SOLAR ECLIPSE EYE SAFETY
AN INTRODUCTION

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SOLAR ECLIPSE PLANNING WORKSHOP

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SOLAR RETINOPATHY

- “Retinal burns”
  - Associated with sungazing
    - Galileo
      - first telescopic observations of sunspots
      - poor vision late in life
        - solar retinopathy? (NOT likely!)
    - WWII aircrews
      - retinal burns after missions
    - “Acid heads” of 1970s
      - LSD and sungazing

SOLAR ECLIPSES AND RETINAL BURNS

- Keightley et al 2000
  - solar eclipse of 11 August 1999
  - 70 cases in United Kingdom
    - recognizable retinal burns
    - all resolved over a period of weeks
  - eye protection
    - 35% sunglasses
    - 15% eclipse “glasses”
    - 50% no protection

SOLAR ECLIPSE EYE INJURIES

- Painless
  - no pain sensors in retina
- Latent period
  - 12 to 48 h delay of onset of symptoms
  - wavelength dependent
- Visual recovery highly variable
  - depends on exposure conditions
- Optical aids increase severity
  - thermal effects add to photochemical

WHO IS AT RISK

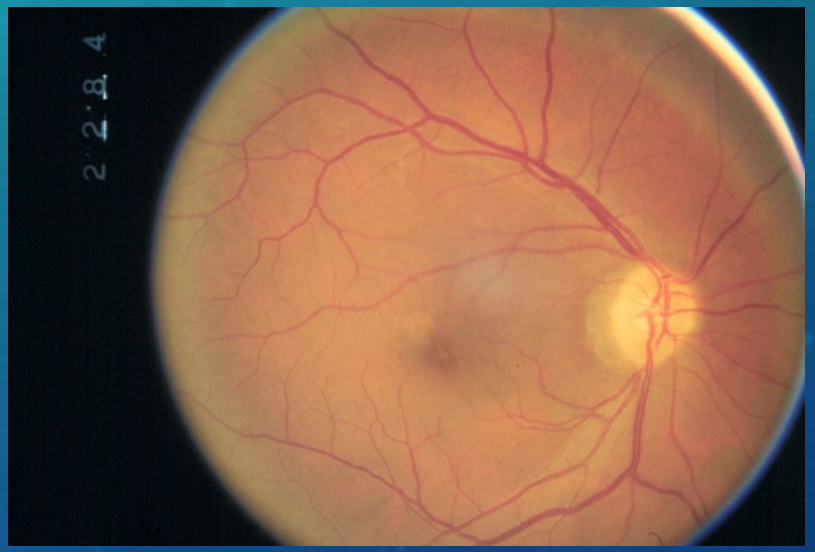
- Everybody!

- Most likely person to be injured
  - Young adult (more likely male)
    - Unaware of, or ignored warnings
    - No or inappropriate protection
    - Reported symptoms next morning

