Semiconductor Manufacturing Technician Skill Standards

Equipment Technician

Maricopa Advanced Technology Education Center
Maricopa Community College District, Tempe, Arizona

MATEC

Sponsors and Contributing Organizations

The development of the Semiconductor Manufacturing Technician Skill Standards - Equipment Technician was sponsored with major funding from the Maricopa Advanced Technology Education Center through a grant from the National Science Foundation Advanced Technological Education (ATE) Program #DUE 9908419 to the Maricopa Community Colleges.

The project was conducted with support and authorization of the SEMATECH and SEMI/SEMATECH Technician Training Council.

Additional financial support for the project was provided by:

Companies that contributed significantly to the development, profiling and validation effort include:

AMD
Applied Materials
Digital
Huntair
IBM
Intel
Microchip
Motorola
ST Microelectronics
Texas Instruments

The development and publication of the Semiconductor Manufacturing Technician Skill Standards - Equipment Technician, has been a joint and collaborative effort between the SEMATECH and SEMI/SEMATECH Technician Training Council, the Maricopa Advanced Technology Education Center and Richland College. We are grateful to the many industry participants who participated in the development and validation process. These technicians and supervisors donated their time and effort to insure the relevancy and currency of the standards.

The following members of the SEMATECH and SEMI/SEMATECH Technician Training Council contributed to the development of these skill standards.

Gayle Bowles Haecker - ATSI
Jeff Dauphinee - IBM
Brent Donham - Richland College
Dick Harris - Texas Instruments
David Hata - Portland Community College
Pamela Hull - Richland College
Deonis James - Intel
Brent Kesterson - Richland College
Michael Lesiecki - MATEC
Wendi Martin - Huntair
Randy Metevier - Applied Materials
Dawn-Mechelle Nold - Texas SOICC
Peter Parsons - PRI Automation
John Paul - Motorola
Ezra Penermon - Texas Instruments
Fred Schuneman - Pierce College
David Silver - Synopsys
Diane Stone - Intel
Jim Thompson - IBM
Gayland Thorn - Intel
Mike Torrez - Intel
Ngoc Truong - Richland College
Keith Whiteside - Texas Instruments

Brent Kesterson at Richland College was primarily responsible for the process of development and validation. He and his colleagues from industry and academia are acknowledged as the key contributors to this document.

Michael Lesiecki, Ph.D.
Director
Maricopa Advanced Technology Education Center

Cover photo courtesy of SpeedFam-IPEC.

For More Information

Maricopa Advanced Technology Education Center
2323 West 14th Street
Tempe, Arizona 85281

http://matec.org
matec@maricopa.edu

480.517.8650 phone
480.517.8669 fax

SEmiconductor MAnufacturing TECHnology
2706 Montopolis Drive
Austin, Texas 78741

http://www.sematech.org

Any opinions, findings and conclusions or recommendations in this material are those of the authors and committee and do not necessarily reflect the view of the National Science Foundation.

To order additional copies or for more information on MATEC Curriculum Products, visit our web site at: http://matec.org, or call us at 480.517.8650.

Design and Layout by: Leslie Jabara

Overview

Skill Standards

Appendix

Background

The SEMATECH and SEMI/SEMATECH Technician Training Council **(1)** Taskforce was formed in 1997 to address the problem statement:

> "There is a lack of defined skill standards for semiconductor equipment technicians that can be communicated to economic and workforce initiatives and educational institutions."

The objective of the taskforce was to develop industry defined and validated skill standards for entry level equipment technicians focused on skills needed in the first six months on the job. The taskforce asked Brent Kesterson of Richland College to facilitate the project using the Performance Criteria Analysis List (PCAL®) approach.

The final skill standard statements are designed to establish performance and are directly related to what technicians actually do at the worksite. Many of the standards are designed for using information, communication and interpersonal skills. In addition, some of the standards are related to the technician's ability to apply basic principles of chemistry, physics and math.

PCAL Process

The PCAL process is an effective method developed by Richland College to determine specifically what skills graduates will need to be successful on the job. In addition to identifying the specific performance criteria (skills or behaviors) required, the PCAL includes data concerning how important each skill is for success, how proficient a worker needs to be at each skill, how difficult each skill is to learn, and how frequently each skill is used. After researching many pertinent documents the Richland Instructional Design staff drafted a list of over 200 skills required to be successful as a semiconductor equipment technician. This list was presented to the SEMI/SEMATECH Technician Training Council Task Force. The taskforce members reviewed and revised the draft list in collaboration with subject matter experts (SMEs) around the country. The final PCAL contained 247 performance criteria (observable and measurable behaviors).

