A wear analysis study of selected alternative foundry tooling materials using impact abrasion testing

L. Fred Vondra

University of Northern Iowa

Copyright © L. Fred Vonda - 1992

Follow this and additional works at: https://scholarworks.uni.edu/etd

Part of the Industrial Technology Commons, and the Metallurgy Commons

Let us know how access to this document benefits you

Recommended Citation

Vondra, L. Fred, 'A wear analysis study of selected alternative foundry tooling materials using impact abrasion testing' (1992). Electronic Theses and Dissertations. 818.

https://scholarworks.uni.edu/etd/818

This Open Access Dissertation is brought to you for free and open access by the Graduate College at UNI ScholarWorks. It has been accepted for inclusion in Electronic Theses and Dissertations by an authorized administrator of UNI ScholarWorks. For more information, please contact scholarworks@uni.edu.
INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.
A wear analysis study of selected alternative foundry tooling materials using impact abrasion testing

Vondra, L. Fred, D.I.T.
University of Northern Iowa, 1992
A WEAR ANALYSIS STUDY OF SELECTED
ALTERNATIVE FOUNDRY TOOLING MATERIALS
USING IMPACT ABRASION TESTING

A Dissertation

Submitted

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Industrial Technology

Approved:

Dr. M. F. Fahmy, Advisor
Dr. Scott C. Helzer, Co-Advisor
Dr. Barry J. Wilson
Dr. Robert H. Decker

L. Fred Vondra

University of Northern Iowa

December 1992
A WEAR ANALYSIS STUDY OF SELECTED
ALTERNATIVE FOUNDRY TOOLING MATERIALS
USING IMPACT ABRASION TESTING

An Abstract of a Dissertation
Submitted
In Partial Fulfillment
of the Requirements for the Degree
Doctor of Industrial Technology

Approved:

Faculty Advisor

Dean of the Graduate College

L. Fred Vondra
University of Northern Iowa
December 1992
ABSTRACT

The purpose of this study was to simulate the wear characteristics of foundry tooling using an impact abrasion test apparatus. The wear characteristic was exhibited by non-metallic materials and was measured as a function of percentage weight loss and was benchmarked against Class 30 gray iron. The research question focused on whether or not a non-metallic material exists that exhibits comparable or superior wear characteristics to Class 30 gray iron for possible consideration as tooling materials for foundry applications. The information obtained adds to knowledge and is useful to foundry professionals in making tooling decisions.

The 34 test materials were procured from leading non-metallic tooling manufacturers as well as from non-traditional sources. The test procedure used 2 samples of each material tested independently for 3 four hour cycles. The samples were cleaned and weighed and the abradant changed after each 4 hour cycle. The test apparatus was used in three previous studies to experiment on potential tooling materials.

Upon analysis of the data, a wear factor equation was developed to better interpret the tool life as compared to Class 30 gray iron. The development of this wear factor can indicate to a foundry professional how
long he/she can expect a tool to last as compared to cast iron.

Of the non-metallic materials tested there was a wide range in percentage weight loss numbers exhibited. The best performer in terms of percentage weight loss was the Conathane TU-900 exhibiting a 0.3440% weight loss and a wear factor of 2.97. The worst performer was the Ultralloy 40 demonstrating a 9.5043 percentage weight loss with a corresponding wear factor of 81.93.

It appears from the data generated in this study that there is no alternative non-metallic material that exhibits the wear resistance of Class 30 gray iron. However, comparing the results of other tests done previously, it is concluded that with new formulations it is only a matter of time before a non-metallic material will demonstrate the wear resistance of iron.
ACKNOWLEDGMENTS

I would like to extend my sincere thanks to my advisor Dr. Mohammed F. Fahmy for his assistance and interest in the preparation of this dissertation. My Co-Advisor Dr. Scott C. Helzer also receives my thanks for his inspiration and knowledge pertaining to my research and for being a good friend.

I would also like to extend my gratitude to Drs. John T. Fecik, Robert H. Decker, and Barry J. Wilson for their professional assistance. Special thanks go to the management of the John Deere Waterloo Foundry and also to the Alternative Tooling Committee for their assistance with my research.

To the staff of the Metal Casting Center, thanks for your assistance and patience during this exercise. I sincerely appreciate everyone's efforts.

To my parents Lubomir and Muriel words cannot say how I truly feel about you. Your backing and faith have been my inspiration. Dad, I would not have finished if you left us. Also, Michele, Cathy, and Mark, thanks for being around when I needed you.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I THE PROBLEM</td>
<td>1</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td>3</td>
</tr>
<tr>
<td>Purpose of the Study</td>
<td>3</td>
</tr>
<tr>
<td>Research Question</td>
<td>3</td>
</tr>
<tr>
<td>Importance of the Study</td>
<td>4</td>
</tr>
<tr>
<td>Assumptions</td>
<td>7</td>
</tr>
<tr>
<td>Limitations of the Study</td>
<td>8</td>
</tr>
<tr>
<td>Definition of Terms</td>
<td>8</td>
</tr>
<tr>
<td>II REVIEW OF RELATED LITERATURE</td>
<td>10</td>
</tr>
<tr>
<td>Introduction</td>
<td>10</td>
</tr>
<tr>
<td>Materials</td>
<td>11</td>
</tr>
<tr>
<td>Abrasion Tests</td>
<td>13</td>
</tr>
<tr>
<td>Summary</td>
<td>19</td>
</tr>
<tr>
<td>III METHODOLOGY</td>
<td>21</td>
</tr>
<tr>
<td>Introduction</td>
<td>21</td>
</tr>
<tr>
<td>Test Materials</td>
<td>21</td>
</tr>
<tr>
<td>Polyurethane Elastomers</td>
<td>22</td>
</tr>
<tr>
<td>Steel Filled Polyurethane Elastomers</td>
<td>29</td>
</tr>
<tr>
<td>Elastomeric Surface Coats</td>
<td>29</td>
</tr>
</tbody>
</table>

LIST OF TABLES ..................................... v
LIST OF FIGURES...................................... vi
<table>
<thead>
<tr>
<th>III</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyurethane/Epoxy Alloy</td>
<td>30</td>
</tr>
<tr>
<td>Epoxies</td>
<td>30</td>
</tr>
<tr>
<td>Plastic Liquid Molding Compounds</td>
<td>30</td>
</tr>
<tr>
<td>Polymer Ceramic Composites</td>
<td>31</td>
</tr>
<tr>
<td>Stereolithography Photopolymer</td>
<td>32</td>
</tr>
<tr>
<td>Artificial Modeling Material</td>
<td>32</td>
</tr>
<tr>
<td>Metallic Tooling Materials</td>
<td>32</td>
</tr>
<tr>
<td>Test Procedure</td>
<td>33</td>
</tr>
<tr>
<td>Wear Factor</td>
<td>36</td>
</tr>
<tr>
<td>Electron Microscopy Analysis</td>
<td>37</td>
</tr>
<tr>
<td>IV PRESENTATION OF DATA</td>
<td>51</td>
</tr>
<tr>
<td>Materials Tested</td>
<td>52</td>
</tr>
<tr>
<td>Polyurethane Elastomers</td>
<td>52</td>
</tr>
<tr>
<td>Epoxies</td>
<td>56</td>
</tr>
<tr>
<td>Plastic Liquid Molding Compounds</td>
<td>57</td>
</tr>
<tr>
<td>Polymer Ceramic Composites</td>
<td>58</td>
</tr>
<tr>
<td>Stereolithography Photopolymer</td>
<td>59</td>
</tr>
<tr>
<td>Artificial Modeling Material</td>
<td>61</td>
</tr>
<tr>
<td>Metallic Tooling Materials</td>
<td>62</td>
</tr>
<tr>
<td>Wear Factor Analysis</td>
<td>64</td>
</tr>
<tr>
<td>Scanning Electron Microscopy Analysis</td>
<td>65</td>
</tr>
<tr>
<td>V SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS</td>
<td>71</td>
</tr>
<tr>
<td>Restatement of the Problem and Purpose</td>
<td>71</td>
</tr>
<tr>
<td>Summary of Findings</td>
<td>71</td>
</tr>
<tr>
<td>V</td>
<td>Page</td>
</tr>
<tr>
<td>---</td>
<td>------</td>
</tr>
<tr>
<td>Conclusions</td>
<td>73</td>
</tr>
<tr>
<td>Recommendations</td>
<td>76</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>78</td>
</tr>
<tr>
<td>APPENDIX A: LIST OF MATERIALS TESTED</td>
<td>80</td>
</tr>
<tr>
<td>APPENDIX B: MATERIAL SAFETY DATA SHEETS (MSDS)</td>
<td>82</td>
</tr>
<tr>
<td>APPENDIX C: IMPACT ABRASION TEST DATA SHEETS</td>
<td>257</td>
</tr>
<tr>
<td>APPENDIX D: SLOPE COMPARISONS OF REMAINING MATERIALS</td>
<td>292</td>
</tr>
<tr>
<td>Table</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>1. Wear Analysis Table</td>
<td>68</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1.</td>
<td>Drawing of impact abrasion testing apparatus</td>
</tr>
<tr>
<td>2.</td>
<td>Non-abraded surface of Hexcel 3160</td>
</tr>
<tr>
<td>3.</td>
<td>Abraded surface of Hexcel 3160</td>
</tr>
<tr>
<td>5.</td>
<td>Abraded surface of J&amp;J Plaz-Tec ceramic</td>
</tr>
<tr>
<td>6.</td>
<td>Non-abraded surface of Mastercast 703</td>
</tr>
<tr>
<td>7.</td>
<td>Abraded surface of Mastercast 703</td>
</tr>
<tr>
<td>8.</td>
<td>Non-abraded surface of Class 30 gray iron</td>
</tr>
<tr>
<td>9.</td>
<td>Abraded surface of Class 30 gray iron</td>
</tr>
<tr>
<td>10.</td>
<td>Elemental analysis of J&amp;J Plaz-Tec Ceramic area B604.20a</td>
</tr>
<tr>
<td>11.</td>
<td>Elemental analysis of J&amp;J Plaz-Tec Ceramic area B604.20b</td>
</tr>
<tr>
<td>12.</td>
<td>Elemental analysis of J&amp;J Plaz-Tec Ceramic area B604.20c</td>
</tr>
<tr>
<td>13.</td>
<td>Elemental analysis of J&amp;J Plaz-Tec Ceramic area B604.20d</td>
</tr>
<tr>
<td>14.</td>
<td>Elemental analysis of Mastercast 703 area B604.15a</td>
</tr>
<tr>
<td>15.</td>
<td>Elemental analysis of Mastercast 703 area B604.15b</td>
</tr>
<tr>
<td>16.</td>
<td>Elemental analysis of Mastercast 703 area B604.15c</td>
</tr>
<tr>
<td>17.</td>
<td>Elemental analysis of Mastercast 703 area B604.15d</td>
</tr>
<tr>
<td>18.</td>
<td>Slope comparison of TU-900 to gray iron</td>
</tr>
<tr>
<td>19.</td>
<td>Slope comparison of TU-956 to gray iron</td>
</tr>
</tbody>
</table>
20. Slope comparison of Uralite 3530 to gray iron ........................................ 55
21. Slope comparison of Mastercast 703 to gray iron .................................. 56
22. Slope comparison of Hapcast 5730 to gray iron ....................................... 57
23. Slope comparison of 301/308 Epoxical to gray iron ................................... 58
24. Slope comparison of Ultralloy 40 to gray iron ........................................ 59
25. Slope comparison of Ultralloy 50 to gray iron ........................................ 60
26. Slope comparison of fiberglass backed ceramic to gray iron ......................... 61
27. Slope comparison of ceramic to gray iron . .................................................. 62
28. Slope comparison of LMB 5086 to gray iron . ............................................. 63
29. Slope comparison of Renshape 450 to gray iron ....................................... 64
30. Slope comparison of silicon bronze to gray iron ....................................... 65
31. Slope comparison of 1020 low carbon steel gray iron ................................ 66
32. Slope comparison of 304 stainless to gray iron .......................................... 67
CHAPTER I
THE PROBLEM

Introduction

In an effort to remain competitive, the cast metals industry must endeavor to control all aspects of their operation including costs. Foundries, members of the cast metals industry which use sand as the primary component for molds and cores, are no exception. One important and expensive segment of the overall foundry operation is the area of pattern and corebox tooling. Crowley (1988) stated, "In today's competitive environment foundry management must diligently control every aspect of their operations. And tooling costs, along with every other production cost, must be reviewed" (p. 30). Brown (1983) further stated that this area is critical if a foundry is undertaking modernization to remain competitive. A jobbing foundry can expect to pay as much as million dollars to install a high production molding machine with associated peripheral equipment. New patterns must be built to operate in conjunction with this expensive acquisition. Corresponding dollar amounts suggest a major investment on the part of production tooling for this equipment.

Historically, the material of choice in molding and corebox tooling has been cast iron, with some stainless steels, carbon steels and even bronze alloys. These
materials, although very expensive, are very durable and can withstand the severe foundry environment. They have been the most common tooling materials for hundreds of years.

In today's low bid environment new materials are being experimented with to reduce the cost of foundry tooling. Although some new materials are showing great promise, in general, they are not being taken seriously by the traditional foundry professionals.

One arena of tooling experimentation is in non-metallic materials. Some of these materials show great promise for foundry tooling applications. With the advent of new alternative materials, foundries must reexamine the potential economic advantages offered by this unique family of tooling materials.

A major area of concern with regard to non-metallic materials is the ability to resist wear. The foundry environment in which tooling performs is very abrasive. Sand, the primary foundry molding and coremaking material, is driven or blown under pressure onto the pattern or into the corebox. It is this pressure, which is needed to compact the sand and shape the mold or core. This pressure acts as a multiplier to the sand's already natural abrasiveness.
This research is focused on an analysis of wear rates of selected alternative tooling materials. It is theorized that some materials may exhibit wear resistance characteristics as good or better than cast iron. Such findings would contribute to the body of technical knowledge being generated for foundry use. The discovery of low cost non-traditional materials may help the foundry industry be more productive and competitive in the world economy.

Statement of the Problem

The problem of this study was to analyze the wear characteristics of selected alternative tooling materials. These materials have a potential use as alternative tooling equipment in the foundry for production operations.

Purpose of the Study

The purpose of this study was to simulate the wear characteristics of foundry tooling using an impact abrasion test apparatus. This wear characteristic will be measured as a function of percentage weight loss as exhibited by selected alternative tooling materials to be benchmarked against Class 30 gray iron.

Research Question

The research question that was addressed in this study focused on determining if there was an alternative tooling material that exhibited a comparable or superior wear rate,
as measured by impact abrasion testing, when compared to Class 30 gray iron. A second aspect of the research question addressed whether or not a mathematical indices or factor could be calculated to compare tooling life of the tested materials to Class 30 gray iron. For purposes of this research the tested materials were broken down into the following seven groups: Polyurethane Elastomers, Epoxies, Plastic Liquid Molding Compounds, Polymer Ceramic Composites, Stereolithography Photopolymer, Artificial Modeling Material, and Metallic Tooling Materials. A list of materials that were tested in this study can be found in Appendix A.

**Importance of the Study**

Cast iron has been the most commonly available and widely used material for foundry tooling. Reasons include: material availability, the relative ease in shaping into the desired configurations, the excellent wear characteristics, its ability to withstand foundry chemicals, and its ability to survive long production runs with very little dimensional change.

However, costs, including excessive tooling charges which are usually passed on as a transfer expense, are now being scrutinized by the consumer. Casting purchasers are much more involved in the processes used to make their product than in the past. Aylward (1988) stated "It is
essential to recognize that we are dealing with an increasingly sophisticated purchasing profession that knows exactly what it wants and will settle for nothing less" (p. 159). Foundries are no longer allowed to ship scrap and expect to forget about it. In many cases, the foundry is required to buy back scrap castings, paying the value added costs plus transportation and handling charges associated with getting it back to the plant. It is becoming imperative that finished castings are of the highest quality and lowest cost.

In many cases, the tooling used to make a customer's castings is owned by that client. To reduce a client's part costs, and enhance competitiveness, it is imperative that tooling costs be as low as possible but still provide high levels of quality.

There are some areas of concern regarding non-metallic tooling. In some cases, tooling life is shortened by the rough treatment experienced in the foundry. Non-metallic materials will break under severe bumping and dropping and can easily be damaged. Also, most non-metallic materials are intolerant of welding spatter and many chemicals found in normal foundry operations.

Construction of epoxy and polyurethane tooling requires special treatment also. Most epoxies and polyurethanes come in a two part system of resin and
hardener. Some of the individual resin and hardener parts release fumes that are toxic to humans. They also may cause a dermatitis reaction to the skin. However, after the two parts have been mixed and polymerization has occurred, they become inert and are no longer harmful. Therefore, special care in the form of proper ventilation and skin barrier protection must be provided when using these materials to construct tooling.

Storage can also be a problem for metallic as well as non-metallic tooling. Most metallic tooling materials can oxidize over time and may yield or creep because of internal stresses introduced during its manufacture, causing dimensional problems. Non-metallic tooling materials, while not suffering from potential oxidation or stress relieving phenomena, also have problems. If care is not taken in the rigging of non-metallic tooling the equipment can become damaged beyond use. Proper material handling must be taken into consideration when using non-metallic tooling.

Another area of concern for foundry clients is lead time. Although iron tooling has advantages in longevity and in other areas, it is a very expensive material to shape into the desired design. A fully machined iron tool can take months to deliver as well as being expensive and difficult to modify.
In this era of Just-In-Time (JIT) deliveries and low product inventories, a foundry's customers cannot afford to wait months to receive their first castings. Backens (1991) stated that in many cases a foundry's ability to receive work is predicated on how soon the customer can get castings. Print to casting time must be reduced to remain competitive (p. 2).

Assumptions

The research was conducted using the following assumptions:

1. That tooling wear can be simulated by the impact abrasion test apparatus.

2. That wear incurred under laboratory conditions is representative of the material loss in a production foundry environment.

3. That specimen preparation did not adversely affect the wear characteristics of the specimens.

4. That Class 30 gray iron can be considered a benchmark material for comparison.

5. That those samples tested represent the family of materials known as metallic and non-metallic tooling materials.
Limitations of the Study

The study was limited to:

1. The use of the impact abrasion apparatus as used in previous research at the University of Northern Iowa and Case Western Reserve University.

2. The use of 58-62 AFS grain fineness number (GFN) sub-angular to round silica sand as the abrasive.

3. The percentage weight loss incurred during the testing cycle.

4. The selected metallic and non-metallic materials including those conventionally used and some more recently developed.

5. The materials to be used as sampled regardless of surface preparation i.e. cast, cut, or machined to correct size.

6. The testing of materials containing no carcinogens.

Definition of Terms

The following terms are used in this study and are defined here for the purpose of clarity:

Acicular structure: A microstructure characterized by needle shaped constituents. (Sylvia, 1990, p. 300)

Corebox: Box with an opening in which the core is formed. (Sylvia, 1990, p. 310)

Epoxy: Containing oxygen attached to two different atoms already connected to a ring. A word often used by itself for epoxy resin. (American Foundrymen's Society, 1986, p. 306)
Jobbing Foundry: A foundry engaged in the manufacture of numerous types of castings not intended for use in its own product. Usually refers to a foundry making castings for many other companies. (Wieser, 1980, p. 19)

Pattern: Model of wood, metal, plaster, or other material used in making a mold. (Sylvia, 1990, p. 322)

Polymerization: The hardening or setting of plastic materials, as epoxy, urethane, when the resin and hardener are mixed together. (American Foundrymen's Society, 1986, p. 306)

Polyurethane: Synthetic resin polymer used for pattern material, ranging from dense elastomer to expanded, spongy, lightweight. (American Foundrymen's Society, 1986, p. 306)

Rigging: Equipment used for making a mold. (Sylvia, 1990, p. 325)

Urethane Elastomer: A resilient rubberlike pattern compound which has excellent abrasion resistance. It is a castable plastic requiring a hardener to complete polymerization. (American Foundrymen's Society, 1986, p. 307)
CHAPTER II
REVIEW OF RELATED LITERATURE

Introduction

This review of literature covers published articles and research pertaining to alternative tooling materials. Also, included is research in foundry competitiveness and those tests specifically designed to measure wear resistance of unconventional tooling materials.

Foundry tooling is an area that has not been thoroughly investigated to help foundries become more competitive. Huskonen (1987) stated:

A necessary evil. That's the way some foundrymen view the patterns, coreboxes, and related equipment they need to produce castings. Unfortunately, that attitude tends to close off those foundrymen from a resource that they could well utilize in these very competitive times. (p. 40)

Foundry management is realizing the potential benefits of lowering tooling costs and reducing lead times. Backens (1991) stated: "Management of the John Deere Waterloo Foundry has determined that one way they could improve their competitiveness in the casting industry would be to find alternative materials for tooling" (p. 1).

Research being done on potential non-metallic tooling materials is not new. Burton (1961) investigated epoxy resins and isocyanates (polyurethanes) for foundry tooling as far back as 1961. He stated:
Introduction of the epoxides to the foundry industry has greatly stimulated the imagination in pattern construction particularly where abrasion resistance is concerned, and is principally influenced by the versatility of the materials in liquid form. Complexity of shape or size is still further enhanced by the elimination of machining to the end product. This signifies to some extent that abrasion resistive materials may be introduced to the pattern or core box at indicated or anticipated wear sections with little or no effort on the part of the builder. (p. 304)

Materials

Wood is the original material used for foundry tooling. It has always been readily available, inexpensive and easily formed into the desired shape. Consequently, it is still in use today, especially for master and prototype tooling. However, it also has disadvantages. Wood, being a cellular material, has very poor wear resistance and also has a tendency to pick up moisture which causes distortion. Hence, it is typically not used as tooling for medium to long production runs.

Plastics are being used in more foundry tooling applications in recent years. Although any kind of transition to plastics as a tooling material is slow in coming, there is evidence that they have a place in tooling applications. Bex (1990a) stated:

Wood is still widely used to fabricate master patterns for metal castings, and metal certainly retains its place as the pattern material of choice for high volume tooling such as that used in automotive production foundries. Increasingly, however, plastics are being selected as an alternative pattern material. Once a master reverse is constructed, plastic patterns can be
duplicated and repaired quickly and easily. They also can save time and money. (p. 43)

Plastics are also being used more because of new formulations in their chemistry which give them advantages in such areas as wear resistance and chemical compatibility. These latest formulations are showing characteristics desirable as potential tooling materials. Bex (1990b) further stated:

Plastics, particularly epoxies and polyurethanes make accurate and durable patterns. They are insensitive to moisture and many chemical mold sprays, offer superior dimensional stability, weigh less than metal counterparts and can be compounded to be extremely hard or highly flexible. (p. 46)

Of the plastic materials, epoxy resins have been in existence the longest. They are still the least expensive plastic material for constructing foundry tooling, are easier to work with and, in general, have a superior surface finish to polyurethanes. However, they have a disadvantage in that shrinkage during construction becomes a problem, especially in heavy cross sectional areas. Also, based on past studies, they do not possess the wear resistance characteristics of polyurethanes.

Materials that are becoming more common for use as alternative foundry tooling are polyurethane elastomers. Historically, polyurethanes designed for foundry applications were restricted to master patterns and prototype work. Bralower (1989) stated:
In the 1980s, various improvements in polyurethane materials, equipment and processes have allowed plastics to move out of the pattern shop and onto the foundry shop floor. Once limited mostly to master patterns, plastics have moved further into production tooling. (p. 37)

New materials being experimented with include castable ceramics and fiberglass. Typically, fiberglass has been used in the foundry industry as a backing media to give strength and rigidity to unstable surface materials. It is with this purpose that fiberglass is used, in many cases, as a back up for castable ceramics.

Ceramics are being experimented on because of their perceived resistance to abrasion. It is only recently that ceramics have been available in castable form. These ceramics generally have an acicular free flowing structure which allows them to be cast into the desired shape. Therefore, they are starting to generate interest as with other castable materials, such as polyurethane elastomers, for use as foundry tooling.

Abrasion Tests

As discussed previously, it is advantageous to the foundry industry to find materials that are less expensive and have shorter construction lead times. It must also be realized that all metallic tools are shaped, or constructed, in a similar fashion. Metallic tooling is fabricated or machined using some form of metal removal operation to achieve the desired shape. Most non-metallic materials are
cast into shape thereby saving time and expense in making tooling.

In order to test metallic and non-metallic materials, and be able to translate the results into usable data for sound decision making, a test similar to actual foundry production conditions had to be devised. Well known, and highly used, mechanical tests i.e., hardness or tensile, do not give the desired data that correlates with abrasion resistance. Shah (1984) stated:

Resistance to abrasion is significantly affected by factors, such as test conditions, type of abradant, and development and dissipation of heat during the test cycle. Many different types of abrasion-measuring equipment have been developed. However, the correlation between the test results and actual abrasion-related wear in real life remains very poor. The tests do, however, provide relative ranking of materials in certain order when performed under specified set of conditions. (p. 73)

The American Society for Testing and Materials (ASTM) defines resistance to abrasion as "the ability of a material to withstand mechanical action such as rubbing, scraping, or erosion, that tends progressively to remove material from its surface" (1991, p. 405).

Gouwens, in 1965, first recognized the need to simulate the abrasive conditions experienced by foundry tooling. He utilized two different testing apparatuses in an effort to simulate abrasion conditions. The two tests conducted were pressure abrasion and impact abrasion.
Pressure abrasion was conducted using a device known as the Haworth abrasive wear tester and has been used primarily for testing metallic materials. The equipment utilizes a segmented rubber wheel, under a load, which maintains a desired pressure on the sample. Sand is picked up by the wheel segments as it passes through a pan containing the abrasive and deposited on the sample. A rapid abrasion occurs as sand is carried between the rubber wheel and the sample. Gouwens (1965) stated: "The conditions of applied pressure, abrasive grain shape, and water or oil lubrication can be varied and thus replicate the abrasion encountered during pressurized abrasive conditions" (p. 402).

Impact abrasion was also tested in Gouwens' study. This type of test is completely different than the Haworth abrasive wear tester which uses contact pressure to actuate the abrasive media. Impact abrasion seems to more closely resemble the wearing action experienced by tooling, especially the process of core blowing. Gouwens (1965) stated:

It is well known that abrasion under pressure, as accomplished in the Haworth test, may be quite different than abrasion by sand impact. Since core blowing is primarily an impact condition, a second test procedure was needed to replicate abrasive conditions encountered. (p. 402)

The impact abrasion test uses the contact energy of falling sand as it cascades into a high speed impeller to achieve the wearing action. Equipment used for this test
consists of: a 10 inch glass drum, a high speed impeller, a means of introducing a nitrogen atmosphere, and a variable speed drive mechanism. The drum rotates at a speed which allows the sand to fall from about the 10 o'clock position. The sand then falls into the high speed impeller, mounted inside the drum, where impact occurs. The nitrogen atmosphere was required to prevent oxidation of the primarily metal samples due to the moisture in the sand abrasive. Samples are mounted in the high speed fixture and act as the blades of an impeller.

The test itself consisted of three four hour segments. Each sample was weighed prior to and after each segment and the weights recorded. Gouwens had difficulty interpreting the results of these tests. This was due primarily because the plastics tested absorbed the core oil which was included as a part of his sand mixture. Volume loss, measured in cubic inches of material lost, was also recorded.

Gouwens (1965) also did field studies of wear resistance to compare his laboratory data to actual production runs. He utilized test bars designed as a truncated cone shape with a corner removed. These test bars were mounted in a corebox directly under a sand stream. The test bars were weighed and measured before and after a production run of cores. Observations were made of the test bars after production runs of 500, 1500, and 3500 cores.
Gouwens found that the results of his truncated cone tests were consistent with laboratory wear data with regards to the metals tested. However, the results from the truncated cone tests suffered the same problem as the laboratory data when comparing the non-metallics. This problem was the absorption of the core oils by the non-metallic materials during testing. The measurement of the actual absorption was not possible therefore his data was inconclusive.

Maier and Wallace (1977) duplicated Gouwens' experiment with a few exceptions. Essentially, the differences were in the sand used as the abrasive and the materials tested. They also did not conduct a truncated cone test. The sand used was a dry silica as compared to Gouwens' oil-bonded mixture of water, core oil, cereal binder, western bentonite, iron oxide, kerosene and Ottawa sand. Gouwens tested a few metallics (3), and existing non-metallic (6) materials. Maier and Wallace tested mostly metallics (15), with fewer non-metallics (9).

Maier and Wallace (1977) also categorized their samples in homogeneous and coated or plated materials. Also, they included average weight loss per specimen, the scatter or lowest and highest value in percentage weight loss among the specimens, and the rate of weight loss as well as percentage weight loss in their recordings. Of the 24 materials
tested, 16 were deemed acceptable as potential pattern materials. Maier and Wallace stated:

The wear rate of 16 pattern materials, including all of the metals and one polymer, exhibited a weight loss of 1.6% or less in this severe test; the wear resistance of each of these materials could be adequate for most types of patterns. (p. 161)

Another study, conducted by Helzer (1988), further duplicated the research of Gouwens, Maier and Wallace. Essentially the same procedures were used as the aforementioned researchers. The only differences discovered were in AFS grain fineness of the sand used as the abrasive and the materials tested. Maier and Wallace used 69 AFS gfn silica sand, Helzer incorporated a silica sand of 58-64 AFS gfn. The materials tested was the other difference reported by the two studies. The majority of Maier and Wallace's materials tested were metallics, conversely Helzer studied mostly non-metallics.

Helzer further arranged his materials into four major groups. These include: metallic pattern materials, plated pattern materials, non-filled polymers, and filled polymers containing metal or ceramic fillers. Hardness tests of the metallic pattern materials were also incorporated into the study as well as an observation of dimensional changes. The conclusions observed in the study varied according to material. It was reported that similar materials, according
to group, behaved in an analogous manner. Helzer (1988) stated:

A total of 45 pattern materials were tested in this study. The weight losses ranged from 0.026% to over 7% of the material weight. Most of the materials exhibited very good dimensional stability under testing. All of the pattern materials exhibited a very linear wear line. (p. 285)

Summary

It is apparent that a limited amount of literature pertaining to wear resistance of foundry tooling materials exists. An exhaustive literature search was made to review as many resources as possible during the course of this study.

From the literature reviewed, it is apparent that impact abrasion is the test deemed most similar to actual wear resistance as shown by the three studies analyzed. Another commonality between the three studies was the measurement criteria used, namely weight loss. Incentives for conducting the studies were based on finding materials that would function in the foundry environment. Also, finding materials that were cost effective and reasonably easy to construct, with short lead times, were desirable characteristics taken into consideration.

As new materials, particularly non-metallics, are being developed it is obvious that further research should be conducted to investigate their characteristics under the same conditions as previous studies. The results of this
research would help foundry management make sound tooling decisions that perhaps allows them to be more competitive and productive in the metal casting industry.
CHAPTER III
METHODOLOGY

Introduction

Research in foundry processes for the improvement of competitiveness and productivity is being done in many areas. Areas of intense research to assist foundries include: improving casting quality, reducing lead times for product deliveries, and automating certain processes.

It is the area of reducing casting construction lead times that has benefit from this research in the foundry industry. The non-metallic materials were selected for this study because of their ease of construction and reduced lead times. The metallic samples were selected as a means of comparison to the non-metallics and cast iron, the benchmark material.

Test Materials

The samples selected for this study were supplied by four leading industrial manufacturers of non-metallic tooling materials. In most cases the materials were furnished by the manufacturer to the desired size specifications. Also, some non-traditional materials were tested for experimental purposes to analyze their tooling applicability. Six of these non-metallics have never been used for foundry tooling materials. Also, three other metals that have been used for foundry tooling, besides
Class 30 gray iron, were tested to see how they compare to iron. Following is a description of each material, by major type, that was selected for this study. Further information about these materials in the form of Material Safety Data Sheets can be found in Appendix B.

**Polyurethane Elastomers**

*6414-3 from Ciba-Geigy.* This material is an amber or red colored two-component (Parts A & B) polyurethane elastomer with a 55-65 Shore D hardness. It is generally shaped by casting. The material is to be of a fairly consistent thickness from 0.06 in. to 0.12 in. The elastomer must be backed up with an appropriate filler material or metal to maintain dimensional integrity. Mixing ratios used were: Part A 100, Part B 60 by weight. Applications include both coreboxes and patterns.

*TDP 186-1 from Ciba-Geigy.* This material is a red colored two-component (Parts A & B) polyurethane elastomer with a 78 Shore D hardness. It is generally shaped by casting. The material is to be of a fairly consistent thickness not more than 0.12 in. The elastomer must be backed up with an appropriate filler material or metal for dimensional stability. Mixing ratios used were: Part A 100, Part B 60 by weight. Applications include both coreboxes and patterns.
Uralite 3156 from Hexcel. This material is an amber or black colored two-component (Parts A & B) polyurethane elastomer with a 60 Shore D hardness. It is generally applied by casting onto a prepared surface. The material is to be of a fairly consistent thickness not more than 0.12 in. The elastomer must be backed up with an appropriate filler material if it is not cast into shape. Mixing ratios used were: Part A 100, Part B 36 by weight or Part A 100, Part B 34 by volume. Applications include both coreboxes and patterns.

Uralite 3160 from Hexcel. This material is a brown colored two-component (Parts A & B) polyurethane elastomer with a 70 Shore D hardness. It is generally applied by casting onto a prepared surface. The material is to be of a fairly consistent thickness not more than 0.12 in. The elastomer must be backed up with an appropriate filler material if it is not cast into shape. Mixing ratios used were: Part A 100, Part B 60 by weight. Applications include both coreboxes and patterns.

Uralite 3500 from Hexcel. This material is a brown colored two-component (Parts A & B) polyurethane elastomer with a 70 Shore D hardness. It is generally applied by casting onto a prepared surface. The material is to be of a fairly consistent thickness not more than 0.12 in. The elastomer must be backed up with an appropriate filler
material or casting. Mixing ratios used were: Part A 100, Part B 60 by weight. Applications include both coreboxes and patterns.

**Uralite 3501 from Hexcel.** This material is an amber colored two-component (Parts A & B) polyurethane elastomer with a 60 Shore D hardness. It is generally applied by casting onto a prepared surface. The material is to be of a fairly consistent thickness not more than 0.12 in. The elastomer must be backed up with an appropriate filler material or casting. Mixing ratios used were: Part A 100, Part B 43 by weight and has a slightly shorter work life than the Uralite 3500. Applications include both coreboxes and patterns.

**Uralite 3502 from Hexcel.** This material is a brown colored two-component (Parts A & B) polyurethane elastomer with a 55-60 Shore D hardness. It is generally applied by casting onto a prepared surface. The material is to be of a fairly consistent thickness not more than 0.12 in. The elastomer should be backed up with an appropriate filler material or casting. Mixing ratios should be: Part A 100, Part B 60 by weight and has a significantly longer work life than the Uralite 3500 and 3501. Applications include both coreboxes and patterns.

**Uralite 3503 from Hexcel.** This material is a brown colored two-component (Parts A & B) polyurethane elastomer
with a 95 Shore A hardness. It is generally applied by casting onto a prepared surface. The material is to be of a fairly consistent thickness not more than 0.12 in. The elastomer must be backed up with an appropriate filler material or casting. Mixing ratios used were: Part A 100, Part B 60 by weight and has a significantly longer work life than the Uralite 3502. Applications include both coreboxes and patterns.

Uralite 3530 from Hexcel. This material is a red colored two-component (Parts A & B) polyurethane elastomer with a 65 Shore D hardness. It is generally applied by casting onto a prepared surface. The material is to be of a fairly consistent thickness not more than 0.12 in. The elastomer must be backed up with an appropriate filler material or casting. Mixing ratios used were: Part A 100, Part B 50 by weight. Applications can be considered for both coreboxes and patterns.

Uralite 3534 from Hexcel. This material is a red colored two-component (Parts A & B) polyurethane elastomer with a 95 Shore A hardness. It is generally applied by casting onto a prepared surface. The material is to be of a fairly consistent thickness not more than 0.12 in. The elastomer must be backed up with an appropriate filler material or casting. Mixing ratios used were: Part A 100,
Part B 28 by weight. Applications can be considered for both coreboxes and patterns.

**Conathane TU-900 from Conap.** This material is an amber colored two-component (Parts A & B) polyurethane elastomer with an 85-95 Shore A hardness. It is generally applied by casting onto a prepared surface. The material is to be of a fairly consistent thickness not more than 0.12 in. The elastomer must be backed up with an appropriate filler material or casting. Mixing ratios used were: Part A 100, Part B 38 by weight. Applications can be considered for both coreboxes and patterns.

**Conathane TU-956 from Conap.** This material is an amber colored two-component (Parts A & B) polyurethane elastomer with a 50-60 Shore D hardness. It is generally applied by casting onto a prepared surface. The material is to be of a fairly consistent thickness not more than 0.12 in. The elastomer must be backed up with an appropriate filler material or casting. Mixing ratios used were: Part A 100, Part B 28 by weight. Applications can be considered for both coreboxes and patterns.

**Conathane TU-961 from Conap.** This material is a dark red colored two-component (Parts A & B) polyurethane elastomer with a 60 Shore D hardness. It is generally applied by casting onto a prepared surface. The material is to be of a fairly consistent thickness not more than 0.12
in. The elastomer must be backed up with an appropriate filler material or casting. Mixing ratios used were: Part A 100, Part B 50 by weight. Applications can be considered for both coreboxes and patterns.

**Conathane TU-981 from Conap.** This material is an amber or black colored two-component (Parts A & B) polyurethane elastomer with a 60-70 Shore D hardness. It is generally applied by casting onto a prepared surface. The material is to be of a fairly consistent thickness not more than 0.12 in. The elastomer must be backed up with an appropriate filler material or casting. Mixing ratios used were: Part A 100, Part B 60 by weight. Applications can be considered for both coreboxes and patterns.

**Hapflex 595 from Hapco.** This material is a black colored two-component (Parts A & B) polyurethane elastomer with a 90-95 Shore A hardness. It is generally applied by casting, brushing or spraying onto a prepared surface. The material is to be of a fairly consistent thickness from 0.06 in. to 0.12 in. The elastomer must be backed up with an appropriate filler material or casting. Mixing ratios used were: Part A 100, Part B 100 by weight. Applications can be considered for both coreboxes and patterns.

**Hapflex 595-HP from Hapco.** This material is a black colored two-component (Parts A & B) polyurethane elastomer with a 90-95 Shore A hardness. It is generally applied by
casting, brushing or spraying onto a prepared surface. The material is to be of fairly consistent thickness from 0.06 in. to 0.12 in. The elastomer must be backed up with an appropriate filler material or casting. Mixing ratios used were: Part A 100, Part B 100 by weight. Applications can be considered for both coreboxes and patterns.

**Hapflex 665 from Hapco.** This material is a black colored two-component (Parts A & B) polyurethane elastomer with a 65 Shore D hardness. It is generally applied by casting, brushing or spraying onto a prepared surface. The material is to be of a fairly consistent thickness from 0.06 in. to 0.12 in. The elastomer must be backed up with an appropriate filler material or casting. Mixing ratios used were: Part A 100, Part B 100 by weight. Applications can be considered for both coreboxes and patterns.

**Hapflex 665-HP from Hapco.** This material is a black colored two-component (Parts A & B) polyurethane elastomer with a 65 Shore D hardness. It is generally applied by casting, brushing or spraying onto a prepared surface. The material is to be of a fairly consistent thickness from 0.06 in. to 0.12 in. The elastomer must be backed up with an appropriate filler material or casting. Mixing ratios used were: Part A 100, Part B 100 by weight. Applications can be considered for both coreboxes and patterns.
Steel Filled Polyurethane Elastomers

Hapcast 3730/7 from Hapco. This material is a steel filled plastic casting urethane system with a 90 Shore D hardness. The resin is mixed with hardeners at various ratios depending on desired characteristics of finished product. After mixing, the material is poured into a mold or cavity in a thin stream from a height of 8-12 in. The material can be cast in all thicknesses and cures in approximately 48 hr. Applications can be considered for no-bake coreboxes.

Elastomeric Surface Coats

Hapcoat 597 from Hapco. This material is a medium hardness (Shore A 90-95) elastomeric, abrasion resistant, thixotropic, surface coat. After mixing, the material is applied with a brush to a 0.06-0.12 in. thickness. The mixing ratios used were: Part A 100, Part B 75 by weight. Applications can include both coreboxes and patterns.

Hapcoat 667 from Hapco. This material is a Shore D 65 hardness surface coat. It is a thixotropic, abrasion resistant, elastomeric material. After mixing, the material is applied with a brush to a 0.06-0.12 in. thickness. The mixing ratios used were: Part A 100, Part B 75 by weight. Applications can include both coreboxes and patterns.
Polyurethane/Epoxy Alloy

Hapcast 5730 from Hapco. This material is a rigid, high impact, thermoset, Polymer Alloy. It is generally applied by casting onto a prepared surface. The alloy does not require a backing material and is easily machinable to required dimensions. The mixing ratios used were: Part A 100, Part B 13 by weight. Applications can include coreboxes and patterns.

Epoxies

301/308 Epoxical from U.S. Gypsum. This material is an aluminum filled epoxy resin system. It is generally applied by casting onto a prepared surface. The material has an 80 Shore D hardness. Mixing ratios should be: 7 Parts Resin to 1 Part Hardener. Applications can include prototype coreboxes and patterns.

Mastercast 703 from Kindt-Collins. This material is an aluminum filled epoxy system. It is generally applied by casting onto a prepared surface and has an 80 Shore D hardness. Mixing ratios used were: Part A 100, Part B 100 by weight. Applications can include prototype coreboxes and patterns.

Plastic Liquid Molding Compounds

Ultralloy 40 from Hapco. This material is a tough, fast curing, low shrinkage plastic. It is generally applied by casting onto a prepared surface and can be cast into thin
or thick sections. It has a 80 Shore D hardness. Mixing ratios used were: Part A 100, Part B 100 by weight. Applications include prototype and short run production coreboxes and patterns.

**Ultralloy 50 from Hapco.** This material is a tough, fast curing, low shrinkage plastic. It is generally applied by casting onto a prepared surface and can be cast into thin or thick sections. It has a 90 Shore D hardness. Mixing ratios used were: Part A 100, Part B 100 by weight. Applications can include prototype and short run production coreboxes and patterns.

**Polymer Ceramic Composites**

**Plaz-Tec Ceramic from J & J Corporation.** This material is a new castable ceramic composite with potential tooling applications. It is generally applied by casting or spraying onto a prepared surface. A rigid backing material is required for strength purposes. Mixing and hardness data is confidential to the manufacturer. It may have pattern and corebox tooling application.

**Plaz-Tec Fiberglass backed Ceramic from J & J Corporation.** This material is a new fiberglass backed castable ceramic composite with potential tooling applications. It is generally applied by spraying onto a prepared surface followed by a backing of fiberglass. Mixing and hardness data is confidential to the
manufacturer. It may have pattern and corebox tooling application.

**Stereolithography Photopolymer**

LMB 5086 Photopolymer from Ciba-Geigy for 3D Systems. This material is a one-component photo curable liquid resin system. The system requires a special processor with computer interface to create the desired tooling. Also, the system requires an ultraviolet laser attachment to activate the polymer. This is a very new technology which may have foundry tooling applications.

**Artificial Modeling Material**

Renshape 450 from Ciba-Geigy. This is an isotropic, easily machined, dimensionally stable master pattern material. It can be shaped using standard woodworking tools to desired dimensions. The material has a 65 Shore D hardness with no shrinkage problems. It should only be used for prototype and very short production runs. Applications can include patterns but is highly unlikely for coreboxes.

**Metallic Tooling Materials**

American Iron and Steel Institute (AISI) 1020 low carbon steel. This material is a plain carbon steel with 20 points (or $0.20\%$) of $1\%$ carbon. Hot rolled 1020 steel has a tensile strength of 68,000 psi and a BHN of 135. Hardened 1020 steel has a 90,000 psi tensile with a 179 BHN. AISI 1020 low carbon steel is not used as extensively as gray
iron for tooling purposes. However, it does exhibit excellent wear characteristics.

**304 stainless steel.** This is an austenitic, chrome-nickel, tough alloy that can be cold worked. It is typically used for very high production tooling applications because of its excellent wear characteristics. It is also more expensive than most conventional tooling materials. General characteristics include a 61 RA hardness and an 80,000 psi tensile strength.

**Silicon bronze.** This is a high silicon non-ferrous metal with a 96% copper, 3% silicon and 1% manganese composition. It is a fairly frequently used material for foundry tooling applications because of its good wear characteristics and machinability. General characteristics include a 40-97 RB hardness with a 56,000 to 110,000 psi tensile strength.

**Class 30 gray iron.** This material is the benchmark substance for the study. A typical Class 30 iron has a tensile strength of 30,000 psi and a BHN of 215. A major reason for the use of gray iron for foundry tooling is its machinability; it can be shaped to desired dimension with relative ease, and it also has good wear characteristics.

**Test Procedure**

The abrasion testing equipment used in this research utilizes a pyrex drum, filled with 5 pounds of sand,
rotating at 82 rpm causing a cascading of the sand onto a fixture which holds the test specimens. The specimens are mounted at a 45 degree angle so as to act as an impeller to the cascading sand. The fixture itself rotates at approximately 1400 rpm in the same direction as the drum. As the sand cascades onto the spinning fixture, impact abrasion occurs to the test specimens. This apparatus was devised for Gouwen's study in the 1960s. A drawing of the impact abrasion test apparatus can be found in Figure 1.

Each specimen was tested for three four-hour cycles in the fixture. Two specimens of each sample material were tested at different times to conform with testing parameters designed earlier for previous studies. The material weights were recorded before the test began and after each four hour cycle. A Mettler Type H15 balance was used to weigh the samples. This balance is a 160 g capacity unit calibrated every 6 months to NIST #732/246690-#523/240932 standards. The 5 pounds of sand contained in the drum was replaced after each cycle to ensure that new media was impacting the specimens. This eliminated any fractured or rounded sand grains which may have lost abrasiveness during the cycle. The molding material used for this research was a 58-62 AFS GFN sub angular to round silica sand. Selected specimens were examined using scanning electron microscopy to investigate wear patterns.
Figure 1. Drawing of impact abrasion testing apparatus.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Wear Factor

Upon analysis of the review of literature, it is apparent that foundry personnel lack a decision making tool, pertaining to wear resistance, for the analysis of data concerning potential tooling materials. Therefore, one intention of this study is to provide a mathematical device, a wear factor, which allows foundry personnel to make an informed decision pertaining to the wear resistance of potential tooling materials.

Cast iron being the benchmark of this study allows for a comparison to other materials. All materials were subjected to the same test procedures which draw a commonality and uniformity to all samples.

A major question asked by foundry professionals is; how well do these new tooling materials wear as compared to cast iron? In order to answer that question, a simple mathematical computation must be administered. The key element of this equation is percentage weight loss.

It was theorized that each material will experience at least some weight loss as a result of the sand abrasion. Because cast iron is the benchmark, it is the material to which all others were compared. Therefore, to arrive at the wear factor, each sample's percentage weight loss number was divided by cast iron's number. This resulting wear factor can indicate to a foundry professional how long he/she can
expect a tool to last in the foundry environment as compared to cast iron.

**Electron Microscopy Analysis**

To investigate the surface of the specimens after impact abrasion, selected materials were analyzed using scanning electron microscopy. In order to conduct this analysis the non-metallic materials had to be coated with a conductive material to facilitate observation. These materials were carbon coated using a Denton model DV-502A vacuum chamber located at a major midwest manufacturing facility. Micrographs of the four selected materials can be found in Figures 2-9.

The purpose of this investigation was to visually examine the erosive effects on the materials after the impact abrasion experience. A visual examination was made comparing the eroded surface to the before test surface. Also, an elemental analysis of two of the materials can be found in Figures 10-17.

A unique capability of the scanning electron microscope is its ability to image a field of view regardless of the surface condition. A microscope, which uses light imaging, shows a two dimensional representation of the viewed surface. Conversely, scanning electron imaging allows for surface observation in three dimensions.
Figure 2. Non-abraded surface of Hexcel 3160.

Figure 3. Abraded surface of Hexcel 3160.
Figure 4. Non-abraded surface of J&J Plaz-Tec ceramic.

Figure 5. Abraded surface of J&J Plaz-Tec ceramic.
Figure 6. Non-abraded surface of Mastercast 703.

Figure 7. Abraded surface of Mastercast 703.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Figure 8. Non-abraded surface of Class 30 gray iron.

Figure 9. Abraded surface of Class 30 gray iron.
Figure 10. Elemental analysis of J&J Plaz-Tec Ceramic area B604.20a.
Figure 11. Elemental analysis of J&J Plaz-Tec ceramic area B604.20b.
Figure 12. Elemental analysis of J&J Plaz-Tec ceramic area B604.20c.
Figure 13. Elemental analysis of J&J Plaz-Tec ceramic area B604.20d.
Figure 14. Elemental analysis of Mastercast 703 area
B604.15a.
Figure 15. Elemental analysis of Mastercast 703 area B604.15b.
Figure 16. Elemental analysis of Mastercast 703 area
B604.15c.
Figure 17. Elemental analysis of Mastercast 703 area B604.15d.
The Tracor Northern ADEM scanning electron microscope was used to examine the specimens. This equipment was also located at a large midwest manufacturing company.
CHAPTER IV
PRESENTATION OF DATA

The purpose of this chapter is to provide a meaningful presentation and interpretation of the data collected for this study. It is intended that the data generated be used by foundry personnel to aid in making tooling decisions.

Samples of the tested materials were obtained from a variety of sources. Some were received directly from the manufacturer for abrasion testing research, others were obtained by personnel from a large midwest foundry's Alternative Tooling Committee. The abrasion tests were conducted in conjunction with the Tooling Committee's task to explore new materials for foundry use.

A list of possible alternative tooling materials for evaluation was compiled from a review of literature. Materials no longer available from the manufacturer or containing known carcinogens were rejected for possible consideration in this study.

The final number of alternative tooling materials tested represented the commercially available substances that have potential as foundry tools. These materials, while not entirely safe to humans, can be handled safely with the proper equipment and precautions. Material Safety Data Sheets (MSDS), obtained from the manufacturers, are included in Appendix B. Impact Abrasion Test Data Sheets of
each individual material are included in Appendix C. When viewing Figures 18 through 32 the vertical axis range is not consistent. Following is an analysis of the materials tested by group.

