

Traffic Safety and Security Division

3M™ Diamond Grade™ Conspicuity Markings

983-71 and 983-21 for Use on School Buses

Product Bulletin 983-71 and 983-21 School Buses
June 2016

Replaces PB 983 dated March 2006

Description

3M™ Diamond Grade™ Conspicuity Markings 983-71 and 983-21 for School Buses are highly retroreflective microprismatic markings designed to enhance the visibility of the sides and rear of school buses. The reflective marking consists of prismatic lenses that are formed in a transparent, synthetic resin, sealed and backed with a pressure sensitive adhesive and clear polymeric liner. Diamond Grade Conspicuity Markings are highly durable providing up to ten years of field performance. 3M's 983 markings have excellent angularity which provides enhanced visibility for drivers.

- Combined fluorescence and retroreflection provides 24-hour enhanced visibility and detection.
- Fluorescence enhances visibility for improved safety.

983-71 and 983-21 for School Buses meets or exceeds FMVSS-217 requirements.

Easy to Apply

- Aggressive pressure sensitive adhesive
- Easy to remove liner
- Available in rolls, packaged pieces, or kiss-cut pieces on a roll. Please refer to the 3M Traffic Safety and Security Division Pricing Catalog for the standard product offering.

Durable

- Pre-sealed edges
- Non-metallic construction
- 10-year warranty

Table 1. Product Codes by Color

Product Code	Color
983-71	Yellow
983-21	Fluorescent Yellow

Typical Physical Properties

Table 2 provides the typical physical properties of 983-71 and 983-21 for School Buses. The information in Table 2 should be considered typical only and should not be used for specification purposes.

Table 2. Typical Physical Properties

Property	Series 983-71 and 983-21 for School Buses Typical Values
Thickness (Caliper)	0.014 inch - 0.018 inch
Whiteness Daytime Luminance Limit Y_T ASTM E1164	27 Yellow 75 Fluorescent Yellow
Gloss ASTM D523 @ 85°	100
Shrinkage ASTM D4956	No substantial change
Flexibility - wrap around 0.125 inch mandrel @ 32° F (0° C)	No cracking
High pressure wash test 45° angle, 1200 psi, 8 inch away	Passes
Adhesion 90° Hanging Weight ASTM D4956	0.2 inch (4 mm)
Minimum Application Temp.	50° F (10° C)
Instron Peel Adhesion 12 inch/minute, 90° pullback	Degreased aluminum 5.3 lb/in (.95 kg/cm) Prepainted panel 3.0 lb/in (0.55 kg/cm) Stainless steel 6.0 lb/in (1.1 kg/cm) FRP 2.5 lb/in (0.52 kg/cm) Tedlar® 3.0 lb/in (0.54 kg/cm) Aluminum Rail 3.5 lb/in (0.56 kg/cm)
Chemical Resistance SAE J1967	Not affected by toluene, #2 diesel fuel, gasoline (leaded) kerosene, TSP detergent, xylene, dilute metal brighteners
Corrosion Resistance ASTM B-117 Salt Spray	No effect - 1000 Hours
Impact Resistance Room Temperature 100 in-lb, 5/8 inch tip	No damage outside impact
Cold Temperature 60 in-lb at -20° F	No damage outside impact

Coefficient of Retroreflection

The values in Table 3 are typical coefficients of retroreflection expressed in candelas per lux per square meter (cd/lux/m²). Conformance to coefficient of retroreflection requirements shall be determined by instrumental method in accordance with ASTM E810 “Test Method of Coefficient of Retroreflection of Retroreflective Sheeting”, and per ASTM E810, the R_{AS} at 0° and 90° rotation are averaged to determine the R_A in Table 3.

Table 3. Typical Coefficient of Retroreflection (R_A) for New Sheeting (cd/lux/m²)

Observation Angle ¹	Entrance Angle ²	983-71 Yellow (FMVSS-217)	983-21 Fluorescent Yellow (FMVSS-217)
0.2 °	-4°	645 (170)	400 (170)
	30°	420 (64)	220 (100)
	45°	235 (N/A)	120 (N/A)
0.5 °	-4°	360 (136)	150 (62)
	30°	180 (45)	75 (45)
	45°	65 (N/A)	40 (N/A)

Typical Physical Characteristics

Table 4 provides the typical physical characteristics of 983-71 and 983-21 for School Buses. The information in Table 4 should be considered typical only and should not be used for specification purposes.