Validating the PCAL

The next step was to validate the PCAL with more SMEs. A total of 41 SMEs from Arizona, New Mexico, Texas and Vermont were gathered in 5 focus group meetings and rated each of the 247 performance criteria for importance, proficiency level, difficulty to learn and frequency of use. A ranking scale of 1 lowest, to 4 highest was used to rate the criteria (see Appendix A for details). The performance criteria were ranked for significance using an algorithm, called the Emphasis Rating (ER, see Appendix A), based on importance, level, frequency and difficulty.

Committees then met to draft the actual skill standard statements using the ranked PCAL list.

Validating Skill Standard Statements

The final step was to insure that industry representative SMEs agreed with the skill standards as stated. To accomplish this, focus groups were conducted at 5 locations in Arizona, Oregon, Texas and Vermont. 20 representatives rated their agreement or disagreement with the skill standards. Significant agreement was documented with the list of skill standard statements. On a Likert Scale of Agreement (-2 = Strongly Disagree, -1 = Disagree, 0 = No Opinion, +1 = Agree, +2 = Strongly Agree) there were only 6 statements that had an average rating of 0 or less (see Appendix B for further details). These six statements were dropped from the final list that is published here. The bulk of the remaining ratings fell between +0.5 and +1.5, indicating strong agreement overall. The final statements were renumbered for convenience to account for the dropouts.

(1) Currently the Technician Performance Improvement Council

Business Applications for Skill Standards*

Skill Standards are not only useful for educators and students, many businesses are finding the Standards helpful in employee hiring, evaluation and development processes. Listed below are applications provided by businesses of possible uses of Skill Standards.

- Review the Functional Job Analysis, specifically assess the functions and tasks for relevancy, frequency and importance for a particular job at your worksite. Develop hiring criteria, identifying which ones are most critical for a new job opening in your company or department.

- Use the scenarios to trigger relevant in-house situations in which an employee may be required to solve typically occurring problems or critical incidents. Customize the scenarios for the particular job; include scenarios during an interview or an in-house problem solving training session.

- Communicate performance expectations for specific tasks by adapting the performance criteria for the particular job in your firm. Define specifically what the employee is expected to know and do, define what success looks like using the Standards.

- Use the performance criteria for evaluating job and task performance.

- Create individual criteria for evaluating job and task performance.

- Create individual development plans based on the identified gaps in performance and skill level; chart an employee's progress toward achieving the skill standard.

*used with permission from the Skills Standards Guidebook I and II, 1997, Washington State Board for Community and Technical Colleges.

- Ask for evidence of achievement for a particular function or task. This could be a demonstration, a portfolio or a description of accomplishments with appropriate documentation.

- Update job descriptions based on the information in the Skill Standards.

- Update compensation based upon the level of complexity required to perform successfully in a given occupational cluster.

- Use the Skill Standards as a benchmark for expected performance; a means for measuring progress.

- Use the Skill Standards as the basis for a certificate or credential to assure employers of the level of proficiency of a new hire or transferred employee.

- Articulate goals based on the Skill Standards for future work performance as roles and responsibilities expand.

- Stimulate strategic thinking about workforce reorganization - evaluate how work gets done using the major functions identified in the Skill Standard.

SEMICONDUCTOR EQUIPMENT TECHNICIAN
JOB DESCRIPTION

Required Education and Experience

Associate degree in electronics, semiconductor manufacturing, microelectronics or related technical field ***or*** equivalent experience.

General Job Duties

Monitors, maintains and performs a variety of complex repairs on semiconductor wafer fabrication equipment to ensure uninterrupted production flow. Also performs periodic preventative maintenance procedures as defined by specifications.

"Equipment technicians like to solve problems."

Provides technical support in the form of troubleshooting, installation, diagnostics, adjustment, repair, modification, assembly and calibration of equipment according to specifications, blueprints, manuals, drawings and verbal or written instructions. Utilizes a structured and comprehensive method to identify the root cause of process or equipment malfunction; implements corrective action after thorough analysis to increase probability of the right fix the first time based on product quality parameters. Performs electrical, mechanical, software troubleshooting and maintenance for related equipment, tools, cable assemblies and fixtures. Checks and calibrates tools, equipment and fixtures using test and diagnostic equipment as required. Cleans and lubricates shafts, bearings, gears and other parts of machinery. Assists in the layout, assembly, installation and maintenance of pipe systems and related equipment. Maintains and monitors maintenance parts stock. Maintains accurate records and logs of work performed, modifications, calibrations, adjustments and parts inventory.

