ems Science of Soldering©

The *Only* Soldering Course That Meets Modern Component Reliability Requirements

ENGINEERING CURRICULUM

Electronics Manufacturing Sciences, Inc.
4285 45th St. S., Saint Petersburg, FL 33711-4431
(727)866–6502
www.emsciences.com

Soldering is the heart of electronics manufacturing. It is also the least understood process and the most common cause of product failures and warranty claims.

Soldering involves a small number of fairly simple chemical, physical and metallurgical forces. Unfortunately, the electronics industry has changed a rather straightforward science into an incomprehensible collection of myths and legends. The difficulty is made worse by training (telling people what to do) rather than educating (showing why).

EMS Science of Soldering© is genuine education. With experiments and demonstrations, the course explains the essential science, exposes the myths, and develops a powerful "recipe" for perfect soldering.

The course teaches by troubleshooting a complex hands–on soldering process problem. In solving the problem (which involves several causes rather than a single root cause), the class learns the critical scientific forces that control all soldering from simple hand soldering to the most complex machine soldering. The class then develops quality and supplier management systems to prevent defects rather than allowing process mistakes and hoping inspection will find the defects.

The following curriculum has been designed to meet the special needs of process, design and quality engineers. A modified curriculum is also available for teaching operators and technicians.

The Science of Soldering© Engineering Content

1. The Core Science

- Wetting forces
- Chemical reactions
- Intermetallic bonds

2. The *EMS Science of Soldering*© Recipe

Clean Surfaces

- Definition and importance
- Contamination
- Oxides

Flux

- Defined
- Types and attributes
- Acidity, ionic contamination and effects on reliability
- The real definition of no–clean flux
- The four uses of flux in electronics soldering
- Selecting fluxes suitable for high reliability applications

Solderability
- Definition and importance
- Solderability of different component and PCB surfaces
- Implications of lead–free component finishes
- Scientific solderability management

Solder
- Defined
- Alloys (leaded and lead–free)
- Mechanical properties (ductility and tensility)
- Lead–free solder differences and techniques
- Failure risks of various alloys

Heat
- Why heat is needed
- How much heat is needed
- Failure modes from overheating
- Scientific heat control and elimination of damage during hand soldering

Soldering vs. Welding
- Definitions
- Significance of surfaces that melt during "soldering" vs. surfaces that do not melt (the overlooked lead–free issue)
- Uses of soldering and welding in electronics assembly

3. Machine Soldering

Wave and Selective (Mini–Wave) Soldering
- The *EMS Science of Soldering Recipe* in wave soldering
- Physical forces determining machine setup
- History of wave soldering evolution (and lessons for today)
- The uses of flux in wave soldering
- Selecting flux
- Selecting components
- Role and effect of turbulent (chip) waves
- The role of nitrogen, when nitrogen is useful and when nitrogen is avoidable expense
- Setting and managing wave profiles
- Design for wave soldering
- Techniques for maximizing process robustness
- Mini–wave selective soldering
- Palletized selective soldering
- Dip selective soldering

Surface Mount Reflow
- The *EMS Science of Soldering Recipe* in surface mount reflow
- Basic concepts and history of process evolution
- Selecting components and consumables
- Design for reflow producibility
- Stencils
- Setting and managing oven profiles
- Secrets of maximum process robustness

4. Lead–Free Solders and Soldering

Choosing the Alloy
- Available alloys
- Physical properties and failure modes
- Risks in extreme operating environments

Choosing Materials
- Fluxes
- Components
- Laminates

Equipment Requirements
- Heat
- Ability to tolerate the alloys
- Wave soldering machines
- Surface mount reflow

Risk Assessment and Avoidance

Warranty Considerations

5. Quality Systems and Reliability

- Inspection and test strategies
- Why visual criteria are not valid for reworked connections
- Understanding the psychology of inspectors and the implications
- 100% vs. sample inspection
- Consequences for reliability

Reliability Criteria
- The sorry truth about “high reliability” soldering
- What solder appearance reveals about machine soldering

- What solder appearance reveals about hand soldering, repairs and rework
- How to identify reworked connections
- Reliability criteria that work

Corrective Actions

- Attacking the cause rather than the symptom
- More inspection is not corrective action

Failures

- Realistic product life expectancy
- Common causes of failure and how to avoid them
- Effects of thermal cycling on solder joint structure and reliability
- The significance of regional failure patterns
- Troubleshooting using the EMS Soldering Recipe and Reliability Criteria

6. Open Discussion

7. Shop Floor Implementation

The class moves to the production floor to assess current soldering processes against the knowledge acquired in the classroom and implement process corrections as appropriate.