EXO TERRA UVB100 8W LAMP REPORT

Testing of the 8W UVB100 T5HO Lamp from Exo Terra

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Tomaskas Ltd

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DISCLAIMER

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The details provided in this document are based on sole use, and the document contains both scientific information as well as personal opinion. Other people may have different results. The tests have been performed to our best knowledge. Although, the tests do not substitute that of a laboratory test. There are uncontrollable variables when testing a small batch of any item. Different items of the same model number may differ due to their manufacturing batch or operating conditions.

This document may refer to the overall exotic animal keeping hobby as the “reptile hobby”, but this is a force of habit – Tomaskas Ltd. does in fact mean the keeping of the broader herpetological spectrum, including invertebrates, amphibians, and even birds.

REASONS FOR TEST

These tests were completed independently on behalf of Exo Terra – a brand of Hagen Group. Hagen Group is based in Canada, but being a global organisation they have a product development and management team in Europe. They produce and sell products for the reptile community all over the world under the Exo Terra brand, and have done for many years.

In order to provide the hobby with a base understanding of such products, it's important that independent tests are conducted. We have a duty, as a community, to look out for each other and share appropriate good practice.

These tests aim to discover if products are suitable for the hobby, independent of the brand's claims. These tests aim to provide a better understanding of the product in question. The product is marketed to primarily be a UVB/UVA2 provision.

This report was paid for by Exo Terra for public release. They have not seen the report before publishing or had any say in redacting information. Tomaskas Ltd. consulted on the product development.

PRODUCT TESTED

The following product was tested:

EXO TERRA UVB100 8W T5HO LAMP

This report summaries a set of tests on 5 lamps (*n=5*) in total. The lamps were provided by Exo Terra, not in final packaging.

Product code is PT2380.

Lamps were uniquely numbered for testing purposes (001-005).

Alongside the lamp product, tests were conducted using the associated fixture from Exo Terra (a prototype unit of the product code PT4255), common Exo Terra enclosures (PT2609, PT2608, and PT2607), as well as components from a new upcoming range of Exo Terra enclosures (The 'Vista' range, specifically product code PT2589). All were provided by Exo Terra for free for testing purposes.

INITIAL OBSERVATIONS

DESCRIPTION AND BUILD QUALITY

The product is a T5 lamp, approx. 313mm in total length. Being glass, it is delicate.

The lamp features a range of markings, including CE, UKCA, Hg, and some other regulatory statements.

The lamps clearly state that they were made in Germany.

There are markings printed on both ends of the glass tube, for batch reporting purposes. Below are details of the codes on each lamp:

Lamp	001	002	003	004	005
Code 1 (Stamped)	IIYY[] 8W REP5	IIYY[] 8W REP5	IIYY[] 8W REP5	IIYY[] 8W REP5	IIYY[] 8W REP5
Code 2 (Black Dot Matrix)	08 PIF	36 PIK	27 PJA	28 PIK	32 PIL
Code 3 (Faded Dot Matrix)	11	14	21	12	11

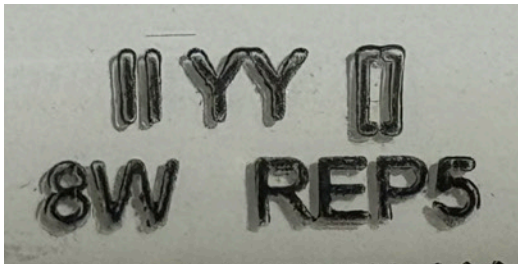
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PHOTOGRAPHS

Here are some images of the lamps, with examples of the codes seen











UV PERFORMANCE

BURN-IN

As it can be presumed that most average consumers will not burn-in their lamp, I have measured the UV as it changes over the first 100 hours of use.

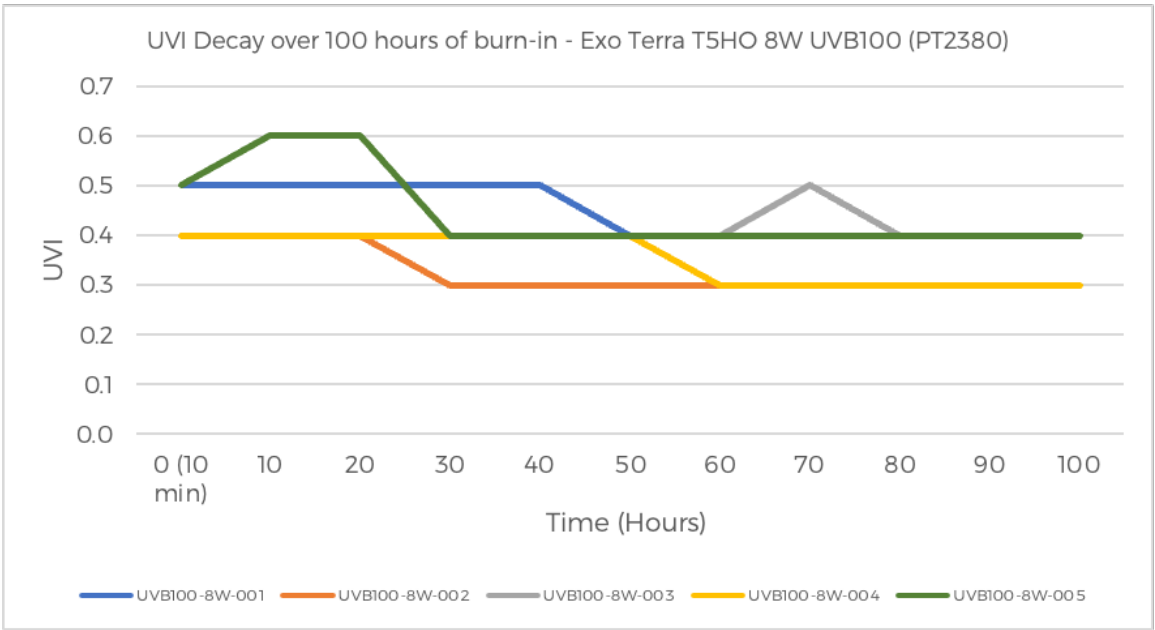
I have measured the UVI (Solarmeter 6.5) and the UVB in μW/cm² (Solarmeter 6.2) at 25cm from the centre of the lamp over the first 100 hours without any fixture in use. Below are the measurements:

Time (hours)		0 (10 mins)	10	20	30	40	50	60	70	80	90	100
001	UVI	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4
	(μW/cm²)	25	25	24	23	23	23	23	23	23	23	23
002	UVI	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	(μW/cm²)	24	24	23	23	22	20	20	22	22	22	22
003	UVI	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4
	(μW/cm²)	24	23	24	22	21	21	23	23	23	23	23
004	UVI	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3
	(μW/cm²)	24	23	21	19	18	18	20	22	22	23	22
005	UVI	0.5	0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	(μW/cm²)	24	23	23	22	21	21	22	22	21	22	22

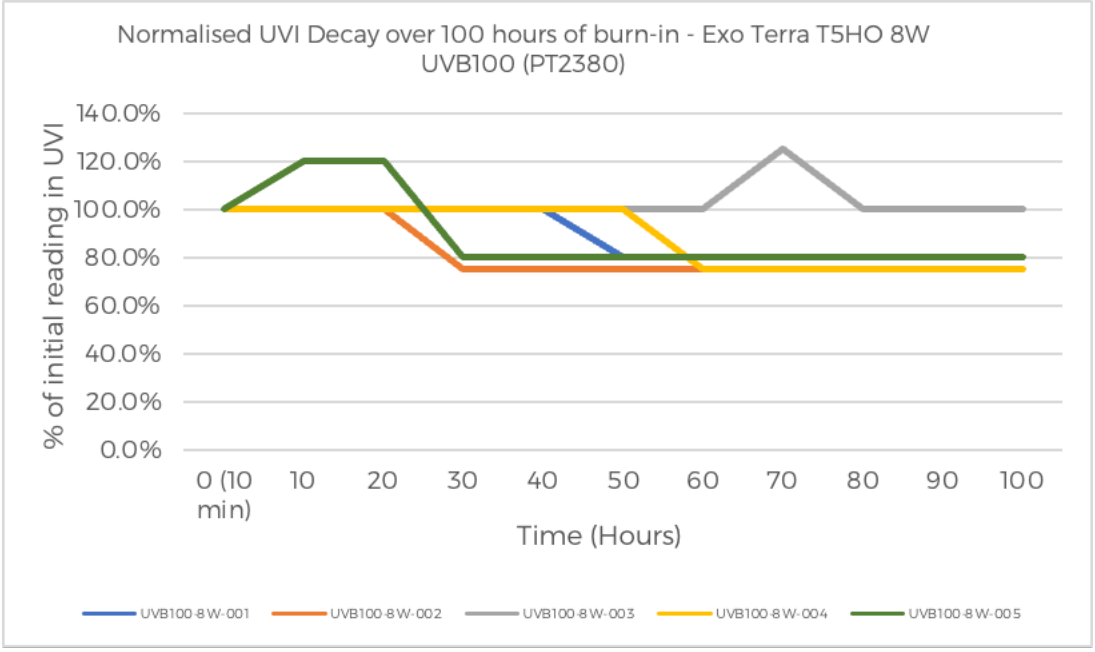
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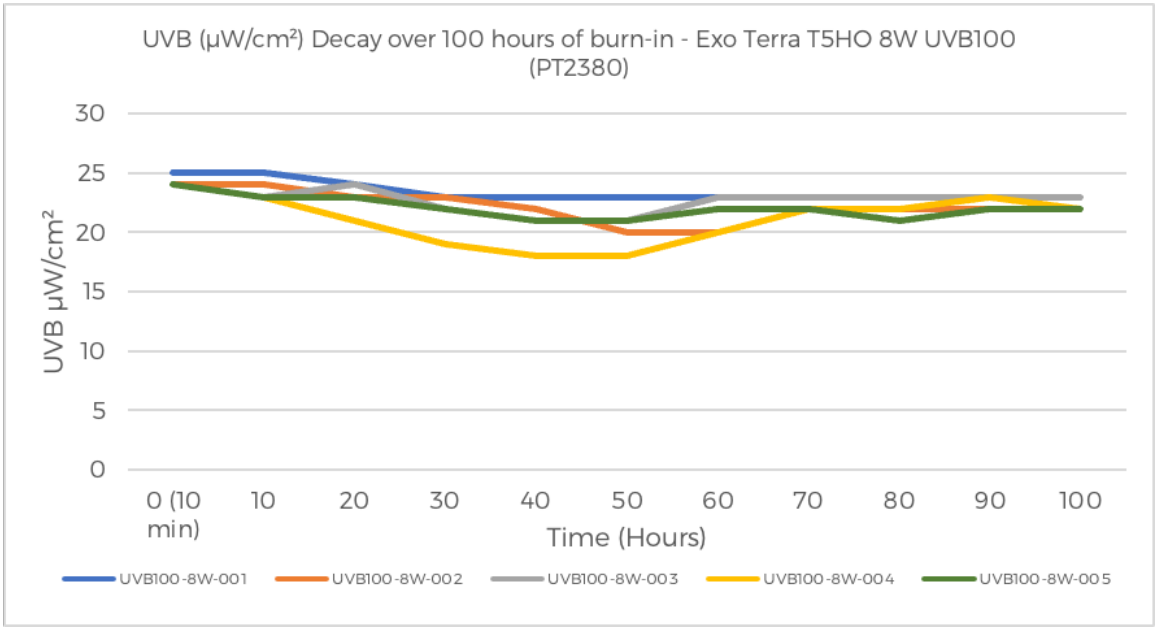
The following is the same data displayed as a graph, for UVI.



