

**2nd
Edition**

Best Practices for Optimal Use

RoadQuake®

Temporary Portable Rumble Strip



Innovations for Safety®



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**RoadQuake® Temporary Portable Rumble Strip*

Preface to the Second Edition:

The overwhelming positive response to our “RoadQuake® Temporary Portable Rumble Strip: Best Practices for Optimal Use” guidebook prompts a Second Edition. That we have acquired more knowledge and experience with RoadQuake Temporary Portable Rumble Strip (RQ TPRS) is really a credit to you, the user.

In this edition:

Because of your concern about exposing workers to live traffic, and possible soft tissue injuries, we have developed an ancillary line of RoadQuake handling equipment. You will find basic information about RoadQuake handling equipment on Pages 37-43.

We also amplified the “Protection of Workers” section, which begins on Page 19.

Other new features include:

- New RQ TPRS Product Improvement
- State DOT Traffic Control Plans
- Examples of road surface conditions
- New typical application drawings
- RQ TPRS and Portable Positive Protection
- Deploying RQ TPRS right side up

We trust our Second Edition will serve you as well as our First Edition. As always, we welcome your comments and questions.

Introduction to Best Practices for Optimal Use:

RoadQuake® 2F Temporary Portable Rumble Strip:

Designed to reduce accidents and save lives, RoadQuake 2F TPRS alerts distracted drivers to changing road conditions, like work zones and check points.

Features:

- Meets Section 6F.87 of the MUTCD, 2009 Edition.
- Generates similar levels of sound and vibration as milled strips.
- For posted speed limits up to 80 mph and temperatures from 0° to 180° F.
- 13" W x 3/4" H x 132" L, when unfolded.
Covers an entire lane.
- Folds to a compact 66" length. Weighs 105 lbs (+ or -).
- Ergonomic handles make installation and storage easy. Non-slip textured surface helps to keep RoadQuake 2F TPRS in place.
- Bevels on both sides enhance motorcycle safety.



New Product Improvement:

We replaced metal chain link hinges with Breakaway Pin Connections. The metal chain link hinges allowed RoadQuake TPRS to fold. However, in extreme situations, the metal chain link hinges had the potential to tear through the polymer tabs at the end of a RoadQuake 2F half.

To better protect the strip itself, we developed the Breakaway Pin Connection. The pin connection consists of the existing RoadQuake 2F bracket, custom steel retaining clip, and impact-modified nylon pins. The Breakaway Pin Connection is designed to separate only under significant stress. The connections should not tear the strip itself, like metal chain link hinges may have done in extreme situations.

We call this a “clean separation.” As the tabs are not damaged during a “clean separation,” users can simply replace the breakaway pins, and return the strip to service.

Our Breakaway Pin Connection design improves RQ TPRS, as the pins can extend the life of a strip.

Contact your PSS Roadway Safety Consultant for information about ordering Breakaway Pin Connections.



Introduction, continued:

Evolution of RoadQuake® Temporary Portable Rumble Strip:

In 2009, **PSS**, formerly Plastic Safety Systems, introduced a revolutionary traffic safety countermeasure, RoadQuake® Temporary Portable Rumble Strip (RQ TPRS). We introduced RoadQuake Modular TPRS in 2012, and RoadQuake 2F Folding TPRS in 2014.

Designed to reduce accidents and save lives, RQ TPRS alerts drivers, especially distracted drivers, to changing road conditions, like work zones.

RQ TPRS is one of the very few traffic control devices that communicates to several senses. Unlike an arrow board, portable changeable message sign, or traffic control sign, which communicate to drivers through sight only, RQ TPRS alerts drivers through sight, feel, and sound.

RQ TPRS is a transverse rumble strip, installed perpendicular to the direction of travel, with the purpose of alerting the drivers' three senses:

- **Seeing** an array of strips across the road.
- **Feeling** the vibration caused by tires travelling over strips that measure $\frac{3}{4}$ " high.
- **Hearing** the familiar "bumpety-bump, thumpety-thump" sound of tires travelling over rumble strips.

Sounds and vibrations generated by RQ TPRS are significant: A University of Kansas Transportation Center study determined that RQ TPRS conveys sound and vibration at levels similar to ground-in, or milled, permanent rumble strips.

From the earliest days of product development, PSS focused on the design of a temporary countermeasure that alerts drivers. Meaning, the temporary device must alert drivers and conform to the surface of the road, without the need for adhesives or fasteners. The temporary countermeasure must also show little movement when in use. TPRS must perform effectively in the extremes of hot and cold temperatures.

Since its inception, PSS has tested over 75 different versions of RQ TPRS. We continually seek to improve a device that is already an effective countermeasure, so that its implementation is near-universal.

Introduction, continued:

However, even revolutionary, life-saving countermeasures have their limits. We discovered those limits during our testing period of RQ TPRS, and with billions of vehicle impacts:

- At various speed limits
- On different types of road surfaces
- In hot and cold, dry and rainy weather
- In a multitude of daily traffic counts
- And with various ratios of truck-to-passenger vehicles therein

From our continual testing procedures, we have developed an extensive body of knowledge, and consider ourselves a leading authority in the manufacture, design and performance of transverse TPRS.

From that knowledge, we now present **“RoadQuake® Temporary Portable Rumble Strip: Best Practices for Optimal Use.”**

Purpose of our Guidebook:

We produced our “Best Practices Guidebook” to provide users with:

- The safest-known methods to deploy RQ TPRS
- The information necessary to achieve optimum performance

In our guidebook, the reader will find information PSS has obtained through internal field-testing. To that knowledge, we have added information derived from users’ field experiences in active work zones.

That said, our recommendations are just that. They may not be appropriate for all applications. State DOT Traffic Plans and engineering judgment should prevail, with worker safety always the foremost priority.

We trust users will consider our guidebook an accurate source of practical information for the optimal use of RQ TPRS, and a worthy complement to the personal field training we offer.

MUTCD Standard and DOT Specifications and Plans:

RQ TPRS meets Section 6F.87 of the MUTCD, 2009 Edition.

To date, several state DOTs have written Traffic Control Plans or specifications for RQ TPRS. In addition, several states have written Public Interest Findings (PIF) for the use of RQ TPRS.

To those interested, PSS will email a file that contains those public DOT documents. Please contact your PSS Roadway Safety Consultant for the file.



Engineering Judgment:

Engineering judgment, as defined in MUTCD, 2009 Edition, Section 1A.13, is “the evaluation of available pertinent information, and the application of appropriate principles, provisions, and practices as contained in this Manual and other sources, for the purpose of deciding upon the applicability, design, operation, or installation of a traffic control device.”

MUTCD further states: “Engineering judgment shall be exercised by an engineer, or by an individual working under the supervision of an engineer, through the application of procedures and criteria established by the engineer. Documentation of engineering judgment is not required.”



PSS recommends that engineering judgment prevail in any decision to use RQ TPRS.

I.) Prior to Deployment:

A.) Examine the road surface at the deployment site:

Determine whether RQ TPRS will perform effectively at the site. RQ TPRS must maintain contact with the road surface. Use RQ TPRS on asphalt and concrete surfaces that are free of stone, gravel and debris.

Do not deploy RQ TPRS on these surfaces:

- Surfaces with fresh seal coat
- Unpaved surfaces (gravel roads)
- Soft pavement (fresh asphalt)

Deploy RQ TPRS with discretion on these surfaces:

- Heavily rutted roads
- Oil-bleeding asphalt
- Bridge decks
- Scarified Roads

See the next two pages for examples.

I.) Prior to Deployment, continued:

1.) Do not use RQ TPRS on these road surfaces:

These conditions could cause excessive movement or embedment of RQ TPRS. Further, these surfaces could cause irreparable damage to RQ TPRS.



Surfaces with Fresh Seal Coat:

Seal coat is a coating that protects and extends the life of asphalt pavement. It requires 24-48 hours to cure before traffic can resume.

Do not deploy RQ TPRS on fresh seal coat. Do not use RQ TPRS until vehicles are allowed back on the road surface.



Unpaved Surfaces (Gravel Roads):

A gravel road is an unpaved road surface to which gravel is applied.

Do not use RQ TPRS on gravel roads. Gravel can act as rollers underneath the strips, causing significant movement, reducing their effectiveness. Gravel can also embed in the bottom of strips, also reducing effectiveness.



