# Influence of the power supplied on the e-liquid consumption and the by-products on emissions

**Sébastien Soulet**, Jérémy Sorin, Charly Pairaud, Maud Mercury, Hélène Lalo
*ingésciences, R&D Department, 2 chemin des Arestieux 33610 Cestas, France*

*U-SAV is a collaborative project between : Le petit Vapoteur, D'Lice, Vapoclope, Ozone, Green Liquides, VDLV, Gaiätrend, ERAG, Ivapote, MyVapors Europe*

## INTRODUCTION

Each e-cigarette user observe that more they increase power, more they produce vapor (others parameters being fixed). Likewise an important vapor generation lead to a high e-liquid consumption. We speak usually about couple « power/resistance value » to describe heating conditions, although the resistance value being not the influential parameter. Indeed, contrary to the commun though, we assume that the essential factor is the resistance's surface. We introduce here the concept of power flux density. It's defined as the ratio of the power delivred to the external surface of the resistance. We demonstrate that resistance's surface is more important that resistance's value for given power and liquid. We have studied e-liquid consumption, by-products generation and connected them to power flux density. Thanks to these results, we are able to give recommendations for « safer » practices (under these study's conditions).

## MATERIALS

Manipulations are realized with U-SAV vaping machine. Cleromizeurs used for these manipulations are CUBIS from Joytech. The wicks are in japanese cotton. The emissions are collected by a cryogenic trap regulated between -45 and -40°C coupled with an impinger containing DNPH solution. E-liquid consumption is measured by mass variation before and after the vaporization process. Emissions are analyzed thanks to a GC-FID-MS and a UPLC-DAD-MS. The parameters programmed in U-SAV interface are listed bellow:

**Sequence proprieties**

| | |
|---|---|
| Number of series | 5 |
| Number of puff by serie | 20 |
| Time between two puffs | 30 s |
| Time between two series | 300 s |

**Ventilation proprieties**

| | |
|---|---|
| Puff duration | 3.0 s |
| Puff period | 30.0 s |
| Maximum flow rate | 1.1 L/min |
| Puff volume | 55.0 mL |

**Heating proprieties**

| | |
|---|---|
| Power supplied | 0-10-20-25-30-40 W |
| Resistance value | 0.5 - 1 -1.5 Ω |
| Surface of wire | 94.2 – 76.0 – 71.6 mm² |
| Metal | Stainless steel |

**E-liquid proprieties**

| | |
|---|---|
| PG-VG ratio (V-V) | 50-50 |
| Ethanol | 10 % |
| Nicotine | 10 mg/mL |
| Density | 1.16 g/mL |

