SAE International™

SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J2591

ISSUED SEP2002

Issued 2002-09

Adaptive Forward Lighting System

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1. ***Scope—***This SAE Recommended Practice applies to motor vehicle Forward Illumination Devices which incorporate adaptive beam pattern capabilities. This document is to be used in conjunction with other forward lighting standards and/or recommended practices which define the base beam procedures, requirements, and guidelines.

2. ***References***

2.1 **Applicable Publications—**The following publications form a part of this specification to the extent specified herein. Unless otherwise specified, the latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or at www.sae.org.

SAE J578—Color Specification
SAE J599—Lighting Inspection Code
SAE J759—Lighting Identification Code

TO PLACE A DOCUMENT ORDER:
Tel: 877-606-7323 (inside USA and Canada)
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: custsvc@sae.org
SAE WEB ADDRESS: http://www.sae.org

2.2 Related Publications—The following publications are provided for information purposes only and is not a required part of this specification.

2.2.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or at www.sae.org.

SAE J565—Semiautomatic Headlamp Beam Switching Devices
SAE J575—Test Methods and Equipment for Lighting Devices and Components for use on Vehicles Less than 2032 mm in Overall Width
SAE J581—Auxiliary High Beam Lamps
SAE J582—Auxiliary Low Beam Lamps
SAE J583—Front Fog Lamps
SAE J852—Front Cornering Lamps for Use on Motor Vehicles
SAE J1383—Performance Requirements for Motor Vehicle Headlamps

2.2.2 FMVSS PUBLICATIONS—Available from the Superintendent of Documents,U. S. Government Printing Office, Mail Stop: SSOP, Washington, DC20402-9320 or at www.nhtsa.dot.gov.

Federal Motor Vehicle Safety Standard 49CFR 571.108
Federal Motor Vehicle Safety Standard 49CFR 564

2.2.3 CMVSS PUBLICATIONS—Available from Transport Canada, Road Safety and Motor Vehicle Regulation Directorate, P.O. Box 8880, Ottawa Post Terminal, Ottawa, Ontario, K1G.3J2 or at www.tc.qc.ca.

CMVSS 108—Canadian Motor Vehicle Safety Standard for Exterior Lighting

2.2.4 ECE PUBLICATIONS—Available from United Nations Economic Commission for Europe, Palais Des Nations, CH-1211, Geneva 10, Switzerland or at www.unece.org.

TRANS/WP.29/GRE/2001/14 – Proposal for draft amendments to regulation No. 112
TRANS/WP.29/GRE/2001/15 – Proposal for draft amendments to regulation No. 48
TRANS/WP.29/GRE/2001/16 – Proposal for draft amendments to regulation No. 98
TRANS/WP.29/GRE/2002/18 – Proposal for a new draft regulation: Uniform provisions concerning the approval of Adaptive Frontlighting Systems (AFS) for motor vehicles
TRANS/WP.29/GRE/2002/19 – Explanatory notes to the proposal for a new draft regulation: Uniform provisions concerning the approval of Adaptive Frontlighting Systems (AFS) for motor vehicles
TRANS/WP.29/GRE/2002/20 – Proposal for draft amendments to regulation No. 48

3. Definitions

3.1 Base Beam—A lamp's beam pattern that meets the lighting function standard or recommended practice without adaptive functionality.

3.2 Adaptive Beam Contributor—A component of a lamp designed to add or subtract light from the base beam to provide adaptive capability.

3.3 Axis of Reference—The characteristic axis of the beam used as the direction of reference (H=0 degree, V=0 degree) for photometric measurement angles.

3.4 Nominal Position—A lamp position where its axis of reference coincident with the vehicle longitudinal axis for front mounted lamps and perpendicular for side mounted lamps.

3.5 **Adaptive Forward Lighting System (AFS)—**A forward lighting system intended to adapt a forward lighting device's beam pattern to improve driver visibility based on inputs such as vehicle speed, road geometry, and/or environmental conditions. The system is comprised of one or more forward lighting devices and the entirety of components required to control and operate the devices.

3.6 **Swivel—**Automatic horizontal and/or vertical movement of the lamp's axis of reference relative to the vehicle longitudinal axis for the purpose of actively directing the beam pattern for improved visibility under driving conditions.