Soft Pavement (Fresh Asphalt):

Fresh asphalt, like seal coat, requires 24-48 hours to cure. Do not deploy RQ TPRS on any soft pavement, like fresh or soft asphalt. Wait until traffic is allowed to resume.

The picture on the left shows the result of RQ TPRS deployed, and the road reopened to traffic, before the asphalt cured.



I.) Prior to Deployment, continued:

2.) Use RQ TPRS with discretion on these road surfaces:

Users can deploy RQ TPRS on these types of surfaces, but must monitor the strips more frequently, as these surfaces may cause excessive movement.



Heavily Rutted Roads:

A rut is a groove or depression in the road surface. Ruts are caused by wear or deformation of the substrate material.



Oil-Bleeding Asphalt:

Bleeding occurs when the asphalt binder fills voids in the aggregate, usually during hot weather.



Bridge Decks:

Most bridges vibrate under traffic. A bridge structure is flexible, and, as designed, vibrates in response to the moving traffic.



Scarified Road:

A Scarified road is one that has had its pavement surface removed in preparation for resurfacing.

I.) Prior to Deployment, continued:

B.) Examine other conditions:



- Do not use RQ TPRS on horizontal curves. The force and angle of the vehicle traveling in the curve could force strips to move to the outside of the curve.
- Identify traffic speeds in advance of and at the work site. RQ TPRS should perform effectively in posted speed limits up to 80 MPH.

- RQ TPRS will perform on roads with slopes, but the strips will move more when downhill than when on relatively flat roads. And, the steeper the slope, the more the strips will move. Engineering judgment should prevail in this application.
- RQ TPRS will perform in temperatures from 0° to 180° F. Excessive snow and rain may limit use of RQ TPRS.



C.) Train the On-Site Workforce:

RQ TPRS training should include:

- Purpose of RQ TPRS: features and benefits.
- How RQ TPRS serves as an audible warning device for workers.
- Why motorcycles can safely traverse RQ TPRS.
- How to safely deploy and remove RQ TPRS, per our “Best Practices Guidebook.”
- How RQ TPRS handling equipment reduces workers’ exposure to live traffic, and reduces possibility of soft tissue injury.

PSS offers both live training and online training. Please contact your PSS Roadway Safety Consultant for more information.

II.) Transport of RQ TPRS:

Several options are of course available for the transport of RQ TPRS to and from the work site. PSS recommends that users plan in advance, as TPRS devices can occupy significant space in a service vehicle.

PSS has designed a complete line of rumble strip handling equipment.

These products:

- Alleviate space limitations.
- Reduce or eliminate superficial injuries to workers.
- Reduce or eliminate workers exposure to live traffic.

Refer to Pages 37-43 for more information. Or, please contact your PSS Roadway Safety Consultant.



III.) Array Configuration and Placement:

A.) Number of Strips in an Array:

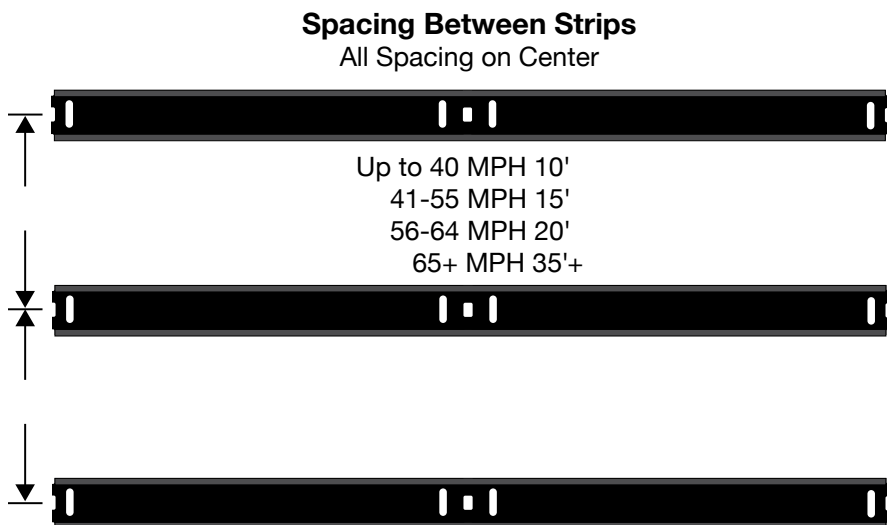
PSS developed the first RQ TPRS in 2006, and introduced the first production version in early 2009.

After years of observation in active work zones, with several studies as support, PSS has determined that three rumble strips per array are sufficient to alert drivers to changing road conditions. Three strips, properly spaced, alert drivers with sufficient sound and vibration so that they refocus on their driving.

As always, follow state DOT Traffic Control (TC) Plans as to the number of strips per array. Absent a TC plan, PSS recommends three rumble strips per array.

B.) Spacing of Strips in an Array:

In the absence of a TC plan, PSS recommends spacing between strips, based on posted speed limits at the deployment location, as shown below:



For posted speeds in excess of 65 MPH: PSS recommends that users increase spacing as posted speed limits increase. Increasing space between rumble strips will improve effectiveness.

III.) Array Configuration and Placement, continued:

C.) Number of Arrays in a Work Zone:

With the experience stated above, **PSS recommends the placement of two each RQ TPRS arrays per travel direction** in advance of changes in road conditions. Two arrays should sufficiently alert drivers, especially distracted drivers, to those changing road conditions.

Traveling over the 1st array, the car produces sound and vibration designed to alert the drivers and make them aware of their surroundings and changing road conditions. Independent research shows that drivers passing over RQ TPRS slow down an average of three to five MPH, as they refocus their attention on driving. And, they may even see the advanced warning signs nearby.

It could be argued that the 2nd array is even more important than the 1st:

The 2nd array warns drivers that:

- The 1st array is not debris on the road.
- The 1st array has been deployed intentionally.
- Drivers will soon approach the change in road condition.
- They must soon take action.
- They should not accelerate as they approach the changing road condition.

The 2nd array also warns on-site workers, especially flaggers, that traffic is nearby and approaching.

As always, follow state DOT TC Plans for the number of arrays in a work zone. But again, absent a TC plan, **PSS recommends two arrays per travel direction.**



Recommended Placement of RQ TPRS Arrays

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Lane Closure on a Two-Lane Roadway, Using Flaggers

Showing one direction only

Speed	B Distance	C Spacing
To 40 MPH	120'	10'
41-55 MPH	160'	15'
56+ MPH	200'	20'
65+ MPH	240'	35'+

C Spacing on Center

C Spacing on Center

Follow state DOT Traffic Control Plans
for sign and lane taper spacing.

Distance
from Sign

B

TPRS
Array

Distance
from Sign

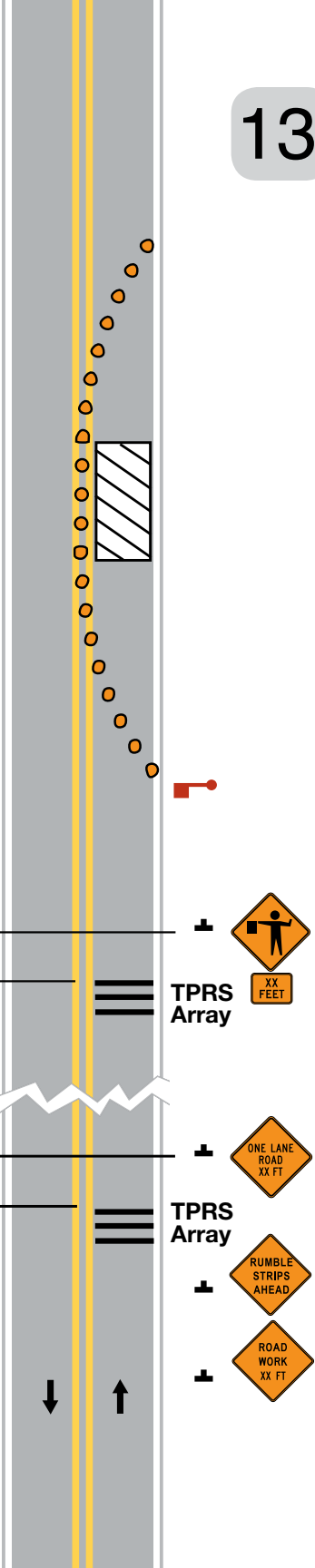
B

TPRS
Array

Follow state DOT TC plans
where available.

