

# Air quality assessment during indoor use of the Tobacco Heating System THS 2.2

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## Introduction and Objectives

Philip Morris International's (PMI) heat-not-burn Tobacco Heating System 2.2 (THS 2.2) uses an electronically controlled heating mechanism to precisely heat specially designed tobacco sticks at operating temperatures well below combustion. As a result, the generated aerosol is composed of mainly water, glycerin and nicotine while the levels of harmful and potentially harmful constituents are significantly decreased compared to cigarettes smoke. In order to address public health concerns about possible presence of polluting substances during indoor use of heated tobacco products which may present an exposure source to potential bystanders, a study was designed using a dedicated controlled room (IAQ room, Figure 1) and applying ventilations conditions recommended to simulate environment representative for residential buildings with natural ventilation ("Residential category III"; EN 15251:2007).



Figure 1: Graphical representation of the IAQ room during the experiments with THS 2.2.

## Methods

- Experiments executed in an environmentally controlled room (IAQ room, Figure 1)
- Ventilation at 0.5 air changes/h (EN 15251:2007)
- Occupant density of 8 m<sup>2</sup>/person (2 volunteer panelists and one PMI staff member)
- Adult experienced IQOS users for the THS 2.2 sessions and cigarette smokers for the *Marlboro Gold* sessions recruited by an external company
- THS 2.2 used under predetermined conditions (2 h, 6 sticks/h, 12 sticks in total) and under consumption with no restraint (2 h, "ad libitum")
- Positive control: *Marlboro Gold* (2 h, 6 cigarettes/h, 12 cigarettes in total)
- Background session (2 h) with the same volunteers as for the product session before each THS 2.2 or *Marlboro Gold* session
- Three replicates of each simulation
- Indoor air concentrations of twenty-three constituents determined (Table 1)

Table 1: List of constituents analyzed during the study and rationale for selection\*.

| Category – (Norm) -[unit]   | Constituents  | Rationale for selection  |
|---|---|--|
| ISO measurement standards for ETS (ISO Norms 15593, 2001; 18144, 2003; 18145, 2003; 11454, 1997) - [µg/m <sup>3</sup> ] | RSP gravimetric, UVPM-THBP, FPM-scopoletin, Solanesol, 3-Ethenylpyridine, <u>Nicotine</u> | PM2.5 & tobacco smoke related particulate matter markers<br>Gas-phase tobacco smoke specific markers |
| ISO measurement standard for TVOCs (ISO 16000-6, 2011) - [µg/m <sup>3</sup> ]   | Total Volatile Organic Compounds (TVOC)   | Air quality marker   |
| Carbonyls - [µg/m <sup>3</sup> ]  | Acetaldehyde, Acrolein, Crotonaldehyde, Formaldehyde                                      | Relevance for air quality  |
| Volatile Organic Compounds (VOCs) - [µg/m <sup>3</sup> ]  | <u>Acrylonitrile</u> , Benzene, 1,3-Butadiene, Isoprene, Toluene                          | Relative abundance in THS2.2 aerosol (i.e. the most abundant)  |
| Tobacco-specific Nitrosamines (TSNAs) - [ng/m <sup>3</sup> ]  | <u>N-nitrosornicotine (NNN)</u><br><u>Nicotine-derived nitrosamine ketone (NNK)</u>       | Carbonyls, VOCs, TSNAs: part of the FDA list of HPHCs  |
| Product-specific compounds: aerosol formers - [µg/m <sup>3</sup> ]  | Glycerin, Propylene Glycol  | Product-specific markers   |
| Inorganics (CO [ppm], NO [ppb], NO <sub>x</sub> [ppb])  | <u>Carbon monoxide</u> , Nitrogen oxide, Nitrogen oxides                                  | Gas-phase tobacco smoke non-specific markers<br>Gas-phase combustion marker                          |