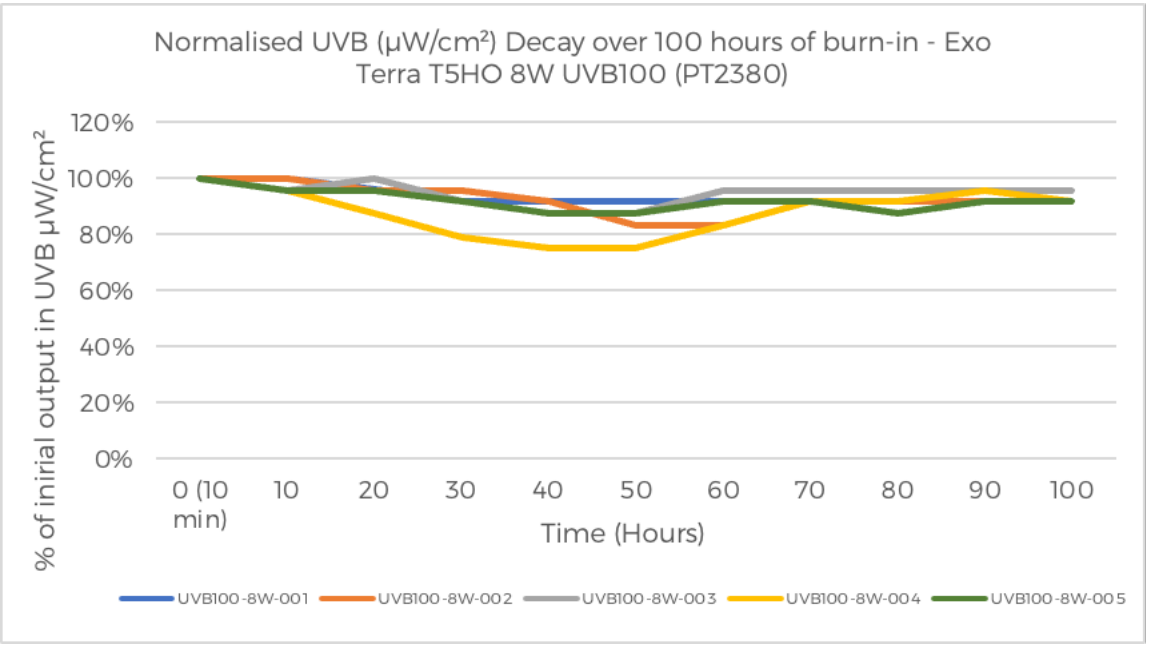
And again, but normalised to the initial reading being 100%.



The following is the same data displayed as a graph, for UVB in µW/cm².



And again, but normalised to the initial reading being 100%.

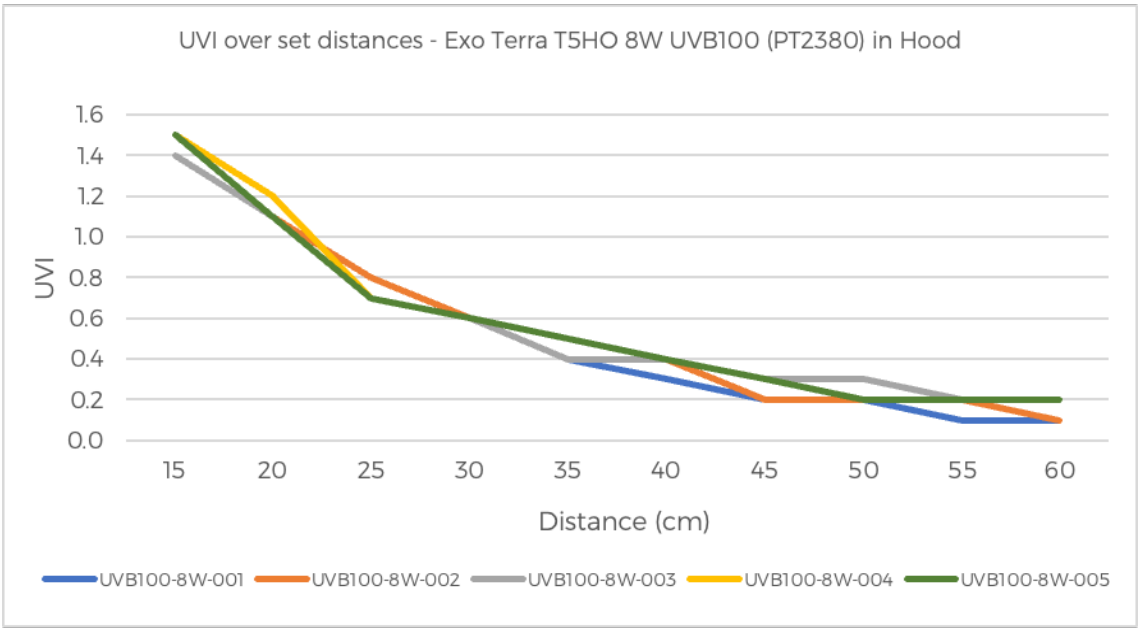


AFTER BURN-IN

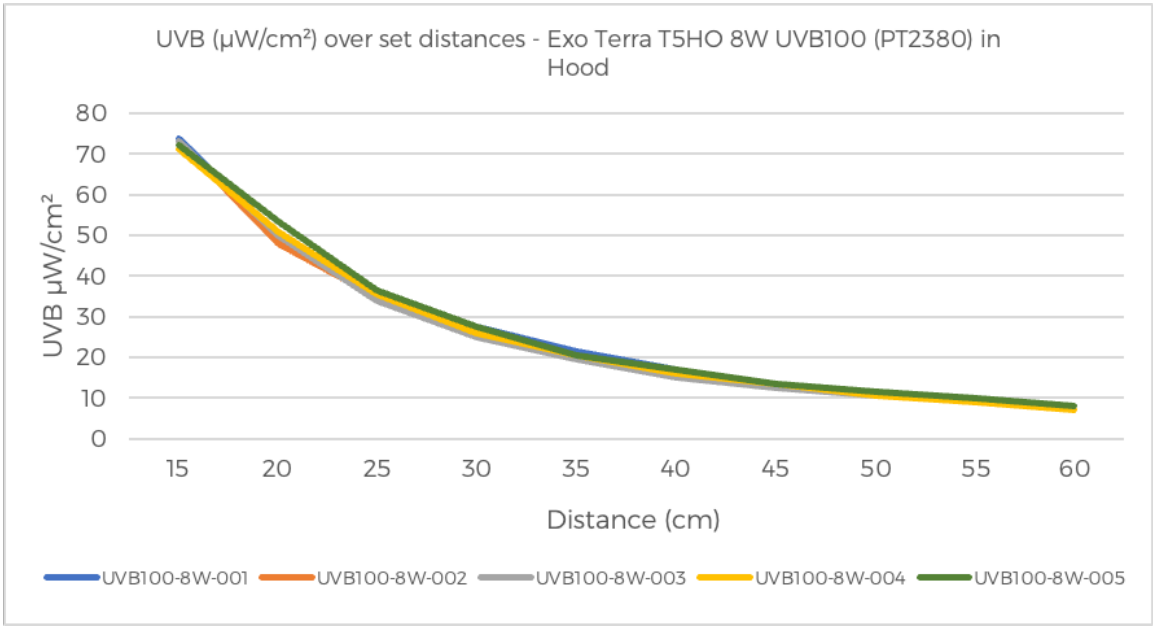
After the burn-in, I measured the UVI (Solarmeter 6.5), the UVB in µW/cm² (Solarmeter 6.2) and lux (RS PRO ILM1335 Light Meter) at set distances for this test. This test was conducted inside the Exo Terra prototype fixture.

Distance (cm)		15	20	25	30	35	40	45	50	55	60
001	UVI	1.4	1.1	0.8	0.6	0.4	0.3	0.2	0.2	0.1	0.1
	(µW/cm²)	74	50	36	28	21	17	13	12	10	8
	lux	1527	1093	775	605	468	381	323	278	222	197
002	UVI	1.5	1.1	0.8	0.6	0.5	0.4	0.2	0.2	0.2	0.1
	(µW/cm²)	73	48	35	25	20	16	12	11	9	8
	lux	1529	1092	799	619	482	390	326	281	227	199
003	UVI	1.4	1.1	0.7	0.6	0.4	0.4	0.3	0.3	0.2	0.2
	(µW/cm²)	73	50	34	25	20	15	12	11	9	7
	lux	1532	1118	809	613	471	370	312	266	234	195
004	UVI	1.5	1.2	0.7	0.6	0.5	0.4	0.3	0.2	0.2	0.2
	(µW/cm²)	71	51	36	26	20	16	13	11	9	7
	lux	1598	1091	803	623	491	395	335	290	241	201
005	UVI	1.5	1.1	0.7	0.6	0.5	0.4	0.3	0.2	0.2	0.2
	(µW/cm²)	72	53	36	28	20	17	13	12	10	8
	lux	1501	1103	802	603	458	368	285	248	221	190

The following is the same data displayed as a graph for UVI.



The following is the same data displayed as a graph for UVB in µW/cm².



The following is the same data displayed as a graph for lux.



IRRADIANCE CHARTS

PURPOSE

The charts in this chapter are an indication of UVI output from the lamp at set distances.

