Technical Circular T-05/14
September 12, 2014

To: All HQ Directors: Operations, Planning and Major Projects
All Regional Directors
All Regional Managers Engineering
All Regional Traffic Engineers (RTE)
All District Managers Transportation

Subject

Setting Curve Advisory Speeds for Passenger Vehicles

1. Purpose

This technical circular replaces Technical Circular T-03/09 and revises the inclination values found in the BC Ministry of Transportation and Infrastructure (BC MoTI) *Manual of Standard Traffic Signs and Pavement Markings.* This circular also introduces an alternative methodology for the survey and evaluation of curve advisory speeds for passenger vehicles. The use of an automated data collection survey system such as the Rieker Inc. *Total Solutions – Curve Advisory Reporting System (CARS)* may now be used.

2. Background

2.1. Ball-Bank Inclination Values

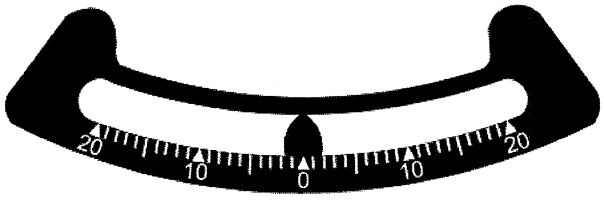
The traditional ball-bank inclination numbers were researched in the mid-1930's and reached wide use acceptance in 1940 with the release of the R.A. Moyer & D.S Berry Highway Research Board paper titled *"Marking Highway Curves with Safe Speed Indications."*

The American *Manual on Uniform Traffic Control Devices (MUTCD)* in 2009 updated the traditional ball-bank inclination values to 16, 14, and 12 degrees (for speeds of ≤ 30 km/h, 40 to 50 km/h, and ≥ 60 km/h, respectively). This change was brought about 1) to adjust the values to make them comparable to the most current American Association of State Highway and Transportation Officials (AASHTO) horizontal curve design guidance, and 2) in recognition of the research that has shown drivers of today (with improved vehicle and tire technologies) often exceed existing posted advisory curve speeds by 11 to 16 km/h.

2.2. Rieker Inc. CARS Curve Advisory Reporting/Testing System

The BC MoTI allows the Rieker Inc. CARS as an alternative to using conventional ball-bank testing procedures for establishing curve advisory speeds. The CARS system is a fully integrated road survey system with internal GPS that automatically records curve radius and super elevation, and determines the recommended safe curve speed. Rieker, Inc. has adjusted their system for use on the BC MoTI highway system.

The "conventional" method of ball-bank testing using a manual or electronic ball-bank indicator remains acceptable for use on BC MoTI highways. The ball-bank indicator used in conventional curve testing should be capable of measuring inclination to at least a1-degree accuracy.



A manual ball-bank indicator, as illustrated above, consists of a steel ball in a sealed glass tube where the ball is free to roll except for the dampening force of the liquid in the tube.

An electronic ball-bank indicator usually consists of an electronic accelerometer capable of measuring lateral forces and accelerations experienced by a driver negotiating a horizontal curve.

3. Policy

As of June 1, 2014, curve advisory speed testing/evaluation is carried out using Table 1. Testing shall only be performed on paved asphalt or concrete highway road surfaces under dry conditions. Testing shall not be performed if the roadway is wet, has any degree of snow cover, or may be icy. In addition, testing shall not be performed on gravel or unpaved roads.

Curve advisory speed should be determined based on free-flowing traffic conditions. Curve advisory speeds should be evaluated when conditions change such as roadway geometrics, surface characteristics, or sight distance.

Prior to implementation, curve advisory speeds and warning signage recommended by qualified curve testing personnel shall be approved by the Regional Traffic Engineer (RTE) and a copy of the recommendations and ball-bank test results supplied to the District Engineer.

The following table correlates the ball-bank reading with a corresponding range of advisory speeds. This table replaces Table 3.1b in the BC MoTI *Manual of Standard Traffic Signs and Pavement Markings,* and Table 1 found in Technical Circular T-03/09.

Table 1 – Speed and Ball-Bank Inclination

Inclination Criteria (Degrees)	Posted Speed Range (km/h)
12°	60 and higher
14°	40 to 50
16°	30 or less

Advisory speeds should be set at a multiple of 10 km/h. Where there are a series of curves, the advisory speed posted should be based on the curve with the lowest advisory speed in the series. However, if the difference in advisory speed between curves is greater than 10 km/h, separate warning signs and advisory speeds should be posted for each curve in the series.

Advisory speed signs, and curve and alignment warning signs shall be selected and placed in accordance with the BC MoTI *Manual of Standard Traffic Signs and Pavement Markings.*

4. Scope and Application

4.1. Using the Rieker Inc. *CARS* system for establishing curve advisory speeds.

The CARS system is a fully integrated road survey system for use to determine curve advisory speeds, and allows a driver to continuously survey kilometres of roads over hours of driving in a day without stopping. Highway telemetry is recorded to the systems tablet as a permanent record for analysis.

