Intersection Proven Safety Countermeasure

Technical Summary:
Backplates with Retroreflective Borders

U.S. Department of Transportation
Federal Highway Administration

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Foreward

In 2012, the Federal Highway Administration, Office of Safety issued a "Guidance Memorandum on Promoting the Implementation of Proven Safety Countermeasures". This guidance took into consideration the latest safety research to advance a group of countermeasures proven highly effective at improving safety. The nine Proven Safety Countermeasures chosen for targeted implementation included Backplates with Retroreflective Borders, defined as "the addition of narrow strips of retroreflective tape or sheeting around the border of the backplates." This combination of traffic signal backplates and retroreflective borders serves to improve and enhance the visibility and conspicuity of the traffic signal indications, ultimately leading to fewer red light running related incidents.

As a means to further promote and advance Backplates with Retroreflective Borders, this Technical Summary and a companion Executive Summary have been prepared to assist transportation professionals with decisions pertaining to their implementation. This document provides a substantive overview of policy, procedural and construction issues. More information on this safety countermeasure can be found on the FHWA website at http://safety.fhwa.dot.gov.

This publication does not supersede any publication; and is a Final version.

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Contents

Easier to see, day or night

Traffic signal backplates—thin plates of material that surround traffic signal indication light arrays—are intended to improve the visibility of the signal by providing a consistent and controlled-contrast background. Attempts to further enhance the visibility and conspicuity of traffic signals, particularly during nighttime hours, have led to the addition of narrow strips of retroreflective tape or sheeting around the border of the backplates. This combination—called backplates with retroreflective borders—frames the signal indication, providing visual benefits during both daytime and nighttime conditions.

Exhibit 1: Retroreflective borders on backplates can provide a visual benefit during both daytime and nighttime conditions. (Source: VDOT)

Retroreflective borders also enhance the visibility of traffic signals for aging and color vision impaired drivers enabling them to understand which signal indication is illuminated. Retroreflective borders may also alert drivers to signalized intersections during periods of power outages when the signals would otherwise be dark, and non-reflective signal heads and backplates would not be visible. FHWA cited the treatment as an "Aging Driver" Best Practice[1] and one of its nine Proven Safety Countermeasures;[2] the treatment was also added as an option in the 2009 Manual on Uniform Control Devices (MUTCD).[3] As a result of successful implementation in varied localities, many U.S. State and local transportation agencies have adopted practices and policies concerning this countermeasure.

Low cost per unit, big safety benefit

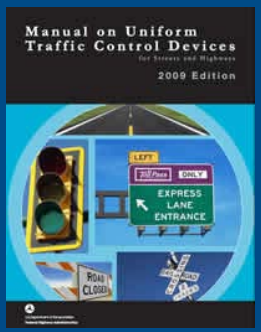
Backplates with retroreflective borders is a safety treatment that does not require significant material or labor costs to install. Depending on the implementation method chosen, costs range from $35 for adding reflective tape to existing backplates to $56-110 for replacing the backplates with reflective material already incorporated.

Reduction in collision claims and injury/fatality crashes: a proven safety measure

The first study of retroreflective backplates was conducted in 1998 in British Columbia,

Included in the Manual of Uniform Traffic Control Devices (MUTCD)

MUTCD Section 4D.12 Visibility, Aiming, and Shielding of Signal Faces



A yellow retroreflective strip with a minimum width of 1 inch and a maximum width of 3 inches may be placed along the perimeter of the face of a signal backplate to project a rectangular appearance at night.

Exhibit 2: In June 2005, yellow retroreflective borders were added to existing backplates at three high-crash locations in Columbia, South Carolina. Simple before- and after- implementation comparisons showed crash reductions at the three sites ranged between 29 percent (total crashes) and 50 percent (late-night/early-morning crashes).[5] (Source: FHWA)

Canada, with ten signalized intersections. What began as a small project turned into a sizable deployment and study, with robust statistical evaluations conducted after several years.

In a paper published in 2005, Sayed et al[4] reported the results of a study testing the application of 75mm-wide retroreflective tape on backplates at 17 signalized intersections. The results showed the total modeled insurance claims were reduced by approximately 15 percent. This 15 percent reduction in all crash types became the basis for the crash modification factor (CMF) of 0.85 as citied in the CMF Clearinghouse, and is referenced by a number of organizations and vendors with regard to the effectiveness of adding retroreflective borders to signals. This remains the most complete study to evaluate the effectiveness of retroreflective borders on backplates exclusively.