Chou & Krailo 1981

PHOTOCHEMICAL INJURY

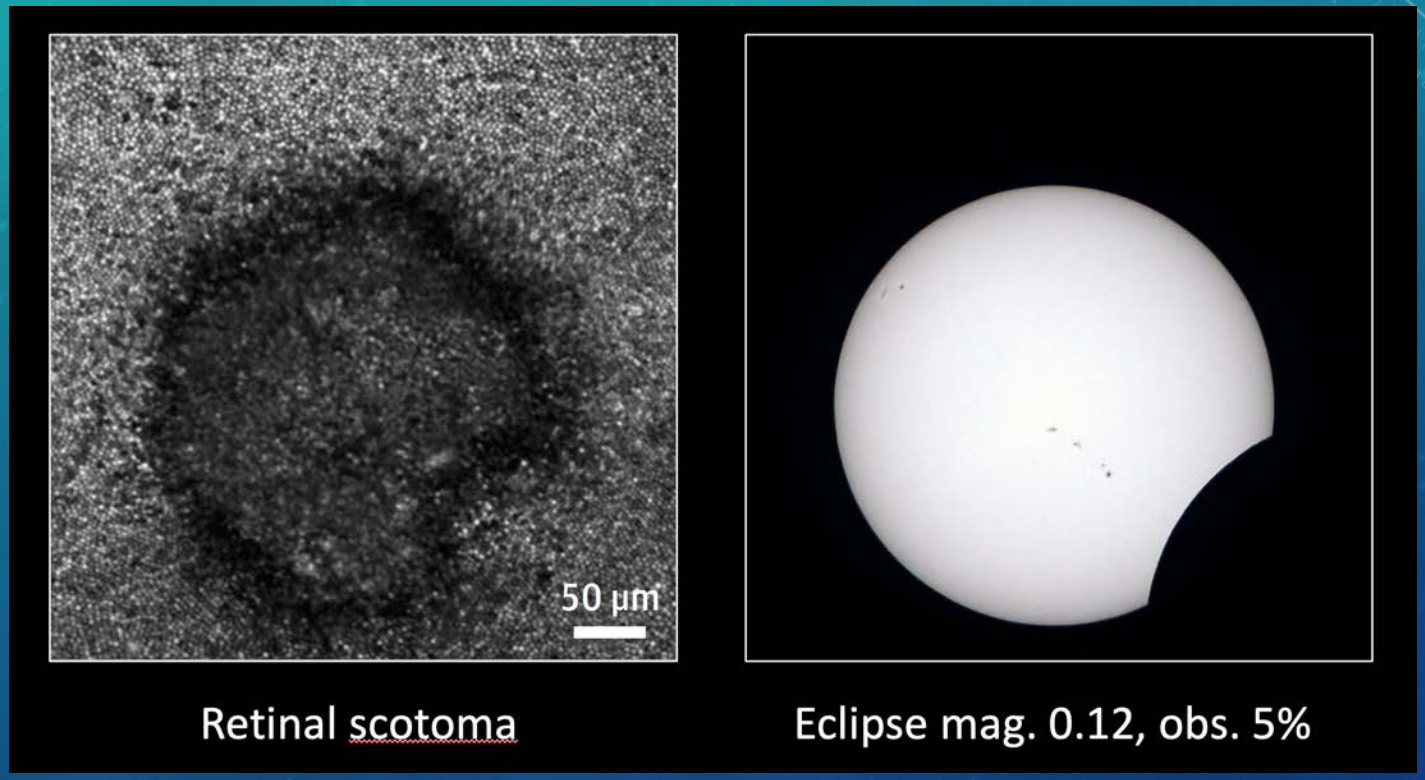
- short wavelength light (blue)
- threshold 3 $W.m^{-2}$
- usually temporary visual loss
- most common type of injury



THERMAL INJURY

- long wavelength visible, IRA, extended short wavelength visible
- threshold 2.8 X 10^4 $W.m^{-2}$
- permanent injury with visual loss
- more common if optical aid was used