The CARS system is based on the FHWA's American MUTCD guidelines on how to determine safe curve speed. Rieker Inc. has worked with the BC MoTI to adjust their system to meet BC MoTI curve analysis guidelines. The CARS system allows an operator to simply drive as many kilometers of road in a day as needed. Once a segment of highway is surveyed, the operator, or an engineering technician can review and analyze individual curve data, anytime, on any computer. The CARS system does not need multiple passes, constant speeds, or manual data input making the job of curve testing safer, faster, and cost effective.

Those who use the CARS system will 1) follow the guidelines and procedures provided by the manufacturer Rieker Inc., and 2) will have taken the Rieker Inc. training, or be trained by a BC MoTI representative who has taken the Rieker Inc. training.

http://www.riekerinc.com/
http://www.riekerinc.com/Total-Solutions-CARS/CARS-PRO_Broch1.pdf

4.2. Using *"Conventional" Ball-Bank Testing Equipment* for establishing curve advisory speeds

The following procedures should be followed when establishing curve advisory speeds.

4.2.1. Vehicle Set-Up Prior to Conducting Ball-Bank Testing

To ensure proper operation of the ball-bank indicator and reliable testing results, the following items should be addressed before conducting testing:

4.2.1.1. Tire Pressure:

Vehicle tire pressure should be checked at the beginning of each day of testing. Prior to checking tire pressure, the vehicle should be driven 5 to 8 km to warm the tires. Tires shall be uniformly inflated to the manufacturer's recommended level.

4.2.1.2. Vehicle Odometer:

The vehicle odometer readings may vary depending on tire pressure and should therefore be checked daily and whenever the tire pressure is adjusted. The distance measured by a vehicle's odometer should be checked for accuracy by comparing its distance measurements against road km markers or a measured distance. The distance that the vehicle odometer is checked against should be at least 3 km. If the distance reading from a vehicle odometer differs from the manually measured distance, then a correlation ratio for distance shall be determined by dividing the actual distance as measured against the odometer distance.

4.2.1.3. Vehicle Speedometer:

If using a manual ball-bank indicator, the accuracy of the vehicle speedometer should be checked at the beginning of each section of roadway being tested or every 1 to 3 days at a minimum. The accuracy of a vehicle's speedometer can be verified using a radar or laser speed meter, or similar device, or by timing the vehicle as it travels a measured distance at a constant speed.

4.2.1.4. Ball-Bank Indicator Calibration and Leveling:

The ball-bank indicator should be calibrated to zero prior to each day of curve testing, or if the ball-bank indicator results become suspect during the testing process.

A manual ball-bank indicator should be calibrated by adjusting the indicator to read zero degrees while the vehicle is on a flat level surface and all testing personnel are in the same position in the vehicle as they would be during testing.

Some electronic ball-bank units have an auto leveling or relative zero feature that allows the device to be calibrated to zero when not on a flat level surface. Follow the manufacturer's instructions for calibration of electronic ball-bank indicators with an auto-leveling or relative zero feature.

Tests may be conducted with a driver only, or both a driver and an observer to record the ball-bank readings. If conducting testing with a driver only and a manual ball-bank indicator, the driver should use a voice and/or video recorder to document readings and observations while driving.

4.2.2. Conventional Ball-Bank Testing Procedure

The following testing procedure should be followed when conducting conventional ball-bank testing. Ball-bank testing should be conducted for each direction and each lane on a curve. Test results may differ based on travel direction and lane position.

For examples of ball-bank testing data sheets, see the attached sample sheets in the Appendix. Alternative presentation of ball-bank results should be approved by the local RTE.

4.2.2.1. Conventional Ball-Bank Test Preparation

1. Ensure the test vehicle and ball-bank indicator equipment have been calibrated and vehicle tire pressure has been checked, and adjusted if necessary, as per the above guidelines including manufacturer's recommendations.

2. For each direction, choose a landmark as the starting position that is well in advance of the curve being examined

3. Drive the curve in each direction, noting the distance from the selected starting position to any signs, intersecting roads, or other landmarks relevant to sign placement. Ensure the locations of the start and end of curve are noted.

4.2.2.2. Conventional Ball-Bank Test Procedure

1. Begin testing at the selected landmark in advance of the curve.

2. Centre the test vehicle in the travel lane driving parallel to the roadway centreline. If no shoulder line is painted, offset the vehicle 0.5 to 1.0 m from the centreline.

3. Begin first trial run at a speed below the expected maximum advisory speed or existing advisory speed.

4. Maintain a constant speed throughout the curve.

5. At the end of each pass through the curve review the test results. Assess the maximum inclination recorded based on the speed driven and Table 1. If the maximum inclination is lower than the angle given in the speed range table, increase speed by 10 km/h and repeat test run. If the maximum inclination is higher than expected based on the table below and speed driven, decrease speed by 10 km/h and repeat test run.

6. Once an appropriate speed for the curve has been determined, continue testing until at least two matching ball-bank readings are achieved for each direction of travel.

7. Including testing preparation and testing, each curve should be driven a minimum of 3 times for each lane, in each direction.

