Reliability Assessment Report

Issue No:
Client: Shindo Industry
Name of sample: Flexible Delineator Post (200 O.D.x80 I.D.xH750(mm))

We certify that this reliability assessment report was prepared by FITI.

January 31, 2011

FITI Testing and Research Institute

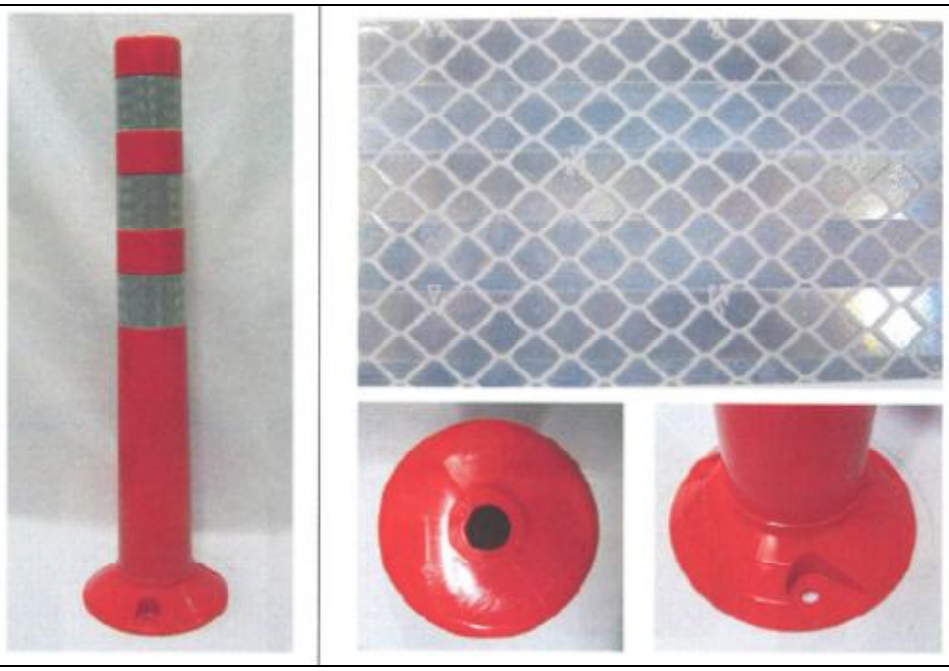
Reliability Assessment Results 1. Test Applicant		
Name of Company	Shindo Industry	
Representative	Yong-Sun Hwang	
Address	922-3 Dongpae-ri Gyoha-eup Paju-si, Gyeonggi-do	
Applicant	Yong-Sun Hwang	
Test Sample	Flexible Delineator Post (200 O.D.x80 I.D.xH750(mm))	
Use of Report	Certification test of reliability of tubular markers for road safety	
No of pages	12	
2. Test conditions and results		
Test standard	RS-FITI-2010-032 'Tubular markers for road safety'	
Test methods	.Quality test: tensile strength, tensile strain, tear strength, hardness, flexural compression, reflective performance, weather resistance (material and reflective sheet) .Reliability testing: shock test (high temperature test, low temperature test, reflective sheet test)	
Test period	Sep 28, 2010-Jan 5, 2011	
Test result	Performance requirements of 'tubular markers for road safety' met test standards in all test items; in reliability test, there was no damage after 500 impacts in high temperature impact test and low temperature impact test; the damage in reflective sheet met test standard after 300 shocks in the durability test of reflective sheet.	
Test-researcher	Written by	Approved by
Senior researcher, YS Yun	Chief of the Center, HJ Gu	Head of FITI, MW Noh

1. Applicant
    - Business name: Shindo Industry
    - Address: 922-3 Dongpae-ri Gyoha-eup Paju-si, Gyeonggi-do
    - Location of factory: 922-3 Dongpae-ri Gyoha-eup Paju-si, Gyeonggi-do

2. Test product: Tubular markers for road safety

The product for reliability test, tubular marker for road safety, is used for road installation to guide driver's eyes and separate the lane. In particular, it is installed at the entry and exit to highway and viaducts, diverged roads where the driver is apt to be confused and sharp curves where incidents frequently happen. These markers are frequently hit by cars because they are installed mainly on the road, so they require high reliability. Thus, it is absolutely necessary to secure the reliability of the product against long use on the road, by conducting impact test simulating the actual state of crash of the product with the vehicles and checks for deterioration in reflective performance.

