



## INTRODUCTION

We present the first vaping machine allowing the control and the reading of all physical parameters in vaporization : power, puff duration and number, resistance value, temperature vapor. Indeed, in order to study the functioning of an e-cigarette and the impact of all vaporization parameters on e-liquid consumption and degradation, LFEL has conceived and developed a machine able to control physical parameters independently of the others. U-SAV « Universal System for Analysis of Vaping » is a machine dedicated to the analysis of e-liquids and e-cigarettes and to the comprehension and fundamental researches of vaping process. Thanks to a well-designed interface, the user can vary all the physical key parameters. U-SAV capacities, versatility and stability are highlighted.

## MATERIALS

Manipulations are realized with U-SAV vaping machine (6 lines). Cloromizeurs 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. The parameters programmed in U-SAV interface are listed bellow, according to AFNOR standard XP-D90-300 part 3 :

Sequence properties		Ventilation properties		Heating properties		E-liquid properties	
Number of series	5	Puff duration	3.0 s	Power supplied	15 W	PG-VG ratio (V-V)	50-50
Number of puff by serie	20	Puff period	30.0 s	Resistance value	1 Ω	Ethanol	10 %
Time between two puffs	30 s	Maximum flow rate	1.1 L/min	Surface of wire	76 mm <sup>2</sup>	Nicotine	10 mg/mL
Time between two series	300 s	Puff volume	55.0 mL	Metal	Stainless steel	Density	1.16g/mL

## METHODS

**Experience 1:** To highlight U-SAV stability, 294 different e-liquids (59 by line) were tested according to AFNOR conditions so as to be declared to TPD compliance. U-SAV is able to generate emissions in the same time, on 6 different and independent lines. A manipulation consists in the generation of 100 puffs on one U-SAV line.

**Experience 2:** In order to evaluate the stability of vaporization process over manipulations, the two standardized e-liquids A and B are used in 18 manipulations (3 experiments on 6 different lines). E-liquids masses are measured before and after vaporization process. Mass variation can be studied.

## RESULTS

Experience 1	Stability during 3 secondes-puff duration	Stability of each puff over 59 manipulations	Stability of 100 puffs on each manipulation
<b>Power</b>	<p>The applied power for a given resistance reach the consign in less than 0.5 s. It presents a stability with less than 15% variation during 2.5 s.</p>	<p>Across 100 puffs, the regulation presents a stability with a variation lower than 15%.</p>	<p>The average applied power presents a stability during all manipulations.</p>
<b>Flow</b>	<p>The applied flow reaches the consign in less that 50ms. It stays stable (less than 5% variation) during the 3 secondes puff.</p>	<p>Across 100 puffs generated in one manipulation, the average flow rate stays stable with less than 5% variation.</p>	<p>The average flow rate presents a stability during all manipulations (less than 5% of variation)</p>
<b>Experience 2</b>	<b>Average</b>	<b>Standard deviation</b>	<b>RSD</b>
<b>E-liquid A</b>	1.074 g	0.084 g	7.86 %
<b>E-liquid B</b>	0.9702 g	0,091 g	9,37%

## CONCLUSION

U-SAV enables the control and real-time monitoring of physical key parameters during vaporization process : power, puff duration and number, resistance value, air flow, vapor temperature. We have demonstrated here U-SAV stability : power and flow are highly stable leading to a consumption with weak deviation. Thanks to its potential and versatility, U-SAV can be used to study vaporization parameters one by one in order to understand the whole process. Thus safe material configuration and behavior will be highlight. Moreover, it can be used as vaping machine for TPD compliance due to its sucessfull characterization according to AFNOR standard XP-D90-300 part 3 (stability on power regulation, flow rate and e-liquid vaporization). This makes U-SAV an ideal vaping machine for TPD compliance.