Open Molding

When you apply to become a Certified Composites Technician (CCT), you take the first step towards achieving excellence in the composites industry, advancing your career, and pursuing comprehensive open molding composites knowledge.

The CCT program is designed to elevate standards in the industry by enhancing individual performance and recognizing those who demonstrate critical knowledge of the composites industry. The CCT designation is a noted symbol of education among employers, employees, and industry professionals. As the industry advances, being a CCT will become increasingly important.

If you are committed to developing your career, attaining the CCT designation will allow others to recognize you as a certified composites industry professional. This Study Guide will cover the steps in becoming a CCT in Open Molding by providing you with critical knowledge and key concepts of the open molding process that will lay the foundation for your growth and understanding as you progress.
Disclaimer

The sole purpose of this Study Guide is to assist in the preparation for the CCT Examination. It is not a formal code or standard of the American Composites Manufacturers Association nor is the information contained herein based upon such a code or standard.

While the Study Guide reflects ACMA’s understanding of current industry practices in general, nothing herein should be viewed as a recommendation by ACMA that any application, technique or process is appropriate in any particular circumstances. Similarly, the fact that a particular application, technique or process is listed in the Study Guide should not be viewed as an endorsement by ACMA of such application, technique or process.

ACMA makes no claims concerning the accuracy or applicability of the information contained in the Study Guide and ACMA is not responsible for the results obtained from the use of such information. Determination of the suitability of the information in the Study Guide other than for the preparation for the CCT Examination is the sole responsibility of the user.

This Study Guide is sold without warranties, express or implied, including but not limited to any implied warranty of merchantability or fitness for a particular purpose. ACMA expressly disclaims all such warranties.

ACMA is not responsible for any damage or loss caused or alleged to be caused by the information contained herein. Accordingly, ACMA shall not be liable for any direct, indirect, incidental, special or consequential damages, resulting from the use of the Study Guide.

ACMA does not accept any liability based on the designation conferred upon an individual who successfully completes the certification program. Any company recognizing the conference of such a designation is responsible for verifying any and all credentials and skills of anyone with the CCT designation.

©2010 American Composites Manufacturers Association
1010 North Glebe Road, Suite 450
Arlington, VA. 22201
Phone: 703-525-0511
Fax: 703-525-0743
www.acmanet.org

All rights reserved.
No part of this book may be reproduced or resold, in any form or by any means, without permission from the publisher.
Printed in the United States.
# Table of Contents

## Module 1
**Gel Coat Application**
- Sec 1: Introduction to Gel Coating Technology .............................................. 7
- Sec 2: Gel Coating Safety ............................................................................ 9
- Sec 3: Gel Coat Storage & Handling ............................................................ 12
- Sec 4: Raw Material Quality Assurance ..................................................... 14
- Sec 5: Overview of Spray Gun Set-Up ......................................................... 14
- Sec 6: Gel Coat Application Methods ......................................................... 15
- Sec 7: Pre-Gel Coat Checklist .................................................................. 17
- Sec 8: Spraying Techniques ....................................................................... 18

## Module 2
**Laminating Technology**
- Sec 1: Introduction .................................................................................... 23
- Sec 2: Objectives of Open Molding Laminating ........................................ 24
- Sec 3: Placement of Reinforcement ............................................................ 24
- Sec 4: Resin-to-Glass Ratio ........................................................................ 26
- Sec 5: Saturation of Fiberglass Reinforcement .......................................... 30
- Sec 6: The Tools of the Trade .................................................................... 31
- Sec 7: Hand Lay-Up Laminating Techniques ............................................. 33
- Sec 8: Spray-Up Laminating Techniques ...................................................... 34
- Sec 9: Properly Curing the Laminate ........................................................... 36
- Sec 10: Specific Hand Lay-Up Laminating Procedures ............................... 37
- Sec 11: Specific Spray-Up Laminating Procedures ...................................... 39
- Sec 12: Wet Laminate Core Material Bonding Procedure ......................... 41
- Sec 13: Laminating Quality Control .............................................................. 42
- Sec 14: Flow Choppers vs. Traditional Choppers ...................................... 43
- Sec 15: Laminating Safety .......................................................................... 44

