



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

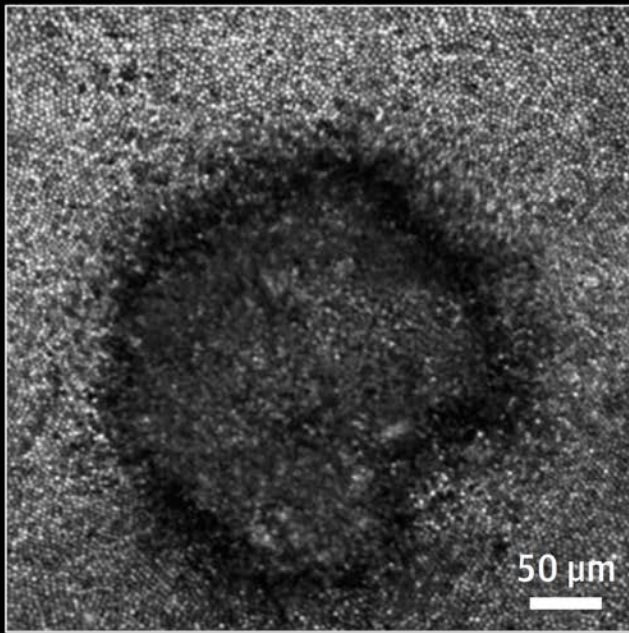


THERMAL INJURY



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

ECLIPSE RETINOPATHY



Retinal scotoma