From MUTCD, 2009 Edition
Typical Application 10

Drawing not to scale.



Recommended Placement of RQ TPRS Arrays

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Double Lane Closure on a Three-Lane Freeway

Speed	B Distance	C Spacing
To 40 MPH	120'	10'
41-55 MPH	160'	15'
56+ MPH	200'	20'
65+ MPH	240'	35'+

C Spacing on Center

C Spacing on Center

Follow state DOT Traffic Control Plans for sign and lane taper spacing.

Distance from Sign **B**

Distance from Sign **B**

Follow state DOT TC plans where available.

From MUTCD, 2009 Edition
Typical Application 37

Drawing not to scale.

END ROAD WORK

END ROAD WORK

RUMBLE STRIPS AHEAD

ROAD WORK 1 MILE

2 RIGHT LANES CLOSED 1/2 MILE

XX MPH

RUMBLE STRIPS AHEAD

ROAD WORK 1 MILE

TPRS Arrays

Recommended Placement of RQ TPRS Arrays

15

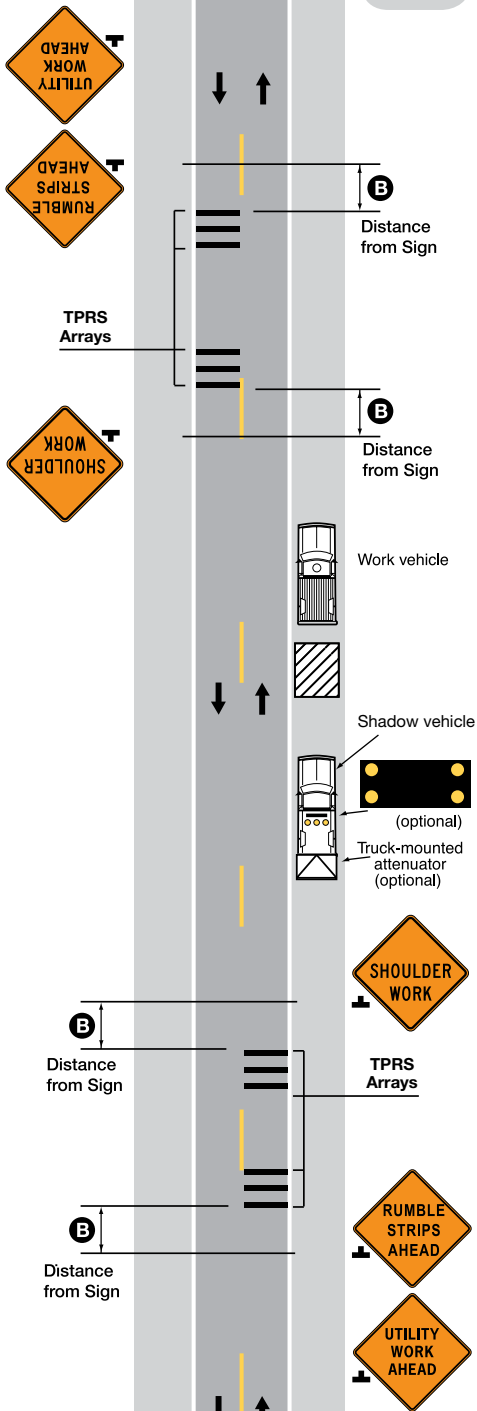
Short-Duration or Mobile Operation on a Shoulder

Speed	B Distance	C Spacing
To 40 MPH	120'	10'
41-55 MPH	160'	15'
56+ MPH	200'	20'
65+ MPH	240'	35'+

C Spacing on Center

C Spacing on Center

Follow state DOT Traffic Control Plans for sign and lane taper spacing.



Follow state DOT TC plans where available.

From MUTCD, 2009 Edition
Typical Application 4

Drawing not to scale.

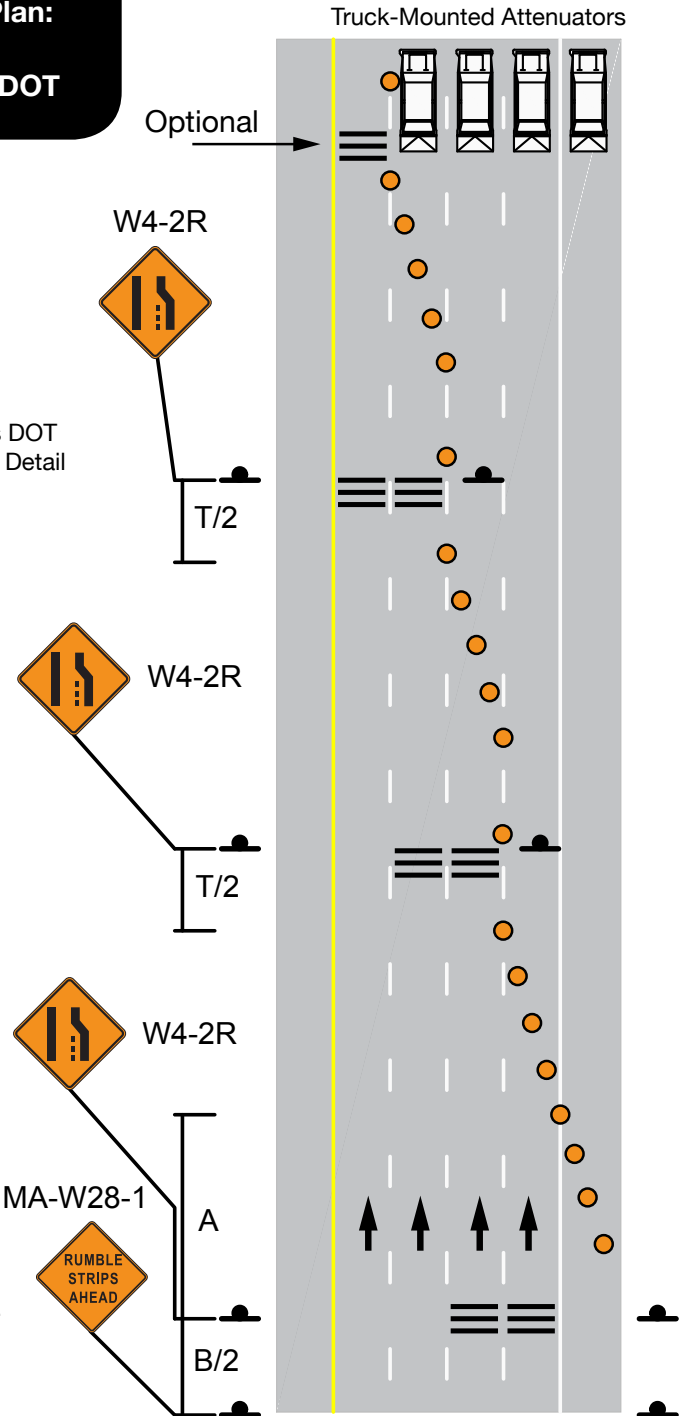
**Example of a
State DOT
Traffic Control Plan:**

Massachusetts DOT

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**Four-Lane
Divided
Roadway
Triple Lane
Closure**