May perform equipment and fixture modifications as directed by manufacturing engineers. Equipment used includes office equipment, power supplies, oscilloscopes, logic analyzers, volt meters, soldering irons, hand tools, power tools and personal computers or other hand/power tools and test equipment. Maintains proficiency in programmable controllers, microprocessors, control circuits, analog/digital circuits, motors and troubleshooting skills.

Skill Standards are quality standards applied to people. They are specific statements of desired skill and knowledge presented in an observable and measurable form.

The statement contains a condition that defines under what circumstances it will be observed and measured. The desired behavior is defined and the standard criteria is stated in terms of "how good is good enough."

An example of a skill standard statement is:

Condition **Behavior**

Given an equipment trainer and multimeter; measure current voltage and resistance; according to specified level of accuracy without supervision.

Standard

The ranking information in terms of importance, proficiency, frequency and difficulty are shown for each statement.

1 - Implementing Quality Principles

Skill Standard Statement

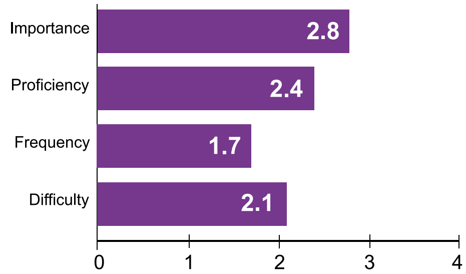
1.1 Condition: Given a series of control charts and process specifications
Behavior: Interpret data of SPC control charts
Standard: Determining if action is required

1.2 Condition: Given a case scenario of unacceptable product quality
Behavior: Communicate trends of machine performance
Standard: Identifying appropriate action

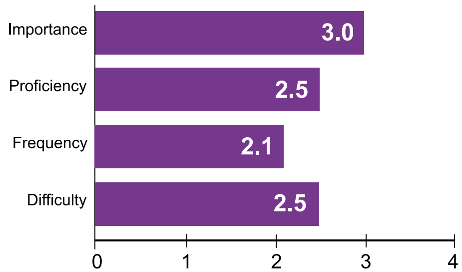
1.3 Condition: Given a set of flow charts and input conditions
Behavior: Analyze flow charts
Standard: Identifying correct conclusion

1.4 Condition: Given ESD protection devices
Behavior: Observe ESD precautions for product and equipment components
Standard: Demonstrating proper use in accordance with appropriate procedures

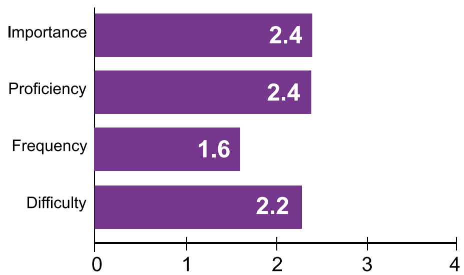
1.1



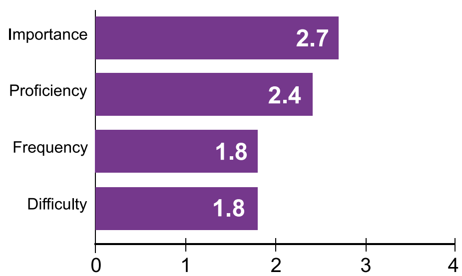
1.2



1.3



1.4



Ranking

For the first 6 months on the job:
Importance - how important is it to know or do
Proficiency - how well must it be done
Frequency - how frequently is the task done or the knowledge applied
Difficulty - how difficult is it to learn or do

Photo courtesy of Texas Instruments.

Ranking

The PCAL (Performance Criteria Analysis List) process uses a ranking scale based upon four factors. For every performance criteria statement (PCS) in the list, a score was assigned as follows for each factor:

IMPORTANCE **(How important is it for entry level employees to know or do the PCS?)**

4	=	Highest	Much higher priority than other PCSs on the list. CRUCIAL and highest priority. Inadequate knowledge or performance of PCS would adversely impact quality or safety of products/services.
3	=	High	Somewhat higher priority than other PCSs on the list. Inadequate knowledge or performance of PCS might adversely impact quality or safety of products/services to some degree.
2	=	Low	Somewhat lower priority than other PCSs on the list. Inadequate performance of PCS may not directly impact quality or safety of products/services.
1	=	Lowest	Much lower priority than other PCSs on the list. Inadequate performance of PCS would not have a direct impact on quality or safety of products/services, but must be performed.

