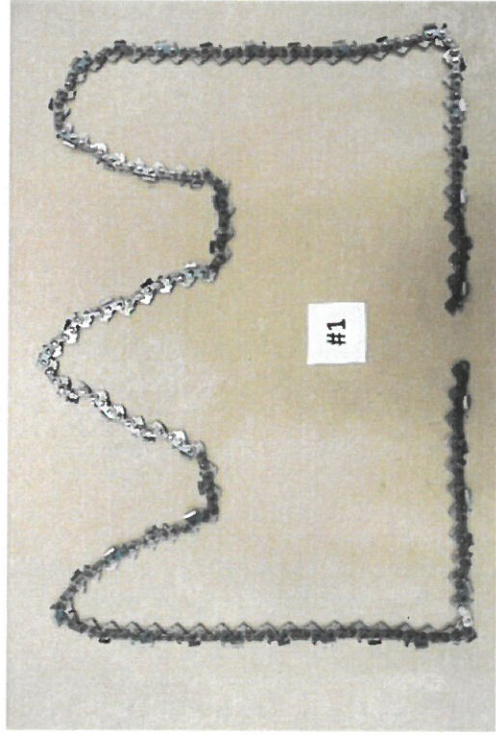
Note: DL - Drive link, SL - Side link, CL - Cutter link. Rivets connecting different segments are denoted by "+"

Table 2. Results from the window sample tests

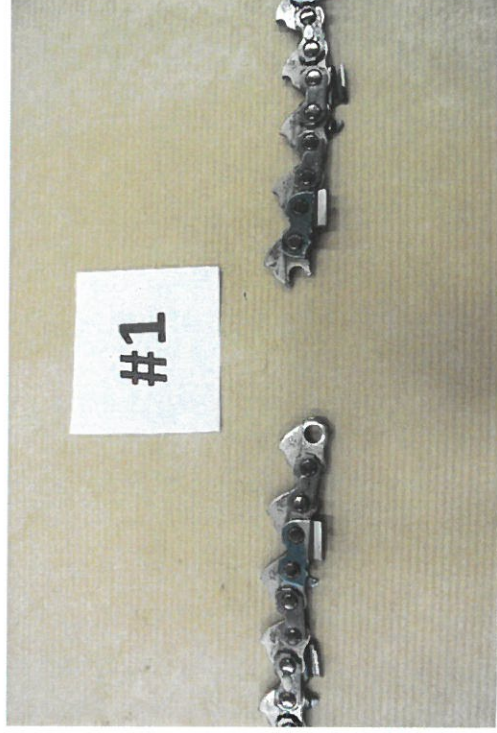
Test ID.	Saw chain speed (m/s)	Shot through (Yes/No)	Saw chain shot type	Saw chain shot angle to horizontal (°)	Saw chain shot angle to window sample (°)	Saw chain shot speed (m/s)	Relevant saw chain shot (Yes/No)	Sample thickness (mm)	Comments
Test #1	48	No	2SL+DL+SL/CL	45	-1	312	Yes	20.1	
Test #2	48	No	DL+2SL+DL	53	7	322	Yes	20.1	Secondary pieces: SL, CL
Test #3	48	No	Several pieces	-	-	-	No	20.1-20.2	Main shot in three pieces: SL, CL, DL+2SL+DL
Test #4	48	No	Several pieces	-	-	-	No	20.1	Main shot in three pieces: SL, CL, DL+2SL+DL
Test #5	48	No	DL+SL/CL+DL	46	0	319	Yes	20.1	
Test #6	48	No	2SL+DL	52	6	-	(Yes)	20.1	Relevant size, but failed speed measurement Secondary pieces: SL, CL
Test #7	48	No	DL	43	-3	394	Yes	20.1	Secondary pieces: SL, CL
Test #8	48	No	DL+2SL+DL	47	1	323	Yes	20.1-20.2	
Test #9	48	No	DL+2SL+DL	44	-2	311	Yes	20.1	
Test #10	48	No	DL+2SL+DL	38	-8	323	Yes	20.0-20.1	
Test #11	48	No	DL+SL/CL	52	6	335	Yes	20.0-20.1	Secondary: DL
Test #12	48	No	DL+2SL+DL	52	6	318	Yes	20.1	Secondary: SL, CL
Test #13	48	No	Several pieces	-	-	-	No	20.1	Main shot in three pieces: SL, CL, DL+2SL Secondary piece: DL
Test #14	48	No	Several pieces	-	-	-	No	20.1	Main shot in three pieces: SL, CL, DL+2SL+DL
Test #15	48	No	DL+2SL+DL	40	-6	326	Yes	20.1	

Note: DL - Drive link, SL - Side link, CL - Cutter link. Rivets connecting different segments are denoted by "+".