Materials Tested

Polyurethane Elastomers

Of the 34 materials tested 22 are combined into the polyurethane elastomer group. Included in this group are the polyurethane elastomers, a steel filled polyurethane elastomer, and two elastomeric surface coats. This group is the largest because of the polyurethane elastomer's perceived compatibility with foundry tooling applications therefore, more of the materials were considered for testing. Some of these materials demonstrated the best wear resistance characteristics of all the non-metallic specimens tested. As mentioned previously all of the specimens tested were compared to Class 30 gray iron, the bench mark material.

The material that had the least percentage weight loss of the polyurethane elastomers tested was Conap's Conathane TU-900. See Figure 18 for the TU-900 visual slope comparison with Class 30 gray iron. Appendix D contains the remaining visual slope comparisons of the materials tested not included in this chapter.
This material exhibited the least percentage weight loss (0.3440%) under test conditions. However, one possible reason for its excellent wear resistance characteristics may be attributed to the material's relative hardness. This is a relatively soft material with a Shore A hardness of 85-95. It has been observed that some softer polyurethane elastomeric materials tended to exhibit lower erosion characteristics.

While displaying good wear characteristics, softer materials may have a disadvantage resisting blow and squeeze.
pressures during core blowing and molding operations. These materials may have difficulty maintaining the necessary dimensional accuracies due to elastic deformation occurring during those pressures.

Another Conap material, Conathane TU-956, exhibited slightly inferior wear resistance compared to the TU-900 under test conditions. See Figure 19 for visual slope comparisons with Class 30 gray iron. However, this material is harder (50-60 Shore D) than TU-900 and may not suffer

\[\text{Figure 19. Slope comparison of TU-956 to gray iron.}\]
from elastic deformation during coremaking and molding pressures. Of the medium hardness polyurethane elastomers tested this material exhibited the least percentage weight loss (0.3670%).

Conversely, the polyurethane elastomer with the greatest percentage weight loss under impact abrasion test conditions was H escort's Uralite 3530. This material is a medium hardness (65 Shore D) elastomer. It exhibited a 2.6088% weight loss during testing. See Figure 20 for visual slope comparisons with Class 30 gray iron.

Figure 20. Slope comparison of Uralite 3530 to gray iron.
Epoxies

Three materials were included in the epoxy group. These include one polyurethane/epoxy alloy and two epoxies. All three materials exhibited inferior percentage weight loss reactions to the impact abrasion testing. Kindt-Collins' Mastercast 703 exhibited the lowest percentage weight loss within the group with a 2.5806%. Figure 21 shows the visual slope comparison with Class 30 gray iron.

![Graph showing comparison of percentage weight loss between Kindt-Collins Mastercast 703 and Class 30 Gray Iron.](image)

**Figure 21.** Slope comparison of Mastercast 703 to gray iron.
Following, within this group, was Hapco's Hapcast 5730 then U.S. Gypsum's 301/308 Epoxical with 3.9476% and 4.0448% weight loss respectively. See Figures 22 and 23 for visual slope comparisons with Class 30 gray iron.

![Graph showing weight loss comparison between Hapcast 5730 and Class 30 gray iron over time.](image)

**Figure 22.** Slope comparison of Hapcast 5730 to gray iron.

**Plastic Liquid Molding Compounds**

Two materials were included in this group, Hapco's Ultralloy 40 and Ultralloy 50. These two materials demonstrated the greatest percentage weight loss of all the specimens tested in this study. Ultralloy 40 exhibited
9.5043% weight loss and Ultralloy 50 7.4140%. Figures 24 and 25 exhibit visual slope comparisons with Class 30 gray iron.

Polymer Ceramic Composites

J&J Corp's two ceramic materials, Plaz-Tec Ceramic and Plaz-Tec Fiberglass backed Ceramic, were included in this group. Both were composed of the same surface material with one having a fiberglass backing. It was observed that the fiberglass backed material exhibited inferior wear resistance after testing (4.7074%) compared to the pure
ceramic composite (2.4957%). See Figures 26 and 27 for visual slope comparisons with Class 30 gray iron. This may have occurred due to the complete erosion of the ceramic surface which is heavier than the fiberglass backing. The fiberglass backing material also experienced erosion thereby possibly accounting for the greater percentage weight loss of the two ceramics.

**Stereolithography Photopolymer**

LMB 5086 was the only photopolymer tested in this study therefore, it was placed into a group of its own. It is a
Figure 25. Slope comparison of Ultralloy 50 to gray iron.

very unique material, being activated and cured by ultraviolet radiation. This material is an early generation photopolymer which is already obsolete and no longer available from the manufacturer. LMB 5086 also demonstrated an inferior percentage weight loss (3.4850%), compared to the majority of test specimens under experimental conditions. See Figure 28 for visual slope comparisons with Class 30 gray iron.
Figure 26. Slope comparison of fiberglass backed ceramic to gray iron.

Artificial Modeling Material

Renshape 450 was the only artificial modeling material tested in this study. It is used extensively for master and prototype tooling. The material was selected for impact abrasion testing due to its extensive use in the foundry industry. While it is widely used for prototype and master tooling in the industry it is not appropriate for production due to its poor wear resistance characteristics, demonstrating a 5.8374% weight loss under test conditions.
Figure 27. Slope comparison of ceramic to gray iron.

See Figure 29 for visual slope comparisons with Class 30 gray iron.

**Metallic Tooling Materials**

Three metallic materials were included in this study besides cast iron. These metallics were included in the study due to their popular use as tooling materials in the foundry industry. Of the four materials in this group only silicon bronze exhibited an inferior percentage weight loss (0.3622%), compared to Class 30 Gray Iron (0.1160%). See Figure 30 for visual slope comparisons of silicon bronze to
Figure 28. Slope comparison LMB 5086 to gray iron.

Class 30 gray iron. The other two metallics, AISI 1020 low carbon steel and 304 stainless steel, exhibiting (0.0313\%) and (0.0310\%) weight loss numbers respectively. See Figures 31 and 32 for visual slope comparisons with Class 30 gray iron.

Helzer, in his 1988 study, also tested AISI 1020 low carbon and 304 stainless steels. The results of the two studies exhibited parallel outcomes. This was to be expected as the same equipment and very similar abrasives were used in the two studies. This also confirms the
Wear Factor Analysis

To further utilize the percentage weight loss numbers and be able to use them for tooling decision making it is necessary to calculate the wear factor conversion. Each final percentage weight loss number must be divided by Class 30 gray iron's integer to arrive at the desired conversion. See Table 1 for a list of all the materials, percentage weight loss numbers, and corresponding wear factors.
Scanning Electron Microscopy Analysis

Scanning Electron Microscopy was used to visually inspect the surface condition of four test materials. Four materials were chosen primarily for general information purposes to observe the before and after impact abrasion surface condition. The specimens represented four of the material groups tested in this study namely: polyurethane elastomers, ceramics, epoxies, and metalics.

Two scans were taken of each of the materials. A before test condition labeled "non-abraded surface" and an
Figure 31. Slope comparison of 1020 low carbon steel to gray iron.

after trial status labeled "abraded surface" The micrographs were taken at 500X in order to magnify the surface well enough to see any potential damage. See Figures 2-9 for micrographs of the four materials scanned.

The micrograph (Figure 2) showing the non-abraded condition of the Hexcel 3160 polyurethane elastomer exhibited a very smooth surface before abrasion. Conversely, the surface after abrasion micrograph as seen in Figure 3 exhibited a rougher condition. There also appears
to be a lodged sand grain or chip imbedded in the material during the testing period.

The J&J Plaz-Tec ceramic material also exhibited a smooth surface before abrasion as displayed in the Figure 4 micrograph. There appears to be two small pockets of filler material on the surface also displayed in the non-abraded micrograph.

The abraded surface micrograph shown in Figure 5 displays a flake-like condition with uniform erosion occurring as shown in this back scatter image.
Table 1

Wear Analysis Table

<table>
<thead>
<tr>
<th>Material</th>
<th>Percent Weight Loss</th>
<th>Wear Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hapco Ultralloy 40</td>
<td>9.5043</td>
<td>81.93</td>
</tr>
<tr>
<td>Hapco Ultralloy 50</td>
<td>7.4140</td>
<td>63.91</td>
</tr>
<tr>
<td>Ciba-Geigy Renshape 450</td>
<td>5.8374</td>
<td>50.32</td>
</tr>
<tr>
<td>J&amp;J Corp. Plaz-Tec Fiber Ceramic</td>
<td>4.7074</td>
<td>40.58</td>
</tr>
<tr>
<td>U.S. Gypsum 301/308 Epoxical</td>
<td>4.0448</td>
<td>34.86</td>
</tr>
<tr>
<td>Hapco Hapcast 5730</td>
<td>3.9476</td>
<td>34.03</td>
</tr>
<tr>
<td>Ciba-Geigy LMB 5086</td>
<td>3.4850</td>
<td>30.04</td>
</tr>
<tr>
<td>Hexcel Uralite 3530</td>
<td>2.6088</td>
<td>22.49</td>
</tr>
<tr>
<td>Kindt-Collins Mastercast 703</td>
<td>2.5806</td>
<td>22.25</td>
</tr>
<tr>
<td>J&amp;J Corp. Plaz-Tec Ceramic</td>
<td>2.4957</td>
<td>21.51</td>
</tr>
<tr>
<td>Hexcel Uralite 3160</td>
<td>2.3614</td>
<td>20.36</td>
</tr>
<tr>
<td>Hapco Hapcast 3730/7</td>
<td>2.2911</td>
<td>19.75</td>
</tr>
<tr>
<td>Ciba-Geigy TDP 186-1</td>
<td>2.1114</td>
<td>18.20</td>
</tr>
<tr>
<td>Hexcel Uralite 3500</td>
<td>1.9733</td>
<td>17.01</td>
</tr>
<tr>
<td>Hexcel Uralite 3156</td>
<td>1.9446</td>
<td>16.76</td>
</tr>
<tr>
<td>Hapco Hapcoat 667</td>
<td>1.9055</td>
<td>16.43</td>
</tr>
<tr>
<td>Hapco Hapflex 665</td>
<td>1.7921</td>
<td>15.45</td>
</tr>
<tr>
<td>Hexcel Uralite 3503</td>
<td>1.6283</td>
<td>14.04</td>
</tr>
<tr>
<td>Hexcel Uralite 3502</td>
<td>1.5954</td>
<td>13.75</td>
</tr>
<tr>
<td>Hapco Hapflex 665 HP</td>
<td>1.5142</td>
<td>13.05</td>
</tr>
<tr>
<td>Conap Conathane TU-961</td>
<td>1.4832</td>
<td>12.79</td>
</tr>
<tr>
<td>Conap Conathane TU-981</td>
<td>1.4810</td>
<td>12.77</td>
</tr>
<tr>
<td>Hexcel Uralite 3501</td>
<td>1.3575</td>
<td>11.70</td>
</tr>
<tr>
<td>Hexcel Uralite 3534</td>
<td>1.0673</td>
<td>9.20</td>
</tr>
<tr>
<td>Hapco Hapflex 595 HP</td>
<td>1.0440</td>
<td>9.00</td>
</tr>
<tr>
<td>Ciba-Geigy 6414-3</td>
<td>0.9903</td>
<td>8.54</td>
</tr>
<tr>
<td>Hapco Hapflex 595</td>
<td>0.9834</td>
<td>8.48</td>
</tr>
<tr>
<td>Hapco Hapcoat 597</td>
<td>0.8775</td>
<td>7.56</td>
</tr>
<tr>
<td>Conap Conathane TU-956</td>
<td>0.3670</td>
<td>3.16</td>
</tr>
<tr>
<td>Silicon Bronze</td>
<td>0.3622</td>
<td>3.12</td>
</tr>
<tr>
<td>Conap Conathane TU-900</td>
<td>0.3440</td>
<td>2.97</td>
</tr>
<tr>
<td>Class 30 Gray Iron</td>
<td>0.1160</td>
<td>1.00</td>
</tr>
<tr>
<td>AISI 1020 Low Carbon Steel</td>
<td>0.0313</td>
<td>0.27</td>
</tr>
<tr>
<td>304 Stainless Steel</td>
<td>0.0310</td>
<td>0.27</td>
</tr>
</tbody>
</table>
An elemental analysis of four specific areas of the specimen, as shown in the micrograph in Figure 5 and denoted by the coding numbers B604.20a, b, c, and d, has also been conducted. The area analyzed, as shown in Figure 10, displays a high concentration of aluminum with no other sizable traces of other elements present. Figure 11 shows high concentrations of silicon and calcium with a small trace of chlorine. Figure 12 displays high concentrations of aluminum and silicon with smaller amounts of calcium, chlorine, and potassium present. Figure 13 exhibits a high concentration of calcium along with a smaller amount of silicon. Also, aluminum, calcium, and chlorine are present in trace amounts. The base material appears to contain high concentrations of aluminum, calcium, and silicon.

The Mastercast 703 epoxy material micrograph exhibits a smooth surface in its non-abraded condition as seen in Figure 6. The micrograph displaying the abraded surface, Figure 7, shows spheroidal filler material partially eroded. Also, it appears that a sphere of filler material has been gouged out of the surface due to impact abrasion.

Figure 7 also displays the four elemental analyses conducted on this material as denoted by the coding numbers B604.15a, b, c, and d. The specific area of the sample elementally analyzed in Figure 7, as shown in Figure 14, displays a high concentration of silicon with smaller traces
of calcium, sodium, magnesium, and aluminum. Figure 15 shows a high concentration of silicon. Figure 16 displays a high concentration of calcium with smaller amounts of silicon, aluminum, chlorine, potassium, and sodium. Figure 17 shows a high concentration of silicon with traces of sodium, magnesium, aluminum, potassium, calcium, and iron present.

The Class 30 gray iron sample micrograph displayed a smooth surface in its non-abraded condition as shown in Figure 8. The streaks displayed in the non-abraded micrograph appear to be machining or grinding marks from the specimen preparation.

The abraded surface micrograph as displayed in Figure 9 shows a uniform erosion of the base material. It appears the harder pearlitic substance withstood the abrasion well while the softer ferritic and graphite material exhibited greater erosion.
CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter provides a summary of findings, conclusions of the study, and recommendations for further research.

Restatement of the Problem and Purpose

The problem of this study was to analyze the wear characteristics of selected non-metallic tooling materials. The purpose of this study was to simulate the wear characteristics of foundry tooling using an impact abrasion test apparatus. This wear characteristic was measured as a function of percentage weight loss as exhibited by non-metallic materials to be benchmarked against Class 30 gray iron.

The following research question was addressed in two phases. First, is there a non-metallic material that exhibits comparable or superior wear rates compared to Class 30 gray iron that could be used as an alternative tooling material? Second, can a wear factor be developed to determine the tool life of the tested materials compared to Class 30 gray iron?

Summary of Findings

Of the materials tested, 22 were included in the polyurethane elastomer group. Some representatives of this group exhibited excellent wear resistance while others
demonstrated poor results after testing. The percentage weight loss range consisted of 0.3440% (Conathane TU-900) to 2.6088% (Uralite 3530). Of all the materials examined, only the polyurethane elastomers and metallics ranked in the top half of those specimens tested.

The Epoxy group, which consisted of three materials, all performed rather poorly under impact abrasion testing. The poorest (301/308 Epoxical), exhibited 4.0448% percentage weight loss, while the best within this group (Mastercast 703) demonstrated a 2.5806%. All three materials ranked in the lower half of those specimens tested.

The poorest materials, exhibiting the highest percentage weight loss numbers, were the two plastic liquid molding compounds. Ultralloy 40 exhibited the poorest percentage weight loss numbers, 9.5043%, while Ultralloy 50 demonstrated the next most unfavorable, 7.4140%.

The Polymer Ceramic materials also exhibited poor percentage weight loss data. The Plaz-Tec fiberglass backed material displayed a 4.7074% weight loss, whereas the pure Plaz-Tec Ceramic exhibited 2.4957%. These two materials have never been used for foundry production tooling.

The LMB 5086 Stereolithography Photopolymer also ranked poorly of the materials tested. It demonstrated a 3.4850% weight loss with only six materials displaying worse wear
resistance in the test. This material was also not designed as a production tooling media.

Renshape 450 Artificial Modeling Material is specifically designed for master and prototype tooling. Consequently, it fared poorly under impact abrasion testing. This material exhibited a 5.8374% weight loss, the third worst tested.

Of the metallic materials tested, two performed better than Class 30 gray iron. These were AISI 1020 low carbon steel and 304 stainless steel. The AISI 1020 demonstrated a 0.0313% weight loss, while the 304 stainless displayed 0.0310%.

**Conclusions**

It appears from the data generated in this study that there is no non-metallic alternative material that exhibits the wear resistance of Class 30 gray iron from a percentage weight loss criteria. Although, a polyurethane elastomer, Conathane TU-900, displayed better wear resistance than silicon bronze. This is the first indication that a non-metallic approaches the wear resistance of a metal included in the study. Of the non-metallic materials studied by Helzer (1988), and Maier and Wallace (1977), there was no indication of a non-metallic material approaching the wear resistance of a metal other than aluminum, which was not included in this study. The Gouwens (1965) study was not
 referenced because of fundamental differences in methodology.

Maier and Wallace (1977) stated that a material which exhibited a 1.6% weight loss or more would not be a suitable material for the construction of production tooling in the foundry industry. Upon further examination of the data in an ordinal progression as presented in Maier and Wallace a natural break point division in the data occurred at 1.6%. The next ordinal measurement in the data occurred at 3.15%. Building on this research foundation the following observations were made in relation to this study.

Of the 34 materials tested in this study 16 met the 1.6% or less criteria for weight loss. Of these, 12 were polyurethane elastomers and 4 were metals. Polyurethane elastomers finished in the top 75% of all the materials tested. The bottom 25% were generally not common tooling materials used in production facilities. Ceramics, while not a common tooling material, may under new formulations have future potential in a production foundry. This is also true for photopolymers with new formulations constantly being developed.

It has also been determined that classifying the materials into type groups for comparison purposes to Class 30 gray iron was a reasonable indicator of performance. Although, some overlap in percentage weight loss and wear

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
factor did occur between the polyurethane elastomer, ceramic and epoxy groups.

The corresponding wear factors displayed some interesting results in relation to percentage weight loss. The Wear Analysis Table lists percentage weight loss and corresponding wear factors. The wear factor indicates the number of tools required to match the wear resistance of Class 30 gray iron. For example, it would take nine tools made of Hapflex 595 HP to equal the wear resistance of one Class 30 gray iron tool. Correspondingly, it would take approximately 82 tools of Ultralloy 40 to equal the wear resistance of Class 30 gray iron. It is also determined that it is possible to mathematically calculate a wear factor that can predict tool life compared to a benchmark material.

The visual slope comparisons of each of the materials varied widely between specimens. Of the 33 materials compared to Class 30 gray iron 14 displayed an upward increase in slope. As the abrasion cycle progressed the percentage weight loss increased over time. This phenomenon may be as a result of the material losing its outer resilient surface exposing the subsurface to the abrasion activity.

Some of the specimens exhibited relatively linear percentage weight loss over time. Of the 33 materials
tested against gray iron 11 displayed this phenomenon. This linear wear characteristic may be attributed to specimen preparation or a consistent physical matrix throughout the material.

The remaining 8 specimens displayed a leveling off or downward trend in the visual slope line. This usually occurs after the first 4 hour wear cycle. A possible reason for this phenomenon may be that the subsurface matrix is more resilient than the outer surface. Once the outer layer is removed a stabilization of material removal occurs.

Recommendations

Based on the findings of this study, it is recommended that tooling materials exhibiting 1.6% weight loss or less, and a corresponding 14 or less wear factor, should be considered as potential tooling for foundry applications. Those materials displaying greater wear factors and percentage weight loss may still have potential tooling application for prototype and short run production.

Further research is recommended to:

1. Study the effects of different sized sand grains, as abrasive media, on potential tooling materials.

2. Repeat the tests conducted in this study with new materials once they are available from the manufacturer.
3. Conduct a cost comparison study to analyze the expenses required to construct non-metallic versus metallic tooling.

4. Conduct a study to compare lead times of constructing non-metallic versus metallic tooling.

5. Study the effects of hardness on wear resistance using impact abrasion testing.

6. Study the effects of foundry chemicals on non-metallic tooling.

7. Compare wear analysis data to dimensional change of tooling materials.
REFERENCES


Bex, T. (1990a). Plastics gain importance as patternmaking material. Modern Casting, 80(9), 43.


APPENDIX A

LIST OF MATERIALS TESTED
Polyurethane Elastomers
6414-3 from Ciba-Geigy
TDP 186-1 from Ciba-Geigy
Uralite 3156 from Hexcel
Uralite 3160 from Hexcel
Uralite 3500 from Hexcel
Uralite 3501 from Hexcel
Uralite 3502 from Hexcel
Uralite 3503 from Hexcel
Uralite 3530 from Hexcel
Uralite 3534 from Hexcel
Conathane TU-900 from Conap
Conathane TU-956 from Conap
Conathane TU-961 from Conap
Conathane TU-981 from Conap
Hapflex 595 from Hapco
Hapflex 595-HP from Hapco
Hapflex 665 from Hapco
Hapflex 665-HP from Hapco
Hapcast 3730/7 from Hapco
Hapcoat 597 from Hapco
Hapcoat 667 from Hapco

Epoxies
Hapcast 5730 from Hapco
301/308 Epoxical from U.S. Gypsum
Mastercast 703 from Kindt-Collins

Plastic Liquid Molding Compounds
Ultralloy 40 from Hapco
Ultralloy 50 from Hapco

Polymer Ceramic Composites
Plaz-Tec Ceramic from J&J Corporation
Plaz-Tec Fiberglass backed Ceramic from J&J Corporation

Stereolithography Photopolymer
LMB 5086 Photopolymer from Ciba-Geigy for 3D Systems

Artificial Modeling Material
Renshape 450 from Ciba-Geigy

Metallic Tooling Materials
AISI 1020 low carbon steel
304 stainless steel
Silicon Bronze
Class 30 gray iron
APPENDIX B

MATERIAL SAFETY DATA SHEETS (MSDS)
MATERIAL SAFETY DATA SHEET

CIBA-GEIGY CORPORATION
FORMULATED SYSTEMS GROUP
4917 DAWN AVE
EAST LANSING, MI 48823
(517) 351-5900

SECTION I - IDENTIFICATION INFORMATION

IDENTITY (TRADENAME): RP 6414-3 RESIN

FAMILY/ChemICAL NAME:
ISOCYANATE

PRODUCT TYPE:
POLYURETHANE

IMPORTANT:
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* * THIS MATERIAL WILL NOT BE SOLD FOR USE IN PRODUCTS *
* * FOR WHICH PROLONGED CONTACT WITH MUCOUS MEMBRANES OR *
* * ABRADED SKIN, OR IMPLANTATION WITHIN THE HUMAN BODY, IS *
* * SPECIFICALLY INTENDED. BECAUSE OF THE WIDE RANGE OF *
* * SUCH POTENTIAL USES, CIBA-GEIGY CORPORATION IS NOT ABLE *
* * TO RECOMMEND THIS MATERIAL AS SAFE AND EFFECTIVE FOR *
* * SUCH USES AND ASSUMES NO LIABILITY FOR ANY SUCH USES. *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

HAZARD STATEMENT:
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* * THIS MATERIAL SAFETY DATA SHEET (MSDS) HAS BEEN *
* * PREPARED IN COMPLIANCE WITH THE FEDERAL OSHA HAZARD *
* * COMMUNICATION STANDARD 29 CFR 1910.1200. *
* * THIS PRODUCT IS CONSIDERED TO BE A HAZARDOUS *
* * CHEMICAL UNDER THAT STANDARD. *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

SECTION II - HAZARDOUS INGREDIENTS

CHEMICAL NAME: ISOPhORONE DIISOCYANATE
COMMON NAME: ISOPhORONE DIISOCYANATE
CAS NUMBER: 004098-71-9

EXPOSURE LIMITS:
ACGIH TLV: 0.005 PPM AIR TWA (SKIN)

RP 6414-3 RESIN
OSHA PEL : 0.005 PPM AIR THA (SKIN)
OSHA STEL : 0.02 PPM AIR (SKIN)
CARCINOGENICITY: THIS MATERIAL IS NOT CONSIDERED TO BE A CARCINOGEN BY NTP, IARC, OR OSHA.

CHEMICAL NAME: METHYLENE BIS(4-CYCLOHEXYLISOCYANATE)
COMMON NAME : HYDROGENATED MDI
CAS NUMBER : 005124-30-1
EXPOSURE LIMITS:
ACGIH TLV : 0.055 MG/M3 AIR THA
OSHA CEILING : 0.11 MG/M3 AIR
CARCINOGENICITY: THIS MATERIAL IS NOT CONSIDERED TO BE A CARCINOGEN BY NTP, IARC, OR OSHA.

CHEMICAL NAME: CYCLOALIPHATIC ISOCYANATE PREPOLYMER
COMMON NAME : CYCLOALIPHATIC ISOCYANATE PREPOLYMER
CAS NUMBER : PMN 88-638
CARCINOGENICITY: THIS MATERIAL IS NOT CONSIDERED TO BE A CARCINOGEN BY NTP, IARC, OR OSHA.

SECTION III—PHYSICAL DATA

APPEARANCE AND ODOR:
TRANSLUCENT LIQUID WITH SLIGHT ODOR
BOILING POINT:
NOT DETERMINED
EVAPORATION RATE:
NOT DETERMINED
PERCENT VAPOR:
NEGLIGIBLE
VAPOR DENSITY:
> 1.0% (AIR = 1)
VAPOR PRESSURE:
NOT ESTABLISHED
SOLUBILITY IN WATER:
REACTS WITH WATER
PH:
NOT DETERMINED
SPECIFIC GRAVITY:
1.06 (WATER = 1)

SECTION IV—FIRE AND EXPLOSION HAZARD DATA

FLASH POINT:
> 300F (EST)
FLAMMABLE LIMITS IN AIR-LOWER:
NOT ESTABLISHED
FLAMMABLE LIMITS IN AIR-UPPER:
NOT ESTABLISHED
EXTINGUISHING MEDIA:
CARBON DIOXIDE, DRY CHEMICAL, FOAM, WATER.
FIRE FIGHTING PROCEDURES—SPECIAL:
RP 6414-3 RESIN
USE SELF-CONTAINED BREATHING APPARATUS.

UNUSUAL FIRE AND EXPLOSION HAZARDS:
DECOMPOSITION AND COMBUSTION PRODUCTS MAY BE TOXIC.
AVOID WATER CONTAMINATION IN CLOSED CONTAINERS OR CONFINED SPACES. CARBON DIOXIDE EVOLVED.

SECTION V—REACTIVITY DATA

STABILITY:
STABLE.

CONDITIONS TO AVOID:
AVOID PROLONGED HEATING OVER 160°F OR STORING BELOW 75°F. AVOID WATER CONTAMINATION.

INCOMPATIBILITY:
WATER; ALCOHOLS; STRONG OXIDIZING AGENTS; STRONG BASES; METAL-ORGANIC COMPOUNDS.

HAZARDOUS DECOMPOSITION PRODUCTS:
COMBUSTION MAY FORM TOXIC MATERIALS. CARBON MONOXIDE, CARBON DIOXIDE, BENZENE; TOLUENE; OXIDES OF NITROGEN; HYDROGEN CYANIDE.

HAZARDOUS POLYMERIZATION:
MAY OCCUR.

CONDITIONS TO AVOID:
CONTAMINATION WITH MOISTURE AND OTHER PRODUCTS THAT REACT WITH ISOCYANATES.

SECTION VI—HEALTH HAZARD DATA

PRIMARY ROUTES OF EXPOSURE:
DERMAL; HEATED PRODUCT MAY PRODUCE INHALABLE VAPORS.

SKIN IRRITATION:
IRRITANT.

EYE IRRITATION:
REGARD AS CORROSIVE.

SENSITIZATION:
CAUSES ALLERGIC SKIN AND RESPIRATORY REACTIONS.

OVEREXPOSURE EFFECTS:
CONTACT WITH LIQUID CAUSES EYE AND SKIN IRRITATION. IF INHALED CAUSES BREATHLESSNESS; CHEST DISCOMFORT, AND REDUCED PULMONARY FUNCTION.

MAY CAUSE ALLERGIC SKIN AND RESPIRATORY REACTIONS IN SOME INDIVIDUALS, LEADING TO ASTHMA TYPE SPASMS OF THE BRONCHIAL TUBES AND DIFFICULTY IN BREATHING.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE:
PERSONS WITH ASTHMATIC-TYPE CONDITIONS, CHRONIC BRONCHITIS, OTHER CHRONIC RESPIRATORY DISEASES; EYE CONDITIONS OR RECURRENT SKIN ECZEMA OR SENSITIZATION SHOULD BE EXCLUDED FROM WORKING WITH ISOCYANATES.

EMERGENCY AND FIRST AID PROCEDURES—EYES:
IMMEDIATELY FLUSH EYES WITH WATER FOR AT LEAST 15 MINUTES. CALL A PHYSICIAN.

EMERGENCY AND FIRST AID PROCEDURES—SKIN:
WASH WITH SOAP AND WATER. REMOVE CONTAMINATED CLOTHING AND

RP 6414-3 RESIN
LAUNDER BEFORE RE-USE.

EMERGENCY AND FIRST AID PROCEDURES-INGESTION:
   IF CONSCIOUS, GIVE PLENTY OF WATER TO DRINK. DO
   NOT INDUCE VOMITING. CALL A PHYSICIAN.

EMERGENCY AND FIRST AID PROCEDURES-INHALATION:
   REMOVE TO FRESH AIR. GIVE OXYGEN AND/OR ARTIFICIAL
   RESPIRATION; IF NEEDED, CALL A PHYSICIAN.

EMERGENCY AND FIRST AID PROCEDURES-OTHER:
   REFERRAL TO A PHYSICIAN IS RECOMMENDED IF THERE IS ANY
   QUESTION ABOUT THE SERIOUSNESS OF ANY INJURY.

SECTION VII-SPILL OR LEAK PROCEDURES

SPILL PROCEDURES:
   ABSORB WITH ABSORBENT MATERIAL AND PLACE IN OPEN TOP
   CONTAINER. UNDER GOOD VENTILATION; DECONTAMINATE ABSORBANT
   AND SPILL AREA WITH A MIXTURE OF 90% WATER, 8% AMMONIA AND
   2% DETERGENT (EXOTHERMIC REACTION). LEAVE VENTILATED 24
   HOURS BEFORE DISPOSAL, AVOID CONTACT.

WASTE DISPOSAL METHODS:
   CONSULT QUALIFIED LOCAL OR CORPORATE PERSONNEL FOR METHOD
   THAT WILL COMPLY WITH LOCAL, STATE AND FEDERAL HEALTH AND
   ENVIRONMENTAL REGULATIONS.

SECTION VIII-SPECIAL PROTECTION INFORMATION

VENTILATION:
   GENERAL MECHANICAL AND LOCAL EXHAUST IN ACCORDANCE WITH
   ACGIH RECOMMENDATIONS.

PROTECTIVE GLOVES:
   IMPERVIOUS SYNTHETIC GLOVES.

EYE PROTECTION:
   WEAR SPLASH-PROOF CHEMICAL GOGGLES.

RESPIRATORY PROTECTION:
   ORGANIC VAPOR RESPIRATOR IF TLV IS NOT EXCEEDED, FOR
   EXPOSURES IN EXCESS OF THE TLV; AN AIR SUPPLIED RESPIRATOR
   WOULD BE REQUIRED.

SECTION IX-SPECIAL PRECAUTIONS

HMIS CODE:
   HEALTH : 2    FIRE : 1    REACTIVITY : 0

HANDLING, SHIPPING AND STORING PRECAUTIONS:
   DANGER CORROSIVE - CAUSES EYE BURNS AND SKIN IRRITATION.
   HARMFUL IF INHALED, MAY CAUSE ALLERGIC SKIN AND
   RESPIRATORY REACTION.
   DO NOT GET IN EYES; AVOID CONTACT WITH SKIN AND
   CLOTHING; AVOID BREATHING VAPOR OR MIST. AVOID
   PROLONGED OR REPEATED CONTACT WITH SKIN. KEEP
   CONTAINER CLOSED, USE WITH ADEQUATE VENTILATION.
   WASH THOROUGHLY AFTER HANDLING.

HANDLING PRECAUTIONS:

RP 6414-3 RESIN

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
NUISANCE DUST MAY BE GENERATED WHEN SANDING OR SAWING CURED MATERIAL.

SECTION X- REGULATORY INFORMATION

DOT PROPER SHIPPING NAME:
LIQUID PLASTIC, N.O.I.

DOT CLASS:
NOT REGULATED.

DOT NUMBER:
GROUP III POISON FOR IATA/IMO SHIPMENTS;
NOT REGULATED BY DOT.

RCRA STATUS:
NOT SPECIFICALLY LISTED AS HAZARDOUS WASTE UNDER RCRA
(40 CFR 261). HOWEVER, IT IS STRONGLY RECOMMENDED THAT
COMPOUND BE TREATED AS A HAZARDOUS WASTE AND DISPOSED OF
ACCORDINGLY.

SARA/TITLE III - TOXIC CHEMICALS LIST:
THIS PRODUCT DOES NOT CONTAIN A TOXIC CHEMICAL FOR ROUTINE
ANNUAL 'TOXIC CHEMICAL RELEASE REPORTING' UNDER SEC. 313
(40 CFR 372).

TSCA INVENTORY STATUS:
CHEMICAL COMPONENTS LISTED ON TSCA INVENTORY.

PENNSYLVANIA RIGHT-TO-KNOW ACT:
THE FOLLOWING IS REQUIRED COMPOSITION INFORMATION

<table>
<thead>
<tr>
<th>CHEMICAL NAME</th>
<th>CAS NUMBER</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CYCLOALIPHATIC ISOCYANATE PREPOLYMER</td>
<td>PMN 88-439</td>
<td>NOT ON PENNSYLVANIA HAZARDOUS SUBSTANCE LIST.</td>
</tr>
<tr>
<td>METHYLENE BIS (4-CYCLOHEXYLISOCYANATE)</td>
<td>05124-30-1</td>
<td>HAZARDOUS SUBSTANCE.</td>
</tr>
<tr>
<td>ISOPHORONE DIISOCYANATE</td>
<td>04098-71-9</td>
<td>HAZARDOUS SUBSTANCE.</td>
</tr>
</tbody>
</table>

ISSUE DATE: 05/30/89
REVISION: 02C
ISSUED BY: M. MUNSELL
FOR FURTHER INFORMATION, PLEASE CONTACT: PRODUCT SAFETY DIR

THE INFORMATION AND RECOMMENDATIONS CONTAINED HEREIN ARE BASED UPON DATA BELIEVED TO BE CORRECT. HOWEVER, NO GUARANTEE OR WARRANTY OF ANY KIND EXPRESSED OR IMPLIED IS MADE WITH RESPECT TO THE INFORMATION CONTAINED HEREIN.

RP 6414-3 RESIN
IDENTITY (TRADE NAME): RP 6414-3 HARDENER

FAMILY/ChemICAL NAME:
AMINE

PRODUCT TYPE:
POLYURETHANE HARDENER

IMPORTANT:
* THIS MATERIAL WILL NOT BE SOLD FOR USE IN PRODUCTS *
* FOR WHICH PROLONGED CONTACT WITH MUCOUS MEMBRANES OR *
* ABRADED SKIN; OR IMPLANTATION WITHIN THE HUMAN BODY; IS *
* SPECIFICALLY INTENDED. BECAUSE OF THE WIDE RANGE OF *
* SUCH POTENTIAL USES, CIBA-GEIGY CORPORATION IS NOT ABLE *
* TO RECOMMEND THIS MATERIAL AS SAFE AND EFFECTIVE FOR *
* SUCH USES AND ASSUMES NO LIABILITY FOR ANY SUCH USES. *

HAZARD STATEMENT:
* THIS MATERIAL SAFETY DATA SHEET (MSDS) HAS BEEN *
* PREPARED IN COMPLIANCE WITH THE FEDERAL OSHA HAZARD *
* COMMUNICATION STANDARD 29 CFR 1910.1200 *
* THIS PRODUCT IS CONSIDERED TO BE A HAZARDOUS *
* CHEMICAL UNDER THAT STANDARD. *

SECTION II—HAZARDOUS INGREDIENTS

CHEMICAL NAME: DI-N-BUTYL phthalate
COMMON NAME : DIBUTYL PHTHALATE
CAS NUMBER : 060894-74-2
EXPOSURE LIMITS:
ACGIH TLV : 5 MG/M3 AIR TWA

RP 6414-3 HARDENER
OSHA PEL: 5 MG/M3 AIR TWA
CARCINOGENICITY: THIS MATERIAL IS NOT CONSIDERED TO BE A CARCINOGEN BY NTP, IARC, OR OSHA.

CHEMICAL NAME: 4,4'-METHYLENEBIS (D-ETHYL-ANILINE)
COMMON NAME: AROMATIC AMINE
CAS NUMBER: 019900-65-3
CARCINOGENICITY: THIS MATERIAL IS NOT CONSIDERED TO BE A CARCINOGEN BY NTP, IARC, OR OSHA.

CHEMICAL NAME: BENZENEDIAMINE, AR, AR-DIETHYL-AR-METHYL-
COMMON NAME: DIETHYL TOLUENE DIAMINE
CAS NUMBER: 069477-98-1
CARCINOGENICITY: THIS MATERIAL IS NOT CONSIDERED TO BE A CARCINOGEN BY NTP, IARC, OR OSHA.

SECTION III—PHYSICAL DATA

APPEARANCE AND ODOR:
- DARK RED LIQUID WITH AMMONIACAL ODOR

BOILING POINT:
- 890F

EVAPORATION RATE:
- NOT DETERMINED

PERCENT VOLATILE:
- 1%

VAPOR DENSITY:
- NOT DETERMINED

VAPOR PRESSURE:
- NOT DETERMINED

SOLUBILITY IN WATER:
- SLIGHT

PH:
- NOT DETERMINED

SPECIFIC GRAVITY:
- 1.05 (WATER = 1)

SECTION IV—FIRE AND EXPLOSION HAZARD DATA

FLASH POINT:
- 200F (EST)

FLAMMABLE LIMITS IN AIR—LOWER:
- NOT ESTABLISHED

FLAMMABLE LIMITS IN AIR—UPPER:
- NOT ESTABLISHED

EXTINGUISHING MEDIA:
- CARBON DIOXIDE, DRY CHEMICAL, FOAM, WATER

FIRE FIGHTING PROCEDURES—SPECIAL:
- USE SELF-CONTAINED BREATHING APPARATUS

UNUSUAL FIRE AND EXPLOSION HAZARDS:
- DECOMPOSITION AND COMBUSTION PRODUCTS MAY BE TOXIC

RP 6414-3 HARDENER
SECTION V—REACTIVITY DATA

STABILITY:
STABLE.
CONDITIONS TO AVOID:
EXCESSIVE HEAT FOR PROLONGED PERIODS OF TIME.
INCOMPATIBILITY:
STRONG OXIDIZING AGENTS, ACIDS, METAL-ORGANIC COMPOUNDS.
HAZARDOUS DECOMPOSITION PRODUCTS:
CONBUSTION MAY FORM TOXIC MATERIALS, SUCH AS CARBON DIOXIDE,
CARBON MONOXIDE.
HAZARDOUS POLYMERIZATION:
WILL NOT OCCUR.

SECTION VI—HEALTH HAZARD DATA

PRIMARY ROUTES OF EXPOSURE:
DERMAL: HEATED PRODUCT MAY PRODUCE INHALABLE VAPORS.
THRESHOLD LIMIT VALUE:
NONE ESTABLISHED FOR THIS PRODUCT. SEE THE HAZARDOUS INGREDIENTS SECTION.
SKIN IRRITATION:
IRRITANT.
EYE IRRITATION:
CORROSIVE. CAUSES BURNS.
SENSITIZATION:
POSSIBLE IN SUSCEPTIBLE INDIVIDUALS.
OVEREXPOSURE EFFECTS:
DANGER CORROSIVE. CAUSES EYE BURNS AND SKIN IRRITATION. MAY CAUSE ALLERGIC SKIN AND RESPIRATORY REACTIONS. ABSORPTION THROUGH SKIN OR INGESTION MAY CAUSE NAUSEA, VOMITING, OR OTHER ILLNESS. INHALATION OF VAPORS MAY CAUSE ASTHMA-LIKE SYMPTOMS SUCH AS WHEEZING, COUGHING, AND SHORTNESS OF BREATH.
MEDICAL CONDITIONS AGRAVATED BY EXPOSURE:
SKIN AND EYE CONDITIONS.
EMERGENCY AND FIRST AID PROCEDURES—EYES:
IMMEDIATELY FLUSH EYES WITH WATER FOR AT LEAST 15 MINUTES. CALL A PHYSICIAN.
EMERGENCY AND FIRST AID PROCEDURES—SKIN:
WASH WITH SOAP AND WATER. REMOVE CONTAMINATED CLOTHING AND LAUNDER BEFORE RE-USE.
EMERGENCY AND FIRST AID PROCEDURES—INGESTION:
IF CONSCIOUS: GIVE PLENTY OF WATER TO DRINK. DO NOT INDUCE VOMITING. CALL A PHYSICIAN.
EMERGENCY AND FIRST AID PROCEDURES—INHALATION:
REMOVE TO FRESH AIR. GIVE OXYGEN AND/OR ARTIFICIAL RESPIRATION; IF NEEDED, CALL A PHYSICIAN.
EMERGENCY AND FIRST AID PROCEDURES—OTHER:
REFERRAL TO A PHYSICIAN IS RECOMMENDED IF THERE IS ANY QUESTION ABOUT THE SERIOUSNESS OF ANY INJURY.

RP 6414-3 HARDENER
SECTION VII - SPILL OR LEAK PROCEDURES

SPILL PROCEDURES:
REMOVE SPILLAGE BY ABSORBING IN ABSORBENT MATERIAL.
AVOID CONTACT.

WASTE DISPOSAL METHODS:
CONSULT QUALIFIED LOCAL OR CORPORATE PERSONNEL FOR METHOD
THAT WILL COMPLY WITH LOCAL, STATE AND FEDERAL HEALTH AND
ENVIRONMENTAL REGULATIONS.

SECTION VIII - SPECIAL PROTECTION INFORMATION

VENTILATION:
GENERAL MECHANICAL AND LOCAL EXHAUST IN ACCORDANCE WITH
ACGIH RECOMMENDATIONS.
PROTECTIVE GLOVES:
IMPERMEABLE GLOVES AND PROTECTIVE CLOTHING.
EYE PROTECTION:
FULL FACE SHIELD.
RESPIRATORY PROTECTION:
USE NIOSH APPROVED ORGANIC VAPOR CARTRIDGE RESPIRATOR
WHEN VAPOR/MIST EXPOSURE IS LIKELY.

SECTION IX - SPECIAL PRECAUTIONS

HMIS CODE:
HEALTH : 2      FIRE : 1      REACTIVITY : 0
HANDLING, SHIPPING AND STORING PRECAUTIONS:
DANGER CORROSIVE - CAUSES EYE BURNS AND SKIN IRRITATION. HARMFUL IF SWALLOWED; IF ABSORBED THROUGH SKIN, OR IF INHALED, MAY CAUSE ALLERGIC SKIN REACTION. DO NOT GET IN EYES, AVOID BREATHING VAPOR OR MIST, AVOID CONTACT WITH SKIN AND CLOTHING. KEEP CONTAINER CLOSED. USE WITH ADEQUATE VENTILATION. WASH THOROUGHLY AFTER HANDLING.

HANDLING PRECAUTIONS:
NUISANCE DUST MAY BE GENERATED WHEN SANDING OR SAWING CURED MATERIAL.

PLEASE NOTE:
THIS PRODUCT CONTAINS DIBUTYL PHthalate WHICH MAY CAUSE ADVERSE REPRODUCTIVE EFFECTS IN LABORATORY ANIMALS. THE RELEVANCE TO HUMANS IS NOT KNOWN.

SECTION X - REGULATORY INFORMATION

DOT PROPER SHIPPING NAME:
LIQUID PLASTIC, N.O.I.
DOT CLASS:
NOT REGULATED.
RCRA STATUS:
NOT A HAZARDOUS WASTE UNDER RCRA (40 CFR 261).

RP 6414-3 HARDENER
IDENTITY (TRADENAME): TDT 186-1 RESIN

FAMILY/ CHEMICAL NAME:
ISOCYANATE
PRODUCT TYPE:
CLEAR CASTABLE URETHANE

IMPORTANT:
*  THIS MATERIAL WILL NOT BE SOLD FOR USE IN PRODUCTS *
*  FOR WHICH PROLONGED CONTACT WITH MUCOUS MEMBRANES OR *
*  ABRADED SKIN, OR IMPLANTATION WITHIN THE HUMAN BODY, IS *
*  SPECIFICALLY INTENDED, BECAUSE OF THE WIDE RANGE OF *
*  SUCH POTENTIAL USES, CIBA-GEIGY CORPORATION IS NOT ABLE *
*  TO RECOMMEND THIS MATERIAL AS SAFE AND EFFECTIVE FOR *
*  SUCH USES AND ASSUMES NO LIABILITY FOR ANY SUCH USES. *

HAZARD STATEMENT :
*  THIS MATERIAL SAFETY DATA SHEET (MSDS) HAS BEEN *
*  PREPARED IN COMPLIANCE WITH THE FEDERAL OSHA HAZARD *
*  COMMUNICATION STANDARD 29 CFR 1910.1200, *
*  THIS PRODUCT IS CONSIDERED TO BE A HAZARDOUS *
*  CHEMICAL UNDER THAT STANDARD, *

CHEMICAL NAME: METHYLENE BIS(4-CYCLOHEXYLISOCYANATE)
COMMON NAME : HYDROGENATED MDI
CAS NUMBER : 005124-30-1
EXPOSURE LIMITS:
ACGIH TLV : 0.055 MG/M3 AIR TWA

TDT 186-1 RESIN
OSHA CEILING: 0.11 mg/m³ AIR
CARCINOGENICITY: THIS MATERIAL IS NOT CONSIDERED TO BE A CARCINOGEN BY NTP; IARC; OR OSHA.

CHEMICAL NAME: N,N,N',N'-TETRAKIS (4-ISOCYANATOCYCLOHEXYL-1,1'-'METHYLENECYCLOHEXYL-4'-CARBAMOYL)-2-OXYPROPYL ETHYLENEDIAMINE
COMMON NAME: CYCLOALIPHATIC ISOCYANATE PREPOLYMER
CAS NUMBER: 56927
CARCINOGENICITY: THIS MATERIAL IS NOT CONSIDERED TO BE A CARCINOGEN BY NTP; IARC; OR OSHA.

SECTION III—PHYSICAL DATA

APPEARANCE:
CLEAR COLORLESS LIQUID.

BOILING POINT:
NOT DETERMINED.

MELTING POINT:
66 F - 73 F

EVAPORATION RATE:
NOT DETERMINED.

PERCENT VOLATILE:
NEGLIGIBLE.

VAPOR DENSITY:
> 1.0% (AIR = 1)

VAPOR PRESSURE:
@ 25°C: 0.00925 mmHg.

SOLUBILITY IN WATER:
REACTS WITH WATER

PH:
NOT DETERMINED.

SPECIFIC GRAVITY:
1.07 - 1.09 (WATER = 1)

SECTION IV—FIRE AND EXPLOSION HAZARD DATA

FLASH POINT:
> 300°F (PMCC)

FLAMMABLE LIMITS IN AIR-LOWER:
NOT ESTABLISHED.

FLAMMABLE LIMITS IN AIR-UPPER:
NOT ESTABLISHED.

EXTINGUISHING MEDIA:
CARBON DIOXIDE; DRY CHEMICAL; FOAM; WATER.

FIRE FIGHTING PROCEDURES-SPECIAL:
USE SELF-CONTAINED BREATHING APPARATUS.

UNUSUAL FIRE AND EXPLOSION HAZARDS:
DECOMPOSITION AND COMBUSTION PRODUCTS MAY BE TOXIC.
AVOID WATER CONTAMINATION IN CLOSED CONTAINERS OR CONFINED SPACES. CARBON DIOXIDE EVOLVED.

TDT 186-1 RESIN
SECTION V-REACTIVITY DATA

STABILITY:
STABLE.

CONDITIONS TO AVOID:
- AVOID PROLONGED HEATING OVER 160°F OR STORING BELOW 70°F. AVOID WATER CONTAMINATION.

INCOMPATIBILITY:
- WATER, ALCOHOLS, STRONG OXIDIZING AGENTS, STRONG BASES, METAL-ORGANIC COMPOUNDS.

HAZARDOUS DECOMPOSITION PRODUCTS:
- COMBUSTION MAY FORM TOXIC MATERIALS: CARBON MONOXIDE, CARBON DIOXIDE, BENZENE, TOLUENE, OXIDES OF NITROGEN, HYDROGEN CYANIDE.

HAZARDOUS POLYMERIZATION:
- MAY OCCUR.

CONDITIONS TO AVOID:
- CONTAMINATION WITH MOISTURE AND OTHER PRODUCTS THAT REACT WITH ISOCYANATES.

SECTION VI-HEALTH HAZARD DATA

PRIMARY ROUTES OF EXPOSURE:
- DERMAL: HEATED PRODUCT MAY PRODUCE INHALABLE VAPORS.

SKIN IRRITATION:
- IRRITANT.

EYE IRRITATION:
- IRRITANT.

SENSITIZATION:
- CAUSES ALLERGIC SKIN AND RESPIRATORY REACTIONS.

OVEREXPOSURE EFFECTS:
- CONTACT WITH LIQUID CAUSES EYE AND SKIN IRRITATION. IF INHALED CAUSES BREATHLESSNESS, CHEST DISCOMFORT, AND REDUCED PULMONARY FUNCTION.
- MAY CAUSE ALLERGIC SKIN AND RESPIRATORY REACTIONS IN SOME INDIVIDUALS, LEADING TO ASTHMA TYPE SPASMS OF THE BRONCHIAL TUBES AND DIFFICULTY IN BREATHING.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE:
- PERSONS WITH ASTHMA-TYPE CONDITIONS, CHRONIC BRONCHITIS, OTHER CHRONIC RESPIRATORY DISEASES, EYE CONDITIONS OR RECURRENT SKIN ECZEMA OR SENSITIZATION SHOULD BE EXCLUDED FROM WORKING WITH ISOCYANATES.