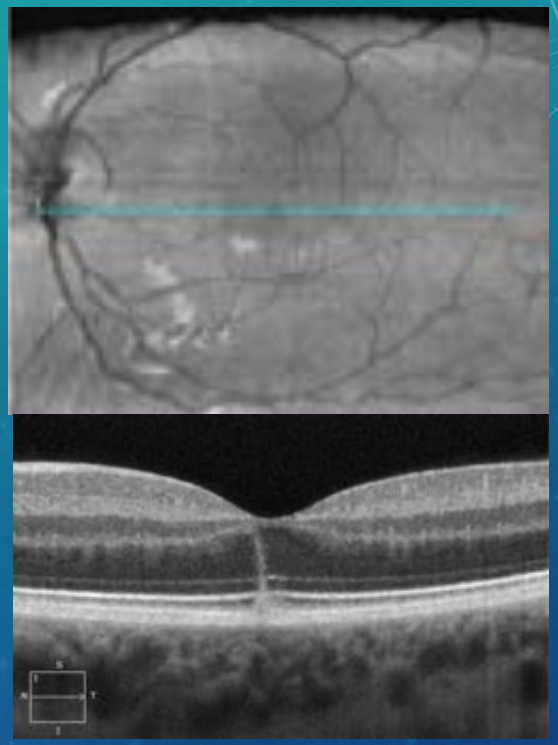
ECLIPSE RETINOPATHY



Wu et al, 2017

EXAMPLE FROM 2017

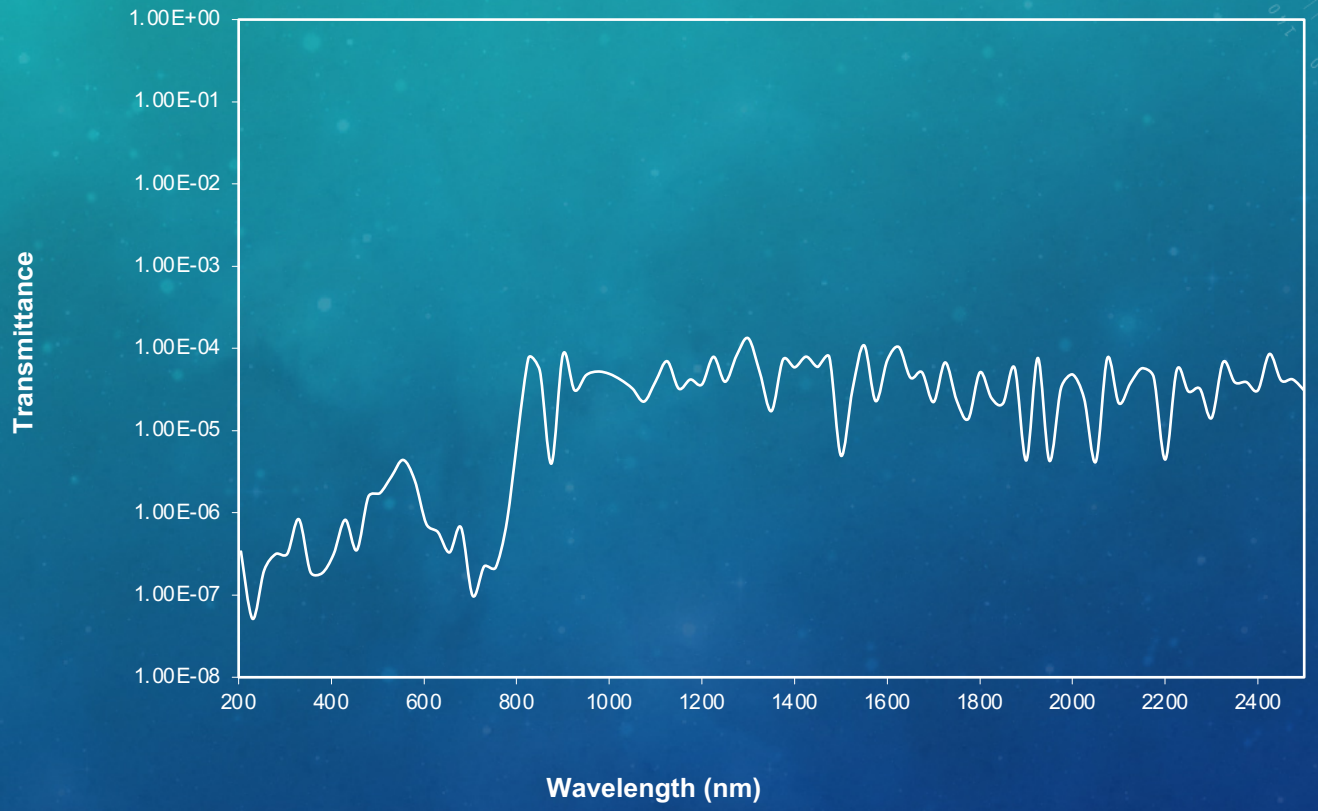
- 18 y.o. male
  - Viewed PSE without protection several minutes
  - Seen next day