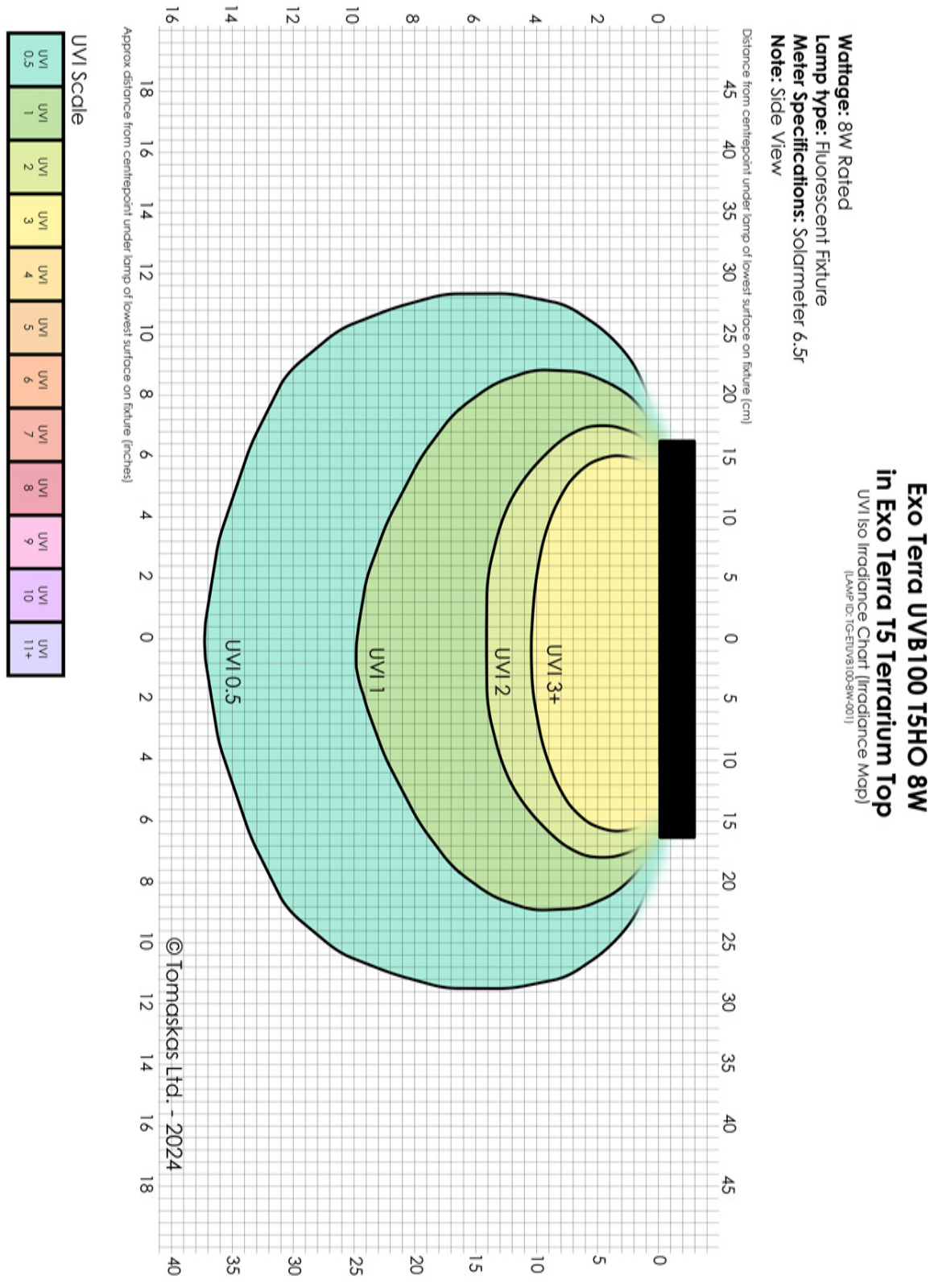
It is possible to visualise how the lamp emits UVB as a whole, using UVI as a figure.

DISCLAIMER

The charts do not make claim to the safety of the lamps, as there is no data on the spectrum included in the charts. The charts are a guide only. The charts are to scale. The charts are from a single lamp, not an average of the batch tested.

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SIDE VIEW



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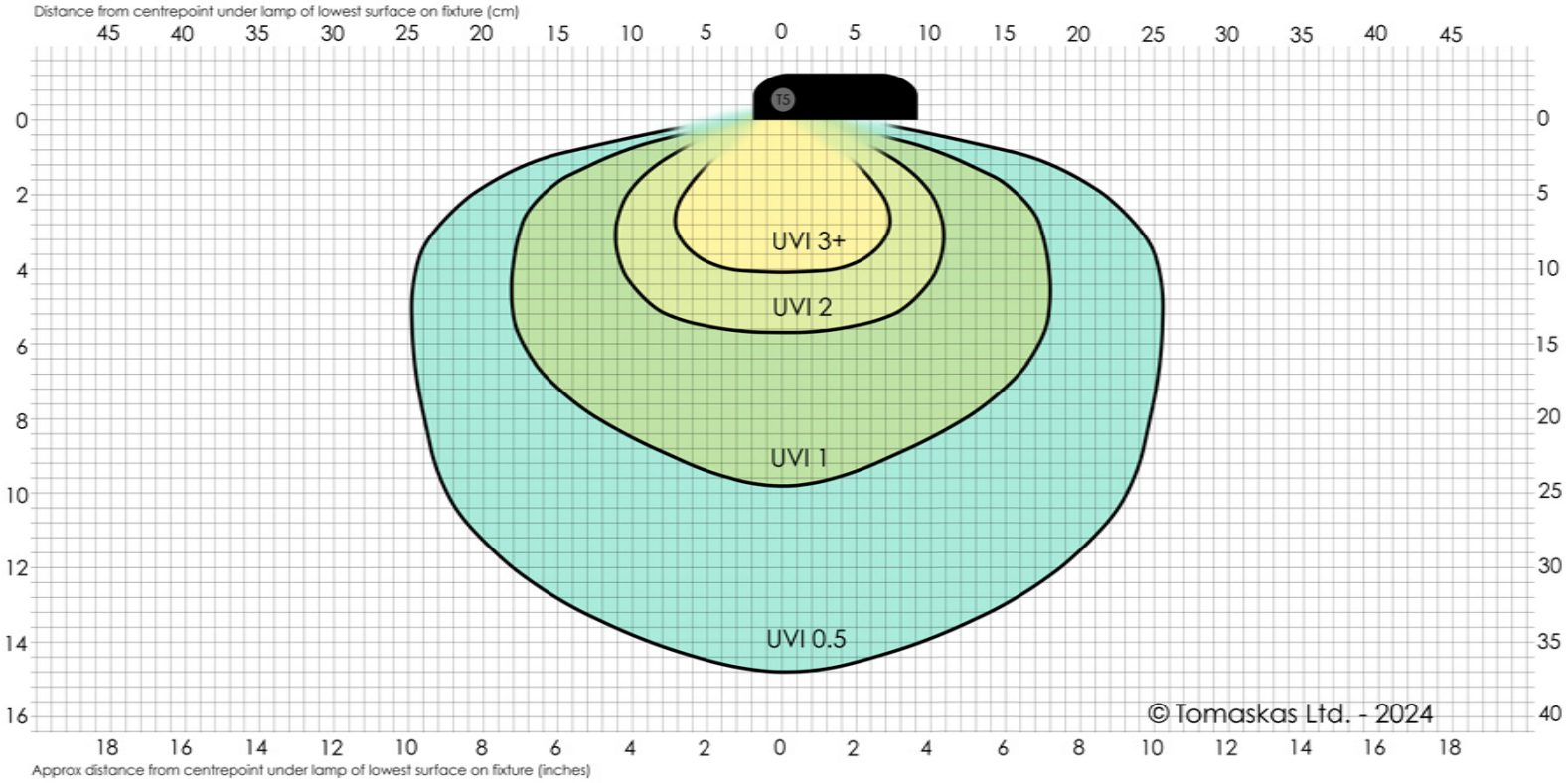
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Exo Terra UVB100 T5HO 8W
in Exo Terra T5 Terrarium Top

UVI Iso Irradiance Chart (Irradiance Map)

(LAMP ID: TG-ETUVB100-8W-001)

Wattage: 8W Rated
Lamp type: Fluorescent Fixture
Meter Specifications: Solarmeter 6.5r
Note: End-on View



UVI Scale

UVI 0.5	UVI 1	UVI 2	UVI 3	UVI 4	UVI 5	UVI 6	UVI 7	UVI 8	UVI 9	UVI 10	UVI 11+

'END-ON' VIEW

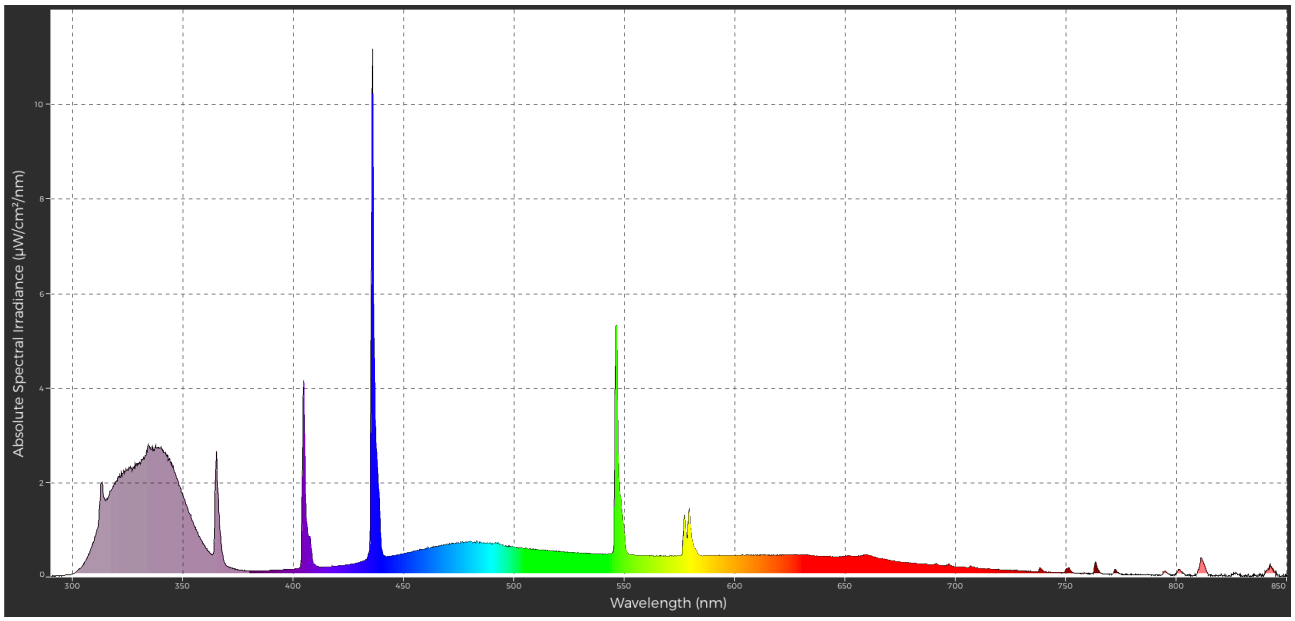
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SPECTRAL MEASUREMENTS

UV AND VIS SPECTRUM (ONE LAMP)