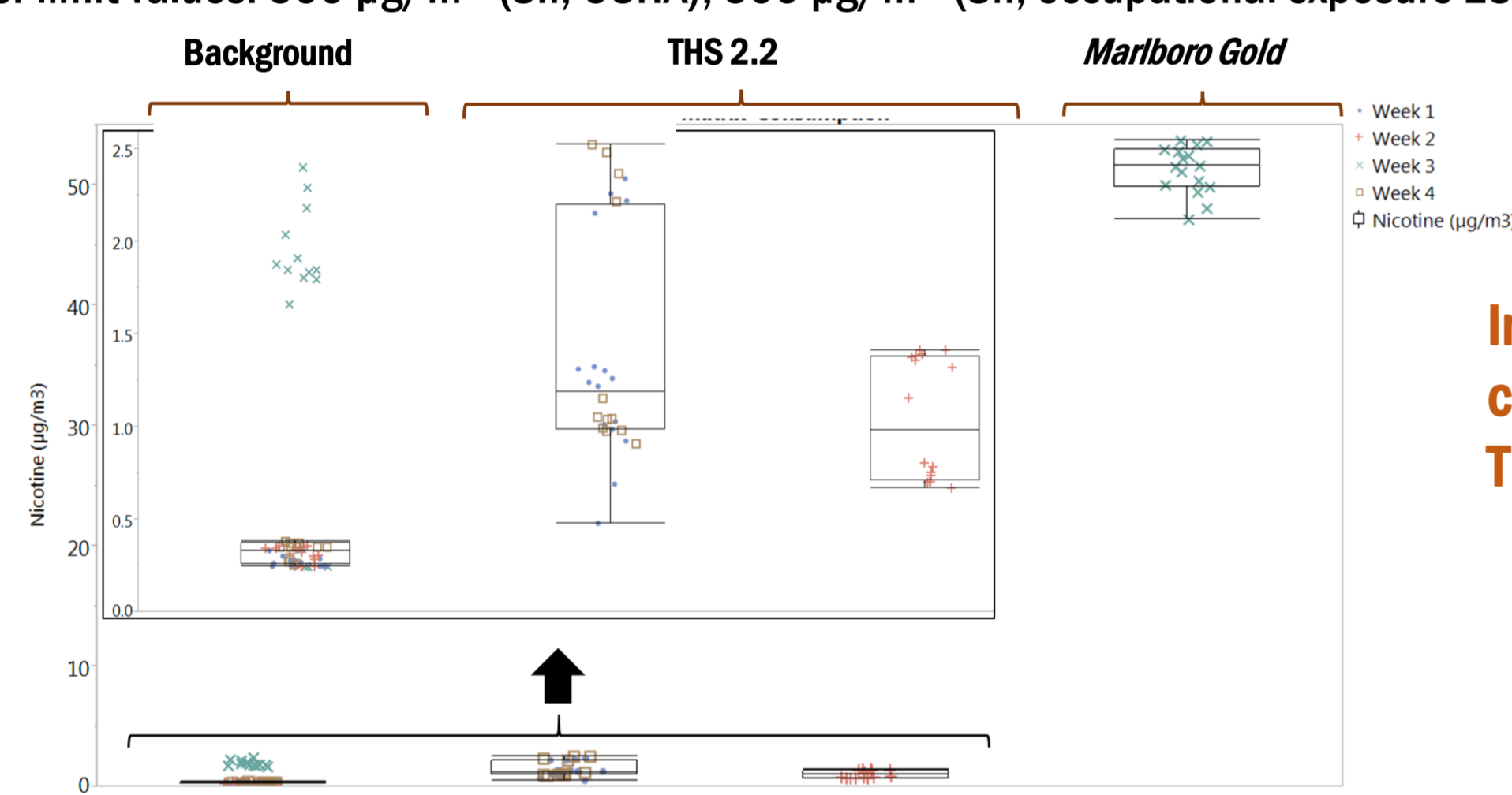
\*Constituents part of FDA list of HPHCs are underlined.

## Results and Discussion

Illustration of the evaluations are presented on Figure 2-Figure 4.

