

## CONTENTS

|                                                                                   |     |
|-----------------------------------------------------------------------------------|-----|
| Abstract.....                                                                     | iii |
| Introduction.....                                                                 | 1   |
| Brake Materials, Products, and Usage.....                                         | 2   |
| Historical Development of Friction Products.....                                  | 2   |
| Requirements for Brake Linings.....                                               | 3   |
| Types of Brake Linings and Manufacturing Processes.....                           | 6   |
| Brake Lining and Repair and Maintenance Practices History.....                    | 8   |
| Selection of Facilities Surveyed.....                                             | 10  |
| Description of Brake Servicing Operations.....                                    | 10  |
| Sample Collection and Analysis Methods.....                                       | 11  |
| Airborne Samples.....                                                             | 11  |
| Bulk Samples.....                                                                 | 12  |
| Work Practices Characterization.....                                              | 13  |
| Compressed Air Blow-off.....                                                      | 13  |
| Compressed Air/Solvent Mist Blow-off.....                                         | 13  |
| Dry Brushing.....                                                                 | 13  |
| Wet Brushing.....                                                                 | 13  |
| Squirt-off.....                                                                   | 13  |
| Vacuum Cleaning.....                                                              | 14  |
| Survey Results and Discussion.....                                                | 15  |
| Asbestos Exposure Levels.....                                                     | 15  |
| TEM Fiber Characterization.....                                                   | 17  |
| Bulk Brake Dust.....                                                              | 21  |
| Trace Metal Analysis.....                                                         | 21  |
| Potential Health Effects from Asbestos Exposure.....                              | 23  |
| Summary.....                                                                      | 25  |
| Conclusion.....                                                                   | 26  |
| Recommendations.....                                                              | 28  |
| Appendix A-References.....                                                        | A-1 |
| Appendix B-Description of Individuals Facilities.....                             | B-1 |
| Appendix C-Recommended Procedures for Asbestos Brake<br>and Clutch Servicing..... | C-1 |

## TABLES

|                                                              |    |
|--------------------------------------------------------------|----|
| 1. Fiber Air Sample Results.....                             | 16 |
| 2. Comparison Between TEM & Optical Microscopy Analysis..... | 18 |
| 3. Fiber Size Data.....                                      | 20 |
| 4. Trace Metal Analyses.....                                 | 22 |