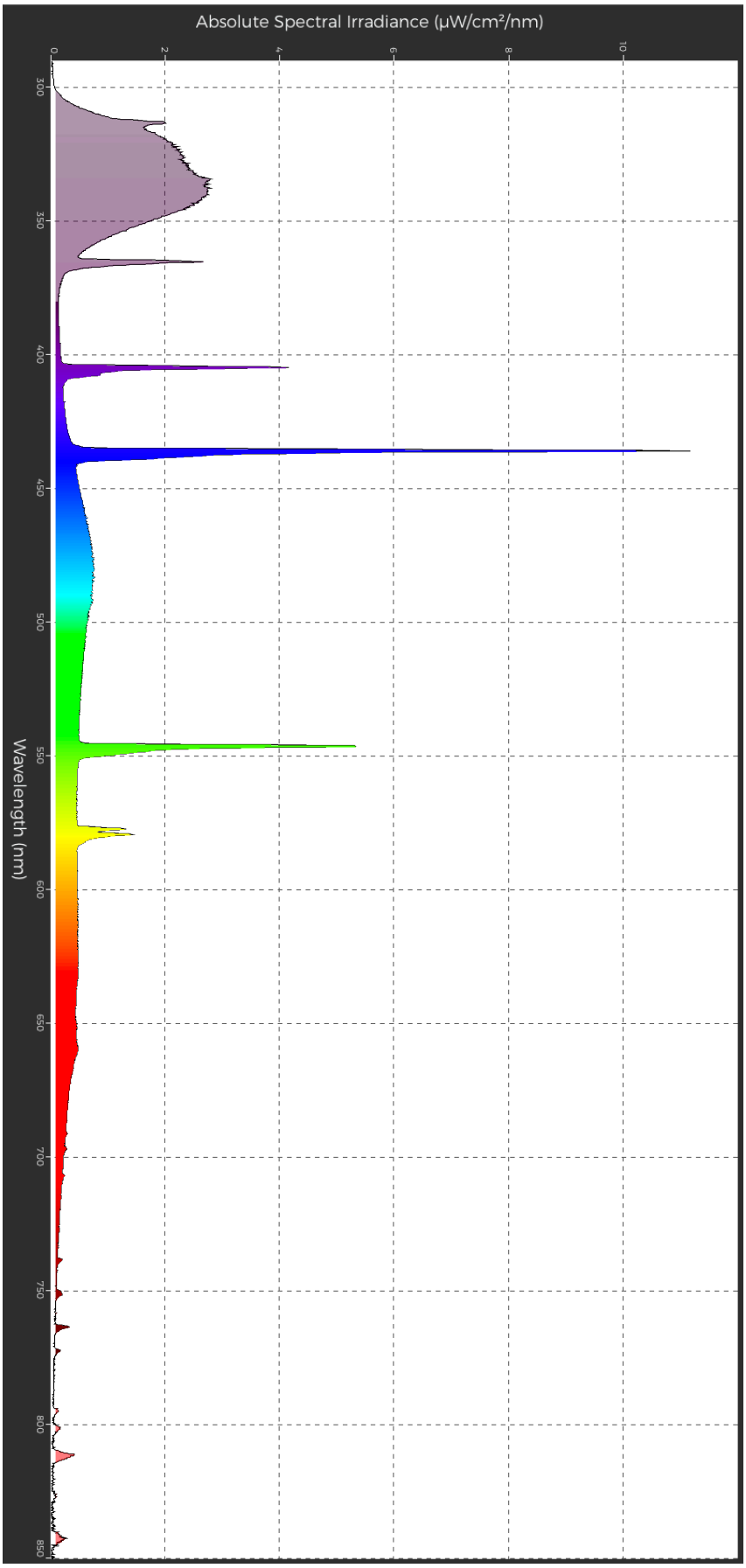
Below is the spectrum from Lamp 001, showing 280-800nm (UVB, UVA, visible light, and the start of IRA). Reading taken whilst in the Exo Terra fixture.



Full page version overleaf.

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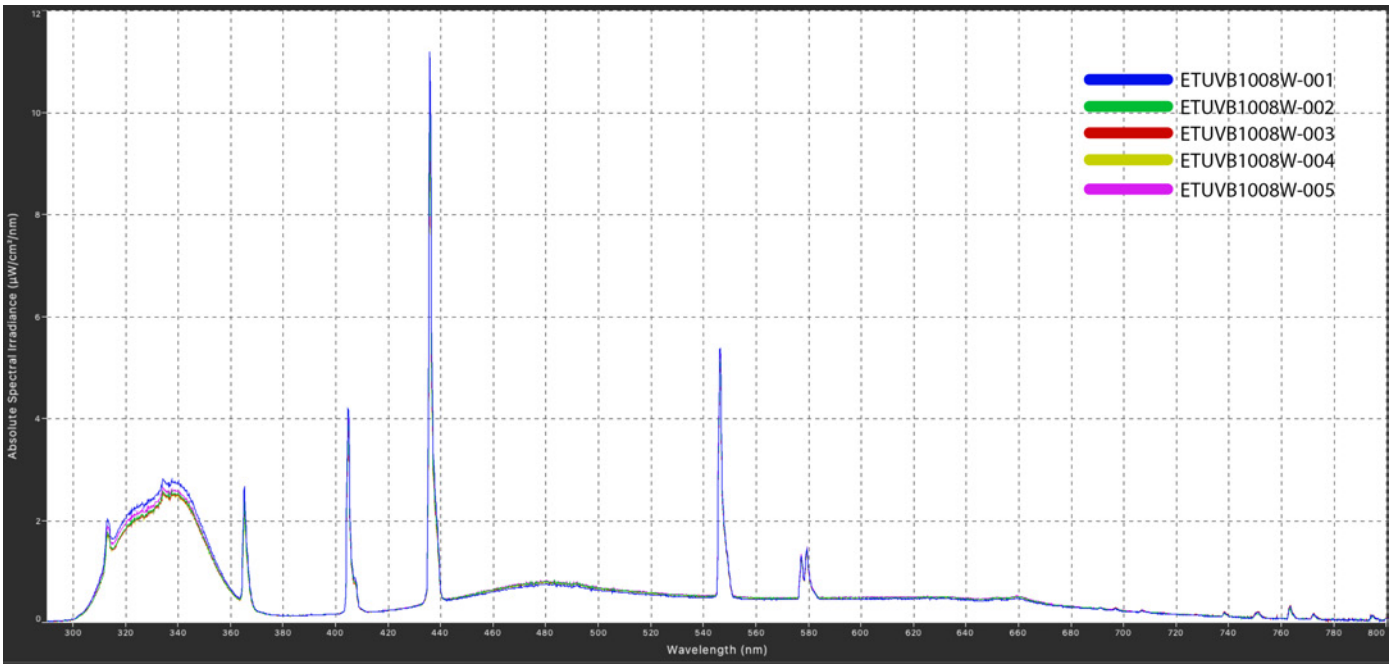


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UV AND VIS SPECTRUM (ALL LAMPS)

Below is the spectrum from all lamps, showing 280-800nm (UVB, UVA, visible light, and the start of IRA). Readings taken whilst in the Exo Terra fixture.

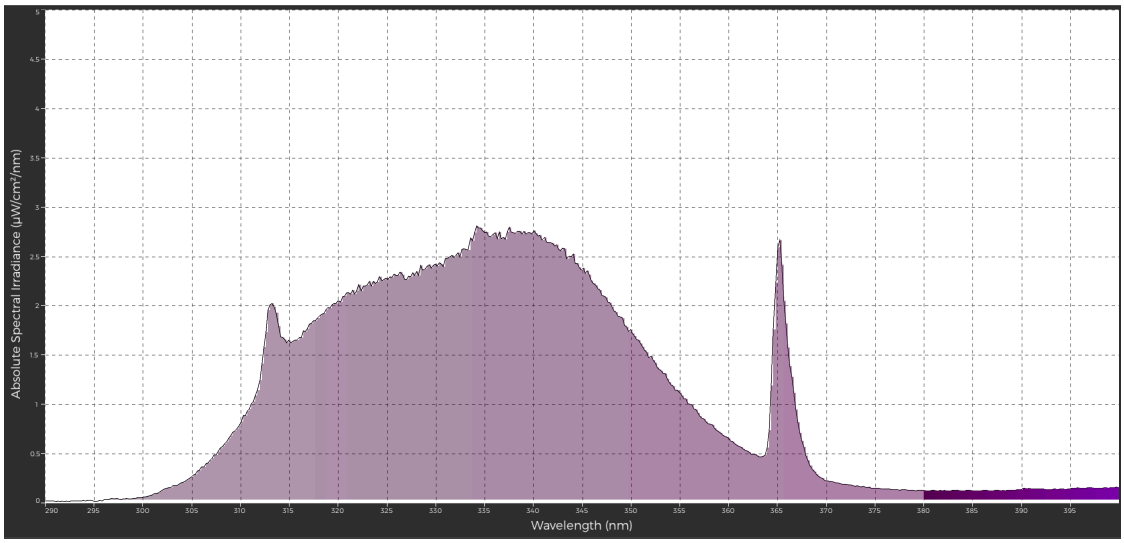


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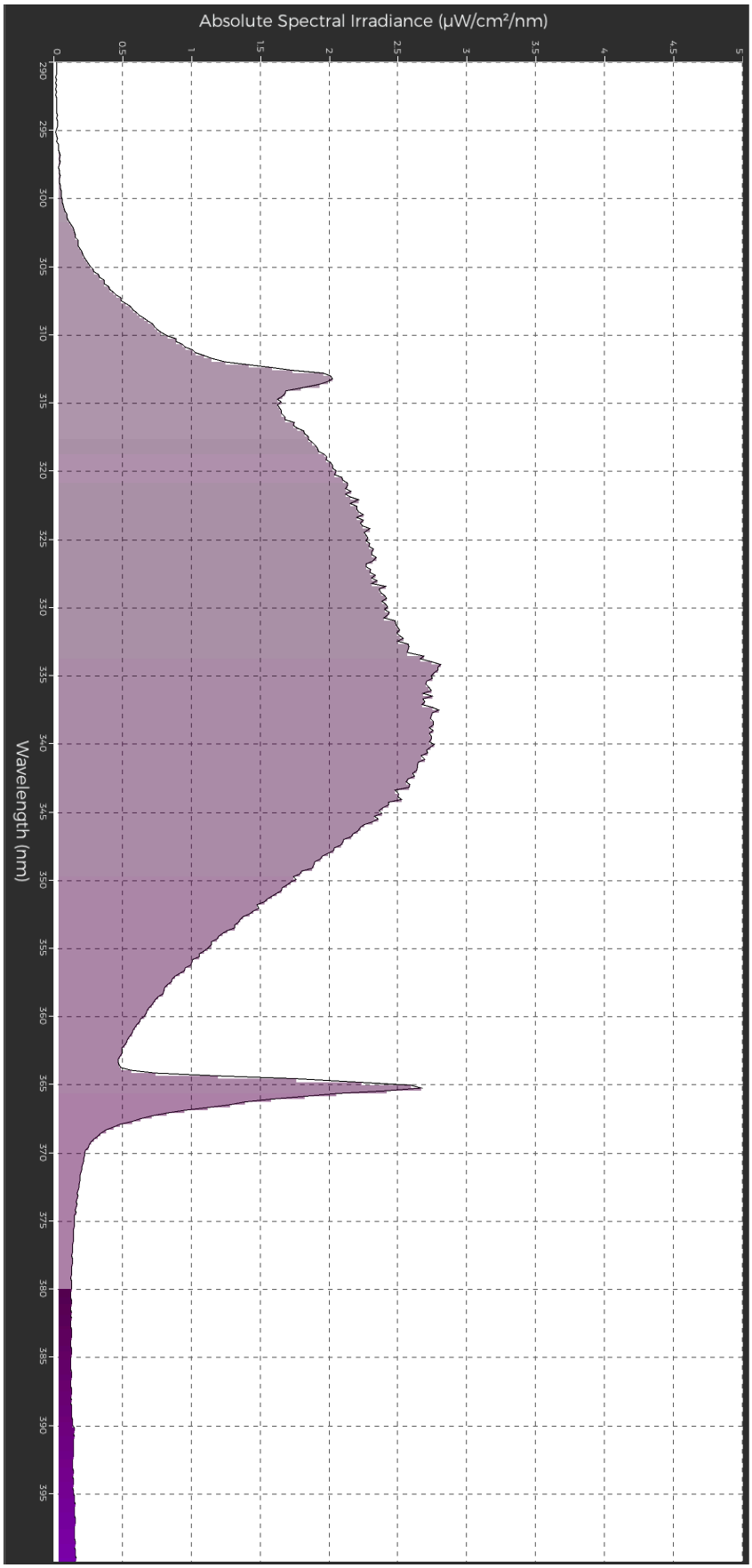
UV SPECTRUM (ONE LAMP)