A closer look at those 17 locations suggests that retroreflective borders on backplates are effective across a broad range of installations. The roads in the study varied in characteristics, ranging from 30 to 55 mph posted speeds, with surrounding land uses that were urban and suburban (with industrial or commercial developments), some with lighting, and some with pedestrian facilities.

Low cost, simple implementation

The most effective means of implementing retroreflective backplates is to adopt them as a standard treatment for signalized intersections across a jurisdiction, so that the treatment will be consistently incorporated into all new construction and modernization projects.

Michigan DOT and Highway Safety Improvement Program (HSIP) Funding

Beginning with FY15 HSIP projects, Michigan DOT now requires retroreflective border backplates for any traffic signal upgrade project, making it an HSIP standard. [6]

Multiple vendor options

The list of State and local agencies using this proven countermeasure grew substantially in the last several years, leading many traffic control device vendors to offer them as a complete product. Agencies should work with their suppliers to determine availability.

Mature process

While retroreflective backplates are a low-cost, fairly simple modification, early adopters have learned to address a short list of possible implementation challenges, such as minimizing installation time, adjusting to the learning curve of integrating new practices and equipment, and physically accessing signal heads.

States have funded these projects in various ways. Some jurisdictions, such as the City of Nashua, New Hampshire, have used Congestion Mitigation and Air Quality (CMAQ) funding to install backplates with retroreflective borders as part of overall signal modernization. Other states, such as Washington, have largely funded installation retrofits through Highway Safety Improvement Program (HSIP) funding.

Exhibit 3: Signals with retroreflective backplates in the City of Nashua, New Hampshire. (Source: VHB)

CASE STUDY: City of Nashua, New Hampshire, LESSONS LEARNED

As part of a larger project to upgrade 68 intersections in its downtown core, the City of Nashua installed retroreflective borders on signal backplates to increase signal conspicuity and improve safety. Louvered, aluminum backplates with a 2-inch strip of yellow reflective tape were installed on approximately 400 signal heads at 41 of the 68 targeted intersections. The majority of these were retrofits of existing signals. Officials cited the FHWA's Proven Countermeasures as a factor in their decision to include the retroreflective backplates as part of the signal upgrade.

The project, completed in 2014, was funded through the Federal participating Congestion Mitigation and Air Quality (CMAQ) program (with an 80/20 Federal/local ratio). Projected benefits include a 40 percent reduction in total crashes due to all of the measures implemented as part of the program, a 13 percent reduction in total crashes due to retroreflective backplates, better intersection levels of service, and improved air quality for the city. (Source: VHB)

Lessons learned during the project include:

- If the signal head isn't removed prior to installation of a backplate, it may be necessary to cut through the backplate to flex it around a signal head. Use a power saw to cut through the backplate, as tin snips can leave ragged and sloppy cuts that prevent the tape from adhering properly to the backplate.
- Providing a list of all signal configurations and manufacturers helps the installation team plan ahead for properly fitting backplates, which saves time in the field.
- Ultimately, the replacement backplates selected were manufactured to fit many types of signal heads. Replacing the backplates while the signal head remained in place was a fairly quick procedure, with an approximate installation time of 10-15 minutes per backplate.

Flexibility in design and materials

Backplates and borders come in various configurations:

Backplate (variations: back plate, backboard). Generally, backplates are made up of a thin strip of material that extends outward from and parallel to a signal face on all sides of a signal housing to provide a background for improved visibility of the signal indications.

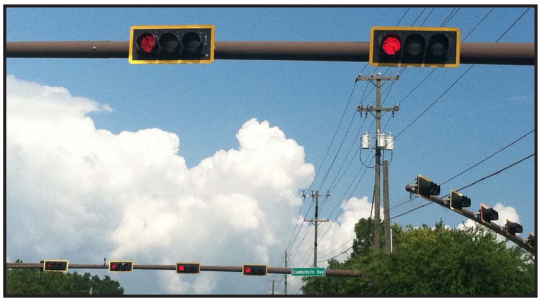


Exhibit 4: The retroreflective border provides a visual reference about the orientation of the signal, particularly during dark conditions. (Source: VHB)

Backplates are typically made of aluminum or ABS plastic. Aluminum allows for color variation through painting, while ABS has a fixed set of colors selected during production. Aluminum is typically a better surface for adhering retroreflective sheeting, but multiple jurisdictions have applied tape to ABS with no notable degradation. Backplate width is driven by the size of signal faces and the respective material specifications for each jurisdiction.

