PERFORMANCE-BASED EQUIPMENT TRAINING

A Performance Improvement Program Developed by the SEMATECH Organizational Learning and Performance Technology Department

PARTICIPANT GUIDE

October 1, 1995

Performance-Based Equipment Training (PBET) Participant Guide

SEMATECH
Technology Transfer 95102995A-TRG

Performance-Based Equipment Training (PBET) Participant Guide

Technology Transfer # **95102995A-TRG**
SEMATECH
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Abstract: This document provides student materials for an entry-level course in the concepts of Performance-Based Equipment Training (PBET), a workshop developed by SEMATECH's Organizational Learning and Performance Technology Department. The course is designed for persons who are responsible for training others in the operation, maintenance, and/or repair of process equipment and is best suited for equipment trainers, technical trainers, and technical training developers. This document explains the basic steps for designing and developing effective training courses, with emphasis on the instructional development process. Its eight modules provide an introduction and modules teaching how to identify, analyze, design, develop, pilot, deliver, and evaluate training courses. It is supplemented by three companion documents: *Performance Based Equipment Training (PBET) Instructor Guide*, Technology Transfer #95102996A-TRG; *Performance-Based Equipment Training (PBET) Transparency Masters*, Technology Transfer #95103004A-TRG; and *Performance-Based Equipment Training (PBET) Templates*, Technology Transfer #95103011A-TRG.

Keywords: Training, Equipment, Quality Management, Manufacturing Technicians

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Table of Contents

1 EXECUTIVE SUMMARY

This document provides student materials for an entry-level course in the concepts of Performance-Based Equipment Training (PBET). It explains the basic steps for designing and developing effective training courses, with emphasis on the instructional module development process. The vision behind these materials is to improve corporate training practices while raising the skill level of the U.S. semiconductor workforce.

The PBET course outlined in this document is designed for persons who are responsible for training others in the operation, maintenance, and/or repair of process equipment. To benefit from this material, a participant need not have a degree in education or engineering, nor have training experience. However, the course is best suited for equipment trainers, technical trainers, and technical training developers. The class schedule for this course is available through the SEMATECH and SEMI/SEMATECH comunications systems.

The course includes eight modules covering the following topics:

- Introduction: Course orientation and characteristics and design phases of PBET
- Identify Module: Perform needs analysis
- Analyze Module: Perform task analysis, write performance objectives, and develop a skills hierarchy
- Design Module: Develop skills tests, describe relevant practice, analyze materials, select delivery method, summarize a PBET lesson, and complete a second PBET lesson plan
- Develop Module: Develop instructional materials
- Pilot Module: Describe trainer characteristics and pilot a short PBET lesson
- Deliver Module: Describe trainer responsibilities, prepare a training curriculum checklist, create an action plan for PBET implementation
- Evaluate Module: Describe evaluation levels

Also, appendixes include course-related forms, lists, and bibliography.

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Your comments and recommendations for continuous improvement of this program are sincerely appreciated. For more information regarding the PBET program and training schedules, contact the Organizational Learning and Performance Technology Department.

SEMATECH and SEMI/SEMATECH member companies may obtain copies of this training manual by contacting the SEMATECH Technology Transfer Department. Refer to Appendix F for information regarding this PBET course and other courses that are available through Tech Transfer.

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The Organizational Learning and Performance Technology Department would like to extend its appreciation to all SEMATECH employees, SEMATECH and SEMI/SEMATECH members, and consultants who contributed to the development of this training program.

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Introduction

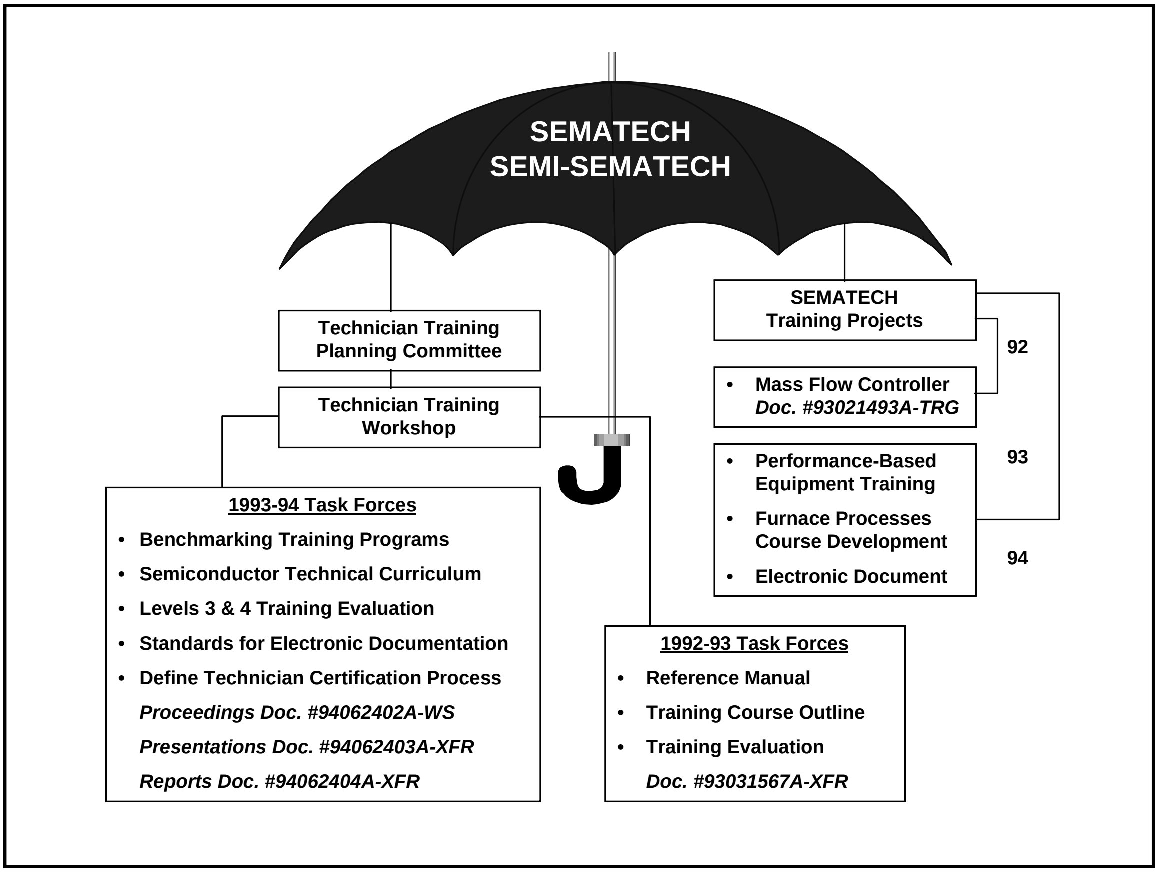
IN-1

PERFORMANCE-BASED EQUIPMENT TRAINING

PURPOSE:

- **Learn Methods for Effective Equipment Training**
- **Learn or Improve Skills for Performing Task Analysis**
- **Perform Skills Analysis and Develop Training Checklists**
- **Learn an Easy Way to Develop Effective Lesson Plans**
- **Develop PBET Materials for a Specific Equipment Training Application**
- **Practice Communication Skills**

This course introduces concepts of Performance-Based Equipment Training (PBET). The basic steps in designing and developing effective training courses will be explained. Most of the time will be spent on the instructional module development process. A simple template (job aid) will be provided to help simplify and accelerate the process of learning how to prepare an effective lesson in PBET for application in your training facility (see Appendix A).



The PBET concept evolved following the 1992 Technician Training Workshop. Two task forces explored the best methods known for technical and equipment training. The results of this research were published and can be obtained through the SEMATECH Technology Transfer Department (Doc. # 93031567A-XFR).

The task forces made some key recommendations that resulted in the creation of this training project. Some of the task forces' recommendations included:

- Training providers should adopt a performance-based training approach
- Training users and suppliers should adopt and use the first three levels of evaluation. (We will cover levels of evaluation later in this course)
- Educate managers on how PBET is efficient, including the business performance improvement process
- Educate trainers on why PBET is necessary and on how to implement the process
- Educate participants on why PBET is necessary and how they will benefit from it

Intended Audience

- **SEMI/SEMATECH Member Companies**
  - **Equipment Suppliers**
  - **OEM Manufacturers**
- **SEMATECH Member Companies**

- **Who should attend this workshop?**
  - **Equipment Trainers**
  - **Technical Training Developers**
  - **Technical Trainers**

    . . . *no experience necessary*

This training session is intended for any participant who is responsible for training others in the operation, maintenance, and/or repair of process equipment.

This is an entry level course in instructional design. Neither a degree in education nor a degree in engineering is required. Training experience is also not necessary.

While the principles presented in this course can benefit anyone who is responsible for training others, equipment trainers, technical trainers, and technical training developers can best profit from this class.

Although this class is instructor-led and foil-driven, interaction with the instructor is always encouraged. Feel free to ask questions. “No question is dumb, except for the thoughts that remain silent and hidden in someone’s conscience.”

You will have an opportunity to exercise your mastery of the concepts presented in this class. Each module will have a practice section as well as a skill test section.

Workshop Logistics

PBET Course Outline

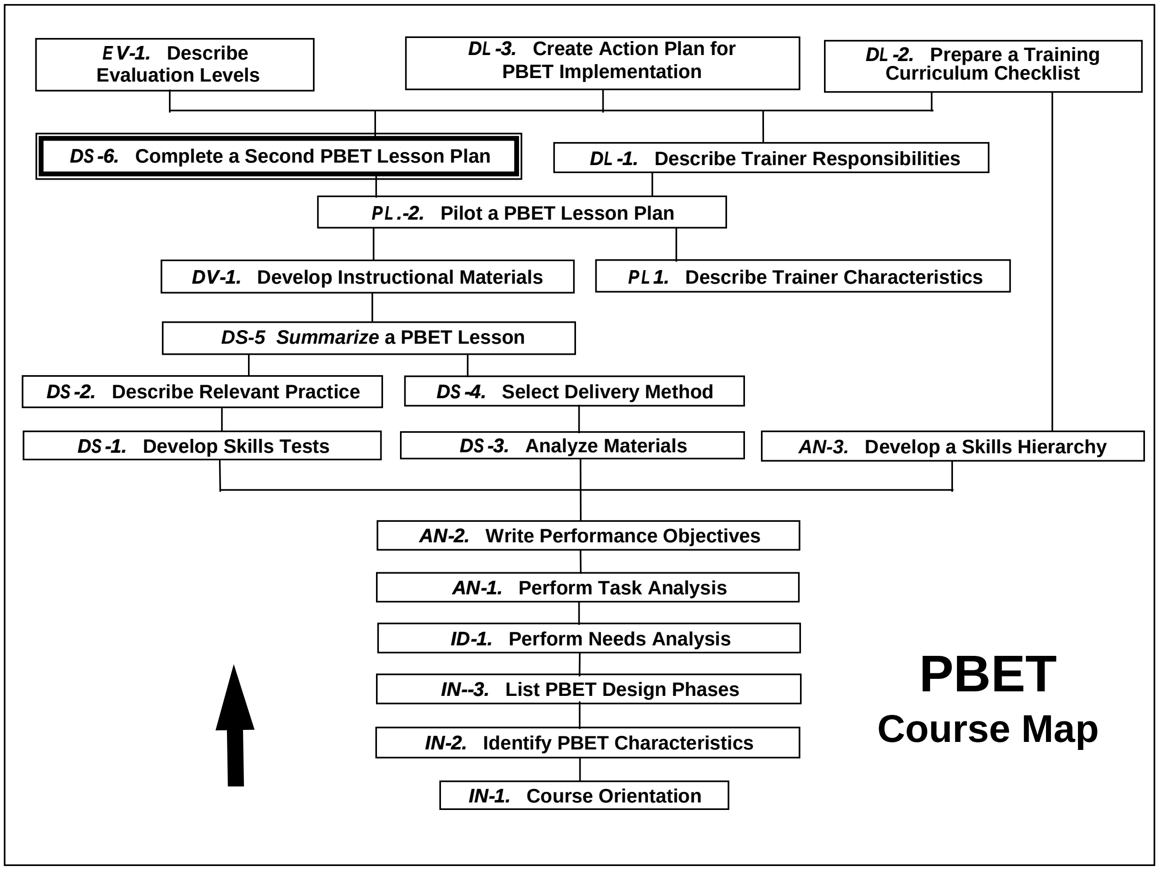
SECTIONS	MOD.#	CONTENT
1 **Introduction**	IN-1	Course Orientation
	IN-2	Identify PBET Characteristics
	IN-3	List PBET Design Phases
2 **Identify**	ID-1	Perform Needs Analysis
3 **Analyze**	AN-1	Perform Task Analysis
	AN-2	Write Performance Objectives
	AN-3	Develop a Skills Hierarchy
4 **Design**	DS-1	Develop Skills Tests
	DS-2	Describe Relevant Practice
	DS-3	Analyze Resource Materials
	DS-4	Select Delivery Method
	DS-5	Summarize a PBET Lesson
	DS-6	Complete a Second PBET Lesson Plan
5 **Develop**	DV-1	Develop Instructional Materials
6 **Pilot**	PL-1	Describe Trainer Characteristics
	PL-2	Pilot a PBET Lesson Plan
7 **Deliver**	DL-1	Describe Trainer Responsibilities
	DL-2	Prepare a Training Curriculum Checklist
	DL-3	Create Action Plan for PBET Implementation
8 **Evaluate**	EV-1	Describe Evaluation Levels

This course is titled Performance-Based Equipment Training. The class schedule for this course is available through the SEMATECH and SEMI/SEMATECH communication systems. The topics/modules this PBET course covers are listed above.

Initially, the PBET course will be offered to trainers and developers from SEMI/SEMATECH member companies. The first round of participants will be selected based on criteria set by SEMATECH member companies.

Most classes are offered in Austin, while some will be presented on the East and West Coasts. The course will become a transferable course in 1995.

The vision SEMATECH has of PBET is to improve training practices while at the same time raising the skill level of the American semiconductor workforce.



This course is an extension of the short session presented at the SEMATECH Technician Training Workshop held in February 1994. Ten modules were covered in that workshop and more were developed subsequent to the February workshop.

The PBET workshop agenda for the week will be as follows: Monday, Tuesday, and Wednesday morning we will cover the first 15 modules of instruction. You will develop a lesson plan for a task assigned by the course instructor. On Wednesday afternoon you will work on developing a second PBET lesson plan for a specific course. The remainder of the modules will be covered on the afternoon of the third day.

PBET Lesson Planning Form

Developer: **Class:**

Module Title:

Target Audience: **Location:**

Module Objective:

Prerequisite Skills:

Skill Test:

Additional Resources:

Training Aids & Media	Tools & Materials

Relevant Practice Description:

Conditions:

Type of Modeling:

Feedback Mechanism:

Module Content Description:

In Appendix A you will find examples of Lesson Planning Forms.

NOTES:

IN-2

IDENTIFY CHARACTERISTICS OF PERFORMANCE-BASED EQUIPMENT TRAINING

OBJECTIVE:

Upon completion of this module, you will identify the six characteristics of Performance-Based Equipment Training (PBET).

Every one of our modules has a performance objective. The performance objective is a clearly stated and measurable description of how participants will perform the intended activity or task. In other words, it describes what the participant is expected to do at the end of the module to demonstrate a desired level of understanding or competency in the specific skill covered.

In this module you will be expected to list, in writing, the six characteristics of Performance-Based Equipment Training.

Performance-Based Equipment Training

DEFINITION:

PBET is equipment training based on front-end analysis that ensures participants are able to reach mastery of job skills as described in clearly stated and measurable learning objectives.

Six Characteristics of PBET

- **Derive performance objectives from analysis**
- **Identify prerequisite skills**
- **Derive course content from performance objectives**
- **Maximize hands-on practice**
- **Develop skill tests to measure competency**
- **Repeat practice and skill tests until mastery is achieved**

The task forces modeled their PBET principles after Performance-Based Training but placed the emphasis on equipment training. They concluded that there are six characteristics of PBET.

Based on their conclusions, Performance-Based Equipment Training:

1. Is based on performance objectives which describe intended results and are derived from analysis of actual needs (i.e., from task and goal analysis).

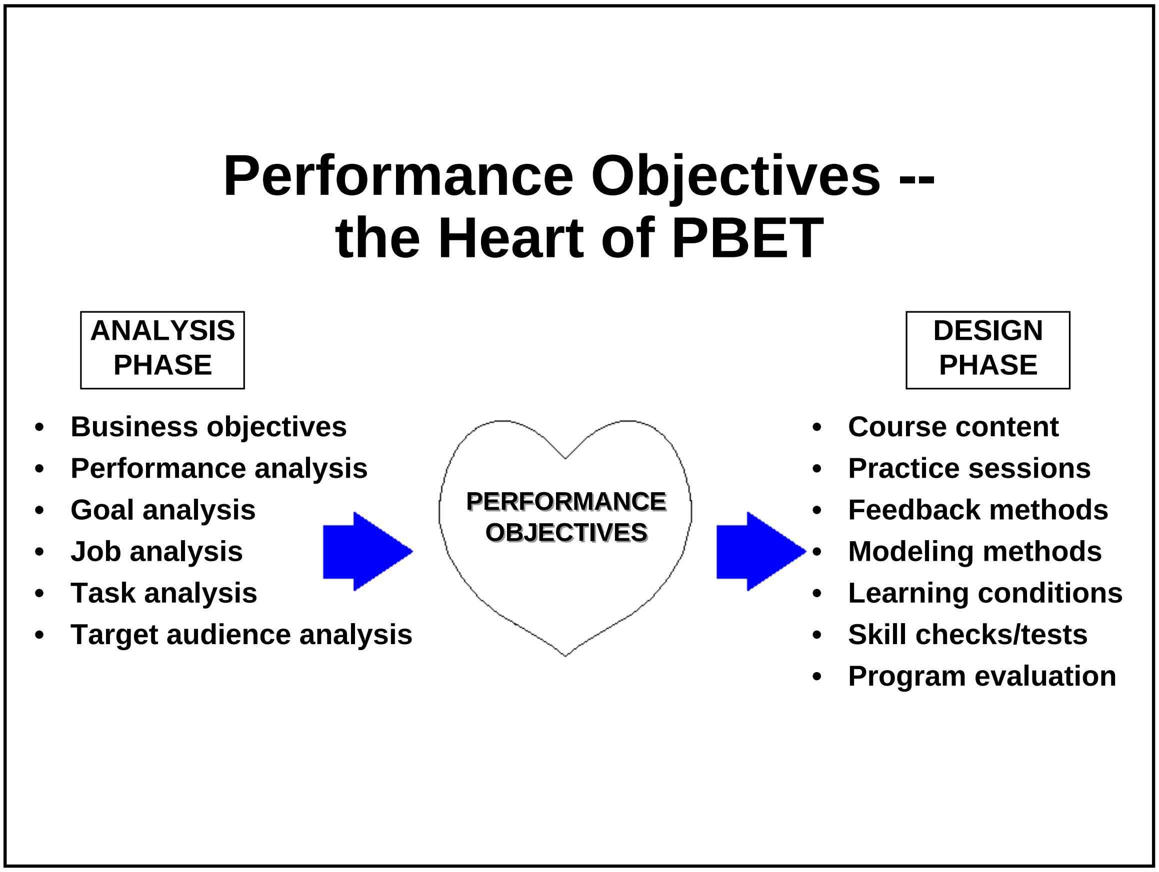
2. Identifies the prerequisite skills participants need to make progress toward the new objectives.

