Euro NCAP
For Safer Cars

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Driver Monitoring Test Procedure

Safe Driving

Technical Bulletin SD 202

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PREFACE

DISCLAIMER: Euro NCAP has taken all reasonable care to ensure that the information published in this protocol is accurate and reflects the technical decisions taken by the organisation. In the unlikely event that this protocol contains a typographical error or any other inaccuracy, Euro NCAP reserves the right to make corrections and determine the assessment and subsequent result of the affected requirement(s).

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INTRODUCTION

The assessment criteria and requirements for Driver Monitoring systems are defined in the Euro NCAP Driver Engagement protocol. That protocol remains the leading document for the assessment of Driver Monitoring performance, functionality and scoring.

This Technical Bulletin provides guidance to Euro NCAP laboratories on how to conduct the Driver Monitoring spot checks referred to in the Driver Engagement assessment. Its purpose is to support consistent and repeatable execution of those spot checks across laboratories. It is not intended to define additional assessment requirements, nor to provide design guidance for Driver Monitoring systems.

The Driver Monitoring assessment is based on a combination of information provided by the Vehicle Manufacturer and spot testing conducted by Euro NCAP laboratories. Euro NCAP requires the Vehicle Manufacturer to provide a dossier containing sufficient technical detail for all relevant Driver Monitoring assessment areas. The dossier shall be provided to the Euro NCAP Secretariat at least two months before any testing begins. The dossier shall follow the guidelines indicated in SD-201 Technical Bulletin.

The spot checks described in this Technical Bulletin are intended to verify selected aspects of the Driver Monitoring information declared by the Vehicle Manufacturer and to support the assessment defined in the Driver Engagement protocol. In addition, each vehicle assessed by Euro NCAP is subject to an on-road evaluation, during which driver acceptance and system behaviour may be reviewed in real-world driving. Where serious driver acceptance issues are identified and attributed to a specific assessed feature, Euro NCAP may consider withholding or withdrawing the score associated with that feature, including where the affected feature is Driver Monitoring.

1 MEASURING EQUIPMENT

Sample and record all video data at a frequency of at least 25Hz.

1.1 Measurements and Variables

T	**Time**
ΔT_{LGA}	Gaze off-road time declared by Vehicle Manufacturer where the driver behaviour is classified as Long Distraction (or LGA – Long Glance Away). T_{LGA} shall be between 3 and 4s.
ΔT_{VATS}	Cumulative gaze off-road time declared by Vehicle Manufacturer where the driver behaviour is classified as Short Distraction (or VATS – Visual Attention Time Sharing). VATS can vary depending on the specific Vehicle Manufacturer implementation. $$\Delta T_{VATS} = \sum_{i=1}^{n} \Delta T_{VATS\_i}$$
ΔT_{sleep}	Eye closure time required to classify a driver as asleep. ΔT_{sleep} is fixed to 3s.
$\Delta T_{microsleep}$	Eye closure time declared by Vehicle Manufacturer where the driver is classified as microsleep. $\Delta T_{microsleep}$ shall be between 1 and 2s.
T_0	Start of test (T_{away} – 4.0s or T_{close} – 4.0s)
T_{away}	Time of first eye movement looking away from forward road view ahead or looking away from gaze location
T_{gaze}	Time of glance first landing on gaze location.
$T_{gaze\_desired}$	Desired time of glance first landing on gaze location.
T_{gaze_limit}	Time boundary under which **T_{gaze}** must be realized.
T_{road}	Time of glance first landing on forward road view ahead
T_{close}	Time of first continuous eyes closed (immediately after no eye is visible)
$T_{close\_desired}$	Desired time of first continuous eyes closed.
T_{close_limit}	Time boundary under which **T_{close_actual}** must be realized.
T_{warn}	Time of required of audio/visual warning (according to protocol requirements or specific strategy)
$T_{warn\_outlier}$	Maximum allowed deviation against T_{warn} caused by outliers in system response
T_{FSS_att}	Time where AEB or FCW activates with attentive driver

T_{FSS_inatt}	Time where AEB or FCW activates with inattentive driver
ΔT_{FSS}	Difference between T_{FSS_att} and T_{FSS_inatt}
T_{LSS_att}	Time where ELK/LKA/LDW activates with attentive driver
T_{LSS_inatt}	Time where ELK/LKA/LDW activates with inattentive driver
ΔT_{LSS}	Difference between T_{LSS_att} and T_{LSS_inatt}
T_{VATS_reset}	Minimum duration of gaze back on road to reset VATS counter

1.2 Measuring Equipment

Equip the VUT with data measurement and acquisition equipment to sample and record data with an accuracy of at least:

- VUT speed to 0.1km/h
- Driver gaze location
- In-vehicle warning(s)

2 TEST CONDITIONS

2.1 Test Track

Conduct tests on a uniform, solid-paved surface.