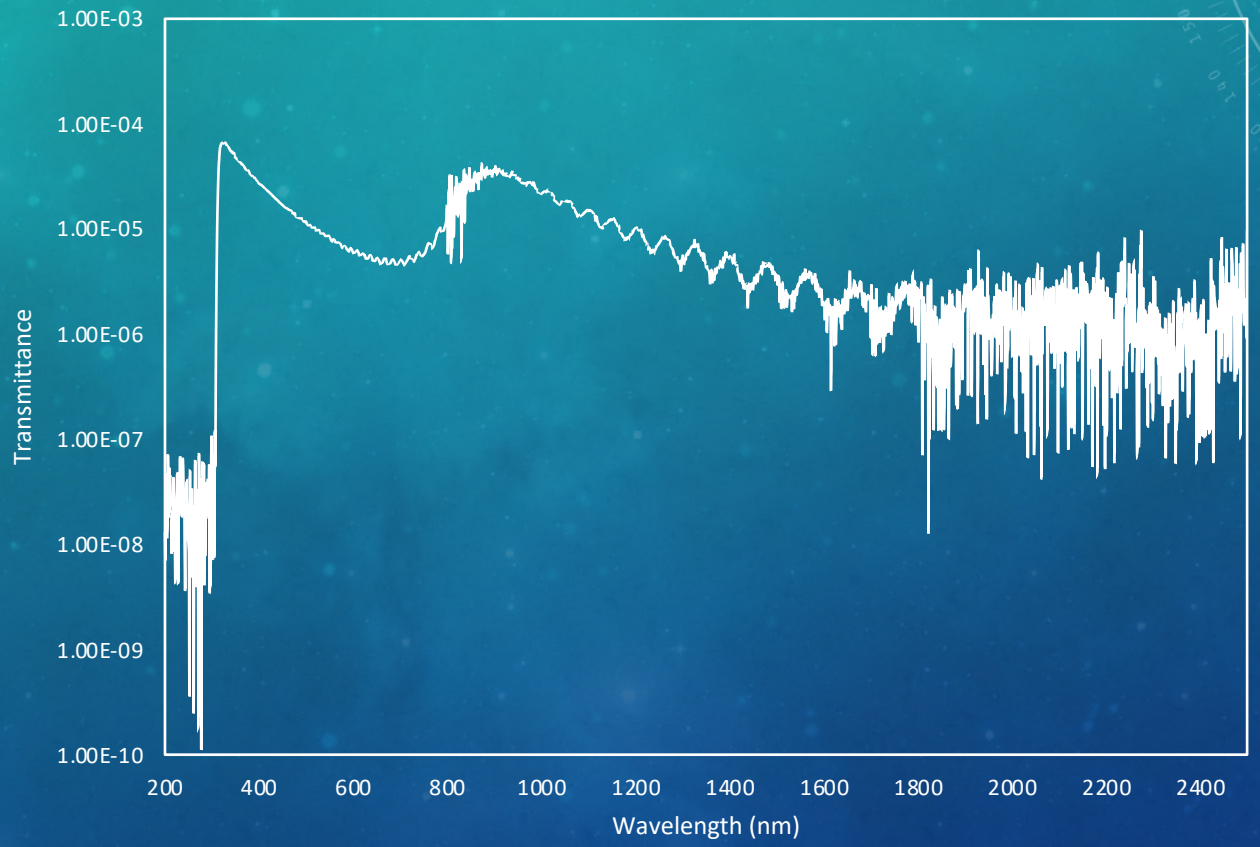
EYE PROTECTION

- Needed whenever any part of the solar disk is visible
  - Partial phases of TSE
  - All the time during annular eclipse