3. Derives the content of instruction from the performance objectives.

4. Designs a course to maximize hands-on practice for skill improvement.

5. Provides skill test (skill checks) for diagnosing difficulties and confirming mastery of the skills.

6. Allows for continued practice on each objective, followed by skill checks, until mastery is demonstrated. (Mastery means an acceptable/adequate level of performance. It does *not* reflect a specific percentage such as 100 percent or 90 percent.)



The single most important step in instructional planning is creating a list of performance objectives. They are the *heart* of the performance-based training program. Performance objectives emerge from needs that are discovered during the analysis phase.

Objectives are participant-oriented. They help answer the question, “How will I know if they can do it?” The answer is, “When they can perform as stated in the objective.”

In a way, performance objectives contribute in two capacities. Initially, they help guide the overall instructional plan, and later in a more detailed capacity, they function within the instructional design. This will be explained later in more detail.

NOTES:

PRACTICE EXERCISE

Place a ✓ next to the statements that represent true characteristics of PBET.

- ☐ **A. Performance objectives are derived from analysis.**
- ☐ **B. Any student, regardless of education, may participate.**
- ☐ **C. Trainees must possess certain prerequisite skills.**
- ☐ **D. Performance objectives determine course content.**
- ☐ **E. Tests determine the ranking of students in a class.**
- ☐ **F. PBET maximizes the use of hands-on practice.**
- ☐ **G. Skill tests determine mastery of skills.**
- ☐ **H. PBET allows for practice on each objective, followed by skill checks, until mastery is demonstrated.**

✐ ✐ ✐ ✐ ✐

In typical performance-based training classes, practice exercises are used so the participants have opportunities to review information that's just been presented. The practice exercise should always be relevant to intended performance.

In the above practice exercise you are asked to select the true characteristics of PBET. Please make your selections and then turn the page to check your answers.

Self-Check

- ☑ **A. <u>Performance objectives</u> are derived from analysis.**
- ☐ **B. Any student, regardless of education, can participate.**
- ☑ **C. Trainees must possess certain <u>prerequisite skills</u>.**
- ☑ **D. Performance objectives determine <u>course content</u>.**
- ☐ **E. Tests determine the ranking of students in a class.**
- ☑ **F. PBET maximizes the use of <u>hands-on practice</u>.**
- ☑ **G. <u>Skill tests</u> determine mastery of skills.**
- ☑ **H. PBET allows for <u>practice</u> on each objective, followed by <u>skill checks</u>, until <u>mastery</u> is demonstrated.**

NOTE: ***If you feel you need more practice, review the module, and then practice writing the six characteristics of PBET on a blank sheet of paper. Otherwise, proceed to the skill test.***

If the participants selected the correct six statements and feel confident that they have achieved mastery of this objective, they may take the skill test. However, if more practice is needed because the desired level of mastery wasn't attained, then the participants may choose to practice the skill further.

For instance, they may choose another method of practice such as *writing* the six PBET characteristics. Once participants are comfortable with their mastery level, they may take the actual skill test.

SKILL TEST

Place a T in front of the statements that are true regarding PBET training.

1. ____ Participants receive an attendance certificate for completing the course.

2. ____ Participants practice a skill until they are ready to take the test.

3. ____ Performance objectives precede the needs analysis phase.

4. ____ Course content is determined solely by subject matter experts.

5. ____ Course content is determined by performance objectives.

6. ____ Skill tests determine mastery of skills.

7. ____ Skill tests are used to grade and compare ranking of course students.

8. ____ Performance objectives are derived once course content is in place.

9. ____ Performance objectives are derived from analysis.

10. ____ Participants, regardless of entry skills, can participate in the class.

11. ____ Participants must have certain prerequisite skills.

12. ____ There is practice for each objective, followed by skill checks, until \mastery is demonstrated.

✐✐✐✐✐

The skill test should match the requirements of the objective as stated earlier in the module.

Again, if the participant does not achieve mastery of the intended skill, then the participant may ask for more practice or assistance, or retake the test until mastery is achieved.

SELF-CHECK

1. ____ **Participants receive an attendance certificate for completing the course.**
2. __T__ **Participants practice a skill until they are ready to take the test.**
3. ____ **Performance objectives precede the needs analysis phase.**
4. ____ **Course content is determined solely by subject matter experts.**
5. __T__ **Course content is determined by performance objectives.**
6. __T__ **Skill tests determine mastery of skills.**
7. ____ **Skill tests are used to grade and compare ranking of course students.**
8. ____ **Performance objectives are derived once course content is in place.**
9. __T__ **Performance objectives are derived from analysis.**
10. ____ **Participants, regardless of entry skills, can participate in the class.**
11. __T__ **Participants must have certain prerequisite skills.**
12. __T__ **There is practice for each objective, followed by skill checks, until mastery is demonstrated.**

IN-3

LIST SEVEN BASIC PHASES IN THE DEVELOPMENT OF PBET SYSTEMS

OBJECTIVE:

List the seven basic phases in the development of Performance-Based Equipment Training (PBET) systems.

The basic phases of development in performance-based equipment training programs or systems may also be referred to as steps.

Seven Basic Phases in the Development of Performance-Based Equipment Training

1. Identify
2. Analyze
3. Design
4. Develop
5. Pilot
6. Deliver
7. Evaluate

These are the seven basic steps of developing performance-based equipment training. They're the steps we used as our structure in the instructional design of PBET. Traditionally, development steps or phases are referred to as ISD, Instructional System Design. Most ISD models follow a similar sequence but may use different terminology. For instance, the step we refer to as "Deliver" may be "Implement" in another ISD model.

Notice that the seven basic steps of developing PBET are used as the tab pages in your participant guide. Behind each tab page there's a list of modules that are covered in that step of development.

As you may recall, the objective for this model is to list the seven steps of developing PBET.

1. Identify a Need

- **Identify a performance discrepancy**
- **Identify a new performance standard**
- **Identify a need for new product training (PBET)**

1. Identify
2. Analyze
3. Design
4. Develop
5. Pilot
6. Deliver
7. Evaluate

There are many reasons for developing training programs, but training isn't always the best or only solution to a performance problem. When a discrepancy or problem in performance is noticed, a performance analysis should be conducted to help determine the cause and possible solutions.

Sometimes training *isn't* the solution. Perhaps the problems stem from inadequate environment, an attitude problem, lack of incentive, no specifications, poor instructions, or no supervision; or perhaps employees aren't in a position to practice their skills. (*Use it or lose it.*)

For instance, if new performance standards have been established, employees' skills may need upgrading. Maybe all that's required to pass along the information to employees is writing new specifications and procedures, followed by a checklist.

New equipment and existing training programs are excellent candidates for applying PBET methodology. When new products are released, this usually means new training programs should be developed; that is unless training already exists for an older model with similar features and processes. When training *is* the solution, performance analysis information can be used in designing the training program.

For more information on performance analysis, consult the bibliography. Mager and Pipe's *Analyzing Performance Problems* is widely used in the industry.

Once it's evident that new or revised equipment training is needed, there are many issues the instructional developer and equipment user need to address, including:

- What are the customer's expectations beyond training objectives? For example, delivery date, deliverables, budget, etc.
- What are the supplier requirements for meeting expectations? For example, time, access to experts, access to equipment, access to baseline data, cost, etc.
- Who has training needs, problems, or skill deficiencies? What is known about this person or group? (Apply target audience analysis and job description analysis.)
- What are the performance problems or needs? (Apply performance analysis and task analysis.)
- Who are the customers/performers in the training evaluation cycle?
- What are the performance (training) objectives? What are the criteria and conditions under which the performer will be evaluated for each training objective?

Note: A suggested checklist of questions for training user/training supplier planning meeting (an expansion of the above list is provided in Appendix A of the 1992-93 Task Force Guidelines on Training Evaluation, SEMATECH DOC. # 93031567A-XFR).

2. Analyze the Needs

- **Perform job/task analysis**
- **Determine target audience**
- **Derive performance objectives from analysis**
  - **Terminal objectives**
  - **Enabling objectives**
  - **Prerequisite objectives**
- **Develop a skills hierarchy**

1. Identify
2. Analyze
3. Design
4. Develop
5. Pilot
6. Deliver
7. Evaluate

The terminology used for analyzing needs is often used synonymously. To quote from the *Trainer's Professional Development Handbook*, "Harless' *front-end analysis* and Mager and Pipe's *performance analysis*, which once signified their specified methods of performance problem solving, have now become synonymous in some circles for the process of needs assessment. So have the terms *task analysis, competency assessment, competency modeling*, and *job analysis*, although each originally referred to a particular approach to analyzing performance problems and determining learning needs."

The second step in the PBET development process is to analyze the needs. During this phase of PBET development, designers and developers look at the business goals as well as the nature of the job and tasks associated with the equipment and the target audience. PBET design is always preceded by a thorough front-end analysis.

Once front-end analysis has been completed, instructional developers are better prepared to determine the performance objectives for the course they will design.

Performance objectives are the statements that appear at the beginning of a training session that explain in clear, simple language what the performer must do to demonstrate competency in a particular skill.

Performance objectives can be categorized into three groups: terminal objectives, enabling objectives, and prerequisite objectives.

The performance objectives are systematically arranged into a skills hierarchy that shows the logical sequence for designing the training (see example on page IN-1-6). The hierarchy of skills helps illustrate how the skills relate to each other while progressing from the simplest to the most complex.

3. Design the Course

- **Develop skill tests (skill check)**
- **Describe relevant practice methods**
- **Analyze supporting instructional and resource materials**
- **Select delivery method and media**
- **Summarize the lesson plans**

1. Identify
2. Analyze
3. Design
4. Develop
5. Pilot
6. Deliver
7. Evaluate

Skill tests are written to match the requirements that are stated in corresponding performance objectives. Tests or skill checks are the evaluation instruments used to measure a participant's performance as compared to the stated objective.

In the design phase, the developer determines the type of practice sessions to include in each instructional module. A provision is made for the training materials and/or the instructor to model or demonstrate the type of performance given in the related objective. Feedback mechanisms are designed so the participant knows how well he or she is doing during the actual training session.

Also, during the design phase, additional resource materials are evaluated to determine their relevance and use in the course, and given budget restraints and delivery date, the appropriate delivery method is selected. Finally, the instructional events sequencing should be summarized for each module or lesson so that the intentions of the designer remain clear throughout the development and delivery phases.

4. Develop Course Materials

- **Determine course content**
- **Develop course materials**
- **Develop instructional aids**

1. Identify
2. Analyze
3. Design
4. Develop
5. Pilot
6. Deliver
7. Evaluate

The development course materials phase is the instructional development phase. This instructional development phase is like the construction phase in the building industry. The building contractor reviews the objectives, examines the skills hierarchy, and knows what and when certain resources are going to be used. Given budget constraints and a delivery date, the builder decides what type of delivery method (equipment, tools) to use to produce the best results. In the training world, this equates decisions about instructor-led courses, self-paced individualized courses, audiovisual aids, and written materials.

5. Pilot the Course

- **Try out the course**
- **Assess course performance**
- **Revise the course**

1. Identify
2. Analyze
3. Design
4. Develop
5. Pilot
6. Deliver
7. Evaluate

Piloting the course is like having the dress rehearsal before the actual performance. The pilot phase is the tryout or test of the course and materials. It also allows for fine-tuning before a course is delivered. The PBET methodology helps ensure that the results will be successful and gratifying to participants, developers, and customers.

Assuming that all phases of the analysis, design, and development were conducted according to the details summarized in preceding discussions, then it is easy to predict success during the first test of the course materials.

The course developer may or may not be the person to teach the course. Perhaps the course can be taught initially by trainers or other subject matter experts under the guidance of the developer. In either case, subject matter experts should be on hand to assess the course performance and to edit course materials as they are presented.

An evaluation sheet should be available for course participants to provide feedback regarding the course, instructor, and course materials.

Based on the outcomes of the pilot class, subject matter experts, trainers, and developers can determine which areas of the course worked well and which components need improvement. The next step is to revise the course as necessary before it is delivered a second time.

6. Deliver the Course

- **Implement the training course**
  - **Participant Guide**
- **Orient and direct the trainers**
  - **Instructor Guide**
- **Arrange practice and feedback**

1. **Identify**
2. **Analyze**
3. **Design**
4. **Develop**
5. **Pilot**
6. **Deliver**
7. **Evaluate**

This is the phase everyone has been waiting for -- it's the indication that all of the hard work of the design and development staff is completed, and now the trainers can begin to implement the course.

In PBET systems, the developers provide an instructor guide and a participant guide, as well as any additional instructional aids that are needed during the course.

The developers may also provide a "train-the-trainer" program to teach trainers how to administer the new course. Training the trainer would include explanation and procedure for modeling the desired performance, adequate time for relevant practice, and how to incorporate feedback into the course.

An evaluation instrument should be available for feedback from class participants regarding the course, instructor, course materials, and their general satisfaction with the training.

7. Evaluate the Course

- **Develop evaluation system**
- **Implement evaluation system**
- **Interpret results and provide feedback**
- **Continue to improve course**

1. **Identify**
2. **Analyze**
3. **Design**
4. **Develop**
5. **Pilot**
6. **Deliver**
7. **Evaluate**

We will use the traditional four levels of evaluation, which we'll cover later in the course.

The evaluation phase attempts to obtain feedback from the customers about the appropriateness and effectiveness of a specific training program.

Review

Seven Phases in the Development of Performance-Based Equipment Training

1. **Identify**
2. **Analyze**
3. **Design**
4. **Develop**
5. **Pilot**
6. **Deliver**
7. **Evaluate**

These are the seven phases or steps of the PBET development process. Let's review the activities of each step.

1. *Identify.* In the first phase there is a request or need for a training course as the result of identifying a performance discrepancy. Identifying a performance standard, the desired outcome, or the need to develop training for a new product is also part of this phase.
2. *Analyze.* At the start of the project, time is spent analyzing various important issues before any design or development work is begun. Issues analyzed include: performance objectives, goals, jobs, tasks, the target audience, and a skills hierarchy.
3. *Design.* In the design phase, information from the analysis phase is used to derive: skill tests to analyze appropriate supporting resources for the course and to design appropriate practice methods. The design phase is the foundation for the content and the structure of the course.

4. *Develop.* This is the construction phase of the process. Decisions are made about the most appropriate delivery and media to use. During this time, individual units of instruction, or modules, are developed. Each module will have its own corresponding performance objective, skill test, set of resources and aids, content, practice, and feedback mechanisms.
5. *Pilot*. When the course materials are completed, the developer must pilot (test) the course. A course evaluation is also used to assess *participant* reaction to the course. Revisions are made as necessary to ensure the course is accurate, relevant, and free of mistakes in content or typing.
6. *Deliver.* At this point the course is ready to be delivered or implemented. The developer gives the trainers an orientation or explanation of how the class is to be conducted.
7. *Evaluate.* Once the course is in place and operational, the developer will want to evaluate or assess the performance of the course. Evaluation instruments are implemented, and the results provide feedback to the developers, trainers, managers, investors, and customers about the adequacy of the course. Feedback data is used primarily to improve the course over its useful lifetime.

PRACTICE EXERCISE

List the seven basic phases in the design of Performance-Based Equipment Training in the correct order:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

Self-Check

Seven Basic Phases in the Design of Performance-Based Equipment Training

1. Identify
2. Analyze
3. Design
4. Develop
5. Pilot
6. Deliver
7. Evaluate

If your list matches the one shown on this foil, and you feel confident that mastery of this objective has been achieved, then you may take the skill test.

If more practice is needed because the desired mastery level has not been attained, then you may practice the skill a little more by actually writing the list of seven phases of PBET on a separate sheet of paper.

When you're ready, you may proceed to take the actual skill test.

SKILL TEST

On a blank sheet of paper, list the seven basic phases in the design of Performance-Based Equipment Training.

When finished, compare your answers with the list provided in this module. Repeat the test if necessary, and ask for additional practice or assistance.

✐✐✐✐✐

The skill test should match the requirements of the objective as stated earlier in the module.

Again, if you do not achieve mastery of the intended skill, then you may ask for more practice or assistance, or retake the test until mastery is achieved.

Identify

ID-1

PERFORM NEEDS ANALYSIS

OBJECTIVE:

Working in teams use the needs analysis worksheet provided for this lesson to analyze a performance problem. Each team will work through the needs analysis process described in this module.

Over the years, much research has been conducted and many books have been written on the subject of needs analysis. This course simplifies the process by utilizing a two-phased approach to this skill: *(1) Identify the performance need.* This phase is triggered by events that lead to concerns about a performance problem. To help you understand why there is concern, you may use four different techniques to gather information to help you analyze the performance problem. *(2) Identify the performance solution.* In this phase you may examine four categories of causes to performance problems. These categories may help you select the correct solution for a specific performance problem.

From this lesson, you will learn to use a worksheet to conduct a simplified needs analysis. You will be provided scenarios of performance problems and the opportunity to use the worksheet with a group of peers to -- (1) select the most appropriate techniques for gathering data, (2) list possible causes of the discrepancy, and (3) list solutions for each possible cause.

