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Solar Eclipse Glasses Degradation II

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Abstract

Solar eclipses offer a unique opportunity for both professional and amateur astronomers. However, direct observation of the Sun without proper eye protection carries serious risks of retinal damage, including eclipse blindness and photothermal injuries. This study examines the effectiveness and potential degradation of solar eclipse glasses over time.

Seventy solar eclipse glasses of various ages were analyzed under identical observation conditions to assess their spectral transmission properties. The evaluation focused on the visible and infrared ranges, acknowledging instrumental limitations in the ultraviolet (UV) and part of the visible spectrum. The study also considers the compliance of these glasses with international safety standards, particularly ISO 12312-2:2015.

The results reveal that glasses from two manufacturers showed evidence of potential

degradation or significant changes on safety standards, and one showed signs of possible degradation, though additional samples would be needed to confirm it. The potential degradation in one manufacturer's glasses was in transmission, which increased over time. The other showed degradation in optical quality but not in transmission. The manufacturer that shows signs of degradation currently uses different materials, so their older products are not directly comparable with current ones.

Some older glasses showed transmission levels above recommended thresholds, while many other old samples were as safe as new ones. However, at first sight, it is currently impossible to determine which old glasses are safe and which are not. This raises concerns about the long-term reliability of eclipse glasses and their possible degradation due to environmental exposure and material aging. Nonetheless, some of these differences may be due not to degradation of the glasses themselves but to changes in standards or manufacturing methods.

These findings highlight the importance of verifying the safety and compliance of eclipse glasses, especially when reused over long periods. While degradation or non-compliance is evident in some brands, others continue to offer the same protection even 20 years later as most new glasses. The study provides valuable insight into the potential obsolescence of these protective filters and underscores the need for regular testing to ensure their effectiveness in protecting vision during solar eclipses.

1 Introduction

Despite the existence of certified eclipse glasses, many people resort to homemade methods for solar observation, which often lack adequate optical properties and can pose serious risks to visual health [4, 3]. The widespread dissemination of safe viewing techniques and compliance with ISO standards are essential to preventing unnecessary eye damage, especially among untrained observers.

As a general precaution, and according to the consulted experts, eclipse glasses should not be the preferred method for observing solar eclipses (except the total phase), during the partial phase and projection methods are preferred.

> There are risks associated with all forms of direct viewing of the sun, even through solar filters, due to: possible manufacturing faults; the availability of filters that do not meet the ISO 12312-2 standard; incorrect usage of filters, such as putting them on too late, or removing them too early during an eclipse; the risk of 'copycat' sungazing through filters that do not meet the ISO 12312-2 standard; the risk of 'sneaking a peek' without shades, especially by children. Regular sunglasses, polaroid filters, dark glasses, welding glasses, X-ray film, photographic neutral density filters, red glass filters and homemade sun filters are not safe for observing the sun. [5]

One of the concerns associated with solar filters is their potential degradation over time. Although studies have been conducted on the long-term degradation of sunglass filters under controlled irradiation conditions [8], there is currently no dedicated study that examines the aging effects on eclipse glasses with a sufficiently large sample size. The possibility of planned obsolescence in certain manufacturing materials, combined with environmental exposure factors, raises important questions about the long-term reliability of these glasses.

To address this gap, we carried out an inspection of 70 eclipse glasses of different ages under identical observational conditions. This study aims to provide an evaluation of the potential degradation effects, particularly in the visible and infrared ranges. Due to instrumental limitations and absolute intensity, measurements in the ultraviolet (UV) and part of the visible spectrum are not considered entirely accurate. However, a comparative analysis of filters of different ages offers insight into whether degradation over time significantly affects the protective capabilities of eclipse glasses.

This report is a continuation of the one published on March 3, 2025 [12], in light of the urgency posed by the upcoming partial eclipse on March 29, 2025 (at the time). The present document is an application and review of that study, with a new acquisition of all the glasses analyzed.

The results of this investigation will contribute to a better understanding of the longevity and safety of solar viewing filters, with potential implications for regulatory recommendations regarding the expiration and reuse of eclipse glasses. Mainly considering tha polimers and coatings can age due to several proceses[2].

2 Setup

The optical workbench at LICA - UCM (Laboratorio de Instrumentación Científica Avanzada, Universidad Complutense de Madrid) is a versatile tool designed for characterizing the spectral transmission properties of eclipse glasses. The setup consists of a **high-power tungsten-halogen lamp (100W, Oriel 6333)** acting as a broadband illumination source, emitting in the visible and infrared ranges. The lamp operates under a **stabilized constant current power supply** (Oriel 68938) to ensure consistency of the spectral output. The emitted light is first directed through a **grating-based Czerny-Turner monochromator** (Oriel Cornerstone 260), which allows for precise selection of wavelengths up to **a resolution of 1 nm**.

To prevent higher-order diffraction from interfering with the measurements, a series of **motorized filter wheels** (Thorlabs FW102C) is incorporated into the system. The first filter wheel contains **Neutral Density (ND) filters** to control the intensity of the incoming light. The second wheel is equipped with **bandpass interference filters** specifically designed to block unwanted second-order spectra, particularly in the infrared region. The corrected monochromatic light is then passed through the test sample, in this case, the eclipse glasses.

A **calibrated silicon photodiode** (OSI PIN-10D) is positioned behind the sample to record the transmitted light intensity. The detector provides a quantitative assessment of the spectral attenuation introduced by the eclipse glasses. The photodiode is connected to a pico-ammeter (Keithley 6485) via a coaxial cable. All measurements were performed under identical conditions to ensure comparability between different samples.

Notably, the current **blocking filters** (BG38, OG570, RG830) were applied to avoid high orders from the blue part of the monochromator spectrum when measuring in the red and infra-red regions but **not in the ultraviolet region and part of the visible spectrum**. As a result, an artificial increase in the measured signal was observed in the

UV range and part of the visible spectrum due to second-order reflections reaching the photodiode. This effect should be considered when interpreting the results.

For each eclipse glasses tested, the calibration photodiode readings were made through a neutral density filter (ND 0.5) to prevent signal saturation. However, we could not use the same ND filter when measuring the glasses to avoid further attenuation in the measured current. Thus, a ND-0.5 transmittance correction step is needed to obtain the final transmittance value. The wavelength step size was set to 2 nm, which sped up the measurements while maintaining an adequate resolution.

Although the main objective of this study was to quantify the transmission properties of eclipse glasses, additional aspects of optical performance were investigated, including the impact of different filter combinations on higher-order diffraction suppression. The results provide valuable insights to the performance of the analyzed samples, though it is important to note that LICA is **not an accredited laboratory**. The findings should be used as scientific reference material rather than official certification data.

The following sections will present a detailed analysis of **transmission spectra, attenuation properties, and the effectiveness of higher-order diffraction suppression strategies**. The different plots were generated with **Matplotlib** for visualization.

In principle, the aim of the characterization was mainly to obtain the spectral transmittance of the filter. However, after finding similar works characterizing similar filters [4], we decided to extend the scope of characterization to other interesting aspects such as the potential degradation of the filter with time comparing different age eclipse glasses. The initial hypothesis, the filters do not degenerate with time significantly. As you will see in the conclusion, we can no longer support that hypothesis.

3 Eclipse Glasses

3.1 Transmission Spectra of Eclipse Glasses

This study presents a technical analysis of 70 unique models of eclipse glasses, collected between the years 1999 and 2025 (see fig. 18), with the aim of assessing their suitability for direct solar observation. The collection encompasses a broad and representative sample of glasses used over more than two decades, both during past eclipses and in preparation for future events.

A systematic effort was made to document glasses from various contexts: from historical models distributed during eclipses, such as the one in 1999, to modern units manufactured more recently. This temporal breadth allows for a comparison of the evolution in materials used, optical quality, information provided to users, and the degree of compliance with safety standards such as ISO 12312-2:2015, CE marking and Notified Body involvement (see fig. 19).

One of the pillars of the study is the technical and instrumental evaluation of each pair of glasses through a controlled photometric calibration process, in which light attenuation was measured using a reference system. Variables such as the date of calibration, the order in which they were measured, and the relative distance to the reference diode were recorded, enabling reliable comparisons between models of different origins or ages.

Key aspects analyzed include:

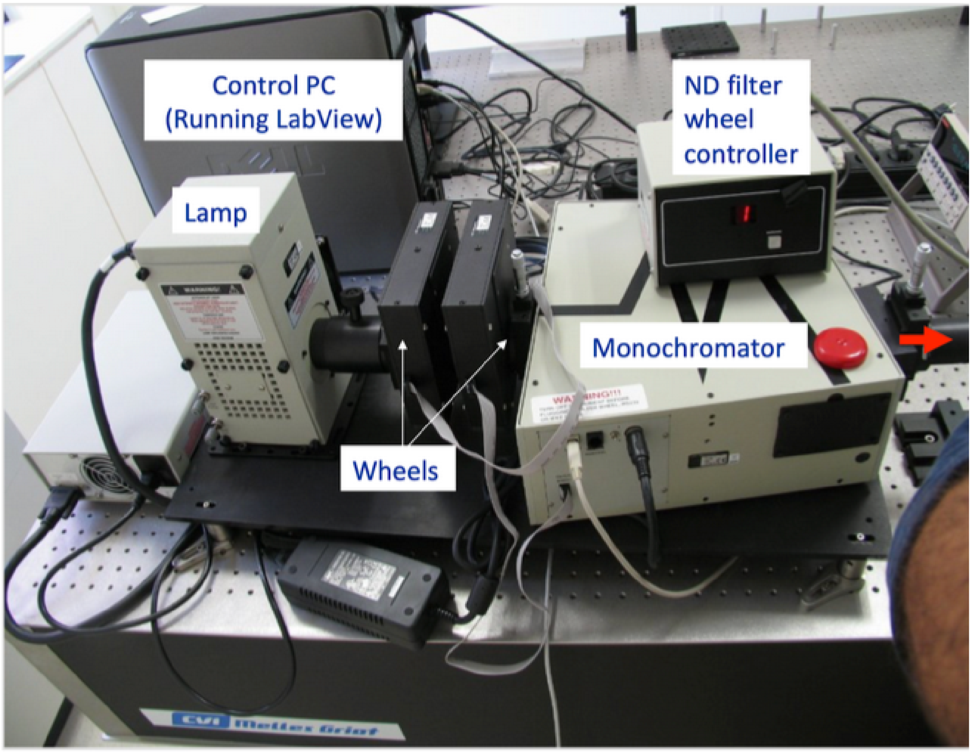

Figure 1: LICA optical bench consisting of a quartz lamp, passing through a monochromator that sends a beam handled in several ways. A primary filter wheel selects suitable band-pass filters to mitigate high order spectra artifacts. A secondary filter wheels contains several neutral density filters to attenuate the incoming light so as not to saturate the detectors (not seen). A Control PC running custom-made LabVIEW applications controls the different elements (monochromator, filter wheels, measurement pico-ammeter).