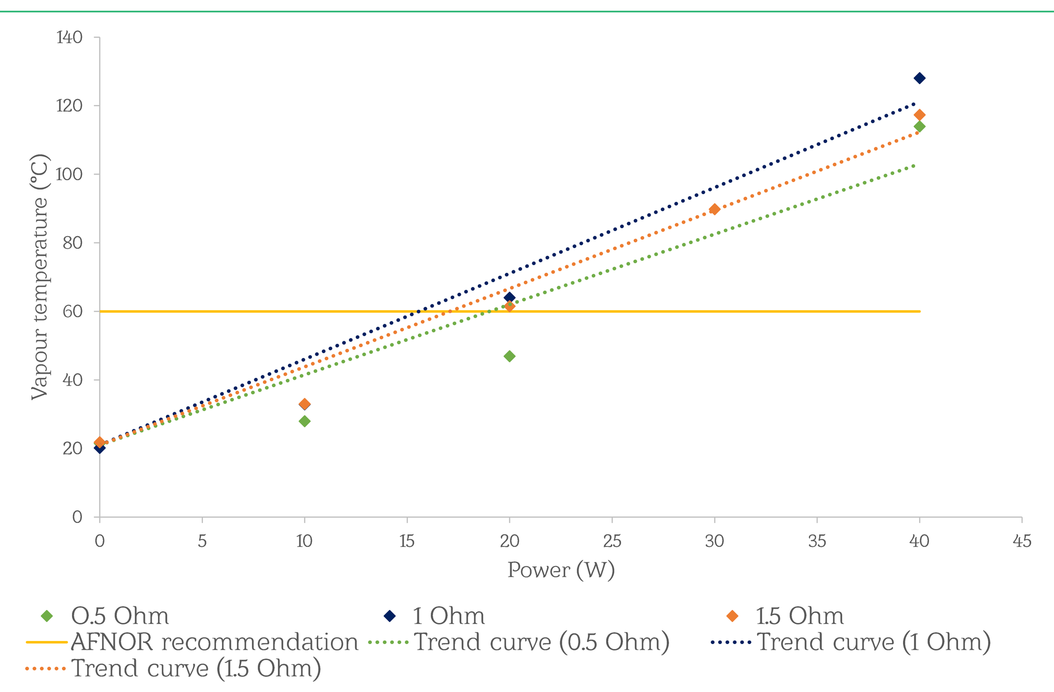
## METHODS

**Experience:** Manipulation consist of varying the power applied on different resistances for a given clearomizer. The power range goes from 0 to 40 W and resistance values are 0.5Ω, 1Ω and 1.5Ω. The protocol used is based on AFNOR standard XP-D90-300 part 3.

