Dr. Jörg Vetter, Radioactive Lenses, November 2018

Radioactive lenses - thoriated glass made Enna, Carl Zeiss Jena, Pentax and more

Vintage radioactive lenses can generate funny situations:
"On 18 January 2010, a passenger's luggage triggered a radiation alarm at the Chelyabinsk airport. The source of radiation was found to be a photo camera lens. The dose rate exceeded the background by 20 times. It is assumed that the lens contained Th-232. "

https://www.nti.org/analysis/articles/russia-radioactive-lens-detected-chelyabinsk-airport/

Introduction to by the author investigated thoriated lenses
To introduce the "charm" of the vintage lenses some basic dates are given and a bokeh shot at the maximum aperture are shown. (Nikon750, built-in flash)

Enna Lithagon 35 3.5

Enna Werk Munic, FRG/BRD (Germany)
production years in the 1950s
5 lenses, 8 blades
A = 3.5-22, Fmin = 0,4m, weight 155g
http://allphotolenses.com/lenses/item/c_3363.html;
https://photobutmore.de/exakta/objektive/enna/

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Flektogon 35 2.8

Carl Zeiss Jena, GDR/DDR (GERMANY), production years 1955 -1961
6 lenses, 9 blades
A = 2.8-16, Fmin = 0,35m, weight 196g
http://allphotolenses.com/lenses/item/c_3859.html

Super-Takumar 55 1.8

Pentax , **Asahi Optical Co., Ltd** Japan, production years: 1975 till 1977,
6 lenses, 6 blades
A = 1.8-22, Fmin = 0,45m, weight 221g
https://www.pentaxforums.com/lensreviews/SMC-Pentax-K-55mm-F1.8-Lens.html

What is a radioactive lens?

Thorium 232 (up to 30% by weight) as thorium oxide (ThO_2) was added in selected glasses used for photographic lenses to improve their optical properties in the years of about 1930 to 1980. Manufactures in the USA, Japan, Germany applied thoriated glass. Might be also that other manufactures - located in other countries- used such glasses.

It has to noticed, that lenses containing lanthanum are not appreciably radioactive – lanthanum is only 1/10,000th as radioactive as thorium. The radioactivity in lanthanum containing lenses is due to the intentional inclusion of thorium. This is a pollution effect.

The author does not find the evidence of antireflective coatings (AR coatings) based on thorium on consumer lenses, e.g. ThF_4 (Link).
https://materion.com/resource-center/product-data-and-related-literature/inorganic-chemicals/fluorides/thorium-fluoride-for-optical-coating