From Massachusetts DOT
Work Zone Standard Detail
Figure 24-1

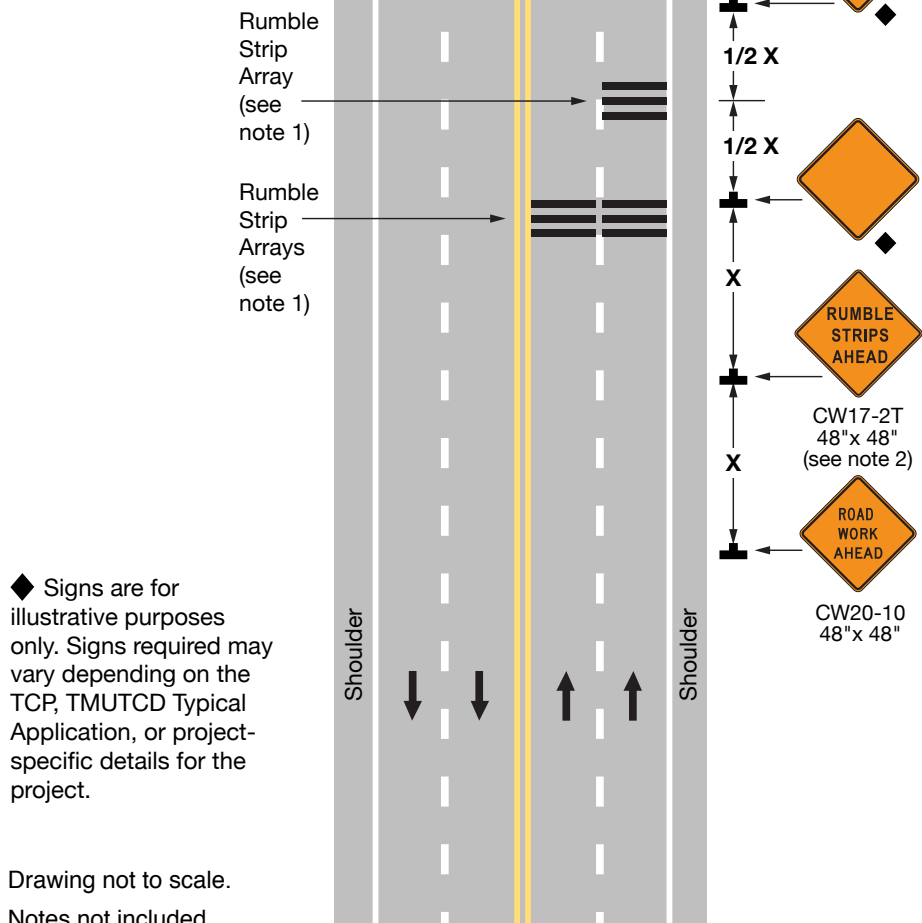


Drawing not to scale.
Notes not included.

**Example of a
State DOT
Traffic Control Plan:
Texas DOT**

**Rumble Strips
for Lane Closure
on Conventional
Roadway**

From TxDOT WZ(RS-1b)

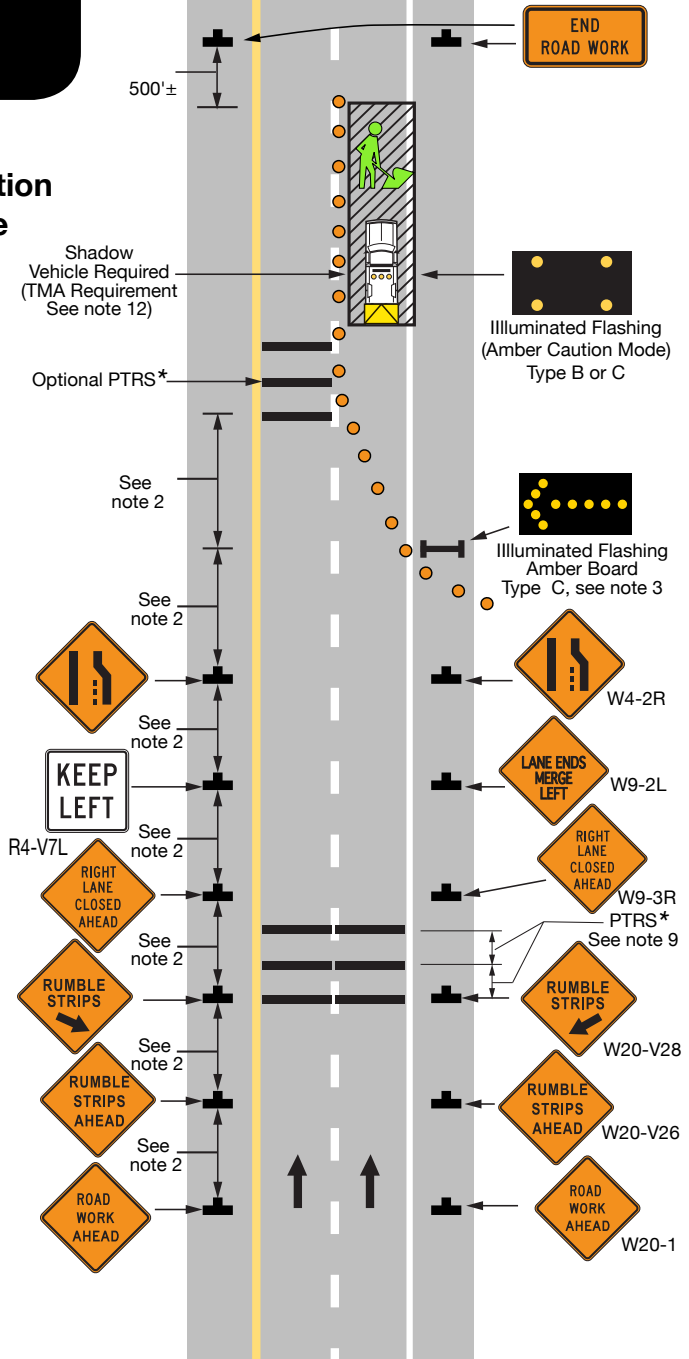


**Example of a
State DOT
Traffic Control Plan:**

Virginia DOT

**Typical Installation
on a Multi-Lane
Roadway**

From Virginia DOT
Memorandum
IIM-TE-386.1
Page 10



*PTRS = TPRS

Drawing not to scale.

Notes not included.

IV.) Protection of Workers:

A.) General Notes:

- Where available, follow state DOT specifications and TC plans for the deployment and use of RQ TPRS arrays.
- Always deploy temporary traffic control (TTC) devices, specified by state DOT traffic plans, to protect workers during deployment of RQ TPRS arrays.
- PSS recommends, where appropriate, that workers use the “Rolling Stop” method to clear travel lanes for deployment of RQ TPRS arrays.
- RAPTOR® Rumble Strip Handling Machine transports, deploys, realigns and retrieves RQ TPRS in work zones, keeping workers off the road, out of live traffic. See Pages 37-43 for all PSS handling equipment options.
- PSS also recommends the use of police vehicles, and vehicles equipped with Truck or Trailer-Mounted Attenuators (TMA), to protect workers during deployment. Placed in the travel lanes upstream of the deployment location, both police and TMA vehicles can protect workers in the travel lanes better than service vehicles.



B.) Lifting Techniques:

PSS recommends RQ users follow lifting guidelines like those from OSHA: Use of proper lifting techniques when performing manual lifts will minimize the risk to the back, but a heavy load still can cause injury even with perfect technique:

- Maintain neutral spine alignment whenever possible. Usually, bending at the knees, not the waist, helps maintain proper spine alignment.
- Keep the load close to the body. For large bulky loads, it may be better to bend at the waist instead of the knees because this will keep the load closer to the body. Do not reach to access a load.
- Minimize bending of the body by keeping the load between shoulder and thigh height when lifting. Keep heavier loads off the floor.
- Lift heavier or bulky loads with a buddy.
- Strengthen back and abdomen muscles that support your spine.

– “OSHA Ergonomics-related eTools, Electrical Contractors”,
www.osha.gov/dts/osta/oshasoft/index.html

IV.) Protection of Workers, continued:

C.) Lifting RQ 2F TPRS:



Step 1: Do not pick up the non-hinged side of RoadQuake® 2F TPRS by hand, as pinching might occur. PSS recommends the use of RoadQuake® T-Handle™, as shown above, to pick the strip up from the non-hinged side.



Step 2: Once in place, remove the T-Handle from the non-hinged side.



Step 3: Then, simply unfold the rumble strip.



Step 4: Place in position.

Further:

- Workers can use RoadQuake T-Handle on either side of the strip.
- Use of hands is acceptable for hinged side only. Do not pick up non-hinged side by hand.

See Pages 37-43 for more information about RoadQuake handling equipment.

Warning:



Do not put your hand through both handles of the non-hinged side of a folded strip when transporting RoadQuake 2F TPRS. Doing so may cause severe pinching or a more serious injury.



If carrying by hand, use the RoadQuake T-Handle on the non-hinged side to transport RoadQuake 2F TPRS.

IV.) Protection of Workers, continued:

D.) Training:

As stated earlier, PSS has developed a “RoadQuake Best Practices” on-site training presentation which is available to RoadQuake users. In addition, we have developed online training. Contact your PSS Roadway Safety Consultant for more information about our training options.