## RESULTS

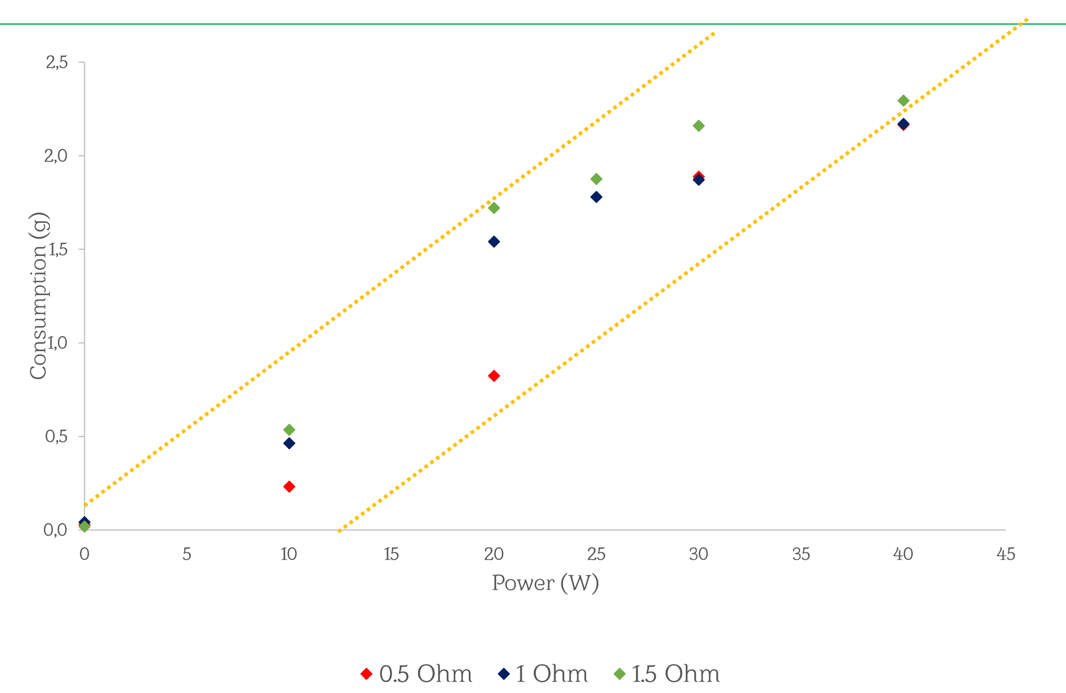
**Experience: Power**

### Vapor temperature



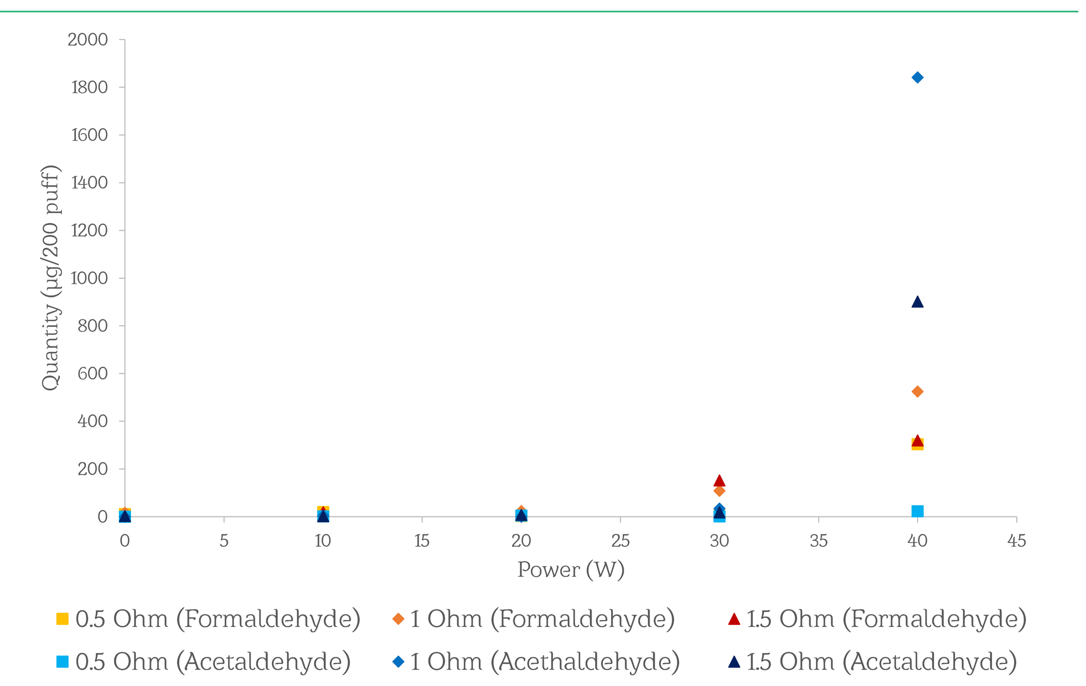

*The vapor temperature increases linearly to power supplied. Each resistance follows his own behavior. We could notice that maximum authorized vapor temperature is reached at 20W.*

### E-liquid consumption




E-liquid's consumption increases with the delivered power. Each resistance follows its own curve, althought their consumption values are close.