Sometimes the backplate is louvered with a series of narrow openings framed at their longer edges with slanting, overlapping fins or slats. Designed to allow air to pass through and better disperse wind loads, louvered backplates are more commonly used in locations prone to high-wind conditions. Retroreflective tape placed over louvers defeats the purpose of the louvers and accelerates degradation of the tape. Application on these backplates may require use of a narrower-width tape. Some states require a border of at least a ½-inch between the tape and any louvers.

Exhibit 5: Signals at a displaced left-turn (DLT) intersection in Fenton, Missouri, have backplates with and without retroreflective borders. (Source: FHWA)

Retroreflective backplate border. A strip of yellow retroreflective sheeting placed along the perimeter edges of a backplate provides a "frame" for the signal face that is visible under both light and dark conditions. Retroreflective tape is coated with glass spheres or engineered microprisms to reflect light back to its source. Typically, it comes in rolls, and has an adhesive backing. Tape can be 1- to 3-inches in width; however, the 2-inch variety is most commonly used, per the specification of States such as Florida, Ohio, Indiana, and South Carolina.

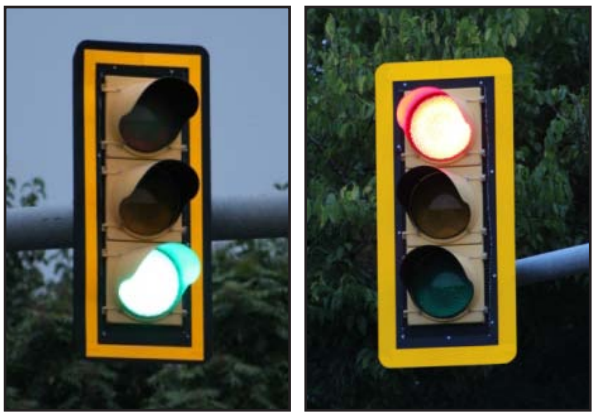


Exhibit 6: There may be variations in the type of retroreflective borders. The backplate on the left has a black border on the outside of the retroreflective border. On the backplate to the right, the retroreflective border extends to the edge of the backplate. (Source: VDOT)

Among the different types of retroreflective sheeting available, prismatic types are most

often used. The most common is ASTM Type XI, but others, including ASTM Types I, III and IV, are also used. The choice of sheeting type is largely driven by State specifications, but may also be influenced by availability of the desired width in a convenient form.

Numerous installation options

Existing traffic signal hardware, available manpower, traffic conditions, and other factors influence the chosen method of installation. Backplates can be installed on the ground if the signal is new or removed, or while the signal/backplate is still hanging. Many agencies take the opportunity to install retroreflective borders on backplates when replacing or updating signal heads.

Exhibit 7: Retroreflective Borders on Backplates Installation Considerations

As part of its implementation of retroreflective borders on backplates, the Virginia Department of Transportation (VDOT) asked Regional Operations Maintenance Managers for ideas about installation methods and retrofitting existing signals. This table is adapted from information gathered by VDOT to evaluate various installation techniques, equipment costs, labor time, maintenance of traffic (MOT) costs, durability, warranty, and potential installation locations.