4. ***Lighting Identification Code—***A lamp with adaptive functionality may be identified by their original function(s) in accordance with SAE J759. In addition, the lamp shall be marked "X" directly after the original function(s) marking.

5. ***Tests***

5.1 All test procedures required by the applicable lighting function's standard or recommended practice shall be performed. In addition, the following tests shall be included, if applicable.

5.1.1 VIBRATION TEST—If the vibration test is required by the standard or recommended practice for the specified device, any components with mechanical movement for adaptive functionality shall be at their nominal position.

5.1.2 PHOTOMETRY TEST

5.1.2.1 The lamp to be tested shall be mounted on a fixture as specified in the standard or recommended practice for each device. Mounting hardware, the test stand, and components shall be those necessary to operate the lamp over all intended adaptive conditions.

5.1.2.2 The lamp to be tested shall be located on the photometer axis as specified in the standard or recommended practice for each device positioned at its nominal position. The lamp aim shall not be adjusted during the test other than for any re-aim allowed by the lighting function's standard or recommended practice.

5.1.2.3 The base beam for the lamp shall be tested with the lamp's axis of reference positioned according to 5.1.2.2.

5.1.2.4 If the base beam swivels, the lamp shall be additionally tested to the intended maximum range of vertical and horizontal movement. If any position(s) within the movement range of the lamp are expected to prevent the lamp from meeting the photometry requirements, these additional positions shall also be tested.

When the axis of reference for the lamp is moved relative to the vehicle longitudinal axis, the goniometer shall be compensated to locate the axis of reference to H=0 degree and V=0 degree.

5.1.2.5 If adaptive beam contributor(s) are utilized with a non-swiveling base beam, the base beam with the contributor(s) shall be additionally tested in each operational mode.

If any adaptive beam contributor is designed to swivel, the nonswiveling base beam with the contributor(s) at their extreme positions shall be additionally tested in each operational mode.

If any position(s) within the movement range of the adaptive beam contributor is expected to prevent the lamp from meeting the photometry requirements, these additional positions shall also be tested.

5.1.2.6 If the base beam swivels and adaptive beam contributor(s) are utilized, the lamp shall be additionally tested with each adaptive beam contributor(s) activated and positioned according to 5.1.2.5 with the base beam's axis of reference positioned as intended for each operational mode according to 5.1.2.4.

5.1.3 Heat Test – If light source(s) are required to be activated during heat testing, the following tests shall apply.

5.1.3.1 Adaptive beam contributor(s) that are only energized during turns are to be energized at the rate of 3 minutes on and 12 minutes off with the function being tested for each operational mode.

5.1.3.2 Adaptive beam contributor(s) that do not comply with 5.1.3.1 shall be energized with the function being tested as specified by the lighting functions standard or recommended practice.

5.1.3.3 Adaptive beam contributors that are only energized independently shall be energized independently during heat testing.

5.1.3.4 Any swiveling component(s) shall be positioned at their nominal position.

5.1.4 Color Test–SAE J578 applies for this document.

6. Requirements

6.1 Test Requirements—The following requirements are in addition to those specified in the standard or recommended practice for each applicable device.

6.1.1 VIBRATION—Vibration requirements outlined in each lighting function's standard or recommended practice shall be met when tested according to 5.1.1.

6.1.2 PHOTOMETRY—Photometric requirements outlined as specified in the standard or recommended practice applicable to the device shall be met with the device in all intended positions and/or adaptive modes specified in 5.1.2.

6.1.3 HEAT—Heat requirements outlined in each lighting function's standard or recommended practice shall be met when tested according to 5.1.3.

6.1.4 COLOR

6.1.4.1 The color of the light from the base beam shall be white within the limits specified in SAE J578.

6.1.4.2 The color of each adaptive beam contributor shall be white within the limits specified in SAE J578.

6.2 Lamp Aim Requirements—If aiming provisions are specified in the standard or recommended practice for the applicable device, all adaptive beam contributors shall comply with the provisions. Adaptive beam contributors can not be aimed independently of the base beam.

