

**Accelerated Exposure of Automotive Exterior Materials
Using a Solar Fresnel Reflector Apparatus****RATIONALE**

This standard is being changed to make spray cycles specified in this standard in conformance with industry practice and with other SAE, ISO and ASTM standards which specify testing using Solar Fresnel Reflector Apparatus .

1. SCOPE

- 1.1 This test method specifies the operating procedures for using a solar fresnel reflector apparatus for the accelerated exposure of various automotive materials.
- 1.2 Sample preparation, test durations, and performance evaluation procedures are covered in material specifications of the different automotive manufacturers.

2. REFERENCES**2.1 Applicable Documents**

The following publications form a part of this specification to the extent specified herein.

2.1.1 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D 859 Test Methods for Silica in Water

ASTM D 4517 Test Method for Low-Level Total Silica in High Purity Water by Flameless Atomic Absorption Spectroscopy

ASTM E 891 Standard Tables for Terrestrial Direct Normal Solar Spectral Irradiance for Air Mass 1.5

ASTM G 90 Standard Practice for Performing Accelerated Outdoor Weathering of Nonmetallic Materials Using Concentrated Natural Sunlight

ASTM G 147 Standard Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests

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2.2 Related Publication

The following publication is provided for information purposes only and is not a required part of this SAE Technical Report.

2.2.1 ASTM Publication

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E 903 Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres

3. DEFINITIONS

3.1 Black Panel Thermometer, n.

A temperature measuring device, the sensing unit of which is covered with a black coating designed to absorb most of the radiant energy encountered in fade/weathering testing.

NOTE: This device provides an estimation of the maximum temperature a specimen may attain during exposure to natural or artificial light.

3.2 Irradiance, Spectral, n.

The radiant power within a specified wavelength interval that falls upon a unit area of exposed surface (W/m^2).

3.3 Irradiance, Total, n.

Radiant power integrated over all wavelengths falling upon a unit area of exposure at a point in time expressed in watts per square meter (W/m^2).

3.4 Irradiation, n.

See radiant exposure.

3.5 Radiant Exposure, n.

The time integral of irradiance expressed in joules per square meter (J/m^2).

3.6 Radiant Exposure, Spectral, n.

The integration of spectral irradiance with respect to time.

3.7 Reference Materials, n.

One or more light fastness standards selected for exposure as a check on a test apparatus and operating conditions.

3.8 Sample, Laboratory, n.

A portion of material taken to represent the lot sample, or the original material, and used in the laboratory as a source of test specimens.

3.9 Specimen, n.

A specific portion of a material or a laboratory sample upon which a test is performed or selected for that purpose.

3.10 Spectral Power Distribution, n.

The variation of power due to the source over the wavelength span of the emitted radiation.

4. SIGNIFICANCE AND USE

This test method is designed to simulate extreme environmental conditions encountered outside a vehicle due to sunlight, heat, and moisture (in the form of humidity, condensation, or rain) for the purpose of predicting the performance of automotive materials.

5. APPARATUS

5.1 The testing apparatus shall be a fresnel-reflecting device possessing 10 flat mirrors which focus direct sunlight onto an air-cooled sample area. A more complete description of the apparatus may be found in ASTM G 90. See Figure 1.

NOTE: The apparatus shall be operated in dry, sunny climates receiving approximately 3500 to 4000 h of sunshine per year and an average annual relative humidity of approximately 25 to 35%.

- | | | | |
|---|---------------------------|---|-----------------------------|
| A | FRESNEL-REFLECTING MIRROR | H | CENTER OF ROTATION |
| B | WATER SPRAY NOZZLE | J | REVERSIBLE MOTOR/GEAR DRIVE |
| C | AIR TUNNEL | K | CLUTCH |
| D | SQUIRREL CAGE BLOWER | L | ALTITUDE ADJUSTMENT MAST |
| E | AIR SWITCH | M | MIRROR BED/FRAME |
| F | SOLAR CELL TRACKER | N | ANCHORS |
| G | SPECIMENS ON TARGET BOARD | P | A-FRAME |