### Nicotine:

- specific marker of Environmental Tobacco Smoke, tobacco heated products and e-cigarettes
- mainstream aerosol of THS 2.2 (Health Canada Intense): 1.32 ± 0.16 mg/stick (mean±CI<sub>95%</sub>)
- guideline upper limit values: 500 µg/m<sup>3</sup> (8h; OSHA), 500 µg/m<sup>3</sup> (8h, occupational exposure EU)

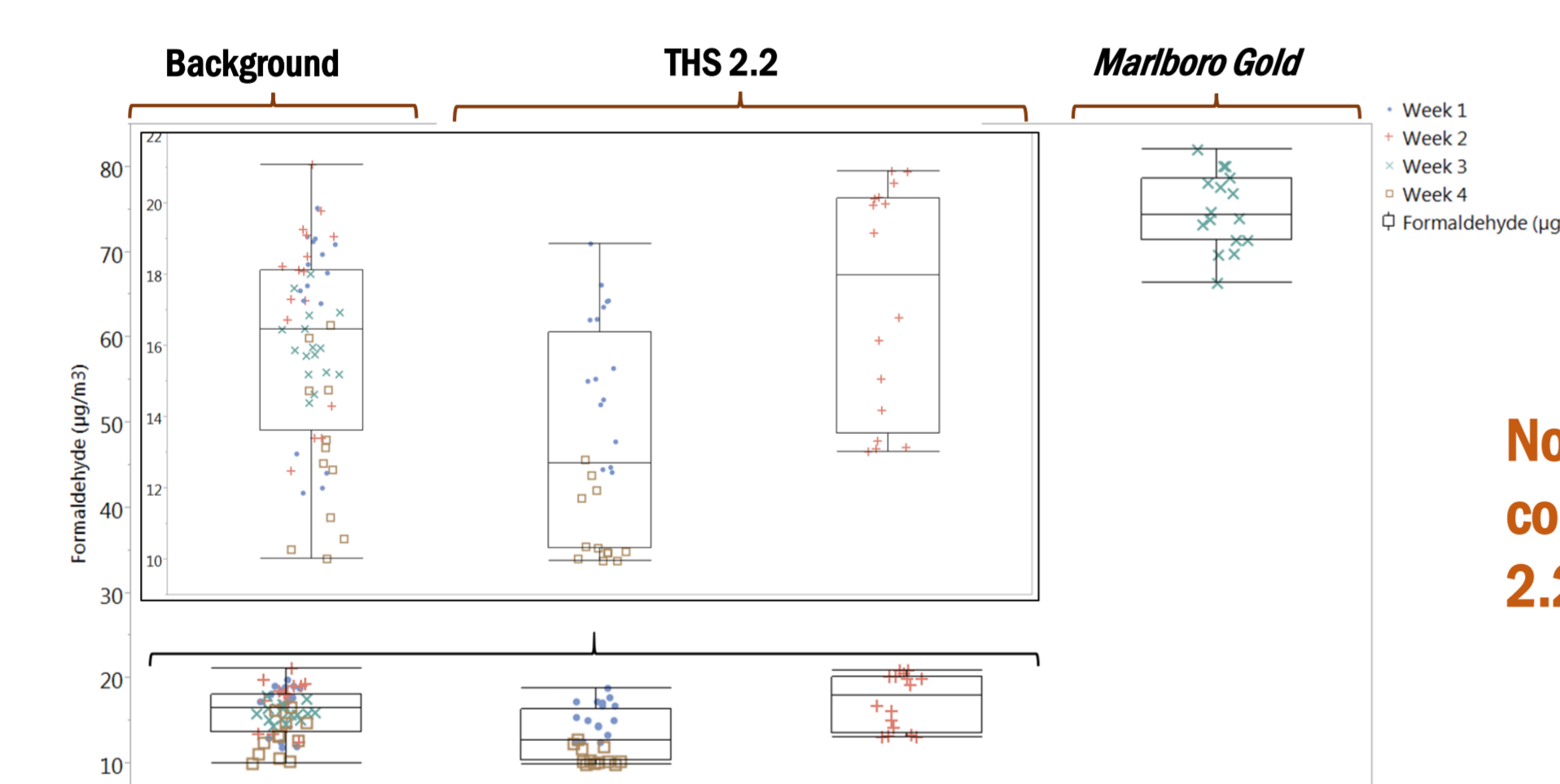


Increase above background concentrations during indoor use of THS 2.2

Figure 2: Comparison of data for nicotine measurements.