Below is the spectrum from Lamp 001, showing 280-400nm (UVB and UVA). Reading taken whilst in the Exo Terra fixture.



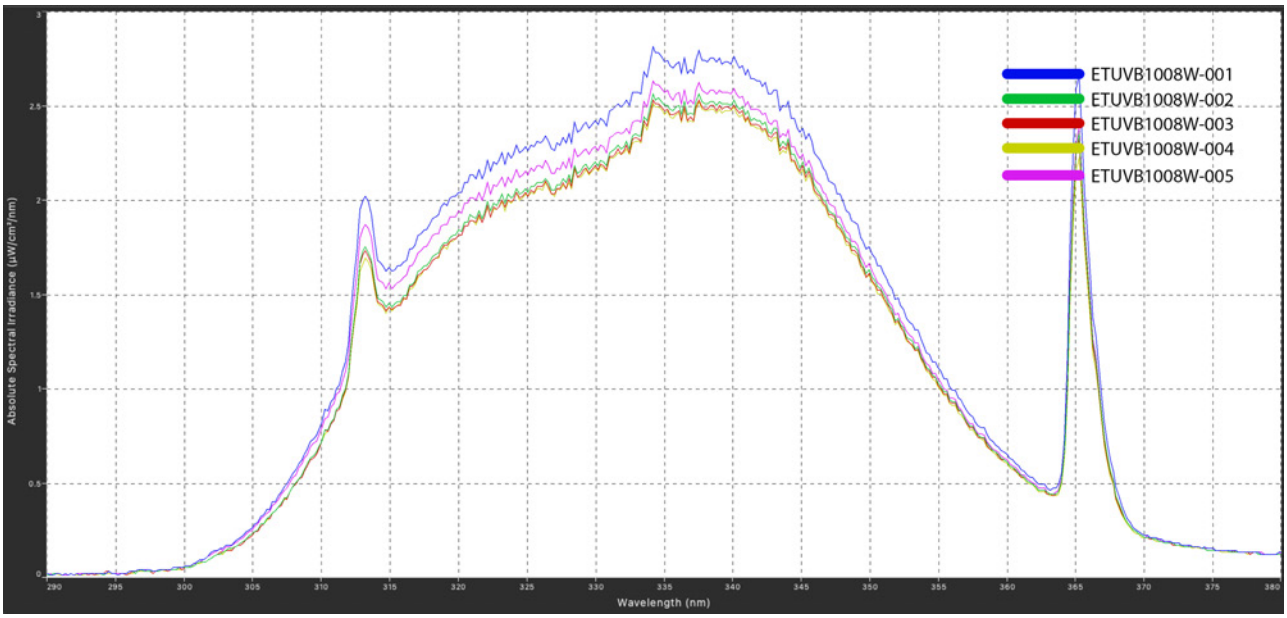
Full page graph is on the next page. Commentary is in a later section.

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Absolute Spectral Irradiance (µW/cm²/nm)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Wavelength (nm)
290
295
300
305
310
315
320
325
330
335
340
345
350
355
360
365
370
375
380
385
390
395

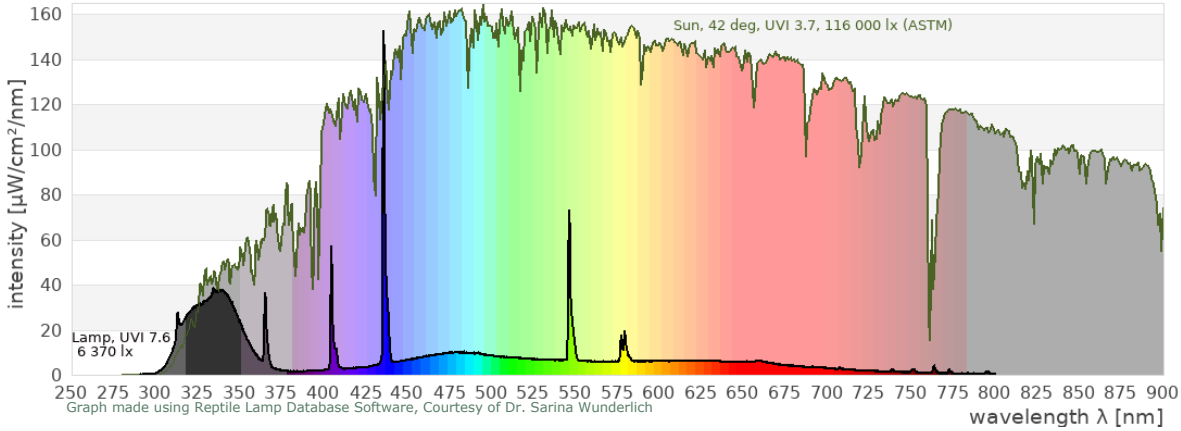
UV SPECTRUM (ALL LAMPS)

Below is the spectrum from all lamps, showing 280-380nm (UVB and most of UVA). Readings taken whilst in the Exo Terra fixture.



SUNLIGHT COMPARISON

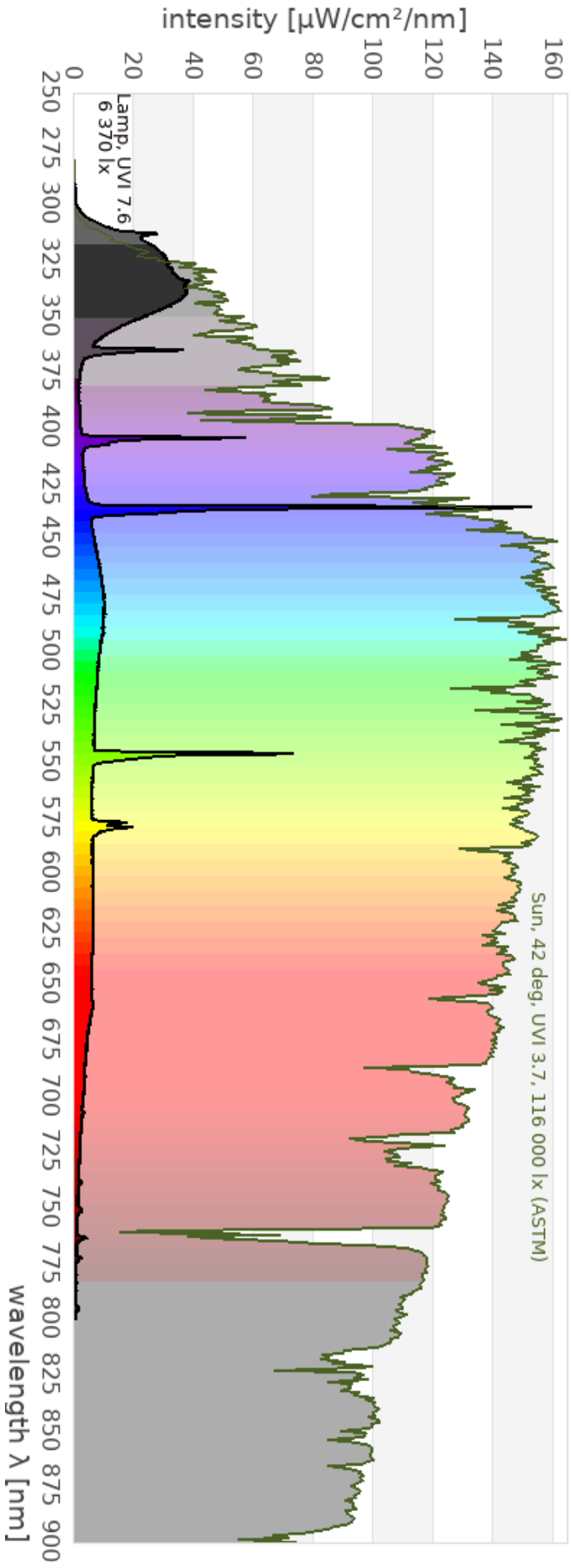
The below chart shows the spectrum from the lamp to sunlight (ASTM sunlight standard spectrum). The spectral plot of the lamp has been up-scaled (to approx. UVI 7.6) in order to be visually comparable to sunlight for the sake of analysis.



Full page graph is on the next page.

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COLOUR MEASUREMENTS

OVERVIEW

The spectrometer software is able to calculate colour values based on the readings from the lamps.

The range of wavelengths used to generate these values is dictated by the CIE. Their range defined is 400nm to 750nm.

These standards are defined as such for human vision only, and they do not take into consideration reptile vision in the UVA range.

I have also used a slightly wider range (350nm to 850nm) to allow analysis of typical reptile photoreceptor excitation by software.

Measurements taken using centre point of lamps at 25cm away, whilst in the Exo Terra fixture.