6.3 Vehicle System Requirements

6.3.1 OPERATION

6.3.1.1 *Deactivation*—A means shall be provided for the driver to deactivate the swiveling functionality of a lamp if it affects the ability to static aim the lamp according to SAE J599. The lamp beam pattern shall then return to its base beam positioned at its nominal position. This can be accomplished by deactivating the adaptive functionality when the vehicle ignition switch is in the "off" position or by some other switching mechanism available to the driver.

6.3.1.2 A means for the driver to deactivate the adaptive functionality of a lamp other than defined in 6.3.1.1 is allowed. The lamp shall than return to its base beam as defined in 6.3.1.1.

6.3.1.3 Other than deactivation, AFS control shall be automatic without additional driver control.

6.3.2 INSTALLATION

6.3.2.1 Adaptive beam contributors that are symmetrically mounted about the vertical centerline of the vehicle at the same height and only illuminated simultaneously shall be mounted such that their lighted edges are within 200 mm horizontally and 400 mm vertically of the nearest illuminated adaptive beam contributor or the base beam. Refer to Figure 1.

6.3.2.2 Beam contributors that do not comply with 6.3.2.1 shall be mounted such that their lighted edge is within 140 mm horizontally and 400 mm vertically of the lighted edge of the nearest adaptive beam contributor or the base beam. Refer to Figure 1.

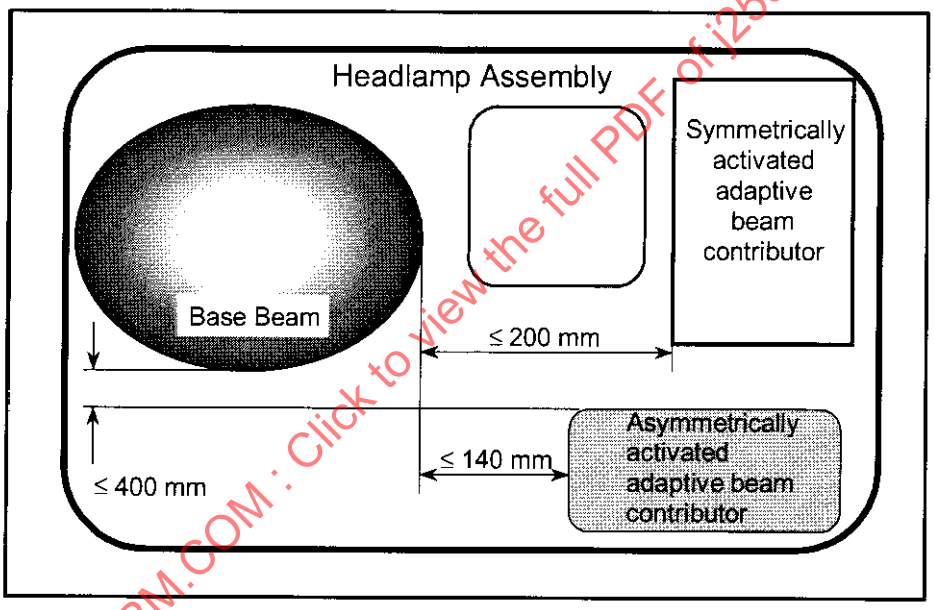

FIGURE 1— ADAPTIVE BEAM CONTRIBUTOR SPACING HEADLAMP EXAMPLE

6.3.3 VERTICAL LAMP SWIVEL

6.3.3.1 The axis of reference for the lamp shall not automatically raise vertically beyond such limit that the maximum photometric values above the H-H line are exceeded when the lamp is tested in its raised state along the nominal vehicle longitudinal axis for forward mounted lamps and perpendicular for side mounted lamps.

6.3.3.2 Automatic vertical displacement that would not comply with 6.3.3.1 is allowed if provisions are included to automatically lower the lamp's axis of reference to comply with 6.3.1.1 when opposing traffic is present.

6.3.3.3 Automatic vertical displacement that would not comply with 6.3.3.1 is allowed if the vertical displacement is only to compensate for temporary changes in the vehicle longitudinal axis relative to the road due to loading or vehicle dynamics i.e., dynamic headlamp leveling.

6.3.4 HORIZONTAL LAMP SWIVEL

6.3.4.1 The angular movement of each low beam headlamp's horizontal axis of reference (H = 0 degree) within the lamp's movement range shall not exceed the angle created between the vehicle longitudinal axis and a line originating at the front center of the vehicle and intersecting the vehicle's turn circle at 140 times the mounting height of the lamp. Refer to Figure 2.

