2020

WEBINAR SERIES

RPUG

Road Profile Users' Group

BEST PRACTICES IN CONTINUOUS FRICTION QUALITY ASSURANCE

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INTRODUCTION

Federal Highway Administration (FHWA) pavement policies (2017):

- The FHWA pavement policy indicates that States shall design pavement to accommodate current and predicted traffic needs in a safe, durable, and cost-effective manner.
- The FHWA policy related to the Highway Safety Improvement Program (HSIP) indicates that each State shall incorporate a process for analyzing available safety data that identifies highway safety improvement projects on the basis of crash experience, crash potential, or other data supported means.
- Pavement friction management includes providing surfaces with adequate and durable friction properties as well as **collecting data** and **performing analysis** to ensure the **effectiveness of the program**.

FRAMEWORK FOR QUALITY ASSURANCE

Goal: Confirm the proposed measurement methodology will yield data in the format and to the quality specified

1) Check

2) Calibrate

3) Validate

- Ensure satisfactory repeatability and reproducibility of measurements and traceability to international standards
- Ensure equipment can measure data elements to a specified accuracy
- Provide evidence of measurement stability
- Define any equipment limitations
- Define factors that may influence results, such as data filtering and whether/how to apply correction factors

FRAMEWORK FOR QUALITY ASSURANCE

ROSANNE recommendations:

1) Countries should adopt a QA system that ensures a combination of elements and work toward an increasingly robust QA system (1-, 2-, and 3-level system)
2) The complexity of the QA system may depend on how many measuring devices of the same type are present

Table 2: Components of the quality assurance procedure with their opportunities and drawbacks

Component	Advantages	Drawbacks
Internal checks	▪ confirmation for the device owners that the devices works correctly and fulfil the requirements ▪ identification of the impact of changes at the device ▪ identification of defects at the device immediately ▪ complete and continuous documentation of the condition of the device ▪ easiest way to prove a proper and stable function of the device to the costumer	▪ additional effort, time and costs for the operating company ▪ operating company: additional tyres needed and comparison measurements with the tyres are necessary to select the appropriate ones
Calibration	▪ all relevant parts of the device will be checked as well as calibrated/adjusted – static and dynamic ▪ regular checks of the stability of the measuring level within the given limits ▪ organised and performed by an independent organisation ▪ more confidence in the devices and their results by external parties as well as contracting bodies ▪ confirmation for the device owners that the devices works correctly and fulfil the requirements	▪ normally only one device at time will be checked, if more devices should be checked at the same time, more space and staff is needed ▪ independent institute needs extra equipment for the comprehensive tests ▪ independent institute: additional tyres needed ▪ additional effort, time and costs for the operating company ▪ reference is needed for the dynamic part of the calibration (number of devices depends on the philosophy of the reference (reference device or reference fleet))

2-Level System:

1) Internal checks and calibration
2) Internal checks and national correlation trials

+ Benefits: Some quality and stability checks of measured values across the year
- Drawbacks: If no match to reference, difficult to determine where/when deviation occurred

3-Level System:

1) Internal checks, calibration, and validation
2) Internal checks, validation, and national correlation trials

+ Benefits: Quality and stability checks of measured values across the year, including against reference measurements
- Drawbacks: Time and resource-intense

FRAMEWORK FOR QUALITY ASSURANCE

ROSANNE recommendations:

1) Countries should adopt a QA system that ensures a combination of elements and work toward an increasingly robust QA system (1-, 2-, and 3-level system)
2) The complexity of the QA system may depend on how many measuring devices of the same type are present

Countries with 2 devices of the same type:

1) Adopt a 2-level system with one of the two systems acting as a reference device that can also perform external checks or participate in national correlation trials

Countries with 3-10 devices of the same type:

1) Adopt a 2-level or 3-level system with external checks performed by a reference device or at least three other devices

Table 2: Components of the quality assurance procedure with their opportunities and drawbacks