E.) Portable Positive Protection (PPP):

Portable Positive Protection (PPP) improves work zone safety: PPP devices separate vehicles from workers, and protect workers from both longitudinal and lateral vehicle intrusions.

PPP devices include movable barriers, or protective vehicles with Truck or Trailer-Mounted Attenuators (TMA).

Because PPP devices are portable, they offer fast installation and removal. They are ideal for short-term, short-duration and mobile operations, which are defined in MUTCD, 2009 Edition, Section 6G.02:

- “Short-term stationary is daytime work that occupies a location for more than one hour within a single daylight period.
- Short-duration is work that occupies a location up to one hour.
- Mobile is work that moves intermittently or continuously.”

Examples of Short-Term, Short-Duration, Mobile Activities:

- Traffic control
- Bridge clearance measurements
- Pavement profiling
- Core sampling
- Edge/guardrail repair
- Pavement marking
- Signal or lighting maintenance
- Rumble strip installation
- Pavement Marker installation
- Crack seal
- Pothole patching
- Asphalt milling
- Seal coat
- Asphalt overlay



These types of work zones can be the most difficult in which to protect workers and drivers. PPP devices can make these work zones safer, and maximize mobility.

For more information about RQ TPRS and PPP applications, please see Page 42.

V.) Deployment of RQ TPRS Arrays:

A.) Advance Warning Signs:

- Where available, follow state DOT specifications and TC plans for the deployment and use of RQ TPRS arrays.
- PSS recommends the deployment and use of warning signs with RQ TPRS arrays. The signs should read, “Rumble Strips Ahead,” or some variation of. The signs alert drivers who are monitoring warning signs that the arrays are supposed to be on the road, not hazards to be avoided.
- Follow state DOT TC plans to determine proper signage placement.
- Where there is no TC plan, or where the plan does not specify “Rumble Strips Ahead” signs, please follow recommendations shown in drawings, “PSS Recommended Placement of RQ TPRS Arrays,” on Pages 13-15.

B.) Site Preparation:

- Determine the proper location from which to deploy RQ TPRS. The safety of the worker is paramount. PSS recommends the use of shoulder or berm whenever available.
- Prior to deployment, sweep area clear of gravel and other debris, if traffic allows. Gravel, stone or other debris may prevent the strips from making contact with the road surface, causing excessive movement of the strips.
- Prior to deployment, determine the proper spacing between strips, as specified in the state DOT TC plan. If a plan is not available, see Page 11, or Pages 13-15, for PSS recommendations.
- To reduce deployment time, mark the pavement with a line, perpendicular to traffic, to identify the placement of each strip. PSS recommends temporary paint marking.

C.) Preparation of Strips:

RoadQuake 2F TPRS is a one-piece device, and requires no assembly.

RoadQuake 2F folds for easier transport. Workers can either unfold RoadQuake 2F and then carry strips to the deployment location, or carry strips folded to the location, and then unfold them in the travel lane.

RAPTOR Rumble Strip Handling Machine transports, deploys, realigns and retrieves RQ TPRS in work zones, keeping workers off the road, out of live traffic. See Pages 37-43 for all PSS handling equipment options.



V.) Deployment of RQ TPRS Arrays, continued:

D.) Deployment of Strips with RoadQuake Handling Equipment:

With RoadQuake Handling Equipment:

- Workers can deploy and move TPRS arrays faster.
- Workers are less exposed to traffic.
- Equipment reduces possible injury caused by lifting and carrying TPRS.

See Pages 37-43 for all PSS handling equipment options.

E.) Manual Deployment of TPRS:

With “Rolling Stop” in operation, traffic control in place, advanced warning signs installed, and the service vehicle with RQ TPRS parked adjacent to the deployment location:

- 1.) Remove RQ TPRS from the service vehicle.
- 2.) Walk strips to the marked lines on the pavement.
- 3.) Lay strips in place.
- 4.) Follow this illustration to deploy TPRS with the top side facing up.



Deploying RQ TPRS upside down can cause significant damage to vehicles, and injury to drivers, passengers and workers.

F.) Warning Visuals:

PSS now applies safety-yellow warning stickers to two brackets on every RQ TPRS. The sticker reads: **INSTALL THIS SIDE DOWN** in both English and Spanish. They are printed in safety-yellow to attract workers' attention.



**INSTALL
THIS SIDE
DOWN**

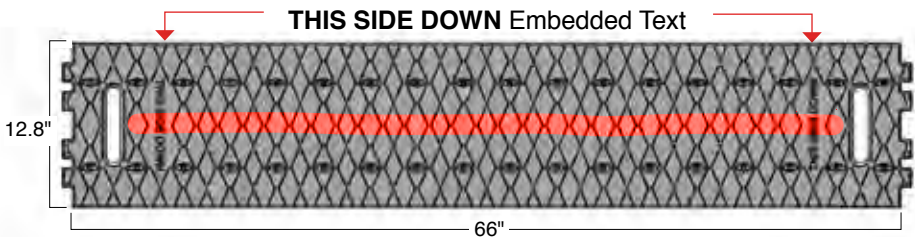
**ESTE
LADO
HACIA
ABAJO**

V.) Deployment of RQ TPRS Arrays, continued:

PSS will soon add a red stripe to the bottom of the entire length of RoadQuake 2F TPRS. The red stripe identifies the bottom of the strip. We will also embed text near the handles that reads: "THIS SIDE DOWN". See graphic below for both visuals.

The text and red stripe on the bottom of the strip send a clear, unmistakable message to workers: the red stripe and text side is the bottom side, which must face the roadway. Bottom side down.

If workers deploy strips correctly, top side up, they will not see any red stripes. If they deploy strips incorrectly, bottom side up, they will clearly see red stripes. They must immediately redeploy those strips, so that the top side is up, before traffic drives over them.



Embedded Text and Red Stripe on Bottom of RoadQuake 2F TPRS (1/2 Strip Shown)

The picture on right reveals multiple errors:

- RQ TPRS strips are deployed upside down, which could cause significant damage to vehicles.
- Strips are spaced incorrectly, reducing their effectiveness. See Page 11 for "Spacing of Strips in an Array."
- Strips are painted over in both roadway paint colors. Drivers who approach the RQ TPRS array could mistake the strips for tire tread or planks of wood. Drivers might attempt to drive around the strips, which could cause crashes. See Page 25 for more information about "Driver Avoidance."

Users must deploy RQ TPRS right-side up, and must space strips properly. Users should also remove the strips from the roadway before striping trucks begin their work.



VI.) Monitor Deployed RQ TPRS Arrays:

A.) Monitoring for Changes in Traffic Queue:

RQ TPRS arrays effectively alert drivers to changes in road conditions, like a lane closure, or slowing or stopped traffic. They lose effectiveness if the traffic queue builds upstream of their location.

Users should constantly monitor the length of queue. If the end of the queue approaches the RQ TPRS arrays, recalculate the new position for the arrays and redeploy them.

B.) Repositioning TPRS Arrays:

If a strip requires repositioning, due to movement, workers should follow the same procedures as with the original deployment.

If engineering judgment dictates that ADT is so high that there are no gaps in traffic for workers to reposition strips manually, thus making that task exceptionally hazardous, then TPRS arrays should be considered inappropriate for manual deployment in that situation.

However, with RAPTOR Rumble Strip Handling Machine, workers can reposition or realign RQ TPRS from the safety of their vehicle.

See Pages 37-43 for more information.

C.) Driver Avoidance:

PSS has received reports of drivers who have attempted to avoid driving over an array by driving around it. This action by the road user may be considered unsafe, but it usually indicates a cognizant action by a driver that is not distracted.

Also, a recent university study reported that driver avoidance was statistically insignificant in work zones that included RQ TPRS. (Contact your PSS Roadway Safety Consultant for more information.)

PSS recommends placing at least one each TTC device, like a plastic traffic drum or 42" channelizer, at each side of an array. Drivers will then know they are to proceed over the array.

Do not place vehicles or workers adjacent to RQ TPRS arrays.