Photos of broken saw chains and saw chain shots in the window test samples



Test #1, Saw chain



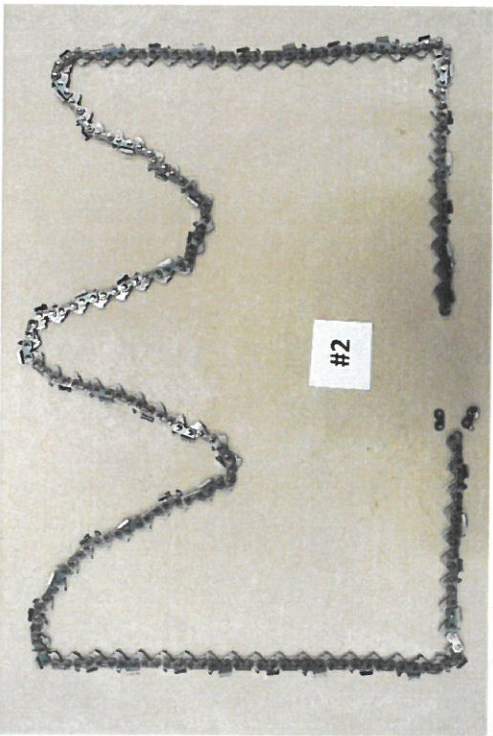
Test #1, Saw chain ends



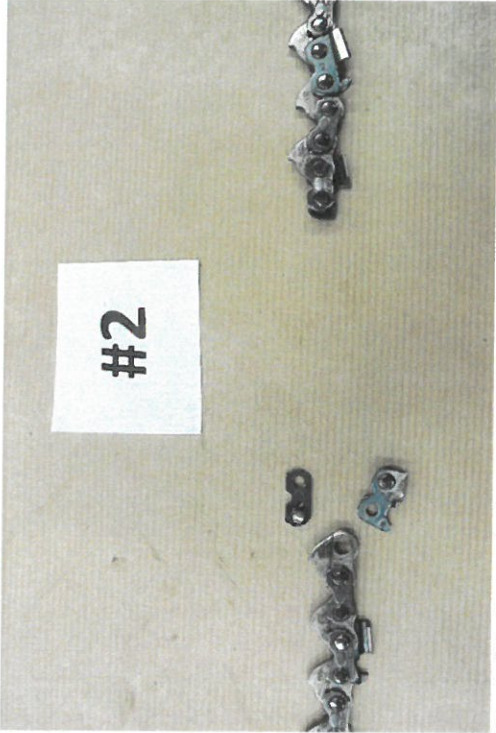
Test #1, Front side of window sample



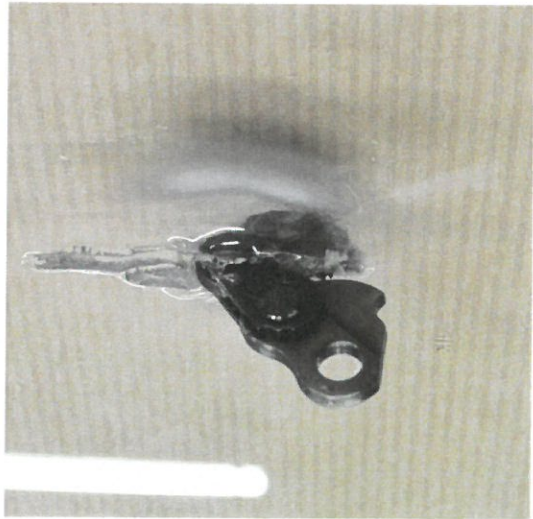
Test #1, Back side of window sample



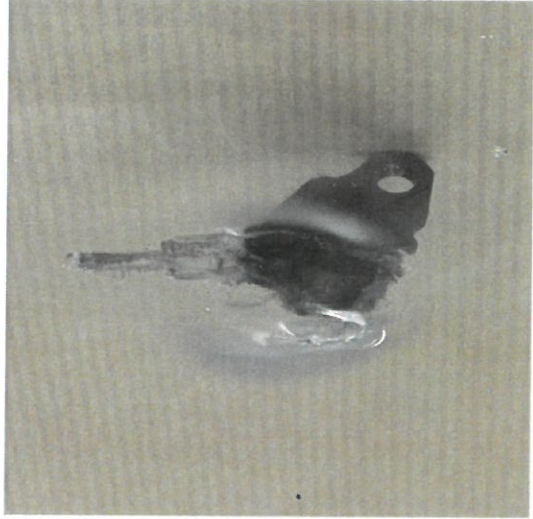
Test #2, Saw chain



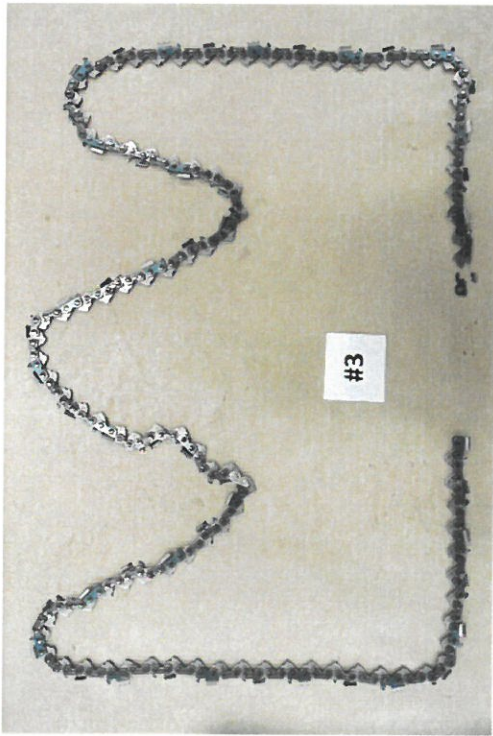