3. Presented test sample: Flexible Delineator Post (200 O.D.x80 I.D.xH750(mm))

Test sample	Flexible Delineator Post (200 O.D.x80 I.D.xH750(mm))
Photos of sample	
Description of sample	Shindo Industry's tubular markers (Flexible Delineator Post (200 ODx80 IDxH750 (mm)) are installed for the purpose of inducing driver's eyes and separating lanes. Flexible Delineator Post is an integral product made from soft polyurethane resin and 3 sheets of high brightness self-reflective sheet were attached on the surface of the product.

4. Test method

RS-FITI-2010-032 'Tubular markers for road safety' was used as the test method and standard for the present certification. Detailed test method is as follows.

4.1 Quality test methods

4.1.1 Tensile test

Dumbbell shaped specimens should be made according to KS M 3824 and punched by the appropriate mold. In this case, the dumbbell specimen shall be taken for its longitudinal direction parallel to the flow of the sample. The maximum tensile strength shall be measured on the break after the specimen was pulled at (300 + / - 30) mm / min of tensile speed. The tensile strength varies depending on the thickness and width of the specimen, so it's normally expressed in tensile stress by dividing the tensile strength by the cross-sectional area of the sample as follows

$$T_B = \frac{F_B}{w \times d} \quad (1)$$

Where, T_B: tensile stress (MPa)
F_B: maximum load (N)
w: width of specimen (mm)
d: thickness of specimen (mm)

4.1.2 Tensile strain

Tensile strain is measured on the break of the specimen in the test of 4.1.1. The initial gauge points shall me marked at the center line of the test specimen at a distance of 20mm after clamping the specimen. Tensile strain is calculated by the following equation after failure.

$$E_B = \frac{L_1 - L_0}{L_0} \times 100 \quad (2)$$

Where, E_B: tensile strain (%)
L_1: gauge length at break (mm)
L_0 initial gauge length (mm)

4.1.3 Tear strength

The specimens should be made in rectangular shape according to KS M 3824, followed by punching with an appropriate mold. In this case, the specimen should be taken for the lengthwise direction to be parallel to the direction of flow of the sample. Since the tear strength varies on the thickness of the specimen, it is expressed in tear strength (N / cm) by dividing the maximum load (N) at failure by the notch thickness (cm).

$$T_R = \frac{F}{t} \quad (3)$$

Where, T_R: tear strength (N / cm)

F: maximum strength (N)

t: notch thickness (cm)

4.1.4 Hardness

A spring, type-A hardness tester of KS M ISO 868 was used for the test. Hardness test is performed by first contacting the surface of the specimen normal to the indenter of the tester, followed by applying the load of 9.8N on the specimen, and immediate reading of the scale of the hardness tester.

4.1.5 Bending Compression

It is the test to reproduce the phenomenon of irreversible compression of the tubular marker on the road by the wheels of the vehicle. A universal tensile tester is used for the test because it can accommodate the finished product as a whole. The test sample should be measured for the recovery within 60 seconds after the compression test, and the tilted angle of the product must be less than 10 degrees compared to the initial state.

a) High-temperature test: test should be performed by applying 5000N for 60seconds on the finished tubular marker sample that is fixed in the specimen holder within 2 minutes after treating the specimen at 70C for 2 hours. The test should be performed 3 times and shall meet the test standard.
b) Low-temperature test: test should be performed by applying 5000N for 60seconds on the finished tubular marker sample that is fixed in the specimen holder within 2 minutes after treating the specimen at -30C for 2 hours. The test should be performed 3 times and shall meet the test standard.