The presence of lane markings is allowed for Driver Monitoring testing. The lane for the VUT and GVT shall have a width of 3.5 to 3.7m. The lane markings on these lanes need to conform to one of the lane markings as defined in UNECE Regulation 130.

2.2 Weather Conditions

For Driver Monitoring testing, no precipitation shall be falling and horizontal visibility at ground level shall be greater than 1km. Wind speeds shall be below 10m/s to minimise GVT disturbance in tests where applicable.

Natural ambient illumination shall be homogenous with no strong shadows cast across the test area other than those caused by the VUT or GVT. Ensure testing is not performed driving towards, or away from the sun when there is direct sunlight.

2.3 Vehicle Preparation

Fit the on-board test equipment and instrumentation in the vehicle to observe the driver application of the test scenario and the relative timing of the Driver Monitoring response. Also fit any associated cables, cabling boxes and power sources.

3 TEST PROCEDURE

3.1 VUT Pre-test Conditioning

A new car is used as delivered to the test laboratory.

If requested by the Vehicle Manufacturer, drive a maximum of 100km on a mixture of urban and rural roads with other traffic and roadside furniture to ‘calibrate’ the sensor system for the collision avoidance technology (FCW and LDW). Avoid harsh acceleration and braking.

Where assessing FCW and/or LDW optimisation, perform a maximum of ten runs at the lowest speed the systems are supposed to work, to ensure proper functioning of the systems ahead of investigating timing optimisation with driver inattention.

3.2 Test Conduct

3.2.1 VUT

Before initiating testing, drive the vehicle for at least 1 minute fully attentive at a speed of ≥10km/h to allow the Driver Monitoring time to identify the driver and enable the system. In case a fault is reported, make adjustments and repeat the process to enable the system.

Check that the system is default ON at the start of every journey and that deactivation of the system is not possible with a momentary single push of a button. The test driver should record the actions required to deactivate the Driver Monitoring system. Check that warning sensitivity thresholds cannot be manually adjusted by the driver.

For vehicles with an automatic transmission select D. For vehicles with a manual transmission select the highest gear where the RPM shall be at least 1500 at the test speed. If fitted, a speed limiting device or cruise control may be used to maintain the VUT speed (not ACC and Lane Centering), unless the Vehicle Manufacturer shows that there are interferences of these devices with Driver Monitoring system in the VUT.

3.2.2 Driver attributes

The test driver shall have attributes in the required range of the variables specified in the Euro NCAP Driver Engagement protocol.

Adjust seating position and driving controls to a comfortable and natural position for the driver to safely drive the vehicle and allow the Driver Monitoring a clear view of the driver’s face.

3.2.3 Driver states

Throughout the different Driver Monitoring tests, the driver should maintain a natural body posture.

3.2.3.1 Distraction

Head turning (for owl movements) or eye-gazing (for lizard movements) shall be directed toward the gaze location at a natural rate of movement.

3.2.3.2 Movement types

3.2.3.2.1 Owl

Head shall turn directly to the gaze location. A maximum time of 0.48 seconds (12 frames @ 25Hz) is permitted to perform the owl gaze transition.

3.2.3.2.2 Lizard

A small rotation of the head is allowed for lizard movements toward gaze locations far from the forward road view (e.g., passenger face). A maximum time of 0.16 seconds (4 frames @ 25Hz) is permitted to perform the lizard gaze transition.

3.2.3.2.3 Body lean rear passenger

Movement should be carried out as if shifting visual attention away from the road and forward-facing position to view over their shoulder to focus on opposite side rear head restraint.

Keeping both hands on the steering wheel, the driver should rotate upper body posture with head turning in owl-like movement to view opposite side rear head restraint at a natural rate of movement. Maintain gaze at the location for up to a maximum of 5 seconds. Return gaze directly to the forward road view after the warning is issued. A maximum time of 1.0 second (25 frames @ 25Hz) is permitted to perform the body lean transition.