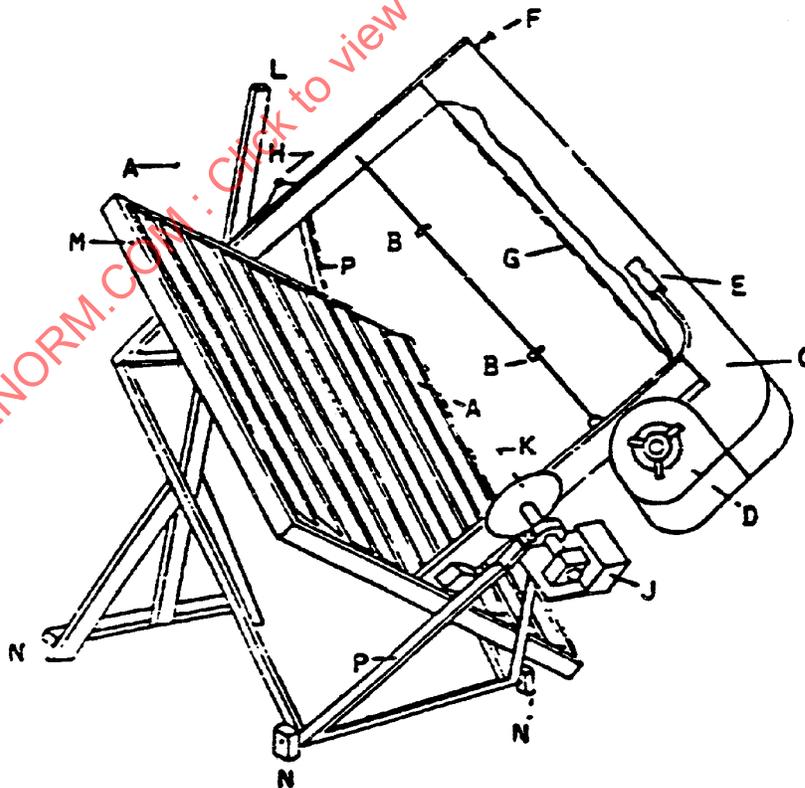


FIGURE 1 - SCHEMATIC OF FRESNEL REFLECTING CONCENTRATOR ACCELERATED WEATHERING MACHINE (SINGLE AXIS TRACKING)

- 5.2 If mirror reflectance cannot be measured directly, the apparatus shall be provided with a mounting area for affixing a removable optical-mirror sample. This sample shall possess a minimum area of 2580 mm² (4 in²). The essential requirement is that the optical-mirror specimen be manufactured from the same batch and lot as the mirror stock-material used to irradiate the target sample area. This sample shall be labelled with a number which identifies which mirrors the sample applies to. The optical mirror sample is mounted at the same time as are the mirrors used to irradiate the sample area, and its specular, spectral reflectance is periodically measured.

- | | | | |
|---|----------------------|---|-------------------------|
| A | AIR PLENUM | I | GEAR BOX, AZIMUTH DRIVE |
| B | AIR BLOWER | J | AIR FLOW SWITCH |
| C | ROTOR ASSEMBLY | K | WATER SPRAY NOZZLE |
| D | TURN TABLE ASSEMBLY | L | CLUTCH DISC, ELEV DRIVE |
| E | A-FRAME ASSEMBLY | M | SOLAR CELLS/SHADOW HAT |
| F | MIRROR | N | SAMPLE PROTECTION DOOR |
| G | GEAR BOX, ELEV DRIVE | O | DOOR RELEASE MECHANISM |
| H | CONTROL BOX | P | AIR DEFLECTOR |