4.1.6 Reflection Performance

Three specimens of the width of 70mm and length 150mm shall be aligned to (210x150) mm according to KS A 3507 for the reflective performance test. The test device is comprised of a light projector with a diameter of the outlet 26mm or less and an optical receiver with its effective diameter of less than 26mm, with the distance (d) between the surface of the specimen and the receiver lens surface adjusted less than 15mm. In this case, standard light source A shall be used, and the spectral sensitivity of the receiver should be consistent with the relative luminous efficiency of the standard observer in principle. In addition, the illuminance of the incident ray on the surface of the specimen must be as uniform as possible. The observation is set to 0.2° and 0.5°, and the incident angle, -4°, 30°, with their directions positive in counter-clockwise direction. For measure, the receiver shall be installed at the specimen facing the projector and the illumination Es is measured. Next, the illumination Et shall be measured on the receiver by the reflection from the specimen at 3 incidence angles for 3 observation angles each, in order to calculate the reflection performance (retro reflection coefficient) R '.

$$R' = \frac{I}{E_s \times A} \quad (4)$$

Where, R′: retro reflection coefficient (cd/ (lx m^2))

Es: illuminance on the plane perpendicular to the incident light, at the center of specimen (lx)

A: surface area of specimen (m^2)

I: brightness (cd) in the direction of the observation axis of the specimen calculated by the following equation

$$I = E_r \times d^2 \quad (5)$$

Where, Et: illuminance on the receiver for the installation of the test equipment (lx)

d: distance between the center f the specimen and the light-receiver (m)

4.1.7 Weathering Performance

This test is to measure the degradation of reflection and discoloration of the reflective sheet, which shall be sampled for the measurement in the state of the actual product. According to ASTM G 155 and using a xenon arc-shaped weather-o-meter, repeating 120 minute-cycle including 102 min- light irradiation followed by 12 minute-light & water spraying, for a total of 500 hours. The irradiance of the light source shall bet set to 0.35W/m2 at 340nm. After the weathering test, reflective performance retention should

be 80% or better at observation angle 0.2° and incidence angle -4°, and the discoloration of the material shall be 7 or under in Delta_E(ΔE^*_{ab}) using the color system defined by KS M 3072.

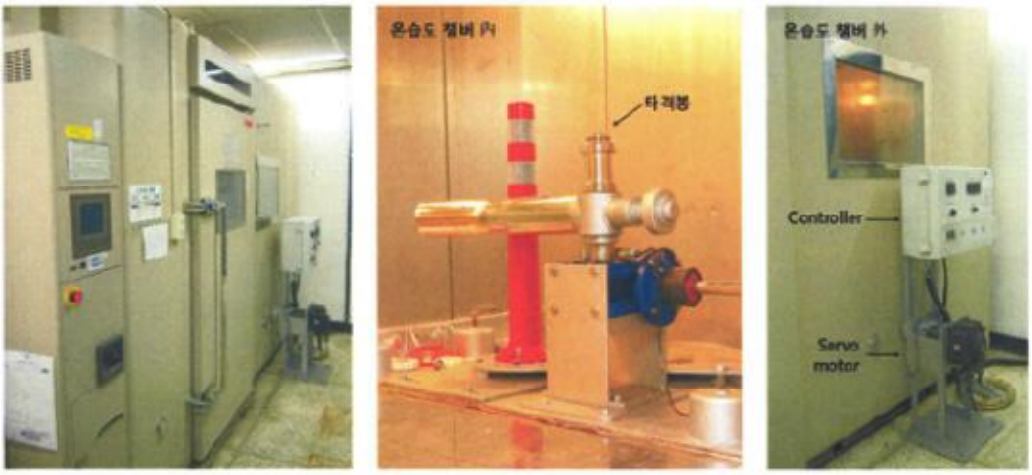
$$\text{Reflective performance retention} = \frac{R'_{500}}{R'_0} \times 100 \qquad (6)$$

Where, R'500: retro reflection coefficient after 500hr weathering (cd/ (lx m^2))

R'o: retro reflection coefficient before weathering (cd/ (lx m^2))

4.2 Reliability Test Methods

In order to simulate a vehicle crash test, which the most important reliability test of the tubular marker, the impact testing machine as in Figure 1 was used that can test the product as it is and reproduce the extreme environmental conditions.