EMERGENCY AND FIRST AID PROCEDURES-EYES:
- IMMEDIATELY FLUSH EYES WITH WATER FOR AT LEAST 15 MINUTES. CALL A PHYSICIAN.

EMERGENCY AND FIRST AID PROCEDURES-SKIN:
- WASH WITH SOAP AND WATER. REMOVE CONTAMINATED CLOTHING AND LAUNDER BEFORE RE-USE.

EMERGENCY AND FIRST AID PROCEDURES-INGESTION:
- IF CONSCIOUS, GIVE PLENTY OF WATER TO DRINK. DO NOT INDUCE VOMITING. CALL A PHYSICIAN.

EMERGENCY AND FIRST AID PROCEDURES-INHALATION:

TDI 186-1 RESIN
REMOVE TO FRESH AIR. GIVE OXYGEN AND/OR ARTIFICIAL RESPIRATION; IF NEEDED, CALL A PHYSICIAN.

EMERGENCY AND FIRST AID PROCEDURES—OTHER:

REFERRAL TO A PHYSICIAN IS RECOMMENDED IF THERE IS ANY QUESTION ABOUT THE SERIOUSNESS OF ANY INJURY.

SECTION VII—SPILL OR LEAK PROCEDURES

SPILL PROCEDURES:

ABSORB WITH ABSORBENT MATERIAL AND PLACE IN OPEN TOP CONTAINER, UNDER GOOD VENTILATION; DECONTAMINATE ABSORBENT AND SPILL AREA WITH A MIXTURE OF 90% WATER, 8% AMMONIA AND 2% DETERGENT (EXOTHERMIC REACTION), LEAVE VENTILATED 24 HOURS BEFORE DISPOSAL; AVOID CONTACT.

WASTE DISPOSAL METHODS:

CONSULT QUALIFIED LOCAL OR CORPORATE PERSONNEL FOR METHOD THAT WILL COMPLY WITH LOCAL, STATE AND FEDERAL HEALTH AND ENVIRONMENTAL REGULATIONS.

SECTION VIII—SPECIAL PROTECTION INFORMATION

VENTILATION:

GENERAL MECHANICAL AND LOCAL EXHAUST IN ACCORDANCE WITH ACGIH RECOMMENDATIONS.

PROTECTIVE GLOVES:

IMPERVIOUS SYNTHETIC GLOVES.

EYE PROTECTION:

WEAR SPLASH-PROOF CHEMICAL GOGGLES.

RESPIRATORY PROTECTION:

ORGANIC VAPOR RESPIRATOR IF TLV IS NOT EXCEEDED; FOR EXPOSURES IN EXCESS OF THE TLV, AN AIR SUPPLIED RESPIRATOR WOULD BE REQUIRED.

SECTION IX—SPECIAL PRECAUTIONS

HHIS CODE:

HEALTH: 2  FIRE: 1  REACTIVITY: 0

HANDLING, SHIPPING AND STORING PRECAUTIONS:

WARNING: HARMFUL IF INHALED; CAUSES SKIN AND EYE IRRITATION; CAUSES ALLERGIC SKIN AND RESPIRATORY REACTION; AVOID CONTACT WITH EYES, SKIN, AND CLOTHING; AVOID BREATHING VAPOR OR MIST; AVOID PROLONGED OR REPEATED CONTACT WITH SKIN; KEEP CONTAINER CLOSED, USE WITH ADEQUATE VENTILATION, WASH THOROUGHLY AFTER HANDLING.

HANDLING PRECAUTIONS:

NUISANCE DUST MAY BE GENERATED WHEN SANDING OR SAWING CURED MATERIAL.

SECTION X—REGULATORY INFORMATION

DOT PROPER SHIPPING NAME:

TDT 186-1 RESIN
LIQUID PLASTIC, N.O.I.

DOT CLASS:
NOT REGULATED.

DOT NUMBER:
GROUP III POISON FOR IATA/IMO SHIPMENTS;
NOT REGULATED BY DOT.

RCRA STATUS:
NOT SPECIFICALLY LISTED AS HAZARDOUS WASTE UNDER RCRA
(40 CFR 261). HOWEVER, IT IS STRONGLY RECOMMENDED THAT
COMPONENT BE TREATED AS A HAZARDOUS WASTE AND DISPOSED OF
ACCORDINGLY.

SARA/TITLE III - TOXIC CHEMICALS LIST:
THIS PRODUCT DOES NOT CONTAIN A TOXIC CHEMICAL FOR ROUTINE
ANNUAL 'TOXIC CHEMICAL RELEASE REPORTING' UNDER SEC. 313
(40 CFR 372).

TSCA INVENTORY STATUS:
CHEMICAL COMPONENTS LISTED ON TSCA INVENTORY.

PENNSYLVANIA RIGHT-TO-KNOW ACT:
THE FOLLOWING IS REQUIRED COMPOSITION INFORMATION:

<table>
<thead>
<tr>
<th>CHEMICAL NAME</th>
<th>CAS NUMBER</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>N,N,N',N'-TETRAKIS(4'-ISOCYANATOCYCLOHEXYL-1,1'-METHYLENE CYCLOHEXYL-4'-CARBAMOYL)-2-OXY PROPYLENEDIAMINE</td>
<td>NOT AVAILABLE</td>
<td>NOT ON PENNSYLVANIA HAZARDOUS SUBSTANCE LIST.* **</td>
</tr>
<tr>
<td>CYCLOHEXANE, 1,1'-METHYLENEBIS 4-ISO CYANATOCYCLOHEXYL-1,1'-METHYLENE CYCLOHEXYL-4'-CARBAMOYL)-2-OXY PROPYLENEDIAMINE</td>
<td>5124-30-1</td>
<td>HAZARDOUS SUBSTANCE.* **</td>
</tr>
</tbody>
</table>

ISSUE DATE: 06/01/89 REVISION: OSC ISSUED BY: PETER HENIGE
FOR FURTHER INFORMATION, PLEASE CONTACT: PRODUCT SAFETY DIR

THE INFORMATION AND RECOMMENDATIONS CONTAINED HEREIN ARE
BASED UPON DATA BELIEVED TO BE CORRECT. HOWEVER, NO GUARANTEE
OR WARRANTY OF ANY KIND EXPRESSED OR IMPLIED IS MADE WITH
RESPECT TO THE INFORMATION CONTAINED HEREIN.

TDI 184-1 RESIN
MATERIAL SAFETY DATA SHEET

CIBA-GEIGY CORPORATION
FORMULATED SYSTEMS GROUP
4917 DAWNE AVE
EAST LANSING, MI 48823
(517) 351-5900

EMERGENCY PHONE NUMBER:
FORMULATED SYSTEMS GROUP
(800) 888-3372

SECTION I - IDENTITY INFORMATION

IDENTITY (TRADE NAME): TDT 186-1 HARDENER

FAMILY/CHEMICAL NAME:
POLYOL
PRODUCT TYPE:
CLEAR CASTABLE URETHANE

IMPORTANT:
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* THIS MATERIAL WILL NOT BE SOLD FOR USE IN PRODUCTS *
* FOR WHICH PROLONGED CONTACT WITH MUCOUS MEMBRANES OR *
* ABRASIVE SKIN, OR IMPLANTATION WITHIN THE HUMAN BODY, IS *
* SPECIFICALLY INTENDED: BECAUSE OF THE WIDE RANGE OF *
* SUCH POTENTIAL USES; CIBA-GEIGY CORPORATION IS NOT ABLE *
* TO RECOMMEND THIS MATERIAL AS SAFE AND EFFECTIVE FOR *
* SUCH USES AND ASSUMES NO LIABILITY FOR ANY SUCH USES. *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

HAZARD STATEMENT:
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* THIS MATERIAL SAFETY DATA SHEET (MSDS) HAS BEEN *
* PREPARED IN COMPLIANCE WITH THE FEDERAL OSHA HAZARD *
* THIS PRODUCT IS NOT CONSIDERED TO BE A HAZARDOUS *
* CHEMICAL UNDER THAT STANDARD. *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

SECTION II - HAZARDOUS INGREDIENTS

THE COMPONENTS OF THIS PRODUCT ARE NOT CONSIDERED TO BE *
HAZARDOUS AS DEFINED BY THE OSHA HAZARD COMMUNICATION *

TDT 186-1 HARDENER

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
SECTION III-FIREFIGHTING DATA

APPEARANCE: CLEAR COLORLESS LIQUID.
BOILING POINT: NOT DETERMINED.
EVAPORATION RATE: NOT DETERMINED.
PERCENT VOLATILE: NEGLIGIBLE.
VAPOR DENSITY: NOT DETERMINED.
VAPOR PRESSURE: @ 25°C, 12 MMHG.
SOLUBILITY IN WATER: MODERATE.
PH: NOT DETERMINED.
SPECIFIC GRAVITY: 1.03 - 1.05 (WATER = 1).

SECTION IV-FIRE AND EXPLOSION HAZARD DATA

FLASH POINT: > 300°F (PMCC).
FLAMMABLE LIMITS IN AIR—LOWER: NOT ESTABLISHED.
FLAMMABLE LIMITS IN AIR—UPPER: NOT ESTABLISHED.
EXTINGUISHING MEDIA: CARBON DIOXIDE, DRY CHEMICAL, FOAM, WATER.
FIRE FIGHTING PROCEDURES—SPECIAL: USE SELF-CONTAINED BREATHING APPARATUS.
UNUSUAL FIRE AND EXPLOSION HAZARDS: DECOMPOSITION AND COMBUSTION PRODUCTS MAY BE TOXIC.

SECTION V-REACTIVITY DATA

STABILITY: STABLE.
CONDITIONS TO AVOID: EXCESSIVE HEAT FOR PROLONGED PERIODS OF TIME.
INCOMPATIBILITY: STRONG OXIDIZERS, ACIDS AND BASES.
HAZARDOUS DECOMPOSITION PRODUCTS: COMBUSTION MAY FORM TOXIC MATERIALS; SUCH AS CARBON DIOXIDE, CARBON MONOXIDE.
HAZARDOUS POLYMERIZATION: WILL NOT OCCUR.

SECTION VI-HEALTH HAZARD DATA

TIT 186-1 HARDENER

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
PRIMARY ROUTES OF EXPOSURE:
DERMAL: HEATED PRODUCT MAY PRODUCE INHALABLE VAPORS.

THRESHOLD LIMIT VALUE:
NONE ESTABLISHED FOR THIS PRODUCT. SEE THE HAZARDOUS INGREDIENTS SECTION.

MEDICAL CONDITIONS AGRGRAVATED BY EXPOSURE:
SKIN AND EYE CONDITIONS.

EMERGENCY AND FIRST AID PROCEDURES—EYES:
IMMEDIATELY FLUSH EYES WITH WATER FOR AT LEAST 15 MINUTES.
CALL A PHYSICIAN.

EMERGENCY AND FIRST AID PROCEDURES—SKIN:
WASH WITH SOAP AND WATER, REMOVE CONTAMINATED CLOTHING AND LAUNDER BEFORE RE-USE.

EMERGENCY AND FIRST AID PROCEDURES—INGESTION:
IF CONSCIOUS, GIVE PLENTY OF WATER TO DRINK, DO NOT INDUCE VOMITING, CALL A PHYSICIAN.

EMERGENCY AND FIRST AID PROCEDURES—INHALATION:
REMOVE TO FRESH AIR. GIVE OXYGEN AND/OR ARTIFICIAL RESPIRATION; IF NEEDED, CALL A PHYSICIAN.

EMERGENCY AND FIRST AID PROCEDURES—OTHER:
REFERRAL TO A PHYSICIAN IS RECOMMENDED IF THERE IS ANY QUESTION ABOUT THE SERIOUSNESS OF ANY INJURY.

SECTION VII—SPILL OR LEAK PROCEDURES

SPILL PROCEDURES:
REMOVE SPILLAGE BY ABSORBING IN ABSORBENT MATERIAL.

WASTE DISPOSAL METHODS:
CONSULT QUALIFIED LOCAL OR CORPORATE PERSONNEL FOR METHOD THAT WILL COMPLY WITH LOCAL, STATE AND FEDERAL HEALTH AND ENVIRONMENTAL REGULATIONS.

SECTION VIII—SPECIAL PROTECTION INFORMATION

VENTILATION:
GENERAL MECHANICAL AND LOCAL EXHAUST IN ACCORDANCE WITH ACGIH RECOMMENDATIONS.

PROTECTIVE GLOVES:
WEAR IMPERMEABLE GLOVES.

EYE PROTECTION:
WEAR SPLASH-PROOF CHEMICAL GOGGLES.

RESPIRATORY PROTECTION:
USE NIOSH APPROVED ORGANIC VAPOR CARTRIDGE RESPIRATOR WHEN VAPOR/MIST EXPOSURE IS LIKELY.

SECTION IX—SPECIAL PRECAUTIONS

HMIS CODE:
HEALTH: 1     FIRE: 1     REACTIVITY: 0

HANDLING, SHIPPING AND STORING PRECAUTIONS:
CAUTION IN ACCORD WITH GOOD INDUSTRIAL PRACTICE, HANDLE WITH DUE CARE. AVOID CONTACT WITH EYES, SKIN, AND CLOTHING. WASH THOROUGHLY AFTER HANDLING.

TDI 186-1 HARDENER
HANDLING PRECAUTIONS:

NUISANCE DUST MAY BE GENERATED WHEN SANDING OR SAWING CURED MATERIAL.

SECTION X - REGULATORY INFORMATION

DOT PROPER SHIPPING NAME:

LIQUID PLASTIC, N.O.I.

DOT CLASS:

NOT REGULATED.

RCRA STATUS:

NOT A HAZARDOUS WASTE UNDER RCRA (40 CFR 261).

SARA/TITLE III - TOXIC CHEMICALS LIST:

THIS PRODUCT DOES NOT CONTAIN A TOXIC CHEMICAL FOR ROUTINE ANNUAL 'TOXIC CHEMICAL RELEASE REPORTING' UNDER SEC. 313 (40 CFR 372).

TSCA INVENTORY STATUS:

CHEMICAL COMPONENTS LISTED ON TSCA INVENTORY.

Pennsylvania Right-to-Know Act:

THE FOLLOWING IS REQUIRED COMPOSITION INFORMATION:

<table>
<thead>
<tr>
<th>CHEMICAL NAME</th>
<th>CAS NUMBER</th>
<th>COMMON NAME</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-PROPANOL, 1,1',1'',1'''- (1,2-ETHANEDIYL)</td>
<td>102-60-3</td>
<td>TETRA{HYDROXYPROPYL)ETHYLENE DIAMINE</td>
<td>NOT ON PENNSYLVANIA HAZARDOUS SUBSTANCE LIST.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>** **</td>
</tr>
<tr>
<td>POLY OXY (METHYL-1,2-ETHANEDIYL) 1,ALPHA, 1,ALPHA, 1,2,3-PROPANETRIYLTRIS OMEGA HYDROXY</td>
<td>25791-96-2</td>
<td>NOT ON PENNSYLVANIA HAZARDOUS SUBSTANCE LIST.</td>
<td>** **</td>
</tr>
<tr>
<td>OXIRANE, METHYL-, POLYMER WITH OXIRANE, ETHER WITH 1,2,3-PROPANETRIOL (3:1)</td>
<td>9082-06-2</td>
<td>NOT ON PENNSYLVANIA HAZARDOUS SUBSTANCE LIST.</td>
<td>** **</td>
</tr>
</tbody>
</table>

ISSUE DATE: 12/10/88  REVISION: 04C  ISSUED BY: PETER HENIGE  FOR FURTHER INFORMATION, PLEASE CONTACT: PRODUCT SAFETY DIR.

THE INFORMATION AND RECOMMENDATIONS CONTAINED HEREIN ARE BASED UPON DATA BELIEVED TO BE CORRECT. HOWEVER, NO GUARANTEE OR WARRANTY OF ANY KIND EXPRESSED OR IMPLIED IS MADE WITH RESPECT TO THE INFORMATION CONTAINED HEREIN.
MATERIAL SAFETY DATA SHEET
URALITE 3156-3158 PART A

SECTION I - IDENTIFICATION

COMPANY NAME........................ HEXCEL CORPORATION - RESINS GROUP
20701 Nordhoff Street, PO Box 2197
Chatsworth, CA 91311
(818) 882-3022

EMERGENCY PHONE NUMBER............. (800) 433-5072 (except California)
(800) 343-4467 (Canada)

CALIFORNIA EMERGENCY PHONE NUMBER.. (800) 367-7527

PRODUCT IDENTIFIER.................. URALITE 3156-3158 PART A

CHEMICAL FAMILY...................... URETHANE PREPOLYMER

SECTION II - HAZARDOUS INGREDIENTS

HAZARDOUS INGREDIENTS

| Dicyclohexylmethane-4,4'-diisocyanate (aka H12 MDI) | 10-30  | .01 ppm | 5124-30-1 |
| Polypropylene Polyethylene Polyglycol/H12 MDI Polymer | 70-90  | Not Established | 68310-52-1 |

SECTION III - PHYSICAL DATA

BOILING POINT........... Not available
MELTING POINT...... Not available

APPEARANCE AND ODOR... Clear liquid with a faint sweet odor

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASHPOINT AND METHOD OF DETERMINATION.. 302°F Cleveland Open Cup
MEANS OF EXTINCTION....................... Use CO2 or dry chemical for small fires. Use water and foam for large ones.

FOR FIRE................................. Since vapors are exceedingly irritating when inhaled, a self-contained breathing apparatus should be available to firemen.
**HMIS-Rating**

<table>
<thead>
<tr>
<th>Category</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health</td>
<td>2</td>
</tr>
<tr>
<td>Flammability</td>
<td>1</td>
</tr>
<tr>
<td>Reactivity</td>
<td>1</td>
</tr>
</tbody>
</table>

**MATERIAL SAFETY DATA SHEET**

**EMERGENCY RESPONSE**

Not listed in the 1990 DOT Emergency Response Guidebook.

**SECTION V - HEALTH HAZARD DATA**

**OVEREXPOSURE EFFECTS**

Skin exposure may cause irritation. Repeated or prolonged exposure can result in dermatitis and skin sensitization (allergic effects). Vapors are exceedingly irritating to mucous membrane and eyes. Can cause acute temporary chest discomfort and breathing difficulty. Vapors can cause respiratory sensitization in susceptible people. Risk of explosion by shock, friction, fire or other sources of ignition. Ingestion may cause gastro-intestinal burning and discomfort. Possibly severe irritation and/or sensitization can result from overexposure to this product. Pre-existing eye, skin, and respiratory disorders may be aggravated by exposure.

**SPECIFIC FIRST AID PROCEDURES**

**EYES:** In case of eye contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

**SKIN CONTACT:** In case of contact, immediately wash skin with soap and plenty of water. Wash contaminated clothing before re-use and destroy contaminated shoes.

**INHALATION:** If inhaled, remove to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Get medical attention.

**INGESTION:** If swallowed, get medical attention immediately. Induce vomiting ONLY upon the advice of a physician.

**SECTION VI - REACTIVITY DATA**

**CHEMICAL STABILITY**

Stable

**INCOMPATIBLE MATERIALS**

Avoid contact with water, alcohols, strong bases, metal compounds or surface active materials.

**HAZARDOUS DECOMPOSITION PRODUCTS**

Carbon dioxide, carbon monoxide, and nitrogen oxides. Isocyanate vapors and mists may also evolve.

**HAZARDOUS POLYMERIZATION**

Will not occur.

**CONDITIONS TO AVOID**

Store in a cool, well ventilated area in tightly closed containers. Avoid moisture contamination.

**SECTION VII - SPILL OR LEAK PROCEDURE**

**RCRA WASTE NUMBER**

None

**URALITE J156-3158 PART A**

Printed: 06/14/1991

Chemetrec: (800) 424-9300

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
WASTE DISPOSAL: Controlled incineration or buried landfill disposal should be in accordance with all federal, state, and local environmental control regulations.

LEAK AND SPILL PROCEDURES: In case of spill, contain with a suitable diking material. Ventilate the area thoroughly. Keep all unnecessary people away. Spilled material should be absorbed in sawdust, sand or other absorbent. Place in an open-top container. Neutralize with a solution of 90-95% water, 5-8% concentrated ammonia and 1-2% detergent before disposal. Keep container open for at least 12 hours so that evolved carbon dioxide can escape.

SECTION VIII - SPECIAL PROTECTION

PERSONAL PROTECTION: HMIS CODE C - SAFETY GLASSES, GLOVES AND SYNTHETIC APRON.

VENTILATION: If handled indoors, provide mechanical exhaust ventilation.

HANDLING PROCEDURES AND EQUIPMENT: Avoid breathing vapors. Keep away from heat, sparks, and open flames. Use adequate ventilation. Wash thoroughly after handling.

SECTION IX - SHIPPING INFORMATION

HAZARD CLASS: N/A

DOT SHIPPING NAME: NOT REGULATED BY THE DEPARTMENT OF TRANSPORTATION.

REPORTABLE QUANTITY (RQ): N/A

UN NUMBER: N/A

NA #: N/A

SECTION X - STORAGE INFORMATION

STORE IN A COOL DRY AREA IN TIGHTLY CLOSED CONTAINERS. AVOID MOISTURE CONTAMINATION.

SECTION XI - REGULATORY INFORMATION

NOTICE: The information herein is presented in good faith and believed to be accurate as of the preparation date shown below. However, no warranty, expressed or implied, is given. Regulatoty requirements are subject to change and may differ from one location to another; it is the buyer's responsibility to ensure that its activities comply with federal, state and local laws. The following specific information is made for the purpose of complying with numerous federal, state and local laws and regulations. THIS INFORMATION IS NOT MEANT TO BE ALL-INCLUSIVE. SELECTED REGULATIONS ARE PRESENTED.

SARA 313 INFO: This product contains the following substances subject to the

URALITE 3156-3158 PART A

HEXCEL - RESINS GROUP

PRINTED: 06/14/1991

CHEMTREC: (800) 424-9300

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

H, MDI is considered an Immediate Health Hazard, Delayed Health Hazard and Reactive Hazard under Sections 311/312 of SARA Title III.

CALIFORNIA PROPOSITION 65:
To the best of our knowledge, this product contains no levels of listed substances, which the state of California has found to cause cancer, birth defects or other reproductive effects.

NEW JERSEY:
The following are listed on the New Jersey Hazardous Substance List:

Dicyclohexylmethane-4,4'-diisocyanate

PENNSYLVANIA:
The following are on the Pennsylvania Hazardous Substance List:
Dicyclohexylmethane-4,4'-diisocyanate

PREPARED BY.............. Deirdre S. Crutchfield
DATE PREPARED............ 06/01/91
PHONE NUMBER OF PREPARER: (818) 882-3022

DISCLAIMER: To the best of our knowledge, the information contained herein is accurate. However, no liability whatsoever is assumed for the accuracy of the information contained herein. Final determination or suitability of a material is the sole responsibility of the user. All material may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

THE PRODUCT FORMULATION INFORMATION CONTAINED HEREIN IS ONLY FOR OCCUPATIONAL SAFETY AND HEALTH RELATED USAGE. ANY MISUSE OF THIS INFORMATION, INCLUDING DIVULGENCE TO THIRD PARTIES OR USE TO GAIN A COMPETITIVE ADVANTAGE IS STRICTLY PROHIBITED.
HEXCEL Resins Group

MATERIAL SAFETY DATA SHEET

URALITE 3156 PART B

SECTION I - IDENTIFICATION

COMPANY NAME ................................ HEXCEL CORPORATION - RESINS GROUP
20701 Nordhoff Street, PO Box 2197
Chatsworth, CA 91311
(310) 882-1022

EMERGENCY PHONE NUMBER ............. (300) 433-5072 (except California)
(800) 343-4457 (Canada)

CALIFORNIA EMERGENCY PHONE NUMBER .. (300) 367-7627

PRODUCT IDENTIFIER ...................... URALITE 3156 PART B

CHEMICAL FAMILY ....................... URETHANE CURATIVE

SECTION II - HAZARDOUS INGREDIENTS

HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>HAZARDOUS INGREDIENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,4' Methylene Dianiline</td>
</tr>
<tr>
<td>Polymethylene Polyphenyl (Polyalkylphenyl) Amine</td>
</tr>
<tr>
<td>Cyclic Anide</td>
</tr>
<tr>
<td>Phenyl Mercuric Alkyl Carboxylate</td>
</tr>
</tbody>
</table>

PERCENT

<table>
<thead>
<tr>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>35-45</td>
</tr>
<tr>
<td>15-35</td>
</tr>
<tr>
<td>20-40</td>
</tr>
<tr>
<td>.03</td>
</tr>
</tbody>
</table>

TLV (Units)

<table>
<thead>
<tr>
<th>TLV (Units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1 ppm</td>
</tr>
<tr>
<td>Not Established</td>
</tr>
<tr>
<td>TWA 100 ppm (estimated)</td>
</tr>
<tr>
<td>Not established</td>
</tr>
</tbody>
</table>

CAS NUMBER

<table>
<thead>
<tr>
<th>CAS NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-77-9</td>
</tr>
<tr>
<td>252-44-70-4</td>
</tr>
<tr>
<td>69178-40-1</td>
</tr>
<tr>
<td>872-50-4</td>
</tr>
<tr>
<td>103-27-5</td>
</tr>
</tbody>
</table>

SECTION III - PHYSICAL DATA

<table>
<thead>
<tr>
<th>BOILING POINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not available</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MELTING POINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not available</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DENSITY (g/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.12</td>
</tr>
</tbody>
</table>

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

<table>
<thead>
<tr>
<th>FLASHPOINT AND METHOD OF DETERMINATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>204°F Cleveland Open Cup</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MEANS OF EXTINGUISHMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use CO₂ or dry chemical for small fires. Use water and foam for large fires.</td>
</tr>
</tbody>
</table>

URALITE 3156 PART B
PRINTED: 06/17/1991

HEXCEL - RESINS GROUP

CHEMTREC: (800) 424-9300

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
FOR FIRE: Since vapors are exceedingly irritating when inhaled, a self-contained breathing apparatus should be available to firemen.

EMERGENCY RESPONSE: Not listed in the DOT 1990 EMERGENCY RESPONSE GUIDEBOOK.

SECTION V - HEALTH HAZARD DATA

OVEREXPOSURE EFFECTS: SUSPECTED CANCER HAZARD: Contains 4,4'-Methylene-dianiline which may cause cancer. The risk depends on the length and level of exposure. Chronic contact or inhalation may also cause liver damage and breathing problems.

DANGER: May be fatal if swallowed! Vapors are exceedingly irritating to mucous membranes and eyes. Repeated exposure may cause skin irritation, leading to sensitization and dermatitis. Eye contact may cause extreme irritation and/or burning. Possibly severe irritation and/or sensitization can result from overexposure to this product. Pre-existing eye, skin, and respiratory disorders may be aggravated by exposure.

SPECIFIC FIRST AID PROCEDURES: In case of eye contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

SPECIFIC FIRST AID PROCEDURES: In case of skin contact, immediately wash skin with soap and plenty of water. Wash contaminated clothing before re-use and destroy contaminated shoes.

SPECIFIC FIRST AID PROCEDURES: In case of inhalation, remove to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Get medical attention.

SPECIFIC FIRST AID PROCEDURES: In case of ingestion, get medical attention immediately. Induce vomiting ONLY upon the advice of a physician.

SECTION VI - REACTIVITY DATA

CHEMICAL STABILITY: Stable

INCOMPATIBLE MATERIALS: Avoid contact with strong oxidizers.

HAZARDOUS DECOMPOSITION PRODUCTS: Carbon dioxide, carbon monoxide, and nitrogen oxides.

HAZARDOUS POLYMERIZATION: Will not occur.

CONDITIONS TO AVOID: Avoid contact with water, alcohols, strong bases, metal compounds or surface active materials.
MATERIAL SAFETY DATA SHEET

**SECTION VII - SPILL OR LEAK PROCEDURE**

WASTE DISPOSAL: None. Controlled incineration or buried landfill disposal should be in accordance with all federal, state and local environmental control regulations.

LEAK AND SPILL PROCEDURES: In case of spill, contain with a suitable diking material. Ventilate the area thoroughly. Keep all unnecessary people away. Spilled material should be absorbed in sawdust, sand or other absorbent. Place into open-topped containers and cover loosely; store for at least 12 hours before sealing container.

**SECTION VIII - SPECIAL PROTECTION**

PERSONAL PROTECTION: HMIS CODE C - SAFETY GLASSES, GLOVES AND SYNTHETIC APRON.

VENTILATION: If handled indoors, provide mechanical exhaust ventilation.

HANDLING PROCEDURES AND EQUIPMENT: Avoid breathing vapors. Keep away from heat, sparks, and open flames. Use adequate ventilation. Wash thoroughly after handling.

**SECTION IX - SHIPPING INFORMATION**

HAZARD CLASS: N/A

DOT SHIPPING NAME: NOT REGULATED BY THE DEPARTMENT OF TRANSPORTATION.

REPORTABLE QUANTITY (RQ): N/A

UN NUMBER: N/A

NA #: N/A

**SECTION X - STORAGE INFORMATION**

STORE IN A COOL DRY AREA IN TIGHTLY CLOSED CONTAINERS. AVOID MOISTURE CONTAMINATION.

**SECTION XI - REGULATORY INFORMATION**

NOTICE: The information herein is presented in good faith and believed to be accurate as of the preparation date shown below. However, no warranty, expressed or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer's responsibility to ensure that its activities comply with federal, state and local laws. The following specific information is made for the purpose of complying with numerous federal, state and local laws and regulations. THIS INFORMATION IS NOT MEANT TO BE ALL-INCLUSIVE. SELECTED REGULATIONS ARE PRESENTED.
MATERIAL SAFETY DATA SHEET

SARA 311 INFO: This product contains the following substances subject to the reporting requirements of Section 311 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

Methylene Dianiline

CALIFORNIA PROPOSITION 65:
The following substances are known to the state of California to cause cancer:
Methylene Dianiline

PREPARED BY.......... Deirdre S. Crutchfield
DATE PREPARED.......... 06/17/91
PHONE NUMBER OF PREPARER. (313) 882-1022

FOOT NOTES

REFERENCES

DISCLAIMER: To the best of our knowledge, the information contained herein is accurate. However, no liability whatsoever is assumed for the accuracy of the information contained herein. Final determination or suitability of a material is the sole responsibility of the user. All material may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

THE PRODUCT FORMULATION INFORMATION CONTAINED HEREIN IS ONLY FOR OCCUPATIONAL SAFETY AND HEALTH RELATED USAGE. ANY MISUSE OF THIS INFORMATION, INCLUDING DIVULGENCE TO THIRD PARTIES OR USE TO GAIN A COMPETITIVE ADVANTAGE IS STRICTLY PROHIBITED.
SECTION I - IDENTIFICATION

COMPANY NAME ....................... HEXCEL CORPORATION - RESINS GROUP
20701 Nordhoff Street, PO Box 2197
Chatsworth, CA 91311
(818) 595-2022

EMERGENCY PHONE NUMBER ............. (300) 433-5072 (except California)
(800) 332-3022 (Canada)

CALIFORNIA EMERGENCY PHONE NUMBER. (800) 367-7527
PRODUCT IDENTIFIER..................... URALITE 3160 PART A
CHEMICAL FAMILY .................... URETHANE PREPOLYMER

SECTION II - HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>HAZARDOUS INGREDIENT</th>
<th>HAZARDOUS TLV (Units)</th>
<th>CAS NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dicyclohexylmethane-4,4', diisocyanate (aka H$_{12}$ MDI)</td>
<td>20-30 0.1 ppm</td>
<td>5124-20-1</td>
</tr>
<tr>
<td>Polyglycol/H$_{12}$MDI Polymer</td>
<td>70-80</td>
<td>Not Established</td>
</tr>
</tbody>
</table>

SECTION III - PHYSICAL DATA

BOILING POINT........ Not available
MELTING POINT...... Not available
VOC (grams/liter)..... Not Applicable
DENSITY (g/ml)...... 1.06

APPEARANCE AND ODOR... Clear to pale yellow liquid with a faintly sweet odor

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASHPOINT AND METHOD OF DETERMINATION.. >300°F Cleveland Open Cup
MEANS OF EXTINCTION........................ Use CO$_2$ or dry chemical for small fires. Use water and foam for large ones.

FOR FIRE.................................. Since vapors are exceedingly irritating when inhaled, a self-contained breathing apparatus should be available to firemen.
EMERGENCY RESPONSE ...................... NOT LISTED IN THE 1990 DOT EMERGENCY RESPONSE GUIDEBOOK.

SECTION V - HEALTH HAZARD DATA

OVEREXPOSURE EFFECTS..... Skin exposure may cause irritation. Repeated or prolonged exposure can result in dermatitis and skin sensitization (allergic effects). Vapors are exceedingly irritating to mucous membrane and eyes. Can cause acute temporary chest discomfort and breathing difficulty. Vapors can cause respiratory sensitization in susceptible people. Risk of explosion by shock, friction, fire or other sources of ignition. Ingestion may cause gastro-intestinal burning and discomfort.

SPECIFIC FIRST AID PROCEDURES ..............

EYES: In case of eye contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

SKIN CONTACT: In case of contact, immediately wash skin with soap and plenty of water. Wash contaminated clothing before re-use and destroy contaminated shoes.

INHALATION: If inhaled, remove to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Get medical attention.

INGESTION: If swallowed, get medical attention immediately. Induce vomiting ONLY upon the advice of a physician.

SECTION VI - REACTIVITY DATA

CHEMICAL STABILITY....... Stable

INCOMPATIBLE MATERIALS: Avoid contact with water, alcohols, strong bases, metal compounds or surface active materials.

HAZARDOUS DECOMPOSITION PRODUCTS............. Carbon dioxide, carbon monoxide, and nitrogen oxides. Isocyanate vapors and mists may also evolve.

HAZARDOUS POLYMERIZATION. Will not occur.

CONDITIONS TO AVOID..... STORE IN A COOL, WELL VENTILATED AREA IN TIGHTLY CLOSED CONTAINERS. AVOID MOISTURE CONTAMINATION.

SECTION VII - SPILL OR LEAK PROCEDURE

RCRA WASTE NUMBER........ None

WASTE DISPOSAL........... Controlled incineration or buried landfill disposal should be in accordance with all federal, state and local environmental control regulations.

URALITE 3160 PART 1

PRINTED: 06/14/1991 -2- CHEMTREC: (800) 424-9300

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
ILL \[384x629\] KMIS-Rating
[384x614] Health 2
[416x614] Reactivity 1
[443x614] MATERIAL SAFETY DATA SHEET Reactivity

LEAK AND SPILL PROCEDURES In case of spill, contain with a suitable diking material. Ventilate the area thoroughly. Keep all unnecessary people away. Spilled material should be absorbed in sawdust, sand or other absorbant. Place in an open-top container. Neutralize with a solution of 90-95% water, 5-8% concentrated ammonia and 1-2% detergent before disposal. Keep container open for at least 12 hours so that evolved carbon dioxide can escape.

SECTION VIII - SPECIAL PROTECTION

PERSONAL PROTECTION...... KMIS CODE C- SAFETY GLASSES, GLOVES AND SYNTHETIC APRON.
VENTILATION.............. If handled indoors, provide mechanical exhaust ventilation.
HANDLING PROCEDURES AND EQUIPMENT............. Avoid breathing vapors. Keep away from heat, sparks, and open flames. Use adequate ventilation. Wash thoroughly after handling.

SECTION IX - SHIPPING INFORMATION

HAZARD CLASS.......... N/A
DOT SHIPPING NAME....... NOT REGULATED BY THE DEPARTMENT OF TRANSPORTATION.
REPORTABLE QUANTITY (RQ). N/A
UN NUMBER................. N/A
MA #..................... N/A

SECTION X - STORAGE INFORMATION

STORE IN A COOL DRY AREA IN TIGHTLY CLOSED CONTAINERS. AVOID MOISTURE CONTAMINATION.

SECTION XI - REGULATORY INFORMATION

NOTICE: The information herein is presented in good faith and believed to be accurate as of the preparation date shown below. However, no warranty, expressed or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer's responsibility to ensure that its activities comply with federal, state and local laws. The following specific information is made for the purpose of complying with numerous federal, state and local laws and regulations. THIS INFORMATION IS NOT MEANT TO BE ALL-INCLUSIVE. SELECTED REGULATIONS ARE PRESENTED.

SARA 313 INFO: This product contains the following substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.
MATERIAL SAFETY DATA SHEET

HMIS-Rating

Health 2
Flammability 1
Reactivity 1

HDI is considered an Immediate Health Hazard, Delayed Health Hazard and Reactive Hazard under Sections 311/312 of SARA Title III.

CALIFORNIA PROPOSITION 65:
To the best of our knowledge, this product contains no levels of listed substances, which the state of California has found to cause cancer, birth defects or other reproductive effects.

NEW JERSEY:
The following are listed on the New Jersey Hazardous Substance List:

Dicyclohexylmethane-4,4'-diisocyanate

PENNSYLVANIA:
The following are on the Pennsylvania Hazardous Substance List:

Dicyclohexylmethane-4,4'-diisocyanate

PREPARED BY.............. Deirdre S. Crutchfield
DATE PREPARED............ 06/01/91
PHONE NUMBER OF PREPARER. (318) 882-3022

FOOT NOTES

REFERENCES

DISCLAIMER: To the best of our knowledge, the information contained herein is accurate. However, no liability whatsoever is assumed for the accuracy of the information contained herein. Final determination or suitability of a material is the sole responsibility of the user. All material may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

THE PRODUCT FORMULATION INFORMATION CONTAINED HEREIN IS ONLY FOR OCCUPATIONAL SAFETY AND HEALTH RELATED USAGE. ANY MISUSE OF THIS INFORMATION, INCLUDING DIVULGENCE TO THIRD PARTIES OR USE TO GAIN A COMPETITIVE ADVANTAGE IS STRICTLY PROHIBITED.
HEXCEL CORPORATION
Resins Group Division

MATERIAL SAFETY DATA SHEET
URALITE 3160 PART B

HMIS-Rating

<table>
<thead>
<tr>
<th>Health</th>
<th>Flammability</th>
<th>Reactivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

SECTION I - IDENTIFICATION

COMPANY NAME.......................... HEXCEL CORPORATION - RESINS GROUP
20701 Nordhoff Street, PO Box 2197
Chatsworth, CA 91311
(818) 882-3022

EMERGENCY PHONE NUMBER.............. (800) 433-5072 (except California)
(800) 343-4467 (Canada)
CALIFORNIA EMERGENCY PHONE NUMBER.. (800) 367-7527
PRODUCT IDENTIFIER................... URALITE 3160 PART B
CHEMICAL FAMILY...................... URETHANE CURATIVE

SECTION II - HAZARDOUS INGREDIENTS

HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>HAZARDOUS INGREDIENT</th>
<th>PERCENT</th>
<th>TLV (Units)</th>
<th>CAS NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,4' Methylene Dianiline</td>
<td>2-10</td>
<td>0.1 ppm</td>
<td>101-77-9</td>
</tr>
<tr>
<td>Polymethylene Polyphenyl &amp; Polyalkylphenyl Amine</td>
<td>40-65</td>
<td>Not Established</td>
<td>252-14-70-4</td>
</tr>
<tr>
<td>Aromatic Alkyl Ester</td>
<td>25-40</td>
<td>5 mg/m³</td>
<td>84-74-2</td>
</tr>
<tr>
<td>Cyclic Amide</td>
<td>2-10</td>
<td>TWA 100 ppm (estimated)</td>
<td>872-50-4</td>
</tr>
</tbody>
</table>

SECTION III - PHYSICAL DATA

BOILING POINT............ Not available
MELTING POINT...... Not Available
VOC (grams/liter)...... Not Applicable
DENSITY (g/ml)........ 1.06
APPEARANCE AND ODOR... Amber liquid with a faint odor

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASHPOINT & METHOD OF DETERMINATION.... Greater than 300°F
MEANS OF EXTINCTION............... Use CO₂ or dry chemical for small fires, and water and foam for large ones.
FOR FIRE......................... Since vapors are exceedingly irritating when inhaled, a self-contained breathing apparatus should be available to firemen.
MATERIAL SAFETY DATA SHEET

EMERGENCY RESPONSE
Not listed in the DOT 1990 EMERGENCY RESPONSE GUIDEBOOK.

SECTION V - HEALTH HAZARD DATA

OVEREXPOSURE EFFECTS.... SUSPECTED CANCER HAZARD: Contains 4,4'-Methylene-dianiline which may cause cancer. The risk depends on the length and level of exposure. Chronic contact or inhalation may also cause liver damage and breathing problems.

DANGER: May be fatal if swallowed! Vapors are exceedingly irritating to mucous membranes and eyes. Repeated exposure may cause skin irritation, leading to sensitization and dermatitis. Eye contact may cause extreme irritation and/or burning. Severe irritation and/or sensitization may result from overexposure to this product. Pre-existing eye, skin, and respiratory disorders may be aggravated by exposure.

EYES: In case of eye contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

SKIN CONTACT: In case of contact, immediately wash skin with soap and plenty of water. Wash contaminated clothing before re-use and destroy contaminated shoes.

INHALATION: If inhaled, remove to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Get medical attention.

INGESTION: If swallowed, get medical attention immediately. Induce vomiting ONLY upon the advice of a physician.

SECTION VI - REACTIVITY DATA

CHEMICAL STABILITY..... Stable
INCOMPATIBLE MATERIALS... Avoid contact with strong oxidizers.
HAZARDOUS DECOMPOSITION Carbon dioxide, carbon monoxide, and nitrogen oxides.
PRODUCTS............. Will not occur.
HAZARDOUS POLYMERIZATION. Do not occur.
CONDITIONS TO AVOID..... Avoid contact with water, alcohols, strong bases, metal compounds or surface active materials.

SECTION VII - SPILL OR LEAK PROCEDURE

RCRA WASTE NUMBER... None
HMIS-Rating

---

Health 3
Flammability 1
Reactivity 0

MATERIAL SAFETY DATA SHEET

WASTE DISPOSAL........... Controlled incineration or buried landfill disposal should be in accordance with all federal, state and local environmental control regulations.

LEAK AND SPILL PROCEDURES In case of spill, contain with a suitable diking material. Ventilate the area thoroughly. Keep all unnecessary people away. Spilled material should be absorbed in sawdust, sand or other absorbant. Place into open-topped containers and cover loosely; store for at least 12 hours before sealing container.

SECTION VIII - SPECIAL PROTECTION

PERSONAL PROTECTION...... HMIS CODE C- SAFETY GLASSES, GLOVES AND SYNTHETIC APRON.

VENTILATION............. If handled indoors, provide mechanical exhaust ventilation.

HANDLING PROCEDURES AND EQUIPMENT........... Avoid breathing vapors. Keep away from heat, sparks, and open flames. Use adequate ventilation. Wash thoroughly after handling.

SECTION IX - SHIPPING INFORMATION

N/A

NOT REGULATED BY THE DEPARTMENT OF TRANSPORTATION.

SECTION X  - STORAGE INFORMATION

STORE IN A COOL DRY AREA IN TIGHTLY CLOSED CONTAINERS. AVOID MOISTURE CONTAMINATION.

SECTION XI - REGULATORY INFORMATION

NOTICE: The information herein is presented in good faith and believed to be accurate as of the preparation date shown below. However, no warranty, expressed or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer's responsibility to ensure that its activities comply with federal, state and local laws. The following specific information is made for the purpose of complying with numerous federal, state and local laws and regulations. THIS INFORMATION IS NOT MEANT TO BE ALL-INCLUSIVE. SELECTED REGULATIONS ARE PRESENTED.

SARA 313 INFO: This product contains the following substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

URALITE 3160 PART B
PRINTED: 10/30/1991

HEXCEL CORPORATION
Resins Group Division

CHEMTREC: (800) 424-9300
Methylene Dianiline

CALIFORNIA PROPOSITION 65:
The following substances are known to the state of California to cause cancer, birth defects or other reproductive effects:
Methylene Dianiline

PREPARED BY............. Deirdre S. Crutchfield
DATE PREPARED........... 06/01/91
PHONE NUMBER OF PREPARER. (818) 882-3022

FOOT NOTES

REFERENCES

DISCLAIMER: The information contained herein is accurate to the best of our knowledge, but no liability whatsoever is assumed. Final determination or suitability of a material is the sole responsibility of the user. All material may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

THE PRODUCT FORMULATION INFORMATION CONTAINED HEREIN IS ONLY FOR OCCUPATIONAL SAFETY AND HEALTH RELATED USAGE. ANY MISUSE OF THIS INFORMATION, INCLUDING DIVULGENCE TO THIRD PARTIES OR USE TO GAIN A COMPETITIVE ADVANTAGE IS STRICTLY PROHIBITED.
HEXCEL: Resins Group

MATERIAL SAFETY DATA SHEET

URALITE 3500 PART A

HMIS-Rating

Health 3
Flammability 1
Reactivity 1

SECTION I - IDENTIFICATION

COMPANY NAME: HEXCEL CORPORATION - RESINS GROUP
20701 Nordhoff Street, PO Box 2197
Chatsworth, CA 91311
(818) 832-3022
(800) 433-5072 (except California)
(800) 343-4467 (Canada)
(800) 367-7527

EMERGENCY PHONE NUMBER: (800) 433-5072 (except California)
CALIFORNIA EMERGENCY PHONE NUMBER... (800) 367-7527
PRODUCT IDENTIFIER: URALITE 3500 PART A
CHEMICAL FAMILY: URETHANE PREPOLYMER

SECTION II - HAZARDOUS INGREDIENTS

HAZARDOUS INGREDIENTS

Dicyclohexylmethane-4,4' diisocyanate (aka HMDI)
Polyether Glycol/H12MDI Polymer

PERCENT

20-35
65-80

TLV (Units)

.01 ppm
Not Established

CAS NUMBER

5124-30-1
52292-18-9

SECTION III - PHYSICAL DATA

BOILING POINT: Not available
MELTING POINT: Not available
VOC (grams/liter): Not Applicable
DENSITY (g/ml): 1.085
APPEARANCE AND ODOR: Clear to pale yellow liquid with a faint sweet odor

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASHPOINT AND METHOD OF DETERMINATION: >350°F Pensky-Martens Closed Cup
MEANS OF EXTINCTION: Use CO2 or dry chemical for small fires. Use water and foam for large ones.

FOR FIRE: Since vapors are exceedingly irritating when inhaled, a self-contained breathing apparatus should be available to firemen.

URALITE 3500 PART A
PRINTED: 06/14/1991

HEXCEL - RESINS GROUP

CHEMTREC: (800) 424-9300

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
HMIS-Rating

MATERIAL SAFETY DATA SHEET

EMERGENCY RESPONSE

OVEREXPOSURE EFFECTS... Skin exposure may cause irritation. Repeated or prolonged exposure can result in dermatitis and skin sensitization (allergic effects). Vapors are exceedingly irritating to mucous membrane and eyes. Can cause acute temporary chest discomfort and breathing difficulty. Vapors can cause respiratory sensitization in susceptible people. Risk of explosion by shock, friction, fire or other sources of ignition. Ingestion may cause gastro-intestinal burning and discomfort. Possibly severe irritation and/or sensitization can result from overexposure to this product. Pre-existing eye, skin, and respiratory disorders may be aggravated by exposure.

SPECIFIC FIRST AID PROCEDURES

EYES: In case of eye contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

SKIN CONTACT: In case of contact, immediately wash skin with soap and plenty of water. Wash contaminated clothing before re-use and destroy contaminated shoes.

INHALATION: If inhaled, remove to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Get medical attention.

INGESTION: If swallowed, get medical attention immediately. Induce vomiting ONLY upon the advice of a physician.
MATERIAL SAFETY DATA SHEET

WASTE DISPOSAL........... Controlled incineration or buried landfill disposal should be in accordance with all federal, state and local environmental control regulations.

LEAK AND SPILL PROCEDURES In case of spill, contain with a suitable diking material. Ventilate the area thoroughly. Keep all unnecessary people away. Spilled material should be absorbed in sawdust, sand or other absorbant. Place in an open-top container. Neutralize with a solution of 90-95% water, 5-8% concentrated ammonia and 1-2% detergent before disposal. Keep container open for at least 12 hours so that evolved carbon dioxide can escape.

SECTION VIII - SPECIAL PROTECTION

PERSONAL PROTECTION...... HMIS CODE H- SPLASH GOGGLES, GLOVES, SYNTHETIC APRON AND ORGANIC VAPOR RESPIRATOR
VENTILATION.............. If handled indoors, provide mechanical exhaust ventilation.
HANDLING PROCEDURES AND EQUIPMENT........... Avoid breathing vapors. Keep away from heat, sparks, and open flames. Use adequate ventilation. Wash thoroughly after handling.

SECTION IX - SHIPPING INFORMATION

HAZARD CLASS............. N/A
DOT SHIPPING NAME........... NOT REGULATED BY THE DEPARTMENT OF TRANSPORTATION.
REPORTABLE QUANTITY (RQ)........... N/A
UN NUMBER...................... N/A
NA #...................... N/A

SECTION X - STORAGE INFORMATION

STORE IN A COOL DRY AREA IN TIGHTLY CLOSED CONTAINERS. AVOID MOISTURE CONTAMINATION.

SECTION XI - REGULATORY INFORMATION

NOTICE: The information herein is presented in good faith and believed to be accurate as of the preparation date shown below. However, no warranty, expressed or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer's responsibility to ensure that its activities comply with federal, state and local laws. The following specific information is made for the purpose of complying with numerous federal, state and local laws and regulations. THIS INFORMATION IS NOT MEANT TO BE ALL-INCLUSIVE. SELECTED REGULATIONS ARE PRESENTED.

SARA 313 INFO: This product contains the following substances subject to the

URALITE 3500 PART A HEXCEL - RESINS GROUP
PRINTED: 06/14/1991 CHEMTREC: (800) 424-9300

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
MATERIAL SAFETY DATA SHEET

reporting requirements of Section 313 of Title III of the Superfund Amendments

H, MDI is considered an Immediate Health Hazard, Delayed Health Hazard
and Reactive Hazard under Sections 311/312 of SARA Title III.

CALIFORNIA PROPOSITION 65:
To the best of our knowledge, this product contains no levels of listed
substances, which the state of California has found to cause cancer, birth
defects or other reproductive effects.