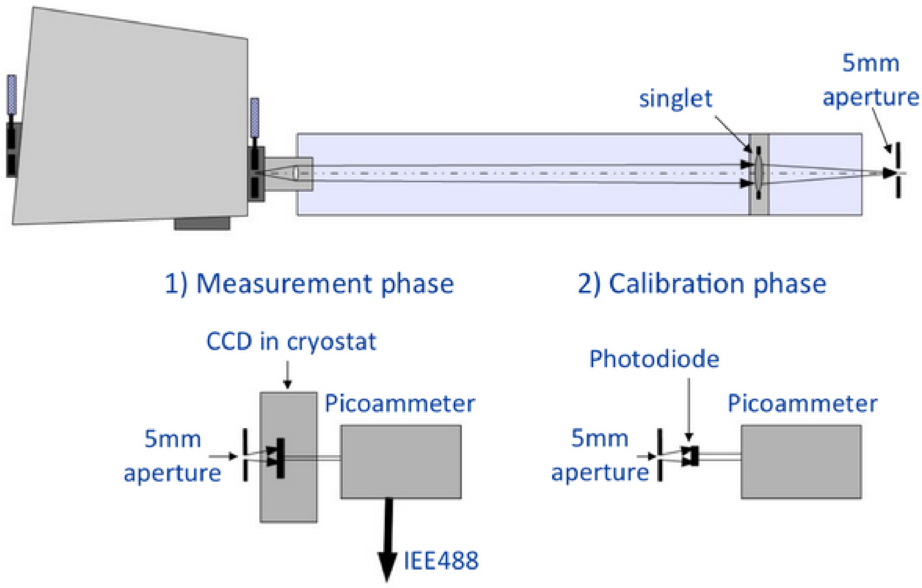

Figure 2: A typical configuration used to measure detectors and filters. The eclipse glasses were placed instead of the CCD detector shown in the figure.

- Filter material: The use of black polymer is predominant, although some variants include additional coatings or metallic layers.
- Declared optical profile: Most glasses exhibit a crescent-type transmission profile, appropriate for solar viewing, but there are also models with additional filters or atypical profiles.
- Technical information: Only a portion of the glasses indicates expiration date, maximum recommended usage time, or specific ISO standards, revealing gaps in traceability and documentation for many models, especially the older ones.
- Languages and instructions: While Spanish and English are the most common, glasses with instructions in multiple languages—or none at all—were also documented.

The analysis also highlights the presence of similar models distributed under different brand names, possibly rebranded, raising questions about the traceability of some commercial batches. Furthermore, significant differences in optical quality were detected even between glasses from the same year or manufacturer, underscoring the importance of independent verification before use in critical events such as solar eclipses.

This study provides an empirical basis to inform institutions, educational centers, and the general public about which glasses are safe and which are not, promoting a culture of safe solar observation based on technical evidence rather than the commercial appearance of the products.

The spectral transmittance of different eclipse glasses analyzed in this study is presented in Figures 4-17. Each plot represents the spectral transmission as a function of wavelength, highlighting the effect of different filter combinations and attenuation properties. The data illustrate the variations in transmission among the samples, particularly in the visible and infrared ranges.

To provide a broader comparison, the individual files can be found on the Zenodo record that correspond to this document as the transmittance curves the same data using $\log_{10}(1/\text{Transmittance})$, which highlights the optical density of each sample and facilitates a clearer comparison of their attenuation properties. The dashed and dotted lines in both figures indicate the maximum permissible transmittance values for luminous, UVA, and infrared radiation according to ISO 12312-2:2015. However, it is important to note that these limits are provided for reference only, as the measurement equipment used in this study is not officially certified.

A summary of the analyzed eclipse glasses, including their year of manufacture, is presented (fig. 18). The data have been anonymized to ensure neutrality in the evaluation, except in cases where evidence of degradation is present, as this information is relevant for clarifying specific issues.

Eclipse glasses show clear evidence of potential degradation over time at least for one manufacturer. This conclusion is drawn from the observation that older glasses tend to exhibit greater variability in measurements, as well as increased light transmission. Such effects are especially pronounced in glasses over 20 years old, according to the available data. The elevated dispersion in transmission values is one of the main indicators suggesting material degradation. It is important to note that this analysis applies specifically to glasses manufactured by Eclipse Shades and does not affect more recently produced models. Also have been found in transmission of the same age on one manufacturer, their Eclipse glasses of 2005 of SOBOMEX. Eclipse glasses of SOBOMEX from newer lot have been found optical quality degradation, but not evidence of changes in the transmission. Finally, some potential degradation has been found on old Eclipse glasses from AstroSolar film, no longer for sale for manufacturing eclipse glasses and explicitly forbidden by the manufacturer currently, who now use different materials.

4 Discussion

The analysis presented in this study indicates that the majority of the eclipse glasses examined comply with the requirements established by the ISO standard, often surpassing the specified thresholds — including the SOBOMEX samples, which are over 20 years old. However, the samples from Rainbow Symphony / Eclipse Shades show a clear trend of increasing transmittance over time, along with greater dispersion in the measurements (see significance in Table 1 and Figure 20). We interpret this behaviour as evidence of material degradation. One of the reasons that has led us to make public the name of this manufacturer is that they currently do not have CE markings, although probably the quality of current glasses can be as good as most of the current certified glasses.

Determining the exact purchase dates of the glasses has proven challenging. Fortunately, the administrative name changes of the institution responsible for supervising the Planetario de Madrid have helped constrain the timeline. The glasses labelled as from 1999 may actually date back to as early as 1994 (coinciding with the partial solar eclipse on May 10, 1994), while those labelled as from 2005 may have been produced as early as 2003 (during the transit of Mercury). The sample from 2008 is the only one with some uncertainty, and its date has been assigned to the earliest plausible point in time.

It should be noted that polymers can degrade through various mechanisms, including heat, exposure to UV radiation, humidity, etc. It is also possible that changes in manufacturing standards over the years may have led to variations in filter transmittance; however, in our opinion, this does not account for the significant dispersion observed in the Eclipse Shades glasses from 1999 and 2005, which is not present in the SOBOMEX glasses. In contrast, the SOBOMEX samples form two distinct clusters rather than showing dispersion. Also, we decided to make public the name of SOBOMEX because we have not been able to find if they still produce eclipse glasses, but their old glasses were of good quality.

For the other manufacturers, we do not have a sufficient number of samples to draw any conclusions. However, it is evident that the spectral behaviour of different materials varies notably, and it would not be surprising if their degradation rates differ accordingly.

In general terms, Mylar-like glasses or Astrosolar film glasses manufactured prior to 2010 do not meet the safety requirements of the 2015 standard. This observation is consistent with current recommendations from Baader Planetarium.

Currently, within our sample of 70 glasses, 40 exhibit, to varying degrees, a level of light leakage above the recommended threshold in the 600–700 nm range. If confirmed to be relevant and accurate (bearing in mind that our laboratory is not certified), this could imply that a substantial number of already-certified glasses may not meet the current standard. Samples have been submitted to a notified laboratory to clarify, for example, whether the ISO 12312-2:2015 requirement refers to average transmittance over the band or to each individual wavelength, and also to serve as a reference for our study. Given the high number of glasses showing this potential leakage, it would be advisable for other laboratories to conduct similar investigations to either confirm or refute these findings.

According to Chou[3], no warnings regarding the obsolescence of solar filters should be issued. In our view, the limited sample analyzed by Chou (22 out of 43 glasses), which focused primarily on compliance with the relatively recent ISO 12312-2:2015, may not be sufficient to evaluate long-term material aging. Such aging, if significant, would in many cases require more than 15 years to manifest. In fact, [3] acknowledges that his study did not perform a systematic analysis of eclipse glasses aging. Perhaps this work may help stimulate a revision of that position.

It should also be noted that not only polymers, aluminized layers, or coatings are subject to degradation. A SOBOMEX glass purchased in 2025, but whose standard indicates it was manufactured between 2008 and 2014, showed signs of optical degradation due to flaking on one of its surfaces. We do not know whether this defect was present from the factory or if it resulted from aging over time.

In any case, any certified eclipse glasses appear to be significantly safer than any homemade observation method. We reaffirm what Chou stated in 2004: *"Misinformation may be just as bad, if not worse, than no information."*

Table 1: Spearman correlation[14] between year of purchase and transmittance for manufacturer F07. A negative coefficient indicates that older glasses tend to have higher transmittance.

Wavelength Band	**Spearman's ρ**	**p-value**
500–600 nm	-0.896	3.2×10^{-9}
600–700 nm	-0.868	3.8×10^{-8}
700–800 nm	-0.831	5.0×10^{-7}

5 Legal Requirements for Selling Eclipse Glasses in Spain

In Spain, as in the rest of the European Union, the sale of eclipse glasses is subject to strict legal requirements to ensure public safety. According to **Regulation (EU) 2016/425 on Personal Protective Equipment (PPE)**, eclipse glasses are classified as **Category II PPE**. This category includes equipment designed to protect against medium-level risks, such as *direct observation of the sun*, which poses a serious hazard to vision if not properly filtered.

To **legally market eclipse glasses in Spain**, the product must carry the **CE marking**, which indicates conformity with European safety standards. However, the CE mark alone is not sufficient. Eclipse glasses must also pass a **conformity assessment procedure** carried out by a **Notified Body**, an independent institution authorized to evaluate whether the product meets all the technical safety requirements. This process includes testing the product against specific European standards, preparing technical documentation, and ensuring clear and adequate user information is provided.

The relevant **harmonized European standard** for eclipse glasses is **EN ISO 12312-2:2015**, titled *"Eye and face protection – Sunglasses and related eyewear – Part 2: Filters for direct observation of the sun"*. Compliance with this standard provides a presumption of conformity with the regulation and ensures the glasses block harmful solar radiation to a safe level suitable for eclipse viewing.