Impact test was done including high temperature test that simulates the extreme summer weather, low temperature test, simulating extreme winter temperatures, and the endurance test of the reflective sheet at standard conditions (20°C, 65% RH).

4.2.1 High temperature impact test

An impact test was conducted at 30km/h after mounting the finished product of tubular marker and waiting for 2 hours at a temperature 50°C and relative humidity of 50%. The appearance of the product was examined after 500 times of the impact test; if damage has occurred before 500 times, the number of the impacts was recorded.

4.2.2 Low temperature impact test

An impact test was conducted at 30km/h after mounting the finished product of tubular marker and waiting for 2 hours at a temperature -20°C and relative humidity of 50%. The appearance of the product was examined after 500 times of the impact test; if damage has occurred before 500 times, the number of the impacts was recorded.

4.2.3 Impact test of reflective sheet

To evaluate the durability of the adhesion of the tubular marker and reflective sheet as the product condition, the reflective sheet endurance test was conducted using an impact tester. The impact test was carried out at a speed of 30km / h in standard conditions (20° C, 65% RH). After the impact test of 300 cycles, the reflective sheet in the impact area was removed from the product and the area retention (%) was calculated of the total area of the sheet still remained on the product compared with the initial state (impact area of the sheet=50% of the total area).

Area retention of the reflective sheet (%) = $$\frac{S_0 - S_{300}}{S_0} \times 100 \qquad (7)$$

where S_{300}: damage area of the sheet after hitting 300 times (cm^2)

S_o: initial Area=50% of total area of the sheet (cm^2)

5. Quality test results

Table 1 summarizes the test results of Flexible Delineator Post (200 O.D.x80 I.D.xH750 (mm)) of Shindo Industry Co., Ltd.

Table 1. Quality test results of Flexible Delineator Post (200 O.D.x80 I.D.xH750 (mm))

Div	Item					Unit	Standard	Result	Decision
material	Tensile stress					MPa	27 minimum	27.2	Pass
	Tensile strain					%	500 min	720	Pass
	Tear strength					N/cm	700 min	1123	Pass
	Hardness					H_A	85 min	88.6	Pass
	Bending compression					°	10 maximum	Within 10	Pass
Reflective sheet	Reflective performance	Observation angle	0.2	Incidence angle	-4	Cd/(lx.m^2)	250 min	554	Pass
			0.2		30		150 min	357	
			0.5		-4		95 min	328	
			0.5		30		65 min	156	
Material & sheet	Weathering performance			Discoloration		ΔE^*_{ab}	7max	4.90	Pass
				Reflective performance(0.2/-4)		Retention (%)	80min	82.4	

6 Reliability Test Results

6.1 Results of the high temperature impact test

Through high-temperature impact test results, it was determined whether material damage has occurred. After the test no damage was found in the three products tested as shown in Figure 2.