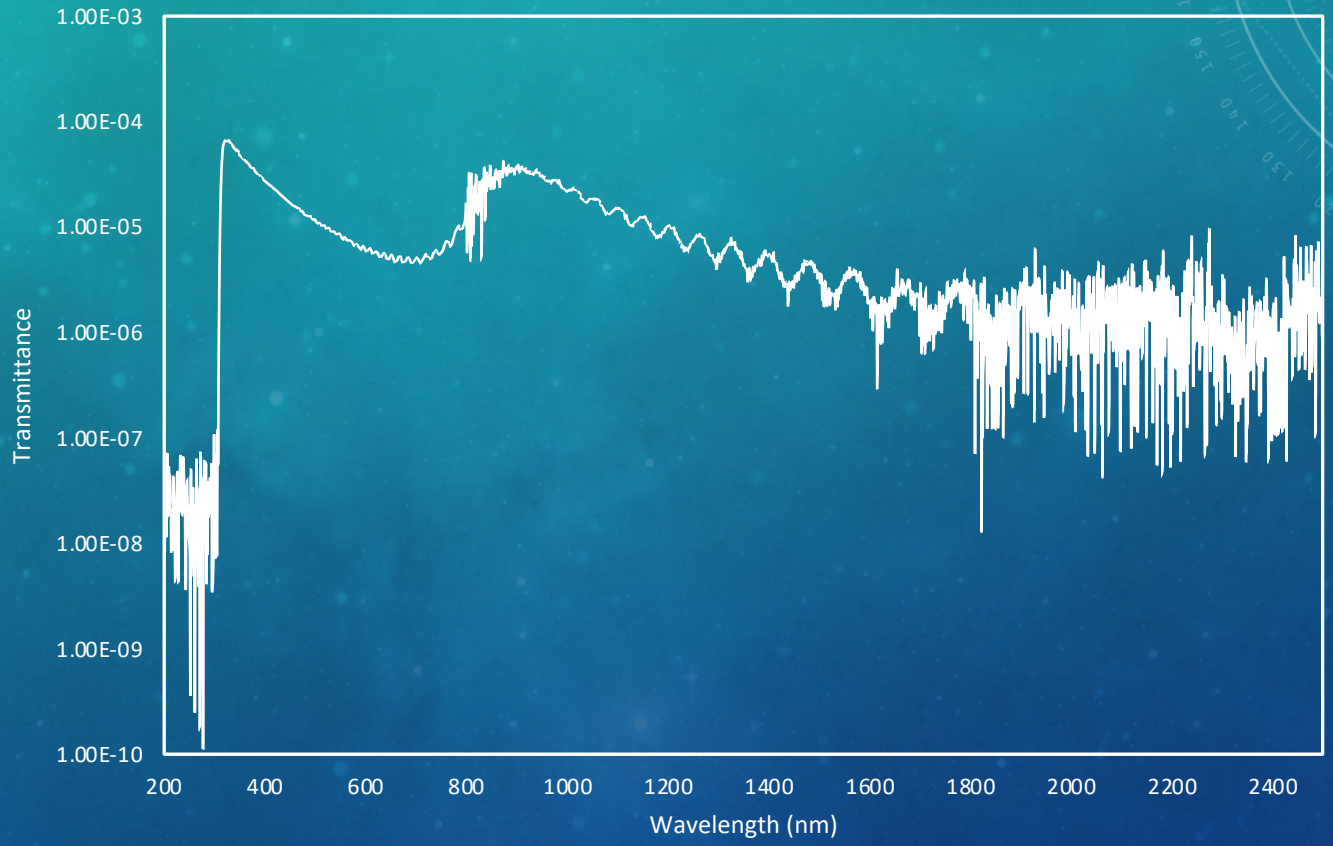
SHADE 14 WELDER'S GLASS



SOLARSKREEN



BAADER ASTROSOLAR SAFETY FILM



1999 SAFETY ISSUE

- Are sputtered metal coatings truly safe?
- Controversy in UK prior to 1999 total solar eclipse
  - “Defects in sputtered coatings are dangerous”
- Several viewers with SolarSkreen lenses found to have bright defects in coatings