Table 4. Typical Physical Characteristics of 983-71 and 983-21 for School Buses

Property	Description
Adhesive color and type	Clear, pressure sensitive
Liner	Translucent polymeric
Application surfaces	Metal or painted metal flat without rivets
Heat resistance	Maintains 70% of original coefficient of retroreflection at ($\alpha=0.2$, $\beta=-4$) after 24 hr. exposure to 170° F (77° C) air
Recommended application temperature (ambient and substrate)	50° F (10° C)
Performance range	-30° F to 200° F (-34° C to +94° C)

Photometrics

Fluorescence

Fluorescent materials absorb short wavelength, invisible, incident radiation (solar energy) and re-emit the radiation as longer wavelength, visible light. This re-emitted energy continues as long as incident radiation is present. These materials are especially effective during dawn, dusk, and overcast days. Fluorescence adds to daytime luminance (apparent brightness) of markings and enhances the visibility of school buses and other vehicles.

¹ Observation Angle – The angle between the illumination axis and the observation axis.

² Entrance Angle – The angle from the illumination axis to the retroreflector axis. The retroreflector axis is an axis perpendicular to the retroreflective surface.

Color Test – Fluorescent Sheetings

Conformance to standard chromaticity (x, y) and luminance factor (Y) requirements shall be determined by instrumental method in accordance with ASTM E991 on sheeting applied to smooth aluminum test panels cut from Alloy 6061-T6 or 5052-H38. The values shall be determined on a HunterLab ColorFlex 45/0 spectrophotometer. Computations shall be done for CIE Illuminant D65 and the 2° standard observer.

Fluorescence Luminance Factor (Y_F) differentiates fluorescent markings from ordinary (nonfluorescent) markings. The additional daytime luminance provided by fluorescence is directly related to the increased conspicuity of fluorescent vehicle markings under varying conditions of daylight illumination encountered in outdoor safety marking applications. The fluorescence luminance factor, Y_F , provides a standardized measure of the marking's fluorescence.

The numerical value of Y_F under specified illumination and viewing conditions: 1) verifies the fluorescence of the marking (for nonfluorescent markings $Y_F=0$) and 2) quantifies the fluorescent efficiency of the marking. The magnitude of Y_F can be used to assess whether the fluorescence of the marking is sufficient to provide high daytime visibility performance under poor visibility conditions. Typical fluorescence luminance factor (Y_F) values of 983-21 fluorescent yellow are given in Table 5.

Table 5. Typical Luminance Factor Values for 3M™ Diamond Grade™ Fluorescent Yellow Conspicuity Markings³

Color	Total Luminance Factor (Y_T)	Total Luminance Factor (Y_F)	Total Luminance Factor (Y_R)
Fluorescent Yellow	75	55	20

Maintenance

Cleaning

Routine washing is recommended for maximum performance. The following cleaning methods are recommended.

- Wash with sponge, cloth or soft brush using water and detergent.
- Automatic truck/car wash or standard high-pressure hand spray:
 - Maximum pressure: 1200 PSI/80 bar.
 - Maximum water/wash solution temperature: 140° F/60° C.
 - Minimum of 12 inches/30 cm distance of cleaning jet(s) from markings.
 - Cleaning wand or jets to be at no greater angle than 45 degrees from perpendicular to the marking surface.
 - Use Spray Tip #1505 (15 degree spray angle, 05 capacity size).
- When using metal brighteners, follow manufacturer's recommendations for dilution. Thoroughly rinse from markings after soaking vehicle.

Storage

- Cool, dry area out of direct sunlight.
- Temperature 65-75° F (18-24° C) humidity 30-50%.
- Store rolls horizontally, in carton or in original packaging.

Shelf Life

- Apply 983-71 and 983-21 for School Buses markings within one year of receipt of material.