6.3.4.2 Horizontal lamp swivel to the left of the vehicle longitudinal axis is only allowed when the vehicle is moving forward. When the vehicle is moving in reverse, the lamp shall be in its nominal position.

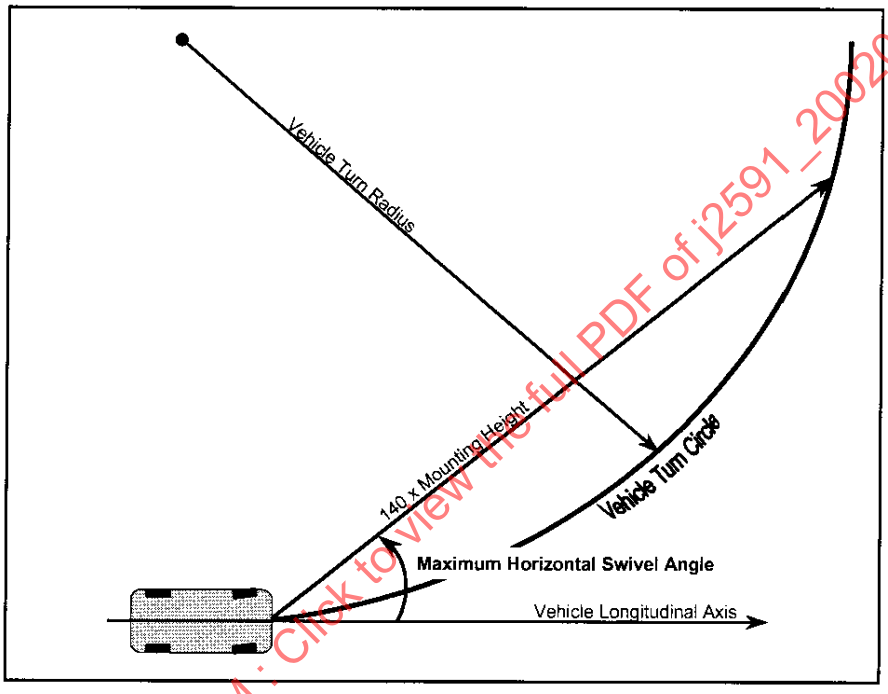

FIGURE 2— MAXIMUM HORIZONTAL SWIVEL ANGLE

6.3.5 VEHICLE AIM—The lamp shall be aimed according to the lighting function's standard or recommended practice with the lamp's adaptive functionality deactivated, if applicable per 6.3.1.1.

6.3.6 SYSTEM MALFUNCTION PROVISIONS—If an adaptive malfunction is detected by the system that would cause an increase in glare to on coming traffic as defined in 6.3.3.1, a means shall be provided to indicate the malfunction to the driver.

7. Guidelines

7.1 All guidelines outlined in the lighting function's standard or recommended practice shall be met under all adaptive conditions.

7.2 **AFS Effectiveness—**Adaptive functionality shall not impair the effectiveness of other lighting equipment or impair the effectiveness of the base beam.

PREPARED BY THE SAE ADAPTIVE FRONT LIGHTING SYSTEMS TASK FORCE OF THE
SAE ROAD ILLUMINATION DEVICES STANDARDS COMMITTEE

Rationale—The following statements give the rationale for SAE J2591.

Recently, it has been recognized that forward lighting lamps can include the ability to modify their beam patterns to improve visibility and/or decrease glare. This is based on discussions with NHTSA since the formation of the SAE AFS task force and NHTSA interpretations given on November 3, 1988 and July 10, 1989. Modifications to the beam pattern would be done to improve the beam pattern for conditions or vehicle maneuvers where the base beam does not provide an optimal pattern to the driver. Modifications are still required to meet the applicable requirements of the lamp.

Most forward lighting standards, recommended practices, and regulations currently do not prohibit modifications to the beam pattern, but they also do not specifically address how to apply requirements when a lamp possesses adaptive capabilities.