	Retrofit Existing Backplate		**Replace Existing Backplate**		**Add New Backplate**	
Installation	In air: Scrape clean, apply tape.	In air: Remove, treat, and reinstall backplate.	In air: Remove and replace backplate.	Ground: Remove signal head and add backplate.	In air: Add new backplate.	Ground: Remove signal head and add new backplate.
Equipment Cost	Low	Low	Low	Mid	High	High
Labor Time	Low	Mid	Mid	High	Mid	High
MOT Cost	Mid	Mid	Mid	High	Mid	High
Durability Concerns	Yes	Yes	Yes	No	No	No
Warranty Concerns	No	Void if backplate is cut.	Void if backplate is cut.	No	No	No
Implementation Locations	• Older signal heads where new backplates do not fit. • Recently installed signal heads with untreated backplates.		• Older signal heads where backplate fits. • Recently installed signal heads with untreated backplates.		• Older or recently installed signal heads where new backplate fits.	
Notes	No signal head brand inventory required.		Backplates are specific to signal head manufacturer (need inventory).		• No signal head inventory required. • May have to replace other equipment (cables, brackets, etc.).	

Methods for placing retroreflective borders on backplates include:

Ordering backplates directly from the distributor with retroreflective tape pre-applied. This option may be best for new and replacement signals. It represents the highest initial material cost, but saves the labor cost of local sign shops applying the tape. However, not all backplates will fit on existing signal heads. For example, the City of Nashua, New Hampshire—where approximately 400 signal heads were retrofitted with retroreflective borders on backplates—required a manufacturer-specific backplate for 15 percent of existing signal heads.

Ordering retroreflective tape (in the desired width) and backplates at the same time, but without pre-application. Utilizing agency sign shop personnel to apply the tape saves on the initial cost of the backplates and provides greater flexibility regarding matching the correct type of backplate to an existing signal head. Cost savings, however, may be offset by labor costs for tape application at the local sign shop.

Ordering retroreflective tape (in the desired width) and applying it to existing backplates. This is the least expensive option initially and may be particularly helpful in a jurisdiction with few backplates to treat or few signals overall. An agency may wish to remove the backplate, clean it thoroughly, and install the tape in the field, or install the tape to the backplate while the signal is hanging. Field installation can be affected by weather conditions.

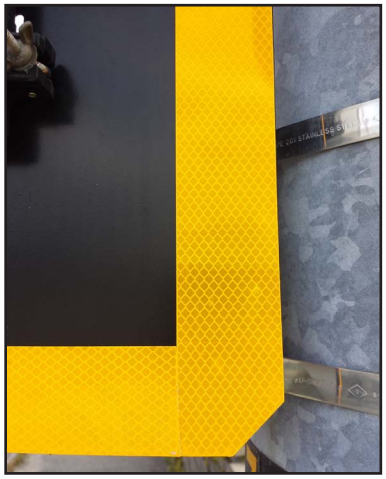


Exhibit 8: Installation details for retroreflective borders on backplates. The photo to the left shows where the backplate was cut along the bottom to fit around the signal head. The backplate was fastened to the signal housing to the left and right of the cut. The photo to the right shows a detail of the applied tape. (Source: VHB)

Widely Implemented Safety Treatment

As of 2014, more than half of U.S. State highway agencies have a policy, specification, or standard for implementing backplates with retroreflective borders.

CASE STUDY: Kentucky's Evaluation of Retroreflective Borders on Traffic Signal Backplates

VISION: The Kentucky Transportation Cabinet (KYTC) sought low-cost safety improvements at urban, high-volume, signalized intersections and rural, high-speed intersections known for increased red-light running.[7]

CHARACTERISTICS: Thirty signalized intersections were chosen throughout Kentucky for their high volume of crashes from 2000 to 2007, high incidence of red-light-running behavior, and high-speed approaches (between 45 and 55 mph).

COST: The costs for implementing the countermeasure were approximately $150 to $180 per signal head, including materials and labor.

IMPLEMENTATION: Two types of retroreflective backplates were installed: black backplates with yellow retroreflective borders, and yellow retroreflective backplates. The retroreflective backplate and border were visible during the day, but conspicuity increased significantly at night and under limited visibility conditions.

Exhibit 9: Treatments were applied to signals on both span wire and mast arms. (Source: FHWA)

RESULTS: A simple before-and-after study showed an aggregate crash reduction at the 30 intersections of 19.6 percent, a 44.4 percent reduction in angle crashes, and a 10 percent reduction in rear-end crashes. Urban and rural results were not differentiated; however, the aggregate reduction exceeded the CMF Clearinghouse's 15 percent expected crash reduction for adding retroreflective orders to signal backplates in urban areas.[8]

CURRENT PRACTICE: KYTC does not require retroreflective backplates;[9] however, when retroreflective plates are installed, a 2-inch wide fluorescent yellow reflective tape is to be applied around the outer perimeter of the face of the backplate. Note that the reflective tape must comply with the latest ATSM Standard for Type IX, Fluorescent Yellow retroreflective sheeting.