PBET SIMPLIFED NEEDS ANALYSIS			
Identify the Performance Need		Identify the Performance Solution	
Informal Triggers			
• **New standards, goals, or outcomes** • **New epuipment, products, or processes** • **A readily apparent performance discrepancy**			

The process of PBET begins with the discovery that there is a performance problem. There are a variety of “triggers” that can instigate a concern about improving performance. Among them are:

- New standards, goals, or desired outcomes
- New equipment, products, or processes
- Examination of performance data

A good analyst will not jump to an immediate solution, such as the “training solution”! Rather, these situations should prompt more careful scrutiny.

PBET SIMPLIFED NEEDS ANALYSIS			
Identify the Performance Need		Identify the Performance Solution	
Informal Triggers	***Formal Techniques***		
• New standards, goals, or outcomes • New epuipment, products, or processes • A readily apparent performance discrepancy	• **Conduct observations** • **Conduct Interviews** • **Conduct surveys and/or questionnaires** • **Examine performance data**		

Performance problems are often difficult to detect. Therer may seem to be obvious symptoms and training is often the most prescribed solution. However, without careful analysis, it is all too easy to spend a lot of money and still have a performance discrepancy. In *Figuring Things Out: A Trainer's Guide to Needs and Task Analysis*, authors, Ron Zemke and Tom Kramlinger, identify four major techniques to use in identifying performance needs:

1. Observations
2. Interviews
3. Surveys/questionnaires
4. Performance data

Their book presents information for trainers who are trying to select the right needs analysis procedure. Their book, and others in the bibliography, can be helpful in creating worksheets and tools for implementing analysis techniques. In addition, guidelines are provided for interpreting the data that is collected.

PBET SIMPLIFED NEEDS ANALYSIS			
Identify the Performance Need		**Identify the Performance Solution**	
Informal Triggers	*Formal Techniques*	***Possible Causes of Performance Problems***	
• New standards, goals, or outcomes • New epuipment, products, or processes • A readily apparent performance discrepancy	• Conduct observations • Conduct Interviews • Conduct surveys and/or questionnaires • Examine performance data	• **Equipment problem** • **Improper or inadequate incentives** • **Lack of information** • **Lack of skills**	

Once the performance need or discrepancy is clearly identified, it is time to consider the possible causes of the problem. One or more of the formal identification techniques may have given you some good clues about the causes. But, it is best to give systematic consideration to four categories of causes:

1. *Equipment problem.* Poor performance can be attributed to equipment related problems, for example: design flaws, unrealistic specifications (wrong tool for the desired task), inaccuracy, out of calibration, too complex, poor ergonomic design, unreliable, and requires too much maintenance.
2. *Improper or inadequate incentives.* Organizations and the environment provide incentives and disincentives. Consider these possibilities: rewarding negative behavior (rewarding high throughput while sacrificing quality), failing to reward positive behavior, and making positive behavior unnecessarily difficult or unpleasant.

3. *Lack of information.* When a person is not provided the information they need to make the correct task decision, they are unable to perform according to standard. But, if the person is told what to do, that may be all that is needed to enable them to do it. So consider systems that provide little or no information: no feedback mechanisms, inadequate feedback mehanisms, no instrumentation available, cannot read instruments, no printed specifications, and poor labeling of parts, tools, manuals, pipes, connections and gauges.
4. *Lack of skills.* When the equipment performs properly, the individual wants to perform according to standard, and the individual has been provided the needed information about the task and the individual still cannot perform according to standard, there is a skill deficiency that needs to be addressed.

Two performance “gurus” have developed expanded models for determining the cause of performance problems:

- Thomas F. Gilbert has developed a six-cell matrix for examining six areas that affect an individual’s ability to perform according to standard. You can find out more by consulting his book, Human Competence -- Engineering Worthy Performance.

- Robert F. Mager has developed a flow chart and a job aid that ensure that no stone is left unturned when seeking the cause of performance problems. His ideas are clearly developed in his book, *Analyzing Performance Problems or You Really Oughta Wanna.*

PBET SIMPLIFED NEEDS ANALYSIS			
Identify the Performance Need		**Identify the Performance Solution**	
Informal Triggers	*Formal Techniques*	*Possible Causes of Performance Problems*	***Possible Solutions to Performance Problems***
• New standards, goals, or outcomes • New epuipment, products, or processes • A readily apparent performance discrepancy	• Conduct observations • Conduct Interviews • Conduct surveys and/or questionnaires • Examine performance data	• Equipment problem • Improper or inadequate incentives • Lack of information • Lack of skills	• **Re-engineering** • **Create or improve incentives** • **Provide feedback or job aids** • **Provide practice or training**

Each of the four categories of causes suggest their own solutions:

1. *Equipment problem.* An equipment problem requires re-engineering.

2. *Improper or inadequate incentives.* An incentive problem requires the creation, the improvement, or the elimination of certain incentives.

3. *Lack of information.* A lack of information requires that information be provided. This may be provided through on-the-job feedbace. Or, it may be provided in the form of job aids which include: specifications sheets, manuals, signs, readbacks, expert systems, electronic performance support systems, or labeling.

4. *Lack of skills.* A lack of skills requires that an individual have a chance to receive renewed practice with feedback or a training program may be required.

PRACTICE EXERCISE

HUMAN PERFORMANCE PROBLEM IDENTIFIED: The business has committed to lowering the percentage of scrap. Data shows that the breakage that occurs while removing wafers from furnaces is higher in Fab 1 than in Fab 2.
ANALYZE: Brainstorm for possible causes and solutions to the problem. Fill in the needs analysis worksheet with specific examples for each item.

(1) How will you gather data?

Observations: ______________________________

Interviews: ______________________________

Surveys: ______________________________

Performance Data: ______________________________

(2) What are some possible causes?	**(3) What are some possible solutions?**
Lack of data or information:	Suggested solution(s):
Problem(s) with equipment or instrument:	Suggested solution(s):
Improper or inadequate incentives:	Suggested solution(s):
Lack of skills:	Suggested solution(s):

SKILL TEST

HUMAN PERFORMANCE PROBLEM IDENTIFIED: Downtime problems on an ion implanter have been traced to problems with ion sources. They are frequently rebuilt incorrectly (parts re-installed backwards or upsidedown) and/or found to be contaminated (bits of bead blasting present).

ANALYZE: Brainstorm for possible causes and solutions to the problem. Fill in the needs analysis worksheet with specific examples for each item.

(1) How will you gather data?
Observations: ____________________
Interviews: ____________________
Surveys: ____________________
Performance Data: ____________________

(2) What are some possible causes?	(3) What are some possible solutions?
Lack of data or information:	Suggested solution(s):
Problem(s) with equipment or instrument:	Suggested solution(s):
Improper or inadequate incentives:	Suggested solution(s):
Lack of skills:	Suggested solution(s):

Analyze

AN-1

PERFORM A TASK ANALYSIS

OBJECTIVE:

Upon completion of this lesson, you will perform a task analysis.

It's beyond the scope of this training session to thoroughly cover the task analysis process. It would probably take four to eight hours to really master the skills of performing a task analysis.

In this lesson, you're expected to remember the eight basic steps in the task analysis process.

Later, you'll have the opportunity to perform a simple task analysis.

Basic Steps of a Task Analysis

1. **Gather and read all relevant documentation**
2. **Interview and observe the expert performers**
3. **Record the steps and decisions involved**
4. **Look for hidden knowledge**
5. **Flowchart the steps in the task**
6. **Detail each step in the task**
7. **List tools, materials, documents, etc.**
8. **Perform the task**

Task analysis is one of the key features of the PBET development process. Analysts use the information obtained from task analysis to determine the skills and background information needed to identify performance objectives and eventually determine the contents of the new course.

Analysts begin by gathering and reading all available documentation on the equipment and tasks. They compile a list of questions regarding information that's not available or isn't clearly defined in the documentation.

After analysts identify people who are regarded as *expert performers,* or *SMEs*, they interview the experts and ask questions about the equipment, tasks, and documentation.

The expert is observed performing the actual tasks the course participants would be expected to perform under the same conditions. Even while the expert explains what is being done at each step of the task, analysts continue to ask questions. Analysts record in writing, audiotape, and/or videotape the steps involved in the performance of the task.

Videotaping is recommended because analysts can give their full attention to the environment, equipment, expert, tools, materials, and interaction as the tasks are being performed. The results of taping are beneficial since an audio/visual capture of the events can be replayed later. Furthermore, parts of the task analysis can be played back during a training session or specific frames captured by computer software to create 35mm slides or overhead transparencies or to include in the actual participant guide.

In the process of conducting a task analysis, analysts are constantly looking for *hidden knowledge* that's not available in the documentation for the equipment, or that experts have failed to mention. Hidden knowledge may include small bits of information, prerequisite skills, concepts, rules, procedures, theory, techniques, or data which the expert may recall from memory and that is required or helpful in the execution of the specific task. Analysts' investigative tactics must be very keen to sense a situation when the expert performer is in the process of recalling hidden knowledge during the performance of a task.

Analysts should be alert, so pertinent knowledge isn't overlooked. These bits of information should be recorded along with the steps, events, tools, and materials that are used in performing the task.

Finally, the detailing of the task in a step-by-step fashion should be refined so it's readable by anyone else. Another recommendation is for analysts to perform the task with the newly written procedure.

VIDEO TASK ANALYSIS EXERCISE

Now you'll have the opportunity to perform an important part of a task analysis. As you observe the expert performer, remember to look for prerequisite skills, types of tools, materials and equipment, hidden knowledge, important concepts, possible hazards and safety procedures, and other related procedures. When the video exercise is completed, think of ways in which you could design an instructional lesson to make it easier to teach someone to perform the task demonstrated in the video.

You will be using the worksheet located on the following page.

Note: An additional task analysis worksheet is located in Appendix A.

PERFORMANCE-BASED EQUIPMENT TRAINING

TASK ANALYSIS WORKSHEET FOR VIDEO EXERCISE

Analyst:________________________________**Date:**________________________________

Subject Matter Expert:____

Location:____

Job or Course Title:____

Task:____

Task Description:____

____

____

____

Importance Statement:____

____

____

____

Prerequisites:____

____

____

____

Tools and Materials:____

____

Hazards and Safety:

Hidden Knowledge:

Critical Concepts:

Other Related Procedures:

Course Design Considerations:

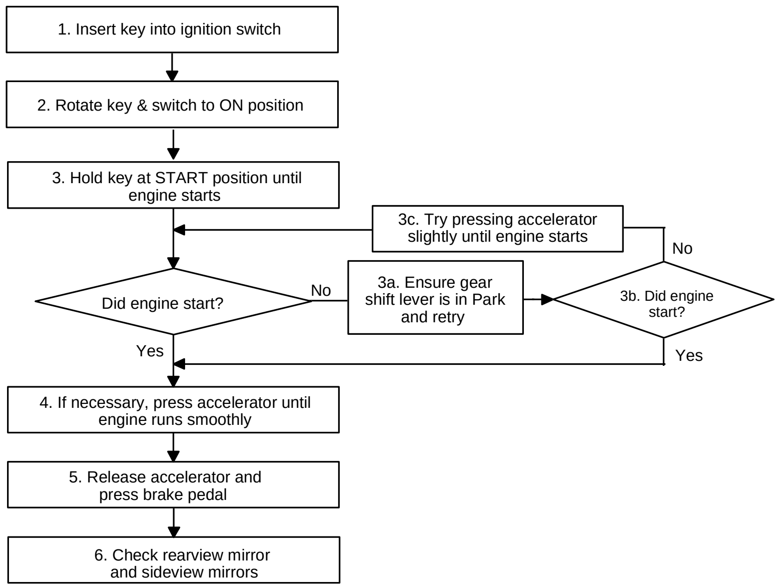
Example No. 1: Task Listing

Starting a Car and Pulling Out from a Parking Space

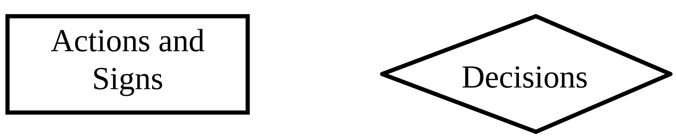
1. **Insert key into ignition switch.**
2. **Rotate the key and ignition switch to ON position.**
3. **Hold key at START position until the engine starts.**
4. **If necessary, using your right foot, press accelerator pedal slightly to keep the engine running.**
5. **Release the accelerator pedal and step on the brake pedal.**
6. **Check rearview mirror and sideview mirrors.**
7. **Place gear shift lever in Reverse (R) position.**

There are different ways to detail a task. The foil on this page illustrates an example of a simple task listing.

Example No. 2: Task Detailing -- Flowcharting



Another way of detailing or listing a task is to put it into flowchart form. Flowcharts work well when thinking through the process, and when making decisions becomes more difficult than *doing* the task. The use of flowcharts makes it easy to see, at a glance, the relationships between steps in the sequence. Actions are always written in rectangles, and decisions are always written in diamonds.



Example No. 3: Task Detailing -- Cause-Effect Relationship Chart

STEP	ACTIONS	RESULTS
1.	Insert key into ignition switch.	Proper key will slip in easily.
2.	Rotate key and ignition switch toward the ON position.	Oil lamp and temp. lamp will light. Listen for sound of seat belt buzzer or door left open.
3.	Hold key at START position until the engine starts.	Engine should start immediately if gear shift lever is in Neutral or Park.
4.	If necessary, press accelerator pedal with right foot to keep engine running.	Engine will sputter and perhaps stop if it is not receiving the right amount of fuel. Listen for the sound of the engine running. It should run smoothly.
5.	Release the accelerator pedal and press on the brake pedal.	You may engage the transmission when the engine is stabilized.
6.	Check rearview mirror and sideview mirrors.	Look for reflection of possible obstructions.
7.	Place gear shift lever in Reverse (R) position.	If placed in the proper position, the letter R will be easily visible and possibly illuminated on the gear shift indicator.

Another way to detail a task is to create a cause-effect relationship chart. There are a variety of charts that can be designed to show how actions performed during the task can result in certain effects. This chart shows the sequence of steps, the actions taken, and the results. It can be used to provide feedback to the *participant* to indicate the effect of the performance.

SKILL TEST

In this module, you will complete a task listing and detailing on a specific task that the course instructor will assign to designated teams. This is the initial step in the development of your first PBET lesson plan.

AN-2

WRITE PERFORMANCE OBJECTIVES

OBJECTIVE:

Prepare at least one performance objective in an area of your expertise. The objective must contain three minimum requirements: *performance*, *condition*, and *standard*.

Note: *Write the objective in the Lesson Planning Form provided for you in this workshop.*

As part of the analysis phase in developing PBET, the instructional designer sets out to describe the performance the participant needs to demonstrate while enrolled in a course. The performance objective serves as this vehicle for description.

The *performance objective* or *instructional objective* is a clear statement that's understood by all participants. The objective is performance-based, specific, measurable or observable, and relevant to the requirements of the course or task to be performed.

An Objective Statement Answers Questions Like These

- **Who is the performer?**
- **What task is the performer expected to do?**
- **How will the performance be evaluated?**
- **How accurate must the performance be?**
- **What are the conditions for performing the task?**
- **What materials and resources will be needed?**
- **When is the performance supposed to occur?**
- **Where is the performance to occur?**

An objective statement provides information that answers typical questions such as those in the foil above.

If a single, clear statement can provide all of the needed information, then there is very little left for the participant to interpret. Objectives take the guesswork out of the training program and ensure that everyone, including instructors and participants, have a clear understanding of what is expected. Course participants should never need to try to out-guess or "psyche-out" the instructor.

Three Characteristics of a Well-Stated Objective

- **Performance**
- **Condition**
- **Standard**

A well-stated objective has at least three components:

- Performance
- Condition
- Standard

Performance tells what action will be performed.

Condition tells how or with what the action will be performed.

And, *Standard* tells the performance standard, criterion, and measurement method.

Three Characteristics of a Well-Stated Objective

No. 1

Performance	**The performance is the action that results from executing the task that is described in the objective.**
<Example>	***Calibrate a QM-500 mass flow controller.***

The performance part of the objective tells what the participants will do as a result of training.

Three Characteristics of a Well-Stated Objective

No. 2

Condition	**The condition describes the environment, location, and/or the situation where the performance is to occur, and it tells what materials, supplies, tools, equipment, and resources may be used while performing the objective.**
<Example>	***In a classroom the trainee will be provided with a mis-calibrated QM-500 MFC, hand tools, and appropriate test instruments.***

The condition part of the objective tells the circumstances or "conditions" that must be present when the performance occurs. The condition should be clearly stated.

Three Characteristics of a Well-Stated Objective

No. 3

Standard	**The standard gives the acceptable level of performance (*standard of performance*). It may be stated in terms of how accurate the performance must be, how many times it must be done, or how much time is allowed.**
<Example>	***The 10 steps of the calibration procedure must be performed in correct sequence according to Spec. No. 4.3.6 and completed within 30 minutes.***

The standard part of the objective tells the acceptable measure or "standard" of performance which the course participant must demonstrate.

Example of a Well-Stated Performance Objective

Given a mis-calibrated QM-500 MFC, hand tools, and appropriate test instruments, the trainee will calibrate a QM-500 mass flow controller according to the 10-step procedure given in Spec. No. 4.3.6. The calibration must follow the correct sequence of steps, and be completed within 30 minutes.

When combined, the three components of the performance objective would appear as in this example. Not all performance objectives, however, need to be as lengthy and wordy as this one.

Questions and Answers to "get at" the Three Parts of a Performance Objective

QUESTIONS	ANSWERS
To get at the <u>performance</u>, ask -- **What exactly do I want technicians to do as a result of this training program which they cannot do now?**	• **Locate** • **Operate** • **Maintain** • **Replace** • **Adjust** • **Disassemble** • **Install** • **Troubleshoot** • **Calibrate**
To get at the <u>conditions</u>, ask -- **Under what conditions should they be able to perform these tasks?**	• **From memory** • **With a standard tool kit** • **While wearing gas mask** • **With schematics**
To get at the <u>standard</u>, ask -- **How well do I want them to perform each of these tasks?**	• **According to Spec XYZ** • **To the component level** • **Within four hours** • **10 out of 12** • **Accurate to 0.01 micron**

Below are four examples of performance-based objectives, each of which contain the performance, the condition, and the standard.

- Given a 14-point daily checklist and an *Astaire Model 1950* stepper, conduct a routine daily inspection and determine without errors the operational readiness of the machine. Note any discrepancies. The results of your inspection must be within range of the specifications given in the checklist.

