DEFINITIONS, CONVERSIONS, and CALCULATIONS for OCCUPATIONAL SAFETY and HEALTH PROFESSIONALS

THIRD EDITION

With Pride & Gratitude, this work is dedicated to my Family: to my wonderful Wife, **Gladys**, who supports me in all my undertakings; and to my two Sons, **Phillip** and **Ryan**, who, every day, make me proud to be their Father; and last, but certainly, not least, to the two newest members of the family, Phil and Ryan's Wives: **Chiki** and **Ayline**

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Edward W. Finucane, PE, QEP, CSP, CIH



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Last, but most certainly not least, I must acknowledge and thank my wife, Gladys. In spite of the fact that her formal education included neither the environment nor the area of occupational safety and health, she proofread the entire text, and in doing so was able to identify numerous areas where my descriptions required clarification, areas where I had omitted important data, etc., etc. Needless to say, to the extent that the material in this book is understandable to its readers, much of the credit must go to her.

AUTHOR

Edward W. Finucane was born in San Francisco, and raised in Stockton, California. He has earned degrees in Engineering from Stanford University, and in Business from Golden Gate University. Professionally, Mr. Finucane has been involved in both the Environmental and the Occupational Safety and Health fields for more than 35 years. During the last twenty five, he has operated his own professional consulting company, High Tech Enterprises, out of offices in Stockton, California. Mr. Finucane is a Registered Professional Engineer [**PE**], a Qualified Environmental Professional [**QEP**], a Certified Safety Professional [**CSP**], and a Certified Industrial Hygienist – Comprehensive Practice [**CIH**].

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For several years, he served on the faculty of the twice yearly course, *Comprehensive Review of Industrial Hygiene*, offered jointly by the Center for Occupational and Environmental Health [University of California at Berkeley, California] and the Northern California Section of the American Industrial Hygiene Association. He is presently a Committee Member of the American Industrial Hygiene Association's Gas and Vapor Detection Committee, and has taught in several Professional Development Courses that have been focused on analytical instrumentation.

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PREFACE

This book is intended to serve several purposes:

- 1. To function as a ready Desk Reference for the Occupational Safety and Health Professional, the Industrial Hygienist, and/or the Environmental Engineer. Such an individual, in the normal development of his or her career, will likely have specialized in some relatively specific sub-area of one of these overall disciplines. For such an individual, there will certainly be occasions when a professional or job related problem or situation will arise, one that falls within the general domain of Occupational Safety and Health, Industrial Hygiene, or the Environment, but is outside of this individual's area of principal focus and competence, and is, therefore, not immediately familiar to him or her. For such cases, this Reference Source will, hopefully, provide a simple path toward the answer.
- 2. To function as a useful Reference Source, Study Guide, or refresher to any individual who is preparing to take either the Core or the Comprehensive Examination for Certification as an Industrial Hygienist, a Safety Professional, an Environmental Engineer, or an Environmental Professional.
- 3. Finally, to assist Students who have embarked on a course of study in one of these disciplines. As a fairly concise compilation of most of the various important mathematical relationships and definitions that these Students will be called upon to utilize as they progress in their profession, it is hoped that this group, too, may find this work to be of some value.

This book, as a Reference Information Source and Example Problem Workbook, contains virtually every Mathematical Relationship, Formula, Definition, and Conversion Factor that any Professional in any of these overall disciplines will ever need or encounter. Every effort has been made to be certain that the information and relationships in it reflect the very best of the current thinking and technological understanding, as these concepts are currently used in the field.

Each of the Problem Solutions in this book contains carefully prepared step-by-step procedures that were followed in developing the requested answer. In addition, these Solutions contain explanations of the reasons and factors that had to be considered and used in completing each step. The underlying goal in generating these very detailed Solutions was that they would constitute a very complete road map that leads from the Problem Statement, itself, all the way to its eventual Solution. It is hoped that the various Problems, most having been developed out of the real life professional experiences of the Author and some of his colleagues, will prove to be representative of the actual situations that a professional in any of these fields might routinely encounter in the normal conduct of his or her professional life; because of this, it is hoped that they, too, will be of special value to both the professional and the prospective professional, alike.

Two final comments for the individual who has chosen to follow, or check out, each specific mathematical step shown in any of the Problem Solutions.