Exhibit 10: Treated signals at a Kentucky intersection. (Source: FHWA)

CASE STUDY: Washington State's Success with Local Implementation of Retroreflective Borders on Traffic Signal Backplates

VISION: The Washington State Department of Transportation (WSDOT) requires the use of backplates for all overhead-mounted displays for new, updated, or rebuilt signal faces. WSDOT has been working with local agencies to retrofit signals with retroreflective backplates, including adding retroreflective tape to existing backplates or adding backplates and tape. WSDOT has funded projects (many of them widespread) in more than 16 jurisdictions; however, many installations are also made directly by local agencies.

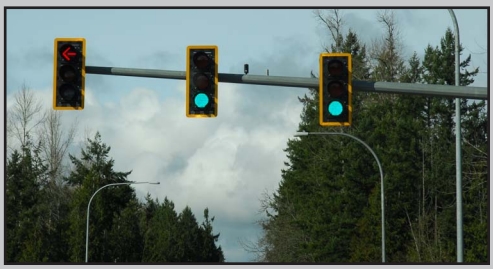


Exhibit 11: Mast-mounted signals with retroreflective borders. (Source: VHB)

CHARACTERISTICS: Many of the State's retroreflective backplate installations have been completed under the Quick Response Safety Program. Under this program, cities, counties, and Tribes could apply for grants for the construction phase of projects that met two goals: (1) to reduce fatal and serious injury collisions on local roads and streets and on State highways that serve as city arterials within any local jurisdiction; and (2) to get safety projects implemented quickly.

COST: The cost for implementing the countermeasure was approximately $450 per intersection.

FUNDING: Funding for retrofitting existing backplates with retroreflective sheeting came through a variety of sources. HSIP funding has been the primary source for local agencies; however, other funding sources have covered installations, including those on the State highway system.

IMPLEMENTATION: Yellow retroreflective borders were added to existing signal backplates, framing the signal head. In some locations without existing backplates, backplates with a retroreflective border were installed. Washington State officials advise that the most common method of installation is to manually apply the tape to backplates.

CURRENT PRACTICE: Backplates are to have a 1-inch to 3-inch wide yellow strip of retroreflective, Type IV, prismatic sheeting around the perimeter to project a rectangular image at night.

CASE STUDY: New Hampshire's Plan for the Future Implementation of Retroreflective Borders on Backplates

VISION: To employ the FHWA proven safety countermeasure throughout the State.

IMPLEMENTATION: The New Hampshire Department of Transportation (NHDOT) reviewed the loading capabilities of their approximately 450 signals. Approximately 90 to 95 percent of the signals have backplates and are mounted on existing mast arms. Signal poles and foundations were designed for aluminum signal heads and backplates at specified distances along the arm. Based on the existing signal designs, NHDOT determined that adding retroreflective tape would be a negligible increase in loading on the mast arms, making a retrofit of signal backplates with retroreflective tape feasible.

Exhibit 12: Treated signals in Nashua, NH. (Source: VHB)

Building on lessons learned in Nashua, NH, NHDOT plans to conduct a pilot program that includes 100 locations, which is almost 25 percent of the State-maintained signalized intersections. (See page 3 of this technical summary for more information on lessons learned.) The pilot will include a field evaluation of the signals to decide which of three methods (taping backplate, retrofitting signal with new backplate, or installing new signal head with backplate) should be proposed and to quantify that information. Upon completion of the pilot, lessons learned will be reviewed to determine the best installation method for the remaining 75 percent of the signalized intersections in New Hampshire.

MATERIALS AND METHODOLOGY: NHDOT conducted a review of signal heads and backplates to determine the types of signal heads in place and which backplates could be used. NHDOT also reviewed methods for installing new retroreflective borders on backplates, including vertical cuts and retaping. Vertical cuts on the sides of existing signal heads would allow NHDOT to avoid taking the signal head down. There was a concern that removing the signal heads may cause the brackets to crack. NHDOT also considered retaping across the face of the plate and the back of the plate. In reviewing the methods for applying tape, NHDOT found that the amount of pressure used when applying the tape is important. The tape also cannot be applied to backplates with flaking or peeling paint. In those instances, installers would need to determine whether to replace the backplate or the whole signal.