- Having available a list of 50 major assemblies and components of the *BRN-1200* diffusion furnace, locate each component on the actual furnace in the fab and in the presence of your trainer. Give a short explanation of the purpose of each item on the list. Acceptable performance is 45 out of 50 components located and explained correctly to your trainer.

- Given a list of 10 parts, a list of functional descriptions, and a pictorial of the *Robby* wafer handler, match each part exactly to its corresponding location in the picture and the appropriate description.

- At the location of the *ZAP-5500* plasma etch system, (1) point out each of six potential equipment hazards, (2) explain the type and significance of each hazard, and (3) briefly state the proper working safety procedures. Each of the six items must agree with the list of hazards and safety descriptions given in the National Laboratory Safety training manual.

Performance Words

Action Words: ☺ ***state, operate, identify, construct, draw, write, describe, calibrate, etc.***

Abstract Words: ☹ ***appreciate, know, understand, apply knowledge, interest, awareness, etc.***

It's helpful to use a list of action verbs when you write objectives. When writing objectives, choose words that describe *actions*. Select words that represent performances that can be observed or measured.

Stay away from words that are *fuzzy abstractions* that can neither be observed nor proven that someone has performed them.

Commonly Used Performance Words

show	**test**	**design**
select	**tune**	**infer***
use	**prove**	**deduce***
find	**justify**	**predict***
state	**apply**	**invent**
draw	**relate**	**discover**
write	**verify**	**propose***
identify*	**specify**	**integrate**
locate*	**contrast**	**synthesize***
gather	**construct**	**generalize***
illustrate	**analyze***	**examine**
describe*	**organize***	**manipulate**
measure	**formulate**	**diagnose**
prepare	**estimate**	**troubleshoot**
classify	**interpret**	**formulate**
compute*	**distinguish**	**facilitate***
discriminate	**compare**	**reorganize**
operate	**determine**	**calibrate**
assemble	**differentiate**	**repair**
adjust	**program**	

** Performance words which may require an indicator*

Performance words may be regarded as skills. Some skills may tend to overlap and dovetail with each other; some may never be used in certain job classifications; and still others may always be used by all job classifications.

Here are some performance words, or skills, that may help to create appropriate performance objectives for your specific audience.

Some performances (*) are invisible or neutral as in compute, organize, or identify. In such cases it is useful to add a visible indicator to the desired performance. For example, to clarify identify, *write*: identify by matching items, pointing, or writing a paragraph.

PRACTICE EXERCISE

Performance	Condition	Standard

Using the list of commonly used performance words, write two performance objectives in the chart above. When you have completed your objectives, review them with your colleagues from your group table.

In the third space in the chart, create a performance objective from your own area of expertise and review it with your colleagues.

Practice Exercise

1. **Having attended at least one class in semiconductor processing, be able to have a sense of appreciation for submicron technology.**
2. **Having attended the Thermite Furnace Class, be able to calibrate a thermocouple.**
3. **Having available 10 wafers and the MiG-19 inspection system, be able to locate 100% of the defects and correctly categorize them according to the station job aid. You will have 30 minutes in which to perform this task.**
4. **Assuming that all tools, parts, and documentation are available, the lamp uniformity must be within 0.5% of the specification.**
5. **Without referring to any resources, locate and describe the function of each component on the BRN-1 gas control panel with 100% accuracy.**

Here is an opportunity to practice differentiating between well-stated objectives and objectives that are not. Read each statement and determine if the statement has all of the elements of a good objective.

Check each objective for the following criteria:

- Does the objective have a performance, that is, an action to be done?
- Does the objective state the condition(s) for performing the action?
- Does the objective indicate the standard of performance for the action?

Circle or mark the objectives that are well-stated.

Self-Check

☹ **1. Having attended at least one class in semiconductor processing, be able to have a sense of <u>appreciation</u> for submicron technology.** ***NO PERFORMANCE WORDS USED***

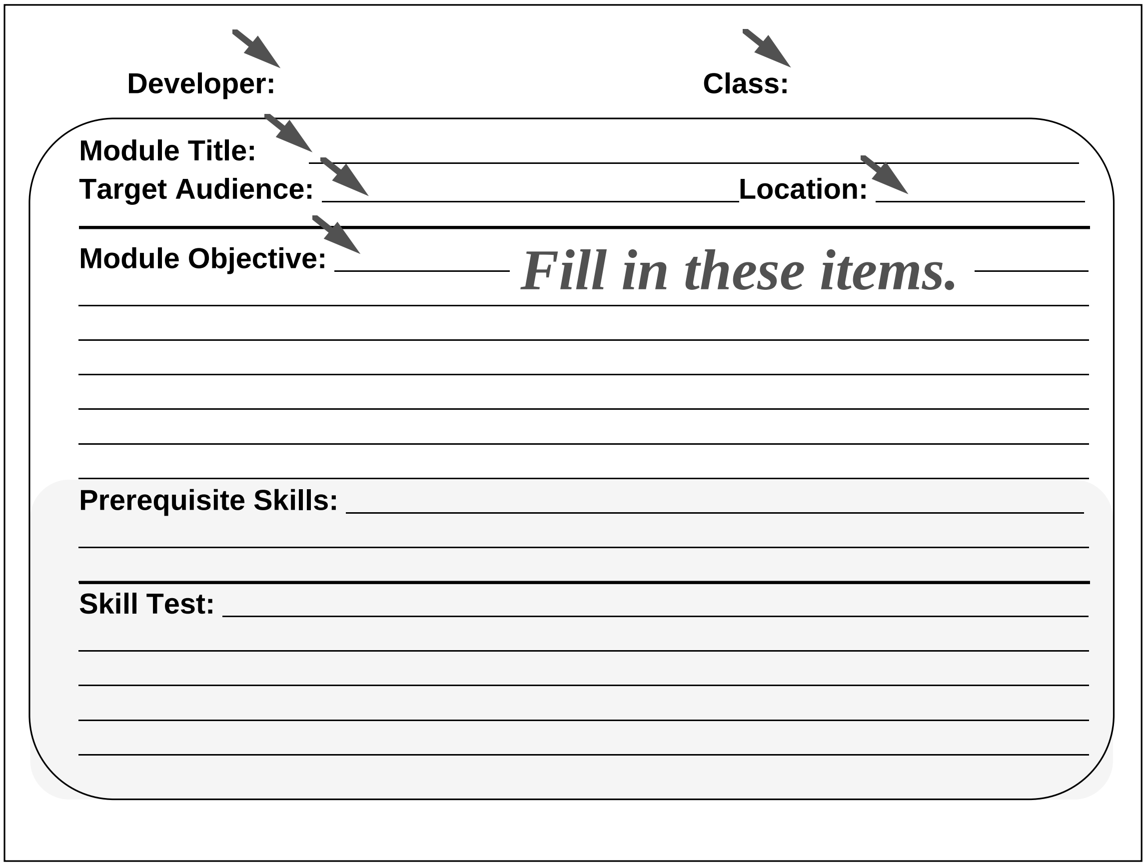
☹ **2. Having attended the Thermite Furnace Class, be able to calibrate a thermocouple.** ***NO CONDITION OR STANDARD***

☺ **3. Having available 10 wafers and the MiG-19 inspection system, be able to locate 100% of the defects and correctly categorize them according to the station job aid. You will have 30 minutes in which to perform this task.** ***GOOD P.O.***

☹ **4. Assuming that all tools, parts, and documentation are available, the lamp uniformity must be within 0.5% of the specification.** ***NO PERFORMANCE IS INDICATED***

☺ **5. Without referring to any resources, locate and describe the function of each component on the BRN-1 gas control panel with 100% accuracy.** ***GOOD PERFORMANCE OBJECTIVE***

When ready, participants may proceed to take the actual skill test.



Developer: Class:

Module Title: ______

Target Audience: ______ Location: ______

Module Objective: ______ Fill in these items. ______

Prerequisite Skills: ______

Skill Test: ______

This is the top of the front side of the SEMATECH Lesson Planning Form provided for participants of this training session*. You will use this form to prepare a complete lesson plan in an area assigned to you by the course instructor. You'll continue to use this sheet for the remainder of this workshop. Please make the following entries at this time:

1. Developer: *Your name*
2. Class Title: *Title of the course*
3. Module Title: *Title of the lesson*
4. Target Audience: *Intended audience*
5. Location: *Where this module will be performed*
6. Module Objective: *The clearly stated performance objective*

* **Note:** Additional copies of the SEMATECH Lesson Planning Form, including a definitions page and one example from an actual training program, can be found in Appendix A of this manual.

SKILL TEST

This test requires that you write two clearly stated objectives. Both objectives must satisfy these minimum requirements:

- **The objective should contain three minimum requirements: *performance, condition,* and *standard.* If necessary, underline the three parts of the objective as you did on page AN-2-8.**
- **The performance part of the objective must not be abstract nor fuzzy. (Review page AN-2-10, if necessary.)**
- **The objective should be written clearly so that a peer will understand what is required.**

1. **The first objective must include the elements which your instructor has written on the flip chart. Use this space to write your first draft. When you are ready, your instructor will review your draft.**

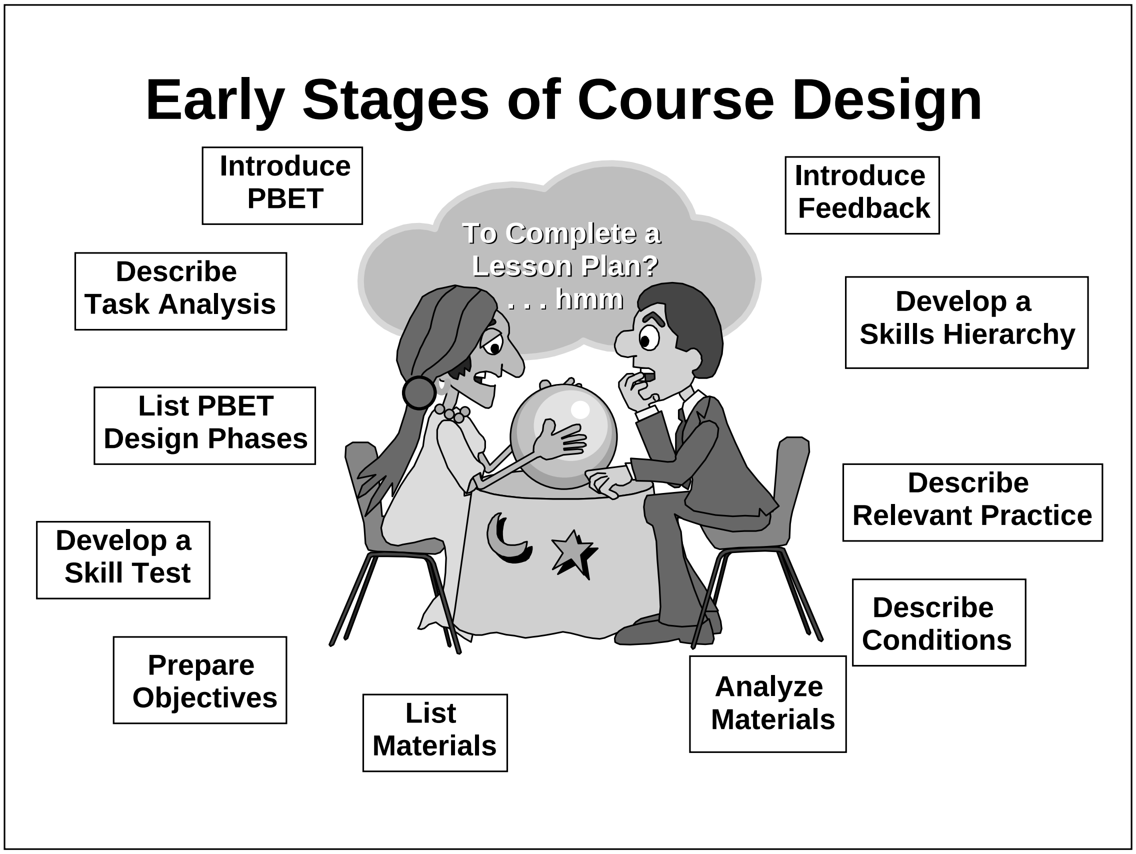
2. **The second objective is to be in an area of your own expertise. On the third day of this class, you will write an entire lesson plan based on the objective you write here today. Use this space to write your first draft. When you are ready, your instructor will review your draft.**

AN-3

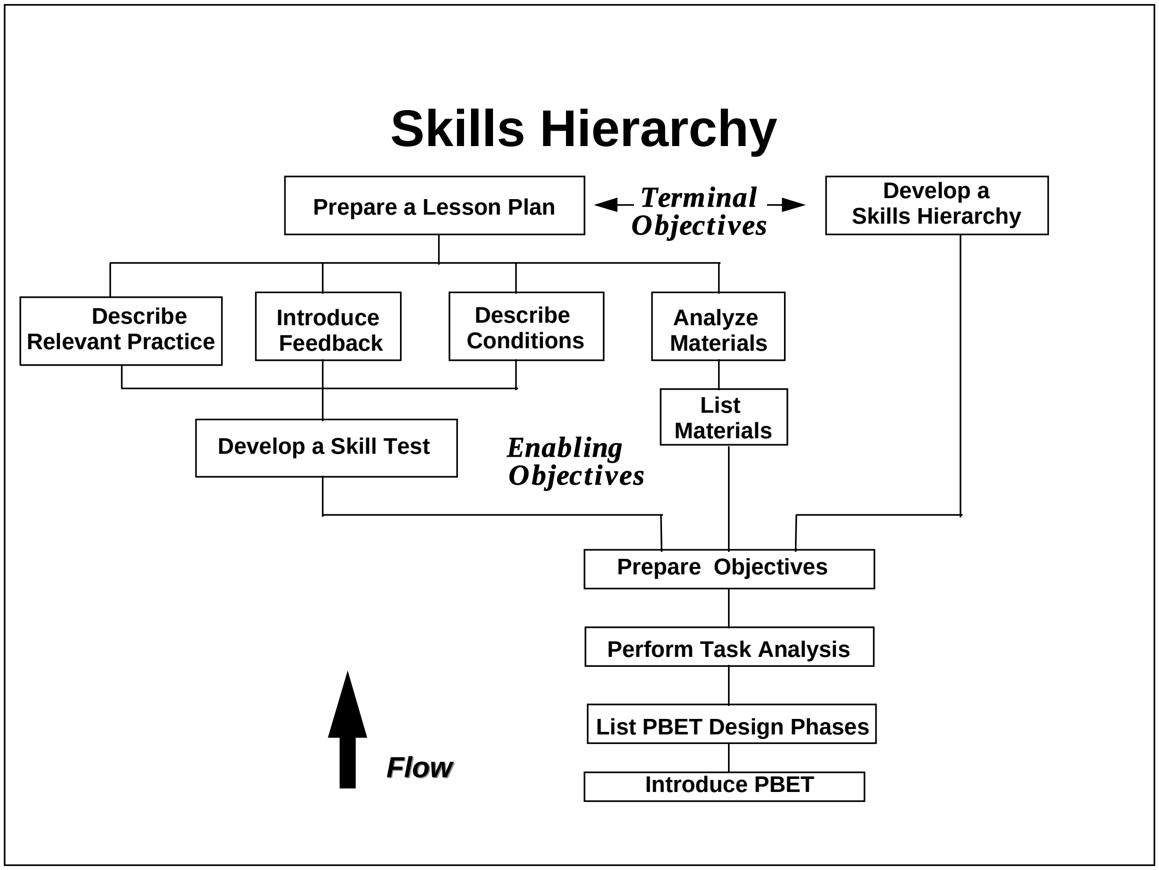
DEVELOP A SKILLS HIERARCHY

OBJECTIVE:

Given a terminal objective for equipment training, develop a skills hierarchy of enabling objectives. Label objectives according to classification -- *terminal*, *enabling*, or *prerequisite*. Show the relationships to each one by drawing a skills hierarchy.



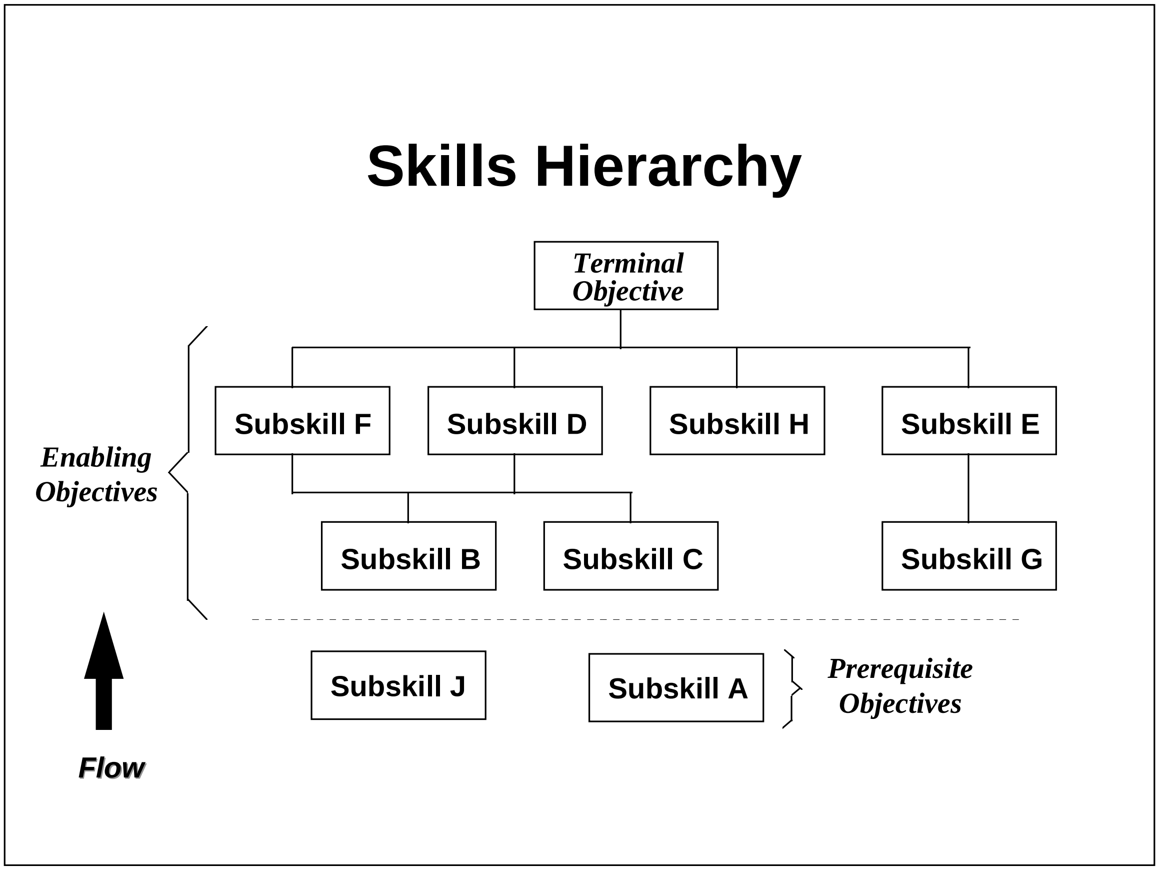
Initially, it may be difficult to see how the organization and structure of the training course will fit together. You may wonder what the logical sequence should be.