## Module 3
**Controlled Spraying**
- Sec 1: Introduction to Spray Application ..................................................... 51
- Sec 2: Controlled Spraying Training Program ............................................. 53
- Sec 3: Spray Application Terminology ....................................................... 57
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sec 4</td>
<td>Application Equipment</td>
<td>60</td>
</tr>
<tr>
<td>Sec 5</td>
<td>Spray Gun Set-Up &amp; Pressure Calibration</td>
<td>63</td>
</tr>
<tr>
<td>Sec 6</td>
<td>Overspray Containment Flanges</td>
<td>69</td>
</tr>
<tr>
<td>Sec 7</td>
<td>Spraying Techniques</td>
<td>71</td>
</tr>
<tr>
<td>Sec 8</td>
<td>Operator Training and Performance Evaluation</td>
<td>72</td>
</tr>
<tr>
<td>Sec 9</td>
<td>Controlled Spraying Summary</td>
<td>77</td>
</tr>
<tr>
<td>Sec 1</td>
<td>Plural Component Application Equipment</td>
<td>83</td>
</tr>
<tr>
<td>Sec 2</td>
<td>Plant Compressed Air System</td>
<td>83</td>
</tr>
<tr>
<td>Sec 3</td>
<td>Grounding of Fluid Handling Equipment</td>
<td>86</td>
</tr>
<tr>
<td>Sec 4</td>
<td>Types of Application Equipment</td>
<td>87</td>
</tr>
<tr>
<td>Sec 5</td>
<td>Non-Atomized Application</td>
<td>91</td>
</tr>
<tr>
<td>Sec 6</td>
<td>Fluid Pumps &amp; Initiator Delivery</td>
<td>92</td>
</tr>
<tr>
<td>Sec 7</td>
<td>General Equipment Operating Principles</td>
<td>94</td>
</tr>
<tr>
<td>Sec 8</td>
<td>Plural Component Equipment Calibration</td>
<td>95</td>
</tr>
<tr>
<td>Sec 9</td>
<td>Equipment Maintenance</td>
<td>98</td>
</tr>
<tr>
<td>Sec 10</td>
<td>Handling MEKP Initiator Safely</td>
<td>99</td>
</tr>
<tr>
<td>Sec 1</td>
<td>Polyester Resin Curing</td>
<td>105</td>
</tr>
<tr>
<td>Sec 2</td>
<td>Viscosity</td>
<td>108</td>
</tr>
<tr>
<td>Sec 3</td>
<td>Gel Coat Formulations</td>
<td>111</td>
</tr>
<tr>
<td>Sec 4</td>
<td>Gel Coat Porosity</td>
<td>115</td>
</tr>
<tr>
<td>Sec 5</td>
<td>Gel Coat Pre-Release</td>
<td>122</td>
</tr>
<tr>
<td>Sec 6</td>
<td>Alligating</td>
<td>124</td>
</tr>
<tr>
<td>Sec 7</td>
<td>Cosmetics and Surface Profiling</td>
<td>127</td>
</tr>
<tr>
<td>Appendix I</td>
<td>Glossary</td>
<td>137</td>
</tr>
<tr>
<td>Appendix II</td>
<td>Instructor’s Supplement, Controlled Spraying Training</td>
<td>165</td>
</tr>
</tbody>
</table>
Gel Coat Application

SECTION 1

Introduction to Gel Coating Technology

Applying gel coat is one of the most critical aspects of composites production. When customers look at a product, their first impression is based on the appearance of the gel coat surface. In addition to its cosmetic qualities, gel coat is used to provide weather and chemical resistance to composite products. The gel coat applicator’s job is to produce the best quality gel coat finish possible.

While the process of spraying gel coat appears relatively simple, exacting procedures are required to produce consistent defect-free finishes. This training module will highlight the proper procedures and methods to produce high-quality gel coat finishes. Once these procedures and methods are understood, many hours of hands-on training will be necessary to develop the skills of a qualified gel coater.

There are three critical components to the gel coating process: the gel coat, the spray equipment and the method of application. These elements must all function properly in order to produce a quality product. Remember, even if the procedure is 90% correct, the result will probably be a rejected part. Success in gel coating means getting the procedures 100% correct, 100% of the time.

What Is Gel Coat?