Manufacturers, importers, and distributors must ensure that the glasses are correctly labeled, accompanied by instructions in Spanish, and traceable through appropriate documentation. Additionally, all entities involved in the commercialization of these products should be prepared to demonstrate compliance with the applicable legislation if requested by market surveillance authorities.

More information about the regulatory framework and a list of Notified Bodies recognized in Spain can be found on the website of the **Spanish Ministry of Industry, Trade and Tourism**, which oversees the enforcement of these requirements. The ministry's guidance confirms that any eclipse viewing equipment sold to the public must adhere to the rules established for Category II PPE, and failure to comply may result in sanctions, product recalls, or legal liability in case of harm.

In conclusion, anyone planning to sell eclipse glasses in Spain must ensure that the product complies fully with **Regulation (EU) 2016/425**, including **CE certification, conformity assessment by a Notified Body, and adherence to the EN ISO 12312-2:2015 standard**. This legal framework is in place to guarantee that consumers are protected when observing solar eclipses and to prevent the distribution of unsafe or counterfeit products.

This information was provided by Jose Manuel Prieto Barrio, Subdirector General de Calidad y Seguridad Industrial (Ministerio de Industria y Turismo).

These are the legal requirements. However, as human beings, we possess free will and individuals are free to disregard these rules at their own risk. Even though there is a high probability that older eclipse glasses may still be safe, public authorities have a duty to act in accordance with the **precautionary principle** and to clearly inform the public about the potential risks associated with such practices.

The standard **ISO 12312-2:2015** currently states that an *expiration date must be included where applicable*, meaning that it is the manufacturer's responsibility to determine whether a date should be printed. The European Union requires manufacturers to retain product samples for up to **10 years**, making it very unlikely that any legal liability could be extended beyond that period.

Furthermore, the official interpretation guide to the standard explains that *an expiration date is not mandatory if the degradation of the materials is not directly linked to the manufacturing date*. In such cases, manufacturers and retailers are obligated to **store the products under ideal conditions** to avoid material degradation—an obligation that neither consumers are expected to know about nor comply with themselves. So, the lack of an expiration date does not necessarily imply that there is no expiration recommended date, moreover, if this can change when the glasses are kept safely. The glasses studied in this document have all been kept in total darkness, not exposed to humidity, nor any agent except maybe the heat of the summer in Spain. Even if the manufacturers could consider that there is not expiration date, that do not mean that there is no level of degradation of the materials that would not recommend their use. Even [3] acknowledges that his research has not been focused on this topic.

All of these considerations go beyond the scope and expertise of the current researchers. We humbly believe that it is the responsibility of the **appropriate authorities and domain experts** to clarify these aspects in detail. However, from the perspective of common sense and in light of the precautionary principle, we believe that—**given the low cost of eclipse glasses—it is unreasonable to risk the visual health of even a single person by using glasses that are 25 years old**.

Additionally, considering that up to **100 million eclipse glasses**[1] may be needed in the coming years, the market segment composed of amateur users who have preserved glasses for over 25 years is likely to be extremely limited. Therefore, **if you send us your 25-year-old glasses and they are not already part of our study sample, we will provide you with a new certified pair at production cost**, up to a limit of **1000 glasses**.

6 Conclusion

This study provides a comprehensive analysis of the potential degradation of solar eclipse glasses over time, assessing their spectral transmittance and compliance with international safety standards. The results indicate that, while most eclipse glasses maintain their protective properties even after several years, certain exceptions highlight the risk of increased transmittance due to material aging. Notably, sample manufacturer F07-a.k.a. Rainbow Synfony/Eclipse Shades exhibited significantly higher transmission than the others when the age of the glases where higher of 15 years, suggesting potential degradation or non-compliance at the time of manufacture for current standards (not necesary at the sales moment). In contrast, other samples over 20 years old, still provided adequate protection.

These findings underscore the importance of periodic testing to verify the integrity of eclipse glasses, as well as the necessity of implementing stricter regulations regarding product traceability. A key issue identified in this study is the difficulty in distinguishing safe older glasses from those that may no longer meet safety standards. Since the degradation process is not uniform and may depend on factors such as storage conditions and material composition, the current lack of clear labeling makes it nearly impossible for the average user to determine whether a given pair of eclipse glasses is still safe to use.

To address this challenge, we propose the following recommendations for future manufacturing and regulatory practices.

- **Manufacturing date labeling:** Eclipse glasses should be clearly labeled with their production date.
- **Estimated obsolescence date:** A manufacturer-provided recommendation on the maximum safe usage period should be included based on material testing.
- **Batch number traceability:** Each pair of eclipse glasses should include a batch number, allowing for improved tracking of potential defects or recalls.
- **Consumer education:** Users should be provided with guidelines on proper storage conditions to minimize degradation risks.

While this study highlights the importance of maintaining high safety standards for solar viewing equipment, further research is required to assess the impact of different storage conditions and manufacturing variations on long-term filter degradation. Future studies should expand the dataset to include a wider range of eclipse glasses from different manufacturers and production years. By improving traceability and standardization, the risk associated with the reuse of old eclipse glasses can be significantly reduced, ensuring safer solar observations for the public.

7 Tools

During this analysis, we have developed our tools to analyze and display the data at LICA Optical bench described in the Introduction and Setup sections.

Author Contributions

R. G. and A. S. M. analyzed the eclipse glasses. The experimental procedure was designed by R. G., A. S. M., and C. T. The software used in the study was developed by C. T. and R. G. The project was conceived and managed by A. S. M., J. G. and J.Z., who also secured the necessary funding. The manuscript was written by A. S. M., R. G., J.Z. and J. G., with all authors contributing to its revision. The selection of eclipse glasses was identified and curated by A.S.M., J.G., N.C.L. and C.T.A.

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We also acknowledge the developers and contributors of the open-source software packages that were essential for the data analysis and visualization in this study, including:

- **Astropy** [11], a community-developed Python package for astronomy.
- **Matplotlib** [7], a powerful library for generating scientific plots.

- **NumPy** [6], a fundamental package for numerical computing in Python.
- **Scikit-learn** [10], used for machine learning applications.

Their continued development and support within the scientific community have been invaluable to this research. We would like to thank ChatGPT, a language model developed by OpenAI, for its assistance with proofreading and programming support[9].

Conflicts of interest

There are no conflicts of interest to declare regarding this study. All authors conducted the research independently, with no financial, personal, or professional relationships that could have influenced the findings or interpretations. This work was carried out with full transparency and in strict adherence to ethical guidelines, ensuring objectivity and integrity in the results.

Although A. S. M. has no financial interest in any eclipse glasses manufacturers, he is involved in the potential future profits of SSC from the sale of eclipse glasses. While no conflicts of interest exist a priori, they could arise a posteriori if the study's findings influence future purchasing decisions. Full CoI disclosure declaration here[13].

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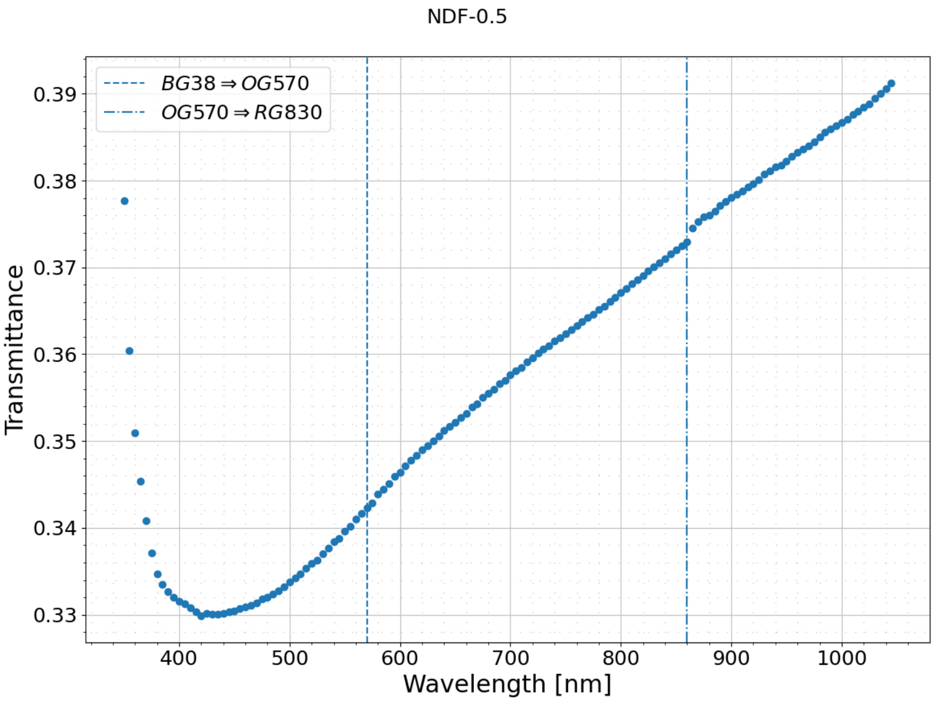

Figure 3: Transmittance of the NDF-0.5 Neutral Density Filter used in the reference photodiode readings. Attenuation is non uniform around 30-40 percent. Leftmost readings above 400 nm are artifacts from second order IR light.