Component	Advantages	Drawbacks
2-level-system (calibration and internal checks)	▪ some additional effort and costs for the operating company/device owner ▪ quality and stability checks of the measured values during the year	▪ no additional checks with the reference systems or other national devices during the year
2-level-system (national correlation trials and internal checks)	▪ some additional effort and costs for the operating company/device owner ▪ quality and stability checks of the measured values during the year	▪ organisation of a national correlation trial with preferably all national devices of one type by an independent organisation ▪ organisation of such trials and the evaluation takes a considerable amount of time ▪ gathering together all national devices (or at least three devices) at the same time is challenging ▪ quality/stability of the mean value depends on the number of devices which take part in the trial ▪ no additional checks with the reference systems or other national devices during the year
3-level-system (calibration, additional external checks and internal checks)	▪ checks about the quality and the stability of the measured values during the year ▪ additional checks with the reference systems or other national devices during the year	▪ (a lot of) additional effort, time and costs for the operating company
3-level-system (national correlation trials, external checks and internal checks)	▪ checks about the quality and the stability of the measured values during the year ▪ additional checks with the reference systems or other national devices during the year	▪ organisation of a national correlation trial with preferably all national devices of one type by an independent organisation ▪ gathering together all national devices (or at least three devices) at the same time is challenging ▪ quality/stability of the mean value depends on the number of devices which take part in the trial ▪ (a lot of) additional effort, time and costs for the operating company

Is that the best practice? Are we done?

Austroads (2015a) said that its efforts are best directed toward the “far more achievable” objective of standardizing across Australia and New Zealand.

ADAPTING A 3-LEVEL US QA SYSTEM

- Establish a rigorous and consistent system of equipment validation, calibration, and checks
- Develop locally-appropriate temperature, speed, and seasonal correction factors
- Reinforce QA management through reporting and external certification

KEY ELEMENTS OF US QA SYSTEM

Key Elements

- Equipment operation and maintenance
- Equipment calibration
- Survey operation and record keeping
- Data recording, processing, and analysis
- Data delivery

Recommended 3-Level QA System: Equipment

Daily	Weekly	Monthly	Other
Vehicle, tire, sensor, and component condition	Dynamic repeatability (distance and readings)	Calibration (load cells, distance, water flow)	Distance calibration – when tires are replaced
Load cell check and calibration		Reference site revalidation	Seasonal site measurements (pre-, in-, post-season)
Sensor/test equipment operations			Correlation exercise and/or reference validation – annually
			Manufacturer's service and calibration - annually

EQUIPMENT QA PRINCIPLES/PROCESS

Best practices:

1) Equipment QA: daily checks, combined with minimum monthly calibration of factors critical to verifying data and data validation program, externally-audited validation and correlation exercises
2) BRSD/BESD support dynamic, in-field analysis, rapid identification of outliers, and broader randomization of factors in controlled trials

Between run:

- Assess repeatability of specific device (same site over repeat runs) to demonstrate device is capable of measuring consistently
- Between run standard deviation (BRSD)

Between equipment:

- Assess reproducibility between different equipment and assess bias of single device against fleet
- Between equipment standard deviation (BESD)

Single equipment over time:

- Repeating surveys on test site(s) to consider changes over time and to apply corrective action, if needed
- Includes between run assessments and bias over time from reference data set

ANNUAL CORRELATION EXERCISES

Best practices:
1) Demonstrating compliance with all pre-exercise checks/calibrations
2) Clear test plan (optimized for number of device, track availability, offsite testing) and early warnings (day-by-day analysis of results)

Overarching purpose: demonstrate that a fleet of high-speed continuous friction devices "continue to perform at a level suitable for use in supporting skid resistance standards"

- Considerations: consistent and reliable measurement and reporting, performed to defined standards of accuracy
- To establish skid, beyond skid, include analysis of: vehicle speed, distance, test wheel weight, water flow – ideally, location referencing and altitude as well
- Protocol:
  - Controlled and live traffic environments
  - Minimum of three test sections (100m+), test a representative section of low/med/high skid
  - Minimum of three laps at target speed
- Analysis:
  - BRSD to assess repeatability of individual devices
  - BESD to assess consistency across devices