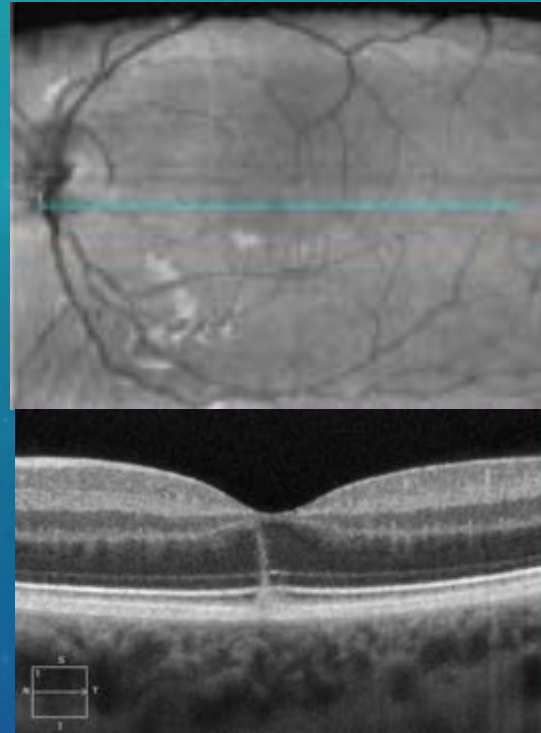


Eclipse mag. 0.12, obs. 5%

Wu et al, 2017

EXAMPLE FROM 2017

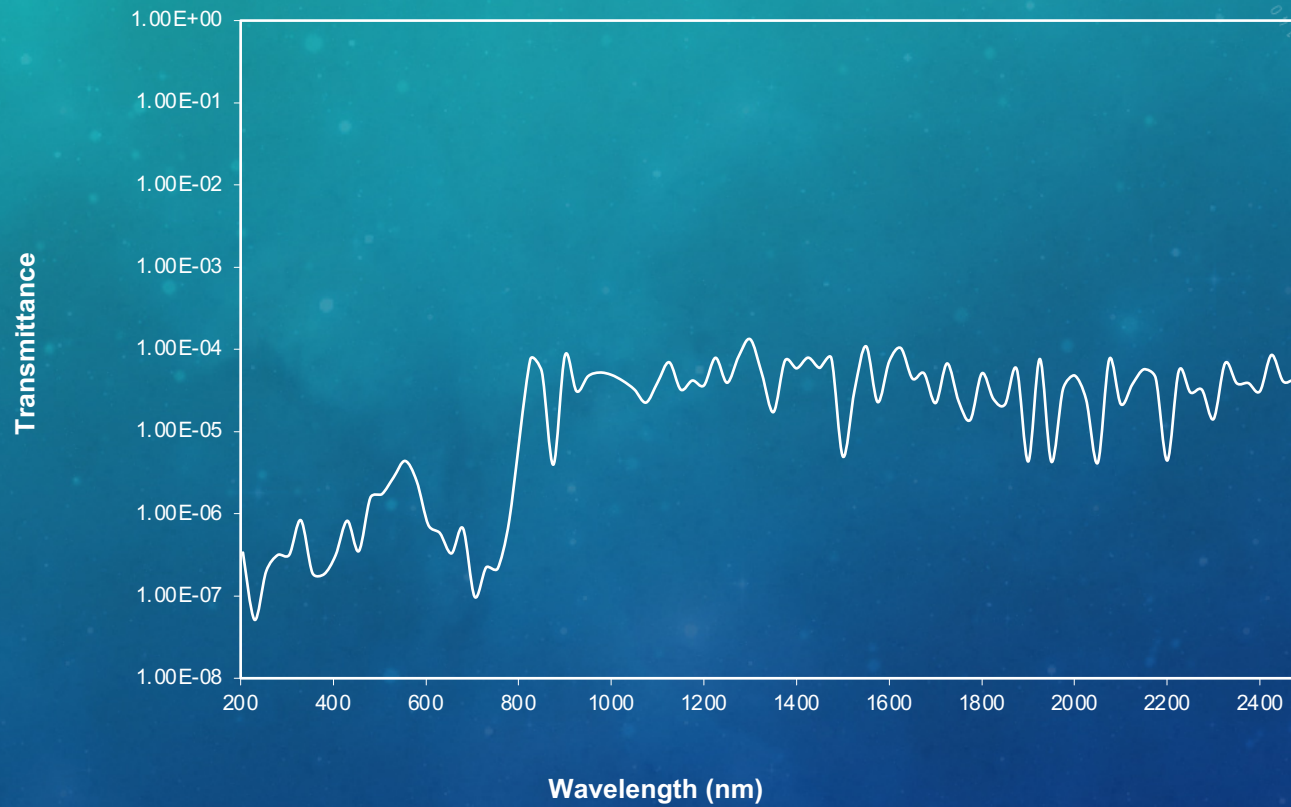
- 18 y.o. male
 - Viewed PSE without protection several minutes
 - Seen next day