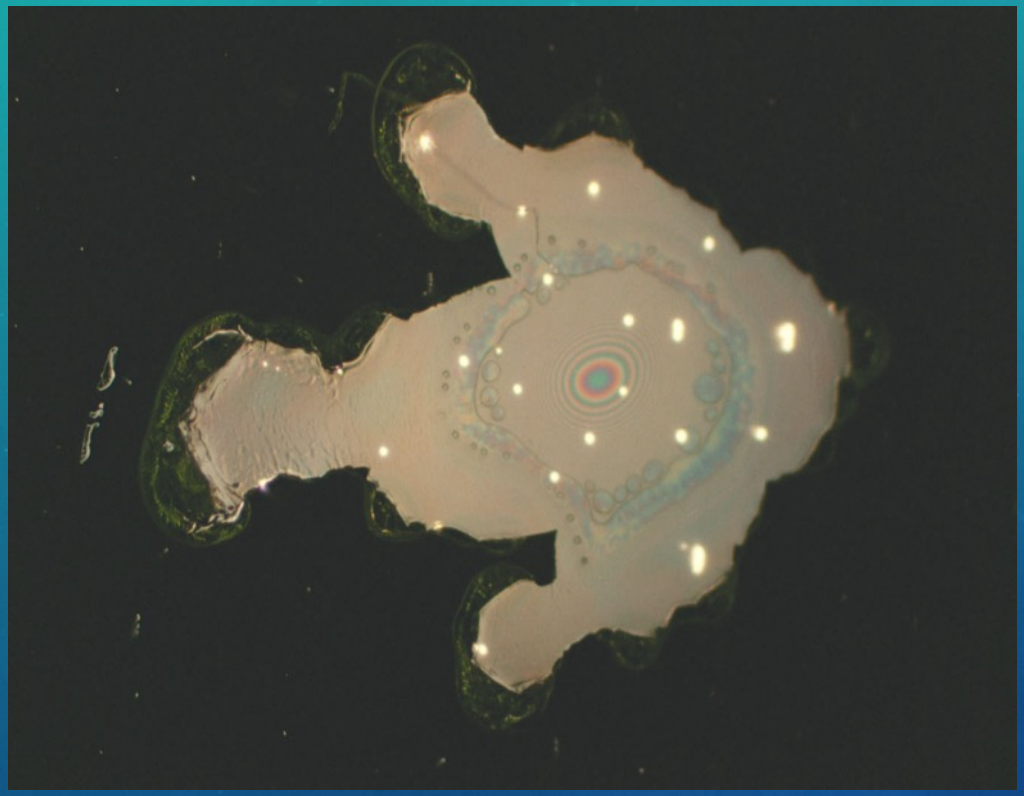
DEFECTS IN VIEWER LENSES

Viewer 3-9
Size 450 X 70 μm

Viewer 5-13
Size 680 μm long
40 - 100 μm wide

Viewer 3-10
Size 450 X 80 μm

“JELLYFISH” DEFECT

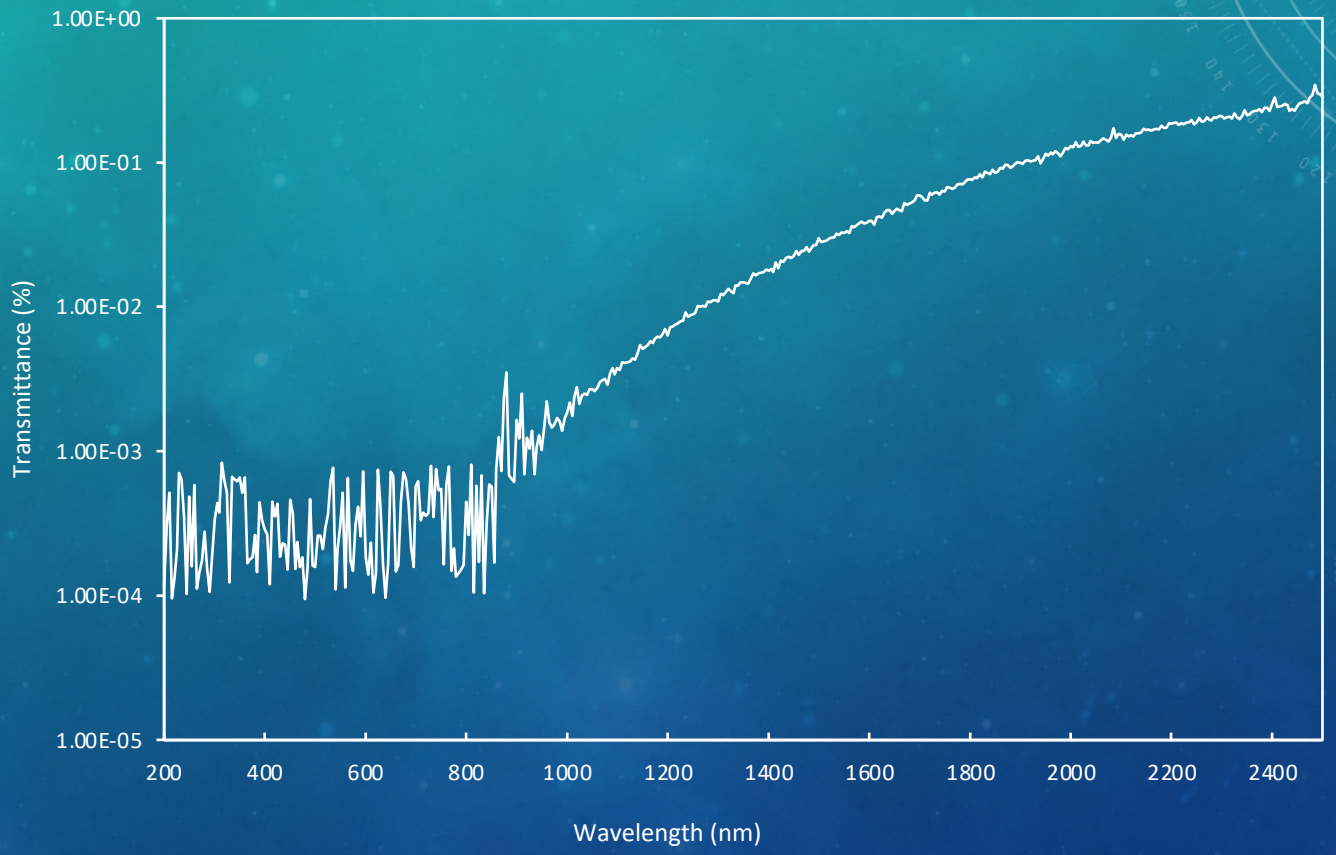


Window defect in one layer of aluminised polyester
Size 800 X 1000 μm

SAFETY OF “PINHOLES”

- Large defects occur rarely in polyester solar filters
  - One of 2 layers of aluminum missing
- Ocular exposure increases if defect centred on pupil
  - Critical exposure time 10^5 times longer than for unprotected eye
- May be a glare source but not hazardous

BLACK POLYMER



SOLAR FILTER STANDARD

- EN 1836: 2005
  - Developed due to controversy of 1999
- ISO 12312-2: 2015
  - Replaced EN 1836: 2005
  - Confirmed by ISO TC172/SC7 in 2020

- A PPE standard (under EC rules)

ISO 12312-2

Eye and face protection – Sunglasses and related eyewear – Part 2: Filters for direct observation of the sun

- Applies ONLY to filters used without optical instruments to observe the Sun directly
- Photographic filters, filters for telescopes and binoculars NOT covered
- Retailers advertising that their products comply

ISO 12312-2

- Requirements
