CRC LETTER

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Maser, laser, electron-volt

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CRC is the abbreviation of Casualty Risk Consulting, a group of experts within Munich Re. The CRC letter examines current issues of relevance to third party liability insurance, from a technical and scientific point of view. The letter also includes notes for risk management, focussing on loss prevention and loss minimization.

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We repeatedly receive inquiries concerning personal accident insurance, or product liability and recall insurance, in connection with lasers. In many cases, questions come up with regard to the frequently used term "electron-volt", which denotes the unit of energy. Therefore, in the following article, we explain terms, present application examples and explore the issue of insurability.

1 Maser

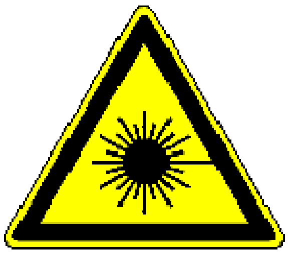
The term "maser" is an abbreviation for "microwave amplifier by stimulated emission of radiation". Masers serve to generate waves in the cm range. Current developments are confined to research; masers are encountered only very rarely in technical products. The maser can to some extent be viewed as the predecessor to the laser.

2 Laser

"Laser" stands for "light amplifier by stimulated emission of radiation".
The primary risks of lasers are potential injury to the eyes and skin, as well as a destructive effect on property.

2.1 Laser types

- Gas laser (e.g. helium-neon laser with 632.8 nm wavelength, red light)
- Dye laser
- Colour centre laser
- Solid-state laser (first laser, developed in 1960)
- Semiconductor laser (laser diodes)
- Chemical laser (HCl, iodine)
- Free electron laser



2.2 Laser applications

- Material processing (shaping, separating, joining, coating, curing, labelling)
- Medicine (ophthalmology, surgery, dermatology, dental medicine, tumour therapy, laser scalpel)
- Measurement technology (precision measurement, tunnel construction, traffic control, barcode reading, fire detection, vibration analysis)

- Science (geodetic surveying by satellite, atomic spectroscopy, molecular analysis, nonlinear optics, cell biology)
- Holography
- Information technology (data storage on CD-ROM and DVD, data transfer via glass fibre, laser printers)
- Military (target designators for autonomous weapons, rangefinders, laser rifles, missile defence)
- Miscellaneous (laser pointers, stage shows, planetariums)

2.3 Laser classes (to DIN EN 60825)

Class 1	Very low power; emitted radiation poses no danger.	CD players, laser printers
Class 1M	Comparable to Class 1: if no optical instruments (lenses, magnifiers, binoculars) are used, the radiation poses no danger.	Laser printers, cash registers
Class 2	Lasers with a beam in the visible portion of the spectrum; short-term exposure (less than 0.25 seconds) poses no danger due to the blink reflex, that is if the eye is not held open deliberately.	Laser pointers, measurement instruments
Class 2M	Comparable to Class 2: if no optical instruments (lenses, magnifiers, binoculars) are used, the radiation poses no danger.	Light shows, laser pointers
Class 3R	The accessible laser radiation is definitely dangerous to the eyes and, under certain circumstances, to the skin as well.	Target equipment for weapons, calibration, measurement
Class 4	The accessible laser radiation is definitely very damaging to the eyes and damaging to the skin. This also applies for diffuse radiation. In addition, the high energy density constitutes a fire and explosion hazard.	Research, material processing

3 Electron-volt

Electron-volt is a unit of energy used specifically in atomic physics.

1 eV is the energy acquired by an electron moving unimpeded through a voltage difference of one volt. The energy is usually expressed in the unit joules [J] (1 J = 1 Ws, watt-second) or kWh (kilowatt-hours). Conversion is very simple: 1 eV = 1.6×10^{-19} J.

Practical example: if a person lifts a paperclip with a mass of 1 g a distance of 10 cm into the air, the “athlete” must expend 0.000981 joules, or roughly 1/1000 joules of energy. Expressed in electron-volts, he expended energy equal to 6,131,250 billion eV!

The mean kinetic energy of a molecule due to thermal motion at room temperature is about 0.04 eV; the energy released during formation of a hydrogen atom is in the region of 13.6 eV; and a photon of visible light has between 1.5 and 3 eV. In particle accelerators, the achievable kinetic energy of particles is about 900 GeV (GeV = gigaelectron-volt = billion electron-volts).

4 Risk management and insurability

Masers are hardly used any more today in technical applications. Accordingly, laser applications are the main concern in underwriting.

4.1 Personal accident insurance

In the German General Terms and Conditions for Personal Accident Insurance (AUB), health impairments caused by radiation are excluded by Section 5.2.2. However, some are included again by the Special Terms and Conditions (BBU).