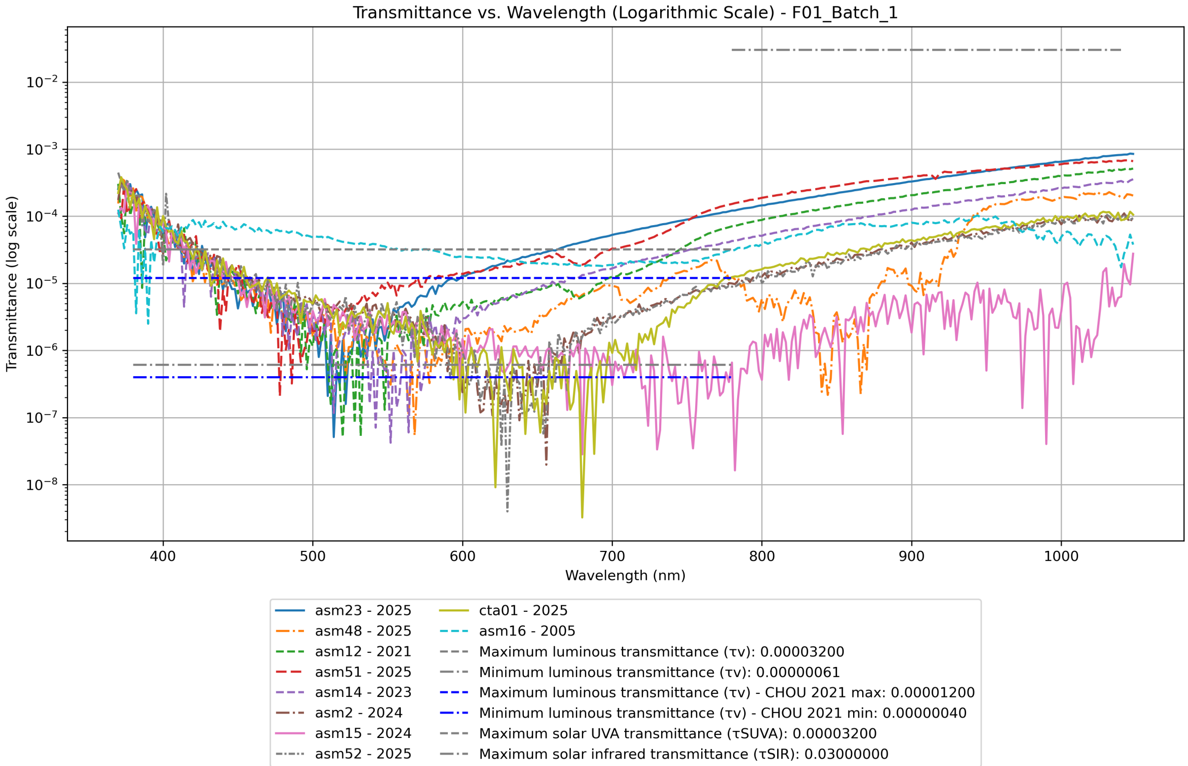

Figure 4: Transmission spectrum of manufacturer F01 (Mixture of unknown manufacturers), batch 1 (logarithmic scale).

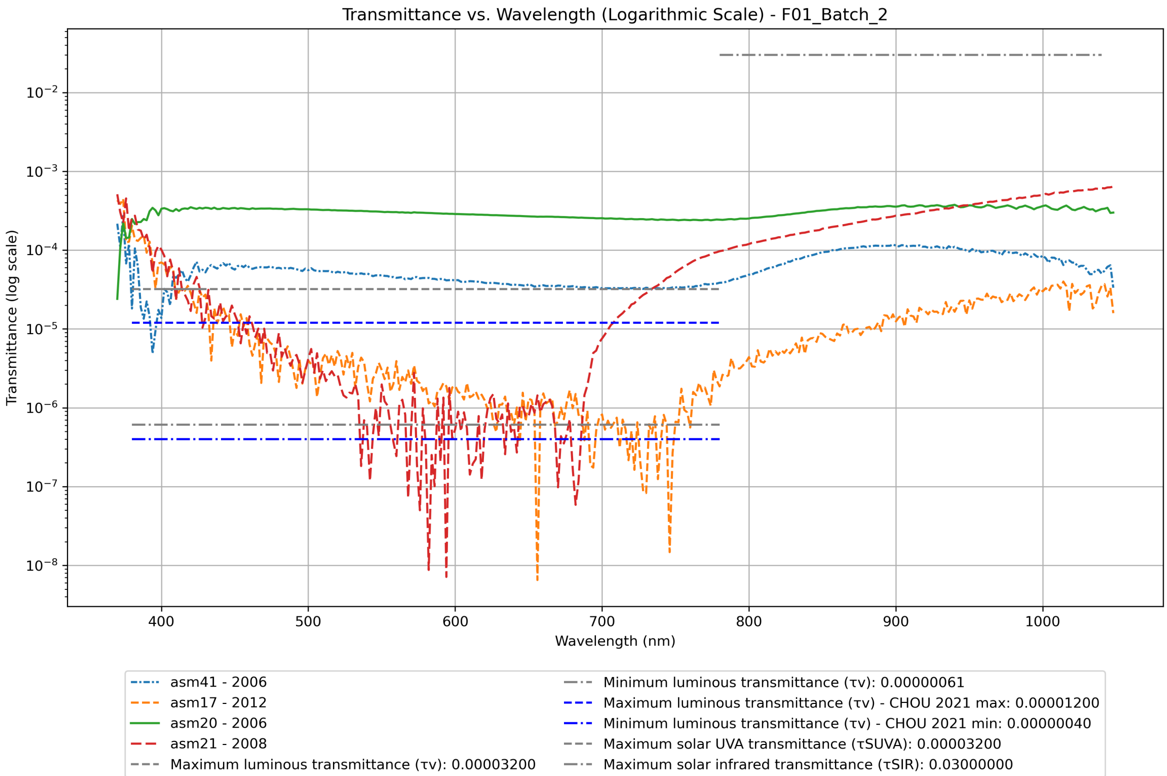

Figure 5: Transmission spectrum of manufacturer F01 (Mixture of unknown manufacturers), batch 2 (logarithmic scale).

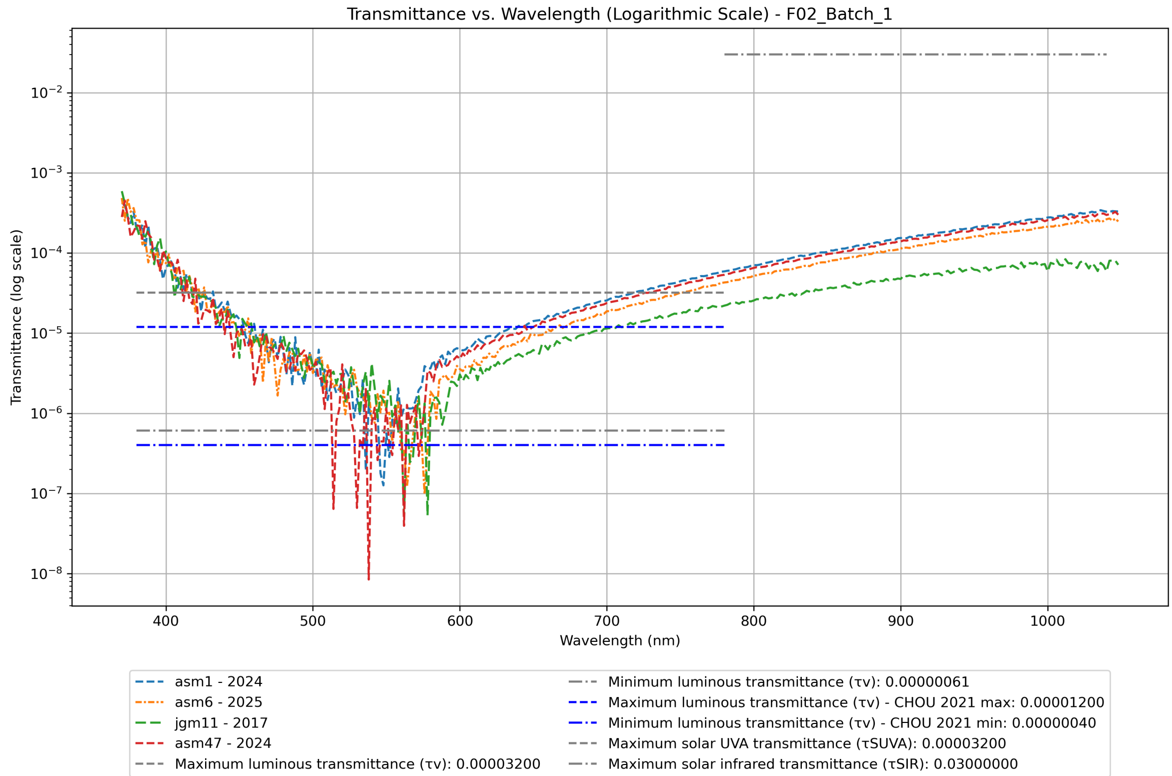

Figure 6: Transmission spectrum of manufacturer F02 (US manufacturer 1), batch 1 (logarithmic scale). ASM1, ASM6, and ASM47 were generic models, whereas JGM11 was a customized one. It is possible that the ASM glasses were acquired more recently, yet produced earlier.

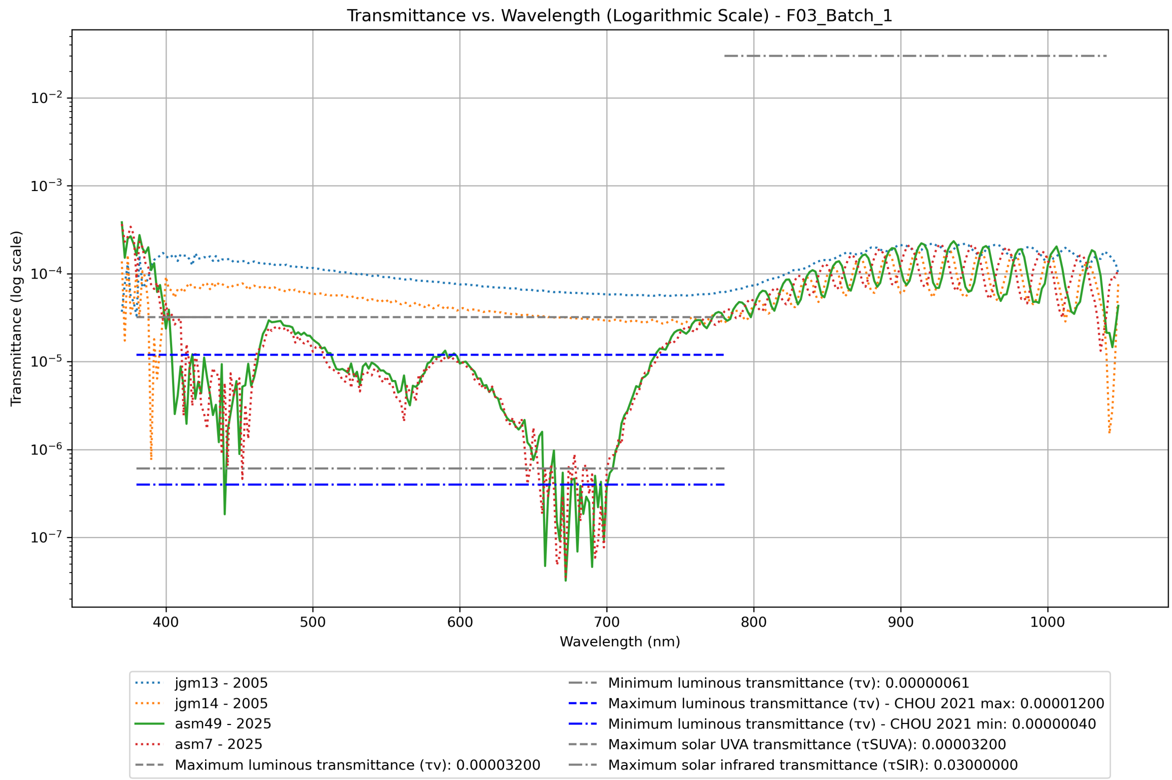

Figure 7: Transmission spectrum of manufacturer F03, batch 1 (logarithmic scale). (GE manufacturer 1) These glasses correspond to Baader Planetarium. Clearly, the 2005 glasses do not match the current standard ISO12312:2-2015, but more significantly, there is a huge difference between the two samples, even if both were kept together without much use for 20 years. The recent samples do match the 12312:2-2015 standard and use different material.