NEW JERSEY:
The following are listed on the New Jersey Hazardous Substance List:

Dicyclohexylmethane-4,4'-diisocyanate

PENNSYLVANIA:
The following are on the Pennsylvania Hazardous Substance List:
Dicyclohexylmethane-4,4'-diisocyanate

PREPARED BY............. Deirdre S. Crutchfield
DATE PREPARED............. 06/01/91
PHONE NUMBER OF PREPARER. (818) 882-3022

FOOT NOTES

REFERENCES

DISCLAIMER: To the best of our knowledge, the information contained herein is
accurate. However, no liability whatsoever is assumed for the accuracy of the
information contained herein. Final determination or suitability of a material
is the sole responsibility of the user. All material may present unknown
health hazards and should be used with caution. Although certain hazards are
described herein, we cannot guarantee that these are the only hazards that
exist.

THE PRODUCT FORMULATION INFORMATION CONTAINED HEREIN IS ONLY FOR OCCUPATIONAL
SAFETY AND HEALTH RELATED USAGE. ANY MISUSE OF THIS INFORMATION, INCLUDING
DIVULGENCE TO THIRD PARTIES OR USE TO GAIN A COMPETITIVE ADVANTAGE IS STRICTLY
PROHIBITED.
HEXCEL CORPORATION
Resins Group Division

MATERIAL SAFETY DATA SHEET
URALITE 3500 PART B

SECTION I - IDENTIFICATION

COMPANY NAME.......................... HEXCEL CORPORATION - RESINS GROUP
20701 Nordhoff Street, PO Box 2197
Chatsworth, CA 91311
(818) 882-3022
EMERGENCY PHONE NUMBER.......... (800) 433-5072 (except California)
(800) 343-4467 (Canada)
CALIFORNIA EMERGENCY PHONE NUMBER... (800) 367-7527
PRODUCT IDENTIFIER.................. URALITE 3500 PART B
CHEMICAL FAMILY...................... URETHANE CURATIVE

SECTION II - HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>HAZARDOUS INGREDIENTS</th>
<th>TLV (Units)</th>
<th>CAS NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymethylene</td>
<td>55-70</td>
<td>19900-65-3</td>
</tr>
<tr>
<td>Polyalkyphenyl Amine</td>
<td>Not Established</td>
<td>126-73-8</td>
</tr>
<tr>
<td>Aliphatic Phosphorus Ester</td>
<td>25-40</td>
<td>2.5 mg/m³</td>
</tr>
</tbody>
</table>

SECTION III - PHYSICAL DATA

<table>
<thead>
<tr>
<th>BOILING POINT</th>
<th>VOC (grams/liter)</th>
<th>APPEARANCE AND ODOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Available</td>
<td>Not Applicable</td>
<td>Transparent amber liquid with a faint odor.</td>
</tr>
</tbody>
</table>

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASHPOINT & METHOD OF DETERMINATION...... >250°F Pensky-Martens Closed Cup
MEANS OF EXTINCTION...................... Use CO₂ or dry chemical for small fires; and water and foam for large ones.
FOR FIRE................................. Since vapors are exceedingly irritating when inhaled, a self-contained breathing apparatus should be available to firemen.
EMERGENCY RESPONSE..................... Not listed in the DOT 1990 EMERGENCY RESPONSE GUIDEBOOK.
MATERIAL SAFETY DATA SHEET

SECTION V - HEALTH HAZARD DATA

OVEREXPOSURE EFFECTS.... Skin exposure may cause irritation. Repeated or prolonged exposure can result in dermatitis and skin sensitization (allergic effects). Ingestion may cause gastro-intestinal burning and discomfort. Eye contact may cause extreme irritation and/or burning. Severe irritation and/or sensitization may result from overexposure to this product. Pre-existing eye, skin, and respiratory disorders may be aggravated by exposure.

SPECIFIC FIRST AID

EYES: In case of eye contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

SKIN CONTACT: In case of contact, immediately wash skin with soap and plenty of water. Wash contaminated clothing before re-use and destroy contaminated shoes.

INHALATION: If inhaled, remove to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Get medical attention.

INGESTION: If swallowed, get medical attention immediately. Induce vomiting ONLY upon the advice of a physician.

SECTION VI - REACTIVITY DATA

CHEMICAL STABILITY....... Stable

INCOMPATIBLE MATERIALS... Avoid contact with strong oxidizers.

HAZARDOUS DECOMPOSITION Carbon dioxide, carbon monoxide, and nitrogen oxides.

PRODUCTS............... Will not occur.

HAZARDOUS POLYMERIZATION. Will not occur.

CONDITIONS TO AVOID..... Avoid strong oxidizers.

SECTION VII - SPILL OR LEAK PROCEDURE

RCRA WASTE NUMBER....... None

WASTE DISPOSAL.......... Controlled incineration or buried landfill disposal should be in accordance with all federal, state and local environmental control regulations.

LEAK AND SPILL PROCEDURES In case of spill, contain with a suitable diking material. Ventilate the area thoroughly. Keep all unnecessary people away. Spilled material should be absorbed in sawdust, sand or other absorbent. Place into open-topped containers and cover loosely; store for at least 12 hours before sealing container.
HEXCEL CORPORATION
Resins Group Division

MATERIAL SAFETY DATA SHEET

IIKXCKL CORPORATION
HMIS-Rating
Health 2
Flammability 1
Reactivity 0

SECTION VIII - SPECIAL PROTECTION

PERSONAL PROTECTION...... HMIS CODE B- SAFETY GLASSES AND GLOVES.
VENTILATION............. If handled indoors, provide mechanical exhaust ventilation.
HANDLING PROCEDURES AND EQUIPMENT........... Avoid breathing vapors. Keep away from heat, sparks, and open flames. Use adequate ventilation. Wash thoroughly after handling.

SECTION IX - SHIPPING INFORMATION

HAZARD CLASS ............. N/A
DOT SHIPPING NAME........... NOT REGULATED BY THE DEPARTMENT OF TRANSPORTATION.
UN NUMBER................. N/A
NA #........................ N/A

SECTION X - STORAGE INFORMATION

STORE IN A COOL DRY AREA IN TIGHTLY CLOSED CONTAINERS. AVOID MOISTURE CONTAMINATION.

SECTION XI - REGULATORY INFORMATION

NOTICE: The information herein is presented in good faith and believed to be accurate as of the preparation date shown below. However, no warranty, expressed or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer’s responsibility to ensure that its activities comply with federal, state and local laws. The following specific information is made for the purpose of complying with numerous federal, state and local laws and regulations. THIS INFORMATION IS NOT MEANT TO BE ALL-INCLUSIVE. SELECTED REGULATIONS ARE PRESENTED.

SARA 313 INFO: This product contains the following substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

None

CALIFORNIA PROPOSITION 65:
To the best of our knowledge, this product contains no levels of listed substances, which the state of California has found to cause cancer, birth defects or other reproductive effects.

PREPARED BY.............. Deirdre S. Crutchfield
DATE PREPARED........... 06/01/91

URALITE 3500 PART B
PRINTED: 09/26/1991

HEXCEL - RESINS GROUP

CHEMTREC: (800) 424-9300

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
HEXCEL CORPORATION
Resins Group Division

MATERIAL SAFETY DATA SHEET

PHONE NUMBER OF PREPARER. (818) 882-3022

HMXIS-Rating

Health 2
Flammability 1
Reactivity 0

FOOT NOTES

REFERENCES

DISCLAIMER: The information contained herein is accurate to the best of our knowledge, but no liability whatsoever is assumed. Final determination or suitability of a material is the sole responsibility of the user. All material may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

THE PRODUCT FORMULATION INFORMATION CONTAINED HEREIN IS ONLY FOR OCCUPATIONAL SAFETY AND HEALTH RELATED USAGE. ANY MISUSE OF THIS INFORMATION, INCLUDING DIVULGENCE TO THIRD PARTIES OR USE TO GAIN A COMPETITIVE ADVANTAGE IS STRICTLY PROHIBITED.
MATERIAL SAFETY DATA SHEET
URALITE 3501 PART A

SECTION I - IDENTIFICATION

COMPANY NAME.......................... HEXCEL CORPORATION - RESINS GROUP
20701 Nordhoff Street, PO Box 2197
Chatsworth, CA 91311

EMERGENCY PHONE NUMBER............. (818) 882-3022
(800) 433-5072 (except California)
(800) 343-4467 (Canada)

CALIFORNIA EMERGENCY PHONE NUMBER.. (800) 367-7527

PRODUCT IDENTIFIER.................... URALITE 3501 PART A

CHEMICAL FAMILY....................... URETHANE PREPOLYMER

SECTION II - HAZARDOUS INGREDIENTS

HAZARDOUS INGREDIENTS HAZARDOUS INGREDIENT TLV (Units) CAS NUMBER
PERCENT

Dicyclohexylmethane-4,4' diisocyanate (aka H12 MDI) 15-35 .01 ppm 5124-30-1

Polyether Glycol/ H12 MDI Polymer 65-85 Not Established 52292-18-9

SECTION III - PHYSICAL DATA

BOILING POINT........ Not available MEETING POINT........Not available
VOC (grams/liter)..... Not Applicable DENSITY (g/ml)......1.074
APPEARANCE AND ODOR... Clear to pale yellow liquid with a faint sweet odor

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASHPOINT AND METHOD OF DETERMINATION.. >300°F Cleveland Open Cup
MEANS OF EXTINCTION...................... Use CO2 or dry chemical for small fires. Use water and foam for large ones.
FOR FIRE................................ Since vapors are exceedingly irritating when inhaled, a self-contained breathing apparatus should be available to firemen.
EMERGENCY RESPONSE

NOT LISTED IN THE 1990 DOT EMERGENCY RESPONSE GUIDEBOOK.

SECTION V - HEALTH HAZARD DATA

OVEREXPOSURE EFFECTS...

Skin exposure may cause irritation. Repeated or prolonged exposure can result in dermatitis and skin sensitization (allergic effects). Vapors are exceedingly irritating to mucous membrane and eyes. Can cause acute temporary chest discomfort and breathing difficulty. Vapors can cause respiratory sensitization in susceptible people. Risk of explosion by shock, friction, fire or other sources of ignition. Ingestion may cause gastro-intestinal burning and discomfort. Possibly severe irritation and/or sensitization can result from overexposure to this product. Pre-existing eye, skin, and respiratory disorders may be aggravated by exposure.

SPECIFIC FIRST AID PROCEDURES..............

EYES: In case of eye contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

SKIN CONTACT: In case of contact, immediately wash skin with soap and plenty of water. Wash contaminated clothing before re-use and destroy contaminated shoes.

INHALATION: If inhaled, remove to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Get medical attention.

INGESTION: If swallowed, get medical attention immediately. Induce vomiting ONLY upon the advice of a physician.

SECTION VI - REACTIVITY DATA

CHEMICAL STABILITY........ Stable

INCOMPATIBLE MATERIALS... Avoid contact with water, alcohols, strong bases, metal compounds or surface active materials.

HAZARDOUS DECOMPOSITION

Carbon dioxide, carbon monoxide, and nitrogen oxides.

PRODUCTS..............

Isocyanate vapors and mists may also evolve.

HAZARDOUS POLYMERIZATION.

Will not occur.

CONDITIONS TO AVOID...... STORE IN A COOL, WELL VENTILATED AREA IN TIGHTLY CLOSED CONTAINERS. AVOID MOISTURE CONTAMINATION.

SECTION VII - SPILL OR LEAK PROCEDURE

RCRA WASTE NUMBER........ None

URALITE 3501 PART A

PRINTED: 06/14/1991

HEXCEL - RESINS GROUP

CHEMTREC: (800) 424-9300

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
WASTE DISPOSAL........... Controlled incineration or buried landfill disposal should be in accordance with all federal, state and local environmental control regulations.

LEAK AND SPILL PROCEDURES In case of spill, contain with a suitable diking material. Ventilate the area thoroughly. Keep all unnecessary people away. Spilled material should be absorbed in sawdust, sand or other absorbent. Place in an open-top container. Neutralize with a solution of 90-95% water, 5-8% concentrated ammonia and 1-2% detergent before disposal. Keep container open for at least 12 hours so that evolved carbon dioxide can escape.

SECTION VIII - SPECIAL PROTECTION

PERSONAL PROTECTION...... HMIS CODE H- SPLASH GOGGLES, GLOVES, SYNTHETIC APRON AND ORGANIC VAPOR RESPIRATOR
VENTILATION.............. If handled indoors, provide mechanical exhaust ventilation.
HANDLING PROCEDURES AND EQUIPMENT........... Avoid breathing vapors. Keep away from heat, sparks, and open flames. Use adequate ventilation. Wash thoroughly after handling.

SECTION X - STORAGE INFORMATION

STORE IN A COOL DRY AREA IN TIGHTLY CLOSED CONTAINERS. AVOID MOISTURE CONTAMINATION.

SECTION XI - REGULATORY INFORMATION

NOTICE: The information herein is presented in good faith and believed to be accurate as of the preparation date shown below. However, no warranty, expressed or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer’s responsibility to ensure that its activities comply with federal, state and local laws. The following specific information is made for the purpose of complying with numerous federal, state and local laws and regulations. THIS INFORMATION IS NOT MEANT TO BE ALL-INCLUSIVE. SELECTED REGULATIONS ARE PRESENTED.

SARA 313 INFO: This product contains the following substances subject to the
HMIS-Rating

Health 3
Flammability 1
Reactivity 1

MATERIAL SAFETY DATA SHEET

reporting requirements of Section 311 of Title III of the Superfund Amendments

H₂₉₋ₓ MDI is considered an Immediate Health Hazard, Delayed Health Hazard
and Reactive Hazard under Sections 311/312 of SARA Title III.

CALIFORNIA PROPOSITION 65:
To the best of our knowledge, this product contains no levels of listed
substances, which the state of California has found to cause cancer, birth
defects or other reproductive effects.

NEW JERSEY:
The following are listed on the New Jersey Hazardous Substance List:

Dicyclohexylmethane-4,4'-diisocyanate

PENNSYLVANIA:
The following are on the Pennsylvania Hazardous Substance List:

Dicyclohexylmethane-4,4'-diisocyanate

PREPARED BY ............... Deirdre S. Crutchfield
DATE PREPARED ............. 06/01/91
PHONE NUMBER OF PREPARER. (818) 882-3022

FOOT NOTES

REFERENCES

DISCLAIMER: To the best of our knowledge, the information contained herein is
accurate. However, no liability whatsoever is assumed for the accuracy of the
information contained herein. Final determination or suitability of a material
is the sole responsibility of the user. All material may present unknown
health hazards and should be used with caution. Although certain hazards are
described herein, we cannot guarantee that these are the only hazards that
exist.

THE PRODUCT FORMULATION INFORMATION CONTAINED HEREIN IS ONLY FOR OCCUPATIONAL
SAFETY AND HEALTH RELATED USAGE. ANY MISUSE OF THIS INFORMATION, INCLUDING
DIVULGENCE TO THIRD PARTIES OR USE TO GAIN A COMPETITIVE ADVANTAGE IS STRICTLY
PROHIBITED.
MATERIAL SAFETY DATA SHEET

URALITE 3501 PART B

SECTION I - IDENTIFICATION

COMPANY NAME.......................... HEXCEL CORPORATION - RESINS GROUP
20701 Nordhoff Street, PO Box 2197
Chatsworth, CA 91311
(818) 882-3022

EMERGENCY PHONE NUMBER.............. (800) 433-5072 (except California)
CALIFORNIA EMERGENCY PHONE NUMBER. (800) 367-7527
PRODUCT IDENTIFIER................... URALITE 3501 PART B
CHEMICAL FAMILY...................... URETHANE CURATIVE

SECTION II - HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>HAZARDOUS INGREDIENT</th>
<th>PERCENT</th>
<th>HAZARDOUS TLV (Units)</th>
<th>CAS NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymethylene</td>
<td>60-75</td>
<td>Not Established</td>
<td>19900-65-3</td>
</tr>
<tr>
<td>Polyalkylphenyl Anine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aliphatic Phosphorus Ester</td>
<td>25-40</td>
<td>2.5 mg/m³</td>
<td>126-73-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SECTION III - PHYSICAL DATA

BOILING POINT........... Not Available
MELTING POINT........ Not Available
VOC (grams/liter)....... Not Applicable
DENSIY (g/ml).......... 1.040
APPEARANCE AND ODOR.... Transparent amber liquid with a faint odor.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASHPOINT & METHOD OF DETERMINATION. >300°F Cleveland Closed Cup
MEANS OF EXTINCTION................. Use CO₂ or dry chemical for small fires, and water and foam for large ones.

FOR FIRE.............................
Since vapors are exceedingly irritating when inhaled, a self-contained breathing apparatus should be available to firemen.

EMERGENCY RESPONSE................
Not listed in the DOT 1990 EMERGENCY RESPONSE GUIDEBOOK.
HEXCEL CORPORATION
Resins Group Division

MATERIAL SAFETY DATA SHEET

-----------------------------------
HEXCEL CORPORATION
Resins Group Division

MATERIAL SAFETY DATA SHEET

HEXCEL CORPORATION
Resins Group Division

OVEREXPOSURE EFFECTS..... Skin exposure may cause irritation. Repeated or prolonged exposure can result in dermatitis and skin sensitization (allergic effects). Ingestion may cause gastro-intestinal burning and discomfort. Eye contact may cause extreme irritation and/or burning. Severe irritation and/or sensitization may result from overexposure to this product. Pre-existing eye, skin, and respiratory disorders may be aggravated by exposure.

SPECIFIC FIRST AID PROCEDURES.......... EYES: In case of eye contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

SKIN CONTACT: In case of contact, immediately wash skin with soap and plenty of water. Wash contaminated clothing before re-use and destroy contaminated shoes.

INHALATION: If inhaled, remove to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Get medical attention.

INGESTION: If swallowed, get medical attention immediately. Induce vomiting ONLY upon the advice of a physician.

REACTIVITY DATA

CHEMICAL STABILITY....... Stable

INCOMPATIBLE MATERIALS... Avoid contact with strong oxidizers.

HAZARDOUS DECOMPOSITION Carbon dioxide, carbon monoxide, and nitrogen oxides.

PRODUCTS............... HAZARDOUS POLYMERIZATION. Will not occur.

CONDITIONS TO AVOID...... Avoid strong oxidizers.

SPILL OR LEAK PROCEDURE

RCRA WASTE NUMBER........ None

WASTE DISPOSAL.......... Controlled incineration or buried landfill disposal should be in accordance with all federal, state and local environmental control regulations.

LEAK AND SPILL PROCEDURES In case of spill, contain with a suitable digging material. Ventilate the area thoroughly. Keep all unnecessary people away. Spilled material should be absorbed in sawdust, sand or other absorbent. Place into open-topped containers and cover loosely; store for at least 12 hours before sealing container.

URALITE 3501 PART B
HEXCEL - RESINS GROUP

PRINTED: 09/30/1991

CHEMTREC: (800) 424-9300

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
HEXCEL CORPORATION
Resins Group Division

MATERIAL SAFETY DATA SHEET

HEXIS-Rating

Health 2
Flammability 1
Reactivity 0

SECTION VII - SPECIAL PROTECTION

PERSONAL PROTECTION... HMIS CODE B- SAFETY GLASSES AND GLOVES.
VENTILATION............ If handled indoors, provide mechanical exhaust ventilation.
HANDLING PROCEDURES AND Avoid breathing vapors. Keep away from heat, sparks,
EQUIPMENT............. and open flames. Use adequate ventilation. Wash thoroughly after handling.

SECTION IX - SHIPPING INFORMATION

HAZARD CLASS........... N/A
DOT SHIPPING NAME...... NOT REGULATED BY THE DEPARTMENT OF TRANSPORTATION.
UN NUMBER............... N/A
NA #...................... N/A

SECTION X - STORAGE INFORMATION

STORE IN A COOL DRY AREA IN TIGHTLY CLOSED CONTAINERS. AVOID MOISTURE
CONTAMINATION.

SECTION XI - REGULATORY INFORMATION

NOTICE: The information herein is presented in good faith and believed to be accurate as of the preparation date shown below. However, no warranty, expressed or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer's responsibility to ensure that its activities comply with federal, state and local laws. The following specific information is made for the purpose of complying with numerous federal, state and local laws and regulations. THIS INFORMATION IS NOT MEANT TO BE ALL-INCLUSIVE. SELECTED REGULATIONS ARE PRESENTED.

SARA 313 INFO: This product contains the following substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

None

CALIFORNIA PROPOSITION 65:
To the best of our knowledge, this product contains no levels of listed substances, which the state of California has found to cause cancer, birth defects or other reproductive effects.

PREPARED BY.............. Deirdre S. Crutchfield
DATE PREPARED............. 06/01/91

URALITE 3501 PART B
PRINTED: 09/30/1991

HEXCEL - RESINS GROUP
CHEMTREC: (800) 424-9300

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
HEXCEL CORPORATION
Rosins Group Division

MATERIAL SAFETY DATA SHEET

PHONE NUMBER OF PREPARER. (818) 882-3022

FOOT NOTES

REFERENCES

DISCLAIMER: The information contained herein is accurate to the best of our knowledge, but no liability whatsoever is assumed. Final determination or suitability of a material is the sole responsibility of the user. All material may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

THE PRODUCT FORMULATION INFORMATION CONTAINED HEREIN IS ONLY FOR OCCUPATIONAL SAFETY AND HEALTH RELATED USAGE. ANY MISUSE OF THIS INFORMATION, INCLUDING DIVULGENCE TO THIRD PARTIES OR USE TO GAIN A COMPETITIVE ADVANTAGE IS STRICTLY PROHIBITED.
HEXCEL CORPORATION
Resins Group Division

MATERIAL SAFETY DATA SHEET
URALITE 3502 PART A

SECTION I - IDENTIFICATION

COMPANY NAME......................... HEXCEL CORPORATION - RESINS GROUP
20701 Nordhoff Street, PO Box 2197
Chatsworth, CA 91311
(818) 882-3022
EMERGENCY PHONE NUMBER............ (800) 433-5072 (except California)
(800) 343-4467 (Canada)
CALIFORNIA EMERGENCY PHONE NUMBER.. (800) 367-7527
PRODUCT IDENTIFIER.................. URALITE 3502 PART A
CHEMICAL FAMILY...................... URETHANE PREPOLYMER

SECTION II - HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>HAZARDOUS INGREDIENT</th>
<th>TLV (Units)</th>
<th>CAS NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dicyclohexylmethane-4,4' diisocyanate (aka H_{12} MDI)</td>
<td>10-30 .01 ppm</td>
<td>5124-30-1</td>
</tr>
<tr>
<td>Polyether Polyglycol/ H_{12} MDI Polymer</td>
<td>85-85 Not Established</td>
<td>52292-18-9</td>
</tr>
<tr>
<td>Aromatic Alkyl Ester</td>
<td>2-10 5 mg/m^3</td>
<td>84-74-2</td>
</tr>
</tbody>
</table>

SECTION III - PHYSICAL DATA

<table>
<thead>
<tr>
<th>PHYSICAL DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOILING POINT.......................... Not Available</td>
</tr>
<tr>
<td>VOC (grams/liter)........................ Not Applicable</td>
</tr>
<tr>
<td>APPEARANCE AND ODOR..................... Clear liquid with a faint sweet odor</td>
</tr>
</tbody>
</table>

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

<table>
<thead>
<tr>
<th>FIRE AND EXPLOSION HAZARD DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLASHPOINT &amp; METHOD OF DETERMINATION.... &gt;300°F Cleveland Open Cup</td>
</tr>
<tr>
<td>MEANS OF EXTINCTION..................... Use CO_{2} or dry chemical for small fires, and water and foam for large ones.</td>
</tr>
<tr>
<td>FOR FIRE............................... Since vapors are exceedingly irritating when inhaled, a self-contained breathing apparatus should be available to firemen.</td>
</tr>
</tbody>
</table>

URALITE 3502 PART A
PRINTED: 09/26/1991

HEXCEL - RESINS GROUP
CHEMTREC: (800) 424-9300

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
HEXCEL CORPORATION
Rosins Group Division

MATERIAL SAFETY DATA SHEET

HEXCEL - RESINS GROUP

EMERGENCY RESPONSE........................ NOT LISTED IN THE 1990 DOT EMERGENCY RESPONSE GUIDEBOOK.

SECTION V - HEALTH HAZARD DATA

OVEREXPOSURE EFFECTS..... Skin exposure may cause irritation. Repeated or prolonged exposure can result in dermatitis and skin sensitization (allergic effects). Vapors are exceedingly irritating to mucous membrane and eyes, causing acute temporary chest discomfort and breathing difficulty. Vapors can cause respiratory sensitization in susceptible people. WARNING: CONTAINS 2-ETHOXYETHANOL. HARMFUL IF INHALED OR ABSORBED THROUGH THE SKIN. BASED ON TESTS WITH LABORATORY ANIMALS, OVEREXPOSURE MAY CAUSE BIRTH DEFECTS, REPRODUCTIVE DISORDERS AND BLOOD DISORDERS.

Ingestion may cause gastro-intestinal burning and discomfort. Severe irritation and/or sensitization may result from overexposure to this product. Pre-existing eye, skin, and respiratory disorders may be aggravated by exposure.

EYES: In case of eye contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

SKIN CONTACT: In case of contact, immediately wash skin with soap and plenty of water. Wash contaminated clothing before re-use and destroy contaminated shoes. INHALATION: If inhaled, remove to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Get medical attention.

INGESTION: If swallowed, get medical attention immediately. Induce vomiting ONLY upon the advice of a physician.

SECTION VI - REACTIVITY DATA

CHEMICAL STABILITY....... Stable

INCOMPATIBLE MATERIALS... Avoid contact with water, alcohols, strong bases, metal compounds or surface active materials.

HAZARDOUS DECOMPOSITION PRODUCTS............... Isocyanate vapors and mists may also evolve.

HAZARDOUS POLYMERIZATION. Will not occur.

CONDITIONS TO AVOID...... STORE IN A COOL, WELL VENTILATED AREA IN TIGHTLY CLOSED CONTAINERS. AVOID MOISTURE CONTAMINATION.
MATERIAL SAFETY DATA SHEET

SECTION VII - SPILL OR LEAK PROCEDURE

RCRA WASTE NUMBER........ None
WASTE DISPOSAL........... Controlled incineration or buried landfill disposal should be in accordance with all federal, state and local environmental control regulations.

LEAK AND SPILL PROCEDURES
In case of spill, contain with a suitable diking material. Ventilate the area thoroughly. Keep all unnecessary people away. Spilled material should be absorbed in sawdust, sand or other absorbent. Place in an open-top container. Neutralize with a solution of 90-95% water, 5-8% concentrated ammonia and 1-2% detergent before disposal. Keep container open for at least 12 hours so that evolved carbon dioxide can escape.

SECTION VIII - SPECIAL PROTECTION

PERSONAL PROTECTION ...... HMIS CODE H- SPLASH GOGGLES, GLOVES, SYNTHETIC APRON AND ORGANIC VAPOR RESPIRATOR
VENTILATION.............. If handled indoors, provide mechanical exhaust ventilation.
HANDLING PROCEDURES AND EQUIPMENT.......... Avoid breathing vapors. Keep away from heat, sparks, and open flames. Use adequate ventilation. Wash thoroughly after handling.

SECTION IX - SHIPPING INFORMATION

HAZARD CLASS.............. N/A
DOT SHIPPING NAME........ NOT REGULATED BY THE DEPARTMENT OF TRANSPORTATION.
UN NUMBER............... N/A
NA #..................... N/A

SECTION X - STORAGE INFORMATION

STORE IN A COOL DRY AREA IN TIGHTLY CLOSED CONTAINERS. AVOID MOISTURE CONTAMINATION.

SECTION XI - REGULATORY INFORMATION

NOTICE: The information herein is presented in good faith and believed to be accurate as of the preparation date shown below. However, no warranty, expressed or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer’s responsibility to ensure that its activities comply with federal, state and local laws. The following specific information is made for the purpose of complying with numerous federal, state and local laws and regulations. THIS INFORMATION IS NOT MEANT TO BE ALL-INCLUSIVE. SELECTED REGULATIONS ARE PRESENTED.

URALITE 3502 PART A
PRINTED: 09/26/1991
CHEMTREC: (800) 424-9300

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
HEXCEL CORPORATION
Resins Group Division

MATERIAL SAFETY DATA SHEET

HEXCEL CORPORATION
Resins Group Division

SARA 313 INFO: This product contains the following substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

Aromatic Alkyl Ester

NOTE: HMDI is considered an Immediate Health Hazard, Delayed Health Hazard and Reactive Hazard under Sections 311/312 of SARA Title III.

CALIFORNIA PROPOSITION 65:
To the best of our knowledge, this product contains no levels of listed substances, which the state of California has found to cause cancer, birth defects or other reproductive effects.

NEW JERSEY:
The following are listed on the New Jersey Hazardous Substance List:

PENNSYLVANIA:
The following are on the Pennsylvania Hazardous Substance List:

PREPARED BY: Deirdre S. Crutchfield
DATE PREPARED: 06/01/91
PHONE NUMBER OF PREPARER: (818) 832-3022

FOOT NOTES

REFERENCES

DISCLAIMER: The information contained herein is accurate to the best of our knowledge, but no liability whatsoever is assumed. Final determination or suitability of a material is the sole responsibility of the user. All material may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

THE PRODUCT FORMULATION INFORMATION CONTAINED HEREIN IS ONLY FOR OCCUPATIONAL SAFETY AND HEALTH RELATED USAGE. ANY MISUSE OF THIS INFORMATION, INCLUDING DIVULGENCE TO THIRD PARTIES OR USE TO GAIN A COMPETITIVE ADVANTAGE IS STRICTLY PROHIBITED.
HEXCEL CORPORATION
Resins Group Division

MATERIAL SAFETY DATA SHEET
URALITE 3502 PART B

--- SECTION I - IDENTIFICATION ---

COMPANY NAME: HEXCEL CORPORATION - RESINS GROUP
20701 Nordhoff Street, PO Box 2197
Chatsworth, CA 91311
(818) 882-3022
EMERGENCY PHONE NUMBER: (800) 433-5072 (except California)
(800) 343-4467 (Canada)
CALIFORNIA EMERGENCY PHONE NUMBER: (800) 367-7527
PRODUCT IDENTIFIER: URALITE 3502 PART B
CHEMICAL FAMILY: URETHANE CURATIVE

--- SECTION II - HAZARDOUS INGREDIENTS ---

<table>
<thead>
<tr>
<th>HAZARDOUS INGREDIENT</th>
<th>PERCENT</th>
<th>TLV (Units)</th>
<th>CAS NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymethylene</td>
<td>40-60</td>
<td>Not Established</td>
<td>19900-65-3</td>
</tr>
<tr>
<td>Polyalkylphenyl Amine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aromatic Alkyl Ester</td>
<td>40-60</td>
<td>5 mg/m³</td>
<td>84-74-2</td>
</tr>
</tbody>
</table>

--- SECTION III - PHYSICAL DATA ---

BOILING POINT: Not Available
MELTING POINT: Not Available
VOC (grams/liter): Not Applicable
DENSITY (g/ml): 1.05
APPEARANCE AND ODOR: Amber liquid with a faint odor.

--- SECTION IV - FIRE AND EXPLOSION HAZARD DATA ---

FLASHPOINT & METHOD OF DETERMINATION: >300°F Cleveland Open Cup
MEANS OF EXTINCTION: Use CO₂ or dry chemical for small fires, and water and foam for large ones.
FOR FIRE: Since vapors are exceedingly irritating when inhaled, a self-contained breathing apparatus should be available to firemen.
EMERGENCY RESPONSE: Not listed in the DOT 1990 EMERGENCY RESPONSE GUIDEBOOK.
HEXCEL CORPORATION
Resins Group Division

MATERIAL SAFETY DATA SHEET

SECTION V - HEALTH HAZARD DATA

OVEREXPOSURE EFFECTS..... Skin exposure may cause irritation. Repeated or prolonged exposure can result in dermatitis and skin sensitization (allergic effects). Ingestion may cause gastro-intestinal burning and discomfort. Eye contact may cause extreme irritation and/or burning. Severe irritation and/or sensitization may result from overexposure to this product. Pre-existing eye, skin, and respiratory disorders may be aggravated by exposure.

SPECIFIC FIRST AID PROCEDURES..............

EYES: In case of eye contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

SKIN CONTACT: In case of contact, immediately wash skin with soap and plenty of water. Wash contaminated clothing before re-use and destroy contaminated shoes.

INHALATION: If inhaled, remove to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Get medical attention.

INGESTION: If swallowed, get medical attention immediately. Induce vomiting ONLY upon the advice of a physician.

SECTION VI - REACTIVITY DATA

CHEMICAL STABILITY..... Stable

HAZARDOUS DECOMPOSITION. Carbon dioxide, carbon monoxide, and nitrogen oxides.

HAZARDOUS POLYMERIZATION. Will not occur.

CONDITIONS TO AVOID. Avoid strong oxidizers.

SECTION VII - SPILL OR LEAK PROCEDURE

RCRA WASTE NUMBER..... None

WASTE DISPOSAL........... Controlled incineration or buried landfill disposal should be in accordance with all federal, state and local environmental control regulations.

LEAK AND SPILL PROCEDURES In case of spill, contain with a suitable diking material. Ventilate the area thoroughly. Keep all unnecessary people away. Spilled material should be absorbed in sawdust, sand or other absorbent. Place into open-topped containers and cover loosely; store for at least 12 hours before sealing container.
HEXCEL CORPORATION
Resins Group Division

MATERIAL SAFETY DATA SHEET

SECTION VIII - SPECIAL PROTECTION

PERSONAL PROTECTION....... HMIS CODE B- SAFETY GLASSES AND GLOVES.
VENTILATION............... If handled indoors, provide mechanical exhaust
                             ventilation.
HANDLING PROCEDURES AND  Avoid breathing vapors. Keep away from heat, sparks,
EQUIPMENT............... and open flames. Use adequate ventilation. Wash
                             thoroughly after handling.

SECTION IX - SHIPPING INFORMATION

HAZARD CLASS.............. N/A
DOT SHIPPING NAME........ NOT REGULATED BY THE DEPARTMENT OF TRANSPORTATION.
UN NUMBER.................. N/A
NA #....................... N/A

SECTION X - STORAGE INFORMATION

STORE IN A COOL DRY AREA IN TIGHTLY CLOSED CONTAINERS. AVOID MOISTURE
                             CONTAMINATION.

SECTION XI - REGULATORY INFORMATION

NOTICE: The information herein is presented in good faith and believed to
be accurate as of the preparation date shown below. However, no warranty,
either expressed or implied, is given. Regulatory requirements are subject to
change and may differ from one location to another; it is the buyer's
responsibility to ensure that its activities comply with federal, state
and local laws. The following specific information is made for the
purpose of complying with numerous federal, state and local laws and
regulations. THIS INFORMATION IS NOT MEANT TO BE ALL-INCLUSIVE. SELECTED
REGULATIONS ARE PRESENTED.

SARA 313 INFO: This product contains the following substances subject to the
reporting requirements of Section 313 of Title III of the Superfund Amendments

Aromatic Alkyl Ester

CALIFORNIA PROPOSITION 65:
To the best of our knowledge, this product contains no levels of listed
substances, which the state of California has found to cause cancer, birth
defects or other reproductive effects.

Prepared by.............. Deirdre S. Crutchfield
Days prepared............ 06/01/91
Phone number of preparer. (818) 882-3022

Printed: 09/26/1991 -3-  CHEMTREC: (800) 424-9300

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
MATERIAL SAFETY DATA SHEET

HMIS-Rating

Health 2
Flammability 1
Reactivity 0

FOOT NOTES

REFERENCES

DISCLAIMER: The information contained herein is accurate to the best of our knowledge, but no liability whatsoever is assumed. Final determination or suitability of a material is the sole responsibility of the user. All material may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

THE PRODUCT FORMULATION INFORMATION CONTAINED HEREIN IS ONLY FOR OCCUPATIONAL SAFETY AND HEALTH RELATED USAGE. ANY MISUSE OF THIS INFORMATION, INCLUDING DIVULGENCE TO THIRD PARTIES OR USE TO GAIN A COMPETITIVE ADVANTAGE IS STRICTLY PROHIBITED.
**HEXCEL CORPORATION**
Resins Group Division

**MATERIAL SAFETY DATA SHEET**

**URALITE 3503 PART A**

---

**SECTION I - IDENTIFICATION**

**COMPANY NAME**
HEXCEL CORPORATION - RESINS GROUP
20701 Nordhoff Street, PO Box 2197
Chatsworth, CA 91311
(818) 892-3022

**EMERGENCY PHONE NUMBER**
(800) 433-5072 (except California)
(800) 343-4467 (Canada)

**CALIFORNIA EMERGENCY PHONE NUMBER**
(800) 367-7527

**PRODUCT IDENTIFIER**
URALITE 3503 PART A

**CHEMICAL FAMILY**
URETHANE PREPOLYMER

---

**SECTION II - HAZARDOUS INGREDIENTS**

<table>
<thead>
<tr>
<th>HAZARDOUS INGREDIENT</th>
<th>PERCENT TLV (Units)</th>
<th>CAS NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dicyclohexylmethylene-4,4'</td>
<td>10-20 .01 ppm ceiling (OSHA)</td>
<td>5124-30-1</td>
</tr>
<tr>
<td>Diisocyanate (aka H_{12} MDI)</td>
<td>.005 ppm TWA (ACGIH)</td>
<td></td>
</tr>
<tr>
<td>Polyether Glycol/ H_{12} MDI Polymer</td>
<td>70-80</td>
<td></td>
</tr>
</tbody>
</table>

**CARCINOGEN LISTINGS BY OSHA, NTP OR IARC**
NO SPECIFIC LISTINGS

---

**SECTION III - PHYSICAL DATA**

<table>
<thead>
<tr>
<th>PROPERTIES</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOILING POINT</td>
<td>Not available</td>
</tr>
<tr>
<td>VOC (grams/liter)</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>MELTING POINT</td>
<td>Not available</td>
</tr>
<tr>
<td>DENSITY (g/ml)</td>
<td>1.07</td>
</tr>
<tr>
<td>APPEARANCE AND ODOR</td>
<td>Clear to pale yellow liquid with a faint sweet odor</td>
</tr>
</tbody>
</table>

---

**SECTION IV - FIRE AND EXPLOSION HAZARD DATA**

**FLASHPOINT & METHOD OF DETERMINATION**
>300°F Cleveland Open Cup

**EMERGENCY RESPONSE**
NOT LISTED IN THE 1990 DOT EMERGENCY RESPONSE GUIDEBOOK.

**MEANS OF EXTINCTION**
Use dry chemical or CO₂ for small fires and water & foam for large ones.

**SPECIAL FIRE HAZARDS**
Since vapors are exceedingly irritating when inhaled, a self-contained breathing apparatus should be available to firemen.

---

URALITE 3503 PART A
PRINTED: 01/15/1992

HEXCEL - RESINS GROUP

CHMTRC: (800) 424-9300

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
MATERIAL SAFETY DATA SHEET

SECTION V - HEALTH HAZARD DATA

PRIMARY ROUTES OF EXPOSURE...

OVEREXPOSURE EFFECTS...

Skin exposure may cause irritation. Repeated or prolonged exposure can result in dermatitis and skin sensitization (allergic effects). Vapors are exceedingly irritating to mucous membrane and eyes, causing acute temporary chest discomfort and breathing difficulty. Vapors can cause respiratory sensitization in susceptible people. Severe irritation and/or sensitization may result from overexposure to this product. Pre-existing eye, skin and respiratory disorders may be aggravated by exposure. Ingestion may cause gastro-intestinal burning and discomfort. Severe irritation and/or sensitization may result from overexposure to this product. Pre-existing eye, skin, and respiratory disorders may be aggravated by exposure.

SPECIFIC FIRST AID PROCEDURES....

EYES: In case of eye contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

SKIN CONTACT: In case of contact, immediately wash skin with soap and plenty of water. Wash contaminated clothing before re-use and destroy contaminated shoes.

INHALATION: If inhaled, remove to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Get medical attention.

INGESTION: If swallowed, get medical attention immediately. Induce vomiting ONLY upon the advice of a physician.

SECTION VI - REACTIVITY DATA

CHEMICAL STABILITY.... Stable

INCOMPATIBLE MATERIALS... Avoid contact with water, alcohols, strong bases, metal compounds or surface active materials.

HAZARDOUS DECOMPOSITION PRODUCTS........... Isocyanate vapors and mists may also evolve.

HAZARDOUS POLYMERIZATION. Will not occur.

CONDITIONS TO AVOID...... Moisture contamination may result in carbon dioxide gas pressure.

SECTION VII - SPILL OR LEAK PROCEDURE

RCRA WASTE NUMBER.... None
WASTE DISPOSAL........... Controlled incineration or buried landfill disposal should be in accordance with all federal, state and local environmental control regulations.

LEAK AND SPILL PROCEDURES In case of spill, contain with a suitable diking material. Ventilate the area thoroughly. Keep all unnecessary people away. Spilled material should be absorbed in sawdust, sand or other absorbent. Place in an open-top container. Neutralize with a solution of 90-95% water, 5-8% concentrated ammonia and 1-2% detergent before disposal. Keep container open for at least 12 hours so that evolved carbon dioxide can escape.

SECTION VIII - SPECIAL PROTECTION

PERSONAL PROTECTION...... HMIS CODE H- Splash Goggles, Gloves, Synthetic Apron and Organic Vapor Respirator. AN APPROVED POSITIVE PRESSURE AIR-SUPPLIED RESPIRATOR IS REQUIRED WHEREVER AIRBORNE ISOCYANATE LEVELS EXCEED PERMISSIBLE EXPOSURE LIMITS.

VENTILATION.............. If handled indoors, provide mechanical exhaust ventilation.

HANDLING PROCEDURES AND equipment.............. Avoid breathing vapors. Keep away from heat, sparks, and open flames. Use adequate ventilation. Wash thoroughly after handling.

SECTION IX - SHIPPING INFORMATION

UN NUMBER...... N/A
DOT SHIPPING NAME... NOT REGULATED BY THE DEPARTMENT OF TRANSPORTATION.
HAZARD CLASS....... N/A

SECTION X - STORAGE INFORMATION

STORE IN A COOL, WELL VENTILATED AREA IN TIGHTLY CLOSED CONTAINERS. AVOID MOISTURE CONTAMINATION.

SECTION XI - REGULATORY INFORMATION

NOTICE: The information herein is presented in good faith and believed to be accurate as of the preparation date shown below. However, no warranty, expressed or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer’s responsibility to ensure that its activities comply with federal, state and local laws. The following specific information is made for the purpose of complying with numerous federal, state and local laws and regulations. THIS INFORMATION IS NOT MEANT TO BE ALL-INCLUSIVE. SELECTED REGULATIONS ARE PRESENTED.
SARA 313 INFORMATION: This product contains the following substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372. H₂-MDI is considered an Immediate Health Hazard, Delayed Health Hazard and Reactive Hazard under Sections 311/312 of SARA Title III.

CALIFORNIA PROPOSITION 65:
To the best of our knowledge, this product contains no levels of listed substances, which the state of California has found to cause cancer, birth defects or other reproductive effects.

NEW JERSEY:
The following are listed on the New Jersey Hazardous Substance List:
Dicyclohexylmethane-4,4’-diisocyanate

PENNSYLVANIA:
The following are on the Pennsylvania Hazardous Substance List:
Dicyclohexylmethane-4,4’-diisocyanate

PREPARED BY.............. Deirdre S. Crutchfield
DATE PREPARED............. 01/07/92
PHONE NUMBER OF PREPARER. (818) 882-1022

FOOT NOTES

REFERENCES

DISCLAIMER: The information contained herein is accurate to the best of our knowledge, but no liability whatsoever is assumed. Final determination or suitability of a material is the sole responsibility of the user. All material may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

THE PRODUCT FORMULATION INFORMATION CONTAINED HEREIN IS ONLY FOR OCCUPATIONAL SAFETY AND HEALTH RELATED USAGE. ANY MISUSE OF THIS INFORMATION, INCLUDING DIVULGENCE TO THIRD PARTIES OR USE TO GAIN A COMPETITIVE ADVANTAGE IS STRICTLY PROHIBITED.
HEXCEL CORPORATION
Resins Group Division

MATERIAL SAFETY DATA SHEET
URALITE 3503 PART B

<table>
<thead>
<tr>
<th>IMIS Rating</th>
<th>Health</th>
<th>Flammability</th>
<th>Reactivity</th>
</tr>
</thead>
</table>

SECTION I - IDENTIFICATION

COMPANY NAME........................ HEXCEL CORPORATION - RESINS GROUP
20701 Nordhoff Street, PO Box 2197
Chatsworth, CA 91311
(818) 882-3022

EMERGENCY PHONE NUMBER.............. (800) 433-5072 (except California)
(800) 343-4467 (Canada)

CALIFORNIA EMERGENCY PHONE NUMBER. (800) 367-7527

PRODUCT IDENTIFIER..................... URALITE 3503 PART B
CHEMICAL FAMILY..................... URETHANE CURATIVE

SECTION II - HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>HAZARDOUS INGREDIENTS</th>
<th>PERCENT TLV (Units) CAS NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymethylenepolyamine</td>
<td>60-75 Not Established 19900-65-3</td>
</tr>
<tr>
<td>Polyalkylphenyl Amine</td>
<td>3</td>
</tr>
<tr>
<td>Aromatic Alkyl Ester</td>
<td>25-40 5 mg/m³ 84-74-2</td>
</tr>
</tbody>
</table>

CARCINOGEN LISTINGS BY OSHA, NTP OR IARC NO SPECIFIC LISTINGS

SECTION III - PHYSICAL DATA

<table>
<thead>
<tr>
<th>BOILING POINT</th>
<th>Not Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>MELTING POINT</td>
<td>Not available</td>
</tr>
<tr>
<td>DENSITY</td>
<td>1.03</td>
</tr>
<tr>
<td>APPEARANCE AND ODOR</td>
<td>Transparent amber liquid with a faint odor.</td>
</tr>
</tbody>
</table>

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASHPOINT & METHOD OF DETERMINATION. >300°F Cleveland Open Cup

EMERGENCY RESPONSE..................... Not listed in the DOT 1990 EMERGENCY RESPONSE GUIDEBOOK.

MEANS OF EXTINCTION.................... Use dry chemical or CO₂ for small fires and water & foam for larger ones.

SPECIAL FIRE HAZARDS................... Since vapors are exceedingly irritating when inhaled, a self-contained breathing apparatus should be available to firemen.

SECTION V - HEALTH HAZARD DATA

URALITE 3503 PART B
PRINTED: 01/16/1992
HEXCEL - RESINS GROUP
CHEMTREC: (800) 424-9300

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
HEXCEL CORPORATION
Resins Group Division

MATERIAL SAFETY DATA SHEET

<table>
<thead>
<tr>
<th>PRIMARY ROUTES OF EXPOSURE</th>
<th>SKIN CONTACT-yes</th>
<th>INHALATION-yes</th>
<th>INGESTION-no</th>
</tr>
</thead>
</table>

OVEREXPOSURE EFFECTS:
Skin exposure may cause irritation. Repeated or prolonged exposure can result in dermatitis and skin sensitization (allergic effects). Ingestion may cause gastro-intestinal burning and discomfort. Eye contact may cause extreme irritation and/or burning. Severe irritation and/or sensitization may result from overexposure to this product. Pre-existing eye, skin, and respiratory disorders may be aggravated by exposure.

SPECIFIC FIRST AID PROCEDURES:

EYES: In case of eye contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

SKIN CONTACT: In case of contact, immediately wash skin with soap and plenty of water. Wash contaminated clothing before re-use and destroy contaminated shoes. INHALATION: If inhaled, remove to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Get medical attention.

INGESTION: If swallowed, get medical attention immediately. Induce vomiting ONLY upon the advice of a physician.

SECTION VI - REACTIVITY DATA

CHEMICAL STABILITY: Stable

INCOMPATIBLE MATERIALS: Avoid contact with strong oxidizers.

HAZARDOUS DECOMPOSITION: Carbon dioxide, carbon monoxide, and nitrogen oxides.

HAZARDOUS POLYMERIZATION: Will not occur.

CONDITIONS TO AVOID: Avoid strong oxidizers.

SECTION VII - SPILL OR LEAK PROCEDURE

RCRA WASTE NUMBER: None

WASTE DISPOSAL: Controlled incineration or buried landfill disposal should be in accordance with all federal, state and local environmental control regulations.

LEAK AND SPILL PROCEDURES: In case of spill, contain with a suitable diking material. Ventilate the area thoroughly. Keep all unnecessary people away. Spilled material should be absorbed in sawdust, sand or other absorbent. Place into open-topped containers and cover loosely; store for at least 12 hours before sealing container.
MATERIAL SAFETY DATA SHEET

SECTION VIII - SPECIAL PROTECTION

PERSONAL PROTECTION........... HMIS CODE B - Safety Glasses and Gloves.
VENTILATION............... If handled indoors, provide mechanical exhaust ventilation.
HANDLING PROCEDURES AND EQUIPMENT........ Avoid breathing vapors. Keep away from heat, sparks, and open flames. Use adequate ventilation. Wash thoroughly after handling.

SECTION IX - SHIPPING INFORMATION

UN NUMBER.... N/A NA #............ N/A
DOT SHIPPING NAME... NOT REGULATED BY THE DEPARTMENT OF TRANSPORTATION.
HAZARD CLASS........ N/A

SECTION X - STORAGE INFORMATION

STORE IN A COOL, WELL VENTILATED AREA IN TIGHTLY CLOSED CONTAINERS. AVOID MOISTURE CONTAMINATION.

SECTION XI - REGULATORY INFORMATION

NOTICE: The information herein is presented in good faith and believed to be accurate as of the preparation date shown below. However, no warranty, expressed or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer’s responsibility to ensure that its activities comply with federal, state and local laws. The following specific information is made for the purpose of complying with numerous federal, state and local laws and regulations. THIS INFORMATION IS NOT MEANT TO BE ALL-INCLUSIVE. SELECTED REGULATIONS ARE PRESENTED.

SARA 313 INFORMATION: This product contains the following substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.
Aromatic Alkyl Ester

CALIFORNIA PROPOSITION 65:
To the best of our knowledge, this product contains no levels of listed substances, which the state of California has found to cause cancer, birth defects or other reproductive effects.