Test #2, Saw chain ends and loose links



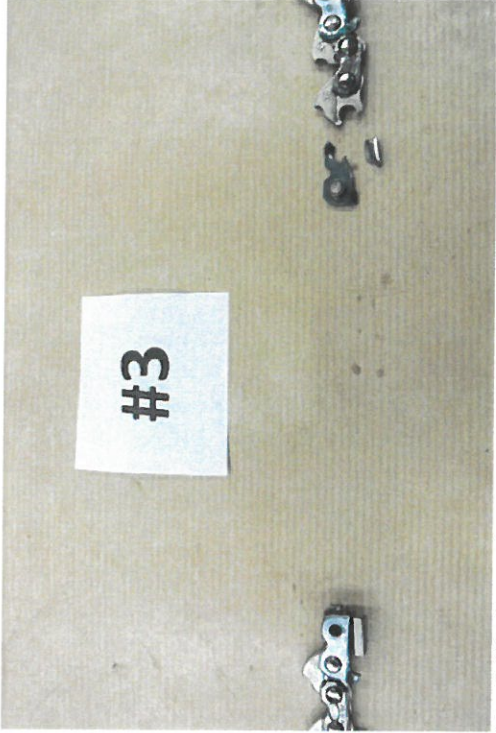
Test #2, Front side of window sample



Test #2, Back side of window sample



Test #3, Saw chain



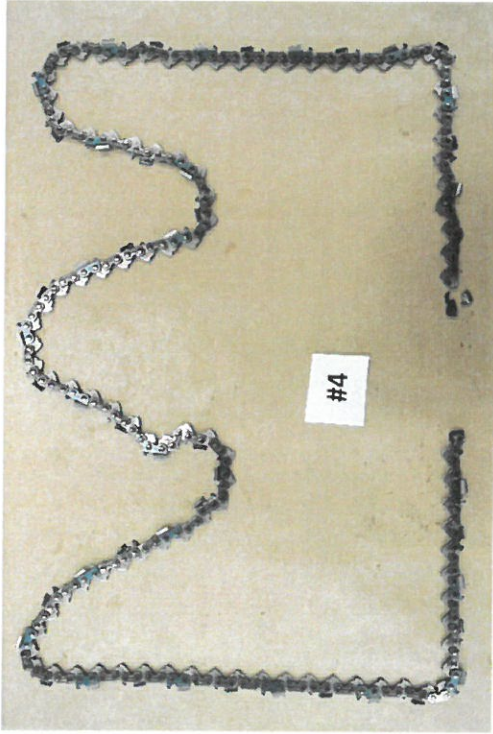
Test #3, Saw chain ends and loose links



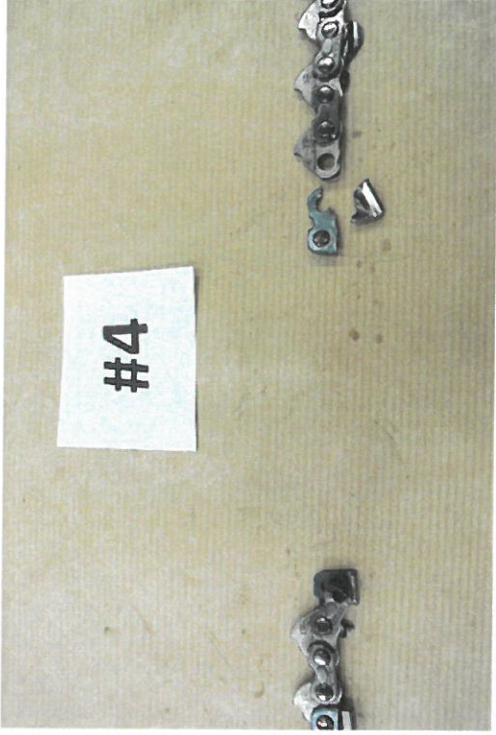
Test #3, Front side of window sample



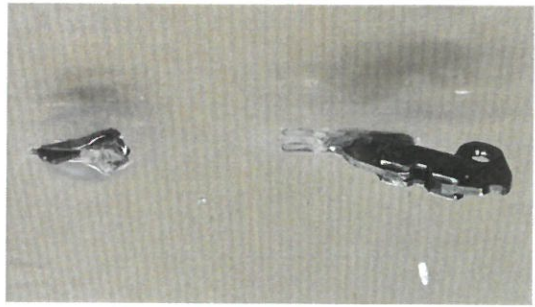
Test #3, Back side of window sample



Test #4, Saw chain