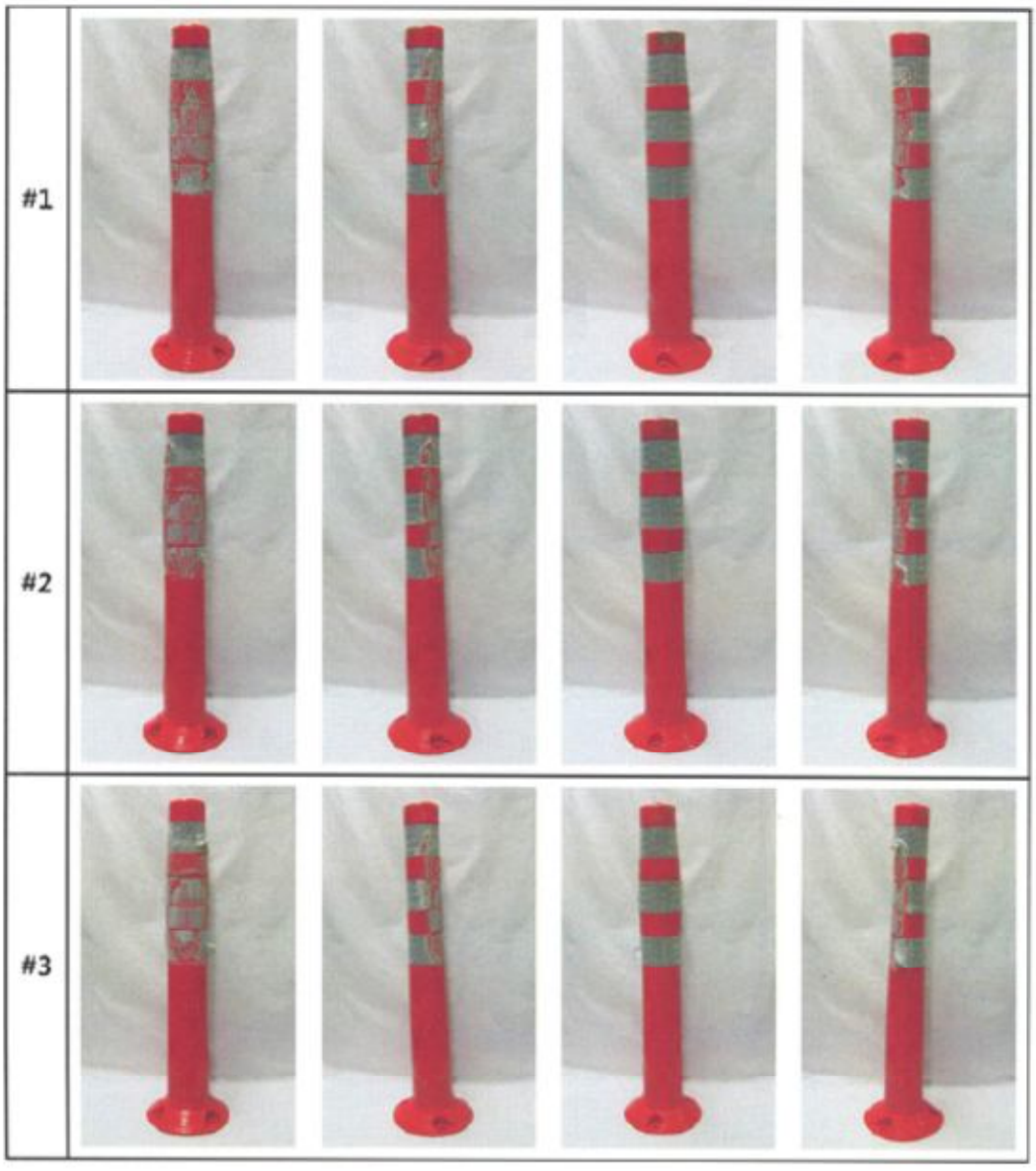


Figure 2. Results of the high temperature impact test

6.2 Results of the low temperature impact test

Through the low-temperature impact test results, it was determined whether material damage has occurred. After the test no damage was found in the three products tested as shown in Figure 3.

