

# TABLE OF CONTENTS

Table of Figures..... IX

Chapter 1: Introduction ..... 1

    The First Law of Infrared Thermography ..... 2

    The Second Law of Infrared Thermography ..... 2

Chapter 2: Physics ..... 5

Chapter 3: Infrared Thermography, Thermal Analysis,  
and Temperature ..... 9

    3.1 History of Temperature and Infrared..... 9

    3.2 Introduction to Temperature .....12

    3.3 Matter.....13

        3.3.1 Solids, Liquids, and Gasses .....14

    3.4 Energy .....15

    3.5 Temperature .....17

        3.5.1 Common Thermometers.....18

        3.5.2 Temperature Scales .....18

            3.5.2.1 Daniel Gabriel Fahrenheit.....19

            3.5.2.2 Anders Celsius .....19

            3.5.2.3 Lord William Thompson Kelvin..... 20

            3.5.2.4 William John Macquorn Rankine .....21

        3.5.3 Temperature Scale Comparison .....21

        3.5.4 Temperature Conversions ..... 22

|                                                          |           |
|----------------------------------------------------------|-----------|
| <b>Chapter 4: Thermodynamics and Heat Transfer .....</b> | <b>23</b> |
| 4.1 Heat .....                                           | 23        |
| 4.2 Thermodynamics .....                                 | 23        |
| The Zeroth Law of Thermodynamics.....                    | 23        |
| The First Law of Thermodynamics .....                    | 23        |
| The Second Law of Thermodynamics .....                   | 23        |
| The Third Law of Thermodynamics .....                    | 24        |
| 4.3 Heat Transfer .....                                  | 24        |
| 4.3.1 Conduction .....                                   | 24        |
| Fourier's Law of Conduction .....                        | 25        |
| 4.3.2 Convection .....                                   | 27        |
| 4.3.3 Change of State .....                              | 30        |
| 4.3.3.1 Latent Heat .....                                | 30        |
| 4.3.4 Specific Heat .....                                | 32        |
| 4.3.5 Heat Transfer by Radiation .....                   | 34        |
| 4.4 Radiation .....                                      | 35        |
| <b>Chaper 5: Electromagnetic Radiation Basics .....</b>  | <b>37</b> |
| 5.1 The Electromagnetic Spectrum .....                   | 39        |
| 5.1.1 Radio Waves.....                                   | 40        |
| 5.1.2 Microwaves.....                                    | 41        |
| 5.1.3 Infrared .....                                     | 41        |
| 5.1.3.1 Night Vision.....                                | 42        |
| 5.1.3.2 Infrared Thermography.....                       | 43        |
| 5.1.3.3 Infrared Film .....                              | 44        |
| 5.1.4 Visible Light .....                                | 44        |
| 5.1.5 Ultraviolet .....                                  | 46        |
| 5.1.6 X-Rays.....                                        | 47        |
| 5.1.7 Gamma Rays .....                                   | 48        |
| 5.1.8 Infrared Regions.....                              | 49        |

|                                                                          |           |
|--------------------------------------------------------------------------|-----------|
| <b>Chapter 6: Infrared Radiation Physics .....</b>                       | <b>53</b> |
| 6.1 Blackbody Radiation.....                                             | 54        |
| 6.2 Infrared Radiation Laws .....                                        | 54        |
| 6.2.1 The Stefan–Boltzmann Law .....                                     | 54        |
| 6.2.2 Wien’s Law .....                                                   | 55        |
| 6.2.3 Planck’s Law .....                                                 | 55        |
| <b>Chapter 7: Real-World Infrared Radiation .....</b>                    | <b>57</b> |
| 7.1 Emissivity.....                                                      | 57        |
| 7.2 Long Wave Emissivity Chart.....                                      | 59        |
| 7.3 Determining Emissivity Using an Infrared<br>Imaging Radiometer ..... | 60        |
| Emissivity Test Procedure .....                                          | 60        |
| <b>Chapter 8: The Infrared Image.....</b>                                | <b>63</b> |
| 8.1 Thermographic Camera Operation.....                                  | 65        |
| 8.2 Getting a Good Image .....                                           | 67        |
| 8.3 Atmospheric Attenuation.....                                         | 68        |
| 8.4 Atmospheric Attenuation Chart.....                                   | 68        |
| 8.5 Angle of View .....                                                  | 69        |
| 8.6 Image Resolution.....                                                | 69        |
| 8.6.1 The Field of View (FOV) .....                                      | 70        |
| 8.6.1.1 Determining Physical Dimensions<br>Using an IR Imager .....      | 71        |
| 8.6.2 The Instantaneous Field Of View (IFOV) .....                       | 72        |
| 8.6.3 The Instantaneous Measurement Field of<br>View (IMFOV) .....       | 75        |
| <b>Chapter 9: Infrared Lenses .....</b>                                  | <b>77</b> |
| <b>Chapter 10: Infrared Windows .....</b>                                | <b>79</b> |
| <b>Chapter 11: Applications .....</b>                                    | <b>81</b> |
| 11.1 Reports .....                                                       | 81        |
| 11.1.1 Report Sections .....                                             | 83        |



|                                              |    |
|----------------------------------------------|----|
| 11.2 Electrical Inspections .....            | 85 |
| 11.2.1 Repair Priority Table .....           | 88 |
| 11.2.2 Load Correction Formula .....         | 89 |
| 11.3 Mechanical Inspections .....            | 89 |
| 11.3.1 Mechanical Reports.....               | 91 |
| 11.3.2 Equipment List .....                  | 91 |
| 11.4 Process Inspections.....                | 92 |
| 11.5 Building Inspections .....              | 93 |
| 11.5.1 Specific Heat .....                   | 94 |
| 11.5.2 Conventional Built-up Flat Roofs..... | 95 |
| 11.5.3 A Few General Rules .....             | 96 |
| <b>Conclusion</b> .....                      | 97 |
| <b>About the Author</b> .....                | 98 |