  - Luminous transmittance
  - Material and surface quality
  - Mounting
  - Dimensions
  - Labelling
- Certification to carry ISO logo
  - Accredited test laboratories

2017 AAS CAMPAIGN

- Eye safety flyer
- Specialist package
  - Educators
  - Eye care providers
  - Media
- Included filter compliance with ISO 12312-2

SO HOW DID THINGS TURN OUT?

- Astronomy, optometry and ophthalmology groups all gave the same advice
- High public awareness of safe viewing practice and equipment
  - Good compliance for the most part…

A NOTABLE EXCEPTION

REPORTED EYE INJURIES

Average age 30

25 cases, 35 eyes

Symptoms:

- Blurry vision 19/25
- Metamorphopsia 5/25
- Scotoma 15/25
- No symptoms: 1/25

Retinal findings:

- Yellow lesion in retina 12/35
- Retinal pigment changes 13/35

American Society of Retinal Specialists

REPORTED EYE INJURIES

- Macula Society
  - 10 retinal injuries
- American Optometric Association
  - 13 retinal injuries

48 cases among 350M people!

FOLLOW-UP STUDY ON FILTERS (CHOU, DAIN, FIENBERG 2021)

- Samples
  - Filters submitted for AAS endorsement
  - Archived filters from BRC collection
- Assessed for compliance with ISO 12312-2