5. Contact

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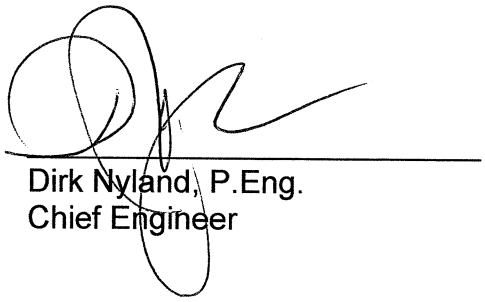

Dirk Nyland, P.Eng.
Chief Engineer

Ball-Bank Testing Data Sheet (Highway Section)

Date:	June 1, 2008	**Analyst(s):**	Chuck Norris
Route:	Hwy XX	**Segment:**	0000
From:	Town Limit	**To:**	Somewhere Road
District:	Rocky Mountain	**Section Length Tested:**	3.0 km
Travel Direction:	**Southbound**	**# Lanes:**	**2**

km	Existing Conditions						Ball Bank Reading Results by Speed									Recommendations	
	Existing Sign Names & Locations	Other Landmarks	Regulatory Speed	Advisory Speed	Curve Deflection (Left, Right)	Curve Limits (Start, End)	20	30	40	50	60	70	80	90	100	Speed	Signs
0.0		Entrance Ave	60														
0.1	W-130																
0.2																	
0.3																	
0.4																	
0.5	G-10																
0.6																	
0.7	W-1L																
0.8																	
0.9				None	Left	Start			3	6	10					60	no change
1.0					Left	End											
1.1																	
1.2																	
1.3	W-7R																
1.4																	
1.5		Hidden Ave															
1.6																	
1.7	W-1R																
1.8																	W-1R
1.9																	
2.0				None	Right	Start			4	7	9					60	sign relocation
2.1																	
2.2					Right	End											
2.3																	
2.4	W-1L, W-22 (50)																W-2L, W-22 (40)
2.5				50	Left	Start			12	14						40	change signs
2.6					Left	End											
2.7																	
2.8	R-4 (60)																
2.9																	
3.0		Terminal Rd															

Comments:

Approving Engineer: Reginald Bald

Signature: _____ **Date:** June 5, 2008

Date:	June 1, 2008	**Analyst(s):**	Chuck Norris
Route:	Hwy XX	**Segment:**	0000
From:	Somewhere Road	**To:**	Town Limit
District:	Rocky Mountain	**Section Length Tested:**	3.0 km
Travel Direction:	**Northbound**	**# Lanes:**	**2**

km	Existing Conditions						Ball Bank Reading Results by Speed									Recommendations	
	Existing Sign Names & Locations	Other Landmarks	Regulatory Speed	Advisory Speed	Curve Deflection (Left, Right)	Curve Limits (Start, End)	20	30	40	50	60	70	80	90	100	Speed	Signs
3.0		Entrance Ave															
2.9	W-130																
2.8																	
2.7																	
2.6																	
2.5	G-10																
2.4																	
2.3																	
2.2																	
2.1					Right	End											
2.0				None	Right	Start			2	6	9					60	no change
1.9																	
1.8	W-1L																
1.7																	
1.6																	
1.5																	
1.4		Park Place															
1.3																	
1.2																	
1.1																	
1.0					Left	End											
0.9																	
0.8				None	Left	Start			5	8	11					60	no change
0.7	W-1L																
0.6																	
0.5					Right	End											
0.4				50	Right	Start			10	12						50	no change
0.3	W-1R, W-22 (50)																
0.2																	
0.1	R-4 (60)																
0.0		Terminal Rd	60														

Comments:

Approving Engineer: Reginald Bald

Signature: _____ **Date:** June 5, 2008

Ball-Bank Testing Data Sheet (Single Curve)

Date:	June 1, 2008	**Analyst(s):**	Chuck Norris
Route:	Hwy XX	**Segment:**	0000
From:	km 22.5	**To:**	km 22.6
District:	Rocky Mountain	**No. of Lanes:**	2

Northbound

Existing Signs: W-1L located 200 m in advance of curve
Other Landmarks: no intersecting roads
Curve Deflection (Left/Right): Left
Posted Speed: 90 km/h
Advisory Speed: no advisory speed

Trial No.	Lane (inside, outside)	Field Measurements		Recommendations	
		Speed on Curve	Deflection	Speed	Signs
1	N/A	70	3	90	no change
2	N/A	80	7		
3	N/A	90	9		
4	N/A	90	9		
5					
6					
7					
8					

Comments:
Highway section has been recently reconstructed with new pavement.
Speed limit was raised from 80 km/h to 90km/h.

Southbound

Existing Signs: W-1R located 200 m in advance of curve
Other Landmarks: no intersecting roads
Curve Deflection (Left/Right): Right
Posted Speed: 90 km/h
Advisory Speed: no advisory speed

Trial No.	Lane (inside, outside)	Field Measurements		Recommendations	
		Speed on Curve	Deflection	Speed	Signs
1	N/A	70	4	90	no change
2	N/A	80	8		
3	N/A	90	10		
4	N/A	90	10		
5					
6					
7					
8					

Comments:
Same as above.

Approving Engineer: Reginald Bald

Signature: _____ **Date:** June 5, 2008