A skills hierarchy is like a road map. It's a graphic representation of paths in a course. It shows how the different levels of subordinate skills serve as enabling objectives that lead to the terminal objectives.

The structure of the hierarchy in this foil shows how instructional elements of a course are logically arranged. It's easy to see which subskills are prerequisites to others. There may be some skills that have no relevance to other skills; these can be performed at any time prior to attempting the terminal objectives.

Normally, instructional designers use shorthand objectives to label individual boxes in the skills hierarchy. This may be why this type of diagram is also referred to as a *shorthand pyramid*. There are different types of performance objectives. The objectives in this slide have been categorized as enabling objectives and terminal objectives.



To design a PBET training course, you need a logical, sound structure you can follow as you organize your course. To determine the best structure for the course, you need to look at your final or *terminal* objectives and their subordinate objectives.

A skills hierarchy indicates where and how the support skills relate to the terminal objective. A *skills hierarchy* provides a structure for relating the different supporting skills and competencies to the terminal objective. The subordinate objectives consist of *enabling* objectives and *prerequisite* objectives.

Three Categories of Objectives

TYPE	DESCRIPTION	EXAMPLES
• Terminal Objectives	These are the significant, final outcomes of a training program.	• Design a process • Troubleshoot problems • Repair equipment • Perform maintenance • Program a process recipe • Operate a machine
• Enabling Objectives	These are the objectives which must be mastered if an individual is to master the terminal objective.	• Write a process recipe • Interpret computer screens • Follow safety procedures • Identify hazards • Locate and describe parts • Describe process steps • List process steps
• Prerequisite Objectives	These are the objectives that state what an individual must have mastered before entering the training course.	• List four areas of a fab • Describe a cleanroom • Use Ohm's law to calculate . . . • Operate a multimeter • Interpret the metric system • Read and write English

Training programs generally have a set of course objectives that organize the sequence of the topics covered. There are three categories of performance objectives as illustrated in this foil. They are:

- Terminal objectives
- Enabling objectives (subordinate to the terminal objective)
- Prerequisite objectives (subordinate to the terminal and enabling objectives).

Guidelines for Interpreting a Skills Hierarchy

- **The skills hierarchy shows which subskills must be learned before going on to a higher skill.**
- **It does not tell which skill out of the entire group should be learned first. There could be a variety of starting points.**
- **It does not indicate the proper sequence in which steps of a task should be performed.**
- **It does not relate anything about the importance of each skill.**
- **The relative importance of a skill in a skills hierarchy does not indicate the degree of difficulty that a person will have learning that skill.**

A skills hierarchy has one main purpose -- it tells you the sequence in which lessons, or modules, can be learned.

A skills hierarchy should not be misunderstood with the steps in a procedure. It is not necessarily the sequence in which a task should be performed. This is because a course designer may have determined that several steps of a task could be learned in any order.

In addition, the lessons listed in a skills hierarchy are not necessarily in the order of importance nor in the order of difficulty.

Guidelines for Developing a Skills Hierarchy

- **Write out the complete terminal objective and place it at the top of the workspace.**
- **Write out all subordinate objectives in short form on individual index cards, sticky note paper, etc.**
- **To organize the hierarchy, look at each objective and ask, "what must I be able to do before I can do this?" Then, position objectives accordingly.**
- **Be ready and willing to create new objectives if required.**
- **All subskills must be derived from terminal skills. If a subskill has no relevance to the terminal skill, it should not be included in the hierarchy.**
- **Skill hierarchies should be validated.**

There is no easy way to develop skills hierarchies; however, the process can be facilitated with the use of index cards or sticky-back paper such as 3-M Post-it Notes™. Write the complete terminal objective and place it at the top of the workspace, then ask yourself, "what (skills) must I be able to do before I can do this?" Place these skills under the terminal objective, then repeat the process for these skills and so on.

To reduce time and errors, the skills hierarchy should be developed and approved by a committee made up of interested parties, such as; trainers, developers, subject matter experts, and customers.

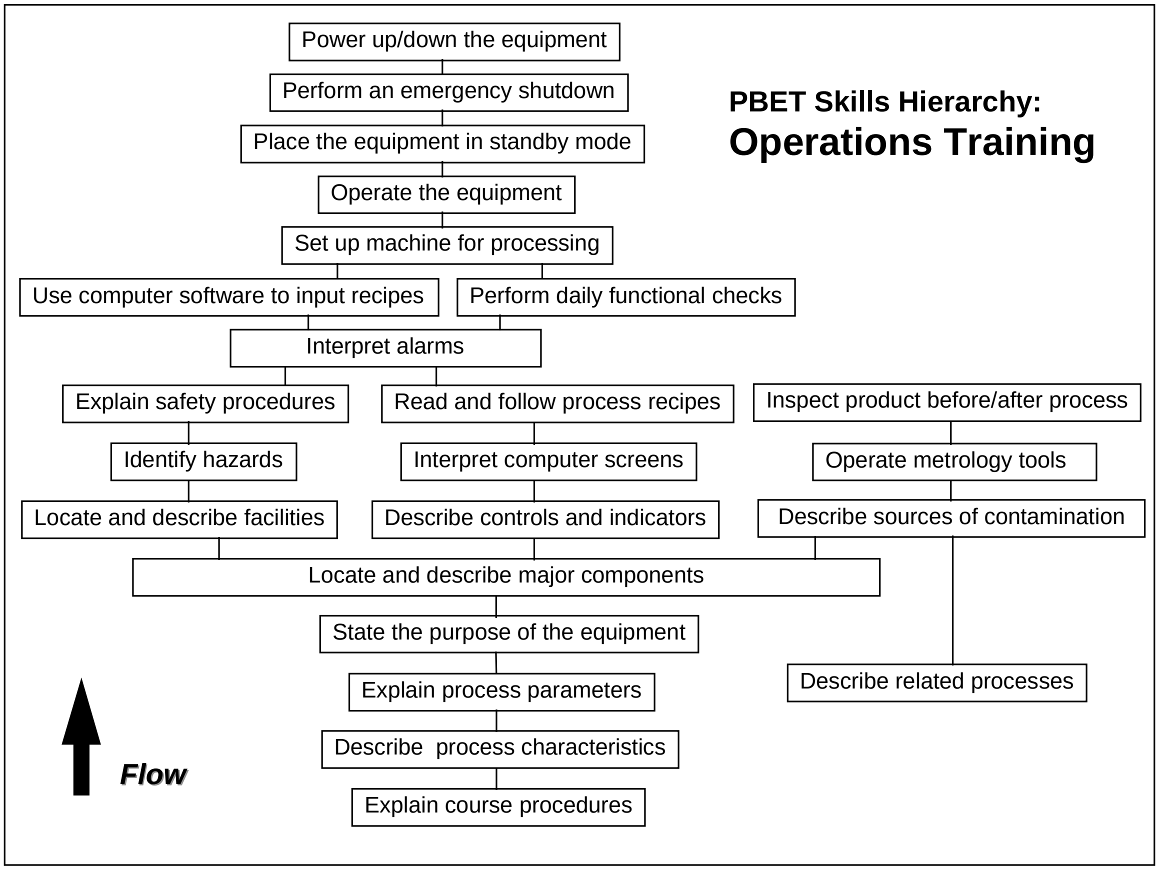
Now is a good time to practice developing a simple skills hierarchy. Your instructor will lead the class through an exercise on designing a skills hierarchy required to "meet and greet an old acquaintance."

Skills Hierarchy Practice Exercise

- **Terminal Objective:**
  - **Perform daily functional checks on manufacturing equipment**
- **Subordinate Shortform Objectives:**
  - **Explain safety procedures**
  - **interpret computer screens**
  - **Interpret alarms**
  - **Describe controls and indicators**
  - **Identify hazards**
  - **Locate major equipment components**
  - **Identify equipment contamination sources**
  - **Describe process characteristics**

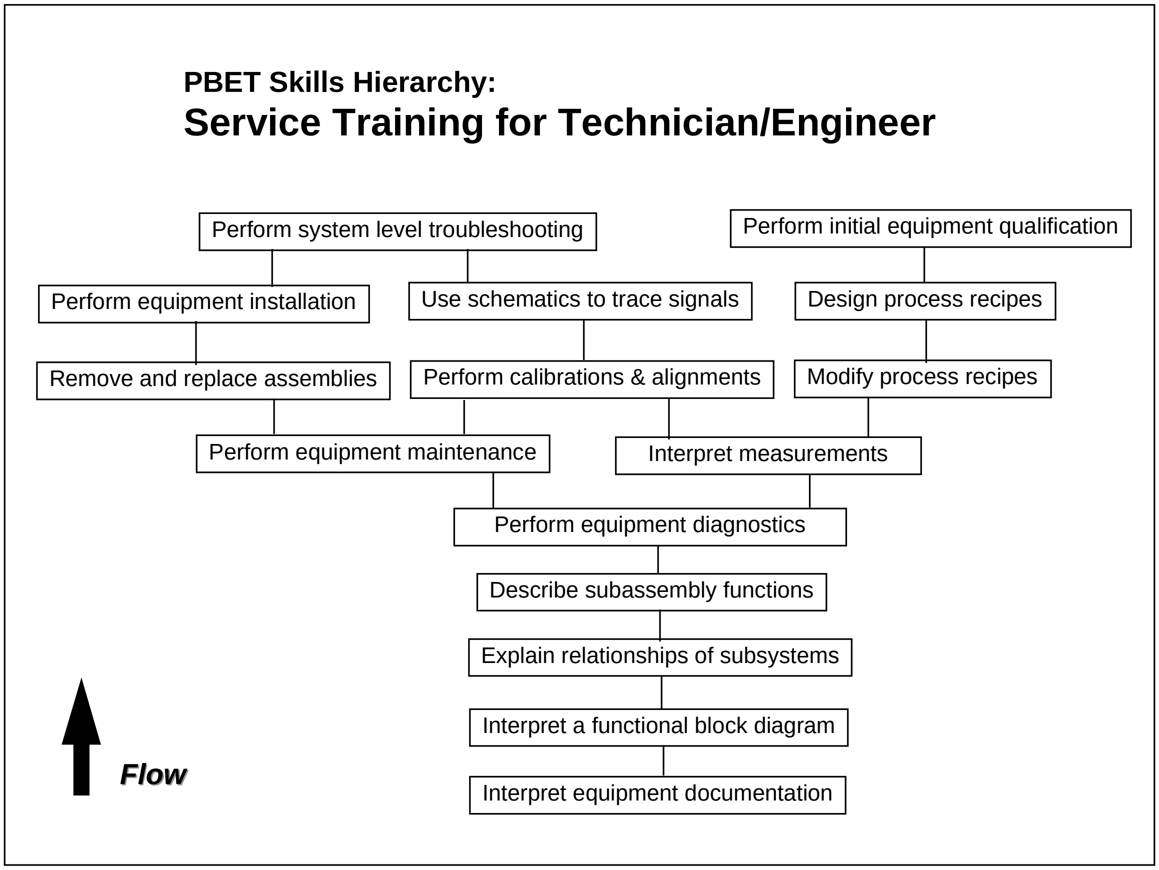
Work with a colleague at your table to build a skills hierarchy from the set of objectives shown on this slide. Remember, for each objective you should ask the question, "what do I need to know first before I can do this and then what do I learn next?"

Use index cards, paper strips, or sticky-back note paper to build the skills hierarchy unless your instructor provides some pre-printed paper strips.



This slide represents a typical skills hierarchy or course map for an equipment operations training course. Most PBET courses designed to train operators, technicians and engineers in the operations and product inspection for a specific processing tool will contain a set of skills similar to these.

Depending on the type of tool -- its complexity and sophistication, and its manufacturer -- the number and types of modules, as well as their sequence may vary.



This is a simplified example of a PBET skills hierarchy for a training course designed for technicians and/or service engineers. It's a training course for the skills and knowledge needed to maintain, troubleshoot, install, and qualify a semiconductor processing tool.

The operation course shown in the preceding foil is to be considered a prerequisite to this service training course. It's easy to see in both examples of PBET course maps how the courses can be easily customized to meet a customer's specific training needs. A skills hierarchy/course map can help you determine with a glance which courses should be taught.

SKILL TEST

- **Gather your team members and brainstorm enabling objectives for a task assigned by your instructor.**
- **Use the 3-M Post-it Notes™ to create a skills hierarchy from these enabling objectives.**
- **Designate the prerequisite objectives by drawing a line between the prerequisite objectives and the enabling objectives**
- **When the skills hierarchy is approved by the instructor, write the prerequisite skills in the Lesson Planning Form.**

✐✐✐✐✐

SUPPLEMENTARY ACTIVITY

You have created a skills hierarchy for the assigned task. On the last day of class you will complete the following skills test for an area in your own expertise.

1. **Select a terminal objective from your own area of expertise or one that the instructor has assigned to you. Create a skills hierarchy consisting of performance objectives, including terminal, enabling, and prerequisite objectives.**

    A. **Start by reducing the subordinate objectives to shorthand objectives.**

    B. **If available, write each shorthand objective on sticky-back paper or index cards. If not available, then use pencil and paper so you can easily erase and make changes.**

    C. **Use a sheet of paper, posterboard, or flipchart paper on which to build the skills hierarchy.**

2. **The skills hierarchy must show which subskill must be learned before going on to higher skills.**

3. **When you have finished, have the workshop instructor or one of the workshop aides review your diagram.**

Design

DS-1

DEVELOP SKILL TESTS

OBJECTIVE:

Given a performance objective for equipment training, develop a skill test to match the requirements of the objective. The test must be conducted under the same conditions as indicated in the corresponding objective. The performance standard must also match that of the stated objective.

The purpose of instruction is to produce improvements in human performance. It should be the instructional goal, therefore, to design the instructional program for success. But, even the finest instructional design techniques and dynamic delivery methods cannot be proven successful unless there is some way to measure the results of the learning activity. This is the reason for having measurement instruments we often refer to as "tests."

Traditional Applications of Tests

Tests come in many different forms. Sometimes tests are used to determine how well course participants perform in comparison to others in the same class, school, area, or country. At other times, tests are used to measure how well course participants perform against the requirements of the course.

Norm-Referenced Testing vs. Performance-Based Testing

		Norm-Referenced Scoring	Performance-Based Scoring
1.	Describe Process Steps	10	✓
2.	Name 25 Major Parts of the System	10	✓
3.	Locate 35 Major Parts of the System	10	✓
4.	Describe Function of 35 Parts	10	✓
5.	Identify 10 Hazards & Explain Safety	0	-
6.	Describe Functions of Controls	10	✓
7.	Perform Daily Equipment Checks	10	✓
8.	Interpret Computer Screens	10	✓
9.	Interpret Process Recipes	10	✓
10.	Operate the System	10	-
	Final Score	90	NC*

**This person is not yet competent or has not yet mastered all of the PBET course requirements.*

In general, there are two ways to look at the results from testing. One is the *norm-referenced* approach, and the other is the *performance-based (competency-based)* approach.

Examine for a moment the results of testing obtained from a technician who attended an equipment operator training course.

In the norm-referenced scoring system, the technician scored a very respectable 90 points out of 100. Despite the fact that the technician either failed the safety section or was not present when it was covered, the overall impression is that the technician passed with a good grade.

On the other hand, the performance-based method of scoring simply indicates an *NC* to inform the technician and others that the course is *not complete* or that the technician is *not yet competent.* The final score remains blank until the requirement is satisfied. Also, if the training system is truly performance-based, the technician would not be allowed to operate the equipment until all the prerequisite skills have been completed, including the safety skills. This explains the blank space next to the Operate the System under the Performance-Based scoring column.

Requirements for Writing Effective PBET Skill Tests

A well-written skill test must be a good match to a well-written performance objective, which is accompanied by three important components:

- **Performance requirement**
- **Conditions under which the performance is to occur**
- **Standard of performance must match the stated objective**

When instructional systems have solid, well-stated objectives that inform course participants what is expected of them at the end of a course or unit of instruction, a well-matched skill test is needed to measure the outcomes of the performance.

The skill test must match the performance objective in terms of the stated performance, the conditions under which it occurs, and the standard for observing or measuring the performance.

Skill Test Example No. 1

WAFER INSPECTION SKILL TEST

OBJECTIVE: Given 10 production wafers of different masking levels, and having available all the necessary resources and metrology tools in the fab, identify which wafers have defects, and locate the area and nature of the defect. The inspections must be 100% accurate and completed within 40 minutes.

SKILL TEST: Perform the following wafer inspection skill test in the presence of your trainer.

- **You will be provided all necessary items you will need for the wafer inspection test including the metrology tool in the fab.**
- **The instructor will provide 10 wafers of known origin and types of process defects.**
- **For each wafer tell the instructor where the defect is located and explain the nature of the defect.**
- **Performance standard is 100% accuracy and will require no more than 40 minutes to complete.**

The foil shown above is a practice exercise. Read the objective and skill test for Example No. 1, and decide if the skill test is appropriate for this example. Discuss your answer with a colleague. If you need assistance, consult with the workshop instructor or assistant.

Skill Test Example No. 2

RUN A FIRST MASK EXPOSURE JOB

OBJECTIVE: Given the proper reticle, resist-coated wafers, and a job number, load the reticle and the wafers into the *Astaire-1950 Stepper*, call up the proper job parameters, and execute a first mask exposure job. Your performance will be evaluated by the course instructor against the Operations Specifications.

SKILL TEST: At the designated stepper, explain to your trainer the procedure for executing a first mask exposure job.