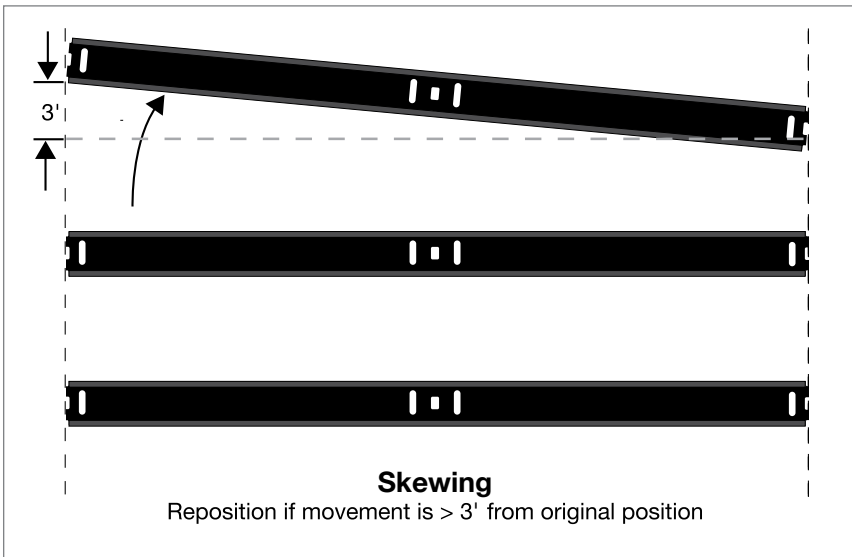
VI.) Monitor Deployed RQ TPRS Arrays, continued:

D.) Types of Movement and Allowance Guidelines:

PSS has identified three types of movement:

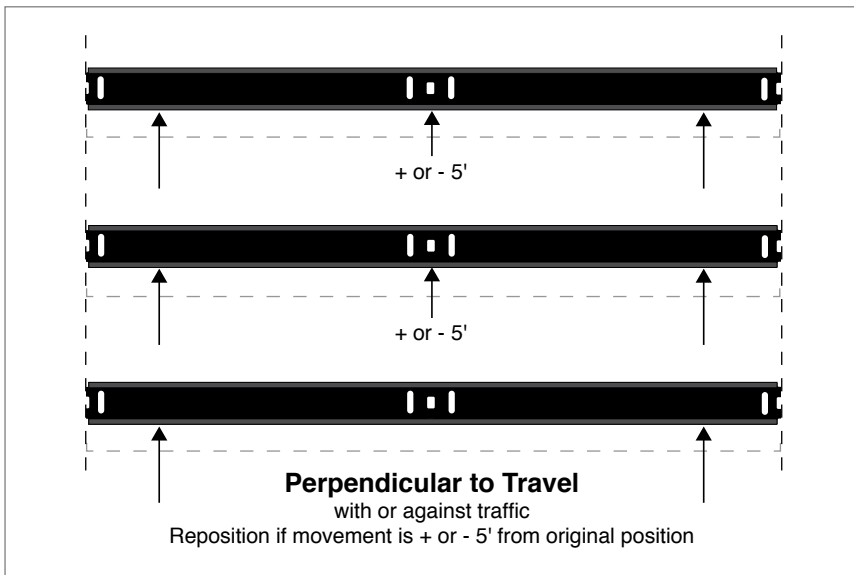
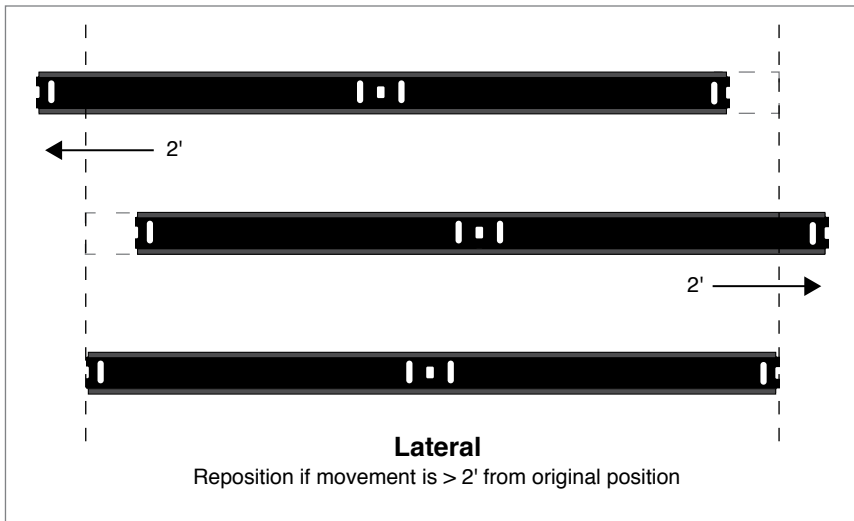
- 1.) **Skewing:** TPRS may deviate from a straight line, either from the centerline of the road towards the shoulder, or vice versa.
- 2.) **Lateral movement:** TPRS may move side-to-side, from the shoulder of the road to the centerline, or vice versa.
- 3.) **Movement Perpendicular to Travel:** TPRS may move as an array in the direction of traffic, or in the opposite direction, from the original deployment position.

Refer to the following graphics for suggested allowances of each type of movement:



VI.) Monitor Deployed RQ TPRS Arrays, continued:

Refer to the following graphics for suggested allowances of each type of movement:





VII.) Removal, Security, Cleaning:

A.) Removal and Security:

Workers should follow the same procedures for removing RQ TPRS arrays as when deploying them.

RQ TPRS is a temporary device, and subject to theft. RQ TPRS should not be left at the work site after workers leave. If users choose to leave them at the site, PSS recommends stacking the strips, and running a bicycle cable lock through the handles. Several strips locked together could weigh far more than practical to carry away.

Rather than leaving strips in an accessible area, PSS recommends that workers secure RQ TPRS in a locked vehicle or building, or in a yard behind locked security fencing. Workers may of course leave RQ TPRS in our CRIB® Cargo Carrier, or RoadQuake RAPTOR Rumble Strip Handling Machine, but the vehicle should be secured in a building or behind security fencing.



CRIB® Locks deter theft.

B.) Cleaning Instructions:

To remove gravel, stones, mud or other material, we recommend using a water-based cleaner and a stiff brush to scrub the strip clean. A good cleaning should only take minutes.

We do not recommend, and caution users to avoid, oil-based cleaners and solvents. Oil-based cleaners can degrade engineered polymer products, like RQ TPRS, and affect performance.

VIII.) RQ TPRS Inspection:

A.) Inspection and Service Life:

The life expectancy of RQ TPRS under normal use is three years. RQ TPRS nevertheless requires routine inspection and cleaning.

PSS recommends daily inspection of RQ TPRS retrieved from active work zones. Users should inspect for gravel, mud, stones or asphalt embedded in the bottom surface of RQ TPRS. If left as is, extraneous material could affect performance. See "Cleaning Instructions" above.

Users should also inspect each RQ TPRS to determine if it had been damaged when deployed, or if it has reached the end of its service life.

VIII.) RQ TPRS Inspection, continued:

B.) Types of Wear and Damage:

Normal Wear - Serviceable: The strip shows wear from use, but is serviceable, which means that the strip can still be used on the roadway.

Normal Wear - End of Service Life: The strip shows use and wear, and has reached the end of its service life. The strip must no longer be used on the roadway.

Incident - Serviceable: The strip suffered damage from a vehicle. Chains, pipes, and mufflers that drag from vehicles can cause surface damage to RQ TPRS. Because the damage is isolated, the strip can be used on the roadway.

Incident - End of Service Life: The strip suffered damage from a vehicle. As a result, it cannot be used on the roadway.

A selection of pictures of damaged RQ TPRS follows. Not all categories are included. Our recommended courses of action include the PSS Recycling Program.

Please contact your Roadway Safety Consultant for more information.

Normal Wear:

Type of RQ TPRS: RoadQuake 2F, bottom of strip

Type of Damage: Torn rubber around four iron ballast bars

Determination: Normal Wear - Serviceable

Recommended Action: Continue use.



VIII.) RQ TPRS Inspection, continued:

Type of RQ TPRS: RoadQuake 2F, bottom of strip

Type of Damage: Torn rubber around ballast bar; torn tab; obsolete link

Determination: Normal Wear - Serviceable

Recommended Action: Daily inspection. Recycle if tear reduces performance of strip.