Table 1 – Acceptance Criteria for Skid resistance measurements

Parameter	Acceptability Limit
Between run standard deviation (BRSD)	Investigate if >3 SR on 100m lengths
Between Equipment standard deviation (BESD) on closed site (e.g. test track)	≤2.7 SR
Between Equipment standard deviation (BESD) on live site (e.g. network route)	≤2.8 SR

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EQUIPMENT VALIDATION: PRE-SEASON

Recommended for:
1) Distributed fleets or new fleet additions
2) Held alongside cross-national correlation exercises to establish traceability

- Pre-season validation of continuous friction survey equipment should include:
  - Minimum of 10 runs over two consecutive days (5 runs per day) at three different speeds (randomized running order) which span the minimum and maximum expected survey speeds.
  - Repeatability and bias testing to evaluate speed dependency, temperature correction, speed correction (and if both wheelpaths are measured, then also wheel bias and cornering effects) – distance measurement, location referencing, and vehicle speed also of interest.
  - Compare vehicle to vehicle (same and different day), vehicle by day, vehicle performance vs. previous year.
  - Success criteria that prescribes thresholds for all measured values using coefficient of variation, standard deviation, r^2, and bias error.
  - Static (QA, reference site, or test facility) and dynamic (100km road trial) to demonstrate validity of measurements and data deliverable.

SELECTING PRE-SEASON VALIDATION SITES

Best practices:

1) Agree to a collaborative process – mutual agreement on test parameters, local site selection knowledge, time and resources to obtain traffic-controlled reference measurements, costs incurred
2) Validate all vehicles that may be used over the course of the survey season

Suggested site criteria:

- Minimum number of sites = 5, minimum site length = 500m
- Sites should cover a range of SC values from 0.35 to 0.55 (NZTA) (45-70 SC) and at least three sites should have texture ranging from 0.5 to 3.5mm MPD
- Include at least one site with tight radius curves and range of gradients
- Validation sites should be generally representative of the pavements to be surveyed, e.g.:
  - PCC (Austroads)
  - Chip seal (NZTA)
  - Open-graded asphalt (HE)
- Bias and repeatability testing on a 30km site to assess measurement in real working situation to demonstrate between run/between equipment, data processing outputs, etc.

EQUIPMENT VALIDATION: ONGOING BENCHMARKING

Recommended for:

1) Confirming equipment's on-road performance is consistent with daily calibration checks
2) Providing linkage back to pre-season validation exercise and annual correlation exercise
3) Timely visibility into trends and factors impacting results

Reference Validation:

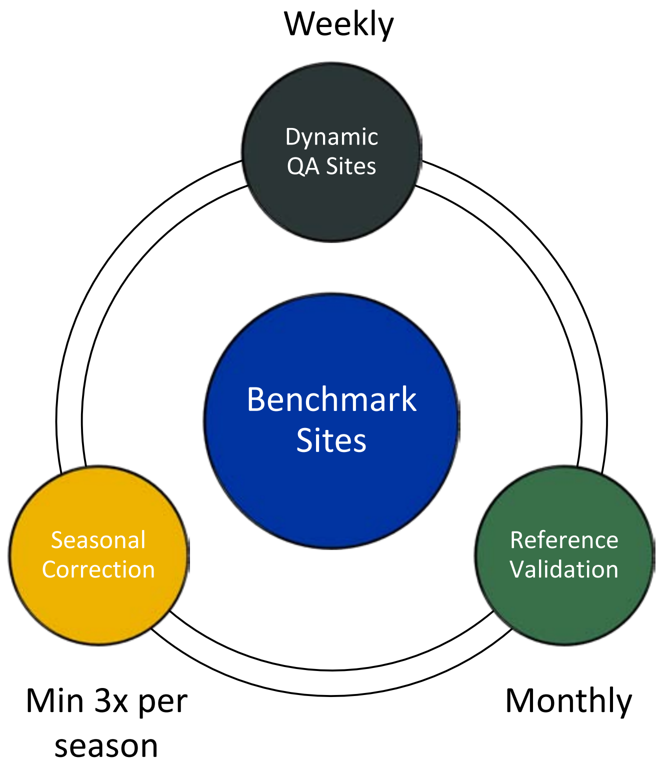
- Repeat surveys on a minimum monthly basis – purpose is to demonstrate ongoing repeatability and assess whether any bias has been introduced into measurements since reference data were collected