CURRENT PRACTICE: NHDOT is in the planning stages of the pilot project to implement retroreflective borders on backplates, but has also adopted a blanket policy that any new signal or modernization project will include 2-inch retroreflective backplates.

CASE STUDY: Virginia's Systemic Plan to Implement Retroreflective Borders on Backplates

Exhibit 13: An intersection in Virginia with treated signals. (Source: VDOT)

VISION: Virginia Department of Transportation (VDOT) plans to implement retroreflective borders on backplates as a safety improvement that benefits all regions and districts.

FUNDING: The backplates will be funded through VDOT's Open Container funds.

IMPLEMENTATION: VDOT plans to begin systemic installations on VDOT-identified Corridors of Statewide Significance (CoSS), and to create a longer-term specification that can be used for isolated intersections in the future. Installations began in the fall of 2014.

MATERIALS AND METHODOLOGY: In order to determine the best method of applying the retroreflective borders on backplates, VDOT asked Regional Operations Maintenance Managers to contribute ideas on best methods and retrofit. VDOT also reviewed methods employed by other States and determined that many use 2-inch strips and prismatic sheeting while others use fluorescent yellow. VDOT's Materials Division is researching the size and type of strips that should be recommended. (For more information, see page 5 for Retroreflective Borders on Backplates Installation Considerations.)

CURRENT PRACTICE: VDOT is creating a standard for applying the retroreflective borders on backplates and determining the implementation priority of signalized intersections along VDOT's CoSS. Next steps include working with the regions to identify final deployment locations and possibly conducting a pilot study to determine the time necessary for a retrofit.

Endnotes

[1] FHWA, Handbook for Designing Roadways for the Aging Population, FHWA-SA-14-015, June 2014 (http://safety.fhwa.dot.gov/older_users/handbook/)

[2] FHWA, Office of Safety, Proven Safety Countermeasures web site. (http://safety.fhwa.dot.gov/provencountermeasures/)

[3] FHWA, Manual on Uniform Traffic Control Devices (MUTCD), 2009 Edition. (http://mutcd.fhwa.dot.gov/pdfs/2009/pdf_index.htm)

[4] Sayed, T., Leur, P., and Pump, J., "Safety Impact of Increased Traffic Signal Backboards Conspicuity." 2005 TRB 84th Annual Meeting: Compendium of Papers CD-ROM, Vol. TRB#05-16, Washington, D.C., (2005)

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[6] Michigan Department of Transportation, Fiscal Year 2015 Federal Local Safety Program Call Letter, July 16, 2013. (http://www.michigan.gov/documents/mdot/MDOT_-_LAP_-_FY_2014_Safety_Program_Call_Letter_391978_7.pdf)

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Florida Department of Transportation, Plan Preparation Manual, Chapter 7 Traffic & ITS Design (Section 7.4.17). (http://www.dot.state.fl.us/rddesign/PPMManual/2009/Volume1/zChap07.pdf)

Senior Mobility Series: Article 4 - Marking the Way to Greater Safety, FHWA Public Roads Volume 70/No. 1 (http://www.fhwa.dot.gov/publications/publicroads/06jul/08.cfm)

Crash Modification Factor (CMF) Clearinghouse [quick search "retroreflective backplate"] (http://www.cmfclearinghouse.org/)

Evaluating Impact on Safety of Improved Signal Visibility at Urban Signalized Intersections (http://pubsindex.trb.org/view.aspx?id=800943)

Missouri DOT Engineering Policy Guide Traffic Control Signal Features (http://epg.modot.org/index.php?title=902.5_Traffic_Control_Signal_Features_%28MUTCD_Chapter_4D%29)

Road Safety Performance Associated with Improved Traffic Signal Design and Increased Signal Conspicuity (http://mutcd.fhwa.dot.gov/texts/miska/miska02.htm#toc)

Washington Department of Transportation Design Manual (http://www.wsdot.wa.gov/publications/manuals/fulltext/m22-01/m22-01.06revision.pdf)

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