History of the thorium containing lenses

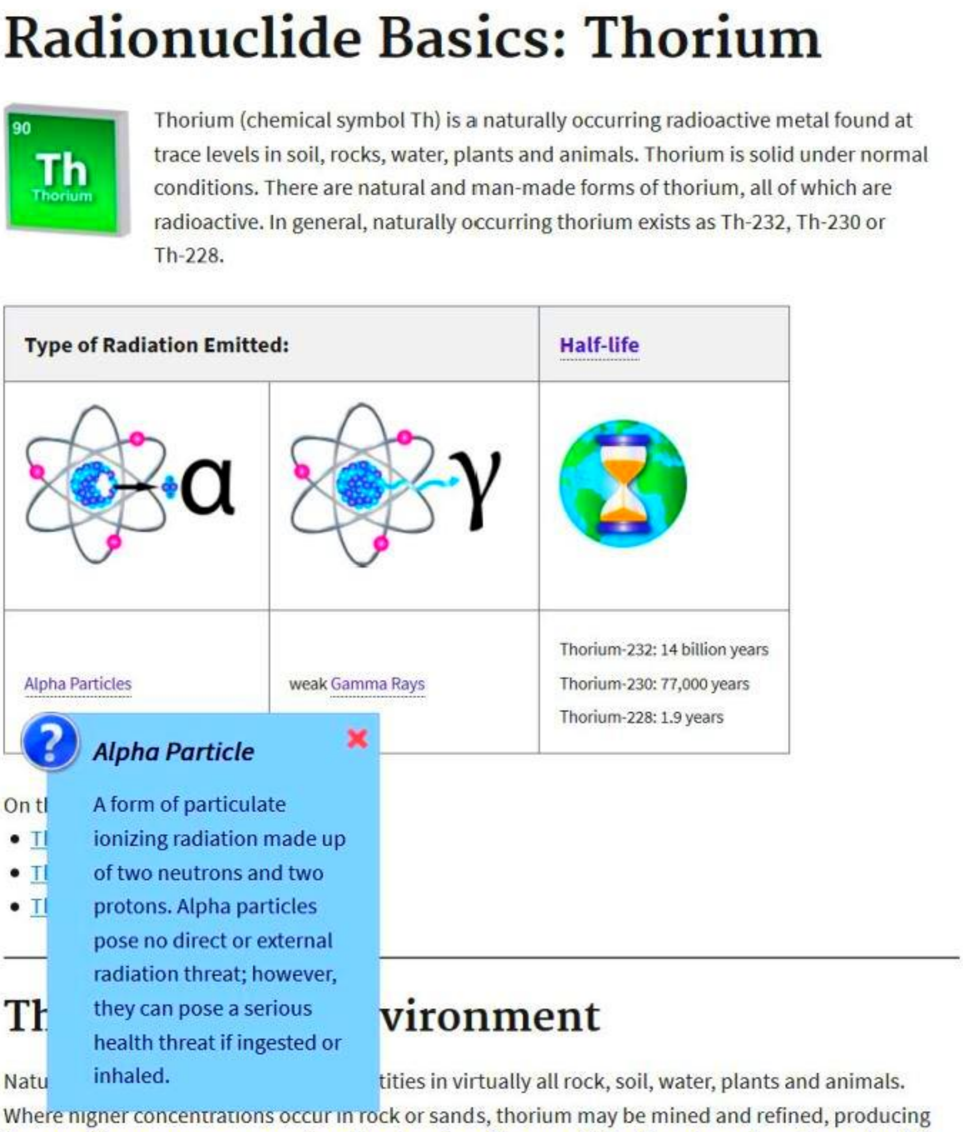
A high index of refraction results in a high bending of the light. As a result a reduction of the curvature of the lenses is possible. The lenses can be thinner produced, hence the costs per lens decreases. In tendency, a glass with a high refractive index have also a high dispersion. The combination of high refractivity and low dispersion allows lens designers to minimize chromatic aberration. George W. Morey invented (mid of the 1930‘s) the effect that by adding thorium 232 to the glass, a high refractivity can be achieved while maintaining a low dispersion (patent US2,150,694). Later more patent applications were filed by KODAK (e.g. US 2,241,249).
https://en.wikipedia.org/wiki/George_W._Morey

Thorium as a radioactive element helium-4 nucleus
Thorium 232 is a naturally occurring radioactive isotope. The extensive decay chain ends with the stable lead. Thorium emits alpha particles and have a weak gamma rays.
https://en.wikipedia.org/wiki/Thorium
 “**Alpha particles** consist of tw protons and two neutrons bound together into a particle identical to a helium-4 nucleus…. They are able to be stopped by a few centimeters air, or by the skin.”

https://en.wikipedia.org/wiki/Alpha_particle

“A **gamma ray** or **gamma radiation** (symbol **γ** or γ {\displaystyle \gamma }), is a penetrating electromagnetic radiation rising from the radioactive decay of atomic nuclei… .Due to their penetrating nature, gamma rays require large amounts of shielding mass to reduce them to levels which are not harmful to living cells, in contrast to alpha particles which can be stopped by paper or skin, and beta particles, which can be shielded by thin aluminium. Gamma rays are best absorbed by materials with high atomic numbers and high density, which contribute to the total stopping power.”
https://en.wikipedia.org/wiki/Gamma_ray

Remark for lens collectors:
Thorium can, depending on the mixture of other elements in the lens, result in moderate to severe browning of the glass.


Radionuclide Basics: Thorium

Thorium (chemical symbol Th) is a naturally occurring radioactive metal found at trace levels in soil, rocks, water, plants and animals. Thorium is solid under normal conditions. There are natural and man-made forms of thorium, all of which are radioactive. In general, naturally occurring thorium exists as Th-232, Th-230 or Th-228.

Type of Radiation Emitted:		Half-life
α	γ	
Alpha Particles	weak Gamma Rays	Thorium-232: 14 billion years Thorium-230: 77,000 years Thorium-228: 1.9 years

Alpha Particle

A form of particulate ionizing radiation made up of two neutrons and two protons. Alpha particles pose no direct or external radiation threat; however, they can pose a serious health threat if ingested or inhaled.