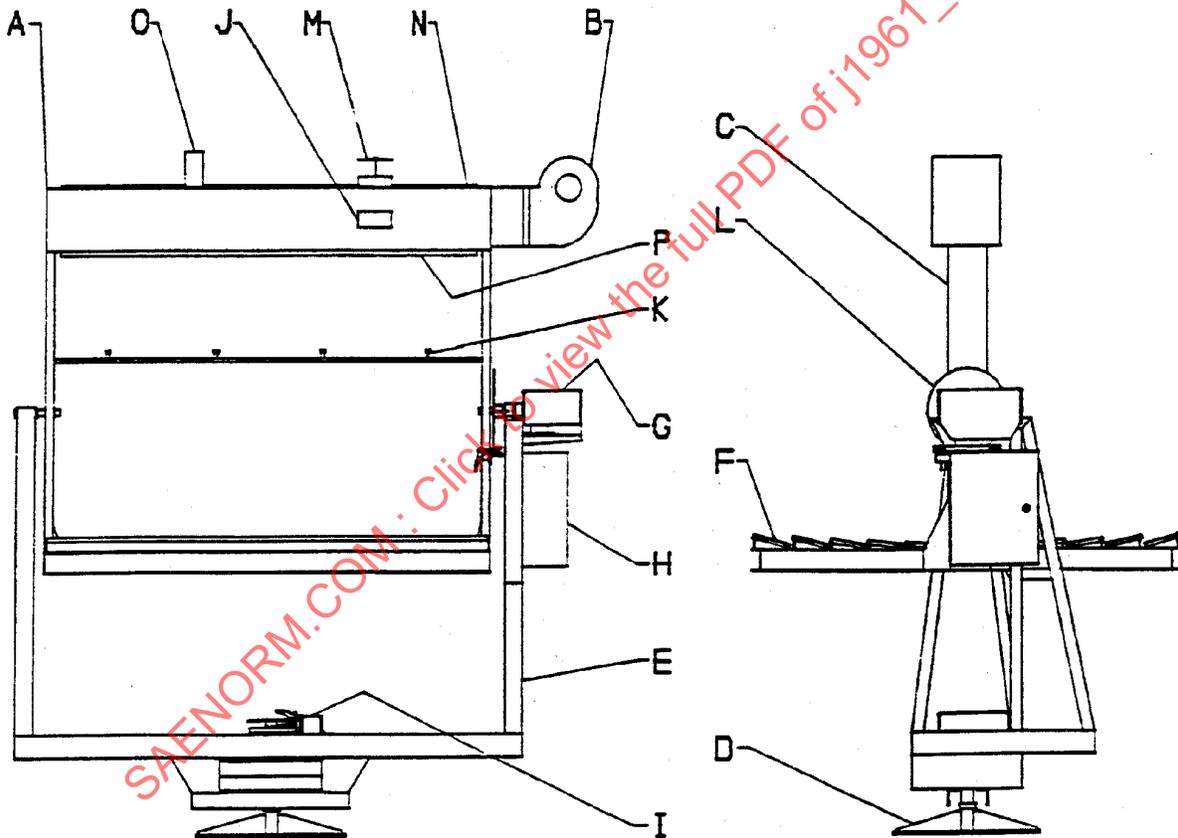


FIGURE 2 - DUAL AXIS TRACKING

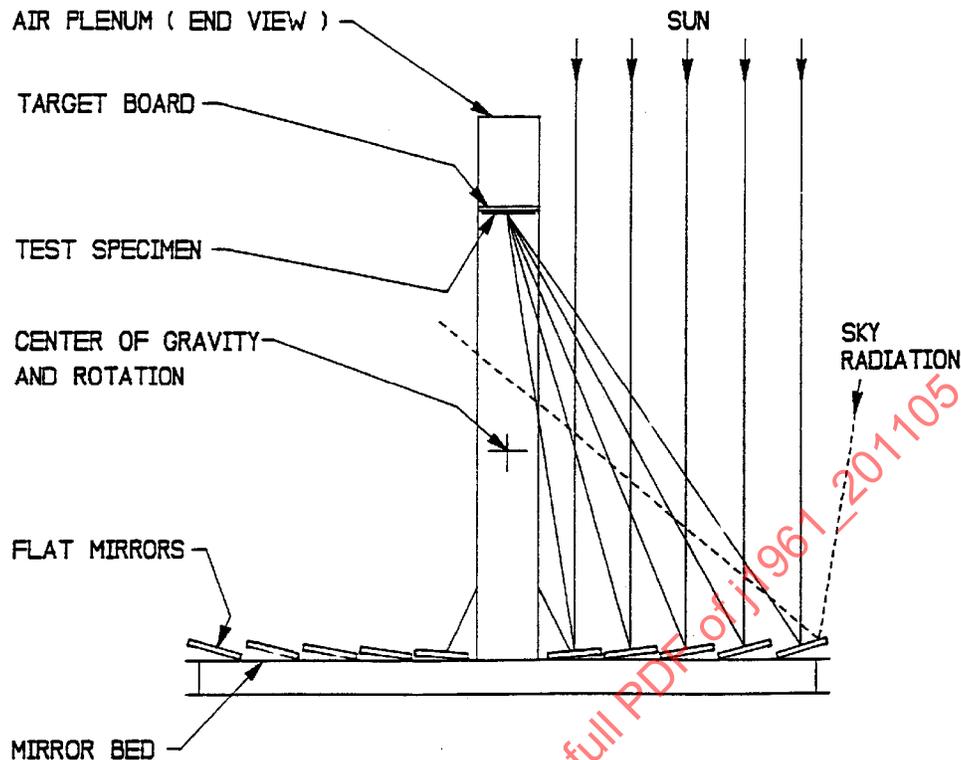


FIGURE 3 - ACCELERATED EXPOSURE OF AUTOMOTIVE EXTERIOR MATERIALS USING A SOLAR FRESNEL REFLECTOR APPARATUS EXPOSURE REPORT FORM

5.3 A black panel thermometer may optionally be mounted onto the sample exposure area to assist in monitoring expected maximum sample temperatures. The device shall be constructed by affixing the sensing element to the front surface of a metal panel measuring 5 x 13 x 0.16 cm (2 x 5 x 0.06 in) or any other convenient size. The sensor can be attached using a thermally conductive epoxy such as Part Number EC-286 from Therm-X of California or equivalent. The front surface of the panel shall be then coated with DuPont 93 005 Delux® Super Black Enamel, or other gloss black automotive coating.

NOTE: ASTM Committee G03 on Durability is currently addressing the issue of Black Panel thermometers as a result of widely different temperature data reported by commercial testing agencies.

5.4 Water Quality

5.4.1 The purity of water used for specimen spray is very important. Without proper treatment to remove cations, anions, organics, and particularly silica, exposed panels will develop spots or stains that do not occur in exterior exposures.

5.4.2 Water used for specimen spray shall leave no objectionable deposits or stains on the exposed specimens. It is strongly recommended that the water contain a maximum of 1 ppm solids and a maximum of 0.2 ppm silica. Silica levels should be determined using the procedures defined in ASTM D 859 or ASTM D 4517. Prepackaged analysis kits are commercially available that are capable of detecting silica levels of less than 200 parts per billion (ppb). A combination of deionization and reverse osmosis treatment can effectively produce water with the desired purity. If the spray water used is above 1 ppm solids, the solids and silica levels must be reported.

6. CALIBRATION AND MAINTENANCE

