National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Methods for *determining TNCO* in tobacco smoke

This factsheet provides information about the methods for collecting smoke from cigarettes, to analyse smoke components such as tar, nicotine and carbon monoxide (TNCO). The factsheet was commissioned by the Dutch Ministry of Health, Welfare and Sports.

Highlights

- The Organization for Standardisation (ISO) method currently specified in the European Tobacco Products Directive (EU TPD) leads to an underestimation of the amounts of TNCO to which smokers are exposed.
- Cigarette filter ventilation lowers ISO measured TNCO yields, by diluting smoke with clean air, whereas smokers puff more intensely to obtain their desired level of nicotine.
- The World Health Organisation (WHO) Intense method is a reliable method that leads to higher TNCO levels than the ISO method and to levels that are closer to those that smokers inhale.
- Testing methods for tobacco product regulation should have no industry involvement[1].
- WHO TobLabNet methods ensure the generation of independent and reliable information on tobacco products' contents and emissions for regulatory purposes.

Measuring TNCO in tobacco smoke

Tobacco smoke contains many harmful substances, such as tar, nicotine, carbon monoxide, tobacco-specific nitrosamines, acetaldehyde and acrolein. To measure the amount of a harmful substance in smoke, a smoking machine is used to generate smoke. This machine smokes cigarettes in accordance with an established method. In the Netherlands and the other EU Member States, TNCO emissions are measured using an ISO method, as specified in the European Tobacco Products Directive (TPD). This must be done to verify that products comply with the maximum permissible quantities of TNCO. Cigarette smoke is permitted to contain a maximum of 10 mg of tar, 1 mg of nicotine and 10 mg of carbon monoxide per cigarette, when machine smoked with the ISO method.

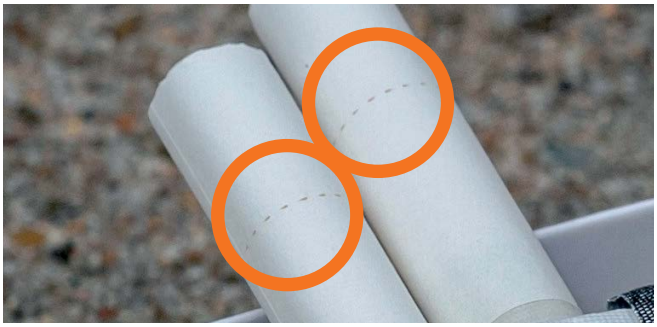

Figure 1. Cigarettes with filter ventilation holes

ISO method underestimates emissions

However, the ISO method does not accurately reflect the amount of (harmful) substances that smokers inhale. This is due to several reasons. Most importantly, when using the ISO method, ventilation holes in cigarette filters allow clean air to enter, which dilutes the smoke (figure 1). Smokers cover these holes with their lips and fingers, and/or inhale larger or more frequent puffs to compensate for diluted smoke.

The main addictive component in cigarette smoke is nicotine and smokers need a certain amount of nicotine to maintain their addiction. Therefore, they adapt their smoking behaviour to the nicotine levels present in smoke [2-6]. Thus, due to more intense smoking and closing of the ventilation holes, more harmful substances end up in the smoke inhaled by smokers than when measured using the ISO method (see figure 2). The machine measured TNCO levels are therefore lower than the amounts inhaled by smokers. Moreover, as the amount of filter ventilation varies between cigarette brands and types, TNCO levels measured by the ISO method differ between brands and types accordingly.