On tl
- Tl
- Tl
- Tl

Tl vironment

Natu tities in virtually all rock, soil, water, plants and animals. Where higher concentrations occur in rock or sands, thorium may be mined and refined, producing

https://www.epa.gov/radiation/radionuclide-basics-thorium#self

Measurement of the lens radiation: experimental set up

A Geiger counter SV500 was used. The SV500 was manufactured by Frieseke & Hoepfner FAG Kugelfischer for the Army of FRG/BRD (GERMANY) in 1983.
An external universal probe for gamma/beta radiation measurements was in use. Please notice that this kind of probes do not detect alpha radiation!
The focusing of the lenses was set to infinity.
The shorted distance between the probe and the lens was selected in order to measure the highest radiation level.
The highest radiation level was always measured at the rear lens, not at the front lens!

Experimental Results and Discussions

The measurement results are showing for each lens.

The lowest radiation level has the Lithagon with 0,25 mrad/h followed by the Flektogon with 0,5 mrad/h. The highest radiation level of 1,25 mrad/h has the Super-Takumar.
Again I have to point out, that the measurement was done in the shortest possible position to the rear lens!
In a distance of about 1 to 5 cm no radiation was measurable with that set up!

Lets take the highest measured radiation of 1,25 mrad/h = 12,5 μSv/h.
Lets compare it with the effective dose depending from flight heights.
Similar values are possible in high flight heights!
Up to 15 μSv/h in a flight height of 15 km!

*If we calculate the exposition over one year (24hours*365 days) - using the radiation of the Takumar- we get a dose of about 11 rad = 0,11 Sv.*
But only in the short distance to the rear lens!

http://www.bfs.de/SharedDocs/Downloads/BfS/DE/broschueren/ion/stth-hoehenstrahlung.pdf?__blob=publicationFile&v=5

Health risk: Are these radioactive lenses dangerous

In general the health hazards presented by radioactive lenses are not fully understood. Through often handling and use, these lenses can expose the body to alpha and beta and gamma rays.
Radioactive lenses can never be considered truly safe for usage! However we can conclude also: theses vintage lenses do not will kill you if they are carefully used.

Some facts
– Normally you never time will have a nearly zero distance to the rear lens, like the measurements were done. The lens is at least in between 5cm to 10cm away from your eyes, when it’s mounted to the camera.

– The **eyes** are very sensitive, it’s better to keep radioactive sources far away from this organ! And to reduce the time of use!

- The most dangerous situation is to have a piece of the lens (an alpha particle source) in the body, but this can only be caused by strange accidents!

Some rules
1) Do not sleep with lens!
2) Do not store them in your cloths (trouser pockets)!
3) Do not hold them up close to your eyes for prolonged periods.
4) Do not grind the glass!
5) Do not “eat” glass parts!
6) The use of a front glass filter and or of a “metal” lens cap (standard for the Super-Takumar) is recommended.
7) Do not collect hundreds of radioactive lenses and store them in the same room near your bed!
8) Store the radioactive lenses safe, so that children are not able to get them!

Have fun with your VINTAGE RADIOACTIVE LENSES!!!!

Links to radioactive lenses

http://camerapedia.wikia.com/wiki/Radioactive_lenses

http://camera-wiki.org/wiki/Radioactive_lenses

https://www.orau.org/ptp/collection/consumer%20products/cameralens.htm

https://mbphotox.wordpress.com/2015/07/25/radioactive-lenses/

https://petapixel.com/2018/06/07/a-radioactive-lens/

https://www.flickr.com/groups/98706667@N00/discuss/72157629299272095/

http://dsider.co.uk/bills-blogs/radioactive-camera-lenses/

http://thecameraforum.com/radioactive-lenses/

https://www.fourmilab.ch/documents/radiation/lens/

http://www.konbini.com/ch-de/actualite/chaud/radioaktive-linsen-in-alten-kameras-gefunden/

http://cinematechnic.com/optics/super-baltar

Appendix
Radiation levels units:
1 Sv = 1000 mSv (millisieverts) = 1,000,000 µSv (microsieverts) = 100 rem = 100,000 mrem (millirem)

- 1 mSv = 100 mrem = 0.1 rem
- 1 µSv = 0.1 mrem
- 1 rem = 0.01 Sv = 10 mSv
- 1 mrem = 0.00001 Sv = 0.01 mSv = 10 µSv

1 R = 1 rad = 1 rem = 0.01 Sv = 10 mSv = 10 mGy = 0.01 Gy (gray).