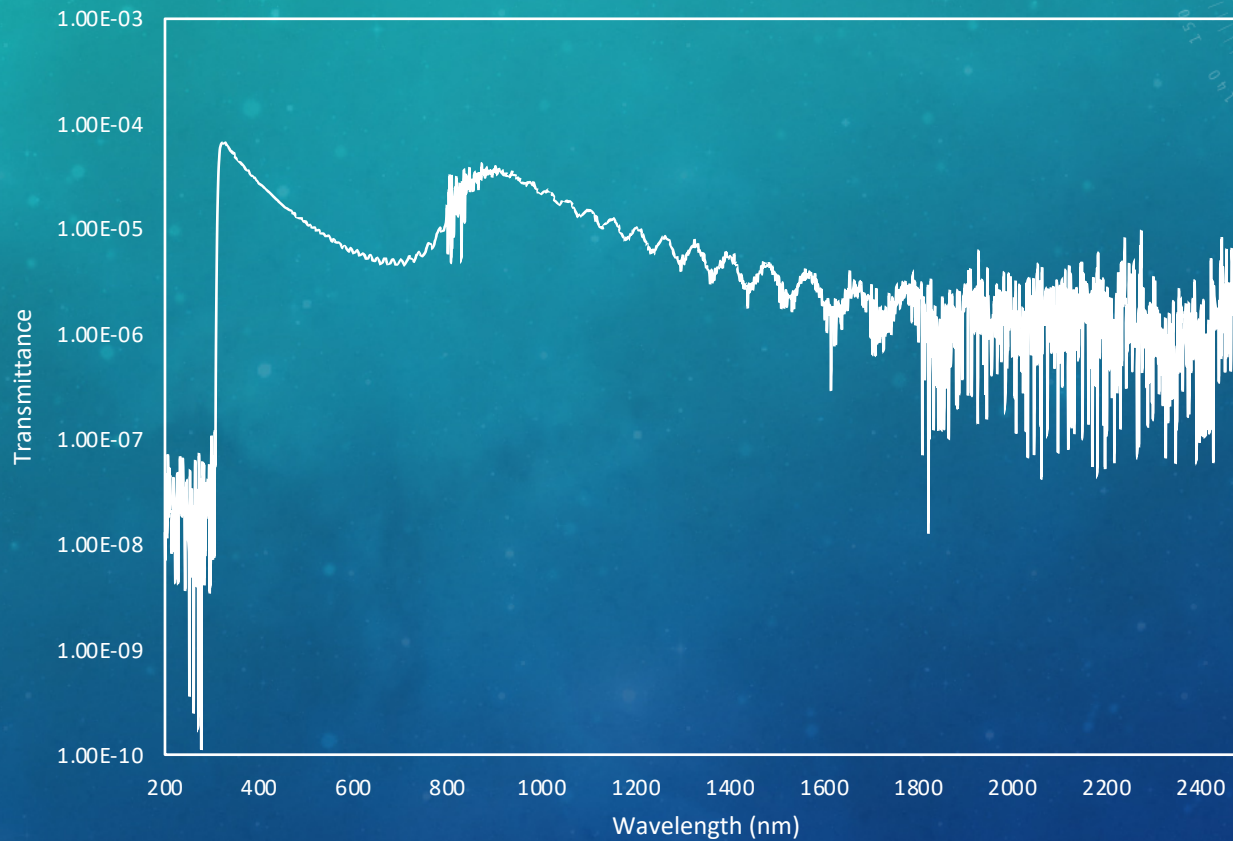
EYE PROTECTION

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

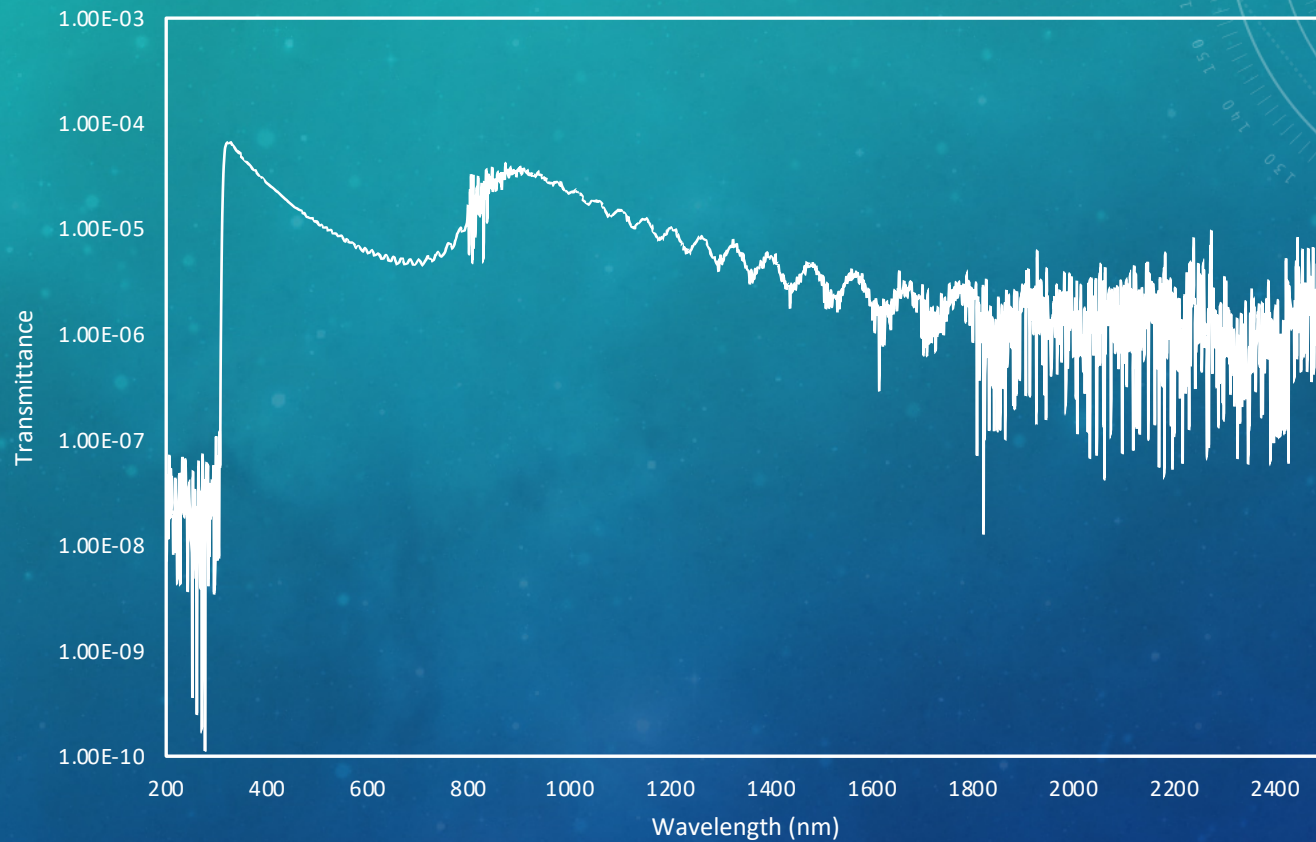
SHADE 14 WELDER'S GLASS



SOLARSKREEN



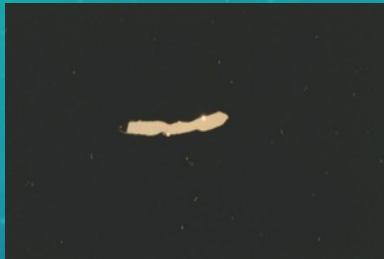