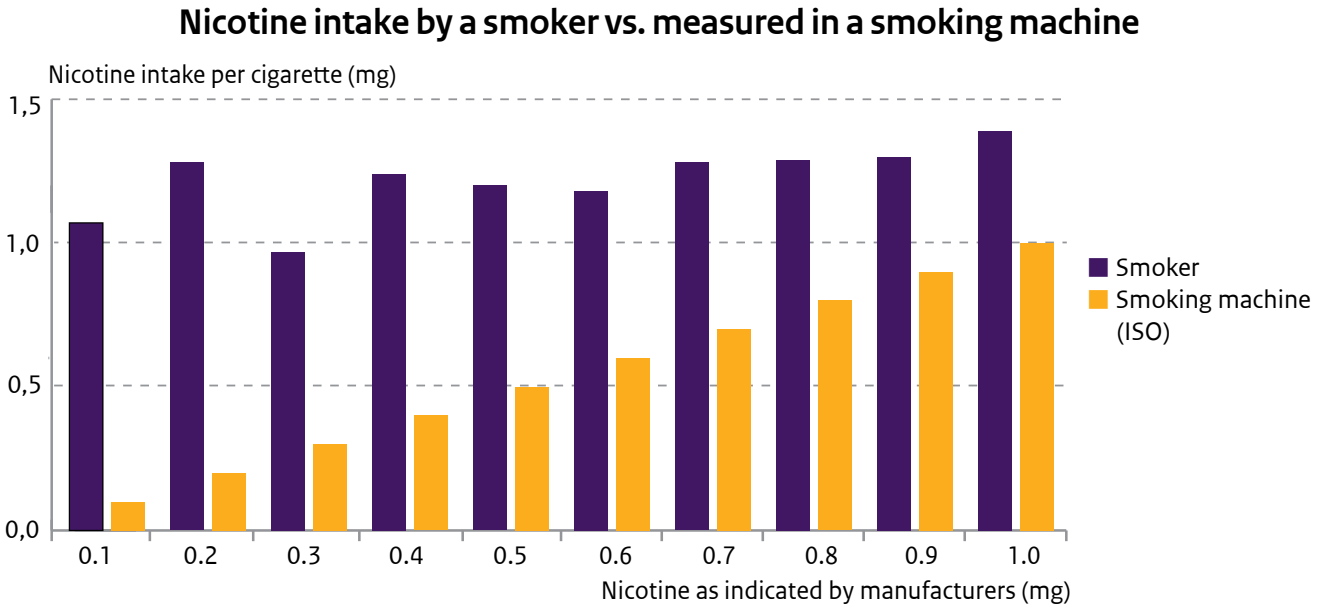

Figure 2. The amount of nicotine measured using a smoking machine with the ISO method, compared to the estimated amount of nicotine that a smoker inhales from the same cigarette (data from Jarvis et al. 2001[7]). Nicotine intake per cigarette is about eight times greater than machine-smoked yields at the lowest deliveries and 1.4 times greater for the highest yield cigarettes. Low machine-smoked yields are mainly achieved through filter ventilation. More filter ventilation results in more diluted smoke and thus lower yields, whereas the amount of nicotine that a smoker inhales remains the same. So smokers can get roughly as much nicotine from any cigarette by adapting their behaviour.

WHO Intense method

Another smoke generation method developed by Health Canada and validated and recommended by the WHO involves more intense puffing and combustion conditions and also takes into account the covering of ventilation holes (see Figure 3). This WHO Intense method is known to produce higher TNCO levels than the ISO method, which are closer to human exposure. In addition, due to covering of all ventilation holes, differences in TNCO emissions between cigarette brands and types largely disappear when the WHO Intense method is used.

Human smoking versus machine smoking

It is important to note that human smoking behaviour is diverse and no machine smoking method can represent all sorts of smoking behaviour. Machine smoking measurements are useful for characterizing cigarette emissions for example to compare products for research purposes or market surveillance. However, they are not a valid measure of human exposure and are not intended for this purpose. Consequently, TNCO levels based on machine smoking can give a false impression of human exposure and risk.

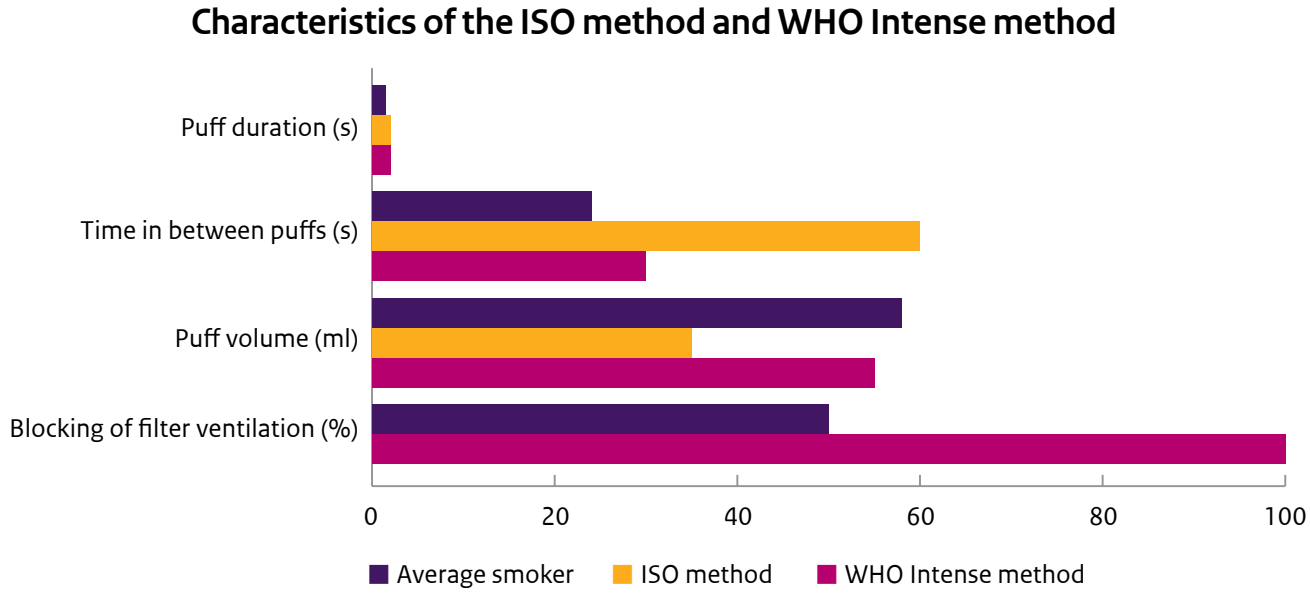

Figure 3. Characteristics of the ISO method and WHO Intense method for generating smoke using a smoking machine. An indication of the behaviour of an average smoker is added for comparison.