Excerpt from the Special Terms and Conditions for Personal Accident Insurance (BBU)

14. Radiation losses (cf. Section 5.2.2 AUB 2001)

In amendment to Section 5.2.2 AUB 2001, health impairments due to

- X-rays,
- Laser radiation,
- Maser radiation (e.g. microwave),
- Artificially generated ultraviolet rays, and
- High-energy radiation with a hardness of up to 100 electron-volts

are covered if they do not result from the routine use of instruments that generate radiation and are not occupational diseases.

In other words, health impairments are covered if they result from sporadic exposure to high-energy radiation up to 100 eV, or the other types of radiation listed above (x-ray, laser, maser, UV). To illustrate: the paperclip-lifter in our example would have to lift the paperclip an enormous distance of 1.63 billionths of a millimetre!

Does this mean that 100 eV are a negligible or virtually non-existent amount of energy? Yes and no. In our daily lives: Yes.

In atomic physics: No! If just a few electron-volts (typically 10 eV) are transferred to a single atom, it is sufficient to turn the atom into an ion, i.e., to snatch away one of the atom's electrons. Electromagnetic radiation is associated with the conversion of energy. Based on the formula derived by the atomic physicist Max Planck, E = h x f, there is a direct relationship between the frequency of the radiation and the energy. In the formula, E = energy, h = Planck's quantum of action (a natural constant in physics = 4.135671×10^{-15} eVs) and f = frequency of the radiation.

After this brief excursion into atomic physics, let's return to personal accident insurance and the Special Terms and Conditions (BBU). If Planck's formula is solved for frequency (i.e. f = E/h), and the 100 eV from BBU is given, the result is a frequency of about 24 PHz (PHz = petahertz = 1,000 billion hertz = 1,000 billion oscillations per second). A quick look at the electromagnetic frequency spectrum shows that this frequency is in the ultraviolet (UV) radiation range. The higher the energy (in eV), the higher the frequency of the radiation: the spectrum goes on through the x-ray range and, starting at roughly 12,400 eV (or 12.4 keV, kiloelectron-volts) reaches the gamma rays.

In other words, when it comes to other high-energy rays, the limit of 100 eV in the German BBU is critical and should always be observed! Casualty Risk Consulting (CRC, CUGC1.4.1) is available for assessing other limit values, e.g. in international terms and conditions.

4.2 Product liability and recall insurance

Risk analysis and the analysis of insurability in product liability and recall insurance naturally focus on the products manufactured by an insured. Therefore, only laser products are addressed below.

4.2.1 Capital goods

An individual risk analysis must always be performed based on the use of the product – depending on the laser class and the product's field of application, i.e. the loss potential (divided into personal injury and property damage).

In accordance with the applications described under Section 2.2, this primarily includes products for material processing and measurement technology, or goods used in medical and information technology, as well as science.

In analysing the risk, the underwriter should focus not only on standard criteria, but also on aspects such as performance of exposure analyses by the manufacturer, examination of predictable misuse and incorrect operation.

4.2.2 Consumer products

Particular caution is also advised when it comes to consumer products. These products are usually in Classes 1 or 2, meaning that they have only low laser power. However, defective products can exist on the market because of design, manufacturing or instruction errors.

Laser pointers: According to studies conducted in 1998 by Heinrich-Heine University in Düsseldorf, laser pointers purchased in Germany often display higher power ratings than indicated in the product information. A prohibitive order issued in 2003 by the German Federal Institute for Occupational Safety and Health (BAuA) under the provisions of the German Instrument and

Product Safety Act proves that dangerous products (often imports with a forged CE mark) continue to appear on European markets.

Laser pointer "Key Chain Laser; Hi-Output", Type: PM 24/00RE, EAN Code: unknown; show booths at a fun fair in Recklinghausen, Germany. 1) Oliver Wilmering, Diepenstr. 30, D-40625 Düsseldorf, 2) Johann Mikli, Fichtenstr. 28, D-58640 Iserlohn, 3) Georg Hasenkamp, Gildestr. 30, D-48157 Münster and 4) Renate Wilke, Heiksfeld 24, D-44805 Bochum; Primary deficiencies: the permissible values for laser power and radiation intensity are exceeded by a factor of roughly 4. The manufacturer indicates laser Class 2. In reality, the laser pointer falls into laser Class 3 and thus poses a potential danger for the eyes. Responsible government agency: Recklinghausen State Agency for Occupational Safety, Hubertusstr. 13, D-45657 Recklinghausen; file no. 8221.1-130, -132-133, -135, -136/03-Lu; (UV 023/03)

Prohibitive order of the BAuA (source BAuA)

Laser printers: These products are only rarely the subject of recall campaigns. The reasons to date were not the laser units themselves, but rather faulty assembly or electrical components, which led to electric shocks or shorted circuits and subsequent fires.

CD players, CD/DVD drives: These products have no known technical product safety deficiencies that have led to losses on account of the laser.

Depending on the market in which the product is used and the expectations of entitlement prevailing there, cases involving such products should also be examined to determine how carefully the manufacturer has tested foreseeable misuse. Insuring recall costs requires the existence of a recall plan.