- 6.1 At least every six months, measure the specular reflectance of each mirror in two places along the mirror's centerline using a portable specular reflectometer with narrow-band-pass filters centered at 310 nm wavelength: (1) 15 cm (6 in) from the north edge, and (2) 15 cm (6 in) from the south edge. Visibly inspect each mirror and measure any additional areas which appear non-uniform. Update the value of P_s employing actual average values of specular reflectance. Replace individual mirrors if the average 310 nm specular reflectance is less than 0.65 (65%).
- 6.2 If measurement of specular reflectance of the mirrors used in exposure devices is not practical, mount small, representative specimens of the mirror material. Place the representative specimens next to the mirror locations described in 5.1. These representative specimens must be of the same material and lot number as the mirrors used in the instrument. The representative specimens must also be installed at the same time as the mirrors. At least every six months, measure the specular reflectance of the representative specimens at 310 nm. Replace individual mirrors if the average 310 nm specular reflectance of the representative specimens is less than 0.65 (65%).
- 6.3 Mirrors shall be checked for mirror focus monthly in accordance with the procedure specified in ASTM G 90 and refocused if required at that time.
- 6.4 The safety mechanism used to protect samples in the event of a power outage shall be checked monthly to make sure it operates properly in all positions.
- 6.5 Clean mirrors (and removable mirror samples) at intervals necessary to maintain the reflectance specified in 6.1. To maintain optimum specular reflectance, it is recommended that mirrors be cleaned on an established frequency to minimize the effects of surface deposits that may alter spectral irradiance at the target area.
- 6.6 Clean black panel thermometers at an interval necessary to maintain optical performance.