PREPARED BY............. Deirdre S. Crutchfield
DATE PREPARED............. 01/07/92
PHONE NUMBER OF PREPARER. (818) 882-3022

FOOT NOTES

URALITE 3503 PART B
PRINTED: 01/16/1992 -3-

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
HEXCEL CORPORATION
Resins Group Division

MATERIAL SAFETY DATA SHEET

HEMIS Rating
Health 2
Flammability 1
Reactivity 0

REFERENCES

DISCLAIMER: The information contained herein is accurate to the best of our knowledge, but no liability whatsoever is assumed. Final determination or suitability of a material is the sole responsibility of the user. All material may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

THE PRODUCT FORMULATION INFORMATION CONTAINED HEREIN IS ONLY FOR OCCUPATIONAL SAFETY AND HEALTH RELATED USAGE. ANY MISUSE OF THIS INFORMATION, INCLUDING DIVULGENCE TO THIRD PARTIES OR USE TO GAIN A COMPETITIVE ADVANTAGE IS STRICTLY PROHIBITED.
HEXCEL CORPORATION has provided the product formulation information contained herein for occupational safety and health-related usage. Any misuse of this information including divulgance to third parties or use to gain a competitive advantage is strictly prohibited.

Section 1: MATERIAL AND MANUFACTURER IDENTIFICATION

Manufacturer: D-U-N-S No. C031-3053
HEXCEL CORPORATION - Chemical Products Division
22701 Northoff Street - PO Box 2191
C restarting, GA 30131

Emergency Telephone Numbers:
800/443-3073 (Except CA)
800/391-7527 (California only)

Chemical Name/Synonyms: Chemical Family:

Prepolymer/Adhesive curing Agent: 104-40-0
URALITE 3530

C O T Status: Not regulated by DOT
Shipping Nomenclature: Plastic, Liquid, VSI
Hazard Class: None
UN/NA Number: None

Section II: HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>CAS No(s)</th>
<th>Part A</th>
<th>%</th>
<th>CAS No(s)</th>
<th>Part B</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>5121-30-1</td>
<td>Free Monomer Dicy-</td>
<td>18-28</td>
<td>19000-46-5</td>
<td>Polyurethane</td>
<td>56-70</td>
</tr>
<tr>
<td></td>
<td>cleyhyl Methane 4,4'-</td>
<td></td>
<td></td>
<td></td>
<td>Not est.</td>
</tr>
<tr>
<td></td>
<td>Disocyanate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>61130-52-1</td>
<td>Polyurethane Glyc-</td>
<td>62-78</td>
<td>44-14-2</td>
<td>Aromatic Alky-</td>
<td>24-38</td>
</tr>
<tr>
<td></td>
<td>col/Dicyclohexyl</td>
<td></td>
<td></td>
<td></td>
<td>Ester</td>
</tr>
<tr>
<td></td>
<td>Methane 4,4'-disocy-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>nate Polymer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blending Filler</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7331-65-9</td>
<td>Silicon Dioxide</td>
<td>2-10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Section III: PHYSICAL DATA

Boiling Point (°F): Not available

Vapor Pressure (mm Hg):
Part A: < 0.005 at 75°F
Part B: < 0.00201 at 75°F

Vapor Density (Air = 1): Not available

Solubility in Water: Part A: Reactive
Part B: Very slightly soluble

Appearance/Odor: Part A: Translucent faint amber paste - sweet odor
Part B: Red liquid - faint odor

Section IV: FLAMMABILITY (NFPA) - I

Flash Point (Method Tested):
Part A: > 330°F - OCS
Part B: > 330°F - OCS

Extinguishing Media: Water spray, alcohol foams, CO₂, dry chemicals

Special Fire Fighting Procedures: Vapors and/or combustion products are toxic and exceedingly irritating when inhaled. Self-contained breathing apparatus and the usual fireman's body protection garments should be worn.

Section V: FIRE AND EXPLOSION HAZARD DATA

Part B: FLAMMABILITY (NFPA) - I

Flash Point (Method Tested):
Part A: > 330°F - OCS
Part B: > 330°F - OCS

Extinguishing Media: Water spray, alcohol foams, CO₂, dry chemicals

Special Fire Fighting Procedures: Vapors and/or combustion products are toxic and exceedingly irritating when inhaled. Self-contained breathing apparatus and the usual fireman's body protection garments should be worn.

Unusual Fire and Explosion Hazards: None

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
URALITE 3530

SECTION V: HEALTH HAZARD DATA

Part A: (MPHA) - 1

Threshold limit value: Part A: Not established

Conditions to Avoid: Prevent skin and eye contact. Do not breathe vapors.

Primary Routes of Entry: Inhalation, skin contact.

Effects of Overexposure: Part A: Prolonged skin contact may cause dermatitis. Eye contact is very irritating. Exposure to vapors may cause chest discomfort, coughing, and reduced pulmonary function. Inhalation is very harmful and may cause poisoning. Part B: Fever, chills, anorexia, vomiting. May cause temporary liver damage and methemoglobin (cyanosis).

Emergency Medical Conditions: Pre-existing eye, skin, and respiratory disorders may be aggravated by exposure to this product.

Emergency and First Aid Procedures: Skin Contact: Prompt washing with soap and water. Ingestion: Call a physician at once. Induce vomiting only on a physician’s advice. Eye Contact: Irrigate promptly with clear water for 15 minutes and call a physician.

Part B: REACTIVITY (MPHA) - 0

Conditions to Avoid: Avoid heat.

STABILITY: Stable

Incompatibilities (Materials to Avoid): Avoid contact with water, alcohols, strong bases, metal compounds, and surface active materials.

Hazardous Decomposition Products: Combustion may result in carbon monoxide, carbon dioxide, and oxides of nitrogen, oxides of phosphorus.

HAZARDS: Conditions to Avoid: Moisture contamination may form CO2 gas pressure.

POLARIZATION: Will not occur. X

SECTION VII: SPILL OR LEAK PROCEDURE

Steps to be Taken in Case Material is Released or Spilled: Ventilate area thoroughly. Spilled compound should be absorbed in sawdust or other absorbents. Store temporarily in an open container. Absorbed Part A should be treated with a solution of water, ammonia, and isopropanol before disposal.

Waste Disposal Method: Contain in sealed containers. Dispose of in chemical waste landfill or use controlled incineration. Disposal must be in accordance with all federal, state, and local environmental control regulations with respect to health, water, land, or air pollution. If questions arise, consult a certified environmental waste disposal contractor.

RCRA Hazardous Waste Number: None

SECTION VIII: SPECIAL PROTECTION INFORMATION

Respiratory Protection (Specify Type): Any thorough ventilation system is adequate. In closed environment use respirator with organic vapor canister.

VENTILATION: Local Exhaust: X

If handled indoors provide local mechanical exhaust ventilation. It should be sufficient to remove any possible gases generated in the work area.

Mechanical Exhaust: Preferred.

Protective Gloves: Heavy disposable rubber gloves or butyl rubber gloves are best when contact and handling is frequent. Use cotton linings.

Eye Protection: Safety glasses with side shields or plastic goggles.

Other Protective Equipment: Protective hand creams and routine change of disposable work bench covering (e.g. Kraft paper) suggested especially if staining due to contact is a frequent possibility.

SECTION IX: SPECIAL PRECAUTIONS

Precautions to be Taken in Handling and Storage: Store in cool, dry area in tightly closed containers.

Other Precautions: Avoid contact with skin or clothing. Contaminated clothing must be laundered before wearing. Contaminated shoes must be thoroughly cleaned or discarded.

Prepared by: P. H. Cuthbert

Date: April 10, 1969
**Section 1: MATERIALS AND MANUFACTURER IDENTIFICATION**

**Manufacturer:**
- Hexcel Corporation - Chemical Products Division
  - 3330 Woodruff Street - Suite 210
  - Costa Mesa, CA 92626

**Emergency Telephone Numbers:**
- 818/882-6323 (California only)
- 818/882-3322 (except CA)
- 600/432-3322 (to CA)
- 800/367-7527 (California only)

**Chemical Name/Synonyms:**
- Chemical Family: Polyurethane Curing Agent
- Formula: N/A

**DOT Status:**
- Shipping Requirements: N/A
- Hazard Class: N/A
- UN No.: N/A

**Section II: HAZARDOUS INGREDIENTS**

<table>
<thead>
<tr>
<th>CAS No.</th>
<th>Part A</th>
<th>%</th>
<th>PEL/TLV (Units)</th>
<th>CAS No.</th>
<th>Part B</th>
<th>%</th>
<th>PEL/TLV (Units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5124-35-1</td>
<td>Free Monopropylcyclohexyl Methane 4,4'-Disocyanate</td>
<td>10-23</td>
<td>0.01</td>
<td>19250-65-3</td>
<td>Polymethyltiranyle (Polyurethane)</td>
<td>0.5-35</td>
<td>0.5</td>
</tr>
<tr>
<td>5819-52-1</td>
<td>Polyisopropylcyclohexyl Methane 4,4'-Disocyanate/Polymethyltiranyle (Polyurethane)</td>
<td>85-95</td>
<td>not ass.</td>
<td>[24-74-1]</td>
<td>[24-74-1]</td>
<td>18-40</td>
<td>5 scale</td>
</tr>
<tr>
<td>7261-69-9</td>
<td>Silicon Dioxide</td>
<td>2-8</td>
<td>not ass.</td>
<td>7261-69-9</td>
<td>Silicon Dioxide</td>
<td>2-8</td>
<td>not ass.</td>
</tr>
</tbody>
</table>

**Section III: PHYSICAL DATA**

- **Density (g/mL):** Not available
- **Vapor Pressure (mm Hg):**
  - Part A: at 75°F > 0.0025
  - Part B: at 75°F < 0.00001

- **Vapor Density (Air = 1):** Not available
- **Solubility in Water:**
  - Part A: Reactive
  - Part B: Very slightly soluble
- **Appearance/ Odor:**
  - Part A: Translucent blue, green paste, sweet odor
  - Part B: Red paste - faint odor

**Part A FLAMMABILITY (NFPA) - 1**

**Section IV: FIRE AND EXPLOSION HAZARD DATA**

- **Flash Point (Method Used):**
  - Part A: > 300°F - COC
  - Part B: > 300°F - COC

- **Flammable Limits (in Air):**
  - Part A: Unknown
  - Part B: Unknown

- **Extinguishing Media:**
  - CO₂, dry chemicals for small fires. Water and foam for large fires.
  - Special Fire Fighting Procedures: Vapor and/or combustion products are toxic and irritating. Inhalation of vapor may cause self-contained breathing apparatus and the usual fireman's body protection garments should be worn.

**Section V: UNUSUAL FIRE AND EXPLOSION HAZARDS:** None

---

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
**Health & Safety**

---

**Precautions to Avoid:**
- Prevent skin and eye contact. Do not breathe vapors.
- Avoid contact with skin, eyes, and respiratory organs.

**Effects of Overexposure:**
- Fumes or fumes may cause dermatitis. Eye contact is very irritating. Prolonged exposure to vapors may cause chipped discs, coughing, and reduced pulmonary function. Vision is very normal in the cause sensing. Part B: Fever, chills, anorexia, vomiting. May cause temporary liver damage and enzymatic reactions.

**Emergency and First Aid Procedures:**
- Skin Contact: Prevent skin and eye contact. Do not breathe vapors. Do not wash with soap and water. Ingestion: Call a physician at once. Arrange prompt medical attention. Eye Contact: Irrigate promptly with clear water for 15 minutes. Use a physician.

**Stability:**
- Stable

**Incompatibility (Materials to Avoid):**
- Avoid contact with water, alcohols, strong bases, metal compounds, and surface active materials.

**Inert Gas Decomposition Products:**
- Combustion may result in carbon monoxide, carbon dioxide, and oxides of nitrogen, oxides of phosphorus.

**Hazardous Decomposition Products:**
- Combustion may result in carbon monoxide, carbon dioxide, and oxides of nitrogen, oxides of phosphorus.

**Hazards to Avoid:**
- Moisture contamination may cause CO, gas pressure.

**Conditions to Avoid:**
- Avoid contact with water, alcohols, strong bases, metal compounds, and surface active materials.

**Section VIII: Spill or Leak Procedures**
- Spills to be taken in case material is released or spilled. Ventilate area thoroughly. Spills compound should be absorbed in sawdust or other absorbents. Store temporarily in a closed container. Absorbed Part A should be treated with a solution of water, ammonia, and isopropyl alcohol before disposal.

**Hazardous Waste Number:**
- None

**Section IX: Special Precautions**
- Precautions to be taken in handling and storing: Store in cool, dry area in tightly closed containers.

**Prepared by:**
- P. H. Cuthbert

**Date:**
- April 10, 1999
Note: This form is to be used to comply with OSHA's Hazard Communication Standard, 29 CFR 1910.1200. Blank spaces are not permitted.

Trade Name: CONATHANE TU-900 Part A
Chemical Name, common name: Complex Mixture Polyurethane Prepolymer

Material may present a dust hazard if cut, ground or machined after curing.

Boiling Point: ND
Specific Gravity (H2O=1): 1.06
Vapor Pressure, mm Hg @ 25°C: 0.01
Vapor Density (air=1): >1
Melting Pt./Range: ND
Evaporation rate (Ether=1): ND
Solubility in Water: REACTS
Physical State: LIQUID
Percent volatile by volume: NIL
Appearance and Odor: CLEAR VISCOS LIQUID, NO DISTINCT ODOR

Flash Point, F (Method): > 395 CC
Flammable Limits: ND LEL: ND UEL: ND

Extinguishing Materials:
-XX-Water Spray -XX-Dry Chemical -XX-Carbon Dioxide
-XX-Foam -ND-Other:

Special Firefighting Procedures:
Fire fighters should wear self contained breathing apparatus.

Unusual Fire and Explosion Hazards:
Toxic gases may be present as a result of thermal decomposition or combustion. Closed container may explode when exposed to extreme heat. Use cold water spray to cool fire exposed containers to reduce the risk of rupture. Closed container may also burst if contaminated with water due to CO2 evolved.

ACUTE TOXICITY (Routes of entry)

Inhalation:
Lowest Lethal Concentration of dicyclohexyl methane diisocyanate 200 mg/m3 (19 ppm) 4 hrs.-rat.
Inhalation of dust and vapors at concentrations above the TLV can irritate (burning sensation) the mucous membranes in the respiratory tract (nose, throat, lungs) causing runny nose, sore throat, coughing, chest discomfort, shortness of
breath and reduced lung function (breathing obstruction). Persons
with a preexisting, nonspecific bronchial hyperreactivity can
respond to concentrations below the intended TLV with similar
symptoms as well as an asthma attack. Exposure well above the TLV
may lead to bronchitis, bronchial spasm and pulmonary edema
(fluid in the lungs). These effects are usually reversible.
Chemical or hypersensitive pneumonitis, with flu-like symptoms
(e.g., fever, chills), has also been reported.

Ingestion:
(Acute Exposure) Can result in irritation and corrosive
action in the mouth, stomach tissue and digestive tract.

Eye Contact:
Mild irritant; reversible—rabbit
(Acute Exposure) Liquid, aerosols or vapors are irritating
and can cause tearing, reddening and swelling.

Skin Contact:
Skin irritant and sensitizer—Guinea Pig
Isocyanates react with skin protein and moisture and can
cause irritation which may include the following symptoms:
reddening, swelling, rash, scaling or blistering. Cured
material is difficult to remove. Experience indicates that
direct skin contact is the route of exposure most likely to
cause sensitization. Once sensitized, an individual may react
even to airborne levels below the TLV with the following
symptoms: itching and tingling of the earlobes and neck, rash,
hives, swelling of the arms and legs or other symptoms common to
allergic dermatitis. These symptoms may be immediate or delayed
several hours.

Skin Absorption: ND

CHRONIC TOXICITY
Carcinogenicity: XXX—No
Not listed as a carcinogen.
-NA—Yes: ---NA—NTP ---NA—IARC -NA—Federal OSHA

Target Organ Affected:
Specific target organ information not available at this time.

Effects of Overexposure:
Material is a primary skin irritant and potent skin
sensitizer. Experience indicates that direct skin contact is
the route of exposure most likely to cause sensitization.
Once sensitized an individual may react to airborne levels
below the TLV with the following symptoms: itching and
 Tingling of the earlobe and neck, rash, hives, swelling of
the arms and legs or symptoms common to allergy dermatitis
(rash). Inhalation of vapors or spray mist may also cause
irritation of the respiratory tract (dry throat, cough,
shortness of breath, chest tightness). These symptoms could
be immediate or delayed up to several hours. Similar to many
non-specific asthmatic responses, there are reports that once
sensitized an individual can experience these symptoms
upon exposure to dust, cold air or other irritants. This
increased lung sensitivity can persist for weeks and in
severe cases for several years. Chronic overexposure to
isocyanate has also been reported to cause lung damage (including decrease in lung function) which may be permanent. Sensitization can either be temporary or permanent.

Medical Conditions Aggravated By Exposure:
Existing lung conditions and dermal conditions may be aggravated by use of this material.

FIRST AID: EMERGENCY PROCEDURES
Eye Contact:
Flush with clean, lukewarm water (low pressure) for at least 15 minutes, occasionally lifting eye lids. Obtain immediate medical attention.

Skin Contact:
Remove contaminated clothing. Wash skin promptly and thoroughly with soap and water. After washing, cover affected areas with polyethylene glycol (300-500 mol.wt.) and wash again with soap and water. Wash contaminated clothing thoroughly before reuse. Allergic dermatitis should be treated by a physician to relieve the symptoms. For severe exposures, get under safety shower after removing clothing. Seek medical attention if irritation or allergic dermatitis symptoms develop, or if gross exposure occurs.

Inhalation: Move to an area free from further risk of exposure. Administer oxygen or artificial respiration as needed. Obtain medical attention. Asthmatic-type symptoms may develop and may be immediate or delayed up to several hours. Treatment is essentially symptomatic. Consult physician.

Ingested:
DO NOT INDUCE VOMITING. Give 1 to 2 cups of milk or water to drink. DO NOT GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS OR CONVULSING PERSON. Consult a physician.

Recommendations to Physician:
Eyes: Stain for evidence of corneal injury. If cornea is burned, instill antibiotic steroid preparation frequently. Workplace vapors have produced reversible corneal epithelial edema impairing vision. This compound is a known skin sensitizer. Treat symptomatically as for contact dermatitis or thermal burns. There is no specific antidote for ingestion treat symptomatically. Inducing vomiting is contraindicated because of the irritating nature of this compound. Inhalation treatment is essentially symptomatic.

An individual having a dermal or pulmonary sensitization reaction to this material should be removed from exposure to any isocyanate.

VI. REACTIVITY DATA

Stability:
-XXX-Stable: ----Unstable

Conditions to Avoid:
Contact with moisture and other materials which react with isocyanates. Temperatures above maximum storage temperature.

Incompatibility (materials to avoid):
Moisture and other materials that react with isocyanates.

Hazardous Decomposition Products
Oxides of nitrogen, hydrogen cyanide, carbon dioxide and carbon monoxide.

Hazardous Polymerization: --May Occur X-Will not occur

Conditions to avoid: Temperatures above maximum storage temperatures.

======= VII. SPILL, LEAK AND DISPOSAL PROCEDURES ======

Steps to be taken if material is released or spilled:
Consult section VIII for proper protective equipment.
Evacuate non essential personnel. Ventilate the area. Dike or impound spilled material and control further spillage if feasible. Notify appropriate authorities if necessary.
Cover spill with sawdust, vermiculite, Fuller's earth or other absorbent material; pour liquid decontaminant over spillage -- allow to react at least ten min., collect material in open containers -- add further amounts of decontaminant solution. Remove containers to safe place -- cover LOOSELY. Wash down area with decontaminant and flush area with water.
Decontamination solutions: Ammonium hydroxide (0-10%), detergent (2-5%) and balance water; or solution of Union Carbide's Tergitol TMN-10 (20%) and water (80%).

Waste Disposal Method:
-XX-Incinerate -NA-Landfill according to any Local, State and Federal Regulations.

Incineration is method of choice. Empty containers must be handled with care due to product residue. decontamination of containers prior to disposal is usually recommended.
Contact your disposal company for details.

======= VIII. SPECIAL HANDLING INFORMATION ======

Respiratory Protection:
A respirator that is recommended or approved for use in isocyanate containing environments (air purifying or fresh air supplied) may be necessary. The use of a positive pressure supplied air respirator is mandatory when: airborne isocyanate concentrations are not known or exceed 0.005 ppm; operations are performed in a confined space or area with limited ventilation; material is heated. An air-purifying respirator is not generally recommended due to the poor warning properties, (e.g. odor or irritation, of this material. By the time the worker would detect leakage of the face seal or breakthrough of the filter cartridge, his exposure could be well above the TLV. Consider the type of application, airborne isocyanate concentrations and materials being used concurrently when determining respirator use and selection. Observe OSHA regulations for respirator use (29CFR 1910.134).

Ventilation:
Exhaust ventilation sufficient to keep the airborne concentration below the TLV must be utilized. Exhaust ventilation should be provided in accordance with the guidelines in INDUSTRIAL VENTILATION published by the American Conference of Governmental Hygienists.

Local exhaust: Recommended

Exhaust air may need to be cleaned by scrubbers or filters.
Skin Protection:
Chemical resistant gloves. Cover as much of the exposed skin area as possible with appropriate clothing. If skin creams are used, keep the area protected only by the cream to a minimum. When there is potential for a major splash directly onto the skin, such as when breaking into lines, a full acid suit is required. When the application may result in airborne vapor or mist, a full, permeation resistant, protective suit including head covering and face shield, gloves, and overshoes is required.

Eye Protection:
Chemical worker's goggles. Safety glasses with side shields.

Other Protective Clothing or Equipment:
Apron and face shield. Safety showers and eye wash stations should be available. Cover as much of exposed skin area as necessary with appropriate clothing.


Handling and Storage:
Storage temperature (min/max): 32F(0C) / 122F (50C)

Other Precautions:
Keep away from heat, sparks and open flame. Store in tightly closed container and protect from moisture and foreign materials.

Additional Information

SARA Title III Requirements:

Chemical Name Section: 302 CERCLA 313
Materials Not Listed
T.S.C.A. Status: On Inventory
CALIFORNIA SCAQMD RULE 443.1 VOC'S:
Volatile Organic Components (VOC'S)=Substances with vapor pressure of =>0.5mmHg at 104'C (219.2'F).

This product contains <1g/liter VOC'S and <1g/liter VOC'S (less water and exempt compounds)

Name(print): George C. Karpin
Signature: Karpin
Title: Toxicological Coordinator
Date of last revision: 7/25/90
Phone number provided.

To the best of our knowledge, the information contained therein is accurate and meets all State and Federal Guidelines. However, CONAP INC. does not assume any liability whatsoever for the accuracy or completeness of the information contained herein. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot
guarantee that these are the only hazards which exist. Final determination of the suitability of any material is the sole responsibility of the user.

*CONATHANE is a Registered Trademark of CONAP, INC.

Date approved 7/35/90 Approved: ____________________________
ND=Not Determined
NA=Not Applicable

4/26/90 Approved: ____________________________
Note: This form is to be used to comply with OSHA’s Hazard Communication Standard, 29 CFR 1910.1200. Blank spaces are not permitted.

I. IDENTIFICATION

Trade Name: CONATHANE* TU-900 Part B Date: 05/01/91
Chemical Name, common name: Complex Mixture

II. HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>Chemical Names</th>
<th>CAS No.</th>
<th>%</th>
<th>ACGIH(TLV)</th>
<th>OSHA(PEL)</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diethyltoluene diamine</td>
<td>68479-98-1</td>
<td>20-30%</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Polyalkoxylated Polyol</td>
<td>25322-69-4</td>
<td>&lt;10%</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

Material may present a dust hazard if cut, ground, or machined after curing.

III. PHYSICAL DATA

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling Point</td>
<td>ND</td>
</tr>
<tr>
<td>Specific Gravity (H2O=1)</td>
<td>1.01</td>
</tr>
<tr>
<td>Vapor Pressure, mm Hg</td>
<td>ND</td>
</tr>
<tr>
<td>Melting Pt./Range</td>
<td>ND</td>
</tr>
<tr>
<td>Evaporation rate (Ether=1)</td>
<td>ND</td>
</tr>
<tr>
<td>Solubility in Water</td>
<td>ND</td>
</tr>
<tr>
<td>Physical State</td>
<td>LIQUID</td>
</tr>
<tr>
<td>Percent volatile by volume</td>
<td>Nil</td>
</tr>
<tr>
<td>Appearance and Odor</td>
<td>Amber colored liquid.</td>
</tr>
</tbody>
</table>

IV. FIRE AND EXPLOSION DATA

Flash Point, F (Method): > 275 F (TCC)
Extinguishing Materials:
(X)-Water Spray
(X)-Dry Chemical
(X)-Carbon Dioxide
(X)-Foam
-ND-Other:
Special Firefighting Procedures: None
Unusual Fire and Explosion Hazards: None

V. HEALTH HAZARD INFORMATION

ACUTE TOXICITY (Routes of entry)
Inhalation:
Not expected to be a route of exposure due to low volatility at room temperature. However, if heated material may give off significant amounts of vapor.
Ingestion: Toxic by ingestion. Do not ingested material.
Eye Contact:
Severe irritation. Material may cause eye damage that is reversible.
Skin Contact:
Skin irritant. Expected to be toxic by dermal absorption.
Skin Absorption: Expected to be toxic.

CHRONIC TOXICITY
Carcinogenicity:--X--No
Not listed as a carcinogen.
--NA-NTP --NA-IARC --NAFederal OSHA
Target Organ Affected:
A two year feeding study in rats is in progress. Preliminary data from this study indicates that Diethyltoluene diamine causes pancreatic effects, liver, thyroid and possibly the adrenal glands and eyes in laboratory animals. An increase in the number of tumors in the liver and thyroid of male rats was found. Diethyltoluenediamine has been tested in an extensive battery of in vivo and in vitro short term assays. The results of the battery as a whole predict that Diethyltoluene diamine will not exhibit carcinogenic activity in animal bioassays. Nonreproducible activity was demonstrated by Diethyltoluene diamine in the Ames test and BALB/3T3 cell point mutation assay. Mutagenic activity has also been reported in the in vitro cytogenetics assay.
There are increased incidents of liver tumors (hepatocellular carcinomas) and thyroid tumors (follicular cell adenomas) in male rats at the highest dose level (70ppm in the diet). These are not rare tumors in the strain of rats tested in the study, but are usually found at a low level. No increase in pancreatic tumors was found even though the pancreas was the target organ in such chronic tests. Toxic effects were found in the pancreas and liver of the high dose male rats. Effects may also have been found in the adrenal glands and eyes of these rats. Evaluation of tissues from the control and high dose female rats is underway.

Effects of Overexposure:
Severe eye irritant. In rare instances, sensitization to DETA has been reported to occur in humans.

Medical Conditions Aggravated By Exposure: ND

FIRST AID: EMERGENCY PROCEDURES
Eye Contact:
Begin immediate eye irrigation with cool water. Consult a physician if irritation persists.
Skin Contact:
Flush skin with water. Wash skin with soap and water. Remove contaminated clothing and shoes. Clean contaminated clothing thoroughly before reuse.
Inhalation:
Remove victim to fresh air. If breathing is difficult administer oxygen. If victim has stopped breathing administer artificial respiration. Do not give anything by mouth to an unconscious person. Get medical attention.
Ingested:
Induce vomiting immediately by giving two glasses of water and sticking finger down throat. Never give anything by mouth to an unconscious person.

Recommendations to Physician: Follow standard procedures.

REACTIVITY DATA
Stability: --X--Stable --NA-Unstable

Conditions to Avoid: None
Incompatibility (materials to avoid): None

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Hazardous Decomposition Products:
Carbon dioxide, oxides of nitrogen, carbon monoxide.
Hazardous Polymerization: NA-May Occur  X-Will not occur
Conditions to avoid: None

====== VII. SPILL, LEAK AND DISPOSAL PROCEDURES ======
Steps to be taken if material is released or spilled:
Consult section VIII for proper protective equipment.
Contain any spills with dikes or absorbents to prevent
migration and entry into sewer and streams. Take up small
spills with dry chemical absorbent. Large spills may be
taken up with pump or vacuum and finished off with dry
chemical absorbent. May require excavation of contaminated
soil.
Waste Disposal Methods:
This material may contain leachable elemental mercury as
determined by the Toxic Chemical Leaching Procedure
(TCLP). The levels of mercury are in sufficient quantity
to classify this material as a D009 Hazardous Waste.
Dispose of in accordance with all applicable local State
and Federal regulations.

======= VIII. SPECIAL HANDLING INFORMATION =======
Respiratory Protection:
NIOSH approved organic respirator when exposed to heated
vapors. Observe OSHA regulations for respirator use (29 CFR
1910.134).
Ventilation:
Local exhaust-At source of heated vapors.
Mechanical-Recommended
Protective Gloves: Resistant to chemical penetration.
Eye Protection: Chemical goggles.
Other Protective Clothing or Equipment: If skin contact or
contamination of clothing is likely, protective clothing
should be worn.
Work Practices, hygienic practices:
Use good industrial hygiene.

====== IX. SPECIAL PRECAUTIONS ======
Handling and Storage:
Other Precautions: None.

====== X. ADDITIONAL INFORMATION ======
SARA Title III Requirements:
Chemical Name Section: 302 CERCLA 313
| Materials not listed. |
=================================
T.S.C.A. Status: On Inventory

Name(print): George C. Karpin
Signature: ____________________________
Title: Toxicological Coordinator
Date last revision 5/1/91
In case of accident use the phone number provided.

To the best of our knowledge, the information contained
herein is accurate and meets all State and Federal
guidelines. However, CONAP INC. does not assume any
Page 3B
liability what so ever for the accuracy or completeness of the information contained herein. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist. Final determination of the suitability of any material is the sole responsibility of the user.

*CONATHANE IS A REGISTERED TRADEMARK OF CONAP, INC.

Date approved: 5/6/91  Approved:
ND=Not Determined
NA=Not Applicable
Date approved: 5/6/91  Approved:
Note: This form is to be used to comply with OSHA's Hazard Communication Standard, 29 CFR 1910.1200. Blank spaces are not permitted.

Trade Name: CONATHANE® TU-956 Part A Date: 9/21/89
Chemical Name, common name: Polyurethane Prepolymer

Chemical Names   CAS No. % ACGIH(TLV) OSHA(PEL) Other
Dicyclohexylmethane-4,4'-Diisocyanate 5124-30-1 <10% 0.005ppm .01ppm Ceiling ND

Material may present a dust hazard if cut, ground or machined after curing.

Boiling Point: ND !Specific Gravity (H2O=1): 1.06
Vapor Pressure, mm Hg @25°C .001
Vapor Density (air=1): >1
Melting Pt./Range: ND !Evaporation rate (Ether=1): ND
Solubility in Water: REACTS !Physical State: LIQUID
Percent volatile by volume: NIL
Appearance and Odor: CLEAR VISCOUS LIQUID, NO DISTINCT ODOR

Flash Point,F (Method): > 395 CC
Flammable Limits: ND LEL: ND UEL: ND
Extinguishing Materials:
-XX-Water Spray -XX-Dry Chemical -XX-Carbon Dioxide
-XX-Foam -ND-Other:

Special Firefighting Procedures:
Fire fighters should wear self contained breathing apparatus.

Unusual Fire and Explosion Hazards:
Toxic gases may be present as a result of thermal decomposition or combustion. Closed container may explode when exposed to extreme heat. Use cold water spray to cool fire exposed containers to reduce the risk of rupture.
Closed container may also burst if contaminated with water due to CO2 evolved.

ACUTE TOXICITY (Routes of entry)
Inhalation:
Lowest Lethal Concentration of dicyclohexyl methane diisocyanate 200 mg/m3 (19 ppm) 4 hrs.--rat.
Inhalation of dust and vapors at concentrations above the
TLV can irritate (burning sensation) the mucous membranes in the respiratory tract (nose, throat, lungs) causing runny nose, sore throat, coughing, chest discomfort, shortness of breath and reduced lung function (breathing obstruction). Persons with a preexisting, nonspecific bronchial hyperreactivity can respond to concentrations below the intended TLV with similar symptoms as well as an asthma attack. Exposure well above the TLV may lead to bronchitis. Bronchial spasm and pulmonary edema (fluid in the lungs). These effects are usually reversible. Chemical or hypersensitive pneumonitis, with flu-like symptoms (e.g. fever, chills), has also been reported.

Ingestion:
(Acute Exposure) Can result in irritation and corrosive action in the mouth, stomach tissue and digestive tract.

Eye Contact:
Mild irritant; reversible—rabbit
(Acute Exposure) Liquid, aerosols or vapors are irritating and can cause tearing, reddening and swelling.

Skin Contact:
Skin irritant and sensitizer—Guinea Pig
Isocyanates react with skin protein and moisture and can cause irritation which may include the following symptoms: reddening, swelling, rash, scaling or blistering. Cured material is difficult to remove. Experience indicates that direct skin contact is the route of exposure most likely to cause sensitization. Once sensitized, an individual may react even to airborne levels below the TLV with the following symptoms; itching and tingling of the earlobes and neck, rash, hives, swelling of the arms and legs or other symptoms common to allergic dermatitis. These symptoms may be immediate or delayed several hours.

Skin Absorption:
ND

CHRONIC TOXICITY
Carcinogenicity:—XXX—No
-NA—Yes: ——NA—NTP —NA—IARC —NA—Federal OSHA

Target Organ Affected:
Specific target organ information not available at this time.

Effects of Overexposure:
Material is a primary skin irritant and potent skin sensitizer. Experience indicates that direct skin contact is the route of exposure most likely to cause sensitization. Once sensitized an individual may react to airborne levels below the TLV with the following symptoms; itching and tingling of the earlobe and neck, rash, hives, swelling of the arms and legs or symptoms common to allergic dermatitis (rash). Inhalation of vapors or spray mist may also cause
irritation of the respiratory tract (dry throat, cough, shortness of breath, chest tightness). These symptoms could be immediate or delayed up to several hours. Similar to many non-specific asthmatic responses, there are reports that once sensitized an individual can experience these symptoms upon exposure to dust, cold air or other irritants. This increased lung sensitivity can persist for weeks and in severe cases for several years. Chronic overexposure to isocyanate has also been reported to cause lung damage (including decrease in lung function) which may be permanent. Sensitization can either be temporary or permanent.

Medical Conditions Aggravated By Exposure:
Existing lung conditions and dermal conditions may be aggravated by use of this material.

FIRST AID: EMERGENCY PROCEDURES

Eye Contact:
Flush with clean, lukewarm water (low pressure) for at least 15 minutes, occasionally lifting eye lids. Obtain immediate medical attention.

Skin Contact:
Remove contaminated clothing. Wash skin promptly and thoroughly with soap and water. After washing, cover affected areas with polyethylene glycol (300-500 mol.wt.) and wash again with soap and water. Wash contaminated clothing thoroughly before reuse. Allergic dermatitis should be treated by a physician to relieve the symptoms. For severe exposures, get under safety shower after removing clothing. Seek medical attention if irritation or allergic dermatitis symptoms develop, or if gross exposure occurs.

Inhalation:
Move to an area free from further risk of exposure. Administer oxygen or artificial respiration as needed. Obtain medical attention. Asthmatic-type symptoms may develop and may be immediate or delayed up to several hours. Treatment is essentially symptomatic. Consult physician.

Ingested:
DO NOT INDUCE VOMITING. Give 1 to 2 cups of milk or water to drink. DO NOT GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS OR CONVULSING PERSON. Consult a physician.

Recommendations to Physician:
Eyes: Stain for evidence of corneal injury. If cornea is burned, instill antibiotic steroid preparation frequently. Workplace vapors have produced reversible corneal epithelial edema impairing vision. This compound is a known skin sensitizer. Treat symptomatically as for contact dermatitis or thermal burns. There is no specific antidote for ingestion treat symptomatically. Inducing vomiting is
contraindicated because of the irritating nature of this compound. Inhalation treatment is essentially symptomatic. An individual having a dermal or pulmonary sensitization reaction to this material should be removed from exposure to any isocyanate.

VI. REACTIVITY DATA

Stability: -XXX-Stable: ----Unstable

Conditions to Avoid:
Contact with moisture and other materials which react with isocyanates. Temperatures above maximum storage temperature. Incompatibility (materials to avoid):
Moisture and other materials that react with isocyanates.

Hazardous Decomposition Products:
Oxides of nitrogen, hydrogen cyanide, carbon dioxide and carbon monoxide.

Hazardous Polymerization: --May Occur X-Will not occur

Conditions to avoid:
Temperatures above maximum storage temperatures.

VII. SPILL, LEAK AND DISPOSAL PROCEDURES

Steps to be taken if material is released or spilled:
Consult section VIII for proper protective equipment. Evacuate non essential personnel. Ventilate the area. Dike or impound spilled material and control further spillage if feasible. Notify appropriate authorities if necessary. Cover spill with sawdust, vermiculite, Fuller's earth or other absorbent material; pour liquid decontaminant over spillage -- allow to react at least ten min., collect material in open containers -- add further amounts of decontaminant solution. Remove containers to safe place -- cover LOOSELY. Wash down area with decontaminant and flush area with water.

Decontamination solutions: Ammonium hydroxide (0-10%), detergent (2-5%) and balance water; or solution of Union Carbide's Tergitol TMN-10 (20%) and water (80%).

Waste Disposal Method:
-XX-Incinerate -NA-Landfill according to any Local, State and Federal Regulations.

Incineration is method of choice. Empty containers must be handled with care due to product residue. decontamination of containers prior to disposal is usually recommended. Contact your disposal company for details.

VIII. SPECIAL HANDLING INFORMATION

Respiratory Protection:
A respirator that is recommended or approved for use in isocyanate containing environments (air purifying or fresh air supplied) may be necessary. The use of a positive pressure supplied air respirator is mandatory when: airborne isocyanate concentrations are not known or exceed 0.005 ppm; operations are performed in a confined space or area with limited ventilation; material is heated. An
air-purifying respirator is not generally recommended due to the poor warning properties, (e.g., odor or irritation, of this material. By the time the worker would detect leakage of the face seal or breakthrough of the filter cartridge, his exposure could be well above the TLV. Consider the type of application, airborne isocyanate concentrations and materials being used concurrently when determining respirator use and selection. Observe OSHA regulations for respirator use (29CFR 1910.134).

Ventilation:
Exhaust ventilation sufficient to keep the airborne concentration below the TLV must be utilized. Exhaust ventilation should be provided in accordance with the guidelines in INDUSTRIAL VENTILATION published by the American Conference of Governmental Hygienists. Local exhaust: Recommended
Exhaust air may need to be cleaned by scrubbers or filters to reduce environmental contamination.

Skin Protection:
Chemical resistant gloves. Cover as much of the exposed skin area as possible with appropriate clothing. If skin creams are used, keep the area protected only by the cream to a minimum. When there is potential for a major splash directly onto the skin, such as when breaking into lines, a full acid suit is required. When the application may result in airborne vapor or mist, a full, permeation resistant, protective suit including head covering and face shield, gloves, and overshoes is required.

Eye Protection:
Chemical workers goggles. Safety glasses with side shields.

Other Protective Clothing or Equipment:
Apron and face shield. Safety showers and eye wash stations should be available. Cover as much of exposed skin area as necessary with appropriate clothing.

Work Practices, hygienic practices
Use good hygiene.

=============== IX SPECIAL PRECAUTIONS ===============

Handling and Storage:
Storage temperature (min/max): 32F (0C) / 122F (50C)
Other Precautions:
Keep away from heat, sparks and open flame. Store in tightly closed container and protect from moisture and foreign materials.

=============== X ADDITIONAL INFORMATION ===============

SARA Title III Requirements:
Chemical Name | Section: 302 CERCLA 313
| Materials Not Listed |
T.S.C.A. Status: On Inventory
Name (print): George C. Karpin

Signature: George C. Karpin, M.D.

Title: Toxicological Coordinator

In case of accident use the phone number provided.

Date of last revision: 9/21/89

To the best of our knowledge, the information contained therein is accurate and meets all State and Federal Guidelines. However, CONAP INC. does not assume any liability whatsoever for the accuracy or completeness of the information contained herein. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist. Final determination of the suitability of any material is the sole responsibility of the user.

*CONATHANE is a Registered Trademark of CONAP, INC.

Date approved: 9/21/89

Approved: William R. Johnson

ND = Not Determined

NA = Not Applicable

Approved: 9/24/89
### I. IDENTIFICATION

**Trade Name:** CONATHANE® TU-956 Part B  
**Date:** 5/10/91

**Chemical Name, common name:** Complex Mixture

### II. HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>CAS No.</th>
<th>%</th>
<th>ACGIH TLV</th>
<th>OSHA PEL</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diethyltoluene diamine</td>
<td>68479-98-1</td>
<td>50-60%</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Oxypropylated Polyether</td>
<td>25791-96-2</td>
<td>&lt;10%</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Polyether Diol</td>
<td>25322-69-4</td>
<td>&lt;20%</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>2,2-Dimethyl-1,3-propanediol</td>
<td>126-30-7</td>
<td>&lt;5%</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

Material may present a dust hazard if cut, ground, or machined after curing.

### III. PHYSICAL DATA

- **Boiling Point:** ND
- **Specific Gravity (H2O=1):** ND
- **Vapor Pressure, mm Hg:** ND
- **Vapor Density (air=1):** ND
- **Melting Pt./Range:** ND
- **Evaporation rate (Ether=1):** ND
- **Solubility in Water:** ND
- **Physical State:** LIQUID
- **Percent volatile by volume:** Nil
- **Appearance and Odor:** Amber colored liquid.

### IV. FIRE AND EXPLOSION DATA

- **Flash Point,F (Method):** > 275 F (TCC)
- **Flammability Limits:** LEL: ND  UEL: ND
- **Extinguishing Materials:** (X)-Water Spray  (X)-Dry Chemical  (X)-Carbon Dioxide  (X)-Foam  -ND-Other:
- **Special Firefighting Procedures:** None
- **Unusual Fire and Explosion Hazards:** None

### V. HEALTH HAZARD INFORMATION

#### ACUTE TOXICITY (Routes of entry)
- **Inhalation:** No data available.
- **Ingestion:** Expected to be toxic. Do Not ingest.
- **Eye Contact:** May cause minor irritation.
- **Skin Contact:** Mild skin irritant.
- **Skin Absorption:** Expected to be toxic.

#### CHRONIC TOXICITY
- **Carcinogenicity:** --X--No
- **Not listed as a carcinogen.**
- **NA-NTF**  **---NA-IARC**  **--NAFederal OSHA**
- **Target Organ Affected:**
- **A two year feeding study in rats is in progress.**
Preliminary data from this study indicates that Diethyltoluene diamine causes pancreatic effects in laboratory animals. Diethyltoluenediamine has been tested in an extensive battery of in vivo and in vitro short term assays. The results of the battery as a whole predict that Diethyltoluene diamine will not exhibit carcinogenic activity in and animal bioassay. Nonreproducible activity was demonstrated by Diethyltoluene diamine in the Ames test and BALB/3T3 cell point mutation assay. Mutagenic activity has also been reported in the in vitro cytogenetics assay. There are increased incidence of liver tumors (hepatocellular carcinomas) and thyroid tumors (follicular cell adenomas) in male rats at the highest dose level (70ppm in the diet). These are not rare tumors in the strain of rats tested in the study, but are usually found at a low level. No increase in pancreatic tumors was found even though the pancreas was the target organ in subchronic tests. Toxic effects were found in the pancreas and liver of the high dose male rats. Effects may also have been found in the adrenal glands and eyes of these rats. Evaluation of tissues from the control and high dose female rats is underway.

Effects of Overexposure:
Mild eye irritant.; In rare instances, sensitization to DETA has been reported to occur in humans.

Medical Conditions Aggravated By Exposure: ND

FIRST AID: EMERGENCY PROCEDURES
Eye Contact:
Begin immediate eye irrigation with cool water. Consult a physician if irritation persists.
Skin Contact:
Flush skin with water. Wash skin with soap and water. Remove contaminated clothing and shoes. Clean contaminated clothing thoroughly before reuse.
Inhalation:
Remove victim to fresh air. If breathing is difficult administer oxygen. If victim has stopped breathing administer artificial respiration. Do not give anything by mouth to an unconscious person. Get medical attention.
Ingested:
Induce vomiting immediately by giving two glasses of water and sticking finger down throat. Never give anything by mouth to an unconscious person.
Recommendations to Physician: Follow standard procedures.

REACTIVITY DATA
Stability: --X--Stable
--NA-Unstable

Conditions to Avoid: None
Incompatibility (materials to avoid): None
Hazardous Decomposition Products:
Carbon dioxide, oxides of nitrogen, carbon monoxide.
Hazardous Polymerization: NA-May Occur X-Will not occur
Conditions to avoid: None
VII. SPILL, LEAK AND DISPOSAL PROCEDURES

Steps to be taken if material is released or spilled:
Consult section VIII for proper protective equipment.
Contain any spills with dikes or absorbents to prevent
migration and entry into sewer and streams. Take up small
spills with dry chemical absorbent. Large spills may be
taken up with pump or vacuum and finished off with dry
chemical absorbent. May require excavation of contaminated
soil.

Waste Disposal Methods:
This material may contain leachable elemental mercury as
determined by the Toxic Chemical Leaching Procedure (TCLP). The
levels of mercury are in sufficient quantity to classify this
material as a D009 Hazardous Waste.
Dispose of in accordance with all applicable local State and
Federal regulations.

VIII. SPECIAL HANDLING INFORMATION

Respiratory Protection:
NIOSH approved organic respirator when exposed to heated
vapors. Observe OSHA regulations for respirator use (29 CFR
1910.134).

Ventilation: Local exhaust—At source of heated vapors.

Mechanical Recommended

Protective Gloves: Resistant to chemical penetration.

Eye Protection: Chemical goggles.

Other Protective Clothing or Equipment: If skin contact or
contamination of clothing is likely, protective clothing
should be worn.


IX. SPECIAL PRECAUTIONS

Handling and Storage: None

Other Precautions: None.

X. ADDITIONAL INFORMATION

SARA Title III Requirements:

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Section: 302</th>
<th>CERCLA</th>
<th>313</th>
</tr>
</thead>
</table>

| Materials not listed. |

T.S.C.A. Status: On Inventory

Name(print): George C. Karpin
Signature: !This formulation is subject
Title: Toxicological Coordinator
Date last revision: 5/10/91
Phone number provided.

To the best of our knowledge, the information contained
herein is accurate and meets all State and Federal
guidelines. However, CONAP INC. does not assume any
liability what so ever for the accuracy or completeness of
the information contained herein. All materials may present
unknown hazards and should be used with caution. Although
certain hazards are described herein, we cannot guarantee
that these are the only hazards which exist. Final
determination of the suitability of any material is the
sole responsibility of the user.

*CONATHANE is a Registered Trademark of CONAP, INC.

Date approved: 5/10/91 Approved: 
ND=Not Determined
NA=Not Applicable
Date approved: 5/13/91 Approved:
## IDENTIFICATION

<table>
<thead>
<tr>
<th>Chemical Names</th>
<th>CAS No.</th>
<th>%</th>
<th>ACGIH(TLV)</th>
<th>OSHA(PEL)</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dicyclohexylmethane-4,4'-Diisocyanate</td>
<td>5124-30-1</td>
<td>&lt;10%</td>
<td>0.005ppm</td>
<td>0.1 ppm Ceiling</td>
<td></td>
</tr>
<tr>
<td>Di n-Butyl Phthalate</td>
<td>84-74-2</td>
<td>&lt;10%</td>
<td>5mg/m3</td>
<td>5mg/m3</td>
<td>ND</td>
</tr>
</tbody>
</table>

Material may present a dust hazard if cut, ground or machined after curing.

## PHYSICAL DATA

- **Boiling Point:** ND
- **Specific Gravity (H2O=1):** 1.05
- **Vapor Pressure, mm Hg @25C:** 0.001
- **Vapor Density (air=1):** >1
- **Evaporation rate (Ether=1):** ND
- **Physical State:** LIQUID
- **Percent volatile by volume:** NIL
- **Appearance and Odor:** CLEAR VISCOUS LIQUID, NO DISTINCT ODOR

## FIRE AND EXPLOSION DATA

- **Flash Point,F (Method):** > 395 CC
- **Flammable Limits:** ND LEL: ND UEL: ND
- **Extinguishing Materials:**
  - XX-Water Spray
  - XX-Dry Chemical
  - XX-Carbon Dioxide
  - ND-Other:
- **Special Firefighting Procedures:**
  - Fire fighters should wear self contained breathing apparatus.
  - Unusual Fire and Explosion Hazards:
  - Toxic gases may be present as a result of thermal decomposition or combustion. Closed container may explode when exposed to extreme heat. Use cold water spray to cool fire exposed containers to reduce the risk of rupture. Closed container may also burst if contaminated with water due to CO2 evolved.

## HEALTH HAZARD INFORMATION

### ACUTE TOXICITY (Routes of entry)

#### Inhalation:
- Lowest Lethal Concentration of dicyclohexyl methane diisocyanate 200 mg/m3 (19 ppm) 4 hrs.-rat.
- Inhalation of dust and vapors at concentrations above the TLV can irritate (burning sensation) the mucous membranes in the respiratory tract (nose, throat, lungs) causing runny nose, sore throat, coughing, chest discomfort, shortness of breath and reduced lung function/breathing
obstruction. Persons with a preexisting, nonspecific bronchial hyperreactivity can respond to concentrations below the intended TLV with similar symptoms as well as an asthma attack. Exposure well above the TLV may lead to bronchitis. Bronchial spasm and pulmonary edema (fluid in the lungs). These effects are usually reversible.

Chemical or hypersensitive pneumonitis, with flu-like symptoms (e.g., fever, chills), has also been reported.

Ingestion:

(Acute Exposure) Can result in irritation and corrosive action in the mouth, stomach tissue and digestive tract.

Eye Contact: Mild irritant; reversible - rabbit (Acute Exposure) Liquid, aerosols or vapors are irritating and can cause tearing, reddening and swelling.

Skin Contact: Skin irritant and sensitizer - Guinea Pig. Isocyanates react with skin protein and moisture and can cause irritation which may include the following symptoms: reddening, swelling, rash, scaling or blistering. Cured material is difficult to remove. Experience indicates that direct skin contact is the route of exposure most likely to cause sensitization. Once sensitized, an individual may react even to airborne levels below the TLV with the following symptoms: itching and tingling of the earlobes and neck, rash, hives, swelling of the arms and legs or other symptoms common to allergic dermatitis. These symptoms may be immediate or delayed several hours.