3.2.3.2.4 Body lean passenger footwell

Movement should be carried out as if shifting visual attention away from the road and forward-facing position to reach down to the passenger footwell.

Keeping their driver-side hand on the steering wheel, the driver should lean upper body posture with head turning in owl-like movement and reach down towards the centre of the passenger footwell with their passenger side arm at a natural rate of movement. Maintain gaze at the location for up to a maximum of 5 seconds. Return gaze directly to the forward road view after the warning is issued. A maximum time of 1.0 second (25 frames @ 25Hz) is permitted to perform the body lean transition.

4 TEST EXECUTION

This section describes the warning and intervention test execution for the transient and non-transient driver states, which are described in the Euro NCAP Driver Engagement protocol.

For each of the prescribed warning and intervention tests, the driver shall conduct the test wearing one randomly selected occlusion accessory, from the occlusion accessories listed in APPENDIX A.

4.1 Warning tests

Warning tests are intended to verify that warnings are issued at the required conditions. All random selections described in this chapter are done by Euro NCAP and instructed to the Test Laboratory before the test campaign begins.

For tests intended to assess warning timing, drive the test vehicle in a straight line at a speed in the range of 20 to 80km/h. Between T_0 and $T_{away,}$ the driver shall be fully attentive with eyes on the forward road view. The test ends when the warning is issued.

4.1.1 Transient states

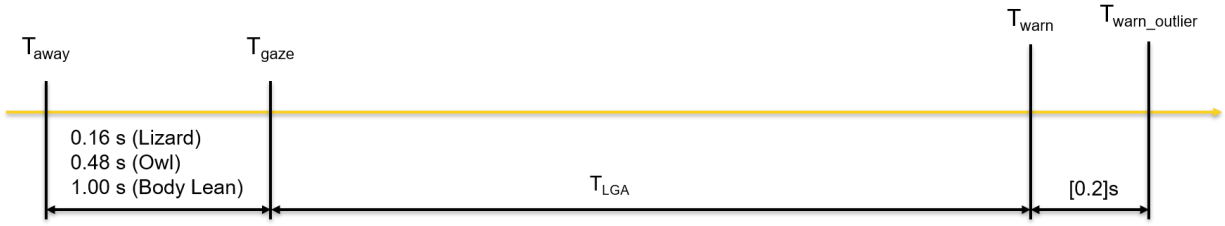
At least half of the gaze locations per movement type across Transient states (excluding driving tasks) that are claimed by the Vehicle Manufacturer are randomly selected for warning tests.

4.1.1.1 Long Distraction

Maintain gaze at the location for up to a maximum of 5 seconds. Return gaze directly to the forward road view after the warning is issued.

Driver shall perform all movement types claimed to function in each long distraction scenario, randomly selecting half of the gaze locations for spot testing. For each distraction scenario and movement type, use dissimilar gaze locations where possible to broaden the assessment.

The tolerance for Long Distraction warning tests is [0.2]s, as illustrated in the diagram below:



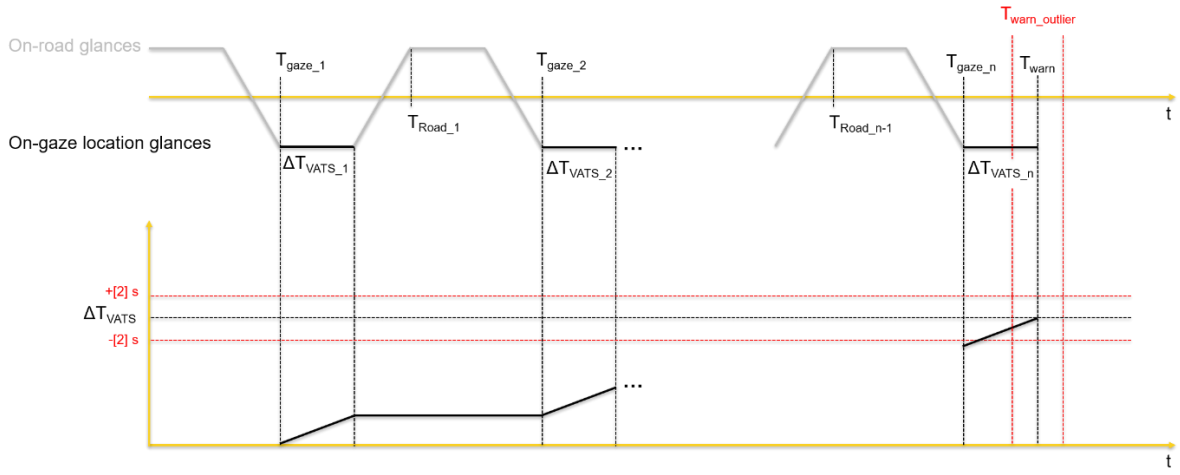
It shall be noted that the tolerance is to account for outliers in system response; the DSM system shall be optimized to consistently trigger Long Distraction warning as per the required timing in the Driver Engagement protocol.