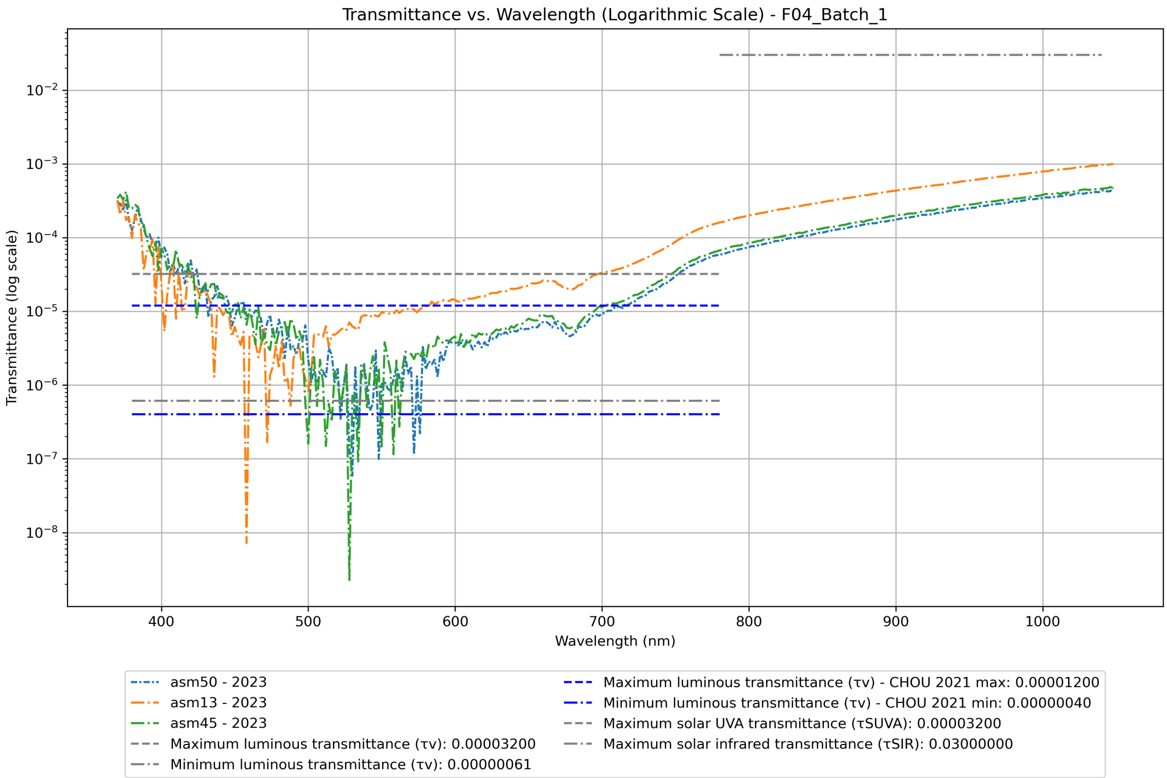

Figure 8: Transmission spectrum of manufacturer F04 (CH manufacturer 1), batch 1 (logarithmic scale).

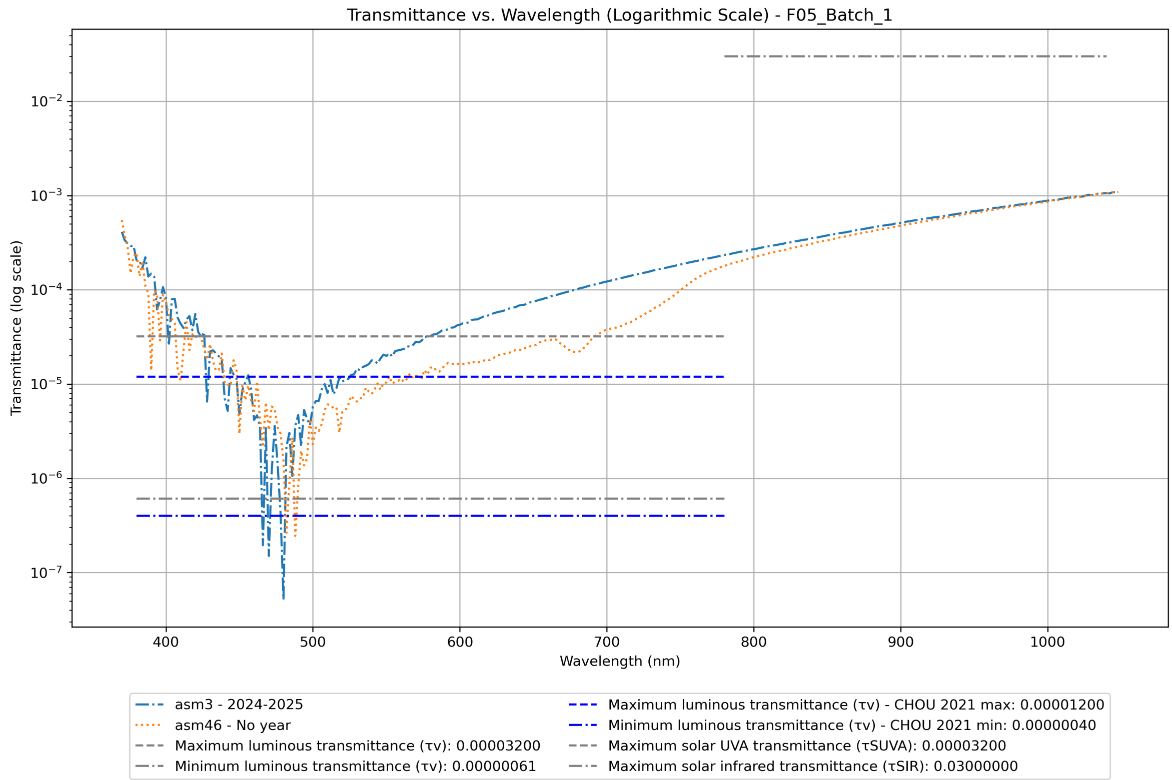

Figure 9: Transmission spectrum of manufacturer F05 (CH manufacturer 2), batch 1 (logarithmic scale). According to the packaging, both glasses are from the same manufacturer, but their transmission differs significantly. In fact, we have doubts as to whether sample ASM3 complies with the ISO 12312-2:2015 standard (see discussion). ASM3 was purchased in Spain, while ASM46 was a sample sent directly from the manufacturer. This suggests that identical packaging could potentially indicate a counterfeit version of a legitimate product. Notably, ASM46 included the manufacturer's address, whereas ASM3 did not. This case highlights the importance of proper labeling.

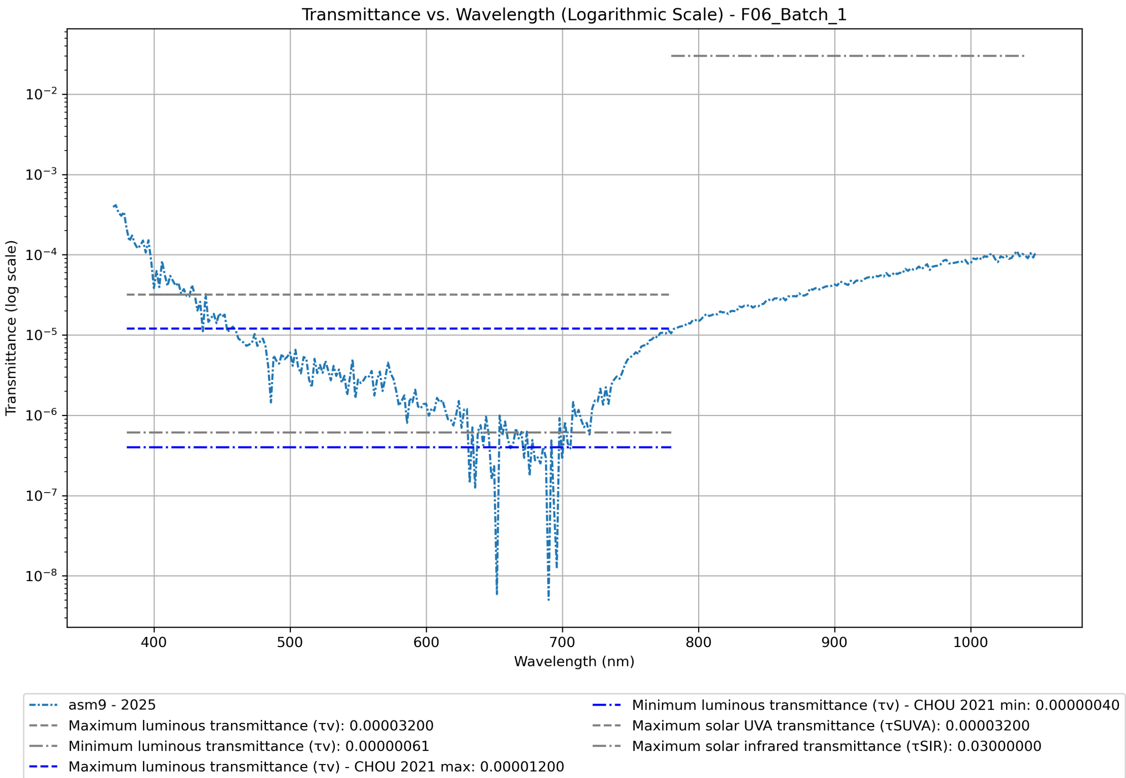

Figure 10: Transmission spectrum of manufacturer F06 (CH manufacturer 3, batch 1 (logarithmic scale).