BAADER ASTROSOLAR SAFETY FILM



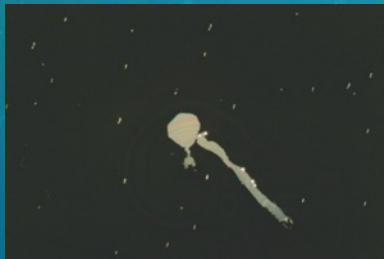
1999 SAFETY ISSUE

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

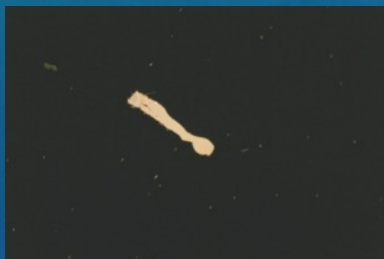
DEFECTS IN VIEWER LENSES



Viewer 3-9
Size 450 X 70 μm

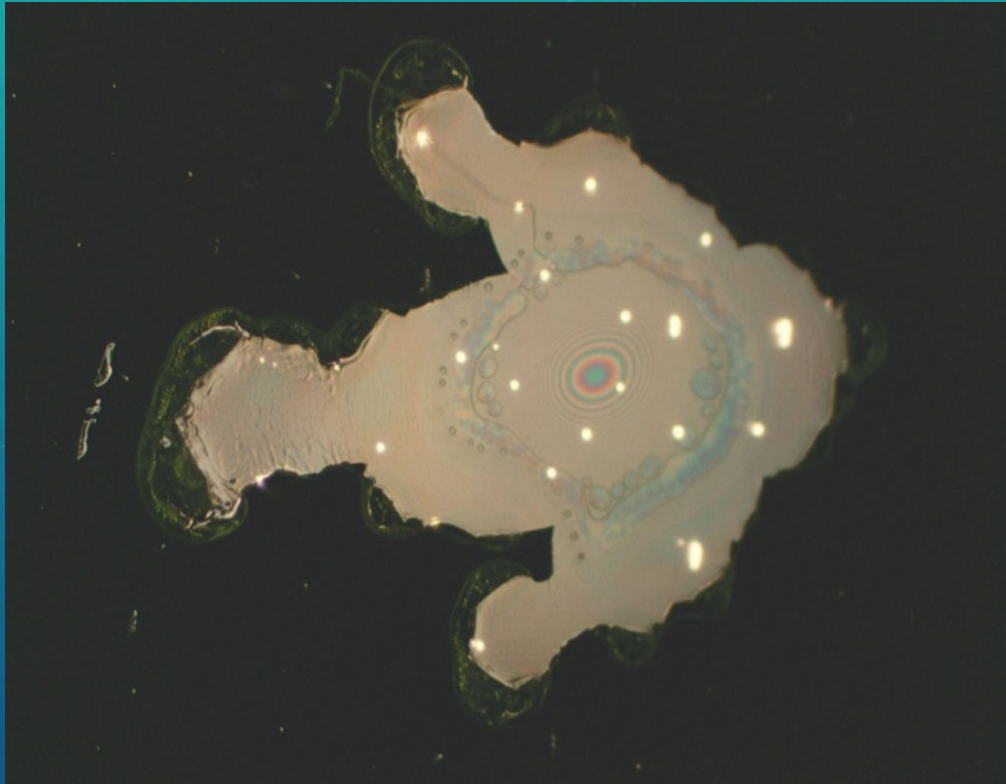


Viewer 5-13
Size 680 μm long
40 - 100 μm wide



Viewer 3-10
Size 450 X 80 μm

“JELLYFISH” DEFECT

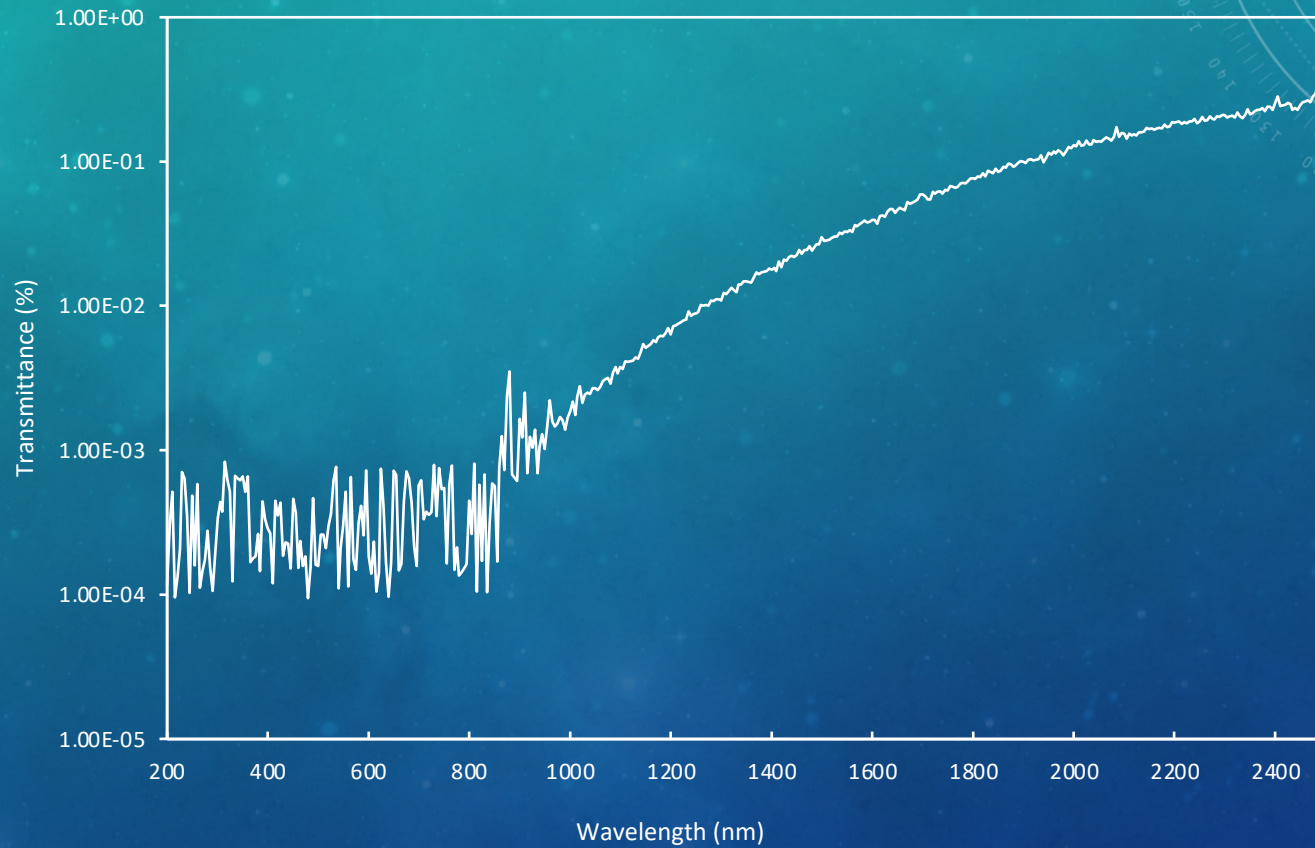


Window defect in