7. TEST PROCEDURES

- 7.1 To insure repeatability of test, maintain the apparatus in accordance with Section 6 and the manufacturer's specifications.
- 7.1.1 Conditioning and handling of test, control, reference, and file specimens shall be according to ASTM G 147.
- 7.2 Mount samples in the exposure area using one of two methods:
- 7.2.1 Noninsulated Exposure

Mount samples into sample holders constructed of a corrosion-resistant metal such as stainless steel or aluminum in an unbacked configuration such that panels can lose heat from back-side cooling.

7.2.2 Insulated Exposure

Mount samples into sample holders such that samples are backed with an insulating water-resistant material such as 13 mm (1/2-in) thick exterior plywood.

- 7.3 Coated metal specimens shall be mounted using either of the two mounting methods in accordance with the schedule in Table 1:

TABLE 1 - MOUNTING CONDITIONS

Time Period	Mounting Condition
November 1 – March 31	Insulated
April 1 – October 31	Noninsulated

- 7.4 Specimens which are not coated metal shall be mounted for a noninsulated exposure.
- 7.5 If a black panel thermometer is mounted onto the sample area with the test samples to be exposed, it shall be mounted using the same mounting condition as the test samples.
- 7.6 Apparatus shall be set up to provide conditions in accordance with one of the cycles in Table 2:

TABLE 2 - SPRAY CYCLES

Cycle	Daytime			Nighttime		
	Spray Duration	Dry-Time Duration	Cycles, h	Spray Duration	Dry-Time Duration	Cycles, h
1	8 min	52 min	1	8 min		water is sprayed on the test specimens at: 9:00 p.m. 12:00 midnight 3:00 a.m.
2	no water spray used			no water spray used		
3	no water spray used			3 min	12 min	4 cycles per hour (from 7PM to 5 AM)

NOTE: Prior to 2010, the spray cycles specified in this method were: Cycle 1 (same as Cycle 3 above), and Cycle 2 (same as Cycle 2 above). These spray cycles were changed to be in conformance to ASTM and ISO standards.

7.7 Spray Orientation

The apparatus shall be positioned so that specimens are sprayed at night either with specimens facing up or down.

7.7.1 Specimens Face Down

The apparatus is oriented with the mirrors below the target specimen area such that nozzles spray high purity water in an upward direction onto the specimens.

7.7.2 Specimens Face Up

The apparatus is oriented with the mirrors above the target specimen area such that nozzles spray high purity water in a downward direction onto the specimens.

NOTE: No data has been presented indicating that exposures performed using different spray orientations provide equivalent results, and as such, may provide different test results.

- 7.8 Expose samples for a predetermined amount of ultraviolet radiant exposure measured in J/m^2 . Determine the solar radiant exposure of the test specimens in accordance with Equations 1 and 2:

$$H_s = M \rho_s \sum_{i=1}^N H_d \quad (\text{Eq. 1})$$

$$\rho_s = \frac{\rho}{M} \sum_{i=1}^M \cos \theta_i \quad (\text{Eq. 2})$$

where: $\theta\rho$

H_s = solar radiant exposure, J/m^2

M = number of mirrors

ρ_s = the cosine corrected specular reflectance

ρ = the average energy-weighted specular reflectance of the mirrors

N = number of days of exposure

θ_i = the angle of incidence of the irradiance from each mirror at the specimen target area

H_d = direct-normal daily solar radiant exposure measured in a 6 degrees field of view

To determine the ultraviolet (295 to 385 nm) solar radiant exposure, H_d in Equation 1 shall be determined as the integration of irradiance with respect to time. Irradiance shall be measured using two ultraviolet radiometers.¹