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COLOUR VALUES

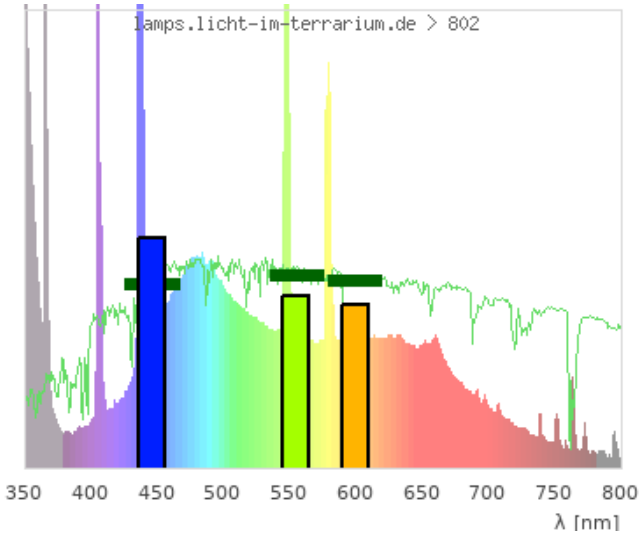
The lamps had colour values checked. Data is below.

Category	Reference	001	002	003	004	005
CCT (Kelvin)		8419K	8086K	8010K	7941K	8010K
R1	Light greyish red	67.6 (8419K)	70.1 (8086K)	70.4 (8010K)	70.5 (7941K)	70.1 (8010K)
R2	Dark greyish yellow	68.7 (8419K)	70.8 (8086K)	70.8 (8010K)	70.5 (7941K)	70.3 (8010K)
R3	Strong yellow green	72.1 (8419K)	72.7 (8086K)	72.6 (8010K)	71.8 (7941K)	72.1 (8010K)
R4	Moderate yellowish green	74.7 (8419K)	76.7 (8086K)	76.8 (8010K)	75.7 (7941K)	76.0 (8010K)
R5	Light bluish green	75.3 (8419K)	77.8 (8086K)	78.2 (8010K)	77.5 (7941K)	77.6 (8010K)
R6	Light blue	75.3 (8419K)	77.7 (8086K)	78.4 (8010K)	78.2 (7941K)	78.1 (8010K)
R7	Light violet	71.2 (8419K)	73.3 (8086K)	73.9 (8010K)	74.1 (7941K)	73.9 (8010K)
R8	Light reddish purple	65.8 (8419K)	68.3 (8086K)	68.8 (8010K)	69.2 (7941K)	68.7 (8010K)
R9	Strong red	69.9 (8419K)	71.6 (8086K)	71.6 (8010K)	72.6 (7941K)	71.7 (8010K)
R10	Strong yellow	58.2 (8419K)	59.2 (8086K)	59.1 (8010K)	58.5 (7941K)	58.5 (8010K)
R11	Strong green	79.6 (8419K)	81.3 (8086K)	81.3 (8010K)	80.1 (7941K)	80.5 (8010K)
R12	Strong blue	85.9 (8419K)	88.2 (8086K)	89.0 (8010K)	89.7 (7941K)	89.1 (8010K)
R13	Light yellowish pink	58.0 (8419K)	61.4 (8086K)	61.7 (8010K)	61.5 (7941K)	61.1 (8010K)
R14	Moderate olive green (leaf)	82.5 (8419K)	83.0 (8086K)	82.9 (8010K)	82.4 (7941K)	82.6 (8010K)
R15	Medium skin tone	65.0 (8419K)	68.2 (8086K)	68.4 (8010K)	68.4 (7941K)	67.9 (8010K)
CRI(a)		71.3 (8419K)	73.4 (8086K)	73.7 (8010K)	73.4 (7941K)	73.3 (8010K)
DC<5.4E-3		TRUE	TRUE	TRUE	TRUE	TRUE

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PHOTORECEPTOR ACTIVITY

Below is a chart showing excitation of the 3 “cone” visual photoreceptors used in human vision, as they would be stimulated by the spectrum on the platforms. The coloured vertical bars show the cone stimulation level; the short green horizontal bars show the equivalent stimulation by natural sunlight. The chart gives a visual representation of how well colour is rendered by humans from the lamps. I have used Lamp 001 for the sake of analysis purposes.

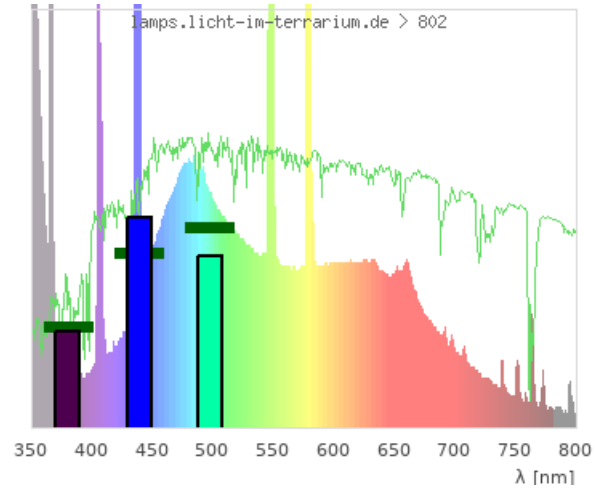


Graph made using Reptile Lamp Database Software, Courtesy of Dr. Sarina Wunderlich

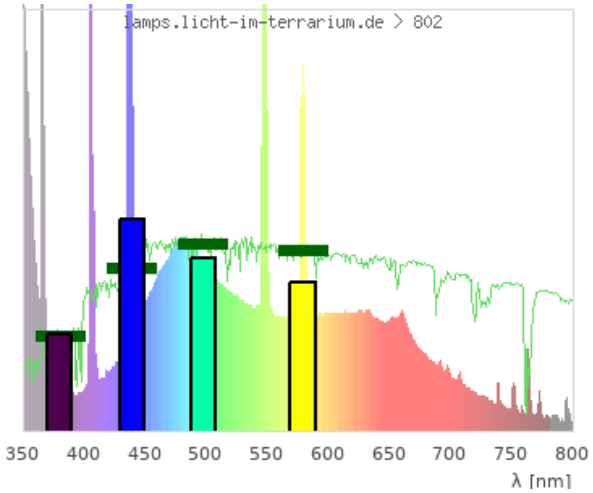
Reptiles have different photoreceptors to humans. And most species are also different to each other. This makes it difficult to quantify and analyse light for reptile vision.

Basic assumptions can be made though. Below are the same charts showing excitation of the "3 cone" visual photoreceptors used by some reptiles and birds (left), and the same for "4 cone" visual photoreceptors used by other species of reptile and birds (right), as they would be stimulated by the spectrum from Lamp 001.

The coloured vertical bars show the cone stimulation level; the short green horizontal bars show the equivalent stimulation by natural sunlight. The charts give a visual representation of how well colour is rendered by an archetyptal species of reptile or bird.



Graph made using Reptile Lamp Database Software, Courtesy of Dr. Sarina Wunderlich



Graph made using Reptile Lamp Database Software, Courtesy of Dr. Sarina Wunderlich

OTHER MEASUREMENTS

OVERVIEW

The spectrometer software is able to ascertain certain values based on the readings from the lamps. Each reading was taken at 25cm where appropriate, after a 100-hour burn-in, all whilst in the Exo Terra fixture. Each lamp was given 60 minutes to warm up before each test. I have listed the General Illuminance (lux), UVB density (μWatt/cm² using SolarMeter 6.2), UVI (SolarmMeter 6.5), SolarMeter Ratio, Power Factor, and average wattage values. Integration began at 270nm and ended at 850nm for spectral measurements. This encompasses the range of UV, visible light, and the very shortest infrared wavelengths. Simpson's rule was used for integration between 270 and 800nm.

This section also contains thermal imaging.

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BASIC MEASUREMENTS

The following are readings taken from the lamps whilst in the Exo Terra reflector after a 100-hour burn-in period, at 25cm from under the fixture. Voltage controlled at 230V.

Category	Lux	(SM6.2) UVB	(SM6.5) UVI	SolarMeter Ratio	Power Factor	Average Wattage
001	775	36	0.8	45 : 1	0.9	7.8W
002	799	35	0.8	44 : 1	0.9	7.9W
003	809	34	0.7	49 : 1	0.9	7.8W
004	803	36	0.7	51 : 1	0.9	7.8W
005	802	36	0.7	51 : 1	0.9	7.8W

LIGHT CATEGORY BREAKDOWN

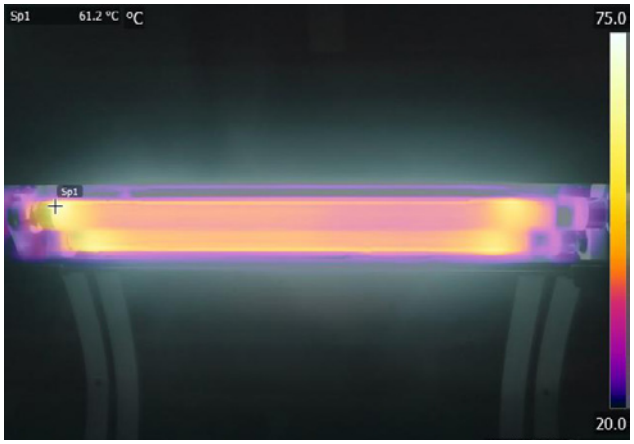
The light from the lamps can be broken down as follows. The measured range for these readings is 270nm to 800nm.

Grouping	Average µW/cm2	Percentage of Total Measured Range
UVC (</=280)	0.00	0.00%
UVB (281-320nm)	20	3.6%
UVA (320-380nm)	93.4	31%
Visible (400-780nm)	187	62%

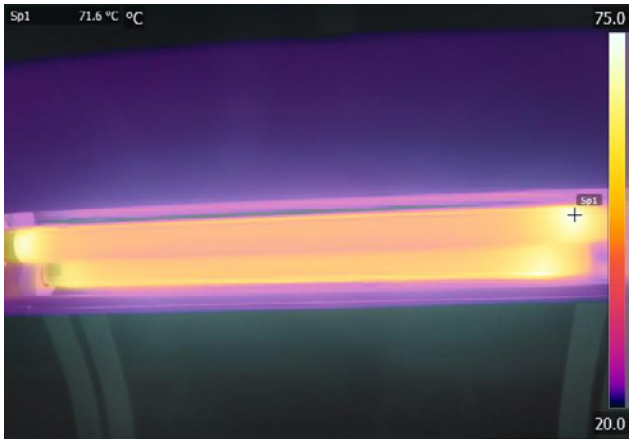
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THERMAL IMAGING

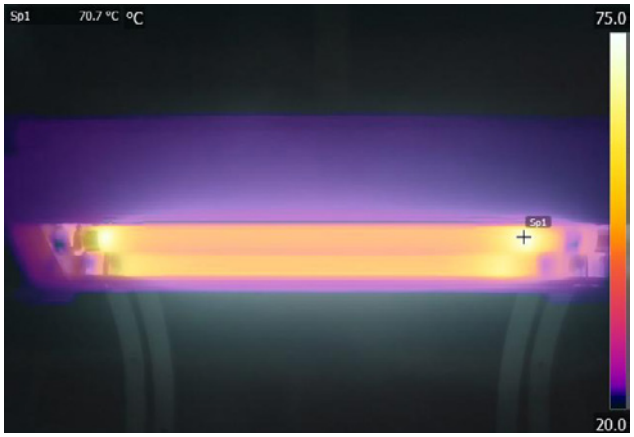
The following thermal image was taken of the lamp after a 100-hour burn-in period. The ambient room temperature was 21.5°C.