### Formaldehyde:

- non-specific marker of Environmental Tobacco Smoke
- ubiquitous in all indoor environments; sources: building materials and consumer products, infiltration of polluted outdoor air, e.g. from areas with intensive vehicles traffic; low levels in exhaled breath (Salthammer et al, 2010)
- mainstream aerosol of THS 2.2 (Health Canada Intense): 5.53 ± 0.69 µg/stick (mean±CI<sub>95%</sub>)
- guideline upper limit values: 100 µg/m<sup>3</sup> (30 min; WHO, 2010), 30 µg/m<sup>3</sup> (EU; Kotzias et al, 2005)

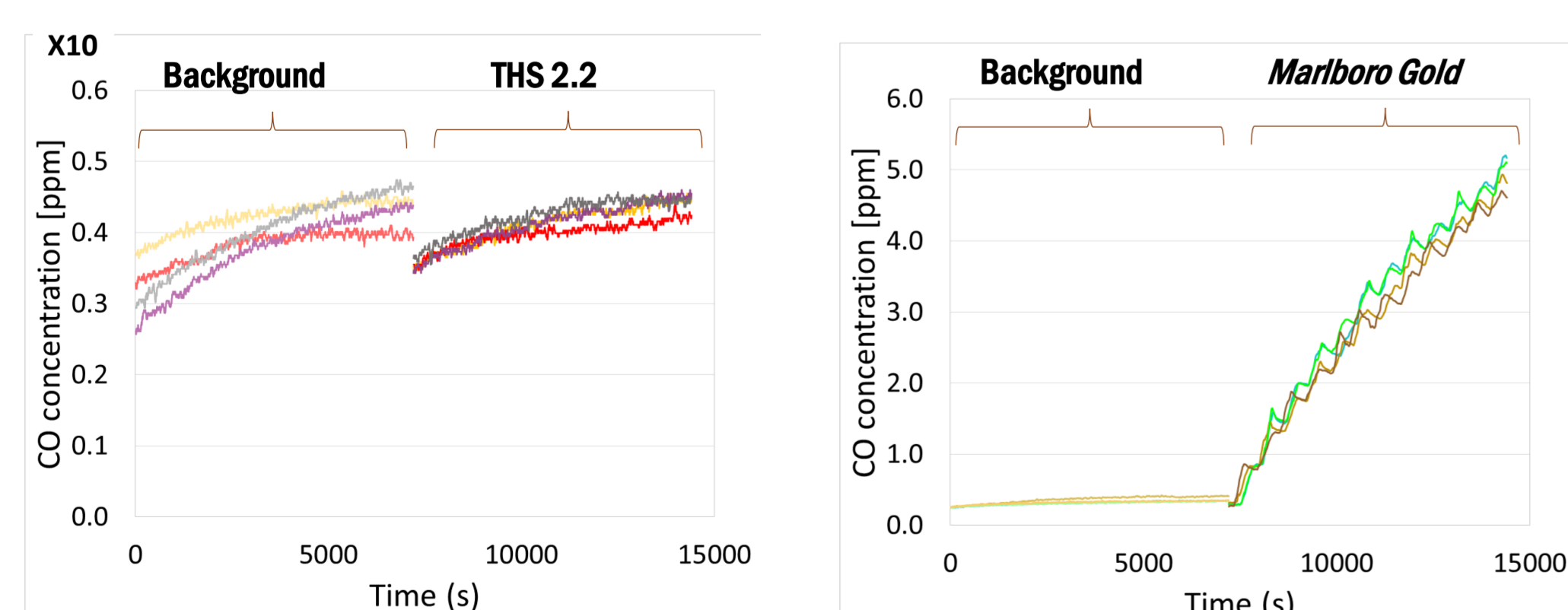


No increase above background concentrations during indoor use of THS 2.2

Figure 3: Comparison of data for formaldehyde measurements.