one layer of
aluminised polyester
Size 800 X 1000 μm

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

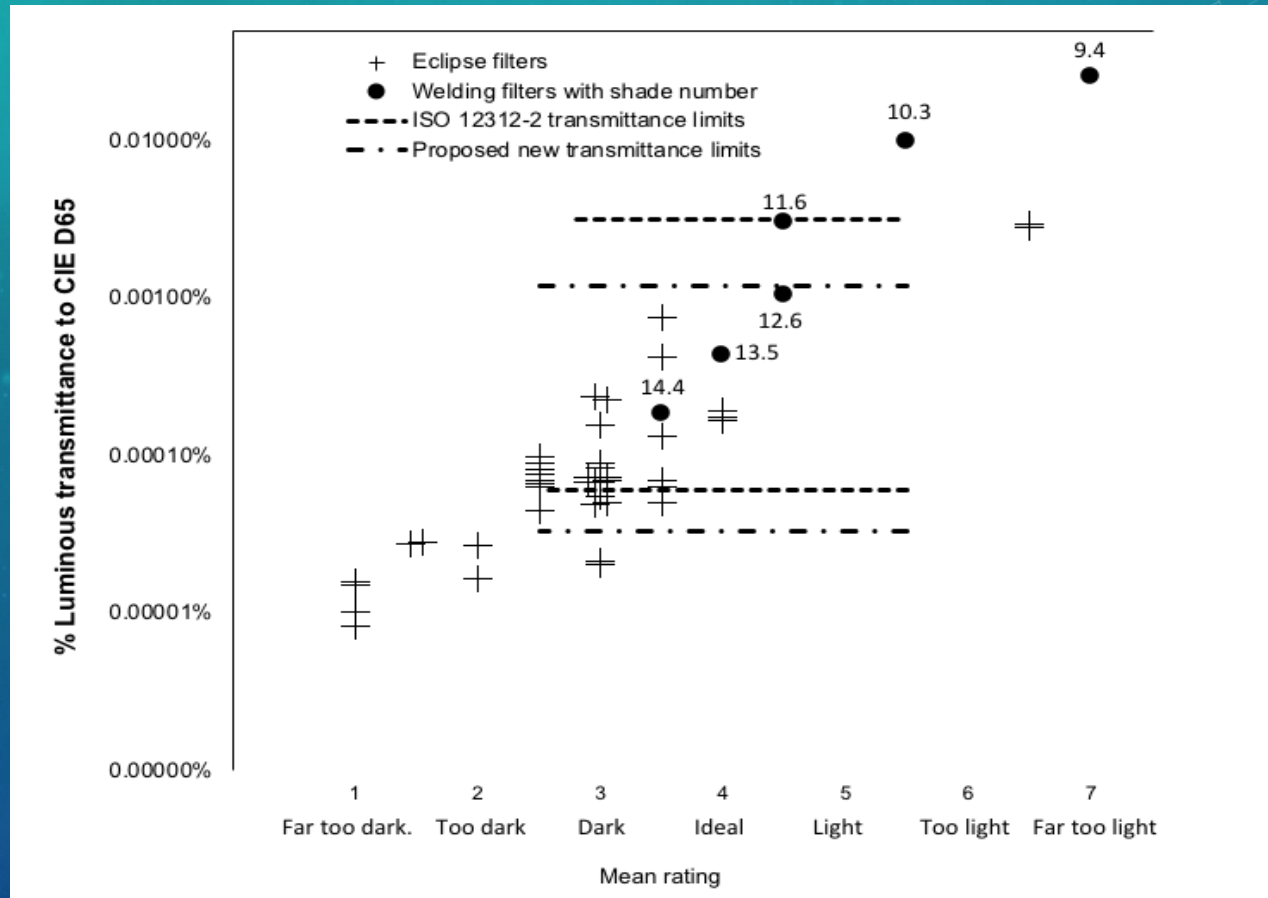
RESULTS – 2

- 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