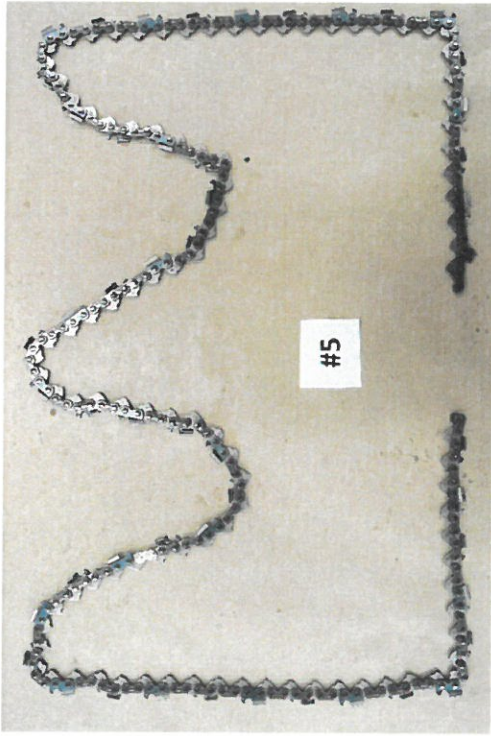
Test #4, Saw chain ends and loose links



Test #4, Front side of window sample



Test #4, Back side of window sample



Test #5, Saw chain



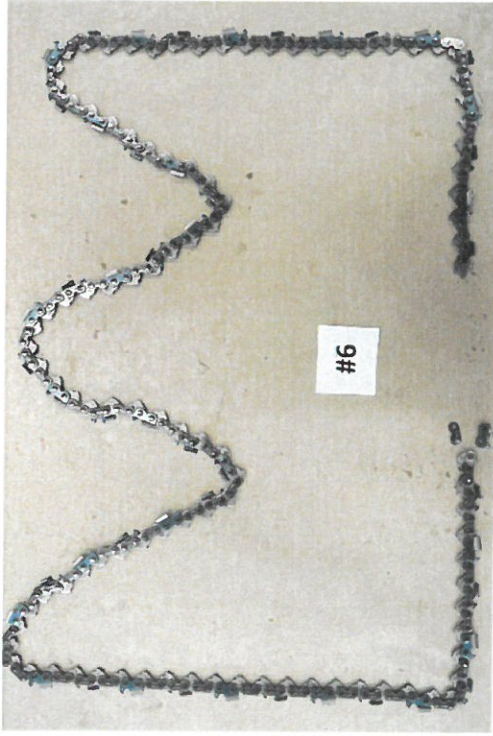
Test #5, Saw chain ends



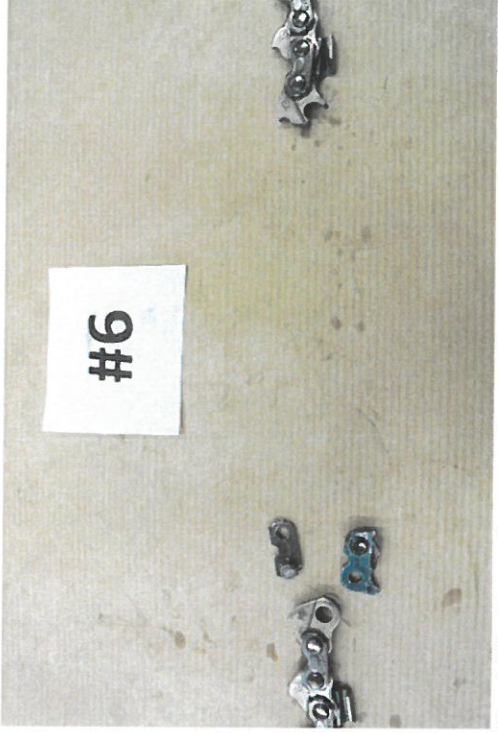
Test #5, Front side of window sample



Test #5, Back side of window sample



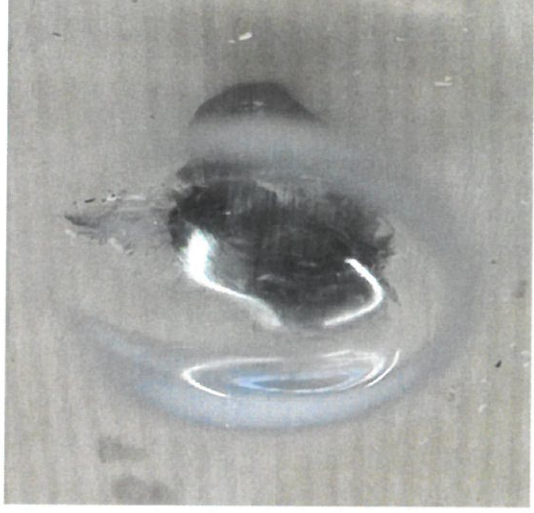
Test #6, Saw chain



Test #6, Saw chain ends and loose links