4.1.1.2 Short Distraction and Phone Use

Movement sequence shall be conducted according to the VATS strategy implemented by the Vehicle Manufacturer, as described in the Driver Monitoring dossier e.g. gazes on-road shall be shorter than the defined T_{VATS_reset}.

Driver shall perform all movement types claimed to function in each short distraction and phone use scenarios, spot testing half of the gaze locations. For each distraction scenario and movement type, use dissimilar gaze locations where possible to broaden the assessment.

T_{warn} for Short Distraction and Phone Use warning is expected at $\Delta T_{VATS} \pm$[2.0] s, as illustrated in the diagram below:



It shall be noted that the tolerance is to account for outliers in system response; the DSM system shall be optimized to consistently trigger VATS warning as per the VATS strategy described by the Vehicle Manufacturer in the Driver Monitoring dossier as per SD-201.

4.1.2 Non-transient states

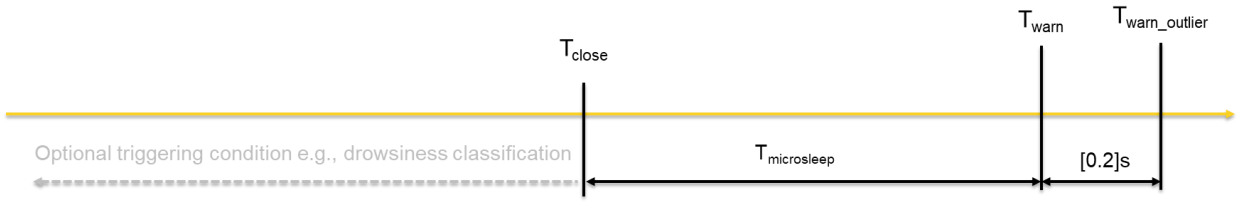
4.1.2.1 Drowsiness and Non-fatigue related impairment

For the impairment driver states, the Vehicle Manufacturer shall supply a dossier detailing the detection strategy and how the system detects impairment. Euro NCAP reserve the right to practically investigate the Driver Monitoring system performance to verify the information in the dossier.

4.1.2.2 Microsleep

Close eyes with a neutral head position for a maximum of 4 seconds. Return gaze directly to the forward road view after the warning is issued.

The tolerance for Microsleep warning tests is [0.2]s, as illustrated in the diagram below:



It shall be noted that the tolerance is to account for outliers in system response; the DSM system shall be optimized to consistently trigger microsleep warning as per the required timing in the Driver Engagement protocol.

Alternatively, a driver microsleep test method as illustrated by the Vehicle Manufacturer in the dossier, and considered acceptable and practicable by Euro NCAP.

4.1.2.3 Sleep

Close eyes with a neutral head position for a maximum of 7 seconds. Return gaze directly to the forward road view after the warning is issued.

The tolerance for Sleep warning tests is [0.2]s, as illustrated in the diagram below:

It shall be noted that the tolerance is to account for outliers in system response; the DSM system shall be optimized to consistently trigger Sleep warning as per the required timing in the Driver Engagement protocol.

Alternatively, a driver sleep test method as illustrated by the Vehicle Manufacturer in the dossier, and considered acceptable and practicable by Euro NCAP.

4.2 Intervention tests

To check Forward and/or Lane Support sensitivity change according to the driver state, testing shall be conducted in the Baseline (attentive) state and in the Transient/Non-transient states. The sensitivity change shall be compared to verify that the criteria is met, according to the Driver Engagement protocol.