Skin Absorption: ND

CHRONIC TOXICITY

Carcinogenicity: -XXX-No
Not considered a carcinogen.
-NA-Yes: ---NA-NTP ---NA-IARC -NA-Federal OSHA

Target Organ Affected:

High doses of Di n-butyl Pthalate administered in the diet to mice throughout gestation have bee associated with embryotoxic and possibly teratogenic effects in this species.

Effects of Overexposure:

Material is a primary skin irritant and potent skin sensitizer. Experience indicates that direct skin contact is the route of exposure most likely to cause sensitization. Once sensitized an individual may react to airborne levels below the TLV with the following symptoms: itching and tingling of the earlobe and neck, rash, hives, swelling of the arms and legs or symptoms common to allergic dermatitis (rash). Inhalation of vapors or spray mist may also cause irritation of the respiratory tract (dry throat, cough, shortness of breath, chest tightness). These symptoms could be immediate or delayed up to several hours.

Similar to many non-specific asthmatic responses, there are reports that once sensitized an individual can experience these symptoms upon exposure to dust, cold air or other irritants. This increased lung sensitivity can persist for weeks and in severe cases for several years. Chronic overexposure to isocyanate has also been reported to cause lung damage
(including decrease in lung function) which may be permanent. Sensitization can either be temporary or permanent.

Medical Conditions Aggravated By Exposure:
Existing lung conditions and dermal conditions may be aggravated by use of this material.

FIRST AID: EMERGENCY PROCEDURES

Eye Contact:
Flush with clean, lukewarm water (low pressure) for at least 15 minutes, occasionally lifting eye lids. Obtain immediate medical attention.

Skin Contact:
Remove contaminated clothing. Wash skin promptly and thoroughly with soap and water. After washing, cover affected areas with polyethylene glycol (300-500 mol.wt.) and wash again with soap and water. Wash contaminated clothing thoroughly before reuse. Allergic dermatitis should be treated by a physician to relieve the symptoms. For severe exposures, get under safety shower after removing clothing. Seek medical attention if irritation or allergic dermatitis symptoms develop, or if gross exposure occurs.

Inhalation:
Move to an area free from further risk of exposure. Administer oxygen or artificial respiration as needed. Obtain medical attention. Asthmatic-type symptoms may develop and may be immediate or delayed up to several hours. Treatment is essentially symptomatic. Consult physician.

Ingested:
DO NOT INDUCE VOMITING. Give 1 to 2 cups of milk or water to drink. DO NOT GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS OR CONVULSING PERSON. Consult a physician.

Recommendations to Physician:
Eyes: Stain for evidence of corneal injury. If cornea is burned, instill antibiotic steroid preparation frequently. Workplace vapors have produced reversible corneal epithelial edema impairing vision. This compound is a known skin sensitizer. Treat symptomatically as for contact dermatitis or thermal burns. There is no specific antidote for ingestion treat symptomatically. Inducing vomiting is contraindicated because of the irritating nature of this compound. Inhalation treatment is essentially symptomatic. An individual having a dermal or pulmonary sensitization reaction to this material should be removed from exposure to any isocyanate.

VI. REACTIVITY DATA

Stability:
-XXX-Stable: ----Unstable

Conditions to Avoid:
Contact with moisture and other materials which react with isocyanates. Temperatures above maximum storage temperature.

Incompatibility (materials to avoid):
Moisture and other materials that react with isocyanates.

Hazardous Decomposition Products:
Oxides of nitrogen, hydrogen cyanide, carbon dioxide and
carbon monoxide.

Hazardous Polymerization: --May Occur \ X-Will not occur

Conditions to avoid: Temperatures above maximum storage temperatures.

======== VII. SPILL, LEAK AND DISPOSAL PROCEDURES ========

Steps to be taken if material is released or spilled:
Consult section VIII for proper protective equipment.
Evacuate non essential personnel. Ventilate the area. Dike or impound spilled material and control further spillage if feasible. Notify appropriate authorities if necessary.
Cover spill with sawdust, vermiculite, Fuller's earth or other absorbent material; pour liquid decontaminant over spillage -- allow to react at least ten min., collect material in open containers -- add further amounts of decontaminate solution. Remove containers to safe place -- cover LOOSELY. Wash down area with decontaminant and flush area with water.

Decontamination solutions: Ammonium hydroxide (0-10%), detergent (2-5%) and balance water; or solution of Union Carbide's Tergitol TMN-10 (20%) and water (80%).

Waste Disposal Method:
-XX-Incinerate -NA-Landfill according to any Local, State and Federal Regulations.

Incineration is method of choice. Empty containers must be handled with care due to product residue. Decontamination of containers prior to disposal is usually recommended. Contact your disposal company for details.

======== VIII. SPECIAL HANDLING INFORMATION ========

Respiratory Protection:
A respirator that is recommended or approved for use in isocyanate containing environments (air purifying or fresh air supplied) may be necessary. The use of a positive pressure supplied air respirator is mandatory when: airborne isocyanate concentrations are not known or exceed 0.005 ppm; operations are performed in a confined space or area with limited ventilation; material is heated. An air-purifying respirator is not generally recommended due to the poor warning properties, (e.g. odor or irritation, of this material. By the time the worker would detect leakage of the face seal or breakthrough of the filter cartridge, his exposure could be well above the TLV. Consider the type of application, airborne isocyanate concentrations and materials being used concurrently when determining respirator use and selection. Observe OSHA regulations for respirator use (29CFR 1910.134).

Ventilation:
Exhaust ventilation sufficient to keep the airborne concentration below the TLV must be utilized. Exhaust ventilation should be provided in accordance with the guidelines in INDUSTRIAL VENTILATION published by the American Conference of Governmental Hygienists.

Local exhaust: Recommended
Exhaust air may need to be cleaned by scrubbers or filters to reduce environmental contamination.
Skin Protection:
Chemical resistant gloves. Cover as much of the exposed skin area as possible with appropriate clothing. If skin creams are used, keep the area protected only by the cream to a minimum. When there is potential for a major splash directly onto the skin, such as when breaking into lines, a full acid suit is required. When the application may result in airborne vapor or mist, a full, permeation resistant, protective suit including head covering and face shield, gloves, and overshoes is required.

Eye Protection:
Chemical workers goggles. Safety glasses with side shields.

Other Protective Clothing or Equipment:
Apron and face shield. Safety showers and eye wash stations should be available. Cover as much of exposed skin area as necessary with appropriate clothing.


Handling and Storage:
Storage temperature (min/max): 32°F (0°C) / 122°F (50°C)

Other Precautions:
Keep away from heat, sparks and open flame. Store in tightly closed container and protect from moisture and foreign materials.

SARA Title III Requirements:

Chemical Name: Di n-butyl Phthalate  
Section: 302 CERCLA 313  
T.S.C.A. Status: On Inventory  
Name (print): George C. Karpin  
Signature:  
Title: Toxicological Coordinator  
Date of last revision: 3/91  
Phone number provided:  

To the best of our knowledge, the information contained therein is accurate and meets all State and Federal Guidelines. However, CONAP INC. does not assume any liability whatsoever for the accuracy or completeness of the information contained herein. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist. Final determination of the suitability of any material is the sole responsibility of the user.

CONATHANE is a Registered Trademark of CONAP, INC.

Date approved: 4/5/91  
Approved:

ND = Not Determined  
NA = Not Applicable  

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
--- MATERIAL SAFETY DATA SHEET ---

### I. IDENTIFICATION

**Trade Name:** CONATHANE TU-361 Part B  
**Chemical Name, common name:** Complex mixture 110

### II. HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>CAS No.</th>
<th>%</th>
<th>ACGIH (TLV)</th>
<th>OSHA (PEL)</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Di n-Butyl Phthalate</td>
<td>84-74-2</td>
<td>40-50%</td>
<td>5 mg/m³</td>
<td>5 mg/m³</td>
<td>ND</td>
</tr>
<tr>
<td>Methylene Bis Anilines</td>
<td>ND</td>
<td>50-60%</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

Material may present a dust hazard if cut, ground, or machined after curing.

### III. PHYSICAL DATA

- **Boiling Point:** ND
- **Specific Gravity (H₂O=1):** ND
- **Vapor Pressure, mm Hg:** ND
- **Vapor Density (air=1):** ND
- **Melting Pt./Range:** ND
- **Evaporation rate (Ether=1):** ND
- **Solubility in Water:** > 25%
- **Physical State:** LIQUID
- **Percent volatile by volume:** Nil
- **Appearance and Odor:** Liquid; No distinct odor

### IV. FIRE AND EXPLOSION DATA

- **Flash Point, °F (Method):** > 200 °F
- **Flammable Limits:** ND
  - LEL: ND
  - UEL: ND

### Extinguishing Materials:

- XX-Water Spray
- XX-Dry Chemical
- XX-Carbon Dioxide
- ND-Other:

### Special Firefighting Procedures:

Use standard turnout equipment. A self-contained breathing apparatus is recommended.

### Unusual Fire and Explosion Hazards:

None

### V. HEALTH HAZARD INFORMATION

#### ACUTE TOXICITY (Routes of entry)

**Inhalation:**

Not considered a route of entry. However, if the product is heated, misted or sprayed, it may cause irritation to the eyes, nose, throat and upper respiratory tract.

#### Ingestion:

Based on Di n-Butyl Phthalate, oral toxicity not established, but based on basis of similar compositions believed very low. Initial symptoms may be delayed and may include nausea, vomiting and dizziness. Additional symptoms may include headache, pain and irritation to the eyes, tearing, conjunctivitis and photophobia. The chronic health effects of this product have not been fully determined.

**Eye Contact:** May cause eye irritation.
Skin Contact: May cause skin irritation and sensitization.

Skin Absorption: ND

CHRONIC TOXICITY
Carcinogenicity: - X - No
Not listed as a carcinogen
---NA-NTP --NA--IARC -NA-Federal OSHA

Target Organ Affected:
High doses of Di Butyl Phthalate administered in the diet to mice throughout gestation have been associated with embryotoxic and possibly teratogenic effects in this species. The dietary administration of Di Butyl Phthalate has produced severe testicular atrophy in rats.

Effects of Overexposure:
Eyes: Mildly irritating.
Ingestion: Non toxic
Skin: Mildly irritating
Inhalation: May be mildly irritating at temperatures above 160 F.

Medical Conditions Aggravated By Exposure: None currently known.

FIRST AID: EMERGENCY PROCEDURES
Eye Contact:
Flush with water for at least 15 minutes. If irritation persists consult physician.

Skin Contact: Wash with soap and water.

Inhalation: Remove person to fresh air.

Ingested: Dilute with 12 oz. of water; consult physician.

Recommendations to Physician: Treat symptoms.

Stability: - X - Stable - ND - Unstable

Conditions to Avoid: None

Incompatibility (materials to avoid):
Strong oxidizers, acids, strong bases

Hazardous Decomposition Products:
From fire and excessive heat: Carbon dioxide and carbon monoxide.

Hazardous Polymerization: ND May Occur X- Will not occur

Conditions to avoid: None

VII. REACTIVITY DATA

Conditions to avoid: None

Steps to be taken if material is released or spilled:
Consult section VII for proper protective equipment.
Soak up product in absorbent material, remove to container for disposal.

Waste Disposal Method:
Dispose according to any Local, State and Federal Regulations.

VIII. SPECIAL HANDLING INFORMATION

Respiratory Protection: None needed under normal conditions.
Ventilation:
Local exhaust--ND-- Mechanical--- XXX - Special-----

Protective Gloves: Impervious plastic or rubber.
Eye Protection: Glasses with side shields.
Other Protective Clothing or Equipment: Eye wash stations. 
Work Practices, hygienic practices: Wash after handling material.

=============== IX SPECIAL PRECAUTIONS ===============
Handling and Storage: Protect material from moisture. 
Other Precautions: None

================ ; < ADDITIONAL INFORMATION ================
SARA Title III Requirements:
Chemical Name
Section: 302 
CERCLA 313

|Di n-Butyl Phthalate | NA | 10lb Listed |

T.S.C.A. Status: On Inventory

Name(print): George C. Karpin
Signature: !to change without notice.
Title: Toxicological Coordinator

Date last revision: 4/3/91
Phone number provided.

To the best of our knowledge, the information contained herein is accurate and meets all State and Federal guidelines. However, CONAP INC. does not assume any liability what so ever for the accuracy or completeness of the information contained herein. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist. Final determination of the suitability of any material is the sole responsibility of the user.

CONATHANE is a Registered Trademark of CONAP, INC.

Date approved: 4/5/91
Approved:

ND=Not Determined
NA=Not Applicable

Date approved: 4/5/91
Approved:
Note: This form is to be used to comply with OSHA's Hazard Communication Standard, 29 CFR 1910.1200. Blank spaces are not permitted.

I. IDENTIFICATION

Trade Name: CONATHANE® TU-981 Part A Date: 2/6/91
Chemical Name, common name: Polyurethane Prepolymer

II. HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>CAS No.</th>
<th>%</th>
<th>ACGIH(TLV)</th>
<th>OSHA(PEL)</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dicyclohexylmethane-4,4'-Diisocyanate</td>
<td>5124-30-1</td>
<td>&lt;10%</td>
<td>0.00 ppm</td>
<td>5 ppm</td>
<td>NA NA</td>
</tr>
<tr>
<td>Meta Tetramethyl Xylene Diisocyanate</td>
<td>2778-42-9</td>
<td>&lt;10%</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

Material may present a dust hazard if cut, ground or machined after curing.

III. PHYSICAL DATA

Boiling Point: ND
Specific Gravity (H2O=1): 1.05
Vapor Pressure, mm Hg @25°C: 0.001
Vapor Density (air=1): 1
Melting Pt./Range: ND
Evaporation rate (Ether=1): ND
Solubility in Water: REACTS
Percent volatile by volume: NIL
Physical State: LIQUID

IV. FIRE AND EXPLOSION DATA

Flash Point, F (Method): > 395 °C
Extinguishing Materials:
-XX-Water Spray -XX-Dry Chemical -XX-Carbon Dioxide
-XX-Foam -ND-Other:

Unusual Fire and Explosion Hazards:
Toxic gases may be present as a result of thermal decomposition or combustion. Closed container may explode when exposed to extreme heat. Use cold water spray to cool fire exposed containers to reduce the risk of rupture. Closed container may also burst if contaminated with water due to CO2 evolved.

V. HEALTH HAZARD INFORMATION

ACUTE TOXICITY (Routes of entry)

Inhalation:
Lowest Lethal Concentration of dicyclohexyl methane diisocyanate 200 mg/m3 (19 ppm) 4 hrs.-rat.

Inhalation of dust and vapors at concentrations above the TLV can irritate (burning sensation) the mucous membranes in the respiratory tract (nose, throat, lungs) causing
runny nose, sore throat, coughing, chest discomfort, shortness of breath and reduced lung function (breathing obstruction). Persons with a preexisting, nonspecific bronchial hyperreactivity can respond to concentrations below the intended TLV with similar symptoms as well as an asthma attack. Exposure well above the TLV may lead to bronchitis, bronchial spasm and pulmonary edema (fluid in the lungs). These effects are usually reversible. Chemical or hypersensitive pneumonitis, with flu-like symptoms (e.g., fever, chills), has also been reported.

Ingestion:
(Acute Exposure) Can result in irritation and corrosive action in the mouth, stomach tissue and digestive tract.

Eye Contact:
Mild irritation was produced with TMXDI during irritation studies.

(Acute Exposure) Liquid, aerosols or vapors are irritating and can cause tearing, reddening and swelling.

Skin Contact:
Skin irritant and sensitizer - Guinea Pig
Isocyanates react with skin protein and moisture and can cause irritation which may include the following symptoms: reddening, swelling, rash, scaling or blistering. Cured material is difficult to remove. Experience indicates that direct skin contact is the route of exposure most likely to cause sensitization. Once sensitized, an individual may react even to airborne levels below the TLV with the following symptoms: itching and tingling of the earlobes and neck, rash, hives, swelling of the arms and legs or other symptoms common to allergic dermatitis. These symptoms may be immediate or delayed several hours.

Skin Absorption:
ND

CHRONIC TOXICITY
Carcinogenicity: -XXX-No
-NA-Yes: ---NA-NTP --NA-IARC -NA-Federal OSHA

Target Organ Affected:
Specific target organ information not available at this time.

Effects of Overexposure:
Material is a primary skin irritant and potent skin sensitizer. Experience indicates that direct skin contact is the route of exposure most likely to cause sensitization. Once sensitized, an individual may react to airborne levels below the TLV with the following symptoms: itching and tingling of the earlobe and neck, rash, hives, swelling of the arms and legs or symptoms common to allergic dermatitis (rash). Inhalation of vapors or spray mist may also cause irritation of the respiratory tract (dry throat, cough, shortness of breath, chest tightness). These symptoms could be immediate or delayed up to several hours. Similar to many non-specific asthmatic responses, there are reports that once
sensitized an individual can experience these symptoms upon exposure to dust, cold air or other irritants. This increased lung sensitivity can persist for weeks and in severe cases for several years. Chronic overexposure to isocyanate has also been reported to cause lung damage (including decrease in lung function) which may be permanent. Sensitization can either be temporary or permanent.

-----------------------------------------------
Medical Conditions Aggravated By Exposure:
Existing lung conditions and dermal conditions may be aggravated by use of this material.

-----------------------------------------------

FIRST AID: EMERGENCY PROCEDURES

Eye Contact:
Flush with clean, lukewarm water (low pressure) for at least 15 minutes, occasionally lifting eye lids. Obtain immediate medical attention.

Skin Contact:
Remove contaminated clothing. Wash skin promptly and thoroughly with soap and water. After washing, cover affected areas with polyethylene glycol (300-500 mol wt.) and wash again with soap and water. Wash contaminated clothing thoroughly before reuse. Allergic dermatitis should be treated by a physician to relieve the symptoms. For severe exposures, get under safety shower after removing clothing. Seek medical attention if irritation or allergic dermatitis symptoms develop, or if gross exposure occurs.

Inhalation:
Move to an area free from further risk of exposure. Administer oxygen or artificial respiration as needed. Obtain medical attention. Asthmatic-type symptoms may develop and may be immediate or delayed up to several hours. Treatment is essentially symptomatic. Consult physician.

Ingested:
DO NOT INDUCE VOMITING. Give 1 to 2 cups of milk or water to drink. DO NOT GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS OR CONVULSING PERSON. Consult a physician.

Recommendations to Physician:
Eyes: Stain for evidence of corneal injury. If cornea is burned, instill antibiotic steroid preparation frequently. Workplace vapors have produced reversible corneal epithelial edema impairing vision. This compound is a known skin sensitizer. Treat symptomatically as for contact dermatitis or thermal burns. There is no specific antidote for ingestion treat symptomatically. Inducing vomiting is contraindicated because of the irritating nature of this compound. Inhalation treatment is essentially symptomatic. An individual having a dermal or pulmonary sensitization reaction to this material should be removed from exposure to any isocyanate.

VI. REACTIVITY DATA

Stability: -XXX-Stable: ----Unstable

Conditions to Avoid:
Contact with moisture and other materials which react with isocyanates. Temperatures above maximum storage temperature.

Incompatibility (materials to avoid):
Moisture and other materials that react with isocyanates.

Hazardous Decomposition Products:
Oxides of nitrogen, hydrogen cyanide, carbon dioxide and carbon monoxide.

Hazardous Polymerization: --May Occur X-Will not occur

Conditions to avoid:
Temperatures above maximum storage temperatures.

VII. SPILL, LEAK AND DISPOSAL PROCEDURES

Steps to be taken if material is released or spilled:
Consult section VIII for proper protective equipment.
Evacuate non essential personnel. Ventilate the area. Dike or impound spilled material and control further spillage if feasible. Notify appropriate authorities if necessary.
Cover spill with sawdust, vermiculite, Fuller's earth or other absorbent material; pour liquid decontaminant over spillage -- allow to react at least ten min., collect material in open containers -- add further amounts of decontaminant solution. Remove containers to safe place -- cover LOOSELY. Wash down area with decontaminant and flush area with water.

Decontamination solutions: Ammonium hydroxide (0-10%), detergent (2-5%) and balance water; or solution of Union Carbide's Tergitol TMN-10 (20%) and water (80%).

Waste Disposal Method:
-XX-Incinerate -NA-Landfill according to any Local, State and Federal Regulations.

Incineration is method of choice. Empty containers must be handled with care due to product residue. Decontamination of containers prior to disposal is usually recommended.
Contact your disposal company for details.

VIII. SPECIAL HANDLING INFORMATION

Respiratory Protection:
A respirator that is recommended or approved for use in isocyanate containing environments (air purifying or fresh air supplied) may be necessary. The use of a positive pressure supplied air respirator is mandatory when: airborne isocyanate concentrations are not known or exceed 0.005 ppm; operations are performed in a confined space or area with limited ventilation; material is heated. An air-purifying respirator is not generally recommended due to the poor warning properties, (e.g. odor or irritation, of this material. By the time the worker would detect leakage of the face seal or breakthrough of the filter cartridge, his exposure could be well above the TLV. Consider the type of application, airborne isocyanate concentrations and materials being used concurrently when determining respirator use and selection. Observe OSHA regulations for respirator use (29CFR 1910.134).

Ventilation:
Exhaust ventilation sufficient to keep the airborne concentration below the TLV must be utilized. Exhaust
ventilation should be provided in accordance with the guidelines in INDUSTRIAL VENTILATION published by the American Conference of Governmental Hygienists.

Local exhaust: Recommended

Exhaust air may need to be cleaned by scrubbers or filters to reduce environmental contamination.

Skin Protection:
Chemical resistant gloves. Cover as much of the exposed skin area as possible with appropriate clothing. If skin creams are used, keep the area protected only by the cream to a minimum. When there is potential for a major splash directly onto the skin, such as when breaking into lines, a full acid suit is required. When the application may result in airborne vapor or mist, a full, permeation resistant, protective suit including head covering and face shield, gloves, and overshoes is required.

Eye Protection:
Chemical workers goggles. Safety glasses with side shields.

Other Protective Clothing or Equipment:
Apron and face shield. Safety showers and eye wash stations should be available. Cover as much of exposed skin area as necessary with appropriate clothing.

Work Practices, hygienic practices:
Use good hygiene.

EXPOSURE CONTROL METHODS:
Where a closed system is not used, good enclosure and local exhaust ventilation should be provided to minimize exposure. Food, beverages, tobacco products should not be carried, stored or consumed where this chemical is in use. Before eating, drinking or smoking wash face and hands with soap and water.

Handling and Storage:
Storage temperature (min/max): 32°F (0°C) / 122°F (50°C)

Other Precautions:
Keep away from heat, sparks and open flame. Store in tightly closed container and protect from moisture and foreign materials.

SARA Title III Requirements:

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Section: 302 CERCLA 313</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials Not Listed</td>
<td></td>
</tr>
</tbody>
</table>

T.S.C.A. Status: Not On Inventory

Name(print): George C. Karpin
Signature: [Signature]
Title: Toxicological Coordinator

In case of accident use the phone number provided.

To the best of our knowledge, the information contained therein is accurate and meets all State and Federal requirements.
Guidelines. However, CONAP INC. does not assume any liability whatsoever for the accuracy or completeness of the information contained herein. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist. Final determination of the suitability of any material is the sole responsibility of the user.

*CONATHANE is a Registered Trademark of CONAP, INC.

Date approved 2/7/91 Approved: __________________________
ND=Not Determined
NA=Not Applicable 2/7/91 Approved: __________________________
 MATERIAL SAFETY DATA SHEET

Note: This form is to be used to comply with OSHA's Hazard Communication Standard, 29 CFR 1910.1200. Blank spaces are not permitted.

I. IDENTIFICATION

Trade Name: CONATHANE* TU-981 Part B Date: 3/5/90

Chemical Name, common name: Complex mixture

II. HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>Chemical Name, CAS No.</th>
<th>%</th>
<th>ACGIH(TLV)</th>
<th>OSHA(PEL)</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Di n-Butyl Phthalate</td>
<td>40-50%</td>
<td>5mg/m^3</td>
<td>5mg/m^3</td>
<td>ND</td>
</tr>
<tr>
<td>Methylene Bis orthoethylAniline</td>
<td>50-70%</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

Material may present a dust hazard if cut, ground, or machined after curing.

III. PHYSICAL DATA

Boiling Point: ND Specific Gravity (H2O=1): 1.06
Vapor Pressure, mm Hg: ND Vapor Density (air=1): ND
Melting Pt./Range: ND Evaporation rate (Ether=1): ND
Solubility in Water: > 25% Physical State: LIQUID
Percent volatile by volume: Nil
Appearance and Odor: Liquid; No distinct odor

IV. FIRE AND EXPLOSION DATA

Flash Point, F (Method): > 200 F
Flammable Limits: LEL: ND UEL: ND
Extinguishing Materials:
-XX-Water Spray -XX-Dry Chemical -XX-Carbon Dioxide
-XX-Foam -ND-Other:
Special Firefighting Procedures:
Use standard turnout equipment. A self contained breathing apparatus is recommended.

Unusual Fire and Explosion Hazards:
None

V. HEALTH HAZARD INFORMATION

ACUTE TOXICITY (Routes of entry)

Inhalation:
Inhalation will cause irritation to the respiratory tract.

Ingestion:
Based on Di n-Butyl Phthalate Oral toxicity not established, but based on basis of similar compositions believed very low. Initial symptoms may be delayed and may include nausea, vomiting and dizziness. Additional symptoms may include headache, pain and irritation to the eyes, tearing, conjunctivitis and photophobia. The chronic health effects of this product have not been fully determined.

Eye Contact:
Will cause severe eye irritation.
Skin Contact:
May cause skin irritation and sensitization.

Skin Absorption:
ND

CHRONIC TOXICITY
Carcinogenicity:- X -No
Not listed as a carcinogen
---NA-NTP --NA--IARC -NA-Federal OSHA

Target Organ Affected:
High doses of Di Butyl Phthalate administered in the diet to mice throughout gestation have been associated with embryotoxic and possibly teratogenic effects in this species. The dietary administration of Di Butyl Phthalate has produced severe testicular atrophy in rats.

Effects of Overexposure:
Eyes: Severely irritating.
Ingestion: Non toxic
Skin: Mildly irritating may cause sensitization.
Inhalation: May cause respiratory tract irritation.

Medical Conditions Aggravated By Exposure:
None currently known.

FIRST AID: EMERGENCY PROCEDURES
Eye Contact:
Flush with water for at least 15 minutes. If irritation persists consult physician.

Skin Contact:
Wash with soap and water.

Inhalation:
Remove person to fresh air.

Ingested:
Dilute with 12 oz. of water; consult physician.

Recommendations to Physician:
Treat symptoms.

VI. REACTIVITY DATA
Stability:
- X -Stable -ND--Unstable

Conditions to Avoid:
ND

Incompatibility (materials to avoid):
Strong oxidizers, acids, strong bases

Hazardous Decomposition Products:
From fire and excessive heat: Carbon dioxide and carbon monoxide.

Hazardous Polymerization:
ND May Occur X-Will not occur

Conditions to avoid:
None

VII. SPILL, LEAK AND DISPOSAL PROCEDURES
Steps to be taken if material is released or spilled:
Consult section VII for proper protective equipment.
Soak up product in absorbent material, remove to container for disposal.

Waste Disposal Method:
Dispose according to any Local, State and Federal Regulations.
VIII. SPECIAL HANDLING INFORMATION

Respiratory Protection:
Organic vapor respirator.

Ventilation:
Local exhaust--ND--Mechanical---XXX--Special---

Eye Protection:
Glasses with side shields.

Other Protective Clothing or Equipment:
Eye wash stations.

Work Practices, Hygienic Practices:
Wash after handling material.

IX. SPECIAL PRECAUTIONS

Handling and Storage:
Protect material from moisture.

Other Precautions:
None

X. ADDITIONAL INFORMATION

SARA Title III Requirements:

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Section</th>
<th>CERCLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Di n-Butyl Phthalate</td>
<td>NA</td>
<td>10lb Listed</td>
</tr>
</tbody>
</table>

T.S.C.A. Status: On Inventory

Name(print): George C. Karpin
Signature: !^°
Title: Toxicological Coordinator

In case of accident use the phone number provided.

To the best of our knowledge, the information contained herein is accurate and meets all State and Federal guidelines. However, CONAP INC. does not assume any liability what so ever for the accuracy or completeness of the information contained herein. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist. Final determination of the suitability of any material is the sole responsibility of the user.

* CONATHANE is a Registered Trademark of CONAP.

Date approved: 3/5/90
Approved: [Signature]

ND=Not Determined
NA=Not Applicable

Date approved: 3/6/90
Approved: [Signature]
Material Safety Data Sheet

Identification
Trade Name: HAPFLEX 595 A

Special Regulatory Hazards

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>CAS No.</th>
<th>Exposure Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methylenes Bis (4-cyclohexylisocyanate)</td>
<td>5124-30-1</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Hazard assessment based on available data.

Physical Data
Appearance and Odor: Colorless, low viscosity liquid- very slight odor
Solubility: Insoluble
Melting Point: NA
Boiling Point: 156°C

<table>
<thead>
<tr>
<th>NA = Not Applicable</th>
<th>ND = Not Determined</th>
<th>MT = more than</th>
<th>LT = less than</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Specific Gravity (H2O=1) = 1.1
Vapor Pressure @ 20°C = NA
Vapor Density (Air=1) = 1

Date Issued: 4/92

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
REACTIVITY DATA
Stability: Stable
Incompatibility: Al, Zn, strong oxidizers, water, alcohol, amines, strong bases, metal compounds or surface active materials
Decomposition Products: Oxides of carbon and nitrogen under burning conditions.

FIRE AND EXPLOSION HAZARD DATA
Flash Point: NA
Extinguishing Media: CO₂ Foam, or dry chemical
Special Fire Fighting Procedures: Water may be ineffective

SPECIAL PROTECTION INFORMATION
Ventilation: May be necessary. Keep container closed when not in use.
Personal Protection: Eye protection, impervious gloves
Good housekeeping practices are recommended.

STORAGE, SPILLS AND DISPOSAL INFORMATION
Storage: Store away from sources of direct heat in a dry area.
Spills: Large spills - Dike up and pump into appropriate containers,
Small spills - Dilute with water and recover or use non-combustible absorbent material/sand and shovel into suitable containers.
Disposal: Incinerate in accordance with local, state, and federal regulations. Keep out of public water supplies.

HEALTH RELATED DATA
Specific Hazard(s): Prolonged or repeated exposure may cause irritation or other allergic responses.
Primary Routes of Entry: Skin contact, eye contact, inhalation.
HEALTH RELATED DATA (cont)

First Aid Procedures:

Eye contact: Flush with water for 15 minutes. Get medical attention.

Skin contact: Wipe excess. Wash with rubbing alcohol, if available, followed by soap and water. Discard shoes if contaminated.

Inhalation: Remove to fresh air.

Information given herein is offered in good faith as accurate, but without guarantee. Conditions of use and suitability of the product for particular uses are beyond our control; all risks of use of the product are therefore assumed by the user and we expressly disclaim all warranties of every kind and nature, including warranties of merchantability and fitness for a particular purpose in respect to the use or suitability of the product. Appropriate warnings and safe handling procedures should be provided to handlers and users.
MATERIAL SAFETY DATA SHEET

IDENTIFICATION
Trade Name: HAPFLEX 695B

SPECIAL REGULATORY HAZARDS

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>CAS#</th>
<th>Exposure Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,4'-Diaminodiphenyl methane</td>
<td>101-77-0</td>
<td>0.1ppm</td>
</tr>
<tr>
<td>1,2-Benzene Diarboxylic acid dibutyl ester</td>
<td>84-74-2</td>
<td>5ppm</td>
</tr>
</tbody>
</table>

Hazard assessment based on available data.

PHYSICAL DATA

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance and Odor</td>
<td>Black Low viscosity liquid, slight odor</td>
</tr>
<tr>
<td>Solubility</td>
<td>Specific Gravity (H₂O=1) 1.1</td>
</tr>
<tr>
<td>Melting Point</td>
<td>NA</td>
</tr>
<tr>
<td>Boiling Point</td>
<td>NA</td>
</tr>
<tr>
<td>Vapor Pressure @ 20°C</td>
<td>NA</td>
</tr>
<tr>
<td>Vapor Density (Air=1)</td>
<td>NA</td>
</tr>
</tbody>
</table>

NA = Not Applicable
ND = Not Determined (opt.)
LT = less than
MT = more than
REACTIVITY DATA
Stability: Stable
Incompatibility: Strong oxidizing agents
Decomposition Products: Oxides of carbon and nitrogen under burning conditions.

FIRE AND EXPLOSION HAZARD DATA
Flash Point: NA
Extinguishing Media: CO₂ Foam, or dry chemical
Special Fire Fighting Procedures: Water may be ineffective

SPECIAL PROTECTION INFORMATION
Ventilation: May be necessary. Keep container closed when not in use.
Personal Protection: Eye protection, impervious gloves
Good housekeeping practices are recommended.

STORAGE, SPILLS AND DISPOSAL INFORMATION
Storage: Store away from sources of direct heat in a dry area.
Spills: Large spills - Dike up and pump into appropriate containers.
        Small spills - Dilute with water and recover or use non-combustible absorbent material/sand and shovel into suitable containers.
Disposal: Incinerate in accordance with local, state, and federal regulations. Keep out of public water supplies.

HEALTH RELATED DATA
Specific Hazard(s): Prolonged or repeated exposure may cause irritation or other allergic responses.
Primary Route(s) of Entry: Skin contact, eye contact, inhalation.
HEALTH RELATED DATA (cont)

First Aid Procedures:

**Eye contact:** Flush with water for 15 minutes. Get medical attention.

**Skin contact:** Wipe excess. Wash with rubbing alcohol, if available, followed by soap and water. Discard shoes if contaminated.

**Inhalation:** Remove to fresh air.

Information given herein is offered in good faith as accurate, but without guarantee. Conditions of use and suitability of the product for particular uses are beyond our control; all risks of use of the product are therefore assumed by the user and we expressly disclaim all warranties of every kind and nature, including warranties of merchantability and fitness for a particular purpose in respect to the use or suitability of the product. Appropriate warnings and safe handling procedures should be provided to handlers and users.
HAPCO INC
383 Circuit Street
Hanover, MA 02339
617-926-8801

MATERIAL SAFETY DATA SHEET

IDENTIFICATION
Trade Name: HAPPLEX 665 A

SPECIAL REGULATORY HAZARDS

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>(ACGIH TLV) Exposure Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methylenediphenylisocyanate</td>
<td>5124-30-1 0.01 ppm</td>
</tr>
</tbody>
</table>

Hazard assessment based on available data.

PHYSICAL DATA

Appearance and Odor: Colorless, low viscosity liquid - very slight odor

Solubility: Insoluble

Melting Point: NA

Boiling Point: 186°C

Specific Gravity (H2O=1) 1.1

Vapor Pressure @ 20°C NA

Vapor Density (Air=1) 1

NA = Not Applicable

ND = Not Determined

MT = More Than

LT = Less Than

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
REACTIVITY DATA
Stability: Stable
Incompatibility: Al, Zn, strong oxidizers, water, alcohols, amines, strong bases, metal compounds or surface active materials
Decomposition Products: Oxides of carbon and nitrogen under burning conditions.

FIRE AND EXPLOSION HAZARD DATA
Flash Point: NA
Extinguishing Media: CO₂ Foam, or dry chemical
Special Fire Fighting Procedures: Water may be ineffective

SPECIAL PROTECTION INFORMATION
Ventilation: May be necessary. Keep container closed when not in use.
Personal Protection: Eye protection, impervious gloves
Good housekeeping practices are recommended.

STORAGE, SPILLS AND DISPOSAL INFORMATION
Storage: Store away from sources of direct heat in a dry area.
Spills: Large spills - Dike up and pump into appropriate containers.
Small spills - Dilute with water and recover or use non-combustible absorbent material/sand and shovel into suitable containers.
Disposal: Incinerate in accordance with local, state, and federal regulations. Keep out of public water supplies.

HEALTH RELATED DATA
Specific Hazard(s): Prolonged or repeated exposure may cause irritation or allergic responses.
Primary Route(s) of Entry: Skin contact, eye contact, inhalation
HEALTH RELATED DATA (cont)

First Aid Procedures:

**Eye contact:** Flush with water for 15 minutes. Get medical attention.

**Skin contact:** Wipe excess. Wash with rubbing alcohol. If available, followed by soap and water. Discard shoes if contaminated.

**Inhalation:** Remove to fresh air.

Information given herein is offered in good faith as accurate, but without guarantee. Conditions of use and suitability of the product for particular uses are beyond our control; all risks of use of the product are therefore assumed by the user and we expressly disclaim all warranties of every kind and nature, including warranties of merchantability and fitness for a particular purpose in respect to the use or suitability of the product. Appropriate warnings and safe handling procedures should be provided to handlers and users.
HAPCO INC  
353 Circuit Street  
Hanover, MA 02339  
617-625-8801

Date Issued: 2/82

MATERIAL SAFETY DATA SHEET

IDENTIFICATION
Trade Name: HAPFLEX 685 B

SPECIAL REGULATORY HAZARDS

<table>
<thead>
<tr>
<th>(ACGIH TLV)</th>
<th>Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAS#</td>
<td>Limit</td>
</tr>
<tr>
<td>101-77-8</td>
<td>0.1 ppm</td>
</tr>
<tr>
<td>84-74-2</td>
<td>5 ppm</td>
</tr>
</tbody>
</table>

Ingredient:
- 4,4'-Diaminodiphenyl methane
- 1,2-Benzene Dicarboxylic acid
- Dibutyl ester

Hazard assessment based on available data.

PHYSICAL DATA

Appearance and Odor: black, low viscosity liquid, slight odor
Solubility: Specific Gravity (H₂O=1) 1:1
Melting Point: Vapor Pressure @ 20°C NA
Boiling Point: NA
Vapor Density (Air=1) NA

NA = Not Applicable  ND = Not Determined  (opt) = Optional
MT = more than  LT = less than

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
REACTIVITY DATA
Stability: Stable
Incompatibility: Strong oxidizing agents
Decomposition Products: Oxides of carbon and nitrogen under burning conditions.

FIRE AND EXPLOSION HAZARD DATA
Flash Point: NA
Extinguishing Media: CO₂ Foam, or dry chemical
Special Fire Fighting Procedures: Water may be ineffective

SPECIAL PROTECTION INFORMATION
Ventilation: May be necessary. Keep container closed when not in use.
Personal Protection: Eye protection, impervious gloves
Good housekeeping practices are recommended.

STORAGE, SPILLS AND DISPOSAL INFORMATION
Storage: Store away from sources of direct heat in a dry area.
Spills: Large spills - Dike up and pump into appropriate containers.
        Small spills - Dilute with water and recover or use non-combustible absorbent material/sand and shovel into suitable containers.
Disposal: Incinerate in accordance with local, state, and federal regulations. Keep out of public water supplies.

HEALTH RELATED DATA
Specific Hazard(s): Prolonged or repeated exposure may cause irritation or other allergic responses.
Primary Route(s) of Entry: Skin contact, eye contact, inhalation
MATERIAL SAFETY DATA SHEET

IDENTIFICATION
Trade Name: HAPCAST 3730

SPECIAL REGULATORY HAZARDS
(ACGIH TLV)

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>CAS#:</th>
<th>Exposure Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diglycidyl ether of bisphenol A</td>
<td>25068-38-6</td>
<td>--</td>
</tr>
<tr>
<td>Tetrahydro-2-Furancarbinol</td>
<td>97-99-4</td>
<td>--</td>
</tr>
</tbody>
</table>

Hazard assessment based on available data.

PHYSICAL DATA

Appearance and Odor: Black, medium viscosity liquid
Solubility: Very Slightly Slightly
Melting Point: NA
Boiling Point: 450°F
Specific Gravity (H₂O=1) 2.43
Vapor Pressure @ 20°C 0.3
Vapor Density (Air=1) NA

NA = Not Applicable  ND = Not Determined  (opt) = Optional
MT = More than  LT = Less than
REACTIVITY DATA
Stability: Stable
Incompatibility: Strong oxidizing agents
Decomposition Products: Oxides of carbon and nitrogen under burning conditions.

FIRE AND EXPLOSION HAZARD DATA
Flash Point: 200°F TCT
Extinguishing Media: CO₂ Foam, or dry chemical
Special Fire Fighting Procedures: Water may be ineffective

SPECIAL PROTECTION INFORMATION
Ventilation: May be necessary. Keep container closed when not in use.
Personal Protection: Eye protection, impervious gloves
Good housekeeping practices are recommended.

STORAGE, SPILLS AND DISPOSAL INFORMATION
Storage: Store away from sources of direct heat in a dry area.
Spills: Large spills - Dike up and pump into appropriate containers.
Small spills - Dilute with water and recover or use non-combustible absorbent material/sand and shovel into suitable containers.
Disposal: Incinerate in accordance with local, state, and federal regulations. Keep out of public water supplies.

HEALTH RELATED DATA
Specific Hazard(s): Prolonged or repeated exposure may cause irritation or other allergic responses.
Primary Route(s) of Entry: Skin contact, eye contact, inhalation.
HEALTH RELATED DATA (cont.)

First Aid Procedures:

Eye contact:  Flush with water for 15 minutes
Get medical attention

Skin contact:  Wipe excess. Wash with rubbing alcohol, if available, followed by soap and water.
Discard shoes if contaminated.

Inhalation:  Remove to fresh air.

Information given herein is offered in good faith as accurate, but without guarantee. Conditions of use and suitability of the product for particular uses are beyond our control; all risks of use of the product are therefore assumed by the user and we expressly disclaim all warranties of every kind and nature, including warranties of merchantability and fitness for a particular purpose in respect to the use or suitability of the product. Appropriate warnings and safe handling procedures should be provided to handlers and users.
MATERIAL SAFETY DATA SHEET

IDENTIFICATION

Trade Name: Hapcoat 597 A

SPECIAL REGULATORY HAZARDS

Ingredient: Methylene Bis (4-Cyclohexylisocyanate)

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>CAS#</th>
<th>Exposure Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methylene Bis</td>
<td>5124-30-1</td>
<td>.01 ppm</td>
</tr>
</tbody>
</table>

Hazard assessment based on available data.

PHYSICAL DATA

Appearance and Odor: Colorless, med. viscosity liquid, very slight odor.

<table>
<thead>
<tr>
<th>Solubility</th>
<th>Specific Gravity (H_2O=1)</th>
<th>Vapor Pressure @ 20°C</th>
<th>Vapor Density (Air=1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>insoluble</td>
<td>1.16</td>
<td>n/a</td>
<td>1</td>
</tr>
</tbody>
</table>

Melting Point: n/a

Boiling Point: 165 °C

NA = Not Applicable  ND = Not Determined  (opt) = optional

MT = more than  LT = less than

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
REACTIVITY DATA
Stability: Stable
Incompatibility: Al, Zn, strong oxidizers, water, alcohols, amines, strong bases, metal compounds or surface active materials
Decomposition Products: Oxides of carbon and nitrogen under burning conditions

FIRE AND EXPLOSION HAZARD DATA
Flash Point: n/a
Extinguishing Media: CO₂ Foam, or dry chemical
Special Fire Fighting Procedures: Water may be ineffective

SPECIAL PROTECTION INFORMATION
Ventilation: May be necessary Keep container closed when not in use.
Personal Protection: Eye protection, impervious gloves
Good housekeeping practices are recommended

STORAGE, SPILLS AND DISPOSAL INFORMATION
Storage: Store away from sources of direct heat in a dry area.
Spills: Large spills - Dike up and pump into appropriate containers.
Small spills - Dilute with water and recover or use non-combustible absorbent material/sand and shovel into suitable containers.
Disposal: Incinerate in accordance with local, state, and federal regulations. Keep out of public water supplies.

HEALTH RELATED DATA
Specific Hazard(s): Prolonged or repeated exposure may cause irritation or other allergic responses.
Primary Route(s) of Entry: Skin contact, eye contact, inhalation
First Aid Procedures:

Eye contact: Flush with water for 15 minutes.
Get medical attention.

Skin contact: Wipe excess. Wash with rubbing alcohol, if available, followed by soap and water.
Discard shoes if contaminated.

Inhalation: Remove to fresh air.

Information given herein is offered in good faith as accurate, but without guarantee. Conditions of use and suitability of the product for particular uses are beyond our control; all risks of use of the product are therefore assumed by the user and we expressly disclaim all warranties of every kind and nature, including warranties of merchantability and fitness for a particular purpose in respect to the use or suitability of the product. Appropriate warnings and safe handling procedures should be provided to handlers and users.
MATERIAL SAFETY DATA SHEET

IDENTIFICATION
Trade Name: Hapcoat 497 B

SPECIAL REGULATORY HAZARDS

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>CAS#</th>
<th>Exposure Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,4' Diaminodiphenyl methane</td>
<td>101-77-9</td>
<td>0.1 ppm</td>
</tr>
<tr>
<td>1,2 Benzene Carboxylic acid dibutyler ester</td>
<td>84-74-2</td>
<td>5 ppm</td>
</tr>
</tbody>
</table>

Hazard assessment based on available data.

PHYSICAL DATA

Appearance and Odor: White, high viscosity paste, slight odor

Solubility: Not determined

Melting Point: n/a

Boiling Point: n/a

Specific Gravity (H₂O=1) 1.1

Vapor Pressure @ 20°C n/a

Vapor Density (Air=1) n/a

NA = Not Applicable  ND = Not Determined  (opt) = optional

MT = more than  LT = less than
REACTION DATA
Stability: Stable
Incompatibility: Strong oxidizing agents
Decomposition Products: Oxides of carbon and nitrogen under burning conditions

FIRE AND EXPLOSION HAZARD DATA
Flash Point: n/a
Extinguishing Media: CO₂ Foam, or dry chemical
Special Fire Fighting Procedures: Water may be ineffective

SPECIAL PROTECTION INFORMATION
Ventilation: May be necessary. Keep container closed when not in use.
Personal Protection: Eye protection, impervious gloves
Good housekeeping practices are recommended.

STORAGE, SPILLS AND DISPOSAL INFORMATION
Storage: Store away from sources of direct heat in a dry area.
Spills: Large spills - Dike up and pump into appropriate containers
Small spills - Dilute with water and recover or use non-combustible absorbent material/sand and shovel into suitable containers.
Disposal: Incinerate in accordance with local, state, and federal regulations. Keep out of public water supplies

HEALTH RELATED DATA
Specific Hazard(s): Prolonged or repeated exposure may cause irritation or other allergic responses.
Primary Route(s) of Entry: Skin contact, eye contact, inhalation
HEALTH RELATED DATA (cont.)

First Aid Procedures:

Eye contact: Flush with water for 15 minutes. Get medical attention.

Skin contact: Wipe excess with rubbing alcohol, if available, followed by soap and water. Discard shoes if contaminated.

Inhalation: Remove to fresh air.

Information given herein is offered in good faith as accurate, but without guarantee. Conditions of use and suitability of the product for particular uses are beyond our control; all risks of use of the product are therefore assumed by the user and we expressly disclaim all warranties of every kind and nature, including warranties of merchantability and fitness for a particular purpose in respect to the use or suitability of the product. Appropriate warnings and safe handling procedures should be provided to handlers and users.
MATERIAL SAFETY DATA SHEET

IDENTIFICATION
Trade Name: HAPCOAT 667 A

SPECIAL REGULATORY HAZARDS

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>CAS#</th>
<th>Exposure Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methylene Bis (4-Cyclohexylisocyanate)</td>
<td>6124-30-1</td>
<td>.01 ppm</td>
</tr>
</tbody>
</table>

Hazard assessment based on available data.

PHYSICAL DATA

Appearance and Odor: Colorless, low viscosity liquid- very slight odor

Solubility: Insoluble
Melting Point: NA
Boiling Point: 185°C

Specific Gravity (H2O=1) 1.1
Vapor Pressure @ 20°C NA
Vapor Density (Air=1) 1

NA= Not Applicable
MT= more than
N.D= Not Determined
L.T= less than

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
**REACTIVITY DATA**

**Stability:** Stable

**Incompatibility:** Al, Zn, strong oxidizers, water, alcohols, amines, strong bases, metal compounds or surface active materials

**Decomposition Products:** Oxides of carbon and nitrogen under burning conditions.

---

**FIRE AND EXPLOSION HAZARD DATA**

**Flash Point:** NA

**Extinguishing Media:** CO₂, Foam, or dry chemical

**Special Fire Fighting Procedures:** Water may be ineffective

---

**SPECIAL PROTECTION INFORMATION**

**Ventilation:** May be necessary. Keep container closed when not in use.

**Personal Protection:** Eye protection, impervious gloves

**Personal Protection:** Good housekeeping practices are recommended.

---

**STORAGE, SPILLS AND DISPOSAL INFORMATION**

**Storage:** Store away from sources of direct heat in a dry area.

**Spills:** Large spills - Dike up and pump into appropriate containers.

Small spills - Dilute with water and recover or use non-combustible absorbent material/sand and shovel into suitable containers.

**Disposal:** Incinerate in accordance with local, state, and federal regulations. Keep out of public water supplies.

---

**HEALTH RELATED DATA**

**Specific Hazard(s):** Prolonged or repeated exposure may cause irritation or other allergic responses.

**Primary Route(s) of Entry:** Skin contact, eye contact, inhalation.
HEALTH RELATED DATA (cont)

First Aid Procedures:

Eye contact:  Flush with water for 15 minutes.  Get medical attention.

Skin contact:  Wipe excess.  Wash with rubbing alcohol, if available, followed by soap and water.  Discard shoes if contaminated.

Inhalation:  Remove to fresh air.

Information given herein is offered in good faith as accurate, but without guarantee.  Conditions of use and suitability of the product for particular uses are beyond our control; all risks of use of the product are therefore assumed by the user and we expressly disclaim all warranties of every kind and nature, including warranties of merchantability and fitness for a particular purpose in respect to the use or suitability of the product.  Appropriate warnings and safe handling procedures should be provided to handlers and users.
MATERIAL SAFETY DATA SHEET

IDENTIFICATION
Trade Name: HAPCOAT 687 B

SPECIAL REGULATORY HAZARDS

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>CAS No.</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,4'-Diaminodiphenyl methane</td>
<td>101-77-9</td>
<td>0.1 ppm</td>
</tr>
<tr>
<td>1,2-Benzenedicarboxylic acid dibutyl ester</td>
<td>84-74-2</td>
<td>5 ppm</td>
</tr>
</tbody>
</table>

Hazard assessment based on available data.