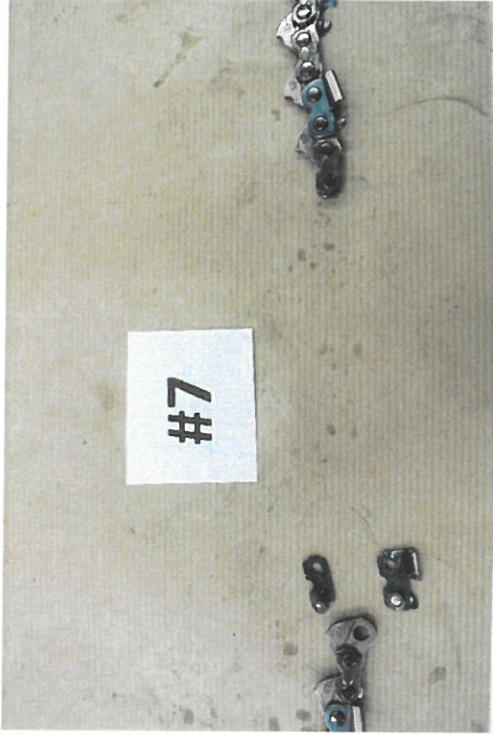
Test #6, Front side of window sample



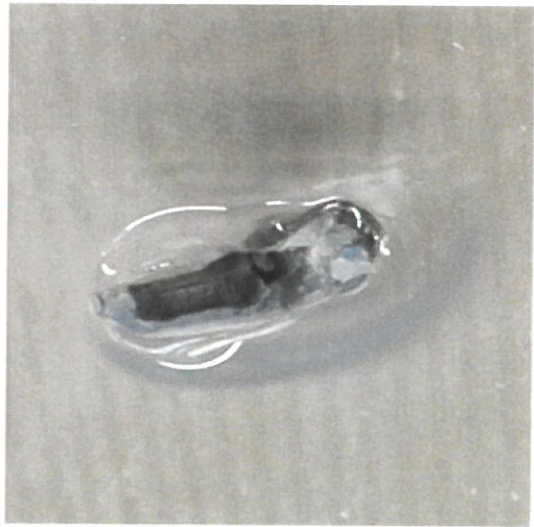
Test #6, Back side of window sample



Test #7, Saw chain



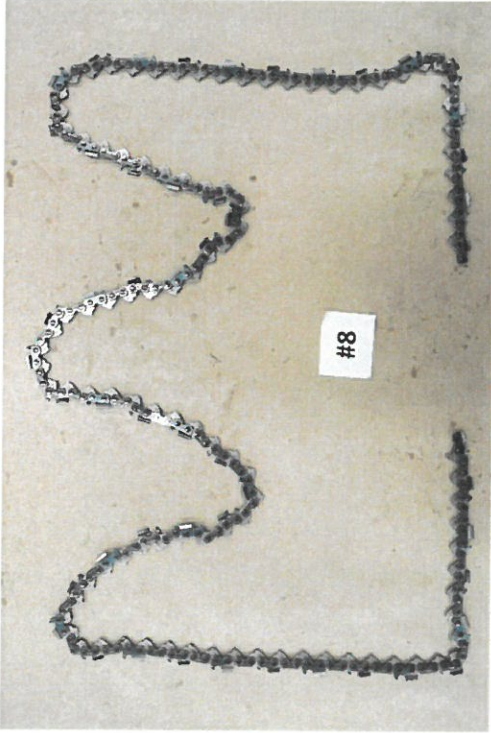
Test #7, Saw chain ends and loose links



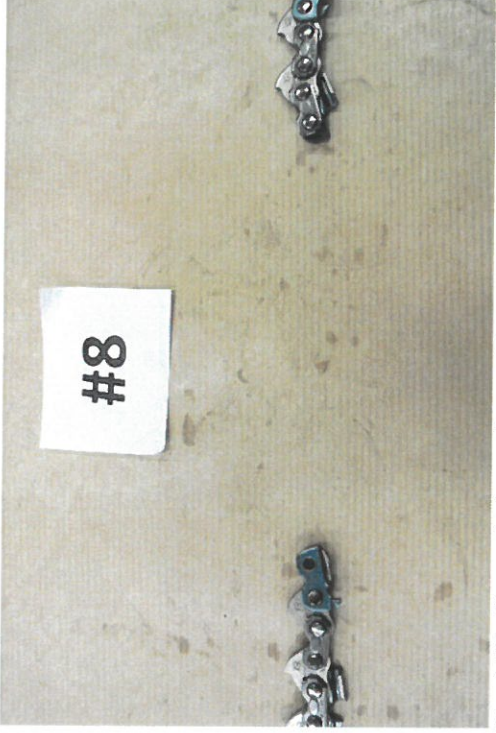
Test #7, Front side of window sample



Test #7, Back side of window sample



Test #8, Saw chain



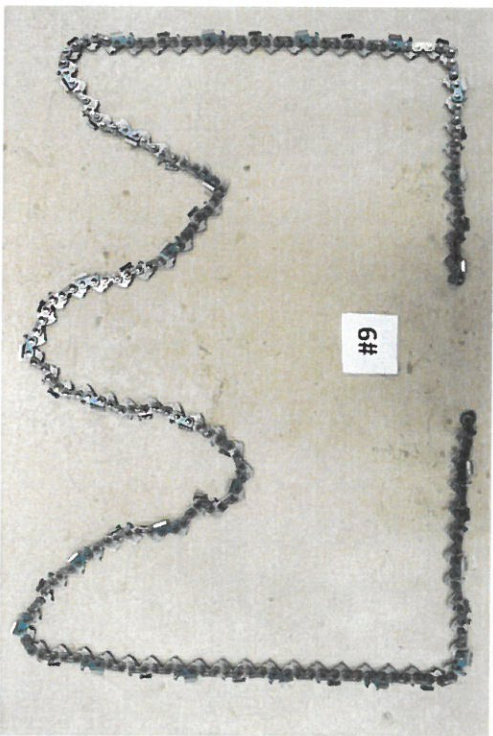