A black-painted permanent shading disk (see Figure 4) is positioned over one radiometer in order to provide a diffuse-only measurement (excluding 6 degrees field of view). H_d is determined using Equation 3:

$$H_d = H - H_{do} \quad (\text{Eq. 3})$$

where:

H_d = hemispherical daily solar radiant exposure

H_{do} = diffuse-only daily solar radiant exposure (excluding direct-normal radiant exposure in a 6 degrees field of view)

The two ultraviolet radiometers shall be calibrated at the same time at least annually against a standard source of spectral irradiance. Instrument calibration constants shall be checked by mounting both instruments at the same orientation for at least 1 h under clear sky conditions. If a difference of more than 2% exists between instruments, they shall be recalibrated.

At least monthly, for 1 h under clear sky conditions, both instruments shall be tracked off-altitude approximately 15 degrees with no shading on the normally shaded instrument's diffuser. If the radiant exposure readings from the two instruments differ by more than 2%, the radiometers shall be recalibrated. Historical radiation data shall be checked on an annual basis to compare results of present radiation measurements.

The measurement of reflectance (ρ) shall be the power-weighted specular reflectance in the wavelength region of 295 to 385 nm, calculated using the air mass 1.5 spectrum and procedure outlined in ASTM E 891.

¹ Available as model TUVR from Eppley Laboratories, 12 Sheffield Avenue, Newport, RI 02840, or equivalent.