RIVM experiment

In 2018, the National Institute for Public Health and the Environment (RIVM) measured TNCO emissions of 100 brands of cigarettes on the Dutch market, using the WHO Intense method. These emissions have been compared with the TNCO levels declared by manufacturers and measured using the ISO method. For all 100 brands, the TNCO levels measured with the WHO Intense method were at least two times and up to 20 times as high as the levels stated by manufacturers (see figure 4). The largest difference between the two methods can be seen for cigarettes with relatively low TNCO levels in the ISO method.

These low TNCO levels are mainly caused by a high degree of filter ventilation in the ISO method. As the WHO Intense method blocks the filter holes, the degree of filter ventilation does not affect the measurement results. Therefore, the differences in measured TNCO levels between cigarette brands are smaller. The ISO TNCO levels fall within the maximum levels stipulated in the TPD and therefore the products comply with the directive. Even though the WHO Intense measured TNCO levels are almost all higher than this.

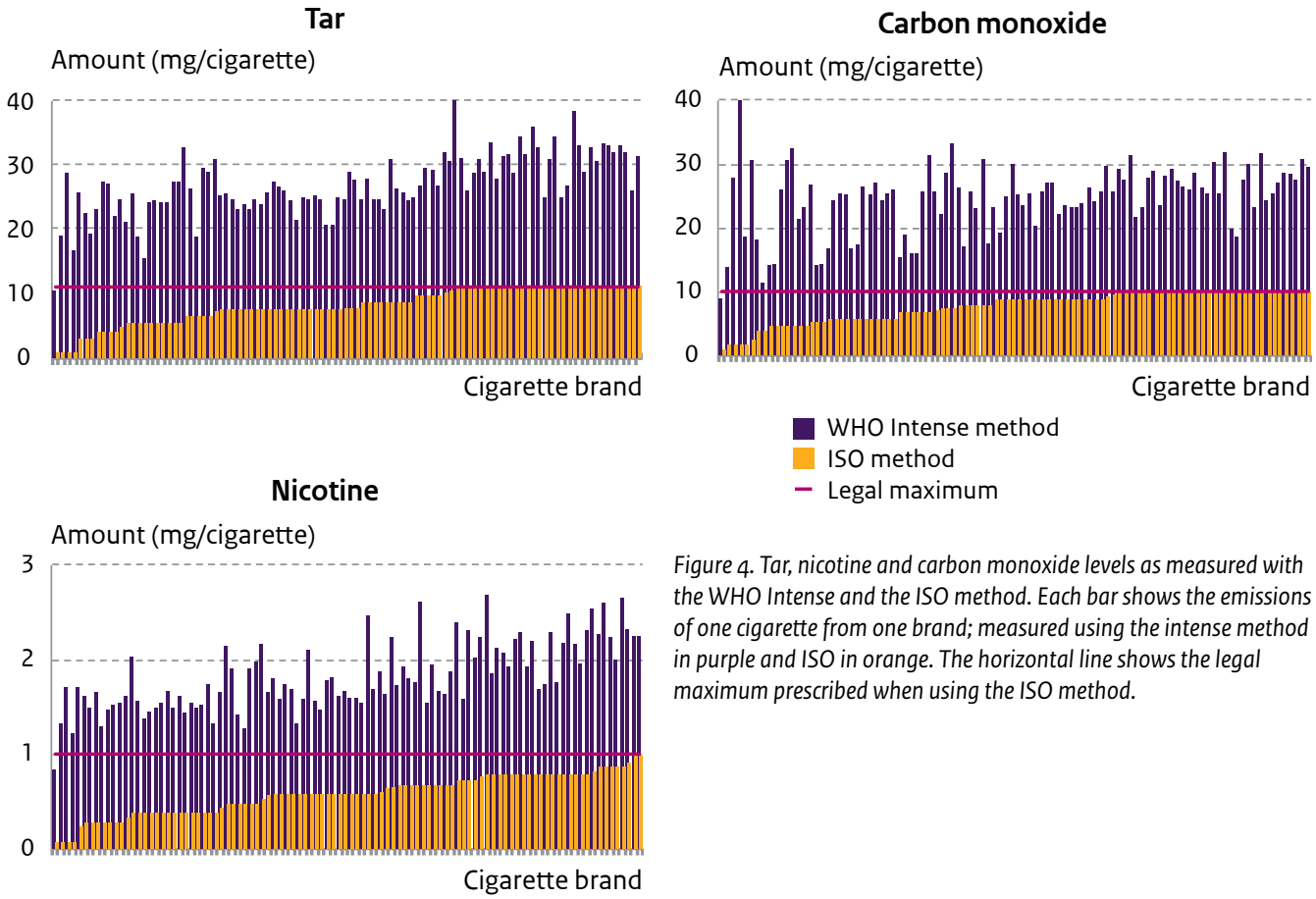

Figure 4. Tar, nicotine and carbon monoxide levels as measured with the WHO Intense and the ISO method. Each bar shows the emissions of one cigarette from one brand; measured using the intense method in purple and ISO in orange. The horizontal line shows the legal maximum prescribed when using the ISO method.

Importance of independent methods

The WHO has been an advocate for independent testing and measurement of the contents and emissions of tobacco products for years. Requirements for this are set out in the associated guidelines for articles 9 and 10 of the Framework Convention on Tobacco Control (FCTC)[8]. In March 2020 the WHO published an **information sheet on WHO TobLabNet methods for measuring priority contents and emissions in tobacco and related products** in which the importance of independent methods was emphasized as follows:

"As tobacco products are manufactured and intricately designed by the tobacco industry, their involvement in developing methods to test these products would be a clear conflict of interest. This is even more crucial given that the tobacco industry has a long history of misleading the public and working against well-intentioned tobacco-control policies. Examples include the use of ventilation holes in cigarettes to manipulate the emissions of tobacco products and promote so-called light and mild tobacco products as an alternative to quitting, while being fully aware that testing of these products, using International Organization for Standardisation (ISO) methods, will result in misleadingly low levels of the measured compounds. Therefore, tobacco industry activities, no matter how they are "dressed up", should always be monitored with caution and scepticism and regulatory test methods should be developed and validated independently of the tobacco industry.