Seasonal Correction:

- Averaging a minimum of three continuous friction surveys at "strategic sites" over the course of a survey season is "essential…to obtaining a more robust estimate of the underlying trends." TRL (2014, 2019)

To note:

- "Benchmark sites" can overlap to some degree
- Additional site locations may be defined by representative climatic areas or by recognized organizational boundary (e.g. Districts, counties)



EQUIPMENT CALIBRATION AND CHECKS

Daily	Weekly	Monthly
Vehicle, tire, sensor, and component condition	Dynamic repeatability (distance and readings)	Calibration (load cells, distance, water flow)
Load cell check and calibration		Reference site revalidation
Sensor/test equipment operations		

- Acts as a complement to and corresponds with ongoing validation
- More uniformity across bodies:
  - Per CEN/ROSANNE: wheel angle, distance, speed, tire pressure, load forces, and water flow
  - Per NZTA: lasers/accelerometers used to measure displacement, load cells, flow meters, data acquisition systems, temperature measurement, geometry measuring devices
- Skid measurement components, e.g.:
  - Static horizontal load cell calibration: ensures the slip ratio 20° is maintained and the slip force can be consistently interpreted in calculating the SR
  - Water flow rate calibration: confirms the accuracy (within ±10%) of the water flow required to achieve the theoretical water film thickness (0.5mm)
  - Distance calibration: confirms the accuracy (within ±0.1%) of the known length of the distance measured by the SCRIM vehicle

LOCALIZED CORRECTION FACTORS

Best practices:

1) Test prior corrections at both regional test facilities (better repeatability run on run) but also in-field where extensive testing will take place (better understanding of localized operational range)
2) Review on a minimum five-year cycle or when there's a significant technical change (review may not be retesting); if relying on regionalized corrections, may need more frequent

- Temperature:
  - BASt = research to develop both seasonal and temp corrections (road and water)
  - TRL = air and surface
  - Vic Roads Test Method RC-42012 – ambient temp
  - NZTA current = air and surface (provisional at high temperature = air, surface, tire)
- Speed:
  - TRL PPR587 = between 30 and 85 kph (18 to 53 mph), standard test speed of 50 kph (31 mph)
  - Proposed AASHTO "continuous measurement" standard = between 15 mph and 55 mph, standard test speed of 40 mph

DEVELOPING QUALITY CONTROL PLANS

Best practices:

1) Store QA documentation: daily/weekly checks, calibration records, validation reports (where available) for both network-level and project surveys
2) QA as component of final report: events and/or incidents, delays and breakdowns, summary of QA/validation, seasonal correction results, etc.

Design

- An equipment program that demonstrates continuity of measurement, repeatability, and comparability
- A data control and validation process with a series of independent quality checks, a secure chain of custody, and multiple failsafes
- A data review process that allows for feedback and refinement

and

Show your work

- QA check/calibration documentation on request
- Standalone reports for pre-season and ongoing validation
- Interim deliverables, including QA results, indicative data (for completeness, formatting, high-level findings)
- Final operational report, including seasonal correction results

TOWARD A ROBUST US QA SYSTEM

Goal:

As states evaluate using high-speed continuous friction measurement to underpin pavement friction management programs, how can we adapt and add to accepted QA practices?

- Establish an annual national correlation exercise and use in conjunction with local validation exercises
- Draw on established standards for both skid and non-skid related measurements, while assessing regionally- and/or locally-derived correction factors
- Develop a common data processing and reporting method to provide a basis for valid comparison of results

Thanks!

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