PHYSICAL DATA
Appearance and Odor: White, thixotropic paste.
Solubility: Specific Gravity (H,D=1) 1.1
Melting Point: NA
Boiling Point: NA

Vapor Pressure @ 20°C: NA
Vapor Density (Air=1): NA

NA= Not Applicable  ND= Not Determined  (opt)=optional
MT= more than  LT= less than
REACTIVITY DATA
Stability: Stable
Incompatibility: Strong oxidizing agents
Decomposition Products: Oxides of carbon and nitrogen under burning conditions.

FIRE AND EXPLOSION HAZARD DATA
Flash Point: NA
Extinguishing Media: CO₂, Foam, or dry chemical
Special Fire Fighting Procedures: Water may be ineffective

SPECIAL PROTECTION INFORMATION
Ventilation: May be necessary. Keep container closed when not in use.
Personal Protection: Eye protection, impervious gloves
Good housekeeping practices are recommended

STORAGE, SPILLS AND DISPOSAL INFORMATION
Storage: Store away from sources of direct heat in a dry area.
Spill: Large spills - Dike up and pump into appropriate containers.
       Small spills - Dilute with water and recover or use non-combustible absorbent material/sand and shovel into suitable containers.
Disposal: Incinerate in accordance with local, state, and federal regulations. Keep out of public water supplies.

HEALTH RELATED DATA
Specific Hazards: Prolonged or repeated exposure may cause irritation or other allergic responses.
Primary Route(s) of Entry: Skin contact, eye contact, inhalation.
HEALTH RELATED DATA (cont)

First Aid Procedures:

Eye contact:  Flush with water for 15 minutes. Get medical attention.

Skin contact:  Wipe excess, Wash with rubbing alcohol, If available, followed by soap and water. Discard shoes if contaminated.

Inhalation:  Remove to fresh air.

Information given herein is offered in good faith as accurate, but without guarantee. Conditions of use and suitability of the product for particular uses are beyond our control; all risks of use of the product are therefore assumed by the user and we expressly disclaim all warranties of every kind and nature, including warranties of merchantability and fitness for a particular purpose in respect to the use or suitability of the product. Appropriate warnings and safe handling procedures should be provided to handlers and users.
MATERIAL SAFETY DATA SHEET

IDENTIFICATION
Trade Name: Kapton 5730 A

SPECIAL REGULATORY HAZARDS

<table>
<thead>
<tr>
<th>Ingredient:</th>
<th>CAS#:</th>
<th>Limit:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,1,2,2,3-Pentamethylybutylphenol</td>
<td>54832-15-2</td>
<td>---</td>
</tr>
<tr>
<td>Tetrahydro-2-Furancarbinol</td>
<td>97-99-4</td>
<td>---</td>
</tr>
<tr>
<td>Diglycidylether Bisphenol A</td>
<td>35088-33-5</td>
<td>---</td>
</tr>
</tbody>
</table>

Hazard assessment based on available data.

PHYSICAL DATA

Appearance and Odor: Alumina color, medium-high viscosity liquid, slight odor
Solubility: Insoluble
Specific Gravity (H2O=1) 1.2-1.5
Melting Point: N/A
Vapor Pressure @ 20°C N/A
Boiling Point: MT400°F
Vapor Density (Air=1) N/A

NA= Not Applicable
N= No
D= Determined
Opt= Optional
MT= More than
< = Less than

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
REACTIVITY DATA
Stability: Stable
Incompatibility: Al, Zn, strong oxidizers, water, alcohols, amines, strong bases, metal compounds or surface active materials
Decomposition Products: Oxides of carbon and nitrogen under burning conditions.

FIRE AND EXPLOSION HAZARD DATA
Flash Point: MT 400°F
Extinguishing Media: CO₂ Foam, or dry chemical
Special Fire Fighting Procedures: Water may be ineffective

SPECIAL PROTECTION INFORMATION
Ventilation: May be necessary. Keep container closed when not in use.
Personal Protection: Eye protection, impervious gloves
Good housekeeping practices are recommended.

STORAGE, SPILLS AND DISPOSAL INFORMATION
Storage: Store away from sources of direct heat in a dry area.

Spill: Large spills - Dike up and pump into appropriate containers.
Small spills - Dilute with water and recover or use noncombustible absorbent material/sand and shovel into suitable containers.

Disposal: Incinerate in accordance with local, state, and federal regulations. Keep out of public water supplies.

HEALTH RELATED DATA
Specific Hazard(s): Prolonged or repeated exposure may cause irritation or other allergic responses.
Primary Route(s) of Entry: Skin contact, eye contact, inhalation
HEALTH RELATED DATA (cont.)

First Aid Procedures:

Eye contact: Flush with water for 15 minutes.  Get medical attention.

Skin contact: Wipe excess. Wash with rubbing alcohol, if available, followed by soap and water. Discard shoes if contaminated.

Inhalation: Remove to fresh air.

Information given herein is offered in good faith as accurate, but without guarantee. Conditions of use and suitability of the product for particular uses are beyond our control; all risks of use of the product are therefore assumed by the user and we expressly disclaim all warranties of every kind and nature, including warranties of merchantability and fitness for a particular purpose, in respect to the use or suitability of the product. Appropriate warnings and safe handling procedures should be provided to handlers and users.
MATERIAL SAFETY DATA SHEET

IDENTIFICATION
Trade Name: Hapcast 5730 B

SPECIAL REGULATORY HAZARDS

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>CAS#</th>
<th>Exposure Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triethylenetetramine</td>
<td>006112-24-3</td>
<td>--</td>
</tr>
<tr>
<td>N,N'-bis (2-aminoethyl) piperazine</td>
<td>006531-38-0</td>
<td>--</td>
</tr>
<tr>
<td>Piperazinyl-ethylenediamine</td>
<td>024028-46-4</td>
<td>--</td>
</tr>
<tr>
<td>Trisaminoethylamine</td>
<td>004097-39-6</td>
<td>--</td>
</tr>
<tr>
<td>Bis (para-aminocyclohexyl)</td>
<td>761-71-3</td>
<td>--</td>
</tr>
<tr>
<td>9-Hydroxylalkyl Diamines (mixture)</td>
<td>NA</td>
<td>--</td>
</tr>
</tbody>
</table>

Hazard assessment based on available data.

PHYSICAL DATA

Appearance and Odor: Amber color, low viscosity liquid, slight amine odor

<table>
<thead>
<tr>
<th>Solubility</th>
<th>Specific Gravity (H,O)</th>
<th>Vapor Pressure @ 20°C</th>
<th>boiling Point: MT 500°F</th>
<th>Vapor Density (Air-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slightly soluble</td>
<td>0.35</td>
<td>LT 1</td>
<td>MT 5</td>
<td></td>
</tr>
</tbody>
</table>

NA = Not Applicable
ND = Not Determined
MT = More than
LT = Less than

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
REACTIVITY DATA
Stability: Stable
Incompatibility: Strong oxidizing agents
Decomposition Products: Oxides of carbon and nitrogen under burning conditions.

FIRE AND EXPLOSION HAZARD DATA
Flash Point: 245°F PMCC
Extinguishing Media: CO₂ Foam, or dry chemical
Special Fire Fighting Procedures: Water may be ineffective

SPECIAL PROTECTION INFORMATION
Ventilation: May be necessary. Keep container closed when not in use.
Personal Protection: Eye protection, impervious gloves
Good housekeeping practices are recommended.

STORAGE, SPILLS AND DISPOSAL INFORMATION
Storage: Store away from sources of direct heat in a dry area.
Spills: Large spills - Hike up and pump into appropriate containers.
       Small spills - Dilute with water and recover or use non-combustible absorbent material/sand and shovel into suitable containers.
Disposal: Incinerate in accordance with local, state, and federal regulations. Keep out of public water supplies.

HEALTH RELATED DATA
Specific Hazard(s): Prolonged or repeated exposure may cause irritation or other allergic responses.
Primary Route(s) of Entry: contact, eye contact, inhalation
HEALTH RELATED DATA (cont.)

First Aid Procedures:

Eye contact: Flush with water for 15 minutes. Get medical attention.

Skin contact: Wipe excess. Wash with rubbing alcohol, if available, followed by soap and water. Discard shoes if contaminated.

Inhalation: Remove to fresh air.

Information given herein is offered in good faith as accurate, but without guarantee. Conditions of use and suitability of the product for particular uses are beyond our control; all risks of use of the product are therefore assumed by the user and we expressly disclaim all warranties of every kind and nature, including warranties of merchantability and fitness for a particular purpose in respect to the use or suitability of the product. Appropriate warnings and safe handling procedures should be provided to handlers and users.
Material Safety Data Sheet

Dap Inc.
P.O. Box 277
Dayton, Ohio 45401-0277

Product: EPOXICAL 301 THICK
SECTION CASTING RESIN
Internal ID: 71262

NSDS No: DAP / 71262
Revision: 1
Date: September 30, 1988

National Paint and Coatings Association
Hazardous Material Identification System

| HEALTH HAZARD | 2 - Moderate |
| FLAMMABILITY HAZARD | 2 - Moderate |
| REACTIVITY HAZARD | 1 - Slight |
| PERSONAL PROTECTION | D - Face Shield, Gloves, Apron |

SECTION I. MATERIAL IDENTIFICATION

Trade/Material Name: EPOXICAL 301 THICK SECTION CASTING RESIN

Description: EPOXY RESIN

CAS: Mixture

NSDS REVISION DATE: December 27, 1990

Shipping Name (49 CFR 172.101): Plastic Liquid n.o.s.
D.O.T. ID No. (49 CFR 172.101): None
D.O.T. label required (49 CFR 172.101): None

EPA Hazard Class - if discarded (40 CFR 261):
D001 - Ignitable

Manufacturer: Dap Inc.
P.O. Box 277
Dayton, OH 45401-0277

Phone: 1-800-543-3840
In Ohio 1-513-667-4461

SECTION II. INGREDIENTS AND HAZARDS

Ingredient Name: CAS Number: Percent: Exposure Limits:

Bisphenol A diglycidyl ether polymer 25068-38-6 <35 NE
n-Butyl glycidyl ether 2426-08-6 <25 ACGIH TLV: 25ppm
OSHA PEL: 50ppm TWA

Remaining ingredients are not regulated by OSHA and are considered to be trade secrets.

SECTION III. PHYSICAL DATA

Appearance & Odor: Viscous, aluminum colored liquid

Boiling point: 327 °F
Vapor pressure: 3 mm Hg @ 25 °C
Water solubility (X): Slight
Vapor density (air=1): 4.5

Evaporation rate: NE
Specific gravity (H₂O=1): 2.1
% volatile by volume: NE

Page 1 —— PHYSICAL DATA continues on page 2——

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
PHYSICAL DATA continued from page 1

During Application and Curing:
VOC less water less volatile solvent (g/liter): 0
VOC material (g/liter): 0

SECTION IV. FIRE AND EXPLOSION DATA

Flash Point (method): >120 °F (PMCC) Limits: LEL X: NE UEL X: NE
Extinguishing Media: Foam, carbon dioxide, dry chemical, water fog
Unusual fire or explosion hazards: Containers may explode if exposed to extreme heat. Eliminate sources of ignition: electrical equipment, sparks and flame. Do not put in contact with caustics or oxidizing materials.
Special fire-fighting procedures: Full protective equipment, including self-contained breathing apparatus, is recommended to protect from combustion products. Cool exposed surfaces with water.

SECTION V. REACTIVITY DATA

Material is stable Hazardous polymerization will not occur
Chemical incompatibilities: Strong oxidizers
Conditions to avoid: Excessive heat and freezing
Hazardous decomposition Products: Carbon Monoxide, Carbon Dioxide, Aldehydes

SECTION VI. HEALTH HAZARD INFORMATION

This product is NOT considered a carcinogen by the NTP, IARC and OSHA.
Medical conditions which may be aggravated by contact: Allergy, eczema or skin conditions.
Primary entry route(s): Skin contact
Acute effects: May irritate eyes, skin and respiratory tract.
Chronic effect(s): May cause sensitization. May cause defatting of the skin leading to dermatitis.
First aid:
Eye contact: Flush with large amounts of water for 15 minutes. Contact a physician immediately.
Skin contact: Wash with soap and water.

Page 2 —— HEALTH HAZARD INFORMATION continues on page 3 —— Page 2
HEALTH HAZARD INFORMATION continued from page 2

Inhalation: Remove to fresh air. Contact physician immediately.

Ingestion: Do not induce vomiting. Dilute by giving water or milk to drink if victim is conscious. Contact physician or Regional Poison Control Center immediately.

SECTION VII. SPILL, LEAK AND DISPOSAL PROCEDURES

Spill / Leak procedures: Use absorbent material or scrape up dried material and place into containers.

Waste management / Disposal: Dispose of according to federal, state and local standards. Do not reuse empty containers. Liquids cannot be disposed of in a landfill.

SECTION VIII. SPECIAL PROTECTION INFORMATION

Personal protective equipment:

- Goggles: Wear full face shield.
- Gloves: Impervious gloves.
- Respirator: If 8-hour exposure limit or value is exceeded use an approved NIOSH/OSHA respirator. Consult your safety equipment supplier and the OSHA regulation, 29 CFR 1910.134 for respirator requirements.

Workplace considerations:

- Ventilation: Provide sufficient mechanical ventilation (local or general exhaust) to maintain exposure below PEL and TLV.
- Safety stations: Provide eyewash and impervious apron if body contact with product may occur. Barrier creams may be used.
- Contaminated equipment: Wash contaminated clothing before reuse.

SECTION IX. SPECIAL PRECAUTIONS

Storage segregation: Store away from oxidizers.

Special handling / storage: Keep containers tightly closed when not in use. Keep containers from excessive heat and freezing. Provide ventilation in storage area. Keep out of reach of children. Do not store at temperatures above 120 °F.

This data is offered in good faith as typical values and not as a product specification. No warranty, either expressed or implied, is hereby made. The recommended industrial hygiene and safe handling procedures are believed to be generally applicable. However, each user should review these recommendations in the specific context of the intended use and determine whether they are appropriate.
Material Safety Data Sheet

DAP Inc.
P.O. Box 277
Dayton, Ohio 45401-0277

Product: EPOXICAL 308 MASS CASTING HARDENER
Internal ID: 71276
MSDS No: DAP / 71276
Revision: 1
Date: November 7, 1988

SECTION I. MATERIAL IDENTIFICATION

Trade/Material Name: EPOXICAL 308 MASS CASTING HARDENER
Description: EPOXY HARDENER

D.O.T. ID No. (49 CFR 172.101): UN 1760
D.O.T. label required (49 CFR 172.101): Corrosive
EPA Hazard Class - if discarded (40 CFR 261): Corrosive D-002

Manufacturer: DAP Inc.
P.O. Box 277
Dayton, OH 45401-0277
Phone: 1-800-543-3840
In Ohio 1-513-667-4461

SECTION II. INGREDIENTS AND HAZARDS

Ingredient Name: Tall Oil Fatty Acids, Reaction Products with Polyethylene Polymamines, Unsaturated Dimer Acids, Reaction Products with Polyethylene Polymamines
CAS Number: 68910-93-0 68410-23-1
Percent: 45-55 45-55
Exposure Limits: NE NE

Remaining ingredients are not regulated by OSHA and are considered trade secrets.

SECTION III. PHYSICAL DATA

Appearance & Odor: Amber liquid with amine odor
Boiling point: NE
Vapor pressure: NE
Water solubility (Z): Nil
Vapor density (air-l): NE
Evaporation rate: NE
Specific gravity (H2O-1): 0.99
A volatile by volume: Nil
VOC less water less volatile solvent (g/liter): 0
VOC material (g/liter): 0

Page 1 —— MSDS 71276 continues on page 2 —— Page 1
Material Safety Data Sheet

DAP Inc.  
P.O. Box 277  
Dayton, Ohio 45401-0277  

Product: EPOXICAL 308 MASS CASTING HARDENER  
Internal ID: 71276  
MSDS No: DAP / 71276  
Revision: 1  
Date: November 7, 1988

SECTION IV. FIRE AND EXPLOSION DATA

Flash Point (method): >275 °F (PMCC)  
Limits: LEL %: NE  
UEL %: NE  

Extinguishing Media: Chemical foam, carbon dioxide, dry chemical and water fog  

Unusual fire or explosion hazards: Containers may explode if exposed to extreme heat. Eliminate sources of ignition: electrical equipment, sparks and flame.  

Special fire-fighting procedures: Full protective equipment, including self-contained breathing apparatus, is recommended to protect from combustion products. Cool exposed surfaces with water.

SECTION V. REACTIVITY DATA

Material is stable. Hazardous polymerization will not occur  

Chemical incompatibilities: Strong oxidizing agents  

Hazardous decomposition Products: Nitrogen oxides, carbon monoxide, carbon dioxide and aldehydes.

SECTION VI. HEALTH HAZARD INFORMATION

This product is not considered a carcinogen by NTP, IARC or OSHA. *  

Medical conditions which may be aggravated by contact: Allergies  

Primary entry route(s): Skin contact and inhalation of vapors  

Acute effects: Will cause burns to eyes and skin. High concentrations of vapors can cause severe eye and respiratory tract irritation. Liquid causes severe damage to mucous membranes if swallowed.  

Chronic effect(s): Prolonged or repeated exposure may cause asthma and skin sensitization or other allergic response.  

First aid:

Eye contact: Flush with large amounts of water for 15 minutes. CONTACT PHYSICIAN IMMEDIATELY.  

Skin contact: Immediately flush skin with water for 15 minutes while removing contaminated clothing. Contact physician immediately.  

Inhalation: Remove to fresh air. Contact physician immediately.  

Ingestion: Do not induce vomiting. Dilute by giving water or milk to drink if victim is conscious. CONTACT PHYSICIAN OR REGIONAL POISON CONTROL CENTER IMMEDIATELY.

MSDS 71276 continues on page 3
Material Safety Data Sheet

DAP Inc.
P.O. Box 277
Dayton, Ohio 45401-0277

Product: EPOXICAL 308 MASS CASTING HARDENER
Internal ID: 71276
MSDS No: DAP / 71276
Revision: 1
Date: November 7, 1988

SECTION VII. SPILL, LEAK AND DISPOSAL PROCEDURES

Spill / Leak procedures: Dike spill area. Use absorbent material and place into containers.

Waste management / Disposal: Dispose of according to federal, state and local standards. Do not reuse empty containers. Discarded material should be incinerated at a permitted facility. Liquids cannot be disposed of in a landfill.

SECTION VIII. SPECIAL PROTECTION INFORMATION

Personal protective equipment:
- Goggles: Wear full face shield
- Gloves: Impervious gloves
- Respirator: NIOSH/OSHA approved respiratory protection required in the absence of proper environmental control. For emergencies a full-face respirator or self-contained breathing apparatus is recommended.

Workplace considerations:
- Ventilation: Breathing of vapors must be avoided. Ventilation must be sufficient to control vapors. This material should be confined as far as possible within sealed or covered equipment in which case normal ventilation should be adequate. Special (local) ventilation will be needed in areas where vapors are expected to be vented.
- Safety stations:
  - Provide eyewash and impervious apron if body contact with product may occur. Barrier creams may be used.
- Contaminated equipment:
  - Wash contaminated clothing before reuse. Discard contaminated leather goods.

SECTION IX. SPECIAL PRECAUTIONS

Storage segregation: Store away from strong oxidizers.

Special handling / storage: Keep containers tightly closed when not in use. Keep containers from excessive heat and freezing. Provide ventilation in storage area. Keep out of reach of children. Do not store at temperatures above 275 °F

DOT Class: Corrosive Material

This data is offered in good faith as typical values and not as a product specification. No warranty, either expressed or implied, is hereby made. The recommended industrial hygiene and safe handling procedures are believed to be generally applicable. However, each user should review these recommendations in the specific context of the intended use and determine if they are appropriate.

End of MSDS 71276
MATERIAL SAFETY DATA SHEET

MASTERCAST 703 A

MANUFACTURED FOR:
THE KINDT COLLINS COMPANY
12651 ELMWOOD AVENUE
CLEVELAND, OH 44111

EMERGENCY INFORMATION:
ROCKY MOUNTAIN POISON AND DRUG CENTER
645 BANNOCK STREET
DENVER, COLORADO 80204-4507
(303) 623-5716

SECTION I - PRODUCT IDENTIFICATION

TRADE NAME AND SYNONYMS: MASTERCAST 703 A
CHEMICAL FAMILY: POLYMETHYLENE POLYPHENYL ISOCYANATE SOLUTION
FORMULA: PROPRIETARY COMPLEX MIXTURE - TRADE SECRET

SECTION II - HAZARDOUS INGREDIENTS

[NOTE: SEE FINAL PAGE OF MSDS FOR DEFINITIONS OF ABBREVIATIONS AND SYMBOLS.]

PIGMENTS 50-70% TLV UNITS N.A.
VEHICLE PMPPI 17-30% TLV UNITS .02 PPM (VAPOR PRESSURE <0.00001 MMHG @ 25 DEGREES C.)
ADDITIVES 5-15% TLV UNITS .5 PPM (VAPOR PRESSURE <0.1 MMHG @ 25 DEGREES C.)

EXISTING CAS NOS. AVAILABLE ON ALL INGREDIENTS ON AN EMERGENCY BASIS.

THE MIXTURE CONTAINS NO KNOWN CARCINOGENS.

SECTION III - PHYSICAL DATA

BOILING POINT: >300 DEGREES F.

VAPOR PRESSURE: (<1 MMHG @ 25 DEGREES C.)
VAPOR DENSITY: (AIR=1) APPROXIMATELY 8.0
SPECIFIC GRAVITY: (WATER =1) 1.6
SOLUBILITY IN WATER: REACTS WITH WATER
PERCENT VOLATILE BY VOLUME: 5-10%
EVAPORATION RATE: (BUTYL ACETATE = 1) <1

APPEARANCE AND ODOR: BROWN LIQUID, SLIGHT AROMATIC ODOR

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT: >300 DEGREES F.
FLAMMABLE LIMITS: N.E.
EXTINGUISHING MEDIA: USE TYPE ABC EXTINGUISHER
SPECIAL FIRE-FIGHTING PROCEDURE: FIREFIGHTERS SHOULD WEAR SELF-CONTAINED BREATHING APPARATUS IN ADDITION TO NORMAL PROTECTIVE TURNOUT CLOTHING.

UNUSUAL FIRE AND EXPLOSION HAZARDS: AVOID WATER CONTAMINATION IN CLOSED CONTAINERS OR CONFINED AREAS. (CARBON DIOXIDE EVOLVED -)

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
MATERIAL SAFETY DATA SHEET

MASTERCAST 703 A

SECTION V - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE: .02 PPM ON PMPPI, MIXTURE N.E.

EFFECTS OF ACUTE EXPOSURE:

EYES - MAY CAUSE TEARING
SKIN - MINOR IRRITATION MAY OCCUR
INHALATION - BREATHLESSNESS, SEVERE COUGHING, CHEST DISCOMFORT

EFFECTS OF CHRONIC EXPOSURE: NONE KNOWN

EMERGENCY AND FIRST AID PROCEDURES:

EYES: FLUSH WITH COPIOUS AMOUNTS OF WATER FOR 15 MINUTES; CONTACT PHYSICIAN
SKIN: WASH WITH SOAP AND WATER.
INGESTION: INDUCE VOMITING, CONTACT PHYSICIAN IMMEDIATELY.

IF ANY IRRITATION OR OTHER SYMPTOMS PERSIST, SEE A PHYSICIAN.

SECTION VI - CHEMICAL REACTIVITY

STABILITY: STABLE UNDER NORMAL CONDITIONS
CONDITIONS TO AVOID: AVOID TEMPERATURES ABOVE 120 DEGREES F.
INCOMPATIBILITY (MATERIALS TO AVOID): WATER, STRONG BASES, ALCOHOLS, METAL COMPOUNDS
HAZARDOUS DECOMPOSITION PRODUCTS: 2500 DEGREES F - CARBON MONOXIDE, NITROGEN OXIDES, TRACES OF HYDROGEN CYANIDE.
HAZARDOUS POLYMERIZATION: MAY OCCUR

CONDITIONS TO AVOID: CONTAMINATION BY MOISTURE, CONTAMINATED CONTAINERS SHOULD BE LEFT VENTED

SECTION VII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN: ABSORB ON ABSORBENT MATERIAL.

WASTE DISPOSAL: INCINERATE OR DISPOSE IN A HAZARDOUS WASTE LANDFILL WHICH COMPLIES WITH LOCAL, STATE, AND FEDERAL REGULATIONS. DO NOT DISCHARGE INTO PUBLIC WATERWAYS OR SEWERS.
MATERIAL SAFETY DATA SHEET

MASTERCAST 703 A

SECTION VIII - SPECIAL PROTECTION AND PROCEDURES

RESPIRATORY PROTECTION: USE NIOSH APPROVED EQUIPMENT IF AIRBORNE EXPOSURE IS EXCESSIVE.

VENTILATION: FACE VELOCITY - 60 FPM; USE ONLY WITH ADEQUATE VENTILATION.

PROTECTIVE EQUIPMENT: CHEMICAL RESISTANT PROTECTIVE GLOVES; FOR EYE AND FACE PROTECTION A FACE SHIELD IS RECOMMENDED. A CHEMICAL RESISTANT APRON AND OTHER PROTECTIVE GEAR MAY BE USED AS NEEDED TO REDUCE CHANCES OF CONTACT.

SECTION IX - SPECIAL PRECAUTIONS

HANDLING AND STORAGE: USE GOOD INDUSTRIAL HYGIENE AND SAFETY PRACTICES EMPLOYED WITH ANY INDUSTRIAL CHEMICAL.

WORKPLACE: PRACTICE GOOD HOUSEKEEPING. CLEAN UP SPILLS PROMPTLY.

DISPOSAL: SEE WASTE DISPOSAL.

PERSONAL HYGIENE: GOOD PERSONAL HYGIENE IS MOST IMPORTANT. WASH THOROUGHLY WITH SOAP AND WATER BEFORE EATING, AFTER EACH SHIFT, OR AFTER ANY POSSIBLE CONTACT WITH PRODUCT. LAUNDER WORK CLOTHES FREQUENTLY.

NOTE: SMALL % OF POPULATION MAY DEVELOP ALLERGIC SENSITIVITY LEADING TO ASTHMA-LIKE SYMPTOMS ON SUBSEQUENT EXPOSURES BELOW THE TLV OF PMPP1.

NPCA HMIS RATING: HEALTH 2; FLAMMABILITY 1; REACTIVITY 1; PERSONAL PROTECTION F.

DUST RESPIRATORS ARE ONLY NECESSARY WHEN PERFORMING OPERATIONS SUCH AS GRINDING, MACHINING, OR POLISHING THE CAST PRODUCT.

SYMBOLS AND ABBREVIATIONS

N.A.: NOT APPLICABLE
N.E.: NOT ESTABLISHED
\( > \): GREATER THAN
\(< \): LESS THAN
C.A.S. NO.: CHEMICAL ABSTRACT SERVICE NUMBER
TLV: THRESHOLD LIMIT VALUE (UNITS)
PPM: PARTS PER MILLION
PMPP1: POLY(METHYLENE POLYPHENYL ISOCYANATE
MPH: MILLIMETERS OF MERCURY
FPM: FEET PER MINUTE
NIOSH: NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
NPCA: NATIONAL PAINT & COATINGS ASSOCIATION
HMIS: HAZARDOUS MATERIAL IDENTIFICATION SYSTEM

REVISION DATE: 05/30/86 REVIEWED BY: TOM MCLAUGHLIN
REPLACING DATE OF: 04/30/86 APPROVED BY: JERRY WILSON
MATERIAL SAFETY DATA SHEET

MANUFACTURED FOR: THE KINDT COLLINS COMPANY
MANUFACTURER: THE KINDT COLLINS COMPANY

EMERGENCY INFORMATION:
ROCKY MOUNTAIN POISON AND DRUG CENTER
DENVER, COLORADO 80204-4507
EMERGENCY TELEPHONE: (303) 623-5716

TRADE NAME AND SYNONYMS: MASTERCAST 703 B [OR MASTERCAST 703 PART B]
CHEMICAL FAMILY: POLYETHER POLYOL SOLUTION
FORMULA: PROPRIETARY COMPLEX MIXTURE * TRADE SECRET

SECTION I - PRODUCT IDENTIFICATION

SECTION II - HAZARDOUS INGREDIENTS

SECTION III - PHYSICAL DATA

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

---

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
MATERIAL SAFETY DATA SHEET

MASTERCAST 703 B ALTERNATIVE TO OSHA-20 FORM

SECTION V - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE: N.E.; 50 PPM RECOMMENDED ON MIXTURE

EFFECTS OF ACUTE EXPOSURE:

EYES - MAY CAUSE TEARING
SKIN - MINOR IRRITATION MAY OCCUR
INGESTION - N.E.
INHALATION - N.E.

EFFECTS OF CHRONIC EXPOSURE: NONE KNOWN

EMERGENCY AND FIRST AID PROCEDURES:

EYES: FLUSH WITH COPIOUS AMOUNTS OF WATER FOR 15 MINUTES; CONTACT PHYSICIAN.
SKIN: WASH WITH SOAP AND WATER.
INGESTION: INDUCE VOMITING; CONTACT PHYSICIAN IMMEDIATELY.
INHALATION: REMOVE FROM CONTAMINATED AREA; ADMINISTER OXYGEN.

IF ANY IRRITATION OR OTHER SYMPTOMS PERSIST, SEE A PHYSICIAN.

SECTION VI - CHEMICAL REACTIVITY

STABILITY: STABLE UNDER NORMAL CONDITIONS

CONDITIONS TO AVOID: AVOID TEMPERATURES ABOVE 120 DEGREES F.

INCOMPATIBILITY (MATERIALS TO AVOID): ISOCYANATES

HAZARDOUS DECOMPOSITION PRODUCTS: SMOKE, FUMES, CARBON MONOXIDE

HAZARDOUS POLYMERIZATION: NONE KNOWN

CONDITIONS TO AVOID: CONTAMINATION BY ISOCYANATES

SECTION VII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN: ABSORB ON ABSORBENT MATERIAL.

WASTE DISPOSAL: INCINERATE OR DISPOSE IN A HAZARDOUS WASTE LANDFILL WHICH COMPLIES WITH LOCAL, STATE, AND FEDERAL REGULATIONS. DO NOT DISCHARGE INTO PUBLIC WATERWAYS OR SEWERS.
SECTION VIII - SPECIAL PROTECTION AND PROCEDURES

RESPIRATORY PROTECTION: USE NIOSH APPROVED EQUIPMENT IF AIRBORNE EXPOSURE IS EXCESSIVE.

VENTILATION: FACE VELOCITY ≤ 50 FPM; USE ONLY WITH ADEQUATE VENTILATION.

PROTECTIVE EQUIPMENT: CHEMICAL RESISTANT PROTECTIVE GLOVES; FOR EYE AND FACE PROTECTION A FACE SHIELD IS RECOMMENDED. A CHEMICAL RESISTANT APRON AND OTHER PROTECTIVE GEAR MAY BE USED AS NEEDED TO REDUCE CHANCES OF CONTACT.

SECTION IX - SPECIAL PRECAUTIONS

HANDLING AND STORAGE: USE GOOD INDUSTRIAL HYGIENE AND SAFETY PRACTICES EMPLOYED WITH ANY INDUSTRIAL CHEMICAL.

WORKPLACE: PRACTICE GOOD HOUSEKEEPING. CLEAN UP SPILLS PROMPTLY.

DISPOSAL: SEE WASTE DISPOSAL.

PERSONAL HYGIENE: GOOD PERSONAL HYGIENE IS MOST IMPORTANT. WASH THOROUGHLY WITH SOAP AND WATER BEFORE EATING, AFTER EACH SHIFT, OR AFTER ANY POSSIBLE CONTACT WITH PRODUCT. LAUNDER WORK CLOTHES FREQUENTLY.

NPCA HMIS RATING: HEALTH 2; FLAMMABILITY 1; REACTIVITY 0; PERSONAL PROTECTION F.

DUST RESPIRATORS ARE ONLY NECESSARY WHEN PERFORMING OPERATIONS SUCH AS GRINDING, MACHINING, OR POLISHING THE CAST PRODUCTS.

SYMBOLS AND ABBREVIATIONS

N.A.: NOT APPLICABLE
N.E.: NOT ESTABLISHED
>: GREATER THAN
<: LESS THAN
C.A.S. NO.: CHEMICAL ABSTRACT SERVICE NUMBER
TLV: THRESHOLD LIMIT VALUE (UNITS)
PPM: PARTS PER MILLION
MMHG: MILLIMETERS OF MERCURY
FPM: FEET PER MINUTE
NIOSH: NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
NPCA: NATIONAL PAINT & COATINGS ASSOCIATION
HMIS: HAZARDOUS MATERIAL IDENTIFICATION SYSTEM

REVISION DATE: 05/30/86 REVIEWED BY: TOM MCLAUGHLIN
REPLACING DATE OF: 04/30/84 APPROVED BY: JERRY WILSON
**MATERIAL SAFETY DATA SHEET**

**IDENTIFICATION**

Trade Name: Ultraloy 44 A

**SPECIAL REGULATORY HAZARDS**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>CAS#</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,4 Diphenylmethane Dicyanate</td>
<td>000101-88-8</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Other ingredients are not considered to be hazardous as defined by the OSHA Hazard, found in 29 CFR 1910.1200, and are considered 'Trade Secrets' by Hapco.

Hazard assessment based on available data.

**PHYSICAL DATA**

Appearance and Odor: Amber clear/white, low viscosity liquid, slight odor

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solubility: Water Reacts</td>
<td></td>
</tr>
<tr>
<td>Specific Gravity (H₂O=1)</td>
<td>1.1-1.2</td>
</tr>
<tr>
<td>Melting Point: NA</td>
<td></td>
</tr>
<tr>
<td>Vapor Pressure @ 20°C</td>
<td>.0002</td>
</tr>
<tr>
<td>Boiling Point: NA</td>
<td></td>
</tr>
<tr>
<td>Vapor Density (Air=1)</td>
<td>MT 1.0</td>
</tr>
</tbody>
</table>

NA= Not Applicable  ND= Not Determined  (opt)=optional  MT= more than  LT = less than
REACTIVITY DATA
Stability: Stable
Incompatibility: Al, Zn, strong oxidizers, water, alcohols, amines, strong bases, metal compounds or surface active materials
Decomposition Products: Oxides of carbon and nitrogen under burning conditions.

FIRE AND EXPLOSION HAZARD DATA
Flash Point: MT 200°C
Extinguishing Media: CO₂ Foam, or dry chemical
Special Fire Fighting Procedures: Water may be ineffective

SPECIAL PROTECTION INFORMATION
Ventilation: May be necessary. Keep container closed when not in use.
Personal Protection: Eye protection, impervious gloves
Good housekeeping practices are recommended.

STORAGE, SPILLS AND DISPOSAL INFORMATION
Storage: Store away from sources of direct heat in a dry area.

Spills: Large spills - Dike up and pump into appropriate containers.
Small spills - Dilute with water and recover or use non-combustible absorbent material/sand and shovel into suitable containers.

Disposal: Incinerate in accordance with local, state, and federal regulations. Keep out of public water supplies.

HEALTH RELATED DATA
Specific Hazard(s): Prolonged or repeated exposure may cause irritation or other allergic responses.
Primary Route(s) of Entry: Skin contact, eye contact, inhalation
MATERIAL SAFETY DATA SHEET

IDENTIFICATION
Trade Name: Ultralloy 44 B

SPECIAL REGULATORY HAZARDS

Ingredient: Substituted aromatics 88477-30-5

Other ingredients are not regulated
and are not considered to be hazardous
as defined by OSHA Hazards, found in
29 CFR 1910.1200, and are considered
by Hapco, 'Trade Secrets'.

Hazard assessment based on available data.

PHYSICAL DATA
Appearance and Odor: White translucent, low viscosity liquid,
slight to no odor

Solubility: Slight Specific Gravity (H_2O=1) 1.0
Melting Point: NA Vapor Pressure 8 20°C MT 1
Boiling Point: ND Vapor Density (Air=1) ND

NA= Not Applicable ND= Not Determined (opt)=optional
MT= more than LT = less than
HEALTH RELATED DATA (cont)

First Aid Procedures:

Eye contact: Flush with water for 15 minutes. Get medical attention.

Skin contact: Wipe excess. Wash with rubbing alcohol, if available, followed by soap and water. Discard shoes if contaminated.

Inhalation: Remove to fresh air.

Information given herein is offered in good faith as accurate, but without guarantee. Conditions of use and suitability of the product for particular uses are beyond our control; all risks of use of the product are therefore assumed by the user and we expressly disclaim all warranties of every kind and nature, including warranties of merchantability and fitness for a particular purpose in respect to the use or suitability of the product. Appropriate warnings and safe handling procedures should be provided to handlers and users.
REACTIVITY DATA
Stability: Stable
Incompatibility: Al, Zn, strong oxidizers, water, alcohols, amines, strong bases, metal compounds or surface active materials
Decomposition Products: Oxides of carbon and nitrogen under burning conditions.

FIRE AND EXPLOSION HAZARD DATA
Flash Point: MT 200°C
Extinguishing Media: CO₂, Foam, or dry chemical
Special Fire Fighting Procedures: Water may be ineffective

SPECIAL PROTECTION INFORMATION
Ventilation: May be necessary. Keep container closed when not in use.
Personal Protection: Eye protection, impervious gloves
Good housekeeping practices are recommended.

STORAGE, SPILLS AND DISPOSAL INFORMATION
Storage: Store away from sources of direct heat in a dry area.
Spills: Large spills - Dike up and pump into appropriate containers.
Small spills - Dilute with water and recover or use non-combustible absorbent material/sand and shovel into suitable containers.
Disposal: Incinerate in accordance with local, state, and federal regulations. Keep out of public water supplies.

HEALTH RELATED DATA
Specific Hazard(s): Prolonged or repeated exposure may cause irritation or other allergic responses.
Primary Route(s) of Entry: Skin contact, eye contact, inhalation
First Aid Procedures:

**Eye contact:** Flush with water for 15 minutes.
Get medical attention.

**Skin contact:** Wipe excess. Wash with rubbing alcohol, if available, followed by soap and water.
Discard shoes if contaminated.

**Inhalation:** Remove to fresh air.

Information given herein is offered in good faith as accurate, but without guarantee. Conditions of use and suitability of the product for particular uses are beyond our control; all risks of use of the product are therefore assumed by the user and we expressly disclaim all warranties of every kind and nature, including warranties of merchantability and fitness for a particular purpose in respect to the use or suitability of the product. Appropriate warnings and safe handling procedures should be provided to handlers and users.
IDENTIFICATION
Trade Name: Ultralloy 45 B

SPECIAL REGULATORY HAZARDS

Ingredient: Substituted aromatics
CAS #: 68477-30-6

Other ingredients are not regulated and are not considered to be hazardous as defined by OSHA Hazards, found in 29 CFR 1910.1200, and are considered by Hapco, 'Trade Secrets'.

Hazard assessment based on available data.

PHYSICAL DATA
Appearance and Odor: White translucent, low viscosity liquid, slight to no odor

Solubility: Slight
Specific Gravity (H2O=1) 1.0
Melting Point: NA
Vapor Pressure @ 20°C MT 1
Boiling Point: ND
Vapor Density (Air=1) ND

NA= Not Applicable
MT= more than
ND= Not Determined
LT = less than
(opt)=optional
REACTIVITY DATA
Stability: Stable
Incompatibility: Strong oxidizing agents
Decomposition Products: Oxides of carbon and nitrogen under burning conditions.

FIRE AND EXPLOSION HAZARD DATA
Flash Point: MT 125°C
Extinguishing Media: CO₂, Foam, or dry chemical
Special Fire Fighting Procedures: Water may be ineffective

SPECIAL PROTECTION INFORMATION
Ventilation: May be necessary. Keep container closed when not in use.
Personal Protection: Eye protection, impervious gloves
Good housekeeping practices are recommended.

STORAGE, SPILLS AND DISPOSAL INFORMATION
Storage: Store away from sources of direct heat in a dry area.

Spills: Large spills - Dike up and pump into appropriate containers.
        Small spills - Dilute with water and recover or use non-combustible absorbent material/sand and shovel into suitable containers.

Disposal: Incinerate in accordance with local, state, and federal regulations. Keep out of public water supplies.

HEALTH RELATED DATA
Specific Hazard(s): Prolonged or repeated exposure may cause irritation or other allergic responses.
Primary Route(s) of Entry: Skin contact, eye contact, inhalation
HEALTH RELATED DATA (cont)

First Aid Procedures:

Eye contact: Flush with water for 15 minutes. Get medical attention.

Skin contact: Wipe excess. Wash with rubbing alcohol, if available, followed by soap and water. Discard shoes if contaminated.

Inhalation: Remove to fresh air.

Information given herein is offered in good faith as accurate, but without guarantee. Conditions of use and suitability of the product for particular uses are beyond our control: all risks of use of the product are therefore assumed by the user and we expressly disclaim all warranties of every kind and nature, including warranties of merchantability and fitness for a particular purpose in respect to the use or suitability of the product. Appropriate warnings and safe handling procedures should be provided to handlers and users.
### MATERIAL SAFETY DATA SHEET

#### TRADE NAME
LAZ-TEC

#### MANUFACTURER'S NAME
J & J CORPORATION

#### ADDRESS/STREET
4301 6TH STREET SW

#### PHONE NUMBER (EMERGENCY)
(319) 366-8666

#### CITY
CEDAR RAPIDS

#### STATE
IOWA

#### ZIP CODE
52404

#### CHEMICAL STRUCTURE
CaSiO₃, CALCIUM METASTLICATE

### PRODUCT IDENTIFICATION

<table>
<thead>
<tr>
<th>TRADE NAME</th>
<th>GENERIC NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAZ-TEC</td>
<td>WOLLASTONITE, SURFACE MODIFIED</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MANUFACTURER'S NAME</th>
<th>CAS NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>J &amp; J CORPORATION</td>
<td>13983-17-0</td>
</tr>
</tbody>
</table>

### PRODUCT INGREDIENTS

<table>
<thead>
<tr>
<th>CHEMICAL AND/OR COMMON NAME</th>
<th>CAS NUMBER</th>
<th>TLV/PEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>WOLLASTONITE</td>
<td>13983-17-0</td>
<td>NOT APPLICABLE</td>
</tr>
</tbody>
</table>

TREAT AS NUISANCE DUST. TLV = 10mg/m³, 8HR. TWA (TOTAL DUST)

### PHYSICAL DATA

**DESCRIPTION**
ACICULAR, FREE FLOWING, NON-METALLIC MINERAL POWDER

**SPECIFIC GRAVITY**
0.01 gm/10cc (vollastonite) 2.9

**PERCENT VOLATILE**
LESS THAN 1WT.

**MELTING POINT**
1540° C

### FIRE AND EXPLOSION DATA

**EXTINGUISHING MEDIA**
NOT APPLICABLE

**SPECIAL FIREFIGHTING PROCEDURES**
NOT APPLICABLE

**UNUSUAL FIRE OR EXPLOSION HAZARDS**
NOT APPLICABLE

### HEALTH HAZARD INFORMATION

#### HAZARD BY ROUTES OF EXPOSURE

**INHALATION**
LONG-TERM CUMULATIVE INHALATION OF HEAVY CONCENTRATIONS OF WOLLASTONITE MAY CAUSE RESTRICTION OF THE LARGE AIRWAYS.

**INGESTION**
NONE KNOWN

**SKIN CONTACT/ABSORPTION**
MAY CAUSE MINOR SKIN IRRITATION

**SIGNS AND SYMPTOMS ASSOCIATED WITH EXPOSURE OVER TLV**
NC TLV ASSIGNED

**MEDICAL CONDITIONS WHICH MAY BE AGGRAVATED**
NONE KNOWN

ANY OF PART I LISTED AS A HORMOGEN? INTP. IARC, OSHA
NO

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
V. HEALTH HAZARD INFORMATION (Continued)

EMERGENCY/FIRST AID PROCEDURES

INHALATION
INHALE FRESH AIR

INGESTION
NONE KNOWN

EYE CONTACT
FLUSH EYES THOROUGHLY. IF IRRITATION PERSISTS, SEE A PHYSICIAN.

SKIN CONTACT
GENTLY VAC WITH SOAP AND WATER. IF IRRITATION PERSISTS, SEE A PHYSICIAN.

SKIN ABSORPTION
NONE KNOWN

VI. RECOMMENDATIONS FOR HANDLING

RESPIRATORY PROTECTION
USE OF AN APPROVED RESPIRATOR FOR NUISANCE DUST IS RECOMMENDED.

EYE PROTECTION
USE OF SAFETY GOGGLES IS RECOMMENDED.

PROTECTIVE GLOVES
USE OF GLOVES IS RECOMMENDED.

OTHER PROTECTIVE CLOTHING/EQUIPMENT
PROTECTION OF SKIN FROM EXPOSURE IS RECOMMENDED.

VENTILATION REQUIREMENTS
MECHANICAL VENTILATION IS RECOMMENDED TO MAINTAIN A DUST-FREE WORK PLACE.

VII. REACTIVITY DATA

STABILITY
SURFACE TREATMENTS MAY OXIDIZE OR DECOMPOSE AT ELEVATED TEMPERATURES.

CONDITIONS TO AVOID
NONE KNOWN.

DECOMPOSITION PRODUCTS
BURNING MAY PRODUCE MINOR AMOUNTS OF OXIDES OF CARBON, SILICON, HYDROGEN OR SULFUR.

VIII. CLEAN UP AND DISPOSAL

STEPS TO BE TAKEN IF MATERIAL IS SPILLED
SWEEP OR SHOVEL AND PLACE IN A SUITABLE CONTAINER.

WASTE DISPOSAL METHOD
TO COMPLY WITH FEDERAL, STATE AND LOCAL REGULATIONS.

RCRA REGULATED
- [ ] YES 
[ ] NO

RCRA NUMBER
NONE

CERCLA (Superfund) REPORTABLE QUANTITY
NONE

DOT REGULATED
- [ ] YES 
[ ] NO

DOT PROPER SHIPPING NAME
WOLLASTONITE

DOT HAZARD CLASS
NONE

DOT NUMBER
13981-12-0

IX. SPECIAL PRECAUTIONS

SPECIAL PRECAUTIONS FOR HANDLING AND STORAGE
TEEP DRY AND COOL IN ORIGINAL SHIPPING CONTAINERS UNTIL USE.

OTHER PRECAUTIONS
NONE KNOWN

Prepared By
KENNETH J. SOLLIMAN

Phone No
(518) 963-4262

Title
HEALTH AND SAFETY OFFICER

While the information and recommendations set forth herein are believed to be accurate as of the date hereof, the manufacturer makes no warranty with respect thereto and disclaims all liability from reliance thereon.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
SECTION I IDENTITY

PRODUCT NAME: XB 5149 (FORMERLY CG 2117 HC)
CHEMICAL NAME OR SYNONYMS: Acrylate ester blend
DATE ISSUED: 03/09/92

HAZARD RATING:
TOXICITY: 2  FIRE: 1  REACTIVITY: 2
4 = EXTREME; 3 = HIGH; 2 = MODERATE; 1 = SLIGHT; 0 = SIGNIFICANT;
* = SEE SECTION V;

SECTION II INGREDIENT

### OCCUPATIONAL EXPOSURE

<table>
<thead>
<tr>
<th>CHEMICAL IDENTITY</th>
<th>CAS NO.</th>
<th>FPC</th>
<th>OSHA</th>
<th>ACGIH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aliphatic urethane acrylate resin</td>
<td>TRD SECRET</td>
<td>NE</td>
<td>NE</td>
<td>NE</td>
</tr>
<tr>
<td>Dimethacrylate ester</td>
<td>TRD SECRET</td>
<td>NE</td>
<td>NE</td>
<td>NE</td>
</tr>
<tr>
<td>Diacylate ester</td>
<td>TRD SECRET</td>
<td>NE</td>
<td>NE</td>
<td>NE</td>
</tr>
</tbody>
</table>

These chemicals are not considered to be carcinogenic by NTP, IARC, or OSHA. COMMENTS: NE - NOT ESTABLISHED.

SECTION III PHYSICAL PROPERTIES

### APPEARANCE AND ODOR:
Clear colorless to faint yellow color liquid, Acrylate odor

### VISCOSITY:
-3,000 @ 25°C

### VAPOR PRESSURE (mm Hg):
< 1 @ 20°C

### VAPOR DENSITY (AIR = 1):
> 1

### SOLUBILITY IN WATER:
Insoluble
PERCENT VOLATILE (BY WEIGHT): 0.5
SPECIFIC GRAVITY (WATER = 1): 1.14
EVAPORATION RATE (BUTYL ACETATE = 1): < 1

SECTION IV FIRE AND EXPLOSION HAZARD INFORMATION

FLASH POINT: 129° C Closed Cup
EXTINGUISHING MEDIA:
Foam, CO₂, Dry chemical, Water.
SPECIAL FIRE FIGHTING PROCEDURES:
Wear breathing apparatus (MSHA/NIOSH-approved, pressure demand, self-contained or equivalent.) and full protective gear.
UNUSUAL FIRE AND EXPLOSION HAZARDS:
Heat/Inhibitor deplation/Exposure to radiation/oxidizers can cause spontaneous polymerization generating heat and pressure. Sealed containers can explodes. Decomposition and combustion products may be toxic. Avoid the use of a stream of water to control fire since frothing can occur.

SECTION V HEALTH HAZARD INFORMATION

PRIMARY ROUTES OF EXPOSURE:
Dermal and Inhalation
EFFECT OF OVEREXPOSURE:
INHALATION:
Vapor or mist can cause irritation to the nose and throat.
EYE CONTACT:
Liquid or vapor can cause substantial irritation to eyes.
SKIN CONTACT:
Substance can cause moderate irritation to skin.
INGESTION:
Possibly harmful if swallowed.
DELAYED EFFECTS:
Prolonged or repeated exposure can cause central nervous depression, nausea, headache and dizziness. Also, substance can cause allergic reaction.
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE:
Allergy, eczema or skin conditions.
EMERGENCY AND FIRST AID PROCEDURES:
INHALATION:
Move subject to fresh air. Give artificial respiration if breathing has stopped.
EYE AND SKIN CONTACT:
Flush eyes with large amount of water for at least 15 minutes. Get prompt medical attention. Wash skin thoroughly with soap and water. Remove and wash clothing before reuse.