Type of RQ TPRS: RoadQuake 2 Modular TPRS, at end of tabbed sections

Type of Damage: Damaged ballast bar; missing fiberglass rod

Determination: Normal Wear - End of Service Life

Recommended Action: Recycle locally or through PSS Recycle Program.



Type of RQ TPRS: RoadQuake 2 Modular TPRS, at end of tabbed sections

Type of Damage: Missing fiberglass rod

Determination: Normal Wear - End of Service Life

Recommended Action: Recycle locally or through PSS Recycle Program.



VIII.) RQ TPRS Inspection, continued:

Incidents:

Type of RQ TPRS: RoadQuake 2F, top of strip

Type of Damage: Torn rubber; broken ballast bar; broken handle

Determination: Incident - End of Service Life

Recommended Action: Recycle locally or through PSS Recycle Program.



Type of RQ TPRS: RoadQuake 2F TPRS, top of strip

Type of Damage: Rubber torn to edge of strip

Determination: Incident - End of Service Life

Recommended Action: Recycle locally or through PSS Recycle Program.



Type of RQ TPRS: RoadQuake 2F TPRS, bottom of strip

Type of Damage: Torn rubber around ballast bar

Determination: Incident - Serviceable

Recommended Action: Daily inspection. Recycle if tear reduces performance of strip.





VIII.) RQ TPRS Inspection, continued:

Type of RQ TPRS: RoadQuake 2F TPRS, bottom of strip

Type of Damage: Gouging

Determination: Incident – Serviceable

Recommended Action: Daily inspection. Recycle if gouge reduces performance of strip.



Type of RQ TPRS: RoadQuake 2F TPRS, bottom of strip

Type of Damage: Tar adhered to bottom of strip

Determination: Incident - Serviceable

Recommended Action: Remove tar, and return to service.



Type of RQ TPRS: RoadQuake 2F TPRS, top of strip

Type of Damage: Torn rubber

Determination: Incident – Serviceable

Recommended Action: Daily inspection. Recycle if tear reduces performance of strip.



VIII.) RQ TPRS Inspection, continued:

Type of RQ TPRS: RoadQuake 2F
TPRS, bottom of strip

Type of Damage: Torn rubber

Determination: Incident –
Serviceable

Recommended Action: Daily
inspection. Recycle if tear reduces
performance of strip.



Type of RQ TPRS: RoadQuake 2F
TPRS, bottom of strip

Type of Damage: Gouging

Determination: Incident –
Serviceable

Recommended Action: Daily
inspection. Recycle if gouge
reduces performance of strip.



Type of RQ TPRS: RoadQuake 2
Modular TPRS, top of strip

Type of Damage: Gouging

Determination: Incident –
Serviceable

Recommended Action: Daily
inspection. Recycle if gouge
reduces performance of strip.



RoadQuake Warranty: RoadQuake TPRS is warranted by PSS on a prorated basis to be free from defects in material and workmanship for three years from the date of shipment. Please contact your Roadway Safety Consultant for more information.

IX.) User Alterations:

As we have shown, strips reach the end of their service life:

- Through normal wear, which is by routine use, or
- By an incident, which is damage from a vehicle.

Whether through normal wear, or by incident, users should not deploy any strips that have reached end of service life. Further, users should never alter any strips in an attempt to extend service life.

The pictures on this page and next show strips that have been altered. In these examples, users added metal fasteners and wire to the strips to extend service life. PSS has never road-tested alterations like those shown. As such, we have no practical experience from which to predict results. Regardless, we do not plan to test our strips with alterations. In our considered judgment, alterations like these could alter how a strip interacts with the roadway, and reduce its performance and effectiveness.

Further, alterations could prove hazardous to workers who handle altered strips, and to vehicles that traverse them. Last, user alterations will render our warranty void.

A.) Examples of Alterations: RoadQuake 2 Modular TPRS:

The top picture shows that the fiberglass rod has torn. As the tabs are designed to attach to the fiberglass rod, a torn rod indicates end of service life for this strip.

Rather than take this strip out of service, however, metal fasteners have been attached to the strip, as shown in the bottom picture. These fasteners in essence replace the fiberglass rod; the two modular sections are now permanently attached, which is not how we designed RoadQuake 2 Modular.

For reasons stated above:

- Users should not deploy any strips that have reached end of service life.
- Users should never alter any strips in an attempt to extend service life.



IX.) User Alterations:

B.) Examples of Alterations:

RoadQuake 2F TPRS:

As shown in the top picture, cracks or tears have appeared on the tabs of a RoadQuake 2F TPRS. While the metal chain link hinges remain in place, the two halves of the strip are held together by wire. In the middle picture, users removed the metal chain link hinges, and replaced them with wire. Please refer to the previous page for reasons why users should not alter RQ TPRS under any circumstances.

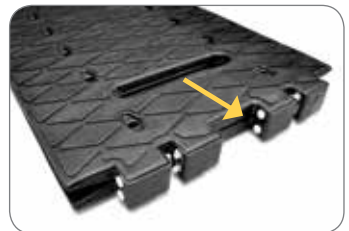
Because metal chain link hinges had the potential to tear through the tabs in extreme incidents or situations, PSS replaced metal chain link hinges with Breakaway Pin Connections.

The Breakaway Pin Connection is designed to separate only under significant stress. The connections should not tear the strip itself, like metal chain link hinges did in extreme incidents or situations.

As such, users who have strips with Breakaway Pin Connections should not routinely encounter torn or cracked tabs due to an incident. Should an incident occur, the pins should break away, and leave the tabs intact.

We call this a “clean separation”. As the tabs are not damaged during a “clean separation”, users can simply replace the breakaway pins, and return the strip to service.

Our Breakaway Pin Connection design improves RQ TPRS, as the pins can extend the life of a strip. Please contact your Roadway Safety Consultant for more information.



Breakaway Pin Connections

RoadQuake Warranty: RoadQuake TPRS is warranted by PSS on a prorated basis to be free from defects in material and workmanship for three years from the date of shipment. Please contact your Roadway Safety Consultant for more information.

IX.) Proposed Specification for TPRS:

Proposed Specification for a Temporary Portable Rumble Strip:

1.0 Scope:

This specification covers portable and temporary rumble strips designed to alert drivers of an upcoming work zone; upcoming work zone workers and/or flaggers; or any situation that will restrict or close the driving lane.

2.0 Pre-qualification:

Materials (rumble strips) shall be considered for use only when sufficient evidence, from the agency's field evaluation, exists to ensure that the materials can reliably conform to this specification.

3.0 Requirements:

The rumble strip shall:

- Have no adhesives or fasteners required for placement
- Be a minimum of 5/8" and a maximum of 13/16" high
- Be used in temperatures of 0° – 180° F without degradation in deployment or safety
- Have ergonomic handles on both ends of unfolded and folded strips
- Be hinged at the midpoint of the strip for ease of installation
- Have a grooved design to reduce the possibility of hydroplaning
- Be flexible along the length of the strip so that it conforms to the road surface
- Withstand vehicles with 80,000 lbs maximum weight, and retain original placement with minimal movement so that performance is not compromised*
- Be deemed safe for use with motorcycles
- Function on roads with posted speed limits up to 80 mph, and retain original placement with minimal movement so that performance is not compromised*

*Minimal movement is defined as incidental movement of the rumble strip.

Performance is compromised if the rumble strips move inconsistently with each other and out of parallel; or if any one strip moves significantly from its original placement in a manner that would compromise performance and safety. See Pages 26-27 for movement allowances.

The rumble strip shall meet Section 6F.87 of the MUTCD, 2009 Edition.

4.0 Certification:

The rumble strip manufacturer shall submit, with each lot or shipment, a certification that states the material supplied will meet all the requirements listed in Section 3.0.

5.0 Product Warranty:

Rumble strips stored and installed with the manufacturer's recommendations shall perform effectively for three years.

RoadQuake® 2F Safety System Components:

Benefits of RoadQuake 2F Safety Systems:

- Workers can deploy and move TPRS arrays faster.
- Workers are less exposed to traffic.
- CRIB® and RoadQuake® T-Handle™ reduce potential for superficial stress caused by lifting and carrying RoadQuake TPRS.