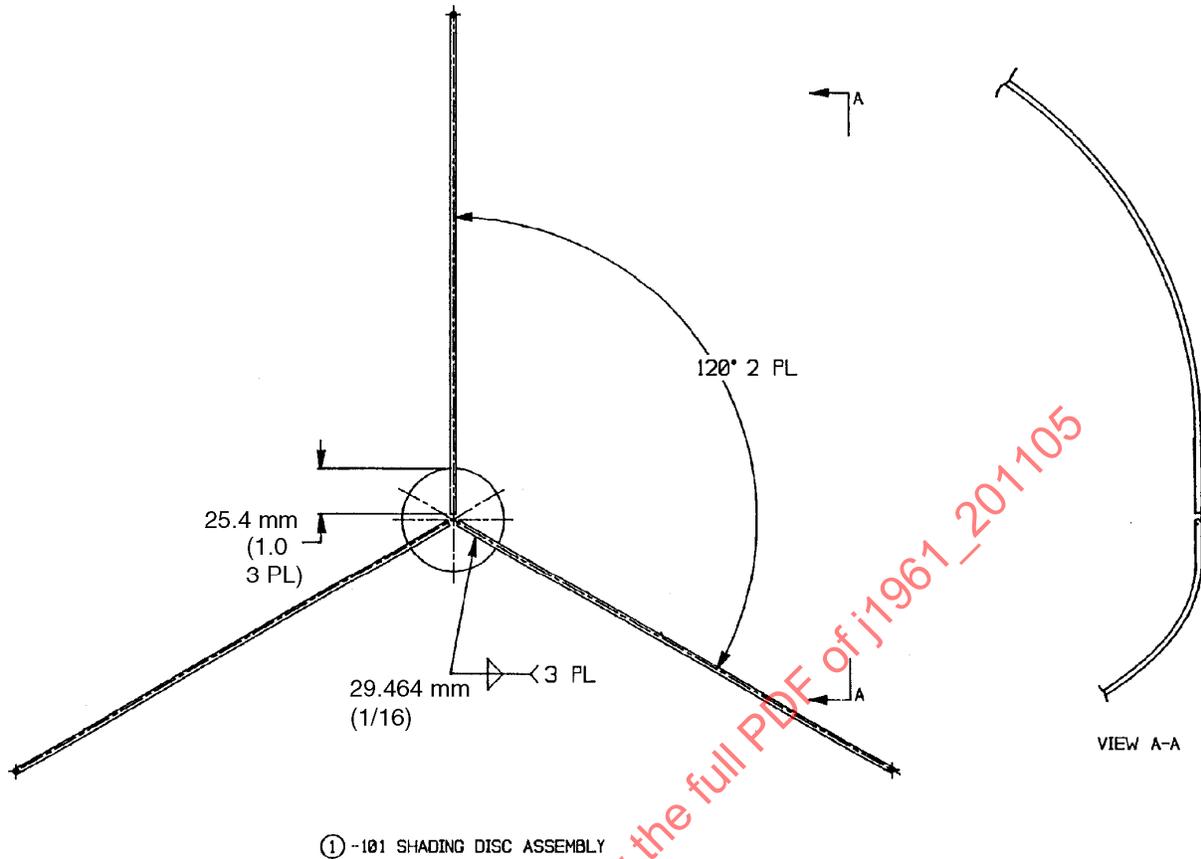


FIGURE 4 - SHADING DISK AND SUPPORT BARS

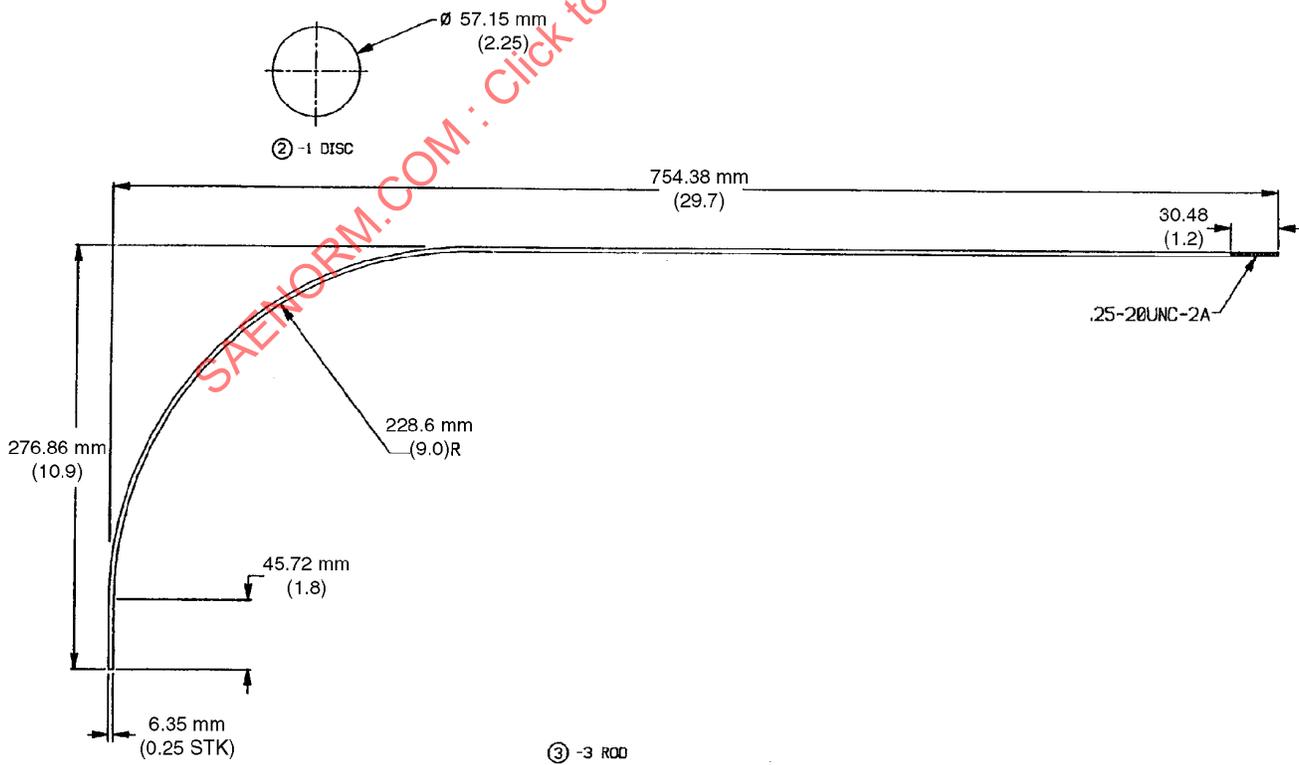


FIGURE 5 - SHADING DISK SUPPORT BAR