This document clarifies and defines the industry agreement for how to apply requirements from current forward lighting standards, recommended practices, or regulations to a forward lighting lamp with adaptive beam pattern capabilities. This document would be used with the current forward lighting requirements for an individual lamp but is not intended to contradict the intent of requirements contained within a lighting standard, recommended practice, or regulation. The goal was to publish this document quickly to provide direction for any company wishing to implement an adaptive system on a vehicle under current regulations.

This document was written to harmonize with the applicable draft ECE documents covering Adaptive Frontlighting Systems or “AFS”. This document is generically an SAE equivalent to the ECE “Fast Track” proposals for bend lighting contained in TRANS/WP.29/GRE/2001/14, 15, and 16. Most of the requirements contained in this document are either based on or a re-worded copy of what is contained in the ECE “Fast Track” proposals or the ECE AFS proposals contained in TRANS/WP.29/GRE/2002/18 and 20. Further explanatory notes are contained in TRANS/WP.29/GRE/2002/19.

Section 1 – Gives the scope of the document. It was decided that this document would address each individual lamp with adaptive capabilities. Creating requirements that would address combining many lamps (i.e., headlamp, foglamp, and cornering lamp) into a forward illumination system was determined to be too complex and would require changes to many lighting standards, recommended practices, and regulations. In addition, this document already covers these conditions.

Sections 2.2.1, 2.2.2, and 2.2.3 – Reference publications that this document could be used in conjunction with. This list may not include all publications.

Section 2.2.4 – Reference the AFS “Fast Track” proposal and the full AFS proposal used as a portion of the basis of this document for harmonization.

Section 3 – All definitions based on definitions contained in either TRANS/WP.29/GRE/2002/18 OR TRANS/WP.29/GRE/2002/20 updated to SAE terminology and modified as described below.

Section 3.1 – Definition taken from TRANS/WP.29/GRE/2002/20 for “basic passing beam” updated to SAE terminology.

Section 3.2 – Definition taken from TRANS/WP.29/GRE/2002/20 for “lighting unit” except that an Adaptive Beam Contributor can subtract light from the base beam.

Section 3.3 – Definition taken from TRANS/WP.29/GRE/2002/18 “system reference axis” modified for a single lamp and updated to SAE terminology.

Section 3.4 – Definition created since this condition is referenced throughout the document.

Section 3.5 – Definition taken from TRANS/WP.29/GRE/2002/18 “Adaptive Front Lighting System” updated to SAE terminology and simplified. The definition contained in TRANS/WP.29/GRE/2002/18 is contained among many sections.

Section 3.6 – Definition taken from TRANS/WP.29/GRE/2002/18 as a combination of “bending mode” and “category 1 bending mode” and updated to SAE terminology.

Section 4 – “X” selected as the additional marking for a lamp with adaptive capabilities. This harmonizes with TRANS/WP.29/GRE/2002/18.

Section 5.1 – Requires all testing from each original lighting function’s standard to be performed. This is to prevent contradicting any current requirement for testing.

Section 5.1.1 – Specifies that the lamp tested shall be positioned with the lamp’s axis of reference coincident with the vehicle longitudinal axis. Vibration testing is generally performed with the lamp positioned at a nominal state. This was deemed to be adequate for testing a lamp with mechanical movement capabilities. In addition, specifying a movement sequence during testing for all the potential lamp configurations would be complex and impractical.

Section 5.1.2.1 – Requires the lamp fixture to be capable of energizing and positioning the lamp over all intended adaptive conditions. This will allow the lamp to be photometered without placing an additional complexity on the test lab to position the adaptive beam contributors or the base beam above what is generally required today.

Section 5.1.2.2 – Requires the lamp’s axis of reference to be coincident with the vehicle longitudinal axis when placed on the positioner (goniometer). Additional re-aiming is not allowed. This is consistent with SAE requirements and the requirements contained in TRANS/WP.29/GRE/2002/18.

Section 5.1.2.3 – Requires the lamp’s base beam to be tested, which is consistent with all current requirements.

Section 5.1.2.4 – Procedure for testing a swiveling lamp for photometrics. The procedure harmonizes with TRANS/WP.29/GRE/2002/18, TRANS/WP.29/GRE/2001/14, TRANS/WP.29/GRE/2001/16, and is consistent with MVSS 108 S7.8.2.2 (b). Requirement to test at any position that may have an influence on the photometric readings is included for clarification. This is to comprehend any influences from reflections off of bright bezels, any influences from the curvature of the lens, any influences of optics, graphics, or radiuses in the lens, etc.