### Carbon monoxide:

- non-specific marker of Environmental Tobacco Smoke
- ubiquitous in ambient air; increased concentration in air due to presence of combustion sources; low levels in exhaled breath (WHO, 2010)
- mainstream aerosol of THS 2.2 (Health Canada Intense): 0.531 ± 0.068 mg/stick (mean±CI<sub>95%</sub>)
- guideline upper limit values: 10 ppm (WHO, 2010), 10 ppm (EU; Kotzias et al, 2005)



No increase above background concentrations during indoor use of THS 2.2

Figure 4: Online measurements of carbon monoxide.

## References

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## Results and Discussion

The study evaluated the indoor impact of THS 2.2 under typical high load conditions for a residential environment:

- high consumption rates for THS 2.2 and cigarettes (6 sticks/h, total of 12 sticks for 2h session; ad libitum. 8-15 sticks for 2h session)
- low ventilation conditions (0.5 air changes/h; EN15251:2007).

The results are summarized in Table 2.

The outcomes of the current study were consistent with those for the other simulated environments ("Residential category I", "Residential category II", "Office" and "Hospitality", Mitova et al, 2016; Table 2).

Table 2: Comparison of the summary results of the current study and the study described in Mitova et al, 2016\*.

| Analyte [unit]                         | THS vs Background (difference in units) |                |                 |        |             | Cigarette vs Background (difference in units) |                |                 |        |             |
|--|---|----------------|-----------------|--------|-------------|---|----------------|-----------------|--------|-------------|
|  | Residential I                           | Residential II | Residential III | Office | Hospitality | Residential I                                 | Residential II | Residential III | Office | Hospitality |
| RSP gravimetric [µg/m <sup>3</sup> ]   |   |                |                 |        |             | 236   | 268            | 642             | 204    | 147         |
| UVPM-THBP [µg/m <sup>3</sup> ]         |   |                |                 |        |             | 39.6  | 40.8           | 92.1            | 38.5   | 18.4        |
| FPM-scopoletin [µg/m <sup>3</sup> ]    |   |                |                 |        |             | 8.05  | 8.5            | 20.4            | 7.88   | 4.04        |
| Solanesol [µg/m <sup>3</sup> ]         |   |                |                 |        |             | 10.2  | 9.84           | 23.8            | 10.2   | 4.68        |
| 3-Ethenylpyridine [µg/m <sup>3</sup> ] |   |                |                 |        |             | 6.02  | 7.61           | 10.5            | 6.39   | 3.94        |
| Nicotine [µg/m <sup>3</sup> ]          | 0.69                                    | 1.81           | 0.70            | 1.10   | 0.66        | 29.7  | 29.1           | 49.8            | 34.7   | 34.6        |
| Acetaldehyde [µg/m <sup>3</sup> ]      | 2.66                                    | 5.09           | 3.26            | 3.65   | 1.40        | 70.2  | 83.8           | 123             | 58.8   | 33.1        |
| Acrolein [µg/m <sup>3</sup> ]          |   |                |                 |        |             | 6.94  | 5.65           | 11.6            | 6.42   | 3.03        |
| Crotonaldehyde [µg/m <sup>3</sup> ]    |   |                |                 |        |             | 2.19  | 2.11           | 3.54            | 2.04   | 0.99        |
| Formaldehyde [µg/m <sup>3</sup> ]      |   |                |                 |        |             | 27.1  | 35.5           | 58.4            | 28.9   | 17.5        |
| Acrylonitrile [µg/m <sup>3</sup> ]     |   |                |                 |        |             | 2.53  | 3.61           | 5.26            | 2.61   | 1.36        |
| Benzene [µg/m <sup>3</sup> ]           |   |                |                 |        |             | 7.09  | 9.24           | 14.4            | 6.58   | 3.5         |
| 1,3-Butadiene [µg/m <sup>3</sup> ]     |   |                |                 |        |             | 13  | 16.8           | 17.4            | 12.6   | 5.79        |
| Isoprene [µg/m <sup>3</sup> ]          |   |                |                 |        |             | 71.5  | 99.4           | 164             | 75.9   | 37          |
| Toluene [µg/m <sup>3</sup> ]           |   |                |                 |        |             | 11.1  | 26.1           | 25              | 14.9   | 8.76        |
| TVOC [µg/m <sup>3</sup> ]              |   |                |                 |        |             | 144   | 451            |                 |        |             |
| NNN [ng/m <sup>3</sup> ]               |   |                |                 |        |             |   |                | 8.89            |        |             |
| NNK [ng/m <sup>3</sup> ]               |   |                |                 |        |             |   |                | 1.49            |        |             |
| Glycerin [µg/m <sup>3</sup> ]          |   |                |                 | 12.1   |             |   |                | 10.3            |        |             |
| Propylene glycol [µg/m <sup>3</sup> ]  |   |                |                 |        |             |   |                | 26.6            |        |             |
| CO [ppm]                               | 1.63                                    | 2.17           | 6.65            | 1.58   | 0.92        |   |                |                 |        |             |
| NO [ppb]                               | 26.2                                    | 35.6           | 59.4            | 27     | 14.8        |   |                |                 |        |             |
| NO <sub>x</sub> [ppb]                  | 29.4                                    | 39.7           | 62.8            | 29.4   | 15.3        |   |                |                 |        |             |