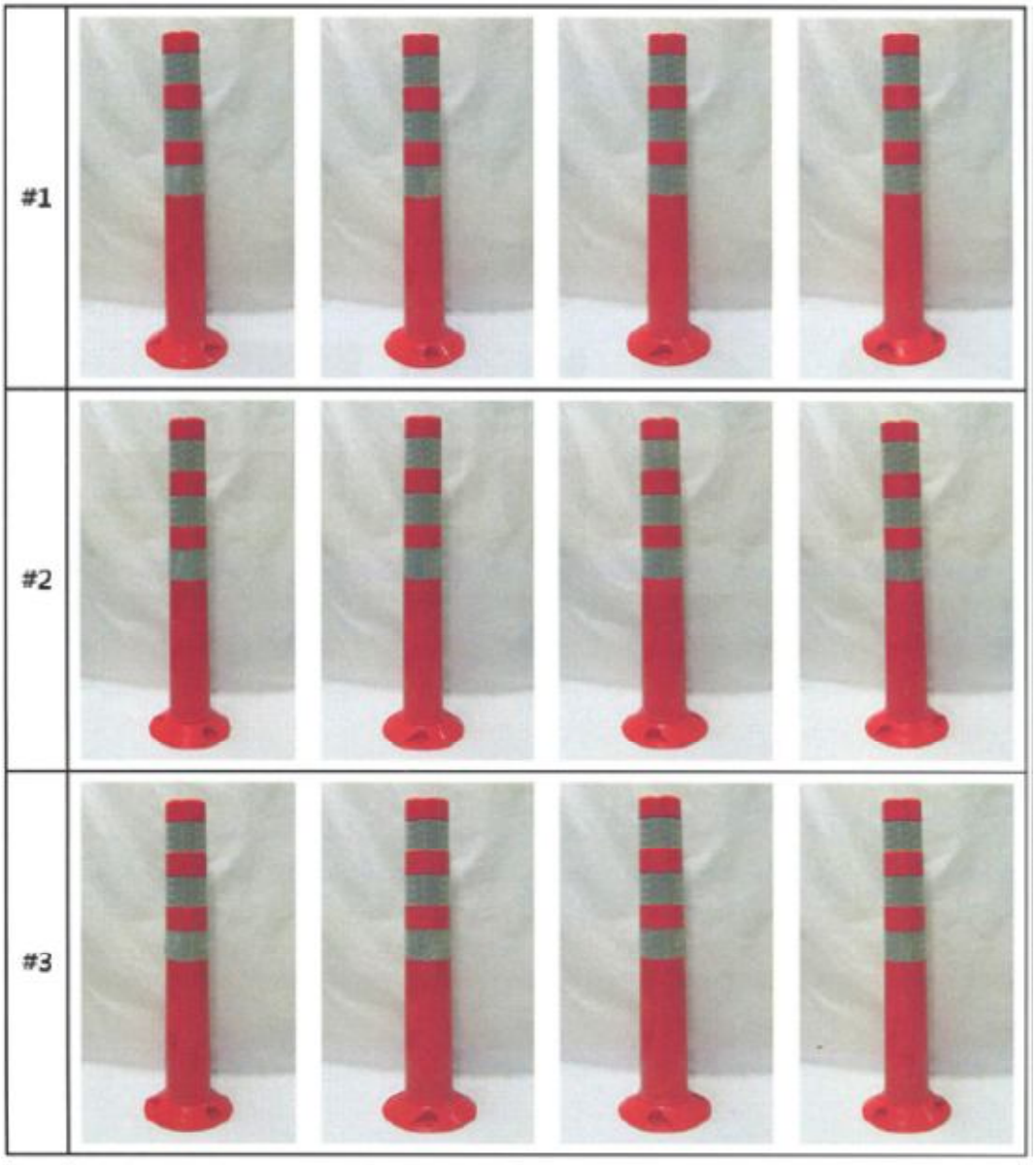


Figure 3. Results of the low temperature impact test

6.3 Results of the reflective sheet impact test

Through the reflective sheet impact test results, it was determined whether material damage has occurred. After the test no damage was found in the three products tested as shown in Figure 4.