RESULTS – 1

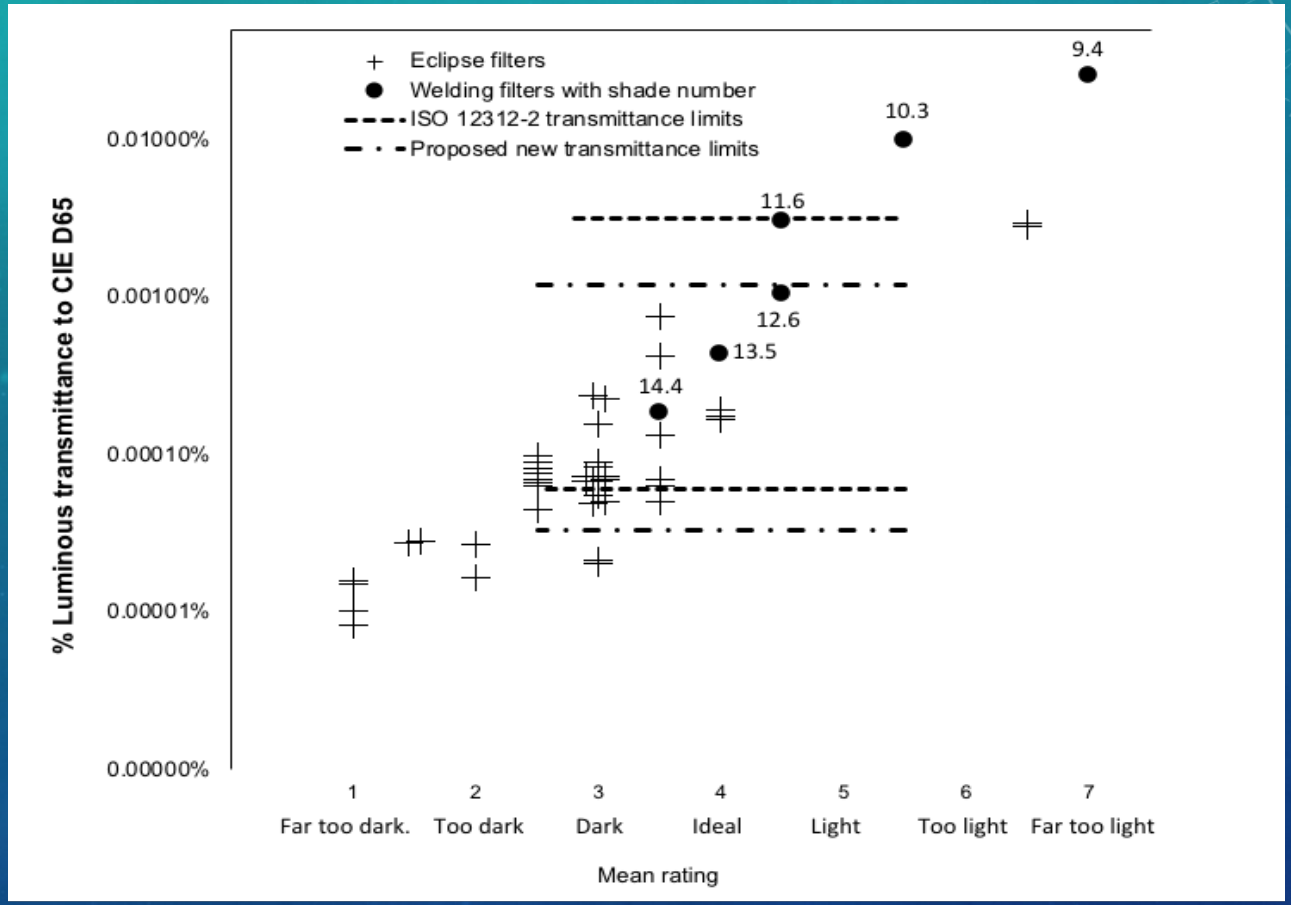
- All filters met UV and IR requirements
- Luminous transmittance
  - Ranged from 0.0000083% to 0.00075%
  - SN 16 to 12
- Correlated luminous transmittance with acceptability of solar image

RESULTS – 2

- Most paper “spectacles” met dimension requirements
  - Sunglass frames with hard filters failed
- Many eclipse glasses and filters did not have compliant labels

SOLAR ECLIPSE GLASSES

PROPOSED NEW LIMITS



REVISIONS TO ISO 12312-2

- Luminous transmittance limits
- Dimensions for paper “frames”
- Allowance for handheld viewers and filters in sunglass frames
- Remove “best before date”

QUESTIONS?

Bucharest, 1999