Test #8, Saw chain ends and loose links



Test #8, Front side of window sample



Test #8, Back side of window sample



Test #9, Saw chain



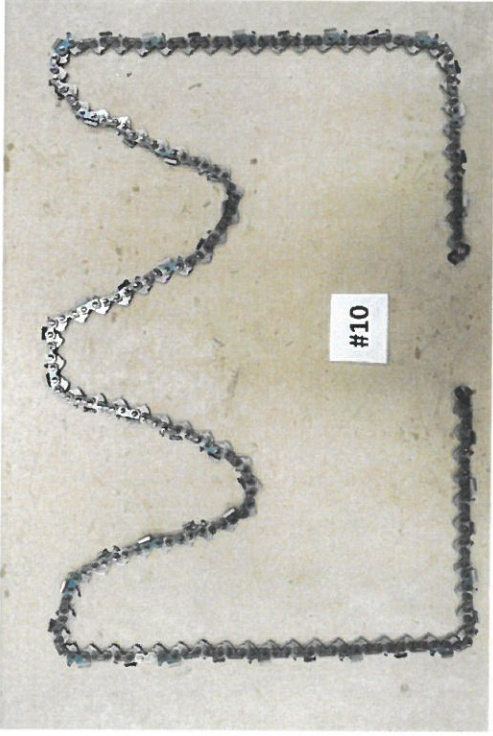
Test #9, Saw chain ends



Test #9, Front side of window sample



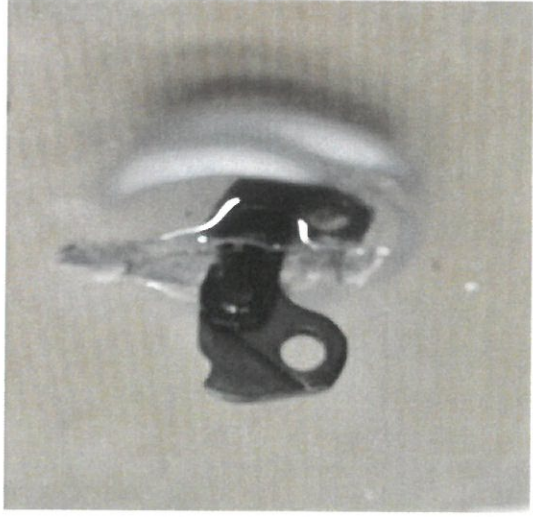
Test #9, Back side of window sample



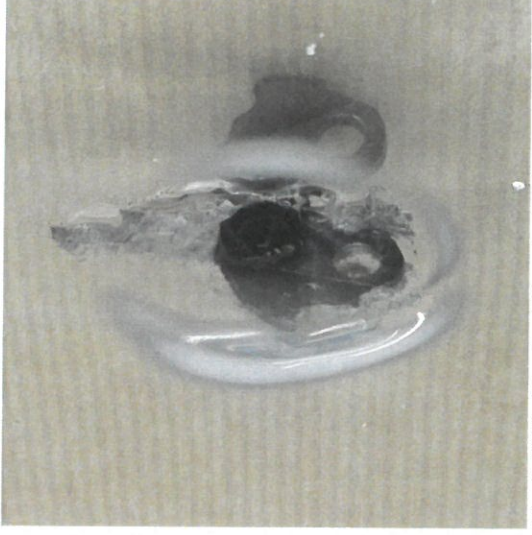
Test #10, Saw chain



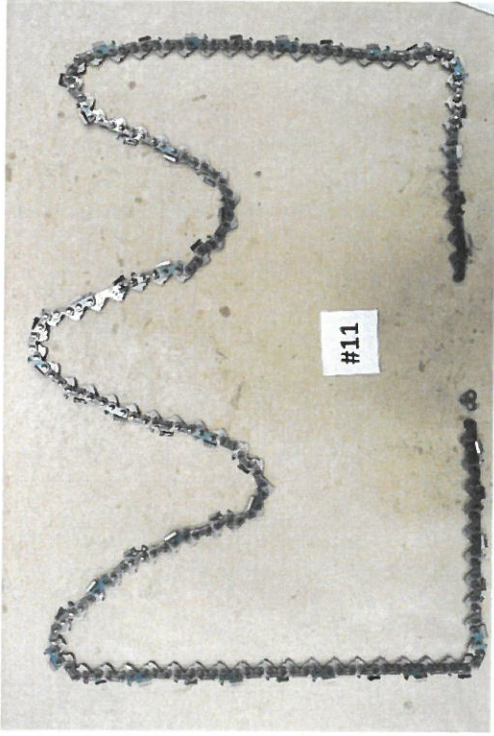