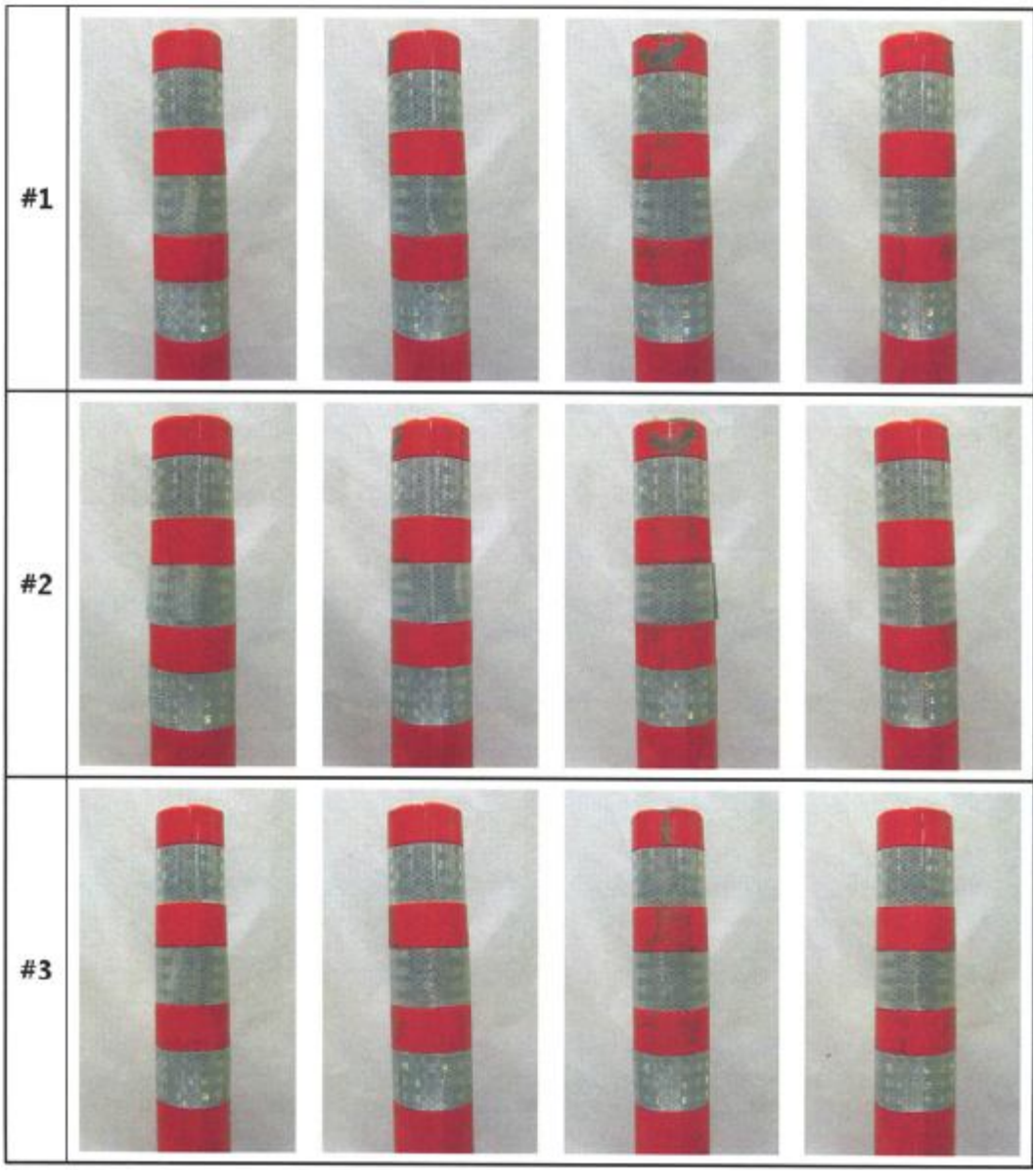


Figure 4. Results of the reflective sheet impact test

6.4 Results of the reliability test

Table 2 summarizes the reliability test results of Flexible Delineator Post (200 O.D.x80 I.D.xH750 (mm)) of Shindo Industry Co., Ltd.

Table 2 Reliability test results of Flexible Delineator Post (200 O.D.x80 I.D.xH750 (mm))

Test item		Test condition	Test standard	Test result	Decision
Impact test	High temp test	.Temp: 50°C .RH: 50% .Impact rate: 30km/h .Impact cycle: 500 cycles	.Damage in material: cracks shorter than 3cm .Recovery: within 10° compared with initial state .No of samples: 3	.Damage: no cracks .Recovery: within 10°	Pass
	Low temp test	.Temp: -20°C .Impact rate: 30km/h .Impact cycle: 500 cycles	.Damage in material: cracks shorter than 3cm .Recovery: within 10° compared with initial state .No of samples: 3	.Damage: no cracks .Recovery: within 10°	Pass
	Reflective sheet durability test	.Temp: 20°C .RH: 65% .Impact rate: 30km/h .Impact cycle: 300 cycles	.Damage of reflective sheet: 80% of the initial area .No of samples: 3	.Damage of reflective sheet: 99% of the initial area undamaged	Pass

7. Reliability Ratings

-Use: Tubular marks for road safety

-Reliability rating: Guaranteed for 500 cycles of high temperature impacts
Guaranteed for 500 cycles of low temperature impacts
Reflective sheet guaranteed for 300 cycles of impacts