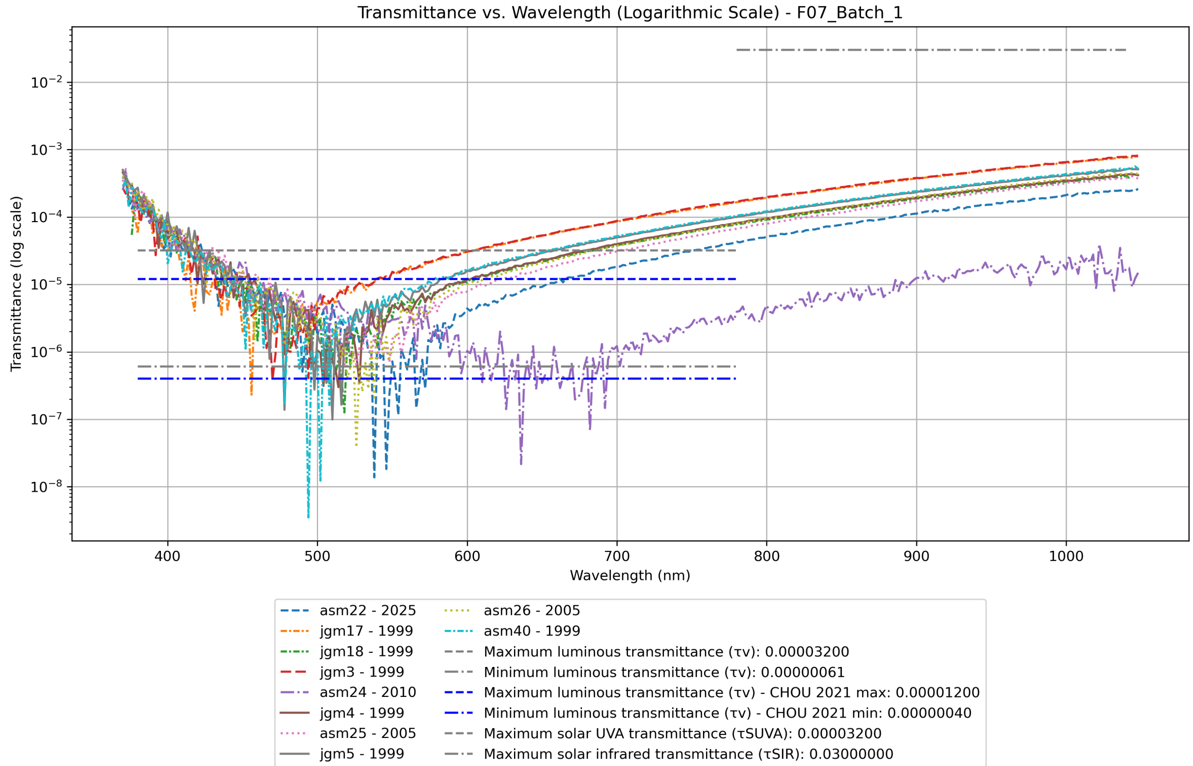

Figure 11: Transmission spectrum of manufacturer F07 (US manufacturer Rainbow Symphony/Eclipse Shades), batch 1 (logarithmic scale). Samples JGM17 and JGM3 are identical models acquired during two different sessions as part of quality control. It can be observed that older glasses tend to exhibit higher transmittance, indicating a potential degradation over time. All of these glasses were distributed by the Planetario de Madrid, except for the most recent ones, which were purchased directly from the manufacturer in the United States.

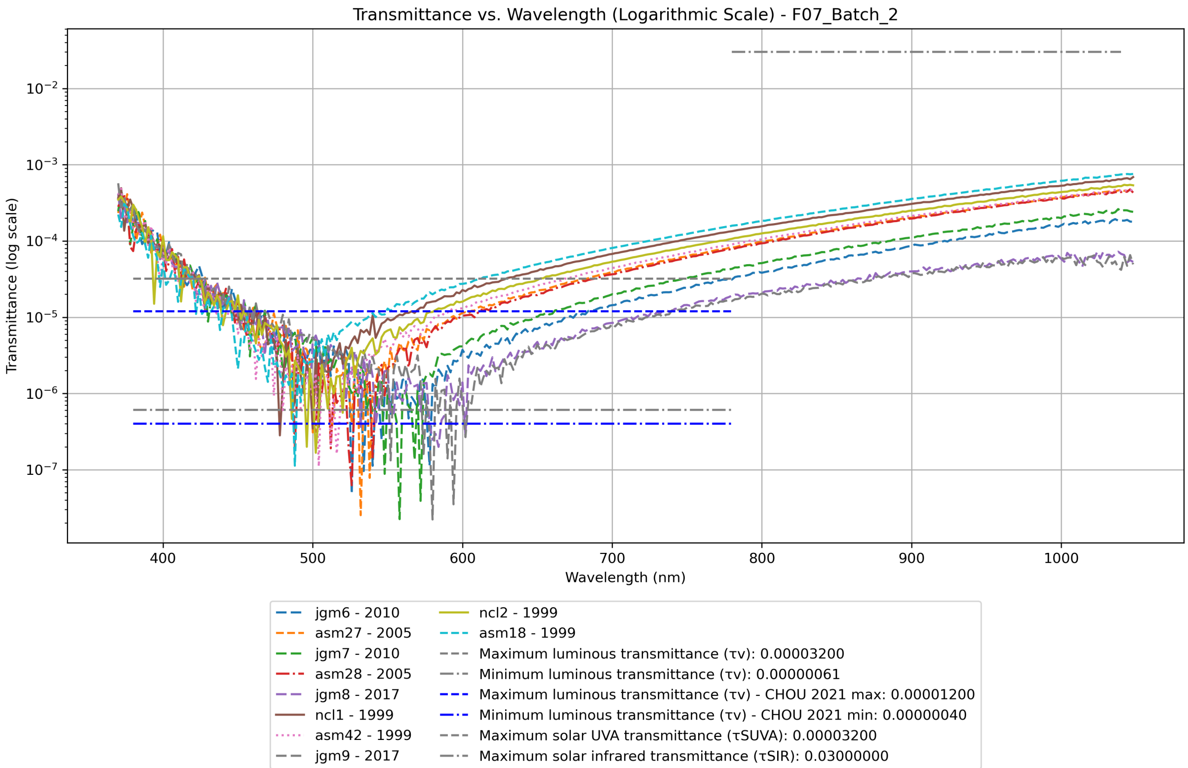

Figure 12: Transmission spectrum of manufacturer F07 (US manufacturer Rainbow Symphony/Eclipse Shades), batch 2 (logarithmic scale).

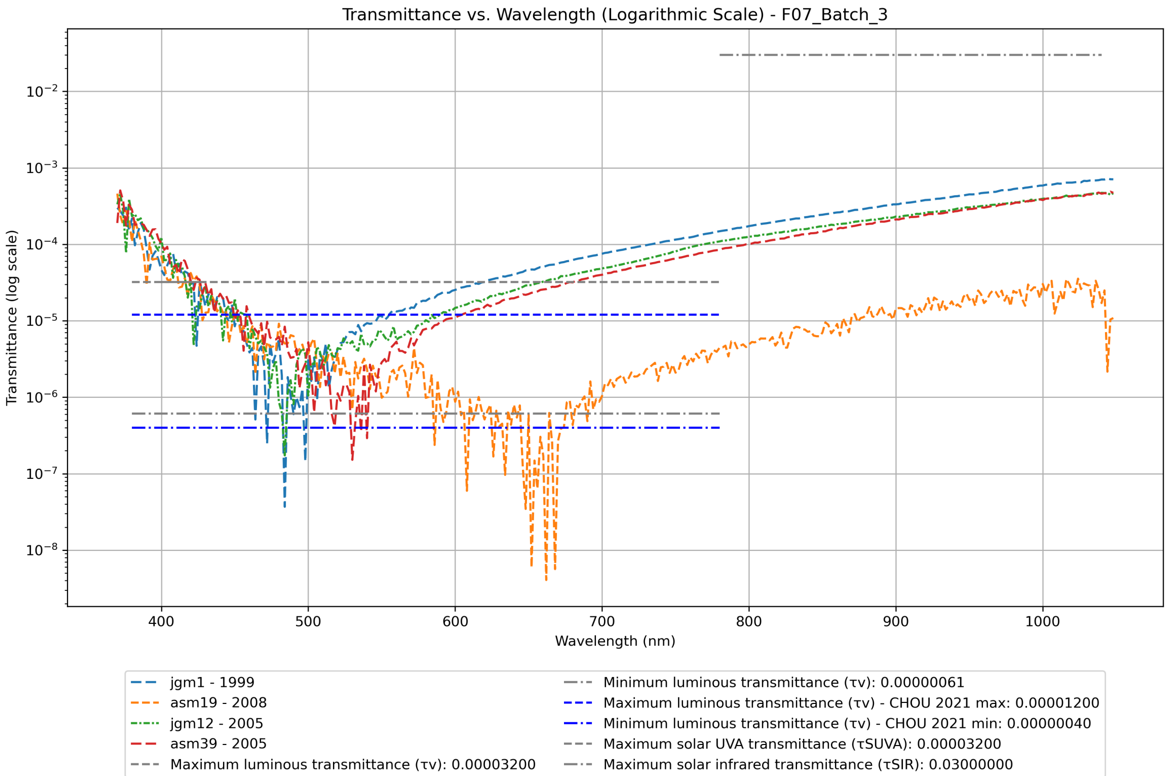

Figure 13: Transmission spectrum of manufacturer F07 (US manufacturer Rainbow Symphony/Eclipse Shades), batch 3 (logarithmic scale).