Test #10, Saw chain ends



Test #10, Front side of window sample



Test #10, Back side of window sample



Test #11, Saw chain



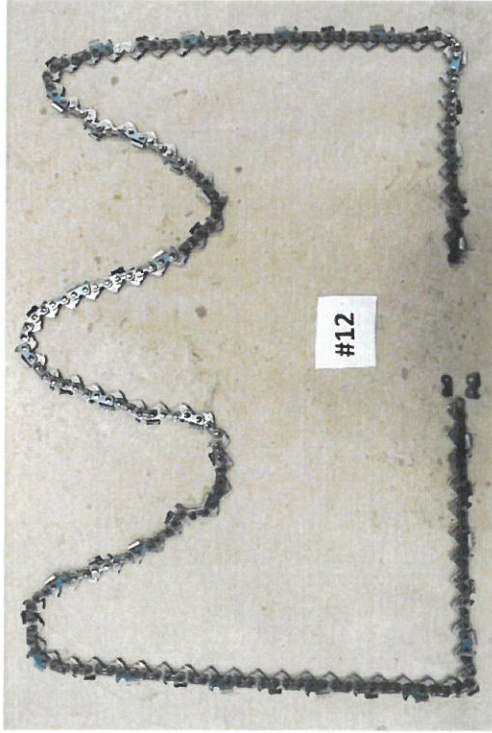
Test #11, Saw chain ends and loose links



Test #11, Front side of window sample



Test #11, Back side of window sample



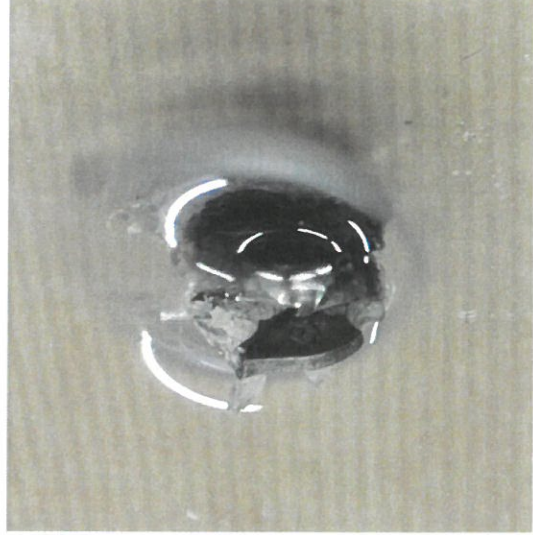
Test #12, Saw chain



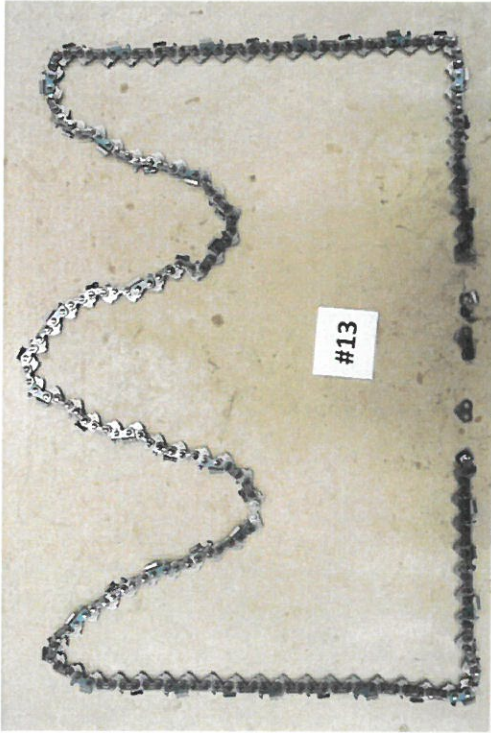
Test #12, Saw chain ends and loose links



