Avoiding mercury emissions during manual flat-panel display disassembly

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Older LCD flat-panel displays feature mercury-containing fluorescent tubes to illuminate the image-transmitting surface. They must be removed from the equipment and disposed of in a special process. Since they are very thin, well-trained staff are needed to extract them. The SN EN 50625 standard specifies that 95 % of the tubes must remain intact during manual disassembly. Swico's Technical Commission carried out a pollutant removal test with five recycling companies in 2018 to verify whether this requirement could be met.

Flat-panel display technology has developed dramatically over the last 10 years. Now that flat-panel displays with LED backlighting have become widespread, thin OLED screens without backlighting are increasingly being offered in laptops and TVs. But older flat-panel displays still have mercury-containing backlights, which means there are special requirements for their disposal. For example, they must be removed with great care during the manual disassembly process so as to prevent breakage and mercury leakage. Once the backlights have been extracted, they must be disposed of in special facilities. To remove the pollutants in a way that is kind to both human health and the environment, the technical specifications set down in the SN EN 50625 standard require 95 % of the tubes to remain intact. In 2018, Swico's Technical Commission required all recycling companies to carry out a pollutant removal test with at least 3 tonnes or 150 pieces of equipment to verify compliance with this standard.

In total, just under 10 tonnes or 1,400 pieces of equipment were dismantled in five plants. 40 % of this equipment were laptops, 30 % PC monitors and 40 % flat-screen TVs. On average, 28 % of these had LED backlights, which were excluded from the test. This was also the case for approx 15 % to 30 % of the laptops, 15 % to 40 % of the TVs and roughly 10 % to 30% of the PC monitors. The percentage of LED appliances has thus increased noticeably compared to 2016 (see the 2017 technical report: TVs 11% to 26 %, PC monitors 0 % to 12 %). (See table)

Quoted studies:

- ↗ "Disposal of Flat Panel Display Monitors in Switzerland – Final Report", Swico Recycling, 3.2011
- ↗ "Anforderungen an die Behandlung spezifischer Elektroaltgeräte unter Ressourcen- und Schadstoffaspekten", Umweltbundesamt, DE, ISSN 1862-4359, 2016
- ↗ S. 391-398, Gefahrstoffe - Reinhaltung der Luft, Fachmagazin Deutschland, Nr. 10 10/2018

Company	Dismantled FPD devices (number)								CCFL backlights			Quality of pollutant removal (% intact CCFL)
	Laptop-FPD		PC-FPD		TV-FPD		TOTAL		Total removed	Breakage before dismantling	Breakage from dismantling	
	CCFL	LED	CCFL	LED	CCFL	LED	CCFL	LED	(g)	(g)	(g)	
Company 1	0	0	75	8	83	16	158	24	8'999	557	18	**99.79%**
				10%		**16%**		**13%**		**6.18%**	**0.21%**	
Company 2	337	161	127	52	83	48	547	261	8'650	1'261	292	**96.05%**
		32%		**29%**		**37%**		**32%**		**14.58%**	**3.95%**	
Company 3	0	0	0	0	176	83	176	83	19'001	2'549	850	**94.83%**
						32%		**32%**		**13.42%**	**5.17%**	
Company 4	2	0	108	0	22	11	0	0	2'328	144	70	**96.82%**
		0%				**33%**				**6.16%**	**3.18%**	
Company 5	50	0	54	7	30	20	134	27	5'710	156	156	**97.19%**
		0%		**11%**		**40%**		**17%**		**2.73%**	**2.81%**	
TOTAL	389	161	364	67	394	178	1015	395	44'688	4'666	1'385	**96.54%**
		29%		**16%**		**31%**		**28%**		**10.44%**	**3.46%**	
		ca. 30%		**10–30%**		**15–40%**		**15–30%**				
		550		431		572		1410				
		39%		31%		41%						

FPD Flat Panel Displays
CCFL Cold Cathode Fluorescent Lamp

Table 1: Comparison of the quality of pollutant removal from background lighting in flat-panel displays from various companies (2018)

The pollutant removal tests revealed that, on average, 3% to 15% of the mercury-containing backlights had already broken during dismantling, despite being transported in pallets and frames. These results reflect findings from Germany (UBA 2017), where around 20% and 13% of tubes removed from televisions and PC monitors respectively had already been damaged.

During manual dismantling as part of the test, 0% to 5.17% of the still-intact backlighting was disassembled by well-trained employees. The companies involved were thus all able to comply with the requirement set down in the standard. However, it is important to bear in mind that the test conditions are not necessarily consistent with everyday life. In day-to-day operation, this strict requirement tends to be more difficult to meet.

Mercury is the only metal that is liquid at room temperature. It evaporates at room temperature, which is why workplace exposure is of particular interest when manually dismantling backlights containing mercury. To estimate the possible exposure risks, individual companies carried out workplace measurements in cooperation with SUVA (the Swiss National Accident Insurance Fund) or by

Manually dismantling a PC monitor

Background lighting containing mercury

engaging specialised companies. Altola AG, which had the measurements carried out by Carbotech AG, deserves special mention as a model example. In 2017 and 2018, personal and stationary measurements were carried out. During LCD disassembly, the MAK value (MAK= maximum workplace concentration) for metallic mercury of 50 µg/m³ was more than 30 times lower at 1.5 µg/m³ for personal measurements, while the measured value of 2.1 µg/m³ for stationary measurements was around 20 times lower. As a general recommendation for occupational health and safety protection, and irrespective of the mercury issue, the authors advise that wet cleaning of work surfaces be carried out as well as using industrial vacuum cleaners with particle filters (filter class H) to clean hall floors. Dry wiping should generally be avoided to prevent stirring up dust.

Measurements in Germany showed slightly higher values. At a workplace featuring workbench extraction, an average concentration of 1.8 µg/m³ (max. 6.4 µg/m³) was found at the worker's head height. Where a workplace was unprotected, the value depending on the number of tubes already destroyed was 6.8 µg/m³ to 17.1 µg/m³ and 20.2 µg/m³ when all the tubes were completely destroyed (UBA 2017). A recently published study revealed values in the range of the Carbotech AG results (Wegscheider 2018), both for dismantling workplaces with and without workplace extraction.

As has already been established, the collection barrels containing broken tubes are the largest source of emissions (Swico 2011 and Wegscheider 2018). Values of over 1,000 µg/m³ and of 180 µg/m³ were measured inside and directly above the barrel respectively, with Wegscheider measuring concentration peaks of over 800 µg/m³ above the barrel. A barrel with a smaller round opening 30 cm above it still produced 80 µg/m³; in the breathing zone, the value was below the 10 µg/m³ measurement limit. Mercury concentrations of between 10 µg/m³ and 100 µg/m³ are also measured in open collection containers with intact tubes, which indicates that illuminants broke during storage. The concentration was below 2 µg/m³ in the breathing zone. Special care should thus be taken when handling both intact and defective tubes.

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What are the most important/surprising findings from the mercury measurements?

'The measurement campaigns confirmed our expectations. Dismantling mercury-containing backlights illustrates the importance of properly coordinated technical, organisational and personal (TOP) protective measures. The work must be closely monitored if good results are to be achieved in the long term.'