Gel coat is a specialized form of polyester or vinyl ester resin that is formulated as an in-mold coating. This in-mold coating becomes the cosmetic outer surface of the final molded part. Gel coat consists of: a base resin, additives to create non-sag properties, inert mineral fillers, and pigments to provide coloration. There are also additives to enhance the stability of the gel coat and to promote the cure. An initiator is added during the application to cure the gel coat film.

Gel coats are designed to cure in a thin film and are typically sprayed in wet film thickness of between .016” and .024”. This is expressed as 16 to 24 thousandths of an inch. Another way of expressing gel coat thickness is in mils. When using mils to express applied gel coat thickness, a thickness of 16 mils to 24 mils is the same as 16 to 24 thousandths of an inch.
Gel coat is normally designed to be sprayed on a mold surface with the laminate then applied over the gel coat film. Since the applied thickness of this in-mold coating is very important, spray application provides the best means of controlling the film thickness.

**Why Is the Application of Gel Coat so Important?**

The performance of the gel coat surface on a finished product is closely tied to how the material is applied. For example, gel coat that is too thick may be prone to cracking, while gel coat that is too thin may not cure properly. If gel coat is over-initiated or under-initiated, curing problems may result which can affect the color and durability of the finished product. In short, the quality of the finished product is closely tied to the quality of the gel coat application.

Another factor closely tied to application method is styrene emissions during the spraying process. The way the spray gun is set up (pressure, tip size), and the operator's spraying technique, has a great influence on the amount of styrene emissions produced during application. Minimizing overspray is a major factor in reducing styrene emissions, maintaining a clean work area, and reducing material waste. (Guidelines for proper controlled spraying will be covered in Module 3-Controlled Spraying.)

**Basic Gel Coat Chemistry**

Most gel coats are based on a polyester resin. Polyester resins are made by reacting an acid with an alcohol in a process called condensation polymerization. This forms a group of molecules known as an ester. The word *poly* means *many* - so polyester literally means *many esters*. Chains of repeating ester molecules are called a polymer. *Styrene monomer* is added to the polyester polymer forming what is known as an unsaturated polyester resin.

The process of curing a polyester resin is known as *crosslinking*. During the curing reaction, the styrene molecules crosslink with the polyester polymer, causing the resin to convert from a liquid to a solid. The addition of an initiator (sometimes incorrectly called a catalyst) moves the reaction forward, causing the styrene molecules to bond with the polyester polymer in the crosslinking reaction.

During the crosslinking reaction, heat is generated. This heat is known as *exotherm*. The exotherm temperature of a curing gel coat is affected by the thickness or the mass of the gel coat. A thin film of gel coat will generate less exotherm and cure slower than the same amount of gel coat concentrated in a cup. In a concentrated mass, gel coat will cure quickly and develop a very high exotherm.
The speed of the crosslinking reaction (gel coat cure) is affected by the formulation of the gel coat, the temperature of the gel coat, and the amount of initiator that is used. The term gel time is used to measure the speed of the reaction. Gel time is the interval from when the initiator is added to when the material transforms from a liquid to a gel in the sample cup. Typically 100 grams of gel coat in a cup will be used to determine gel time.

The crosslinking reaction is highly dependent on temperature and the amount of initiator used. The temperatures of the gel coat, the mold, and the air also have an effect on the rate of cure and the properties of the finished gel coat. The percentage of initiator mixed with the gel coat is a major influence on the speed of curing and the quality of the finished product.

Gel coat manufacturers have a specified working temperature range and an acceptable range for the percentage of initiator for each gel coat. These specifications are based on the chemistry of the product, and the ranges should not be exceeded if the proper cure is expected.

SECTION 2

Gel Coating Safety

Gel coat can be handled safely on a day-to-day basis if the proper procedures are followed. It should be noted however, that polyester resins and gel coats present several potential hazards if they are misused or handled improperly.

The Material Safety Data Sheet (MSDS), which accompanies each shipment of gel coat and is on file with the company, provides detailed requirements for the safe handling of each specific gel coat. The MSDS is the official source for information on all the chemicals that a person may work with or be exposed to during work. Questions concerning proper handling precautions, required personal protection equipment, or hazardous ingredients of a product, should be answered by referring to the MSDS. The potential hazards of gel coat fall into several categories:

- Toxic Hazards
- Spray Equipment Hazards
- Fire Hazards
- Spill Hazards