Are ISO tobacco testing methods independent?

The industry exerts considerable influence on the adopted ISO testing methods for tobacco and tobacco products, as they make up by far the largest percentage of national and international technical committees. This led to WHO establishing an alternative global network of independent laboratories, the WHO Tobacco Laboratory Network (TobLabNet), to develop the methods for testing these products rather than adopting those developed under industry control and manipulation. Consequently, this will ensure the generation of independent and reliable information on tobacco products for regulatory purposes."

References

1. World Health Organization. WHO TobLabNet methods for measuring priority contents and emissions in tobacco and related products. 2020. Accessed February 5th 2021. https://apps.who.int/iris/bitstream/handle/10665/331427/WHO-HEP-HPR-2020.1-eng.pdf?sequence=1&isAllowed=y
2. Djordjevic MV, Fan J, Ferguson S, Hoffmann D. Self-regulation of smoking intensity. Smoke yields of the low-nicotine, low-'tar' cigarettes. *Carcinogenesis*. Sep 1995;16(9):2015-21. doi:10.1093/carcin/16.9.2015
3. Djordjevic MV, Stellman SD, Zang E. Doses of Nicotine and Lung Carcinogens Delivered to Cigarette Smokers. *JNCI: Journal of the National Cancer Institute*. 2000;92(2):106-111. doi:10.1093/jnci/92.2.106
4. Scherer G. Smoking behaviour and compensation: a review of the literature. *Psychopharmacology (Berl)*. Jul 1999;145(1):1-20. doi:10.1007/s002130051027
5. Scherer G, Lee PN. Smoking behaviour and compensation: a review of the literature with meta-analysis. *Regul Toxicol Pharmacol*. Dec 2014;70(3):615-28. doi:10.1016/j.yrtph.2014.09.008
6. Hammond D, Collishaw NE, Callard C. Secret science: tobacco industry research on smoking behaviour and cigarette toxicity. *Lancet*. Mar 4 2006;367(9512):781-7. doi:10.1016/s0140-6736(06)68077-x
7. Jarvis MJ, Boreham R, Primatesta P, Feyerabend C, Bryant A. Nicotine yield from machine-smoked cigarettes and nicotine intakes in smokers: evidence from a representative population survey. *J Natl Cancer Inst*. Jan 17 2001;93(2):134-8. doi:10.1093/jnci/93.2.134
8. World Health Organization. WHO Framework convention on Tobacco control. Geneva2003.

More information

- RIVM website about tobacco research: https://www.rivm.nl/en/tobacco/
- WHO information sheet on WHO TobLabNet methods for measuring priority contents and emissions in tobacco and related products: https://apps.who.int/iris/bitstream/handle/10665/331427/WHO-HEP-HPR-2020.1-eng.pdf?sequence=1&isAllowed=y

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