PROFICIENCY **(How good is good enough for entry level employees to know or do the PCS?)**

4	=	Highest	Can recall and apply complex facts and principles and resolve problems. Can evaluate conditions and make proper decisions using complex facts and principles. Can do all elements of PCS quickly and accurately with no supervision.
3	=	High	Can recall and apply many facts and principles to different situations. Can analyze facts and principles and draw some appropriate conclusions. Can do all elements of PCS. Only needs spot checks of work.
2	=	Low	Can recall some facts and principles. Can state general principles about the subject. Can do many elements of the PCS but requires help on the hardest parts.
1	=	Lowest	Can recognize only simple facts and terms. Can do only simple parts of PCS and must be closely supervised.

FREQUENCY **(How frequently are entry level employees expected to know or do the PCS?)**

4	=	Highest	Spends much more time doing this than most other PCSs on the list.
3	=	High	Spends a little more time doing this than other PCSs on the list.
2	=	Low	Spends somewhat less time doing this than other PCSs on the list.
1	=	Lowest	Spends much less time doing this than other PCSs on the list.

DIFFICULTY **(How difficult is it for entry level employees to know or do the PCS?)**

4	=	Highest	Much more difficult to learn and perform than other PCSs on list.
3	=	High	Somewhat more difficult to learn and perform than other PCSs on list.
2	=	Low	Somewhat easier to learn and perform than other PCSs on list.
1	=	Lowest	Much easier to learn and perform than other PCSs on the list.

A sample shown below illustrates the rating scale.

Skill	Imp	Pro	Fre	Dif
Identify and communicate trends of machine performance	3.5	2.5	2.7	3.2

The values are based on a scale of 0-4, with 4 being the highest rank. The numbers shown are an average of all respondents (41 possible). Similar data exist for the entire list of skills.

Emphasis Rating (ER)

The emphasis rating shown below, combines the importance, proficiency, frequency and difficulty rankings to give a weighted, overall rating. This was used to prioritize and determine which skills were eventually considered most important to be included in the final list.

$$ER = \frac{1}{8}\left[\frac{\left(\frac{\#\text{ of responses}}{41}\right)}{.25} + (\text{Imp x } 3) + \text{Pro} + \text{Fre} + (\text{Dif x } 2)\right]$$

The first term in brackets weights the number of responses compared to the 41 total respondents. Not all respondents replied to every skill in the list if their expertise was outside of the area for example. Thus a skill that is performed by all gives a higher ER.

Both Importance and Difficulty are weighted given multiplying factors of three and two respectively to reflect their emphasis. The term 1/8 normalizes the maximum ER value to 4.0. In the skill example above, there were 41 responses to give an ER as shown below:

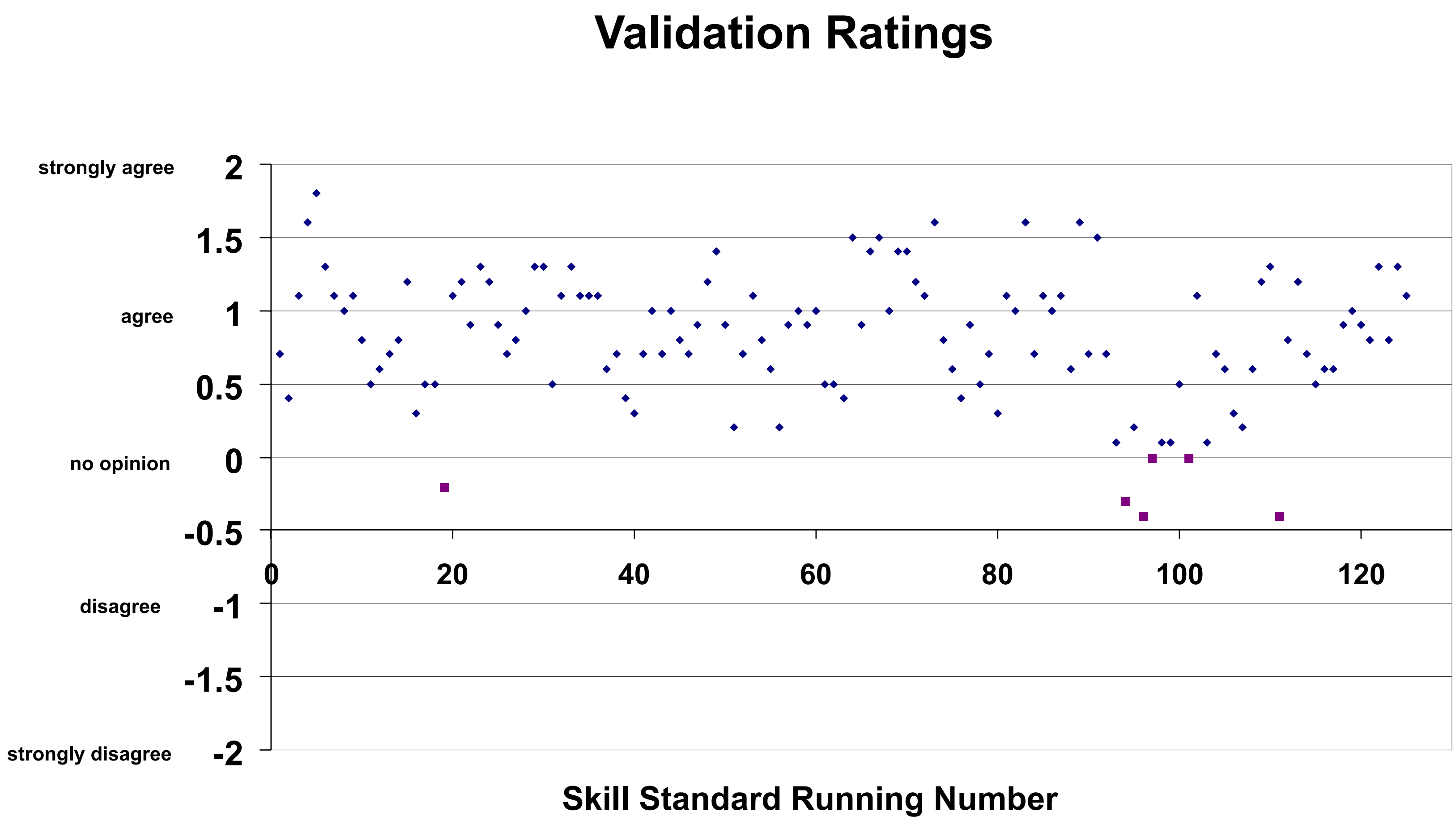
$$ER = \frac{1}{8}\left[\frac{\left(\frac{41}{41}\right)}{.25} + (3.5 \text{ x } 3) + 2.5 + 2.7 + (3.2 \text{ x } 2)\right]$$