In case a test results in the criteria not being met, the Vehicle Manufacturer may contact Euro NCAP and shall elaborate a compelling case to justify a repetition. In case the argument is accepted, the Test Laboratory shall conduct two repetitions (funded by the Vehicle Manufacturer) which shall pass the criteria in order to get awarded with the claimed points.

All random selections described in this chapter are done by Euro NCAP and instructed to the Test Laboratory before the test campaign begins.

The activation timing across Transient, Non-Transient and Baseline driver states (e.g., T_{FSS_inatt}) shall be provided by the Vehicle Manufacturer or determined by the Test Laboratory, , in which case the average of at least three runs will be taken.

In case a specific intervention strategy is used, e.g., Lane Support Sensitivity strategy, the Vehicle Manufacturer shall provide all necessary details to Euro NCAP and the Test Laboratory on how to verify the claimed performance.

4.2.1 Baseline attentive test

Baseline (attentive) tests shall be conducted for each of the designated scenarios (e.g., CCRs 75%) where Forward and/or Lane Support Sensitivity is claimed, so that the attentive sensitivity setting (e.g., T_{FSS_att}) can be compared against transient/non-transient sensitivity setting (e.g., T_{FSS_inatt}).

During the baseline attentive tests, the driver shall be fully attentive to the forward-facing road on the approach to the test target or lane boundary, and not display any signs of distraction, fatigue, or unresponsiveness.

4.2.2 Transient tests

A maximum of eight Transient intervention spot checks shall be conducted by the test laboratory, depending on the performance claimed by the Vehicle Manufacturer:

- One Forward Support Sensitivity or Lane Support Sensitivity intervention spot check per movement type on Long Distraction (Driving Task)
- One Forward Support Sensitivity or Lane Support Sensitivity intervention spot check per movement type on Short Distraction (Driving Task)
- Remaining Forward Support Sensitivity or Lane Support Sensitivity tests to be allocated randomly, ensuring even distribution across different Transient States (including Phone Use where performance is claimed).

4.2.2.1 Forward Support Sensitivity

The Spot checks for Forward Support Sensitivity shall be conducted under a randomly selected Transient driver state (where Forward Support Sensitivity intervention performance is claimed), and in a randomly selected test case from either CCRs, CMRs or CCRm scenarios of the Crash Avoidance – Frontal Collisions protocol, within the following ranges:

- Impact location: between 25 and 50%, or between 50 and 75%
- VUT Speed: $30 \leq V_{VUT,target} \leq 80$ km/h, $V_{VUT} = V_{VUT,target} \pm 5$ km/h

Out of the total number of selected Forward Support Sensitivity spot checks, one randomly selected spot check shall be conducted to verify the sensitivity change latency, and the remainder of the spot checks shall be conducted to verify the sensitivity change timing.

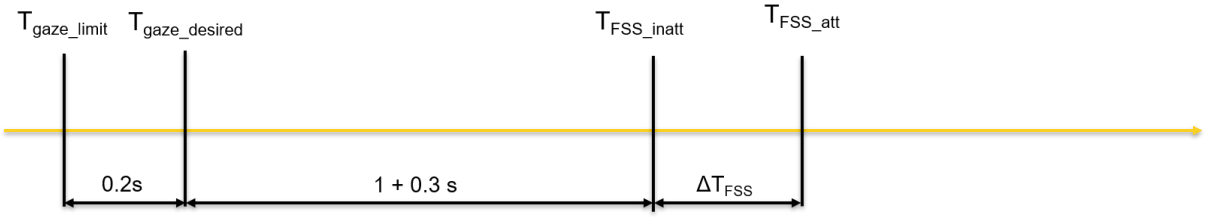
4.2.2.1.1 Sensitivity change timing

Conduct first the Sensitivity change timing tests, in which T_{FSS_inatt} is determined by taking the average of all runs conducted, and later compared to $T_{FSS\_att.}$

In these tests, the driver shall conduct the spot check ensuring $T_{gaze} \geq T_{FSS\_att} + 2.0s$ TTC

4.2.2.1.2 Sensitivity change latency

In this single test, the driver shall conduct the spot check ensuring that T_{gaze} is realized between 1.3 and 1.5 seconds ahead of T_{FSS_inatt}., meaning a 0.2 second tolerance is allowed on T_{gaze} as indicated in the diagram below



It should be noted that DSM system shall be optimized to consistently adjust the Forward Support Sensitivity as required in the Driver Engagement protocol i.e. ≤ 1 second of any continuous gaze away from forward road view.