- **Show him where you would load the wafers and where to place the reticle.**
- **Show him on the stepper which job parameters to use.**

Read the objective and skill test for Example No. 2, and decide if the skill test is appropriate for the objective. Discuss your answer with a colleague. If you need assistance, consult with the workshop instructor or assistant.

Skill Test Example No. 3

PERFORM AN RF GENERATOR ALIGNMENT

OBJECTIVE: Assuming all tools, parts, schematics, and alignment specifications are available, perform a complete alignment on an *FRQ-5000* RF generator. The alignment must be completed in less than 20 minutes and the harmonic distortion <5%.

SKILL TEST: Given the following steps required in the *FRQ-5000* RF generator alignment, number them in the proper order from 1 to 6.

- **Set up the frequency counter for a frequency of 13.5 MHz.**
- **Adjust crystal amplifier for maximum output.**
- **Connect the oscilloscope to the AGC test point.**
- **Adjust the output of the first IFPA to maximum.**
- **Monitor the SWR meter on the front panel.**
- **Adjust the PA LC network for maximum power.**

Read the objective and skill test for Example No. 3, and decide if the skill test is appropriate for the objective. Discuss your answer with a colleague. If you need assistance, consult with the workshop instructor or assistant.

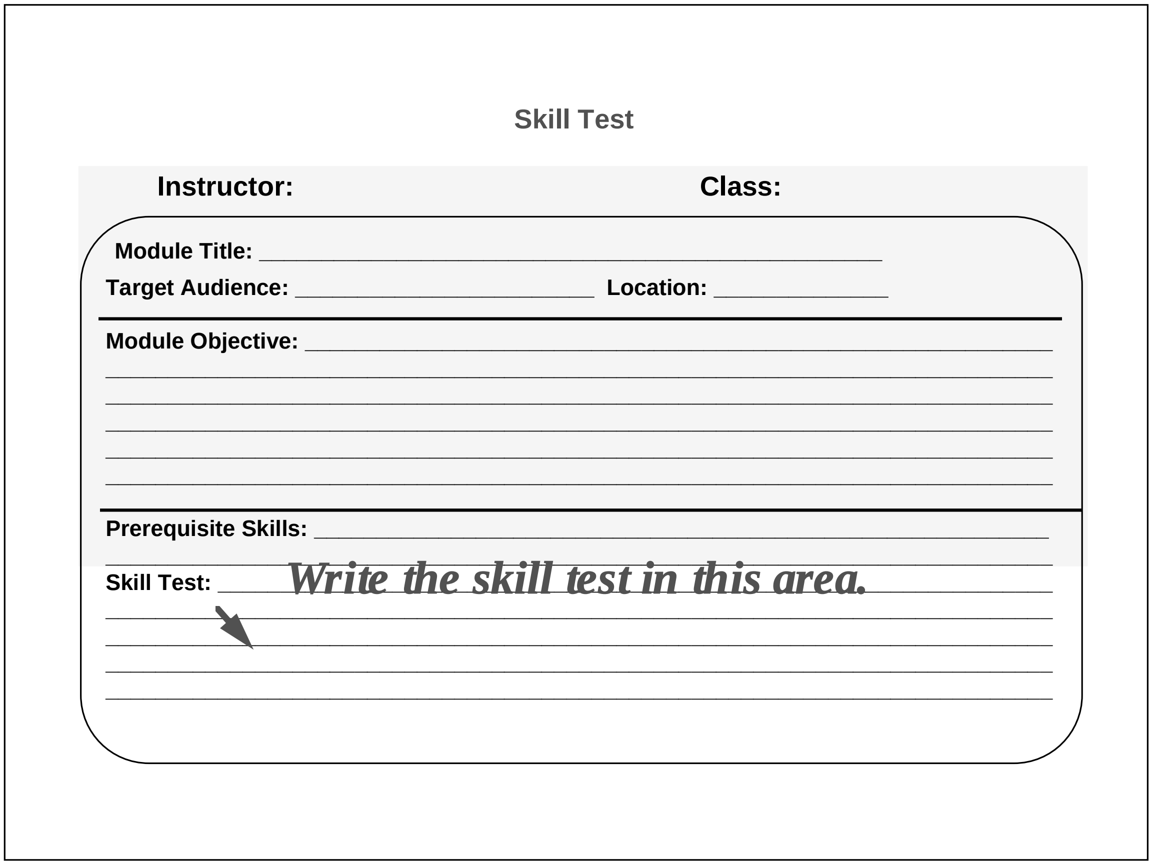
Skill Test Example No. 4

LOCATE AND DESCRIBE SIX PARTS OF A WAFER

OBJECTIVE: Given a diagram of a wafer and the correct wafer terminology, locate the six parts of a wafer by matching the correct descriptions.

SKILL TEST: Using the wafer diagram and the list of matching words and statements from the Appendix, correctly locate and identify the six parts of a wafer.

Read the objective and skill test for Example No. 4, review the Appendix pages and decide if the skill test is appropriate for the objective. Discuss the answer with a colleague. Refer to pages C-8 and C-9 in Appendix C for an example of this test.



Skill Test

Instructor: **Class:**

Module Title: ____________________

Target Audience: ____________________ **Location:** ______________

Module Objective: ____________________

Prerequisite Skills: ____________________

Skill Test: *Write the skill test in this area.*

SKILL TEST

- **Review the module objective with your project colleague.**
- **Review the important elements of designing skill tests as described in this module.**
- **Draft a skill test on separate paper, then review and edit your work so that it conforms to the criteria described in this module. Does the skill test match the objective in terms of: __ performance, __ condition and __ standard?**
- **If it is a "hands-on" test, have you provided instructions for both trainer and trainee in clear, user-friendly language?**
- **If it is a written test, have you provided some sample test items or a clear description of the type of written test that will be given?**
- **Ask the course instructor to review the test description. The instructor will use the same criteria as above to evaluate your work.**
- **When the drafted test is approved by the course instructor, you and your colleague should transfer the extended narrative form to your Lesson Planning Forms.**
- **Now, take your second Lesson Planning Form on which you have already written an objective for a lesson of your own choosing. Design a test for that objective and fill in the Skill Test section. When finished, have the course instructor review this test.**

DS-2

DESCRIBE RELEVANT PRACTICE TO SUPPORT OBJECTIVES

OBJECTIVE:

Given an objective in your area of expertise, write a description of relevant practice that includes a description of the following elements:

- **The activity trainees will be doing when practicing the performance**
- **The conditions under which the practice activity is to occur**
- **A feedback mechanism to inform your trainees how well they are doing**
- **The type of modeling that will be used to demonstrate desired performance**

Four Components of Relevant Practice

• Performance	The activity which the trainees will be doing when they are practicing the intended performance stated in the objective.
• Conditions	Where, how, and with what the relevant practice is to be performed.
• Modeling	The method in which the perform-ance can be demonstrated to the trainees.
• Feedback	The indicators, signs, or cues that trainees can use to measure their own performance.

In order to provide the most effective way of practicing a desired performance, there are four specific components that must be included in describing relevant training practice.

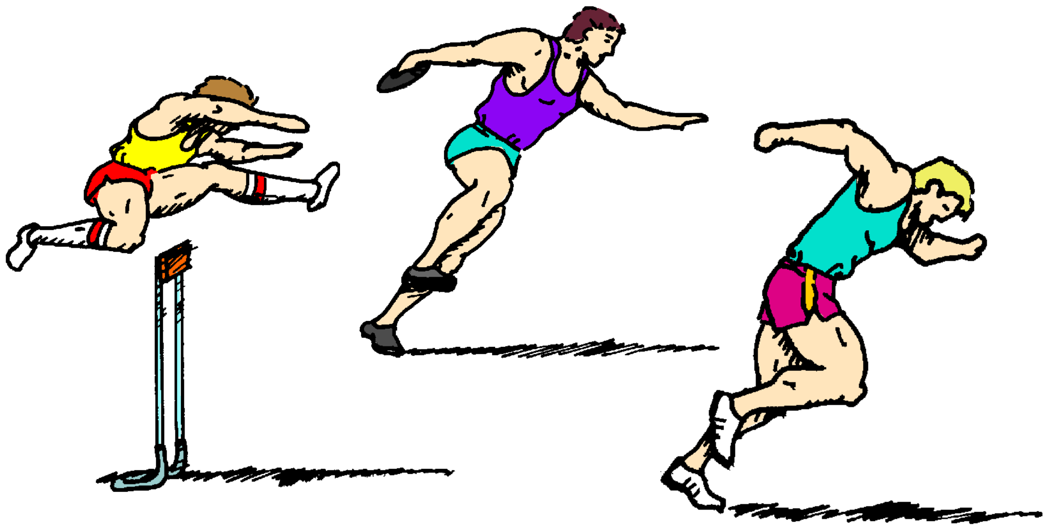
Performance defines what the course participants will be doing when they are practicing the intended skill that's stated in the performance objective. For example, if the objective requires that technicians leak-check the process chamber of an ion implanter, then that's what they should practice.

Conditions describe how and with what the relevant practice will be performed. In some cases a similar activity can be substituted for the actual relevant practice. For example, if the objective requires someone to identify components inside an ion implanter, then a color photograph or videotape of the implanter could be substituted.

Modeling provides a way in which the performance can be demonstrated to a course participant. Again, the trainer or another competent performer can model the desired performance. As with the feedback mechanism, and depending on the type of performance, there may be other ways in which the performance can be modeled.

Feedback wherever possible, provides indicators, signs, or cues that the course participants can use to measure their own performance. And, if that's not possible, feedback provides a means for informing the participants about how well they are progressing.

Relevant Practice



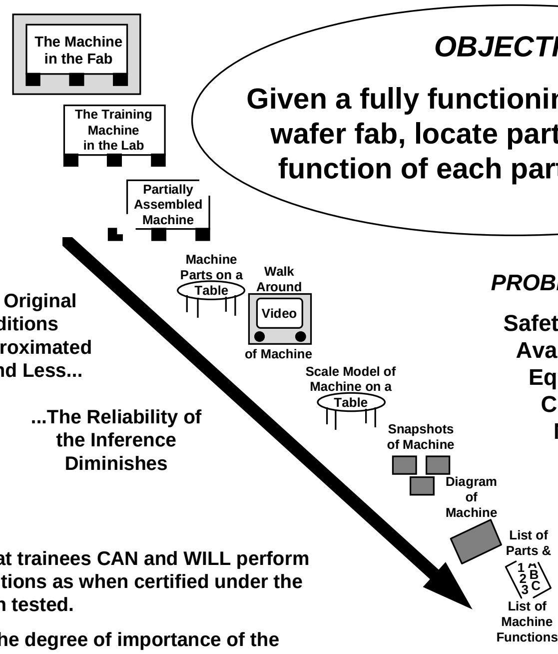
The more we repeat an activity, the more chances we have of improving the outcomes of subsequent performances. Practice must be relevant to the performance objective, otherwise there is little benefit from it.

For instance, in this track and field example, how much improvement can a discus thrower gain by sprinting and hurdling? Probably none. The three skills are unrelated. Throwing the discus requires a different set of skills and physical stature.

Whether in training or athletics, the performance that's practiced should mirror the performance that will be required later.

Relevancy also applies to the conditions of the practice. Conditions during practice should closely resemble the actual conditions that will exist later.

Relevant Conditions Continuum



OBJECTIVE:

Given a fully functioning machine in the wafer fab, locate parts and state one function of each part on Lab List B.

As the Original Conditions Are Approximated Less and Less...

...The Reliability of the Inference Diminishes

PROBLEMS?

Safety?
Available instructors?
Equipment access?
Costs?
Not enough time?
Effort???

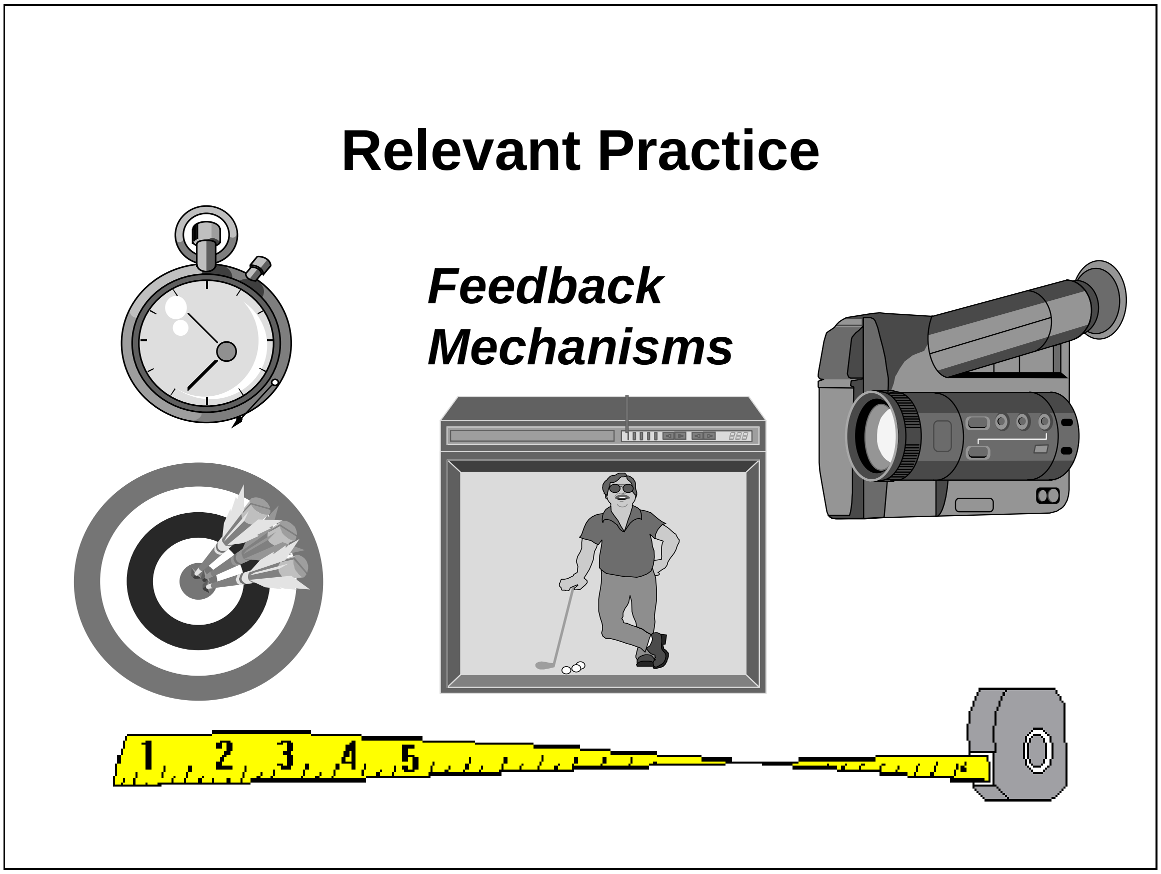
This is the inference: That trainees CAN and WILL perform the same under fab conditions as when certified under the conditions provided when tested.

Does it matter? Only to the degree of importance of the original performance discrepancy.

Relevant Practice

Model Behavior
- ***Demonstrate***
- ***Coach***
- ***Train***

Another way of learning the proper techniques for performing a task during practice is having someone or something demonstrate or model the activity. In athletics, this task is usually handled by coaches and trainers, however, other methods can be used. For example, videotapes, slides, films, etc., can demonstrate or model the necessary activity or procedure.



Athletes and other performers need to know how well they are progressing toward their desired objectives. In the case of the discus thrower, a measuring tape can measure the distance he or she is able to hurl the discus.

The measuring tape becomes the *feedback mechanism* to measure improvement. Unfortunately, if there's no improvement, the measuring tape won't tell him or her how to improve. Once again, a coach or a trainer can provide this feedback. Today, technologists are also using video and computer analysis to improve athletic performance.

Pitfalls to Avoid When Planning Relevant Practice

- **Partial practice**
- **Disproportionate practice**
- **Misdirected practice**
- **Limited practice**

In planning and developing practice that's relevant, avoid the common pitfalls to which some training developers fall victim.

Partial practice – If the objective is to "*calibrate* a vacuum system throttle valve," partial practice would be to "*describe* how to calibrate a vacuum system throttle valve."

Disproportionate practice – Too much practice or too little practice.

Misdirected practice – When performers can rely on other signals for the correct answers, such as wear patterns or the instructor's reaction to clue them to the correct answers.

Limited practice – When practice is limited due to lack of operational equipment, lack of individualized practice and too much group practice; only practicing on paper and diagrams instead of equipment, etc.

1. Examples of Relevant Conditions

Objective: **Given a list of 10 parts belonging to an ion source, locate them and state the purpose of each one.**

1A. Best Case Condition: Have the exact ion source available so students can practice.

1B. Alternative Condition: Have available one or more color photographs of the exact ion source with alphanumeric labels.

2. Other Examples of Relevant Conditions

Objective: **Given a list of 10 parts belonging to an ion source, locate them and state the purpose of each one.**

2A. Best Case Condition: Classroom.

2B. 1st Alternative Condition: Shop area, storage area.

2C. 2nd Alternative Condition: Ion implanter inside fab.

3. Examples of Modeling Methods

Objective: **Given a list of 10 parts belonging to an ion source, locate them and state the purpose of each one.**

3A. **<u>Best Case Modeling Method</u>: A trainer or other technician can point at one part of the ion source, say the name of the part, and describe the purpose of it.**

3B. **<u>Alternative Modeling Method</u>: Provide one or more color pictures; one part of the ion source has a label on it naming the part and a short description of the purpose of the part.**

4. Examples of Feedback Mechanisms

Objective: **Given a list of 10 parts belonging to an ion source, locate them and state the purpose of each one.**

4A. Best Case Feedback Mechanism: A trainer or other technician can inform the trainee of the number of correct responses the trainee made and which specific ones were correct.

4B. Alternative Feedback Mechanism: The trainee will have available a checksheet with the correct responses.

Practice Exercise No. 1

Objective: **Given 10 production wafers of different mask levels, tell which wafers have defects and locate the area and nature of the defect.**

1. **Description of Performance**
   Same as objective
2. **Description of Conditions**
   2A. Best case
   2B. Alternative or none
3. **Description of Modeling Method**
   3A. Best case
   3B. Alternative or none
4. **Description of Feedback Mechanism**
   4A. Best case
   4B. Alternative or none

Decide as a small group what would be the best case and the alternative for the example above. Be prepared to share your answers with the class.