- 1. Each result as it is developed and presented in its final "boxed" format will have been adjusted so as to contain the correct number of significant digits.
- 2. In many of the Problem Solutions, there will, of necessity, be separate steps involving calculations that develop "intermediate" results as an example, please refer to Problem #3.12, from Page 3-32. In this problem there are four major, but separate, sub-results that must be calculated [see the Solution on Pages 3-61 through 3-63] in order to develop the final result that is asked for in the Problem Statement. In order, for the Solution of this Problem, these four steps are described on the following page [labeled i, ii, iii, & iv]:

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- i. Determination of the set of four mass-based concentration TLV Standards from the set of four volumetric based TLV Standards that were provided in the Problem Statement;
- ii. Determination of the overall TLV_{effective} for the entire four component mixture, considered as a whole;
- iii. Determination of the theoretical individual vapor phase concentrations [mass-based] for each of the four components in this mixture i.e., what these concentrations would have to be in order for the previously calculated overall mixture $TLV_{effective}$ to apply to the vapor phase; and
- iv. Finally, a determination of the four volume-based equivalent concentrations corresponding to each of these calculated mass-based concentrations.

For every multi-step Solution, each of the "intermediate" results will also have been reported in an appropriate number of significant digits; however, each subsequent calculation that makes use of any of these "intermediate" results will employ the "unrounded" number value that has been retained in the math coprocessor of the computer or the calculator that is being used to perform the calculations.

Because of this, any individual who methodically checks every step of any Problem Solution in this Text will almost certainly develop "intermediate" results that differ numerically from those in this section. This will be true if the answers that he or she obtains, in this overall stepwise process, were developed from the rounded, rather than the unrounded, "intermediate" values. To understand this situation better, please consider the following specific, in-depth example:

I would like to discuss two specific calculation steps that are presented in the Solution to Problem #3.12 [Page 3-32], as shown on Pages 3-61 through 3-63. The two steps are listed on Pages 3-61 & 3-62 — they involve the determination of the mass-based concentration of Methylene Chloride. This "intermediate" result was calculated to be $189.557 + mg/m^3$, and reported — in its rounded form — as $190 mg/m^3$. In each subsequent calculation step in the Solution to this Problem, the value of this concentration appears to have been used in its rounded form; however, such was never the case. Its unrounded equivalent always remained in the math coprocessor (where it had been carried out to a precision of many decimal places) and in every similar case each such value was always this value — namely, $189.557 + mg/m^3$ — that was used in each subsequent calculation, rather than the indicated rounded 190 mg/m³ value.

To continue with this specific example, consider one of the expressions used to calculate the $TLV_{effective}$ for the entire mixture. The expression to which I refer is shown below:

$$TLV_{effective} = \left(\frac{1}{\frac{0.25}{6,175} + \frac{0.55}{8,361} + \frac{0.15}{2,084} + \frac{0.05}{190}}\right)$$

The final term in the denominator of the overall expression for the $TLV_{effective}$, which is taken from the set of calculations referred to directly above, is listed as:

$$\frac{0.05}{190}$$

PREFACE

If the individual who is carefully checking out each step of each solution carries out this mathematical operation, using these values, on any calculator, he or she will obtain as a result, 2.632×10^{-4} . Clearly, this differs slightly from the listed value of 2.64×10^{-4} ; however, the difference is certainly not great. This latter value derives from using the ratio listed below, since it is the unrounded 189.557+ mg/m³ value that had been maintained in the calculator or computer that is being used. Thus the ratio actually employed in making this math calculation was:

$$\frac{0.05}{189.557481931+} = 2.6391145649 \times 10^{-4}$$

It is this second ratio, in contrast to the first one, that produces the slightly different 2.64×10^{-4} value listed above. Analogous slight deviations will likely occur in every Problem Solution where there are any "intermediate" numerical results, and the Reader should be aware of this possibility.

Should any reader wish to pass on comments or suggestions as to any aspect of the contents of this volume, I can be reached at any of the following locations and/or listings:

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Finally, I would like to compliment and thank any reader who has taken the trouble to wade through all the foregoing commentary. I hope it will be helpful as you progress in your studies or your career. Good luck as you put this volume into practical use.

Edward W. Finucane, PE, QEP, CSP, CIH

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