RoadQuake® T-Handle™



RoadQuake® 2F TPRS



CRIB® Lock



RoadQuake® 2F CRIB® Cargo Carrier



RoadQuake® 2F CRIB® XL Cargo Carrier



Quik-Detach™
CRIB® Mounting System



RoadQuake® 2F
Retrieval System



RoadQuake® RAPTOR®
Rumble Strip Handling Machine

Please contact your PSS Roadway Safety Consultant for more information.

RoadQuake® 2F TPRS:



Temporary:

- No nails, glue or adhesives needed for installation and use.
- Quick installation and removal. No cleanup required.

Portable:

- Transport RoadQuake TPRS with a variety of handling equipment.
- Deploy and retrieve from live traffic manually by a two-person crew.

Durable:

- Three-to-five year life under normal conditions.
- Suitable for use in rain and in temperatures of 0° to 180° F.
- For use in posted speed limits up to 80 mph.



Folds for easy storage and transportation.

Designed to reduce accidents and save lives, RoadQuake 2F TPRS alerts distracted drivers to changing road conditions, like work zones and checkpoints.

RoadQuake 2F TPRS Features:

- Generates similar levels of sounds and vibrations as milled strips.
- For posted speed limits up to 80 mph and temperatures from 0° to 180° F.
- 13" W x 3/4" H x 132" L when unfolded. Covers an entire lane.
- Folds to a compact 66" length. Weighs 105 lbs (+ or -).
- Ergonomic handles make installation and storage easy. Non-slip textured surface helps to keep RoadQuake 2F TPRS in place.
- Bevels on both sides enhance motorcycle safety.
- Meets Section 6F.87 of the MUTCD, 2009 Edition.



MUTCD Section 6F.87 allows for TPRS in colors of white, black and orange. PSS manufactures RQ TPRS in yellow for its international customers.

RoadQuake® 2F CRIB® and CRIB® XL:

CRIB is a fully integrated cargo carrier designed specifically for the transport, deployment, removal, storage and safekeeping of RoadQuake 2F TPRS.

CRIB and CRIB XL Benefits:

- Deployment and removal of an array of RoadQuake 2F TPRS can be a one-person job.
- Reduces overall deployment and removal time.
- Reduces superficial stress to workers that could be caused by lifting and carrying RoadQuake 2F TPRS.
- Eliminates the need to find extra space in crowded vehicles.
- Places RoadQuake 2F TPRS in alignment with deployment location.



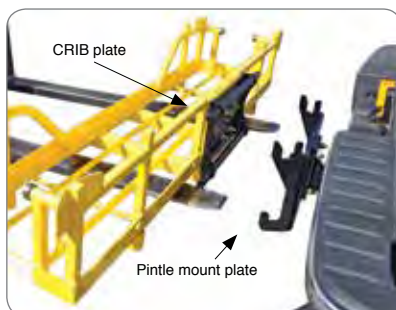
CRIB®

CRIB holds a maximum of six RoadQuake 2F TPRS in their folded position. That's enough to deploy two, three-strip arrays.



CRIB® XL

CRIB XL shown with 48" CRIB Guide Markers. CRIB XL holds a maximum of 12 RoadQuake 2F TPRS in their folded position. That's enough to deploy four, three-strip arrays.



Quik-Detach™ CRIB® Mounting System

With Quik-Detach, users can now attach or remove CRIB or CRIB XL Cargo Carriers with lifting equipment.



RoadQuake® T-Handle™

RoadQuake 2F T-Handle reduces possibility of superficial stress caused by lifting, carrying RoadQuake 2F TPRS.



CRIB® Lock

Deters theft.



RoadQuake® 2F Retrieval System:

Retrieval System pulls RoadQuake 2F Temporary Portable Rumble Strips into CRIB Cargo Carrier with little manual effort.

Retrieval System mounts easily to CRIB devices:

- Reduces workers' exposure to live traffic.
- Reduces manual exertion, possible injury.
- Removal of RoadQuake 2F Rumble Strips is a one-person operation.
- Mounting Hooks and slots attach quickly to either end of CRIB or CRIB XL.
- RQ TPRS can be retrieved from driver or passenger side.
- Use RoadQuake 2F Retrieval System with either CRIB or CRIB XL.
- CRIB holds a maximum of six RoadQuake 2F TPRS.
- CRIB XL holds a maximum of 12 RoadQuake 2F TPRS in their folded position. That's enough to deploy four three-strip arrays.



Retrieval System features a powerful 4.1 HP, 12 V electric motor. Pulls a RoadQuake 2F Rumble Strip into CRIB in less than 10 seconds.



CRIB XL shown with Retrieval System.

RoadQuake® RAPTOR® Rumble Strip Handling Machine:

RAPTOR transports, deploys, realigns and retrieves RoadQuake 2F Temporary Portable Rumble Strip (TPRS) in work zones.

RAPTOR revolutionizes the deployment and retrieval of RoadQuake 2F TPRS:

- Workers operate RAPTOR from the safety of the vehicle.
- Workers no longer deploy or retrieve RoadQuake 2F TPRS manually.
- RAPTOR keeps workers off the road, out of live traffic.
- Workers no longer risk superficial injuries that could be caused by lifting objects like RoadQuake.

RAPTOR improves Work Zone Safety:

- RAPTOR extends the practical use of RoadQuake 2F TPRS in work zones.
- With RAPTOR, RoadQuake is now ideal for use in most short-duration, short-term, and mobile operations.
- RAPTOR can provide Portable Positive Protection for workers.
- RAPTOR mounts to the front of the vehicle. The back of the vehicle is free for other safety equipment, like a Truck or Trailer-Mounted Attenuator (TMA).





RoadQuake® and RAPTOR®:

RQ TPRS in Portable Positive Protection (PPP) Applications:

Many agencies and authorities have well-defined policies about positive protection for workers on the roadway. Please obtain and understand these policies before beginning any roadway work.

We do not consider RoadQuake TPRS a PPP device. However, we do consider RQ TPRS a necessary tool in PPP applications, like the short-term, short-duration or mobile work zones just described.

Designed to reduce accidents and save lives, RQ TPRS alerts distracted drivers in work zones. We recognize that RQ TPRS probably saves the lives of drivers and passengers more than the lives of roadway workers.

Since we introduced RoadQuake 2F TPRS in 2014, we have introduced ancillary products to better protect workers handling the device. CRIB Cargo Carrier and RoadQuake Retrieval System reduce workers' exposure to live traffic during deployment and retrieval; they also reduce the possibility of superficial injury from lifting RQ TPRS.

Both products do their jobs. Both reduce the time it takes workers to manually deploy and remove RQ TPRS from an active work zone.

While they reduce the time, they do not eliminate the ultimate necessity. Even with innovative systems like CRIB and Retrieval System, workers still manually deploy, realign and retrieve RQ TPRS. Which still puts workers in live traffic.

The workers pictured below had to wait for gaps in the oncoming traffic to manually deploy RQ TPRS. However, we have also experienced extremely high ADT work zones where there are no gaps, or the gaps are woefully insufficient to safely deploy RQ TPRS by hand.

As such, we could not in clear conscience recommend the use of RQ TPRS in three-lane or four-lane work zones, especially short-term, short-duration or mobile work zone applications, if workers had to deploy RQ TPRS by hand.

Nor could we in clear conscience recommend the use of RQ TPRS in extremely high ADT work zones, regardless of number of lanes or posted speed limits, if, again, workers had to deploy them by hand.



RoadQuake® and RAPTOR®:

RoadQuake and RAPTOR: A New Best Practice:

We solved the handling issue in early 2018 when we introduced our newest, innovative device, RoadQuake RAPTOR Rumble Strip Handling Machine.

RAPTOR transports, deploys, realigns and retrieves RoadQuake 2F TPRS in work zones, and, as such, has revolutionized the deployment and retrieval of RoadQuake 2F TPRS.

With RAPTOR, users can now confidently deploy RQ TPRS in applications like short-term, short-duration and mobile operations, or three-lane or four-lane closures, without fear of injury to workers.

Our Roadway Safety Consultants will gladly demonstrate the effectiveness of RoadQuake & RAPTOR in your work zones.

*We now consider RoadQuake & RAPTOR the **Best Practice** to reduce accidents and save the lives of distracted drivers, while protecting workers from exposure to live traffic during deployment and retrieval of RoadQuake.*





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