Practice Exercise No. 2

Objective: **Given an *Astaire Stepper* and a 14-step checksheet designated for "daily checks," the trainee will perform each daily check accurately, and relate any errors or nonstandard conditions to the trainer. The trainee must also interpret the nonconforming conditions correctly to the trainer.**

1. Description of Performance
  - **Same as objective**

2. Description of Conditions
  - **2A. Best case**
  - **2B. Alternative or none**

3. Description of Modeling Method
  - **3A. Best case**
  - **3B. Alternative or none**

4. Description of Feedback Mechanism
  - **4A. Best case**
  - **4B. Alternative or none**

Decide as a small group what would be the best case and the alternative for the example above. Be prepared to share your answers with the class.

Here's an easy way to help you remember the steps in the PBET training model. Let's compare it to a more traditional approach to doing on -the-job training.

Traditional OJT Approach	PBET Methodology
1. *Tell them* what they are expected to do	State the *performance objective* up front
2. *Show them* how to do it	*Model* the performance
3. *Let them do it* while you coach them	Give them *relevant practice* with *feedback*
4. *Let them show you*	They perform the *skill test*

SKILL TEST

- **Review the Lesson Planning Form you are developing for the lesson assigned to you by the course instructor.**
- **Review the important elements of relevant practice covered in this module.**
- **Discuss with your project partner various ideas for modeling, arranging conditions, and providing feedback for the trainee's practice session(s).**
- **Fill in the Relevant Practice sections (there are four of them) on the back of your Lesson Planning Form.**

Review your work against this criteria:
__ Performance -- Does the performance statement match the objective?
__ Condition -- Does the condition match the objective?
__ Modeling -- Have you stated who or what will be used to show the trainee how to perform the activity? Have you stated what part of the practice will be modeled (all of it or just a part of it)?
__ Feedback -- Have you stated what indicators, signs, or cues will help trainees measure their own performance, or have you stated who will evaluate/coach the trainee?

- **Ask the instructor to review your "Relevant Practice Description." The instructor will use the same criteria as above to determine "sign off" on this module.**

✐✐✐✐✐

The skill test should match the requirements of the objective as stated earlier in the module.

Again, if the course participant does not achieve mastery of the intended skill, then the participant may ask for assistance, or rework the test until mastery is achieved.

Relevant Practice Description:

Conditions:

Type of Modeling:

Feedback Mechanism:

Module Content Description:

DS-3

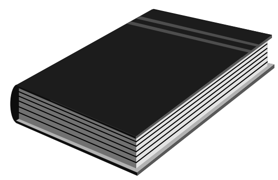
ANALYZE RESOURCE MATERIALS

OBJECTIVE:

Having available resource materials that you will use or that you have previously used to teach a course, diagnose assumptions about entry level skills that are suggested but not explained in the materials.

Select Supporting Resources and Instructional Materials

- Technical Manuals
- Textbooks
- Videotapes
- Slides
- Brochures
- Checklists
- Written Procedures



Regardless of the style of instructional techniques an instructor uses in the course--whether it's traditional instructions, performance-based, self-paced, or group instruction--the developer must evaluate the supporting resources used in the course for relevancy.

Supporting resource materials can take the form of technical manuals, textbooks, videotapes, charts, foils, slides, written procedures, checklists, and even sales brochures. The instructor needs to compare the subject matter resources with the objectives, skill tests, and target audience description of the course.

Evaluate Supporting Resources and Instructional Materials

- **Are there adequate examples for the target audience?**
- **Are the skills and concepts adequately covered?**
- **Is the language or reading level appropriate?**
- **Is it too technical -- not technical enough?**
- **If a student tried the material, what would he or she think?**
- **Are the assumptions made that a learner might not understand?**
- **Is the glossary in the front or the back of the book?**

With the requirements of the performance objective and skill test established, the developers need to evaluate and diagnose the relevance and appropriateness of the material for the audience.

Developers need to determine if the material provides adequate coverage of the subject matter, or what's necessary to supplement the instruction. They may decide to order different material, supplement the course with a visiting lecturer, create the material themselves, or summarize important items for the course participants, etc.

PRACTICE EXERCISE

- **Select an example of text material with which you are not familiar.**
- **Read through it and underline or highlight assumptions.**
- **Compare your list with a colleague's and discuss any differences.**

Select at least one example of text material that deals with a subject in which you cannot claim competence. There are several examples in Appendix B of your notebook.

Read through the text and list any assumptions the writer seems to have made about the beginning skills of his or her readers. Feel free to underline or highlight the assumptions in the examples.

Check your list with a colleague to see if he or she agrees with you.

SKILL TEST

- **Select a written resource for a subject you are responsible for teaching.**
- **Show the material to your instructor so he/she can select a passage for a colleague to diagnose. Typically, the instructor will select the first section in the material.**
- **The instructor will do the same for all course participants.**
- **Exchange materials with another course participant.**
- **- Describe the target audience who would be required to read the material.**
- **- Explain any prerequisite skills/knowledge that the target audience must have before attempting to read the material.**
- **You will review a colleague's resource material for inappropriate assumptions, unclear explanations, confusing information, and inappropriate structure. Make comments and suggestions on a separate sheet of paper or use sticky paper notes to localize problem areas on specific pages of the document.**
- **When you have finished diagnosing a colleague's material, return it to the owner and review each other's materials.**

Write the titles or names of the resources you plan to use in the Lesson Planning form.

✏✏✏✏✏

Module Objective: ____________________

Prerequisite Skills: ____________________

Skill Test: ____________________

Fill in the Additional Resources needed to support the module.

Additional Resources: ____________________

DS-4

SELECT DELIVERY METHOD

OBJECTIVE:

Given the course objectives and performer information, determine the delivery method for the training module you are developing.

By this stage, instructional developers should have a very good idea of the amount and type of content that's needed in the training module. The majority of the design work has been completed along with the task analysis, performance objectives, skill tests, and any review of available resources.

Based on the results of the preliminary analysis and design work, developers can now decide on the delivery method and the type of media to use.

There are a variety of options and solutions for developers to consider as they plan for training effectiveness and learning retention. Developers should consider scheduling and budget constraints when deciding on the best delivery and media methods.

List Additional Instructional Aids and Supporting Materials

TRAINING AIDS & MEDIA	TOOLS & MATERIALS
• Transparency Foils	• Test Wafers
• Equipment Manual	• Hand Tools
• Video	• Test Instruments
• Checklists	• Astaire Stepper
• Flipchart & Markers	• Strip Chart Recorder
• Drawing Board	• Microscope
• Paper & Pencils	• Coater-Developer
• Job Aid	• Calculator
• Camcorder	• SPC Control Charts

Successful instructional developers have learned how to organize a variety of information and activities into a well-planned presentation. They are proactive project managers.

Developers must look ahead into the application they are creating and decide on the best delivery method, media, training aids, tools, and materials to enhance the learning process during the training session. You will find a helpful Training Media Decision Chart in Appendix A (page A-11).

Developers need to determine the importance of sound and motion to the subject. If they're relevant, then video and slide films should be considered. If participants would benefit from a close view of things, then handouts with illustrations or photographs should be considered. If having an enlarged view would be helpful, then posters or charts might be a wise choice. These are just some of the considerations that need to be made by instructional developers.

Turn to the Appendix A to review the sample Lesson Planning Form. This sample explains the type of information that is necessary. Next, review the example of a real Lesson Planning Form, and look at the information that it contains.

SKILL TEST

Review the list of prerequisite skills and enabling objectives for the assigned lesson. Discuss with a colleague the different delivery methods you can use based on: topic, objective, test, and target audience. Consider the information on your Lesson Planning Form and decide the best solutions and a job aid based on: time, cost, effectiveness, and space.

Discuss your job aid idea with the instructor.

✐✐✐✐✐

Additional Resources: ________________________________

Training Aids & Media	**Tools & Materials**

DS-5

Summarize a PBET Lesson

OBJECTIVE:

Having completed all of the prerequisite steps in the PBET Lesson Planning Form, summarize the lesson you are preparing. The summary will be reviewed and approved by the PBET course instructor.

The final step in designing a PBET lesson is to write a description of the strategy for organizing and delivering the lesson. This description can be an outline showing logical sequence of steps to follow in delivering the lesson. It can have enough narrative to explain what concepts need to be introduced, and to describe the type of skills the performers will need to learn and practice. It also explains the types of instructional aids, materials, supplies, equipment, etc., that will be required and how they will be used during the lesson.

In general, a written summary of the lesson helps structure the lesson, and serves as a guide for the development and delivery phase of the lesson.

Items to Include in the Lesson Summary

1. **A description of relevance**
   - **What benefit will the lesson provide?**
     - **» What's in it for the student?**
   - **How does this lesson support**
     - **» The overall training course?**
     - **» A specific training program?**
     - **» A trainee's understanding or skills?**
     - **» A specific task, job, career, etc.?**

The summary of a lesson's content should answer the basic question: "What's in it for me?" In other words, what benefit is the lesson to those who are in attendance?

The lesson summary should have at least one short paragraph describing the relevance of the lesson. In general, the lesson should support any or all of the following: the equipment being studied, the overall training program, a trainee's understanding or skills, and a specific job in the related industry. The lesson must have a "legitimate" reason for being included in a training program, or it could be a waste of valuable time and resources.

Here is an example of a statement of relevancy: "The operating procedures of the Astaire 1950 Stepper were introduced in the preceding lesson of this training program. This lesson covers maintenance requirements. Maintenance, specifically cleaning and lubrication, is very important to ensure the reliable operation of the mechanical parts of the stepper."

Items to Include in the Lesson Summary

2. Logistics

- **Special instructions and/or requirements:**
  - **Instructional aids, media, supplies, etc.**
- **Location, environment, conditions, etc.:**
  - **Room, temperature setting, lighting, special seating**
- **Purchases, reservations, rentals, etc.:**
  - **Equipment, supplies, materials, personnel**

The lesson summary should include any special instructions or requirements, to remind you and others who might need to use the lesson plan, about the logistics involved in the delivery of the lesson. If supplies, materials, equipment, and/or supporting personnel are needed, how will they be procured? Indicate whether arrangements need to be made to purchase, rent, borrow, or reserve any of the items mentioned.

Items to Include in the Lesson Summary

3. **Sequence of events**
   - **Transition into new lesson**
   - **Explain lesson objective *(tell them)***
     - » **Introduce concepts and skills**
   - **Model the desired performance *(show them)***
   - **Provide time for practicing *(let them try it)***
   - **Provide time for skill test *(let them show you)***

The key to success in lesson planning is organization. This part of the PBET lesson designing phase requires the instructional developer to think carefully about each of the important events that will occur in the lesson being designed. This is where a word processor may be helpful to accommodate any changes you might want to make along the way.

You should outline in short narrative form how you will proceed to deliver the lesson. The outline will show the logical sequence of the major parts in your lesson and the approximate time needed to accomplish each part. It will also tell what materials you will need at each step of the lesson and how they will be used.

In this part of the lesson summary, explain how you will follow through the four basic steps of the PBET training process, including; (1) explaining the objective, (2) modeling the performance, (3) relevant practice, and (4) the skill test.

SKILL TEST

- **Review the Lesson Planning Form you are developing for the lesson assigned to you by the course instructor.**
- **Review the key elements of a content description as covered by the instructor in the preceding slides.**
- **Discuss with a colleague the items you will need to include in your Lesson Summary**
- **Draft the Lesson Summary in outline form first before transferring it to the Lesson Planning Form, for example:**
    1. **Description of relevance -- explain why this lesson is important to the trainee**
    2. **Logistics -- list items to be used and how they will be used in the lesson**
    3. **Sequencing of events -- list step-by-step plan for sequencing the introduction, objective, explanation of subject matter, modeling, job aid orientation, practice, and testing.**
- **Ask the course instructor to review the outline. The instructor will use the same criteria as above.**
- **When the summary outline is approved by the course instructor, transfer the extended narrative form to the Lesson Planning Form.**
- **Have the instructor perform a final review of your Lesson Summary and sign-off your checklist.**

✐✐✐✐✐

Write a summary of your lesson plan in this section.

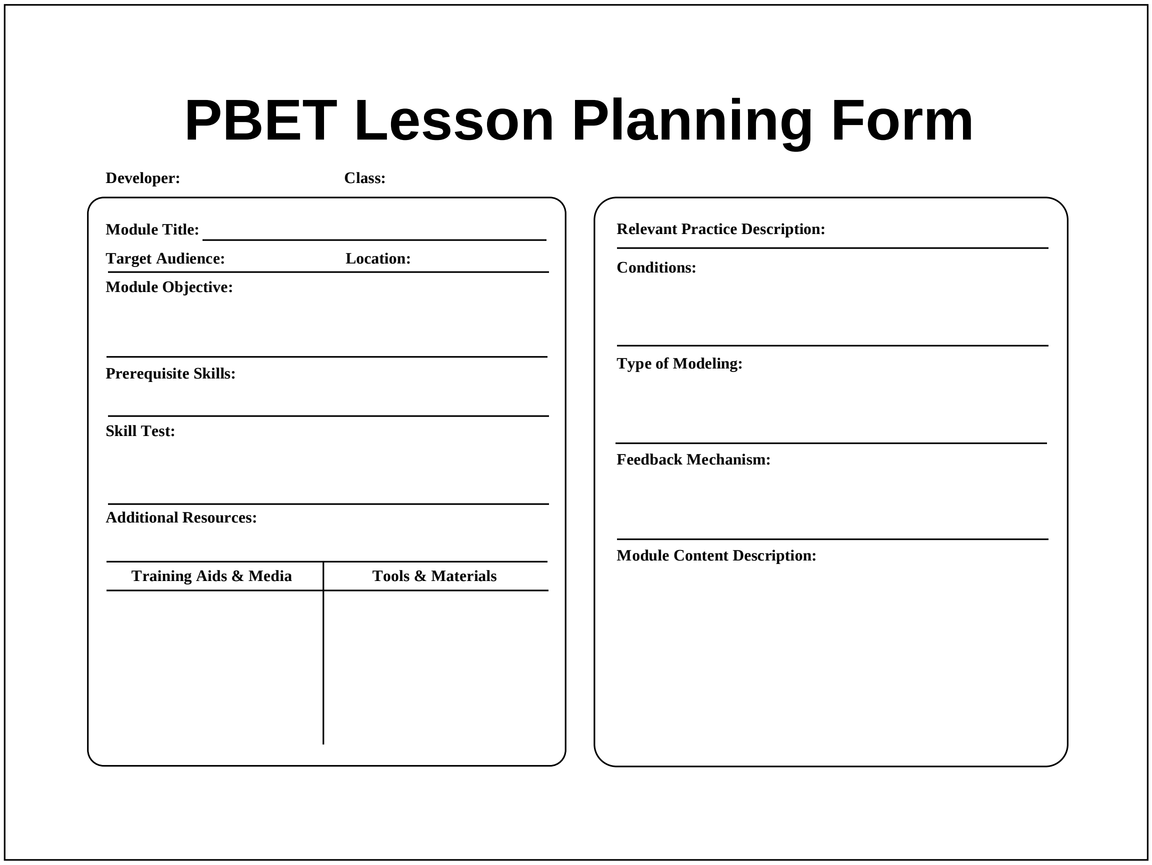
Module Content Description:

DS-6

COMPLETE A SECOND PBET LESSON PLAN

OBJECTIVE:

Given a PBET Lesson Planning Form, prepare at least one lesson plan in an area of your training responsibility. All sections of the form must be completed according to the standards delineated in the PBET Participant Guide.



Through some of the PBET modules, you have been completing a Lesson Planning Form. The Lesson Planning Form will act as your source document as you develop your PBET training. It summarizes in writing the decisions you've made, including:

- Class
- Module title
- Target audience
- Location
- Module objective
- Prerequisite skills
- Skill test
- Additional resources
- Training aids and media
- Tools and materials for practice
- Relevant practice description including:
  - Conditions
  - Type of modeling
  - Feedback mechanism
- Summary of module content

Lesson Planning Form Is Not an Instructor Guide

- **Don't confuse the Lesson Planning Form with the instructor guide.**
- **The Lesson Planning Form acts as an outline for the lessons/modules in PBET training courses.**

The Lesson Planning Form isn't intended to contain the detailed information of your entire training course. It's more of an outline for each of the lessons or modules that are part of your training course. Since the Lesson Planning Forms contain information for each module, they are the perfect documents to review *prior* to instructing the course.

The *instructor guide* is the document that contains all of the modules of your training course as well as the comprehensive details. We will take a closer look at the instructor guide in the Deliver phase of PBET.

The Lesson Planning Form Is Your Outline

- **It contains the instructional decisions you made about your PBET training.**
- **It will guide you as you create the training course.**

The Lesson Planning Form functions as an outline as you develop your instructor guide. It helps you develop each of the modules or lessons that are part of your entire training course.

Every lesson or module is designed and developed so it is a self-contained unit of instruction. While these lessons/modules can stand alone, they are intended to be part of the whole training course. They need to relate to the other lessons/modules in the course you develop.

The Structure of the Lesson

- **Each lesson or module will vary in length.**
- **Lessons or modules may stand alone as self-contained lessons, but they all need a framework or structure.**

Lessons/modules are expected to vary in length. They may also vary in training location, as some may need to be taught in classrooms, some in fabs, labs, etc.

Regardless of their length or content, every lesson/module needs a common structure or form. They need an introduction, a statement of relevance (to the job, a career, etc.), a main content, and a conclusion.

Skill Test

Prepare a second Lesson Plan for a simple lesson in an area of your own training expertise.

You may consult any part of this course manual for assistance, or you may ask any of the course instructors or participants for help.

Refer to the completed sample Lesson Planning Form in Appendix A and Module AN-2, which explains how to write objectives, as you complete your Lesson Planning Form.

Make final adjustments to your Lesson Planning Form, and when you feel you are ready, have your instructor or one of the workshop aides review it. They will review each form and check off each completed item.

When the entire Lesson Planning Form has been completed, both you and the instructor should sign the sheet to indicate mastery of this particular module's objectives.

Develop

DV-1

Develop Instructional Materials

OBJECTIVE:

Having completed a Lesson Planning Form, produce the training aids and media that you will need to support the PBET lesson you are preparing. The materials you create will be reviewed and approved by the PBET course instructor.