$$= 3.3$$

In the process of creating the skill standards, those skills with ER’s of less than 2.0 were not considered.

Validation Data

The skill standards as stated were reviewed for agreement by industry subject matter experts. Using a Likert Scale (-2 = strongly disagree, -1 = disagree, 0 = no opinion, +1 = agree, +2 = strongly agree). The average rating for all the statements is shown on the graph at right. The skill standard statements (six in total) that had a rating ≤ 0 were not included in the final list.


Validation Ratings
strongly agree
agree
no opinion
disagree
strongly disagree
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
20
40
60
80
100
120
Skill Standard Running Number

According to Specification
: A defined specification which will vary depending on the learning and training environment. May be manufacturers' specifications or specifications identified in learning materials.

BOE
: Buffered Oxide Etch

Control Chart
: Used in Statistical Process Control; contains upper and lower control limits, mean, a series of data points and description of parameter being tracked.

CVD
: Chemical Vapor Deposition

DI
: De-Ionized

EBR
: Edge Bead Removal

Equipment Training Device
: Equipment consisting of sufficient components and devices (real or simulated) to enable the learner to demonstrate the skill or knowledge required.

ESD
: Electro-Static Discharge

Flow Chart
A diagram illustrating a process or procedure which often contains inputs, action steps, decision points and outputs.

Maintenance Record Form
A form (soft copy or hard copy) for recording actions, readings and comments used to document maintenance tasks.

MSDS
Material Safety Data Sheet

OSHA
U.S. government agency "Occupational Safety and Health Administration."Proven Techniques
Techniques that have become accepted standards in the industry and classroom learning environments.

QC
Quality Control

RF
Radio Frequency

Scenario
A plausible situation designed to enable proof of compliance with a standard.

SPC
Statistical Process Control

Maricopa Advanced Technology Education Center (MATEC)

Established in 1996, the Maricopa Advanced Technology Education Center (MATEC) is a National Science Foundation (NSF) funded National Center of Excellence. MATEC is intended to be a permanent center for education and workforce development in the semiconductor industry. MATEC provides the key elements that lead to lifelong learning and success for participants who plan to enter and work in the semiconductor industry.

Technician Performance Improvement Council (TPIC)

The TPIC, formerly known as the Technician Training Council, acts as a catalyst to influence the application of effective learning models that support strategic development of semiconductor process and equipment technician training. Council members include technician training professionals from SEMATECH and SEMI/SEMATECH member companies. Much of the council's work is accomplished through task forces which take on projects of relevance to the industry as a whole. Task force results are presented to the general membership and if appropriate are published as technical documents for dissemination.