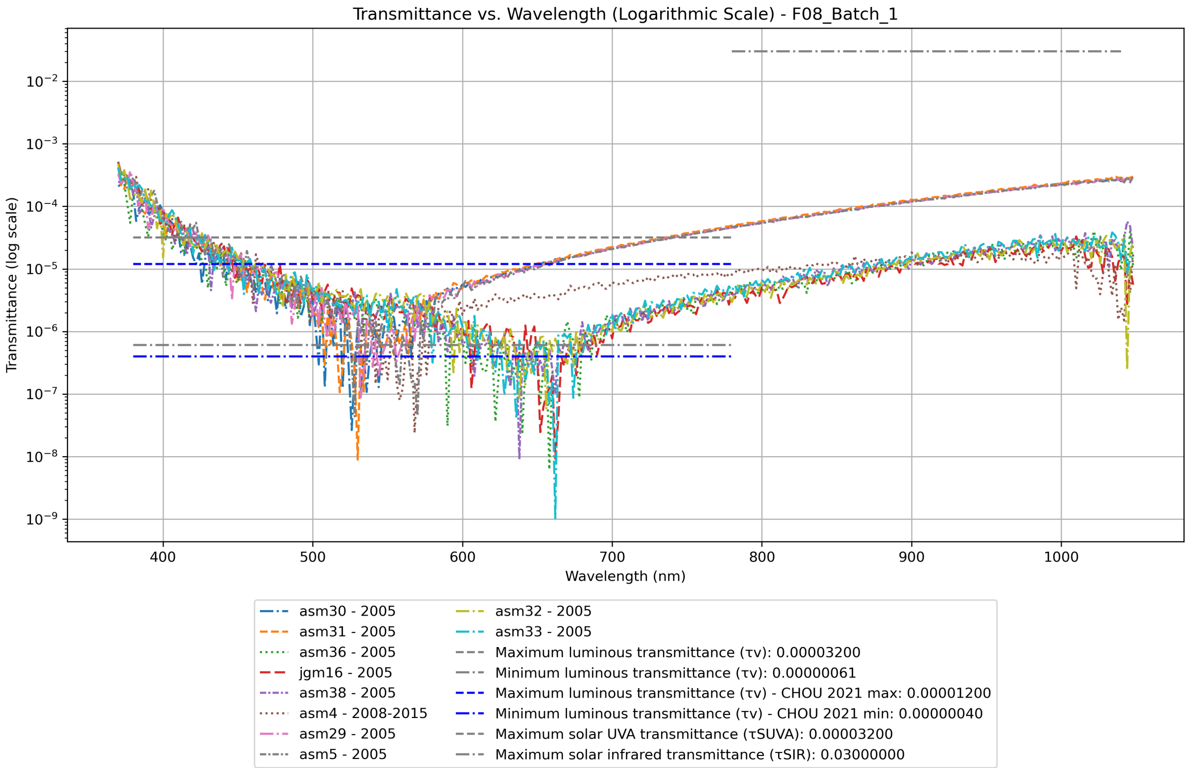

Figure 14: Transmission spectrum of manufacturer F08 (FR manufacturer 1, SOBOMEX), batch 1 (logarithmic scale). We did not observe signs of spectral degradation, but there are two different batches with noticeably different transmission. The 2008 sample is clearly made from a different material than the 2005 ones. Although the 2008 sample shows signs of optical degradation, it appears to remain spectrally safe.

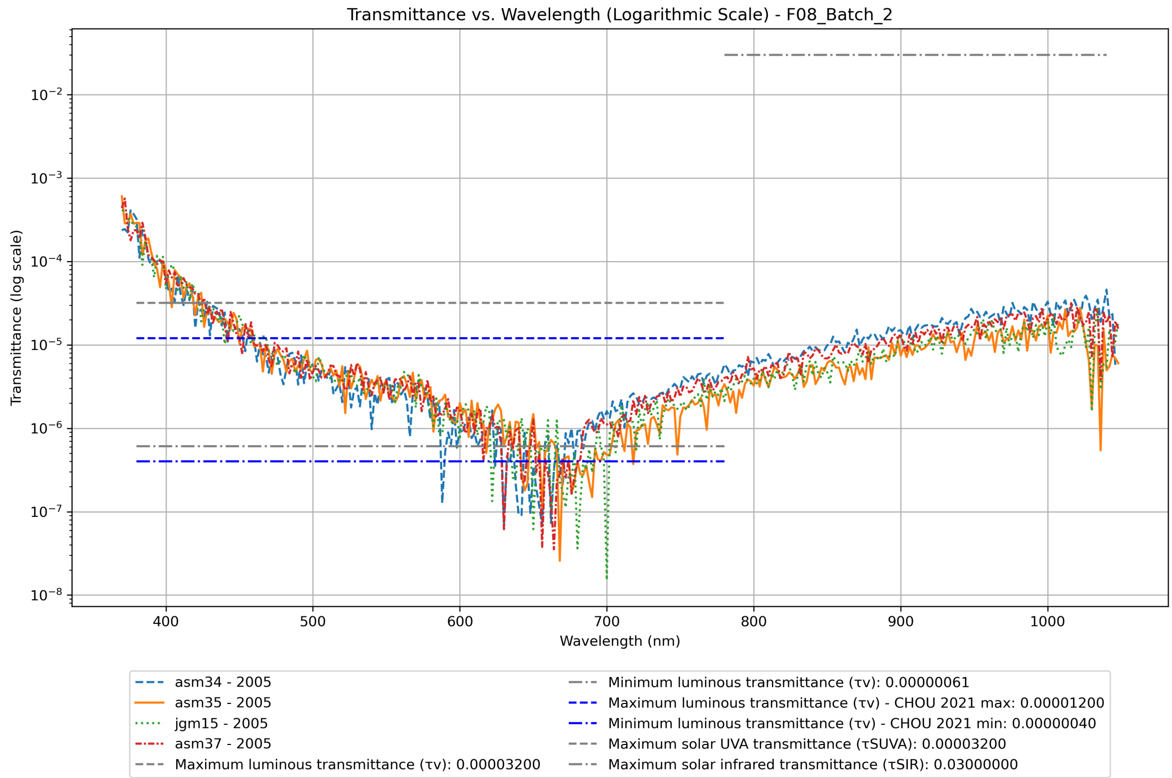

Figure 15: Transmission spectrum of manufacturer F08 (FR manufacturer 1, SOBOMEX), batch 2 (logarithmic scale).

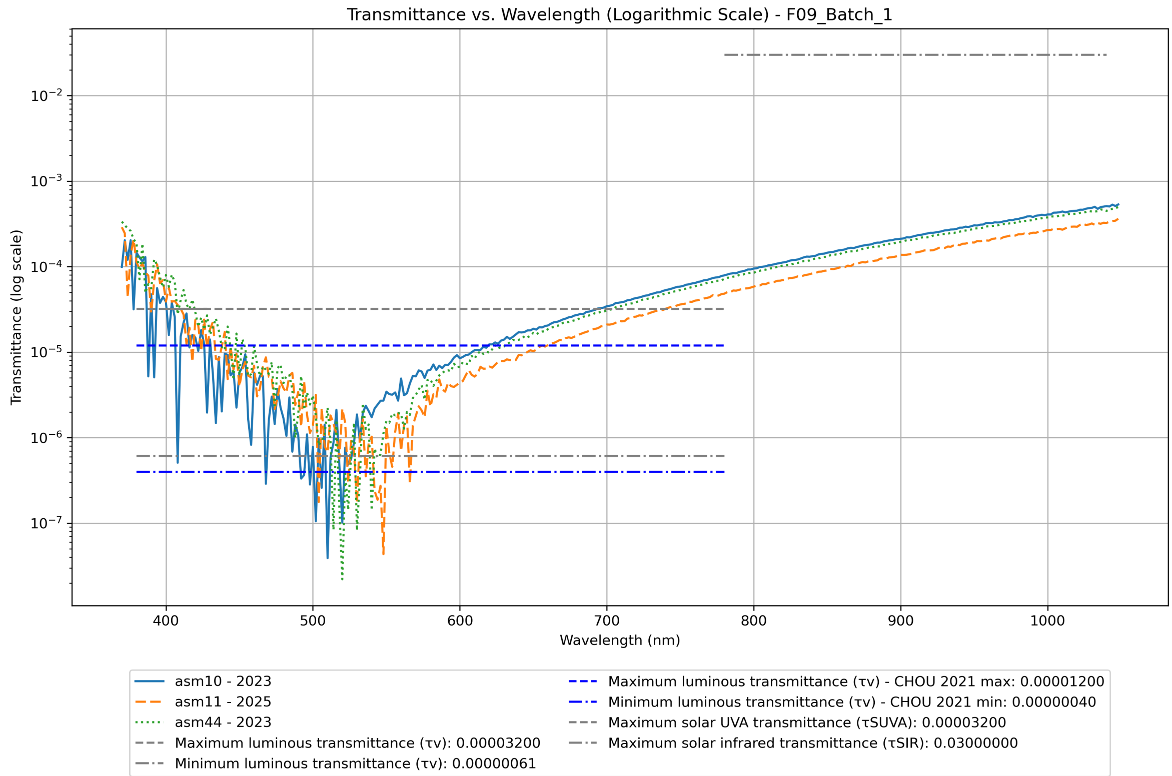

Figure 16: Transmission spectrum of manufacturer F09 (GE manufacturer 2), batch 1 (logarithmic scale).

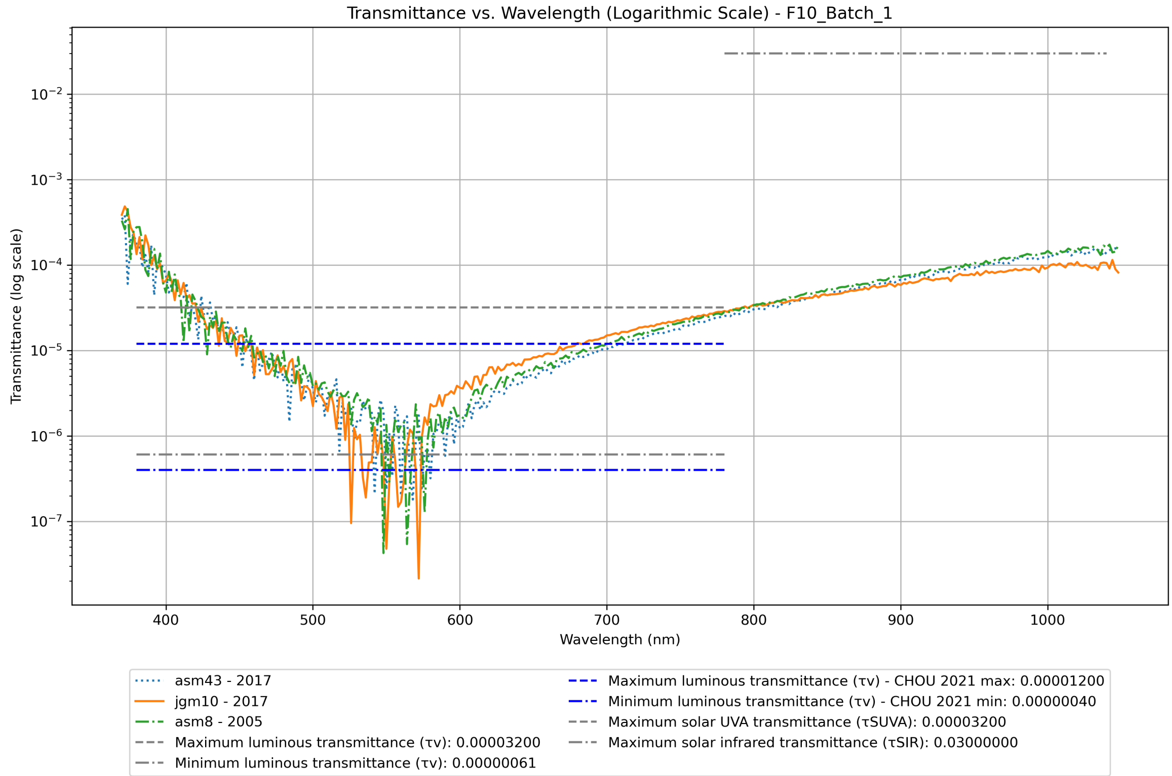

Figure 17: Transmission spectrum of manufacturer F10 (US manufacturer 3), batch 1 (logarithmic scale).