\*The data are background subtracted; THS 2.2: numerical value not shown if the concentration of the constituent in air is not increased above background

## Conclusions

Under simulated "Residential category III" environmental condition, only two HPHCs (nicotine and acetaldehyde) and one specific compound (the aerosol former glycerin) were attributable to the indoor use of THS 2.2:

- nicotine was measured at levels up to 1.48 µg/m<sup>3</sup> (mean with no background subtraction). The European Agency for Safety and Health at Work has established an exposure limit at 500 µg/m<sup>3</sup> (for 8 hours), a level more than 300 times higher than the maximum mean level measured with THS 2.2.
- acetaldehyde was measured at levels up to 9.25 µg/m<sup>3</sup> (mean with no background subtraction), a level that can be directly compared to existing air quality standards (i.e. guidelines value for no significant health risk to individuals exposed to a certain level), for instance:
  - In Japan, the Ministry of Health, Labor and Welfare guidelines recommend a maximum level of 48 µg/m<sup>3</sup>, a level 4 times above the maximum mean level measured with THS 2.2 used indoor.
  - In the INDEX project final report (Kotzias et al, 2005), an exposure limit was set at 200 µg/m<sup>3</sup>, a level 20 times above the maximum mean level measured with THS 2.2 used indoor.
- Glycerin was measured up to 13.3 µg/m<sup>3</sup> (mean with no background subtraction). ACGIH, 2001 sets a reference level at 10 000 µg/m<sup>3</sup>, a concentration more than 750 times above that measured during THS 2.2 use.

In light of the above, and comparing our results with existing air quality guidelines, it can be concluded that under the studied experimental conditions there is no negative impact on the overall Indoor Air Quality when using THS 2.2.

## Abbreviations

ACGIH: American Conference of Governmental Industrial Hygienists; EU: European Union; FPM: Fluorescence Particulate Matter; HPHC: Harmful and Potentially Harmful Constituents; NNK: nicotine-derived nitrosamine ketone; NNN: N-nitrosornicotine; OSHA: US Occupational Health and Safety Administration; PMI: Philip Morris International; RSP: Respirable Suspended Particles; THS: Tobacco Heating System; TVOC: Total Volatile Organic Compounds; UVPM-THBP: Ultraviolet Particulate Matter-2,2',4,4'-tetrahydroxybenzophenone; VOC: Volatile Organic Compounds;