³ Total luminance is defined as the sum of fluorescent and reflected luminance ($Y_T=Y_F+Y_R$) and is determined in accordance with ASTM E2152 and ASTM E2153.

General Performance Considerations

983-71 and 983-21 for School Buses will provide maximum durability when:

- 3M™ recommended procedures are followed.
- Marking is applied to vertical surfaces (within $\pm 20^\circ$ from vertical).

Durability will depend on customer use. Failure to follow the 3M-required techniques may reduce durability. Below are some examples and conditions that may lead to reduced durability:

- Failure to cut markings around rivets, seams and body panels.
- Improper use of high pressure cleaning.
- Contact with non-recommended chemicals or solvents.
- Improper application or surface preparation.
- Horizontal exposure is not recommended.
- Open cells along the edge of the marking may collect dirt but will not reduce the performance of the marking.
- Damage due to external conditions may show loss of adhesion and reflectivity in the immediate area.

Health and Safety Information

Read all health hazard, precautionary, and first aid statements found in the Safety Data Sheet (SDS), Article Information Sheet and/or product label of chemicals prior to handling or use. Consult local regulations and authorities for possible restrictions. Visit us at www.3M.com/us and select SDS search to obtain current Safety Data Sheets.

Warranty

3M Basic Product Warranty

3M™ Diamond Grade™ Conspicuity Marking 983-71 and 983-21 for School Buses (“Product”) is warranted (“Basic Warranty”) to be free of defects in materials and manufacture at the time of shipment and to meet the specifications stated in this product bulletin. If the Product is proven not to have met the Basic Warranty on its shipment date, then a buyer’s exclusive remedy, and 3M’s sole obligation, at 3M’s option, will be a refund or replacement of the Product.

Additional Warranty

3M™ warrants (“3M Warranty”) that a Product sold by 3M to be used for School Buses conspicuity markings in the United States and Canada will remain visible by resisting excessive fading, cracking, peeling, lifting or discoloration for ten (10) years (“Warranty Period”) from the date of original installation (“Installation Date”).

Terms and Conditions

- Product must be processed and applied to a vertically-mounted ($\pm 20^\circ$) 3M recommended substrate as described in this product bulletin and in accordance with all 3M application and fabrication procedures provided in 3M’s product and information folders (including but not limited to [IF 4.9](#)), general performance considerations given in this product bulletin, and applicable technical memos (which will be furnished to the manufacturer upon request).
- Any third-party imaging or altering of the Product not endorsed by 3M will void the 3M Warranty.
- A Product’s failure to meet the 3M Warranty must be solely the result of design or manufacturing defects in the Product and not of (a) outside causes including improper storage, fabrication, handling, maintenance or installation; (b) use of process colors, thinners, coatings or other chemicals not recommended by 3M; (c) use of application procedures not recommended by 3M; (d) exposure to chemicals or solvents not recommended by 3M; (e) abrasion and other physical damage; (f) snow or any other burial of the marking; (g) collisions, vandalism or malicious mischief; (h) or an act of God.

- 3M™ reserves the right to determine the method of replacement. Replacement product will carry the unexpired warranty of the Product it replaces.
- Claims made under this warranty will be honored only if 3M is presented with a traceable record of the Product's Installation Date. Claims made under this warranty will be honored only if 3M is notified of a potential failure within thirty days of discovery, reasonable information requested by 3M is provided, and 3M is permitted to verify the cause of the failure.

Exclusive Limited Remedy and Disclaimer

If the Product is proven not to have met the 3M Warranty during the Warranty Period, then the purchaser's and user's exclusive remedy, and 3M's sole obligation, at 3M's option shall be that 3M will provide replacement of the Product.

THE 3M WARRANTY IS MADE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OR CONDITION OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE, OR ANY IMPLIED WARRANTY ARISING OUT OF A COURSE OF DEALING OR OF PERFORMANCE, CUSTOM OR USAGE OF TRADE.

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Literature Reference

[IF 4.9](#)

Application Instructions for Diamond
Grade Conspicuity Markings Series 983

For Information or Assistance

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