INGESTION:
If swallowed dilute by giving 2 glasses of water to drink. See a physician. Never give anything by mouth to an unconscious person.

SECTION VI REACTIVITY INFORMATION

STABILITY:
Unstable

CONDITION TO AVOID:
Heat, direct Sunlight

HAZARDOUS DECOMPOSITION PRODUCTS:
Carbon monoxide, carbon dioxide, oxides of nitrogen

HAZARDOUS POLYMERIZATION:
May occur.

CONDITION TO AVOID HAZARDOUS POLYMERIZATION:
Heat, UV radiation, free radical initiators, inert gases

INCOMPATIBILITY (MATERIALS TO AVOID):
Strong oxidizing materials, inert gases.

SECTION VII SPILL AND LEAK PROCEDURE INFORMATION

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:
Evacuate the spill area. Wear protective clothing. Dike and absorb spill with inert material. Transfer to containers suitable for disposal. Remove contaminated clothing promptly and wash affected skin areas with soap and water. If spill on a porous surface, ground water contamination must be considered.

WASTE DISPOSAL METHODS:
Incinerate liquid; landfill or incinerate contaminated diking material in accordance with local, state, and federal regulations.

SECTION VIII SPECIAL PROTECTION INFORMATION

VENTILATION TYPE:
Mechanical local exhaust ventilation at point of contaminant release.

RESPIRATORY PROTECTION:
Wear respirator (MSHA/NIOSH-approved) suitable for concentrations and types of air contaminants encountered.

PROTECTIVE GLOVES:
Impervious gloves

EYE PROTECTION:
Chemical splash goggles (ANSI Z-87.1)

OTHER PROTECTIVE EQUIPMENT:
Protective clothing, eyewash facility, safety shower.
SECTION IX STORAGE AND HANDLING INFORMATION

STORAGE TEMPERATURE:

MAXIMUM 35° C

Avoid all skin contact. May cause allergic reaction. Store indoors in a cool, dry area with adequate ventilation. Store out of direct sunlight. PLEASE READ TECHNICAL DATA SHEET BEFORE HANDLING THIS PRODUCT.

SECTION X TOXICITY INFORMATION

IRRITATION:

EYES - Substantial

SKIN - Moderate

SECTION XI MISCELLANEOUS INFORMATION

NOTE TO PHYSICIAN:

Allergic dermatitis or respiratory response in susceptible individuals may be delayed. It may appear after weeks or even months of frequent and prolonged contact.

DOT/IATA SHIPPING/PACKAGING INFORMATION:

DOT PROPER SHIPPING NAME:

Not Restricted, Plastic Liquids

DOT HAZARD CLASS:

Not Regulated

DOT/UN NUMBER:

Not Available

PACKAGING GROUP:

Not Applicable

RCRA STATUS:

Not a hazardous waste under RCRA (40 CFR 261)

CERCLA STATUS:

Not listed

SARA TITLE III - TOXIC CHEMICAL LIST:

This product does not contain toxic chemicals subject to the routine annual "Toxic Chemical Release Notification" under Section 313 (40 CFR 372).

PENNSYLVANIA RIGHT TO KNOW ACT:

The following is required composition information.

This product contains:

(1) Aliphatic urethane acrylate resin (TRD SECRET)
(2) Dimethacrylate ester (TRD SECRET)
(3) Diacylate ester (TRD SECRET)

TOXIC SUBSTANCE CONTROL ACT (TSCA):

INVENTORY STATUS:

Chemical components listed on TSCA inventory.
CALIFORNIA SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT RULE 443.1:
VOLATILE ORGANIC COMPOUNDS:

This product contains 6 mg/liter volatile Organic Compounds. VOC is
Based on Theoretical calculation.

ISSUE DATE: 03/09/92    REVISION: 00M    SUPERSEDES DATE: NA
ISSUED BY: RAJESH S. PATEL
FOR FURTHER INFORMATION, PLEASE CONTACT: PRODUCT SAFETY DIRECTOR

IMPORTANT MESSAGE!!
THE INFORMATION CONTAINED HEREIN IS BASED ON DATA CONSIDERED ACCURATE.
HOWEVER, NO WARRANTY IS EXPRESSED OR IMPLIED REGARDING THE ACCURACY OF THESE
DATA OR THE RESULTS TO BE OBTAINED FROM THE THEREOF.

CIBA-GEIGY CORPORATION ASSUMED NO RESPONSIBILITY FOR PERSONAL INJURY OR
PROPERTY DAMAGE TO VENDEES, USERS, OR THIRD PARTIES CAUSED BY THE MATERIAL.
SUCH VENDEES OR USERS ASSUME ALL RISKS ASSOCIATED WITH THE USE OF THE
MATERIAL.

HAZARD STATEMENT!!
THIS MATERIAL SAFETY DATA SHEET (MSDS) HAS BEEN PREPARED IN COMPLIANCE WITH

THIS PRODUCT IS CONTINUED TO BE A HAZARDOUS CHEMICAL UNDER THAT STANDARD.

PAGE 5
MATERIAL SAFETY DATA SHEET

CIBA-GEIGY CORPORATION
FORMULATED SYSTEMS GROUP
4717 CRAW AVE
EAST LANSING, MI 48823
(517) 351-8900

EMERGENCY PHONE NUMBER:
(800) 888-5572

SECTION I-IDENTITY INFORMATION

IDENTITY (TRADENAME): REN SHAPE (R) 450

FAMILY/ CHEMICAL NAME:
CURED POLYURETHANE

PRODUCT TYPE:
MODELING STOCK

IMPORTANT:
* THIS MATERIAL WILL NOT BE SOLD FOR USE IN PRODUCTS *
* FOR WHICH PROLONGED CONTACT WITH MUCCUS MEMBRANES OR *
* ABRADED SKIN, OR IMPLANTATION WITHIN THE HUMAN BODY, IS *
* SPECIFICALLY INTENDED. BECAUSE OF THE WIDE RANGE OF *
* SUCH POTENTIAL USES, CIBA-GEIGY CORPORATION IS NOT ABLE *
* TO RECOMMEND THIS MATERIAL AS SAFE AND EFFECTIVE FOR *
* SUCH USES AND ASSUMES NO LIABILITY FOR ANY SUCH USES. *

HAZARD STATEMENT:
* THIS MATERIAL SAFETY DATA SHEET (MSDS) HAS BEEN *
* PREPARED IN COMPLIANCE WITH THE FEDERAL OSHA HAZARD *
* THIS PRODUCT IS NOT CONSIDERED TO BE A HAZARDOUS *
* CHEMICAL UNDER THAT STANDARD.

SECTION III-PHYSICAL DATA

APPEARANCE:
BROWN SOLID.

PERCENT VOLATILE:
0%

0 GRAMS/LITER VOC (STATE OF CALIFORNIA)

SOLUBILITY IN WATER:

REN SHAPE (R) 450
IN SOLUBLE.
SPECIFIC GRAVITY:
0.67 (WATER = 1)

SECTION IV—FIRE AND EXPLOSION HAZARD DATA

EXTINGUISHING MEDIA:
CARBON DIOXIDE, DRY CHEMICAL, FOAM, WATER.

FIRE FIGHTING PROCEDURES—SPECIAL:
USE SELF-CONTAINED BREATHING APPARATUS.

UNUSUAL FIRE AND EXPLOSION HAZARDS:
DECOMPOSITION AND COMBUSTION PRODUCTS MAY BE TOXIC.

SECTION V—REACTIVITY DATA

STABILITY:
STABLE.

CONDITIONS TO AVOID:
EXCESSIVE HEAT FOR PROLONGED PERIODS OF TIME.

INCOMPATIBILITY:
STRONG OXIDIZERS, ACIDS AND BASES.

HAZARDOUS DECOMPOSITION PRODUCTS:
COMBUSTION MAY FORM TOXIC MATERIALS. CARBON MONOXIDE, CARBON DIOXIDE, BENZENE, TOLUENE, OXIDES OF NITROGEN, HYDROGEN CYANIDE.

HAZARDOUS POLYMERIZATION:
WILL NOT OCCUR.

SECTION VI—HEALTH HAZARD DATA

PRIMARY ROUTES OF EXPOSURE:
DERMAL OR INHALATION

THRESHOLD LIMIT VALUE:
THIS ARTICLE IS NOT CONSIDERED TO BE HAZARDOUS.

EYE IRRITATION:
DUST DUE TO MACHINING MAY CAUSE IRRITATION.

OVEREXPOSURE EFFECTS:
CURED POLYURETHANE RESINS ARE PRACTICALLY INERT SUBSTANCES WITH NO DEGREE OF TOXICITY.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE:
SKIN AND EYE CONDITIONS.

EMERGENCY AND FIRST AID PROCEDURES—EYES:
IMMEDIATELY FLUSH EYES WITH WATER FOR AT LEAST 15 MINUTES.
CALL A PHYSICIAN.

EMERGENCY AND FIRST AID PROCEDURES—SKIN:
WASH WITH SOAP AND WATER. REMOVE CONTAMINATED CLOTHING AND LAUNDER BEFORE RE-USE.

EMERGENCY AND FIRST AID PROCEDURES—INGESTION:
IF CONSCIOUS; GIVE PLENTY OF WATER TO DRINK. DO NOT INDUCE VOMITING. CALL A PHYSICIAN.

EMERGENCY AND FIRST AID PROCEDURES—INHALATION:
REMOVE TO FRESH AIR. GIVE OXYGEN AND/OR ARTIFICIAL RESPIRATION; IF NEEDED. CALL A PHYSICIAN.
EMERGENCY AND FIRST AID PROCEDURES—OTHER:
REFERRAL TO A PHYSICIAN IS RECOMMENDED IF THERE IS ANY
QUESTION ABOUT THE SERIOUSNESS OF ANY INJURY.

SECTION VII—SPILL OR LEAK PROCEDURES

SPILL PROCEDURES:
Sweep up into approved disposal container.
Thoroughly vacuum area; do not create dusty condition.

WASTE DISPOSAL METHODS:
Consult qualified local or corporate personnel for method
that will comply with local, state and federal health and
environmental regulations.

SECTION VIII—SPECIAL PROTECTION INFORMATION

VENTILATION:
General mechanical and local exhaust in accordance with
ACGIH recommendations.

PROTECTIVE GLOVES:
Wear gloves as a standard handling procedure.

EYE PROTECTION:
Wear chemical goggles to protect against dust particles.

RESPIRATORY PROTECTION:
Use NIOSH approved dust mask, if required.

SECTION IX—SPECIAL PRECAUTIONS

HMIS CODE:
Health: 0  Fire: 1  Reactivity: 0

HANDLING, SHIPPING AND StORING PRECAUTIONS:
CAUTION AVOID DUSTY CONDITIONS; USE WITH ADEQUATE
VENTILATION; AVOID BREATHING DUST;
IN ACCORD WITH GOOD INDUSTRIAL PRACTICE; HANDLE
WITH DUE CARE; AVOID CONTACT WITH EYES, SKIN;
AND CLOTHING. WASH THOROUGHLY AFTER HANDLING.

HANDLING PRECAUTIONS:
NUISANCE DUST MAY BE GENERATED WHEN SANDING OR SAWING
CURED MATERIAL.

SECTION X—REGULATORY INFORMATION

DOT PROPER SHIPPING NAME:
SOLID PLASTIC MASS, N.O.I.

DOT CLASS:
NOT REGULATED.

RCRA STATUS:
NOT A HAZARDOUS WASTE UNDER RCRA (40 CFR 261).

SARA/TITLE III—TOXIC CHEMICALS LIST:
THIS PRODUCT DOES NOT CONTAIN A TOXIC CHEMICAL FOR ROUTINE
ANNUAL ’TOXIC CHEMICAL RELEASE REPORTING’ UNDER SEC. 313
(40 CFR 372).

REN SHAPE (R) 450
TS3A INVENTORY STATUS:
CHEMICAL COMPONENTS LISTED ON TS3A INVENTORY.

PENNSYLVANIA RIGHT-TO-KNOW ACT:
THE FOLLOWING IS REQUIRED COMPOSITION INFORMATION.

CHEMICAL NAME: SPECIFIC CHEMICAL IDENTITY OF THIS COMPONENT IS BEING WITHHELD AS TRADE SECRET.
GENERIC NAME: CURLED POLYURETHANE BOARD.
COMMENTS: NOT ON PENNSYLVANIA HAZARDOUS SUBSTANCE LIST.

ISSUE DATE: 12/10/88 REVISION: 04C ISSUED BY: M. MUNSELL
FOR FURTHER INFORMATION, PLEASE CONTACT: PRODUCT SAFETY DIR.

THE INFORMATION AND RECOMMENDATIONS CONTAINED HEREIN ARE BASED UPON DATA BELIEVED TO BE CORRECT. HOWEVER, NO GUARANTEE OR WARRANTY OF ANY KIND EXPRESSED OR IMPLIED IS MADE WITH RESPECT TO THE INFORMATION CONTAINED HEREIN.
APPENDIX C

IMPACT ABRASION TEST DATA SHEETS
Impact Abrasion Test Data Sheet

Material: CIBA-GEIGY 6414-3

Material Coding Name: CG6414_3

Sample 1: Grams %WL Sample 2: Grams %WL
Start weight: 4.4977 Start weight: 4.1261
4 Hours: 4.4842 .3002 4 Hours: 4.1153 .2617
8 Hours: 4.4705 .6048 8 Hours: 4.0959 .7319
12 Hours: 4.4558 .9316 12 Hours: 4.0826 1.0543

Sample Average: Grams
Start weight: 4.3119
4 Hours: 4.2998
8 Hours: 4.2832
12 Hours: 4.2692

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.7194%</td>
<td>.2806%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>99.3344%</td>
<td>.6656%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>99.0097%</td>
<td>.9903%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: CIBA-GEIGY TDP 186-1

Material Coding Name: CGTDP186

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>4.4258</td>
<td></td>
<td>Start weight:</td>
<td>4.3552</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>4.3955</td>
<td>.6846</td>
<td>4 Hours:</td>
<td>4.3253</td>
<td>.6865</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.3718</td>
<td>1.2201</td>
<td>8 Hours:</td>
<td>4.3015</td>
<td>1.2330</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.3299</td>
<td>2.1668</td>
<td>12 Hours:</td>
<td>4.2657</td>
<td>2.0550</td>
</tr>
</tbody>
</table>

Sample Average: Grams

<table>
<thead>
<tr>
<th>Start weight:</th>
<th>4.3905</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours:</td>
<td>4.3604</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.3367</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.2978</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.3144%</td>
<td>.6856%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>98.7746%</td>
<td>1.2254%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>97.8886%</td>
<td>2.1114%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: URALITE 3156 from Hexcel

Material Coding Name: URAL3156

Sample 1:  
Grams | %WL | Sample 2:  
Grams | %WL
---|---|---|---|
Start weight: 4.3097 |  | Start weight: 4.4737 |
4 Hours: 4.2826 | .6288 | 4 Hours: 4.4484 | .5655
8 Hours: 4.2587 | 1.1834 | 8 Hours: 4.4306 | .9634
12 Hours: 4.2257 | 1.9491 | 12 Hours: 4.3868 | 1.9425

Sample Average:  
Grams
---|---|
Start weight: 4.3917 |
4 Hours: 4.3655 |
8 Hours: 4.3447 |
12 Hours: 4.3063 |

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.4034%</td>
<td>.5966%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>98.9298%</td>
<td>1.0702%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>98.0554%</td>
<td>1.9446%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: URALITE 3160 from Hexcel

Material Coding Name: URAL3160

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight: 4.4609</td>
<td></td>
<td></td>
<td>Start weight: 4.0848</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Hours: 4.4255</td>
<td>.7936</td>
<td></td>
<td>4 Hours: 4.0483</td>
<td>.8936</td>
<td></td>
</tr>
<tr>
<td>8 Hours: 4.3974</td>
<td>1.4235</td>
<td></td>
<td>8 Hours: 4.0265</td>
<td>1.4272</td>
<td></td>
</tr>
<tr>
<td>12 Hours: 4.3495</td>
<td>2.4973</td>
<td></td>
<td>12 Hours: 3.9945</td>
<td>2.2106</td>
<td></td>
</tr>
</tbody>
</table>

Sample Average: Grams

| Start weight: 4.2729 | |
| 4 Hours: 4.2369 | |
| 8 Hours: 4.2120 | |
| 12 Hours: 4.1720 | |

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.1575%</td>
<td>.8425%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>98.5747%</td>
<td>1.4253%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>97.6386%</td>
<td>2.3614%</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Impact Abrasion Test Data Sheet

Material: URALITE 3500 from Hexcel

Material Coding Name: URAL3500

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>4.4205</td>
<td></td>
<td>Start weight:</td>
<td>4.2757</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>4.3959</td>
<td>.5565</td>
<td>4 Hours:</td>
<td>4.2428</td>
<td>.7695</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.3553</td>
<td>1.4749</td>
<td>8 Hours:</td>
<td>4.2144</td>
<td>1.4337</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.3256</td>
<td>2.1468</td>
<td>12 Hours:</td>
<td>4.1989</td>
<td>1.7962</td>
</tr>
</tbody>
</table>

Sample Average: Grams

| Start weight: | 4.3481 |
| 4 Hours: | 4.3194 |
| 8 Hours: | 4.2849 |
| 12 Hours: | 4.2623 |

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.3399%</td>
<td>.6601%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>98.5465%</td>
<td>1.4535%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>98.0267%</td>
<td>1.9733%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: URALITE 3501 from Hexcel

Material Coding Name: URAL3501

<table>
<thead>
<tr>
<th>Sample</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start weight:</td>
<td>4.5068</td>
<td></td>
<td>Start weight:</td>
<td>4.1705</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>4.4786</td>
<td>.6257</td>
<td>4 Hours:</td>
<td>4.1556</td>
<td>.3573</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.4502</td>
<td>1.2559</td>
<td>8 Hours:</td>
<td>4.1468</td>
<td>.5683</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.4302</td>
<td>1.6997</td>
<td>12 Hours:</td>
<td>4.1294</td>
<td>.9855</td>
</tr>
</tbody>
</table>

Sample Average: Grams

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.5022%</td>
<td>.4978%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>99.0735%</td>
<td>.9265%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>98.6425%</td>
<td>1.3575%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: URALITE 3502 from Hexcel

Material Coding Name: URAL3502

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>4.2192</td>
<td></td>
<td>Start weight:</td>
<td>4.3178</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>4.2021</td>
<td>.6948</td>
<td>4 Hours:</td>
<td>4.2878</td>
<td>.6948</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.1915</td>
<td>.6565</td>
<td>8 Hours:</td>
<td>4.2585</td>
<td>1.3734</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.1651</td>
<td>1.2822</td>
<td>12 Hours:</td>
<td>4.2356</td>
<td>1.9037</td>
</tr>
</tbody>
</table>

Sample Average: Grams

| Start weight: | 4.2685 |
| 4 Hours: | 4.2450 |
| 8 Hours: | 4.2250 |
| 12 Hours: | 4.2004 |

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.4495%</td>
<td>.5505%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>98.9809%</td>
<td>1.0191%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>98.4046%</td>
<td>1.5954%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: URALITE 3503 from Hexcel

Material Coding Name: URAL3503

<table>
<thead>
<tr>
<th>Sample 1: Grams</th>
<th>%WL</th>
<th>Sample 2: Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight</td>
<td></td>
<td>Start weight</td>
<td></td>
</tr>
<tr>
<td>4 Hours</td>
<td>4.0984</td>
<td>.5001</td>
<td>4 Hours</td>
</tr>
<tr>
<td>8 Hours</td>
<td>4.0582</td>
<td>1.4761</td>
<td>8 Hours</td>
</tr>
<tr>
<td>12 Hours</td>
<td>4.0253</td>
<td>2.2748</td>
<td>12 Hours</td>
</tr>
</tbody>
</table>

Sample Average: Grams

<table>
<thead>
<tr>
<th>Start weight</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>3.9808</td>
</tr>
<tr>
<td>8 Hours</td>
<td>3.9550</td>
</tr>
<tr>
<td>12 Hours</td>
<td>3.9329</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.5698%</td>
<td>.4302%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>98.9245%</td>
<td>1.0755%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>98.3717%</td>
<td>1.6283%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: URALITE 3530 from Hexcel

Material Coding Name: URAL3530

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>4.5612</td>
<td></td>
<td>Start weight:</td>
<td>4.3164</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>4.5334</td>
<td>.6095</td>
<td>4 Hours:</td>
<td>4.2675</td>
<td>1.1329</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.5096</td>
<td>1.1313</td>
<td>8 Hours:</td>
<td>4.2370</td>
<td>1.8395</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.4673</td>
<td>2.0587</td>
<td>12 Hours:</td>
<td>4.1786</td>
<td>3.1925</td>
</tr>
</tbody>
</table>

Sample Average: Grams

| Start weight: | 4.4388 |
| 4 Hours: | 4.4005 |
| 8 Hours: | 4.3733 |
| 12 Hours: | 4.3230 |

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.1372%</td>
<td>.8628%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>98.5244%</td>
<td>1.4756%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>97.3912%</td>
<td>2.6088%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: URALITE 3534 from Hexcel

Material Coding Name: URAL3534

<table>
<thead>
<tr>
<th>Sample 1: Grams</th>
<th>%WL</th>
<th>Sample 2: Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight: 4.3279</td>
<td></td>
<td>Start weight: 3.9923</td>
<td></td>
</tr>
<tr>
<td>4 Hours: 4.3199</td>
<td>.1848</td>
<td>4 Hours: 3.9735</td>
<td>.4709</td>
</tr>
<tr>
<td>8 Hours: 4.3108</td>
<td>.3951</td>
<td>8 Hours: 3.9688</td>
<td>.5886</td>
</tr>
<tr>
<td>12 Hours: 4.2891</td>
<td>.8965</td>
<td>12 Hours: 3.9422</td>
<td>1.2549</td>
</tr>
</tbody>
</table>

Sample Average: Grams

<table>
<thead>
<tr>
<th>Start weight: 4.1601</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours: 4.1467</td>
</tr>
<tr>
<td>8 Hours: 4.1398</td>
</tr>
<tr>
<td>12 Hours: 4.1157</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.6779%</td>
<td>.3221%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>99.5120%</td>
<td>.4880%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>98.9327%</td>
<td>1.0673%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

**Material:** CONATHANE TU-900 from Conap

**Material Coding Name:** COPTU900

<table>
<thead>
<tr>
<th>Sample 1: Grams</th>
<th>%WL</th>
<th>Sample 2: Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight: 3.8594</td>
<td></td>
<td>Start weight: 4.0469</td>
<td></td>
</tr>
<tr>
<td>4 Hours: 3.8552</td>
<td>.1088</td>
<td>4 Hours: 4.0427</td>
<td>.1038</td>
</tr>
<tr>
<td>8 Hours: 3.8506</td>
<td>.2280</td>
<td>8 Hours: 4.0378</td>
<td>.2249</td>
</tr>
<tr>
<td>12 Hours: 3.8459</td>
<td>.3498</td>
<td>12 Hours: 4.0333</td>
<td>.3361</td>
</tr>
</tbody>
</table>

**Sample Average:** Grams

<table>
<thead>
<tr>
<th>Start weight: 3.9532</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours: 3.9489</td>
</tr>
<tr>
<td>8 Hours: 3.9442</td>
</tr>
<tr>
<td>12 Hours: 3.9396</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.8912%</td>
<td>.1088%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>99.7723%</td>
<td>.2277%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>99.6560%</td>
<td>.3440%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: CONATHANE TU-956 from Conap

Material Coding Name: COPTU956

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>4.1456</td>
<td></td>
<td>Start weight:</td>
<td>4.4112</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>4.1415</td>
<td>.0984</td>
<td>4 Hours:</td>
<td>4.4069</td>
<td>.0975</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.1363</td>
<td>.2243</td>
<td>8 Hours:</td>
<td>4.4016</td>
<td>.2176</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.1305</td>
<td>.3642</td>
<td>12 Hours:</td>
<td>4.3949</td>
<td>.3695</td>
</tr>
</tbody>
</table>

Sample Average: Grams

| Start weight: | 4.2784 |
| 4 Hours:      | 4.2742 |
| 8 Hours:      | 4.2689 |
| 12 Hours:     | 4.2627 |

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.9018%</td>
<td>.0982%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>99.7780%</td>
<td>.2220%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>99.6330%</td>
<td>.3670%</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
**Impact Abrasion Test Data Sheet**

**Material:** CONATHANE TU-961 from Conap

**Material Coding Name:** COPTU961

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>4.4546</td>
<td></td>
<td>Start weight:</td>
<td>4.4184</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>4.4367</td>
<td>.4018</td>
<td>4 Hours:</td>
<td>4.3966</td>
<td>.4934</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.4209</td>
<td>.7565</td>
<td>8 Hours:</td>
<td>4.3776</td>
<td>.9234</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.3897</td>
<td>1.4569</td>
<td>12 Hours:</td>
<td>4.3516</td>
<td>1.5119</td>
</tr>
</tbody>
</table>

**Sample Average: Grams**

| Start weight: | 4.4365 |
| 4 Hours: | 4.4167 |
| 8 Hours: | 4.3993 |
| 12 Hours: | 4.3707 |

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.5537%</td>
<td>0.4463%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>99.1615%</td>
<td>0.8385%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>99.5168%</td>
<td>1.4832%</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Impact Abrasion Test Data Sheet

Material: CONATHANE TU-981 from Conap

Material Coding Name: COPTU981

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>4.1594</td>
<td></td>
<td>Start weight:</td>
<td>3.9570</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>4.1382</td>
<td>.5097</td>
<td>4 Hours:</td>
<td>3.9368</td>
<td>.5105</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.1154</td>
<td>1.0578</td>
<td>8 Hours:</td>
<td>3.9152</td>
<td>1.0564</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.0978</td>
<td>1.4810</td>
<td>12 Hours:</td>
<td>3.8984</td>
<td>1.4809</td>
</tr>
</tbody>
</table>

Sample Average: Grams

| Start weight: | 4.0582 |
| 4 Hours:      | 4.0375 |
| 8 Hours:      | 4.0153 |
| 12 Hours:     | 3.9981 |

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.4899%</td>
<td>.5101%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>98.9429%</td>
<td>1.0571%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>98.5190%</td>
<td>1.4810%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: HAPFLEX 595 from Hapco

Material Coding Name: HPF595

<table>
<thead>
<tr>
<th></th>
<th>Sample 1: Grams</th>
<th>%WL</th>
<th>Sample 2: Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>4.4341</td>
<td></td>
<td>4.4734</td>
<td></td>
</tr>
<tr>
<td>4 Hours</td>
<td>4.3963</td>
<td>.8525</td>
<td>4 Hours: 4.4603</td>
<td>.2928</td>
</tr>
<tr>
<td>8 Hours</td>
<td>4.3856</td>
<td>1.0938</td>
<td>8 Hours: 4.4536</td>
<td>.4426</td>
</tr>
<tr>
<td>12 Hours: 4.3795</td>
<td>1.2314</td>
<td>12 Hours: 4.4404</td>
<td>.7377</td>
<td></td>
</tr>
</tbody>
</table>

Sample Average: Grams

<table>
<thead>
<tr>
<th></th>
<th>Start weight: 4.4538</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>4.4283</td>
</tr>
<tr>
<td>8 Hours</td>
<td>4.4196</td>
</tr>
<tr>
<td>12 Hours: 4.4100</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.4275%</td>
<td>.5725%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>99.2321%</td>
<td>.7679%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>99.0166%</td>
<td>.9834%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

**Material:** HAPFLEX 595 HP from Hapco

**Material Coding Name:** HPF595HP

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>4.3519</td>
<td></td>
<td>Start weight:</td>
<td>4.3648</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>4.3342</td>
<td>.4067</td>
<td>4 Hours:</td>
<td>4.3501</td>
<td>.3392</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.3245</td>
<td>.6296</td>
<td>8 Hours:</td>
<td>4.3363</td>
<td>.6554</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.3083</td>
<td>1.0019</td>
<td>12 Hours:</td>
<td>4.3175</td>
<td>1.0861</td>
</tr>
</tbody>
</table>

**Sample Average:** Grams

<table>
<thead>
<tr>
<th>Start weight:</th>
<th>4.3584</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours:</td>
<td>4.3422</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.3304</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.3129</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.6283%</td>
<td>.3717%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>99.3576%</td>
<td>.6424%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>98.9560%</td>
<td>1.0440%</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Impact Abrasion Test Data Sheet

Material: HAPFLEX 665 from Hapco

Material Coding Name: HPF665

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>4.4741</td>
<td></td>
<td>Start weight:</td>
<td>4.5319</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>4.4416</td>
<td>.7264</td>
<td>4 Hours:</td>
<td>4.5115</td>
<td>.4501</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.4273</td>
<td>1.0460</td>
<td>8 Hours:</td>
<td>4.4773</td>
<td>1.2048</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.3944</td>
<td>1.7814</td>
<td>12 Hours:</td>
<td>4.4502</td>
<td>1.8028</td>
</tr>
</tbody>
</table>

Sample Average: Grams

| Start weight: | 4.5030 |
| 4 Hours: | 4.4766 |
| 8 Hours: | 4.4523 |
| 12 Hours: | 4.4223 |

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.4137%</td>
<td>.5863%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>98.8741%</td>
<td>1.1259%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>98.2079%</td>
<td>1.7921%</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
**Impact Abrasion Test Data Sheet**

**Material:** HAPFLEX 665 HP from Hapco

**Material Coding Name:** HPF665HP

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>4.3217</td>
<td></td>
<td>Start weight:</td>
<td>4.4621</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>4.3181</td>
<td>.0833</td>
<td>4 Hours:</td>
<td>4.4382</td>
<td>.5356</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.2968</td>
<td>.5762</td>
<td>8 Hours:</td>
<td>4.4189</td>
<td>.9682</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.2744</td>
<td>1.0945</td>
<td>12 Hours:</td>
<td>4.3763</td>
<td>1.9229</td>
</tr>
</tbody>
</table>

**Sample Average:** Grams

| Start weight: | 4.3919 |
| 4 Hours: | 4.3782 |
| 8 Hours: | 4.3579 |
| 12 Hours: | 4.3254 |

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.6881%</td>
<td>.3119%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>99.2258%</td>
<td>.7742%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>98.4858%</td>
<td>1.5142%</td>
</tr>
</tbody>
</table>
# Impact Abrasion Test Data Sheet

**Material:** HAPCAST 3730/7 from Hapco  

**Material Coding Name:** HP3730_7  

<table>
<thead>
<tr>
<th>Sample 1</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>10.0536</td>
<td></td>
<td>Start weight:</td>
<td>9.7970</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>9.9655</td>
<td>9.8763</td>
<td>4 Hours:</td>
<td>9.6905</td>
<td>1.0871</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>9.8861</td>
<td>1.6661</td>
<td>8 Hours:</td>
<td>9.6246</td>
<td>1.7597</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>9.8257</td>
<td>2.2668</td>
<td>12 Hours:</td>
<td>9.5701</td>
<td>2.3160</td>
</tr>
</tbody>
</table>

**Sample Average:** Grams  

<table>
<thead>
<tr>
<th></th>
<th>Grams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>9.9253</td>
</tr>
<tr>
<td>4 Hours:</td>
<td>9.8280</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>9.7554</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>9.6979</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.0197%</td>
<td>.9803%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>98.2882%</td>
<td>1.7118%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>97.7089%</td>
<td>2.2911%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: HAPCOAT 597 from Hapco

Material Coding Name: HPCT597

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>4.4453</td>
<td></td>
<td>Start weight:</td>
<td>4.7630</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>4.4342</td>
<td>.2497</td>
<td>4 Hours:</td>
<td>4.7514</td>
<td>.2435</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.4224</td>
<td>.5152</td>
<td>8 Hours:</td>
<td>4.7403</td>
<td>.4766</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.4073</td>
<td>.8548</td>
<td>12 Hours:</td>
<td>4.7203</td>
<td>.8965</td>
</tr>
</tbody>
</table>

Sample Average: Grams

| Start weight:  | 4.6042 |
| 4 Hours:       | 4.5928 |
| 8 Hours:       | 4.5814 |
| 12 Hours:      | 4.5638 |

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.7524%</td>
<td>.2476%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>99.5048%</td>
<td>.4952%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>99.1225%</td>
<td>.8775%</td>
</tr>
</tbody>
</table>
# Impact Abrasion Test Data Sheet

**Material:** HAPCOAT 667 from Hapco  

**Material Coding Name:** HPCT667  

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>4.7866</td>
<td>Start weight:</td>
<td>4.7015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>4.7699</td>
<td>.3489</td>
<td>4 Hours:</td>
<td>4.6742</td>
<td>.5807</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.7385</td>
<td>1.0049</td>
<td>8 Hours:</td>
<td>4.6457</td>
<td>1.1869</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.6953</td>
<td>1.9074</td>
<td>12 Hours:</td>
<td>4.6121</td>
<td>1.9015</td>
</tr>
</tbody>
</table>

**Sample Average:** Grams  

| Start weight: | 4.7441 |
| 4 Hours: | 4.7221 |
| 8 Hours: | 4.6921 |
| 12 Hours: | 4.6537 |

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.5363%</td>
<td>.4637%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>98.9039%</td>
<td>1.0961%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>98.0945%</td>
<td>1.9055%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: HAPCAST 5730 from Hapco

Material Coding Name: HPCS5730

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>5.9419</td>
<td></td>
<td>Start weight:</td>
<td>5.8627</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>5.8405</td>
<td>1.7065</td>
<td>4 Hours:</td>
<td>5.8034</td>
<td>1.0115</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>5.7516</td>
<td>3.2027</td>
<td>8 Hours:</td>
<td>5.7232</td>
<td>2.3794</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>5.6984</td>
<td>4.0980</td>
<td>12 Hours:</td>
<td>5.6401</td>
<td>3.7969</td>
</tr>
</tbody>
</table>

Sample Average: Grams

Start weight: 5.9023

4 Hours: 5.8220

8 Hours: 5.7374

12 Hours: 5.6693

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>98.6395%</td>
<td>1.3605%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>97.2062%</td>
<td>2.7928%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>96.0524%</td>
<td>3.9476%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: 301/308 EPOXICAL from U.S. GYPSUM

Material Coding Name: EPOXICAL

<table>
<thead>
<tr>
<th>Sample</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.9507</td>
<td></td>
<td>2</td>
<td>5.3588</td>
<td></td>
</tr>
<tr>
<td>4 Hours</td>
<td>4.8811</td>
<td>1.4059</td>
<td>4 Hours</td>
<td>5.2710</td>
<td>1.6384</td>
</tr>
<tr>
<td>8 Hours</td>
<td>4.8205</td>
<td>2.6299</td>
<td>8 Hours</td>
<td>5.1921</td>
<td>3.1108</td>
</tr>
<tr>
<td>12 Hours</td>
<td>4.7855</td>
<td>3.3369</td>
<td>12 Hours</td>
<td>5.1070</td>
<td>4.6988</td>
</tr>
</tbody>
</table>

Sample Average: Grams

<table>
<thead>
<tr>
<th></th>
<th>Grams</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>5.1548</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>5.0761</td>
<td></td>
</tr>
<tr>
<td>8 Hours:</td>
<td>5.0063</td>
<td></td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.9463</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>98.4733%</td>
<td>1.5267%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>97.1192%</td>
<td>2.8808%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>95.9552%</td>
<td>4.0448%</td>
</tr>
</tbody>
</table>
## Impact Abrasion Test Data Sheet

**Material:** MASTER CAST 703 from Kindt-Collins

**Material Coding Name:** MASTR703

<table>
<thead>
<tr>
<th>Sample 1: Grams</th>
<th>%WL</th>
<th>Sample 2: Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td></td>
<td>Start weight:</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td></td>
<td>4 Hours:</td>
<td></td>
</tr>
<tr>
<td>8 Hours:</td>
<td></td>
<td>8 Hours:</td>
<td></td>
</tr>
<tr>
<td>12 Hours:</td>
<td></td>
<td>12 Hours:</td>
<td></td>
</tr>
</tbody>
</table>

Sample 1:
- Start weight: 6.2124
- 4 Hours: 6.1427 (1.1219%)
- 8 Hours: 6.1050 (1.7288%)
- 12 Hours: 6.0595 (2.4612%)

Sample 2:
- Start weight: 6.5286
- 4 Hours: 6.464 (0.9527%)
- 8 Hours: 6.4037 (1.9131%)
- 12 Hours: 6.3526 (2.6958%)

**Sample Average:**
- Start weight: 6.3705
- 4 Hours: 6.3046
- 8 Hours: 6.2544
- 12 Hours: 6.2061

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>98.9655%</td>
<td>1.0345%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>98.1775%</td>
<td>1.8225%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>97.4194%</td>
<td>2.5806%</td>
</tr>
</tbody>
</table>
## Impact Abrasion Test Data Sheet

**Material:** ULTRALLOY 40 from Hapco

**Material Coding Name:** ULTRAL40

<table>
<thead>
<tr>
<th>Time</th>
<th>Sample 1: Grams</th>
<th>%WL</th>
<th>Sample 2: Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>4.6496</td>
<td></td>
<td>Start weight:</td>
<td>4.6355</td>
</tr>
<tr>
<td>4 Hours:</td>
<td>4.4669</td>
<td>3.9294</td>
<td>4 Hours:</td>
<td>4.5505</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.3151</td>
<td>7.1942</td>
<td>8 Hours:</td>
<td>4.4105</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.1663</td>
<td>10.3944</td>
<td>12 Hours:</td>
<td>4.3266</td>
</tr>
</tbody>
</table>

**Sample Average:** Grams

<table>
<thead>
<tr>
<th>Time</th>
<th>Start weight:</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>4.6412</td>
<td>97.1451%</td>
<td>2.8549%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>4.5087</td>
<td>94.0016%</td>
<td>5.9984%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>4.2465</td>
<td>91.4957%</td>
<td>9.5043%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: ULTRALLOY 50 from Hapco

Material Coding Name: ULTRAL50

<table>
<thead>
<tr>
<th>Sample</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>4.6645</td>
<td></td>
<td>Start weight:</td>
<td>4.7258</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>4.5046</td>
<td>3.4280</td>
<td>4 Hours:</td>
<td>4.6158</td>
<td>2.3276</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.3703</td>
<td>6.3072</td>
<td>8 Hours:</td>
<td>4.5105</td>
<td>4.5558</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.2797</td>
<td>8.2495</td>
<td>12 Hours:</td>
<td>4.4145</td>
<td>6.5872</td>
</tr>
</tbody>
</table>

Sample Average: Grams

| Start weight: | 4.6952 |
| 4 Hours: | 4.5602 |
| 8 Hours: | 4.4404 |
| 12 Hours: | 4.3471 |

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>97.1247%</td>
<td>2.8753%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>94.5732%</td>
<td>5.4268%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>92.5860%</td>
<td>7.4140%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: PLAZ-TEC CERAMIC COMPOSITE from J&J Corp.

Material Coding Name: CERAMIC

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>7.2754</td>
<td></td>
<td>Start weight:</td>
<td>7.2213</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>7.2184</td>
<td>.7835</td>
<td>4 Hours:</td>
<td>7.1541</td>
<td>.9306</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>7.1661</td>
<td>1.5023</td>
<td>8 Hours:</td>
<td>7.1069</td>
<td>1.5842</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>7.0866</td>
<td>2.5950</td>
<td>12 Hours:</td>
<td>7.0483</td>
<td>2.3957</td>
</tr>
</tbody>
</table>

Sample Average: Grams

| Start weight: | 7.2484 |
| 4 Hours: | 7.1863 |
| 8 Hours: | 7.1365 |
| 12 Hours: | 7.0675 |

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.1433%</td>
<td>.8567%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>98.4562%</td>
<td>1.5438%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>97.5043%</td>
<td>2.4957%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: PLAZ-TEC FIBERGLASS CERAMIC from J&J Corp.

Material Coding Name: FIBERCER

Sample 1: | Grams   | %WL  | Sample 2: | Grams   | %WL  |
-----------|--------|--------|-----------|--------|------|
Start weight: 5.2422 |      |       | Start weight: 5.1329 |        |      |
4 Hours: 5.1680 | 1.4154 | 4 Hours: 5.0445 | 1.7222 |
8 Hours: 5.0557 | 3.5577 | 8 Hours: 4.9574 | 3.4191 |
12 Hours: 4.9994 | 4.6316 | 12 Hours: 4.8874 | 4.7829 |

Sample Average: Grams

Start weight: 5.1876
4 Hours: 5.1063
8 Hours: 5.0066
12 Hours: 4.9434

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>98.4328%</td>
<td>1.5672%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>96.5109%</td>
<td>3.4891%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>95.2926%</td>
<td>4.7074%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: PHOTOPOLYMER LMB 5086 from Ciba-Geigy

Material Coding Name: LMB5086

<table>
<thead>
<tr>
<th>Time</th>
<th>Sample 1: Grams</th>
<th>%WL</th>
<th>Sample 2: Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>4.5708</td>
<td></td>
<td>Start weight:</td>
<td>4.5653</td>
</tr>
<tr>
<td>4 Hours:</td>
<td>4.5258</td>
<td>.9845</td>
<td>4 Hours:</td>
<td>4.5105</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>4.4856</td>
<td>1.8640</td>
<td>8 Hours:</td>
<td>4.4652</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>4.4170</td>
<td>3.3648</td>
<td>12 Hours:</td>
<td>4.4008</td>
</tr>
</tbody>
</table>

Sample Average: Grams

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>98.9076%</td>
<td>1.0924%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>97.9707%</td>
<td>2.0293%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>96.5150%</td>
<td>3.4850%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: RENSHAPE from Ciba-Geigy

Material Coding Name: RENSHAPE

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>2.7040</td>
<td></td>
<td>Start weight:</td>
<td>2.6854</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>2.6493</td>
<td>2.0229</td>
<td>4 Hours:</td>
<td>2.6568</td>
<td>1.0650</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>2.5922</td>
<td>4.1346</td>
<td>8 Hours:</td>
<td>2.6046</td>
<td>3.0089</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>2.5464</td>
<td>5.8284</td>
<td>12 Hours:</td>
<td>2.5284</td>
<td>5.8464</td>
</tr>
</tbody>
</table>

Sample Average: Grams

| Start weight: | 2.6947 |
| 4 Hours: | 2.6531 |
| 8 Hours: | 2.5984 |
| 12 Hours: | 2.5374 |

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>98.4562%</td>
<td>1.5438%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>96.4263%</td>
<td>3.5737%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>94.1626%</td>
<td>5.8374%</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
## Impact Abrasion Test Data Sheet

**Material:** AISI 1020 LOW CARBON STEEL

**Material Coding Name:** AISI1020

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>32.5832</td>
<td></td>
<td>Start weight:</td>
<td>31.3188</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>32.5809</td>
<td>.0071</td>
<td>4 Hours:</td>
<td>31.3169</td>
<td>.0061</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>32.5788</td>
<td>.0135</td>
<td>8 Hours:</td>
<td>31.3118</td>
<td>.0224</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>32.5729</td>
<td>.0316</td>
<td>12 Hours:</td>
<td>31.3091</td>
<td>.0310</td>
</tr>
</tbody>
</table>

**Sample Average:**  
Start weight: 31.9510

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.9934%</td>
<td>.0066%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>99.9822%</td>
<td>.0178%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>99.9687%</td>
<td>.0313%</td>
</tr>
</tbody>
</table>
## Impact Abrasion Test Data Sheet

**Material:** 304 STAINLESS STEEL

**Material Coding Name:** SS304

<table>
<thead>
<tr>
<th>Sample 1: Grams</th>
<th>%WL</th>
<th>Sample 2: Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight: 28.1174</td>
<td></td>
<td>Start weight: 28.0050</td>
<td></td>
</tr>
<tr>
<td>4 Hours: 28.1131</td>
<td>.0153</td>
<td>4 Hours: 28.0015</td>
<td>.0125</td>
</tr>
<tr>
<td>8 Hours: 28.1108</td>
<td>.0235</td>
<td>8 Hours: 27.9986</td>
<td>.0229</td>
</tr>
<tr>
<td>12 Hours: 28.1086</td>
<td>.0313</td>
<td>12 Hours: 27.9964</td>
<td>.0307</td>
</tr>
</tbody>
</table>

**Sample Average:** Grams

<table>
<thead>
<tr>
<th>Start weight: 28.0612</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours: 28.0573</td>
<td></td>
</tr>
<tr>
<td>8 Hours: 28.0547</td>
<td></td>
</tr>
<tr>
<td>12 Hours: 28.0525</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.9861%</td>
<td>.0139%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>99.9768%</td>
<td>.0232%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>99.9690%</td>
<td>.0310%</td>
</tr>
</tbody>
</table>
Impact Abrasion Test Data Sheet

Material: SILICON BRONZE

Material Coding Name: SILIBRON

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>32.8718</td>
<td></td>
<td>Start weight:</td>
<td>33.0597</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>32.8203</td>
<td>.1567</td>
<td>4 Hours:</td>
<td>33.0108</td>
<td>.1479</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>32.7906</td>
<td>.2470</td>
<td>8 Hours:</td>
<td>32.9699</td>
<td>.2716</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>32.7574</td>
<td>.3480</td>
<td>12 Hours:</td>
<td>32.9353</td>
<td>.3763</td>
</tr>
</tbody>
</table>

Sample Average: Grams

| Start weight: | 32.9658 | |
| 4 Hours: | 32.9156 | |
| 8 Hours: | 32.8803 | |
| 12 Hours: | 32.8464 | |

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.8477%</td>
<td>.1523%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>99.7406%</td>
<td>.2594%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>99.6378%</td>
<td>.3622%</td>
</tr>
</tbody>
</table>
**Impact Abrasion Test Data Sheet**

**Material:** CLASS 30 GRAY IRON

**Material Coding Name:** CASTIRON

<table>
<thead>
<tr>
<th>Sample 1:</th>
<th>Grams</th>
<th>%WL</th>
<th>Sample 2:</th>
<th>Grams</th>
<th>%WL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start weight:</td>
<td>28.5813</td>
<td></td>
<td>Start weight:</td>
<td>30.0221</td>
<td></td>
</tr>
<tr>
<td>4 Hours:</td>
<td>28.5737</td>
<td>.0266</td>
<td>4 Hours:</td>
<td>30.0098</td>
<td>.0410</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>28.5624</td>
<td>.0661</td>
<td>8 Hours:</td>
<td>29.9932</td>
<td>.0963</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>28.5553</td>
<td>.0910</td>
<td>12 Hours:</td>
<td>29.9801</td>
<td>.1399</td>
</tr>
</tbody>
</table>

**Sample Average:**

<table>
<thead>
<tr>
<th>Start weight:</th>
<th>29.3017</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours:</td>
<td>29.2918</td>
</tr>
<tr>
<td>8 Hours:</td>
<td>29.2778</td>
</tr>
<tr>
<td>12 Hours:</td>
<td>29.2677</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>% of Start Weight</th>
<th>% Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hours</td>
<td>99.9662%</td>
<td>.0338%</td>
</tr>
<tr>
<td>8 Hours</td>
<td>99.9184%</td>
<td>.0816%</td>
</tr>
<tr>
<td>12 Hours</td>
<td>99.8840%</td>
<td>.1160%</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
APPENDIX D

SLOPE COMPARISONS OF REMAINING MATERIALS
HEXCEL URALITE 3156
versus CLASS 30 GRAY IRON

URALITE
3156
GRAY IRON

PERCENT WEIGHT LOSS

TIME
denotes percentage weight loss comparisons

HEXCEL URALITE 3160
versus CLASS 30 GRAY IRON

URALITE
3160
GRAY IRON

PERCENT WEIGHT LOSS

TIME
denotes percentage weight loss comparisons

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
HEXCEL URALITE 3500
versus CLASS 30 GRAY IRON
URALITE CLASS 30
3500 GRAY IRON

PERCENT WEIGHT LOSS

TIME
denotes percentage weight loss comparisons

HEXCEL URALITE 3501
versus CLASS 30 GRAY IRON
URALITE CLASS 30
3501 GRAY IRON

PERCENT WEIGHT LOSS

TIME
denotes percentage weight loss comparisons

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
HEXCEL URALITE 3502
versus CLASS 30 GRAY IRON

URALITE CLASS 30
3502 GRAY IRON

PERCENT WEIGHT LOSS

TIME
denotes percentage weight loss comparisons

HEXCEL URALITE 3503
versus CLASS 30 GRAY IRON

URALITE CLASS 30
3503 GRAY IRON

PERCENT WEIGHT LOSS

TIME
denotes percentage weight loss comparisons

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
HEXCEL URALITE 3534
versus CLASS 30 GRAY IRON
URALITE
3534
GRAY IRON

PERCENT WEIGHT LOSS

0 HOURS 4 HOURS 8 HOURS 12 HOURS
TIME
denotes percentage weight loss comparisons

CONAP CONATHANE TU-961
versus CLASS 30 GRAY IRON
CONATHANE
TU-961
GRAY IRON

PERCENT WEIGHT LOSS

0 HOURS 4 HOURS 8 HOURS 12 HOURS
TIME
denotes percentage weight loss comparisons

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
CONAP CONATHANE TU-981
versus CLASS 30 GRAY IRON

CONATHANE
CLASS 30
TU-981
GRAY IRON

PERCENT WEIGHT LOSS

TIME
denotes percentage weight loss comparisons

HAPCO HAPFLEX 595
versus CLASS 30 GRAY IRON

HAPFLEX
CLASS 30
595
GRAY IRON

PERCENT WEIGHT LOSS

TIME
denotes percentage weight loss comparisons

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
HAPCO HAPFLEX 665 HP
versus CLASS 30 GRAY IRON

HAPFLEX CLASS 30
665 HP GRAY IRON

PERCENT WEIGHT LOSS

0.0 0.5 1.0 1.5 2.0
0 HOURS 4 HOURS 8 HOURS 12 HOURS

TIME
denotes percentage weight loss

HAPCO HAPCAST 3730/7
versus CLASS 30 GRAY IRON

HAPCAST CLASS 30
3730/7 GRAY IRON

PERCENT WEIGHT LOSS

0 1 2 3
0 HOURS 4 HOURS 8 HOURS 12 HOURS

TIME
denotes percentage weight loss

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.