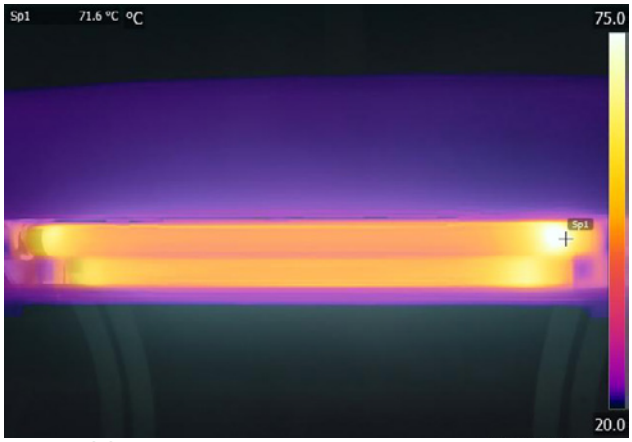
Lamp 001



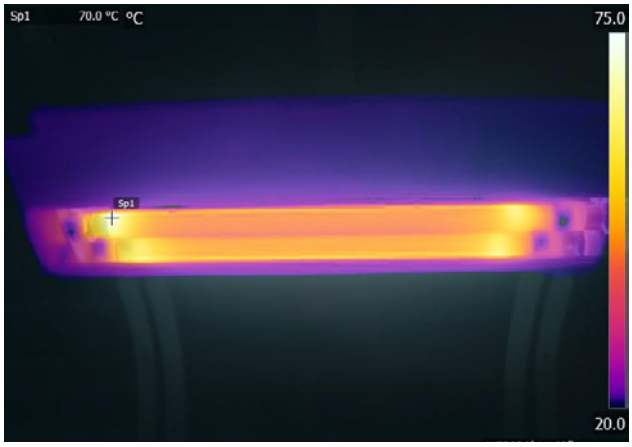
Lamp 002



Lamp 003



Lamp 004



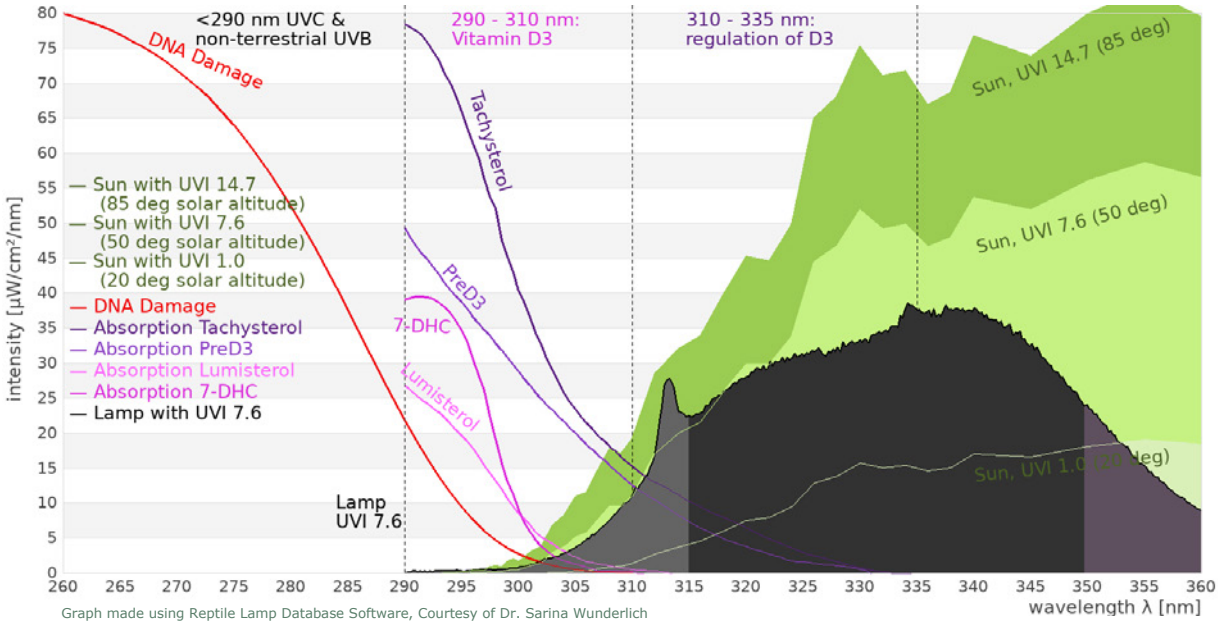
Lamp 005

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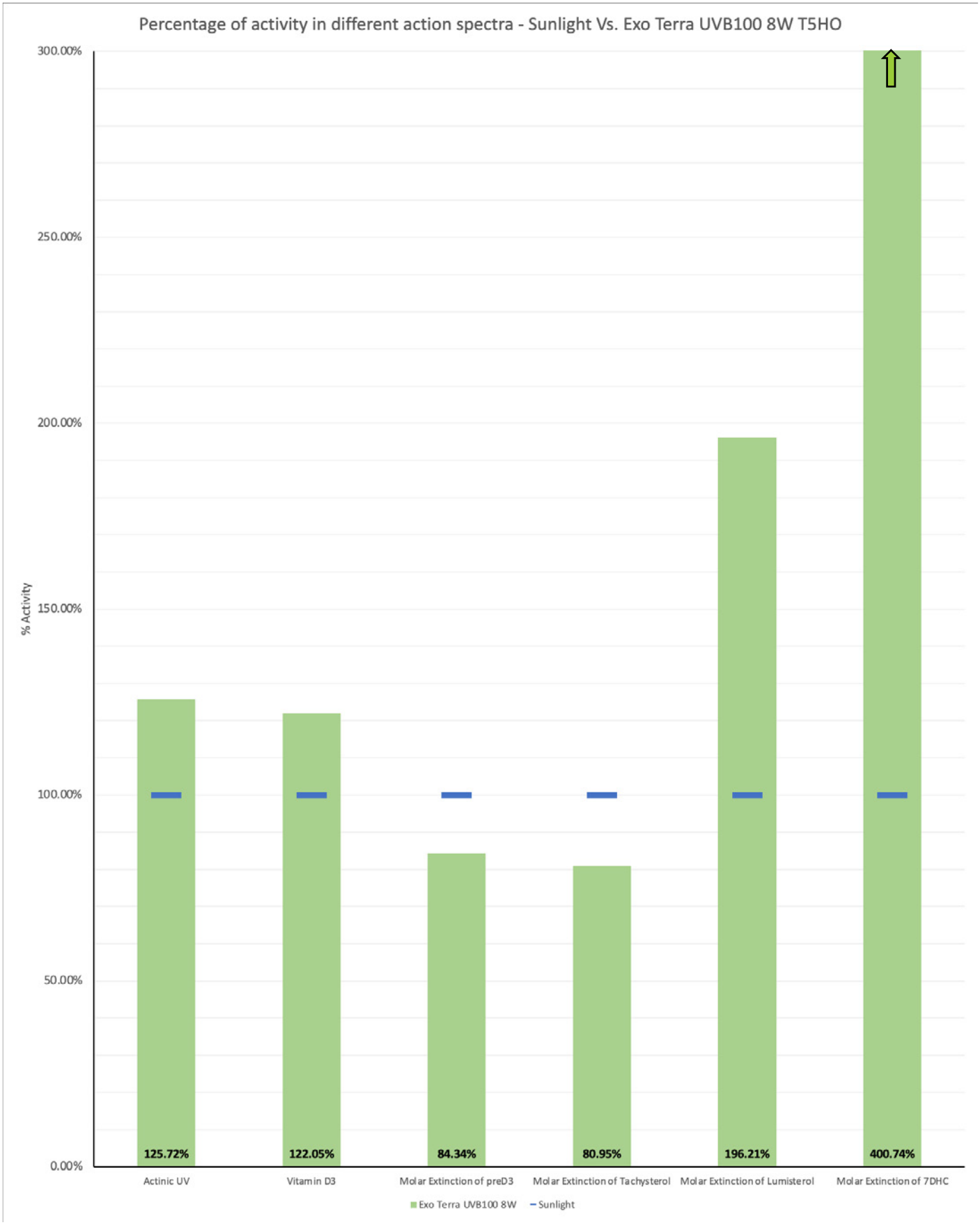
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D3-RELEVANT SPECTRA

I have compared the activity of the spectrum in relation to action spectra related with Vitamin D3 synthesis and actinic activity, and the same expected from sunlight. The spectral plot of the lamp has been up-scaled to UVI 7.6 for analysis purposes.



Graph made using Reptile Lamp Database Software, Courtesy of Dr. Sarina Wunderlich


Percentage of activity in different action spectra - Sunlight Vs. Exo Terra UVB100 8W T5HO
300.00%
250.00%
200.00%
150.00%
100.00%
50.00%
0.00%
% Activity
125.72%
122.05%
84.34%
80.95%
196.21%
400.74%
Actinic UV
Vitamin D3
Molar Extinction of preD3
Molar Extinction of Tachysterol
Molar Extinction of Lumisterol
Molar Extinction of 7DHC
Exo Terra UVB100 8W
Sunlight

COMMENTARY ON FINDINGS

OVERALL

The lamps worked without any faults during the tests.

The lamps all emit UVB at approximately the % claimed on the website.

The lamps did not get overly hot when considering industry standards.

Burn-in was stable over 100 hours on all tested lamps.

SPECTRUM AND D3 SYNTHESIS

The spectrum of UVB and UVA2 is very good. It is the most sun-like I have seen from any reptile-branded T5 lamp with equivalent prescribed usage (such as Arcadia ShadeDweller 7%, or Reptile Systems Zone 1).

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From the data collected, the following can be stated:

1. *The lamps emit no UVC, even at close range.*
2. *The lamps emit safe wavelengths of UVB.*
3. *The lamps emit UVA2 in sunlike proportions to UVB.*
4. *The lamps do not emit unnaturally short-wavelength UVB.*
5. *There is activity in wavelengths associated with Vitamin D3 synthesis.*
6. *The UVB and UVA2 portions of light emitted approximate sunlight very well.*
7. *The UVA1 and visible light portions of light emitted do not approximate sunlight very well.*

In practical terms, this tells us that the lamp will cause the skin to synthesise Vitamin D3. There is high activity in the wavelengths associated with Vitamin D3 regulation (approx. 315-340nm), which means that the lamps can be considered safe.

The Solarmeter Ratio of an average of approximately 48:1 is very similar to sunlight (usually considered around 45-75:1). This is unheard of in other T5HO lamps for reptiles.

The lamps emit insignificant amounts of Near Infrared. This product would not make a useful basking lamp on its own.

The lamps are not very bright, and would not be very useful in illuminating an enclosure of any size. However, these lamps are not intended to supply anything other than a safe UVB/UVA2 provision.