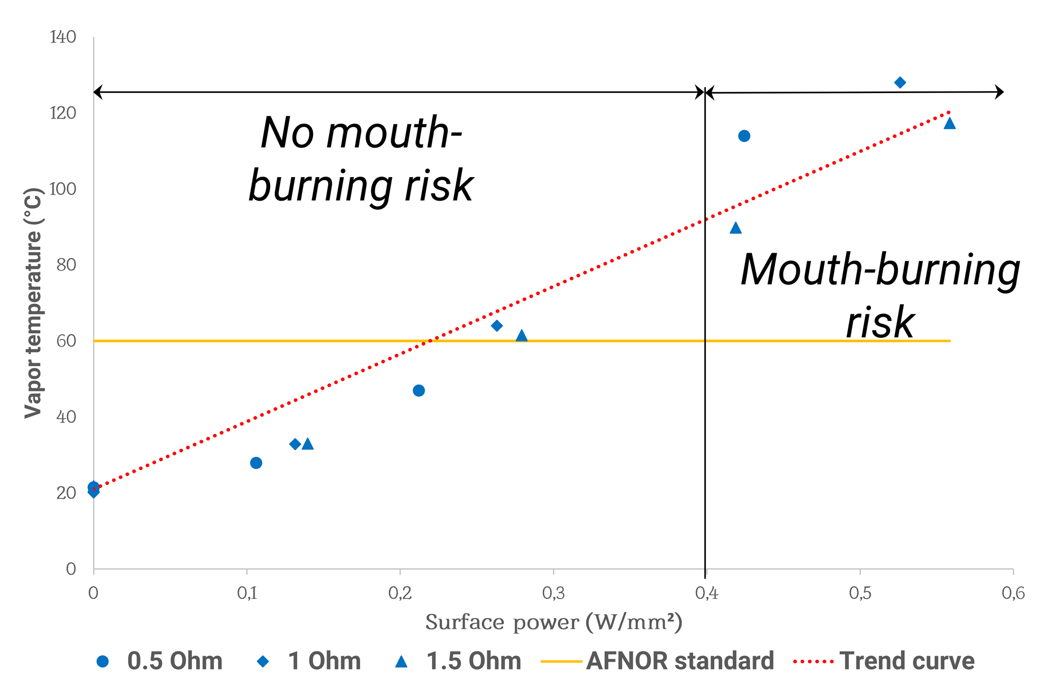
### By-product generation




*The by-products generation appears for all resistance values around 30W.*

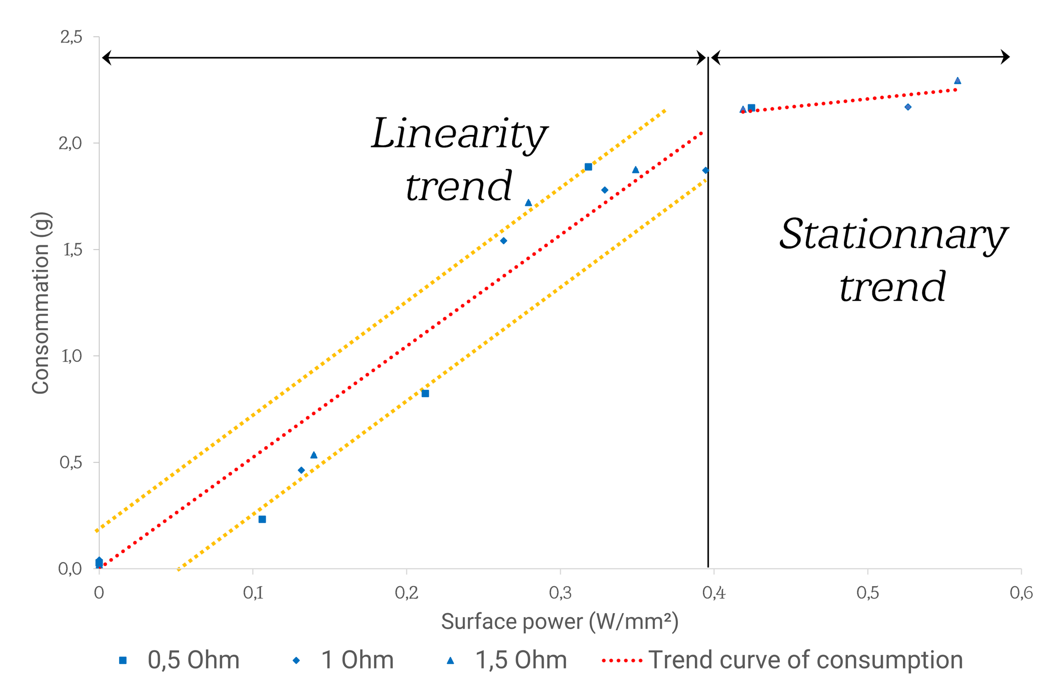
**Experience: Power flux density**

### Vapor temperature



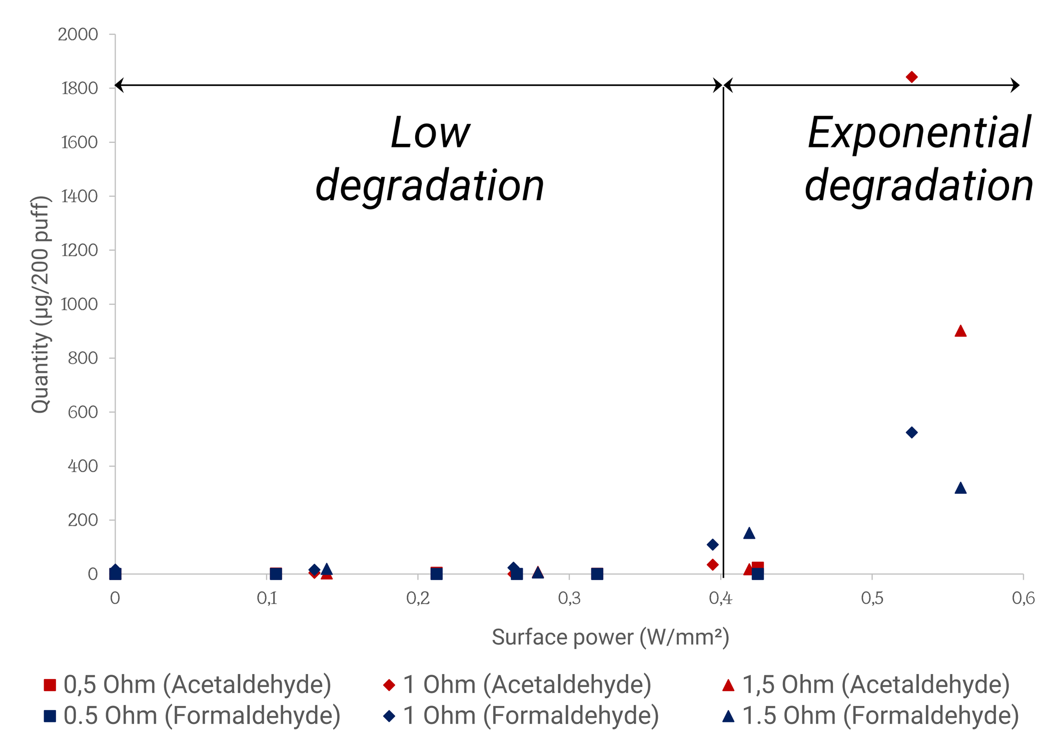

*When observing previous results with power flux density, we notice that the three resistances have the same behavior despite their value.*

### E-liquid consumption




*Whenever resistance values, the power flux density reflects a global linearity of e-liquid consumption between 0 to 0,4 W/mm². We observe that after 0,4 W/mm², the consumption seems to be stationnary.*

### By-product generation




*On this graph, we observe a change occurring at 0,4W/mm². Indeed, by-products generation increases significantly when the consumption reach a stationnary state.*

## CONCLUSION

We have demonstrated that the power flux density is a parameter more important that the couple « power/resistance value ». Based on the surface's resistance, the user can free himself from resistance value. Indeed, by using power flux density, the behavior of the several resistance's values is smoothed. Thanks to this new perspective, we highlight a stationary state where e-liquid consumption stops its rise despite the power increases. We notice an exponantial by-products generation related to this stationary state.

This observation suggests that there is a maximal capacity of vaporization for this device. The wick dries up, because e-liquid does not go up fast enough by capillarity. So beyond this limit, the energy delivred by the battery is got be used to degrade the wick.

For a given device, we are able to predict risky behavior where by-products are highly generated.

## BIBLIOGRAPHY

1. Farsalinos et al, (2015) *E-cigarettes generate high levels of aldehydes only in'dry puff' conditions*, Addiction.
2. Jensen et al. (2015) *Hidden Formaldehyde in E-Cigarette Aerosols*. Environemental New England Journal of medecine.