Section 5.1.2.5 – Procedure for testing a lamp for photometrics with additional light sources. The procedure harmonizes with TRANS/WP.29/GRE/2002/18, TRANS/WP.29/GRE/2001/14, and TRANS/WP.29/GRE/2001/16.

Section 5.1.2.6 – Procedure for testing a swiveling lamp with additional light sources. The procedure harmonizes with TRANS/WP.29/GRE/2002/18 and is consistent with MVSS 108 S7.8.2.2 (b).

Section 5.1.3.1 – Requires steering dependant adaptive beam contributors to be energized during heat testing at a rate of 3 minutes on and 12 minutes off for each operational mode. Energizing steering dependant functions continuously throughout a heat test was deemed too severe and not representative of typical driving. The 3-minute on cycle was taken from the SAE J575 heat test for front cornering lamps. A 5-minute on cycle from TRANS/WP.29/GRE/2002/18 was considered, but deemed too severe. The 12-minute off cycle was taken from the front cornering lamp function in SAE J575. A 15-minute off cycle as specified in TRANS/WP.29/GRE/2002/18 was considered, however, the more severe SAE J575 12 minute off cycle was selected.

Section 5.1.3.2 – Requires any other adaptive beam contributor to be tested with the function. Other adaptive functions did not require special provisions since they could routinely be lit for an extended period of time during normal use.

Section 5.1.3.3 – Requires adaptive beam contributors that are not energized simultaneously to be tested independently. Testing AFS modes that will not be energized together on the vehicle should not be energized together during the testing. This condition would be excessively severe.

Section 5.1.3.4 – Requiring a swiveling lamp or a swiveling component of to be at the nominal position harmonizes with TRANS/WP.29/GRE/2002/18.

Section 5.1.4 – Requires the color test contained in SAE J578. See 6.1.4.

Section 6.1 – All requirements from each original lighting function's standard shall be met. This is to prevent contradicting any current requirement.

Section 6.1.1 – Clarifies that the lamp is required to meet the vibration requirements of the original standard or recommended practice.

Section 6.1.2 – Clarifies that the lamp is required to meet the photometry requirements of the original standard or recommended practice.

Section 6.1.3 – Clarifies that the lamp is required to meet the heat requirements of the original standard or recommended practice.

Sections 6.1.4.1, 6.1.4.2 – Requires that the light from every beam contributor and the base beam be white in color per SAE J578. This was to address the potential of incorporating adaptive beam contributors that did not emit white colored light, but when combined with the base beam and/or other adaptive beam contributors, the total combined beam pattern would be within the white limits. This was deemed to be potentially distracting to the driver and other drivers. Also, this eliminates the potential of an amber adaptive beam contributor, which could be confused with a front turn signal.

Section 6.2.1 – Requires all adaptive beam contributors to meet the original aiming requirements of the function and not be independently adjustable. This would not comply with SAE standards and MVSS 108 and harmonizes with ECE documents TRANS/WP.29/GRE/2001/14 and TRANS/WP.29/GRE/2001/16.

Section 6.3.1.1 – Requires deactivation capability if the adaptive functionality can impair the ability to aim the lamp according to SAE J599. This requirement was chosen over allowing the manufacturer to specify an aim setting different than what is specified in SAE J599, which may cause confusion for the operator. This harmonizes with TRANS/WP.29/GRE/2002/18. It was also clarified that turning the vehicle off was an acceptable means to deactivate the adaptive functionality.

Section 6.3.1.2 – Clarifies that deactivation capability is allowed even if the adaptive functionality does not effect the aim ability of the lamp.

Section 6.3.1.3 – Requires that the adaptive capability of the lamp be automatic and not require additional input from the driver other than inputs that are already available. Examples of inputs that are already available are: turn signal activation, windshield wiper activation, high beam activation, steering angle, global positioning system (GPS), rain sensor, fog sensor, semiautomatic headlamp beam switching, etc. This harmonizes with TRANS/WP.29/GRE/2002/20.