4.2.2.2 Lane Support Sensitivity

The spot checks for Lane Support Sensitivity shall be conducted under a randomly selected Transient driver state (where Lane Support Sensitivity intervention performance is claimed). The test case to be used for verification shall be randomly selected amongst the claimed ranges provided by the Vehicle Manufacturer where Lane Support Sensitivity strategy, e.g., LKA Dashed Line 0.3 m/s at 70 km/h.

The test laboratory shall conduct the spot checks under the selected driver state and record the necessary parameters to verify that the intervention strategy claimed by the Vehicle Manufacturer is realized e.g., LDW/LKA/ELK activation timing, increased overriding torque, no suppression policy, etc. This strategy is to be described by the Vehicle Manufacturer in a dossier as per the SD-201 Technical Bulletin.

4.2.3 Non-transient tests

4.2.3.1 Impairment

Euro NCAP reserve the right to practically investigate whether the claimed intervention strategies of the vehicle meet the criteria after fatigue/non-fatigue impairment has been detected.

4.2.3.2 (Micro)sleep

One spot check shall be conducted for Forward or Lane Support Sensitivity, under the Sleep or Microsleep driver state (where Forward or Lane Support Sensitivity performance is claimed). The test case shall be randomly selected as specified in either 4.2.2.1 or 4.2.2.2.

In this test, the driver shall conduct the spot check ensuring that T_{gaze} is realized between 0.3 and 0.5 seconds ahead of T_{FSS_inatt}.+ $T_{sleep/microsleep}$, meaning a 0.2 second tolerance is allowed on T_{gaze} as indicated in the diagram below

It should be noted that DSM system shall be optimized to consistently adjust the Forward/Lane Support Sensitivity as required in the Driver Engagement protocol i.e. 3 seconds of any continuous eye closure for sleep.

4.2.3.3 Unresponsive Driver

One spot check shall be conducted for Unresponsive Driver (if claimed), either on sleep or distraction options as described below.

4.2.3.3.1 Sleep Option

Close eyes with an initial neutral head position for a minimum of 13 seconds to trigger the EF distinct warning, followed by EF intervention, and maintain closed eyes until the EF intervention is finalized.

Alternatively, using an alternative sleep-like unresponsive driver test method as illustrated by the Vehicle Manufacturer in the dossier, and considered acceptable and practicable by Euro NCAP.

4.2.3.3.2 Distraction Option

Maintain gaze at the driver lap gaze location for up to a minimum of 14 seconds to trigger the EF distinct warning, followed by EF intervention, and maintain the gaze fixation until the EF intervention is finalized.

Alternatively, using an alternative distraction-like unresponsive driver test method as illustrated by the Vehicle Manufacturer in the dossier, and considered acceptable and practicable by Euro NCAP.

4.3 Not functional system test

The driver should obstruct the view of an instrument cluster mounted Driver Monitoring system from identifying the driver by placing their hand and gripping the upper portion of the steering wheel and hold the position for at least 10 seconds.

For Driver Monitoring systems mounted in other locations e.g., rearview mirror, A-Pillar, this test is not necessary unless the Vehicle Manufacturer claimed a non-functional system under any other occlusion type, in which case such occlusion type should be checked as stated above.

4.4 On-road evaluation

During the on-road evaluation on public roads, the test driver shall manually annotate instances of non-relevant Driver Monitoring warnings and/or interventions. Examples include distraction alerts issued while the test driver is gazing on-road, or drowsiness alerts issued while the test driver self-reports a high level of alertness.

The Euro NCAP Secretariat may liaise with the Vehicle Manufacturer where the collected evidence indicates potential driver acceptance concerns related to the Driver Monitoring system during normal driving.

APPENDIX A OCCLUSION ACCESSORIES

Cap – baseball cap with large, curved peak at the front, designed to provide shade over the user's eyes.

Hat – brimless cap that fits the head closely that does not cover any predominant facial feature.

Sunglasses – Sunglasses with <15% transmittance.

Facemask – Type 2R Certified EN14683 facemask, generally manufactured with blue cloth. To be worn covering the chin, mouth the nose, not obscuring the eyes.