Test #12, Front side of window sample



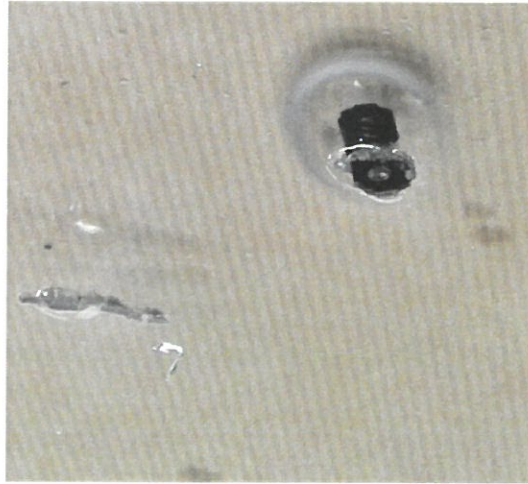
Test #12, Back side of window sample



Test #13, Saw chain



Test #13, Saw chain ends and loose links



Test #13, Front side of window sample



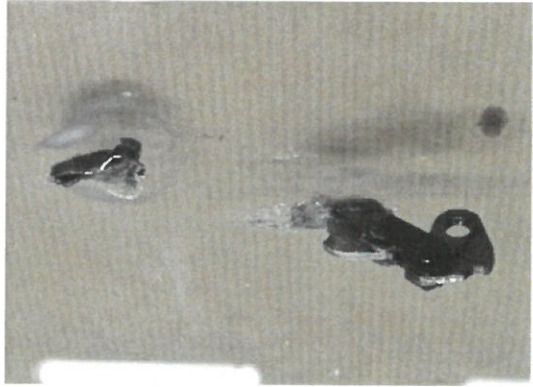
Test #13, Back side of window sample



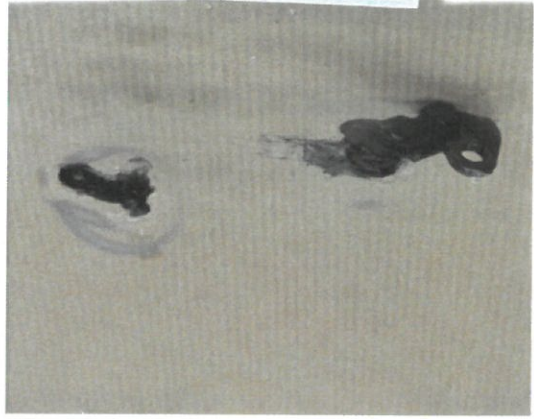
Test #14, Saw chain



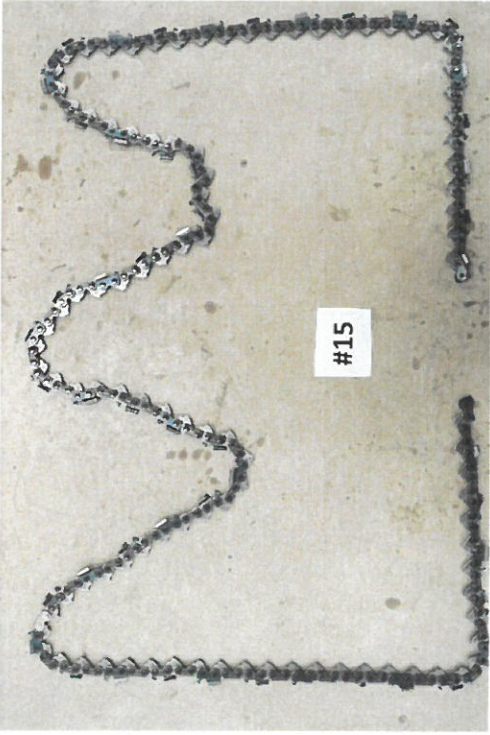
Test #14, Saw chain ends and loose links



Test #14, Front side of window sample



Test #14, Back side of window sample



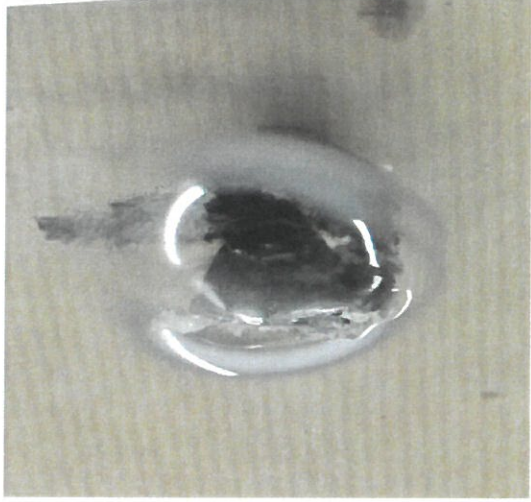
Test #15, Saw chain



Test #15, Saw chain ends



Test #15, Front side of window sample



Test #15, Back side of window sample