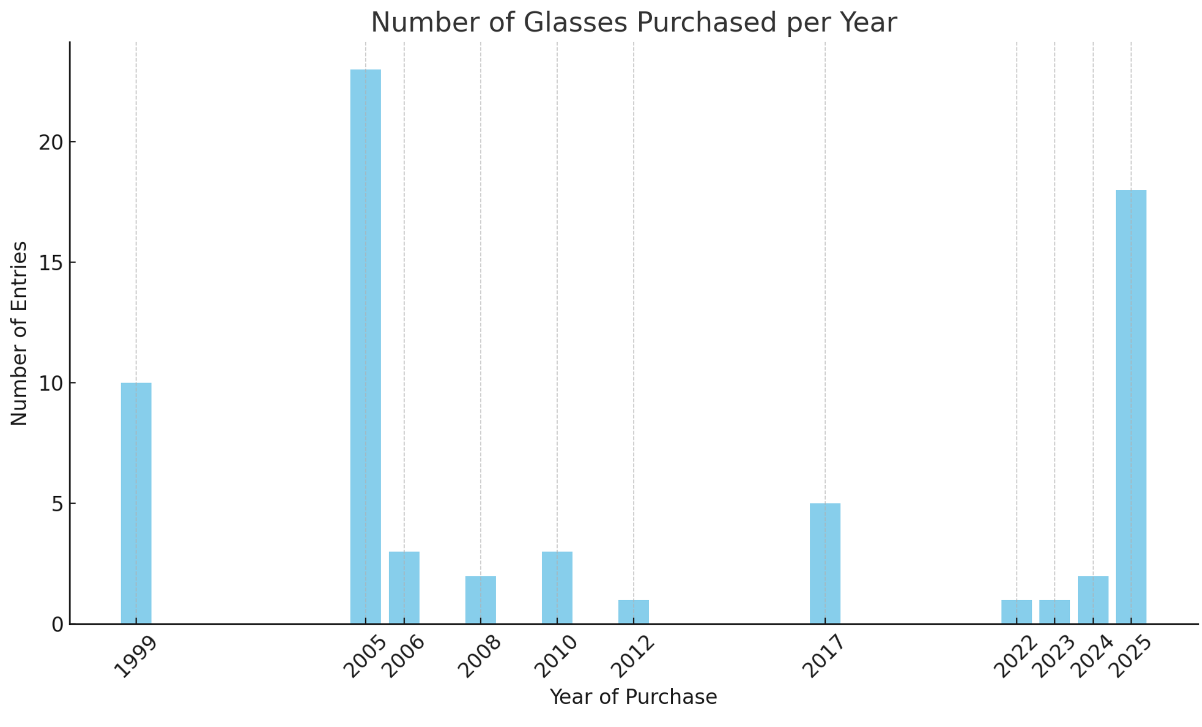

Figure 18: Distribution of the age of the glasses used in the current study.

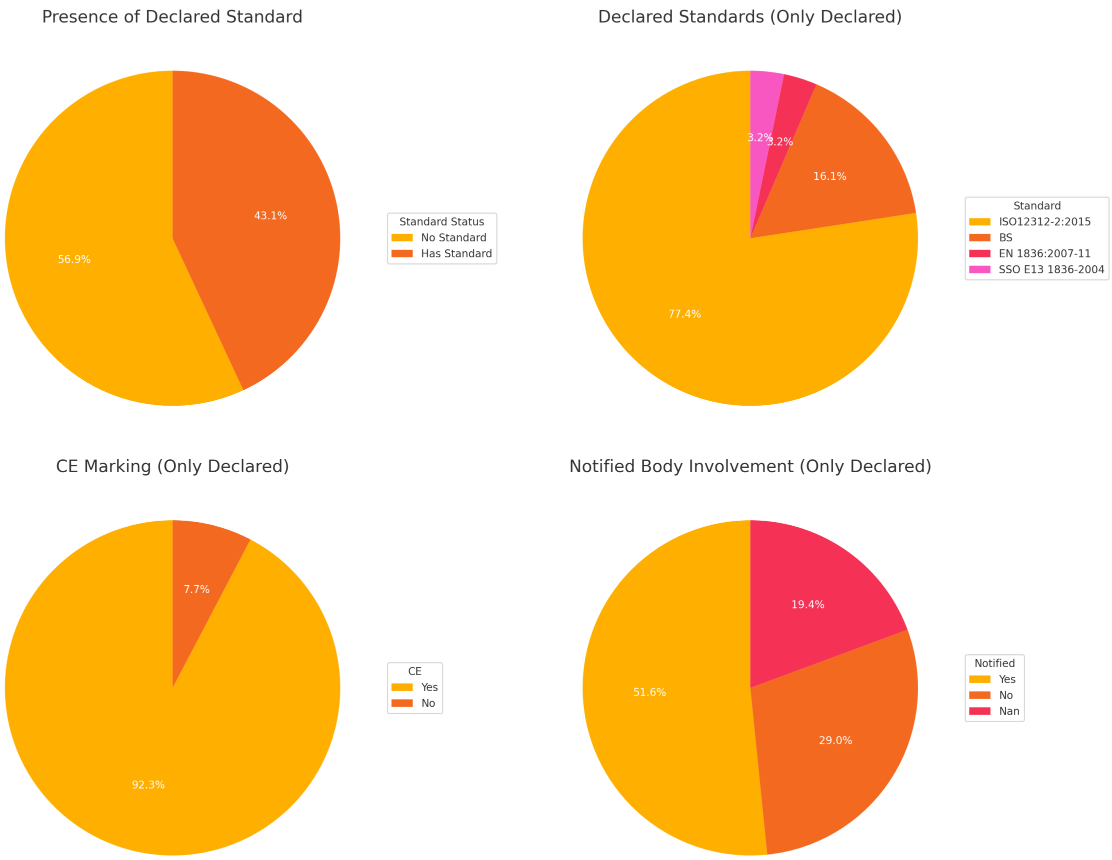

Figure 19: Statistics about several relevant indicators of the quality of these glasses on the packaging.

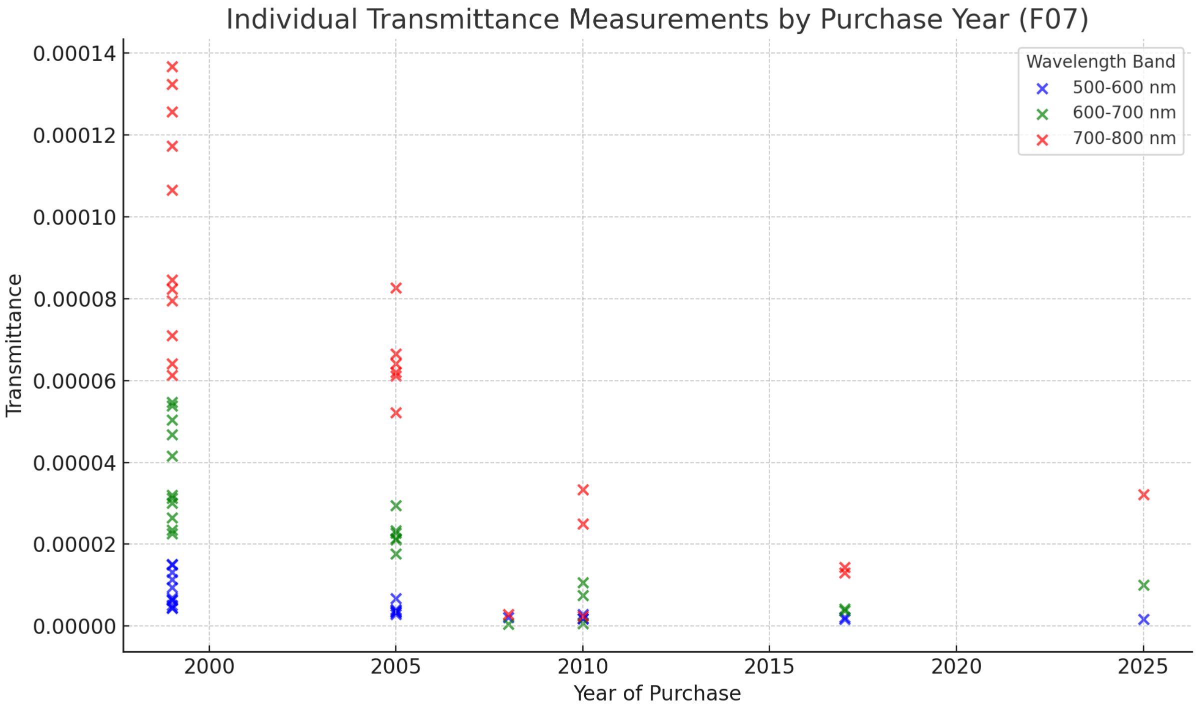

Figure 20: Transmittance of Eclipse Glasses Manufactured by Rainbow Symphony / Eclipse Shades Over the Years