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COLOUR RENDERING AND VISION

The colour, to my eyes, is a blue-ish white. My white skin (R1 or R13) appears an off-pale colour.

This is not abnormal for a fluorescent lamp. Colour rendering is not generally a concern for UVB lamps.

To a reptile, the lamp would likely appear tinted towards the violet and UVA part of the spectrum due to activity from 365 – 500nm being disproportionate to the rest of the spectrum. This is not abnormal for a fluorescent lamp.

The light is homogenous. The colour temperature is around 8000K.

This lamp is not designed to be used for visible light in any way.

OTHER COMMENTS

The lamps would make a safe and effective addition to a setup according to manufacturer's guidance.

The spectrum is unique, and matches sunlight very closely in the appropriate ranges (UVB/UVA2).

The naming convention of UVB100 is something that Exo Terra decided on, which I believe is to match their current branding system. I do not know of a way in which the number '100' applies to the lamp other than when comparing to other lamps in the range ('200' and '300'), it can be seen to be the lower number and presumed to be a lower output lamp.

Despite a similar name as some other lamps from the Exo Terra range (such as PT2186), the spectrum is unique.

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FURTHER TESTS

TEARDOWN

At this point I have not conducted a teardown of the lamp. This could involve reviewing electronics inside.

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TERMINOLOGY USED (GLOSSARY)

As with many things, there may be more than one correct or colloquial way to describe the same item. There may also be common terms used that may not be correct in everyday usage. I've tried to remain consistent throughout the document so that if I refer to a specific part of an item, you as the reader will know with confidence which part I'm referring to.

KIT

This refers to everything that comes in the box, including fittings and instructions.

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LAMP

This refers to the main item in the kit. It is a fluorescent glass tube containing Mercury and a phosphor coating. Some people call this the "bulb".

UVI

This is shorthand for Ultra Violet Index. UVI is a standardised measurement for the appropriate wavelengths of radiation associated with essential biological processes involving the synthesis of Vitamin D3 – it is often used as a measure of solar UV radiation at the Earth's surface in terms of potential damage to the skin and the eye. The higher the UVI, the less time it takes for harm to occur. This document does not aim to educate about this biological process specifically, and further reading is readily available online. It is presumed that you have an understanding of UVI and its relevance to these tests. UVI is not to be confused with UVB. UVI is not to be confused with the Ferguson Zones.

UVB

UVB is the term for part of the electromagnetic spectrum on certain wavelengths, generally between 280 and 320nm. This document does not aim to educate about this specifically, and further reading is readily available online. By continuing, it is presumed that you have an understanding of UVB – including the differences between terrestrial (solar) UVB, which is around 295-320nm, and the more dangerous non-terrestrial (non-solar) UVB, which is from 280nm to around 295nm.

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FERGUSON ZONE(S)

The Ferguson Zones are classification markers for different exposure levels to different UVI. There are 4 Zones. Animals that expose themselves naturally to lower UVI are classified as Ferguson Zone 1, and animals that naturally expose themselves to very high UVI are classified as Ferguson Zone 4. This document does not aim to educate about this specifically, and further reading is readily available online. It is presumed that you have an understanding of Ferguson Zones – including the differences between the different Zones.

COLOUR TEMPERATURE (AND CORRECTED COLOUR TEMPERATURE)

Colour temperature, or CT, is widely used to define the colour appearance of a light source. Colour temperature is technically only used for "true" light sources – defined as a black body that reads close enough to the Planckian locus.

Corrected Colour Temperature, or CCT, is used on a light source that doesn't read close to the Planckian locus.

Both are defined in degrees Kelvin where a Warm White is around 2700K moving to Neutral White at around 4000K to Cool White, 5000K or more. Note that Colour Temperature and CCT do not tell you anything about the colour rendering ability of a light.

This document does not aim to educate about this specifically, and further reading is readily available online. It is presumed that you have an understanding of CT/CCT – including the differences and similarities.

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COLOUR RENDERING (INDEX)/CRI

Broadly defined as an indication of how well a light source can provide wavelengths that allow for certain colours to be visible to the human eye. This is defined by the CIE in greater detail, along with standardisations on measuring the level of colour rendering capability – referred to as the "index" of colour rendering.

Light with a low CRI is less effective as one with a high CRI. The CRI of unobstructed sunlight is 100.

This document does not aim to educate about this specifically, and further reading is readily available online. It is presumed that you have an understanding of CRI.

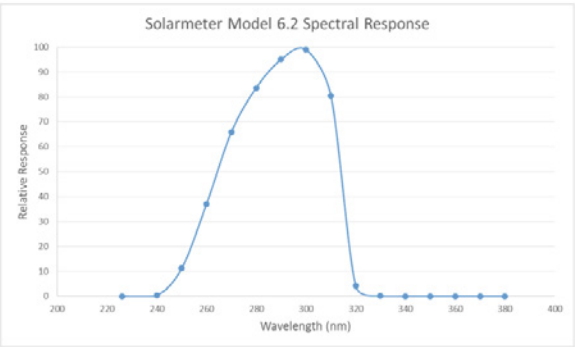
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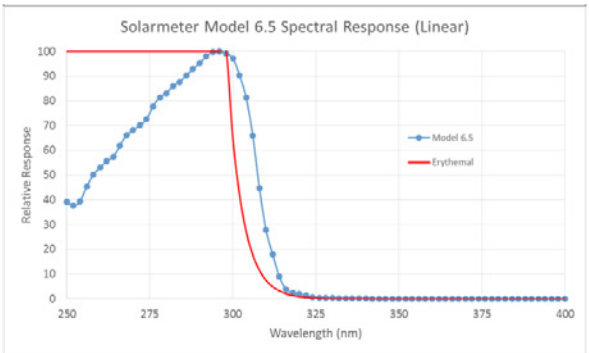
TESTING METHODS

EQUIPMENT

In order to ensure that results are as true and comparable as possible, I have used standardised measuring devices for the tests. I have used a SolarMeter 6.5 for measuring UVI, and a SolarMeter 6.2 for measuring UV in μW/cm².

The spectral response of these broadband meters is shown below. On these graphs, "Erythemal" refers to the action spectrum for the UV Index, since this is derived directly from the action spectrum for skin reddening ("erythema") under UVB.





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To allow for full spectrometry, a calibrated FLAME UV-Vis High Sensitivity Spectrometer from Ocean Optics was used alongside their flagship software – OceanView.

Room temperature measurements were taken with an Inkbird branded digital thermometer, with part number IBS-TH2. The manufacturer claims the device to have an accuracy of ±0.3°C.

A drywipe backboard was used for the "manual" portions of the tests. The backboard was pre-marked with a grid pattern. The grid used is 2.5cm squares. The board is approx. 2mx2m in total. The board does not reflect UV.

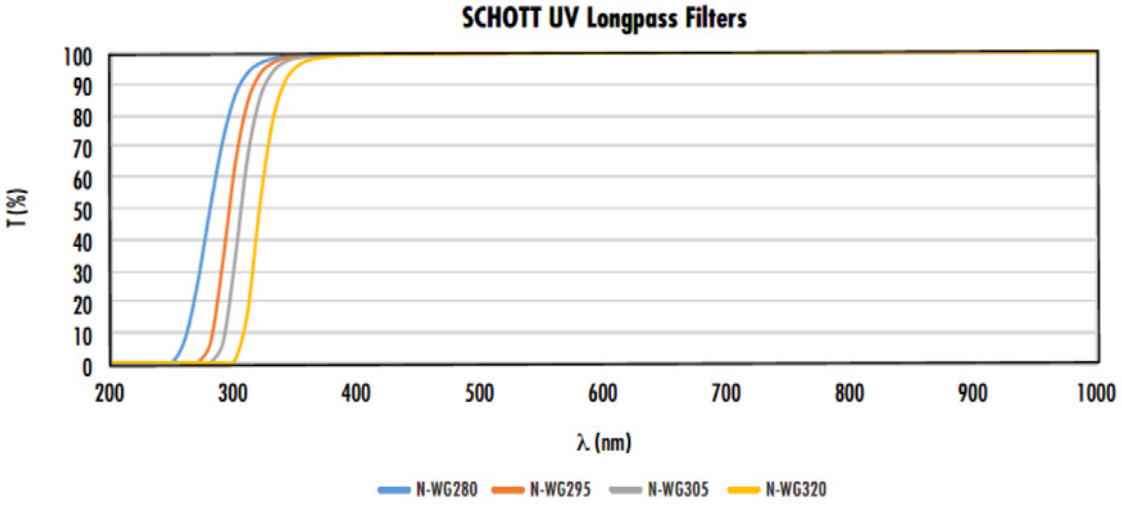
The distance from the unit was determined using a Stanley tape measure, with points marked on the backboard.

A power meter was used, model KWE-PM01, to monitor power usage.

An RS PRO ILM1335 Light Meter was used to manually determine lux values.

The lamp is 220-240V. I used a variac voltage transformer to correctly power the lamp.

SCHOTT N-WG295 Long Pass Glass (WG295 Glass) was used where appropriate to monitor for UVC vs noise on the spectrometer.



METHODS

Precaution was taken with all tests, as there should be when dealing with UVB-emitting devices. "Factor 50" UV protection sun cream was used on skin, with care taken not to spread any onto the equipment or to the lamp.

The method for creating ISO Irradiance charts is very close to the method documented by UV Guide. I have made comparisons with my results and those of the UV Guide, and the results are within tolerances – this means that the results are comparable to those of the UV Guide.
Info here: (http://www.uvguide.co.uk/makingspreadcharts.htm)

Before every test took place, a dry microfibre towel was used to wipe the lamp to ensure that the lamp was clean.

UVI was measured in the testing room before each test to ensure that results were only measuring the lamp and not any other sources.

Spectrometer readings were taken in line with standard processes.

The Reptile Lamp Database, courtesy of Dr. Sarina Wunderlich, was utilised for some technical analysis.

The lamp was given 60 minutes to "warm up" before each individual test, unless otherwise noted.

The lamp had 100 hours of "burn-in" before the tests began, unless otherwise noted.

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SPECIAL THANKS

Special thanks are in order for many friends, colleagues, and partners. I'd like to give a thank you to the following, but there are undoubtedly more that have not been named.

COLLEAGUES

Dr Sarina Wunderlich has kindly allowed me to utilise her Reptile Lamp Database system to generate some technical graphs and datasets.

Rik Van Tiggel at Exo Terra EU was my primary point of contact for arranging the testing of these products.

COPY

Rebecca Baines MA conducted spellchecks and ensured that I was making sense. She also provided much needed coffee.

LITERATURE AND FURTHER READING

In this document I have made comments supported by scientific literature, both peer-reviewed and not. Here is a list of literature that I have either directly referenced, or used in support of points and claims that I've made. The list is not extensive.

PEER-REVIEWED LITERATURE

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