

# TRAINING

## Basics about Vacuum, Leak Detection and Leak Test Methods

## Table of Contents.

<b>Introduction.</b>	<b>7</b>
<b>Some Theory:</b>	<b>7</b>
<b>What is Pressure?</b>	<b>7</b>
<b>What is vacuum?</b>	<b>7</b>
<b>What is Temperature?</b>	<b>8</b>
<b>The Composition of Air.</b>	<b>8</b>
<b>What is partial Pressure?</b>	<b>8</b>
Partial Pressures in Air.	8
<b>Dalton's Law:</b>	<b>9</b>
<b>What is Gas?</b>	<b>9</b>
<b>What is Vapour Pressure?</b>	<b>9</b>
Vapour Pressure of Water at different Temperatures.	10
Vapour Pressure of different Liquids at 20° C.	10
<b>What is „mean free path“?</b>	<b>10</b>
Mean free Paths of different gases.	11
<b>Avogadro's Law:</b>	<b>11</b>
Avogadro's Number:	11
<b>What is a Mole?</b>	<b>11</b>
<b>Boyle's Law.</b>	<b>12</b>
<b>Charles' Law:</b>	<b>13</b>
<b>Gay-Lussac's Law:</b>	<b>13</b>
<b>The scale of absolute temperature:</b>	<b>14</b>
<b>The universal Gas Law.</b>	<b>14</b>
<b>Leak rates.</b>	<b>15</b>
<b>The practical significance of leak rate values.</b>	<b>15</b>
Leak rates in imaginable numbers:	16
Leak rates at the Bubble test:	16
<b>The Flow of Gases through Leaks.</b>	<b>17</b>
<b>Viscous Flow:</b>	<b>17</b>
a.) <b>Turbulent Flow:</b>	<b>18</b>
b.) <b>Laminar Flow:</b>	<b>18</b>
<b>Calculation of an example.</b>	<b>19</b>
Viscosity of some gases	20
<b>Conversion at laminar Flow of Helium Leak rate to Leak rates of other Gases.</b>	<b>20</b>



<b>Molecular Flow:</b>	<b>20</b>
<b>Conversion from weight leak rate to volume leak rate.</b>	<b>22</b>
Conversion of Helium leak rate at molecular Flow to other Gases.	25
<b>Transition Flow.</b>	<b>25</b>
<b>The Flow of Liquids in Leaks.</b>	<b>26</b>
a.) Turbulent Flow:	26
b.) Laminar Flow:	26
<b>Calculation from gas leakrate to liquid leakrate</b>	<b>27</b>
1. Calculation example:	27
2.) Calculation example:	29
3.) Calculation example:	29
<b>Appendix:</b>	<b>31</b>
The Greek Alphabet	31
<b><i>Leak search and Leak Measurement</i></b>	<b>32</b>
<b>Visual Methods:</b>	<b>32</b>
<b>The Water Bath.</b>	<b>33</b>
<b>The Water Pressure Test.</b>	<b>33</b>
<b>The Dye penetrant test.</b>	<b>33</b>
<b>Leak location by discolouring chemicals.</b>	<b>34</b>
Leak search with Ammonia.	34
Discolouring of a burner flame.	34
<b>Leak localisation by observing bubble emissions.</b>	<b>35</b>
Bubble test - Immersion:	36
Bubble test with foam-producing liquids.	36
The so-called vacuum test (Bell Jar Method).	37
Bubble test with immersion into a hot liquid.	38
<b>Pressure Change Methods.</b>	<b>38</b>
<b>Pressure decrease measurement:</b>	<b>38</b>
Pressure decrease measurements with liquids.	38
Pressure decrease measurement with gases.	38
<b>Pressure increase measurement.</b>	<b>40</b>
<b>Pressure difference measurement.</b>	<b>41</b>
<b>Detection limit of the pressure change methods.</b>	<b>42</b>
<b>Leak detection with thermal conductivity sensors.</b>	<b>42</b>
<b>More methods:</b>	<b>43</b>
<b>Example: Tightness control with flow meters.</b>	<b>43</b>
<b><i>Halogen gas Leak test</i></b>	<b>43</b>
<b>Detection limits:</b>	<b>45</b>
Final remarks:	46
<b><i>Leak Detection with Hydrogen.</i></b>	<b>46</b>



<b>Hydrogen the underrated Tracer Gas</b>	<b>46</b>
Thought of as dangerous	47
Non-flammable mixture	48
Less accumulation	48
Hydrogen	48
<b>The Leak test with Helium.</b>	<b>49</b>
Operation of a mass spectrometer.	50
Design of a Quadrupole Mass Spectrometer.	53
The Design Principle of Helium-Leak detectors.	53
The Response Time.	55
Leak search- and Leak rate-Measuring Methods.	57
Vacuum Leak Test	57
Integral Leak Test	57
Sniffer Probe Leaktest	58
Envelope Leaktest	59
Leak test on previously hermetically sealed objects.	61
Helium permeation:	63
The Calibration of Helium Leak detectors:	66
1.) The Permeation-Reference leak:	66
2.) The capillary leaks.	66
Calibration of the Helium Leak Detector.	67
Leak rate Specifications.	69
Leak rate specification for a bicycle tyre.	69
The formal requirements of a leak rate specification.	70
Summary.	71