Up to now we have concentrated our discussions on the analysis and design of the elements that will become a part of the PBET lesson plan. You have completed the requirements of the lesson planning phase, but you have not yet developed the actual materials and aids that will be used in the execution of the pilot or delivery phase.

This module introduces very basic concepts of instructional materials development. This topic is beyond the scope of this course. There are many resources available from universities, community colleges, and consulting firms that can provide these training services.

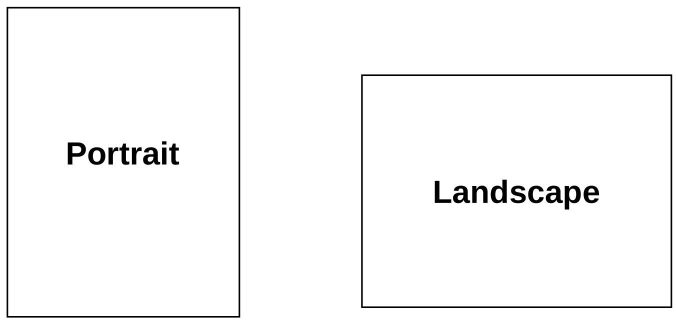
The focus of this module will be on developing the job aid and any other instructional aids you might need to help you pilot your first PBET lesson.

Prepare Training Aids & Materials

- **Checklists and instructions**
- **Flipchart**
- **Drawings**
- **Job aids**
- **Participant's guide**
- **Transparency foils**
- **Photographs**
- **35 mm Slides**
- **Videotape**
- **Other resources**

Design of Overhead Transparency Foils

Formats



Stick to one format or the other. Try not to mix them.

Design of Overhead Transparency Foils (28 pt.)

FONT TYPES, STYLES, SIZES (36 pt.)

24 pt. Helvetica, Normal, **Bold**, *italics*, underline

24 pt. Times Roman, Normal, **Bold**, *italics*, underline

20 pt. Helvetica, Normal, **Bold**, *italics*, underline

20 pt. Times Roman, Normal, **Bold**, *italics*, underline

18 pt. Helvetica, Normal, **Bold**, *italics*, underline

18 pt. Times Roman, Normal, **Bold**, *italics*, underline

14 pt. Helvetica, Normal, **Bold**, *italics*, underline

14 pt. Times Roman, Normal, **Bold**, *italics*, underline

NOTE: Text size on the foil on this page appears 60 percent of actual size.

Design of Overhead Transparency Foils

Use of Color for Text Only

- **Black on white background is easy to read.**
- **Blue on white is fairly easy to read.**
- **Burple on white is also easy to read.**
- **Brown on white is OK too.**
- **Green is not too difficult to read.**
- **But, red is getting difficult to read.**
- **Orange is not so good.**
- **Yellow is one of the worst.**
- **White or yellow on a black background is OK.**

Remember. The four B's are the best.

Design of Overhead Transparency Foils

General Guidelines for Using Foils

- **Try not to exceed more than 8 lines per foil.**
- **Stick to one theme in a foil.**
- **Use bullets rather than paragraph narrative.**
- **Try not to read from the foils.**
- **Use pointers or markers to emphasize a point.**
- **Know when to switch the overhead on and off.**
- **If it's important enough to put on a foil, then give people a chance to read it.**
- **Whenever possible, say it with pictures.**

Guidelines for Using the Flipchart and Marker Boards

- Great for notepad and brainstorming.
- Print large and legibly.
- It’s OK to mix two or three colors.
- Stick to the four B’s.
- Beware of different marker types.
- Use bullets and short sentences.
- Use graphical designs wherever possible.
- Be creative.
- Use soft stick masking tape.

Skill Test

- **Review the Lesson Planning Form you have prepared for the lesson assigned to you by the course instructor.**
- **Review the information covered by the instructor in this module.**
- **Discuss with a colleague the items you will need to include in your job aid and whatever training materials you will need.**
- **Draft the job aid and other materials.**
- **Ask the course instructor to review your draft.**
- **Have the instructor perform a final review and approval of your job aid, and if needed, other materials.**

Pilot

PL-1

DESCRIBE TRAINER CHARACTERISTICS

OBJECTIVE:

Given a scenario in a training activity, be able to select at least five favorable trainer characteristics that could be used in dealing with the situation.

Describe Trainer Characteristics

Think of someone in your past who was exceptional in his/her role as your teacher, coach, boss, or instructor.

Try to recall some of their personal and professional attributes that helped you to successfully complete a course or perform a task. List a few of those attributes here:

____

____

____

____

____

Share these thoughts with a colleague in the audience.

GROUP ACTIVITY: COMPILE TRAINER CHARACTERISTICS

Share your list of effective trainer attributes with the colleagues at your table and discuss each person's list of characteristics.

Compile all of the characteristics you have discussed into a master list and write the group's list on the flipchart. As you compile:

- **Combine similar or duplicate items.**
- **Star (☆) at least three items on your list that your group considers to be the "most important characteristics."**
- **Select a spokesperson to present your list to the class. Compare your ideas with those of the other groups.**

✎✎✎✎✎

The effective PBET trainer sets a positive tone of training by:

- Using positive reinforcement/feedback with trainees. This includes throughout relevant practice, not just waiting for the conclusion of the practice. By using encouragement and positive reinforcement, trainers can lead the trainees to the desired outcome.
- Applying constructive criticism to help participants understand what they need to do to improve their performance.
- Encouraging participation.
- Using words, facial expressions, and body language that signal acceptance rather than disdain or rejection.

Using Plenty of Rewards at Appropriate Times

Why? People tend to repeat things they find rewarding!

A Safe Environment; Not an Anxious ☞ Private, not public, practice. ☞ Relevant, not unpredictable, tests.	A Stimulating Course; Not a Boring One ☞ Variety in voice, pacing, activities. ☞ Student control over length of sessions.
An Ego-Boosting Experience; Not a Humiliating One ☞ "Good accomplishment!" ☞ "Let me write down your suggestion for others."	A Satisfying Time; Not a Frustrating One ☞ Objectives clear at all times. ☞ Time for individual practice is provided for all to succeed.

Also, the effective PBET trainer sets a positive tone of training by:

Avoiding Adverse Reactions

Why? People learn to avoid things they're hit with!

Fear and Anxiety ☞ "You won't understand this, but..." ☞ "Half of you won't be here a month from now." ☞ "I know you're new, but come on up here and show the rest of the class how to rebuild this assembly." ☞ "The test will be a surprise." *Other causes of fear . . .?*	Frustration ☞ Too much information too fast. ☞ Instructor can't be heard. ☞ Print materials unreadable. ☞ Tests not based on objectives. ☞ All students forced to work at the same pace. ☞ Refusing to answer questions. *Other causes of frustration . . .?*
Humiliation ☞ "You've got a long way to go if you're going to run this machine like Jane!" ☞ "Look at this!! I've never seen *that* mistake before!!" *Other causes of humiliation . . .?*	Boredom ☞ Monotonous, repetitious instructor voice. ☞ Student must sit through material he or she already knows. ☞ Room too warm. *Other causes of boredom . . .?*

NOTES:

PRACTICE EXERCISE

Your small group will be assigned one of the following training scenarios. Select one or more of the effective trainer characteristics listed on the flipcharts that could be used to address each particular situation. If none of the characteristics can effectively address the situation, brainstorm some additional skills that would be helpful for a trainer to use. When responding to these exercises, remember that as trainers it is our inherent responsibility to help motivate our learners and to not embarrass them or reduce their self-esteem.

Record your solutions on the flipchart, and be prepared to share these with the class.

1. **There are six participants in a three-day equipment operations class, and all of them have satisfied the necessary prerequisites for the course. One of the participants had to leave class three hours early on the first day, and as a result has fallen behind on the second day of class.**
   Which characteristics of a trainer can be applied to this case? Describe how each skill would best be used. What should the trainer do to improve the participant's opportunities for success?

2. **In a vacuum pump rebuilding class, the instructor always leads the class through an explanation and demonstration of the steps required in the proper assembly and disassembly of a vacuum pump. Each participant is given a copy of the step-by-step procedure to follow along with the instructor. When the demonstration is completed, participants are allowed time to practice the same procedure on their own assigned vacuum pump. During the practice sessions, one of the maintenance technicians wants to know how much vacuum grease to apply onto an O-ring.**
   Which characteristics of a trainer can be applied to this case? Describe how each skill would best be used. What could the instructor do or say that would help the performer remember this part of the task next time?

(continued on next page)

PRACTICE EXERCISE (Continued)

3. **In a particular equipment maintenance training course, participants are required to perform specific functional checks on the machine to determine the tool's readiness for production use. The participants by this time will have already completed a component identification lesson, which would have covered the location of all controls and indicators as well as all major subsystems. One of the maintenance technicians forgot where the water cooling flow indicator is located on the machine.**
   Which characteristics of a trainer can be applied to this case? Describe how each skill would best be used. What could the instructor do or say that would help the performer recall the location of this part?

4. **The instructor of a specific process-related course stated at the beginning of class that the course is intended to be an introductory course for manufacturing technicians having less than 12 months of industry experience. After all participants have introduced themselves, you find out that six of the participants have an average of ten years experience in the subject, and the remaining seven students in the class match the target audience description for the course.**
   How should the trainer handle this situation? Which characteristics of a trainer can be applied to this case? Describe how each skill would best be used.

5. **In a software training class for a specific inspection system, students are required to work together in groups of three. One student in one of the groups appears to be dominating the others in his team and doesn't allow the others time to use the workstation assigned to their group.**
   How should the trainer handle this situation? Which characteristics of a trainer can be applied to this case? Describe how each skill would best be used.

✐ ✐ ✐ ✐ ✐

(continued on next page)

PRACTICE EXERCISE (Continued)

6. **During a process equipment operations class, performers are asked to stop the tool in the middle of the process to simulate an emergency intervention procedure. At some point in the procedure, the performers are required to remove a wafer from the tool with the aid of a vacuum wand. Near the end of the practice exercise, one person in the class accidentally drops the wafer. The wafer breaks and there are pieces of silicon scattered inside the wafer feeding assembly.**

   How should the trainer handle this situation? Which characteristics of a trainer can be applied to this case? Describe how each skill would best be used.

7. **There are six participants in a three-day equipment operations class, and all of them have satisfied the necessary prerequisites for the course. One of the participants had to leave class three hours early on the first day, and as a result will probably fall behind on the second day of class. One of the participant's colleagues volunteered to assist him through lunch and breaks to bring the person up to the level of the others.**

Which characteristics of a trainer can be applied to this case? Describe how each skill would best be used. What should the trainer do?

SKILL TEST

Each participant will repeat the procedure from the practice exercise using one of the scenarios that was not previously used.

When finished, compare your work with others at your table.

✎✎✎✎✎

PL-2

PILOT A SHORT PBET LESSON

OBJECTIVE:

Try out/pilot a short PBET lesson as either a performer or trainer and identify the pilot results.

Performance-Based Equipment Training Requires a Pilot

- **All PBET training courses need a tryout or pilot before the courses are delivered.**
- **The pilot is the first opportunity to try out the efforts from the earlier PBET phases.**

As part of the Pilot phase of PBET, you *try out* the training materials that have been developed. This is the developer's/trainer's opportunity to see how well the materials work in a training situation.

Piloting the materials is an effective way to determine which areas need some improvement, work particularly well, or can even be eliminated.

Piloting PBET Courses

Allows developers to detect areas that:

- **Need some improvement or reorganization**
- **Are successful and work well**
- **Can be eliminated**

During the pilot, developers and trainers need to determine how effective their course design is. They need to pay attention to:

- Content
- Sequence
- Clarity
- Comprehension
- Accuracy
- Relevance
- Training medium
- Practice exercises
- Participation and activity levels
- Time and length

This type of information is best collected during the pilot through observations by subject matter experts and from the course evaluations.

PRACTICE EXERCISE

Pilot the PBET assembly training lesson. As training developers you have:

- **Completed the task analysis**
- **Prepared the objectives**
- **Developed the skills hierarchy**

NOTE: Don't forget to apply the simple 4-step training process:

1. **Tell them what they are going to do -- explain the performance objective**
2. **Show them what/how to do it -- model the intended performance**
3. **Let them do it -- give them practice with feedback**
4. **Let them show you how to do it -- administer the skill test**

It's also during the Pilot phase of PBET that developers have the opportunity to fine-tune the course before the course is delivered.

This practice exercise will provide the opportunity for you to pilot your PBET assembly training lesson.

SKILL TEST

Based on the PBET lesson, identify the areas of the training that work well and the areas that need to be improved.

✐✐✐✐✐

Deliver

DL-1

DESCRIBE PBET TRAINER RESPONSIBILITIES

OBJECTIVE:

List at least five responsibilities of an effective trainer.

In this module, you will brainstorm a list of five responsibilities of an effective trainer. You'll be asked to share this list with other participants in this class.

Everyone's opinions will be combined to create a comprehensive listing of an effective trainer's responsibilities.

GROUP ACTIVITY

Describe Trainer Responsibilities

1. **Each participant will list five responsibilities of an effective trainer; for example:**
   - **Provides quality instruction at all times**
   - **Stays up to date in the latest technology**
   - **Updates the employee's training records**
2. **Share your list with others in your group.**
3. **Compile the group's list on an easel pad.**
4. **Select a spokesperson from each group.**

Procedure:

1. Make a list of at least five responsibilities that you would expect of an effective trainer in your company.

   ____

   ____

   ____

   ____

2. Share your list with other course participants at your table. Feel free to discuss these responsibilities with each other.

3. If an easel pad is available at your table, compile a group list from the participants at your table and write your group's list on the pad.

4. Select a spokesperson for your group, and when the class facilitator calls on your table, your spokesperson will read aloud the list compiled by your group.

SKILL TEST

List five responsibilities of an effective trainer:

NOTES:

DL-2

PREPARE A TRAINING CURRICULUM CHECKLIST

OBJECTIVE:

Having available a skills hierarchy of performance objectives, skill tests, supporting instructional materials, and a detailed task analysis, assemble a training checklist for training others in an area of your own expertise.

SEMATECH Manufacturing Technician Training and Certification Process

PURPOSE:

The purpose of the Manufacturing Technician (MT) Training and Certification program is to document the demonstration of the skills required for safe operating, process monitoring and/or maintaining process equipment according to SEMATECH specification.

SEMATECH Manufacturing Technician (MT) Training and Certification Process is a good example of a certification system. It is the system that is currently used in the training and certifying of manufacturing technicians at SEMATECH.

These techniques can be applied to similar situations, for example:

- Equipment assembly personnel
- Final test personnel
- Field service engineers (FSE)
- Process engineers
- Certification of customers by supplier

What Are Some Other Side Benefits of the MT Certification Program?

- **Provides a "learning by design" attitude rather than by "trial and error."**
- **Forces us to organize and manage the training of all MTs.**
- **Develops a cooperative team environment.**
- **Establishes a baseline for MT skills across all shifts.**
- **Could be tied to advancement requirements within Manufacturing Methods.**

The process for training and certifying manufacturing technicians can be found in the Technician Certification handouts in Appendix C of this notebook. There are four essential documents:

1. SEMATECH MT Certification Process
2. Guidelines for Writing Certification Tests
3. Guidelines for Developing Training and Certification Checklists
4. Manufacturing Technician Training Checklist (example)

How It Works

1. **Communications and Ownership**
   - **Training Request Form Is Issued**
     - » **Shift Manager**
     - » **Document Control**
     - » **Peer Trainer**
       - **Training specialist**
       - **An experienced MT**
       - **Process engineer or technician**
       - **Equipment engineer or technician**
       - **Field service engineer**
     - » **Process Engineer or Technician**
     - » **Equipment Engineer or Technician**
     - » **MT Trainee**
2. **Prepare an Individualized Roadmap**

Read the purpose statement from the SEMATECH MT Training and Certification Process. Brainstorm some other benefits of certifying the technicians and engineers that work on equipment.

Major Steps

Step 1 Kickoff Meeting
- Manager, MT trainee, and peer trainer
- Importance of training, schedule, expectations

Step 2 Roadmap Explanation
- What will be done, how long, how evaluation will be conducted

Step 3 4-Step Training Process
- Trainer tells trainee what the trainee will do
- Trainer explains, shows and answers questions
- Trainee practices and trainer provides coaching
- Trainee explains, shows and answers questions

Step 4 Record Keeping
- Both agree mastery of a skill has occurred
- Both sign and date the training checklist

The foil above shows some of the major steps that are included in the SEMATECH Manufacturing Technician and Certification Process document.

Step 5 Certification Test

- Must achieve competency on performance test (hands-on)
- Written test must be completed
- Both must be done error-free
- Successful completion is determined by assigned engineer or technician
- Remedial action -- engineer or technician will notify the manager and the trainer with further recommendations

Step 6 Recognition

- Sign the certificate and present to MT

Step 7 Recertification

- Significant spec violation
- Significant spec change
- Periodic abbreviated recertification

Steps 5, 6, and 7 in the foil above are also part of the major steps in the SEMATECH Manufacturing Technician and Certification Process document.

Guidelines for Developing Training and Certification Checklists

- **Required Materials**
  - Training Request Form
  - Course Prerequisites
  - Task Analysis
  - List of Training Objectives
  - Relevant Documentation
  - Training Checklist
  - Estimated Time for Completion
  - Certification Test
    - Performance Test
    - Written Test
  - Certification Form

The Guidelines for Developing Training Checklists describe what trainers must do to develop certification training materials. The SEMATECH Guidelines for Developing Training Checklists document, in Appendix C of your notebook, shows the minimum requirements.

Three Parts of a Manufacturing Technician Training Checklist

I. Core Courses

II. Non-Tool Training

III. Tool-Related Skills

The foil above shows the three main categories of the SEMATECH Manufacturing Technician Training Checklist. This checklist is also in Appendix C.

I. CORE COURSES

	DESCRIPTION	TIME
1.	Week One Orientation – PC Windows – E-Mail – HAZCOM – Site Safety – Chemical Safety – Cleanroom Entry Cert.	28
2.	WorkStream Training	14
3.	Semiconductor Process Overview	8
4.	Electrical Safety	6
5.	Lockout/Tagout	1
6.	RS1/Quickstart	7
7.	Intro to Statistical Methods	7.5
8.	Passive Data Collection	7.5

The foil above presents information for some of the core courses from the checklist. Refer to the example of the SEMATECH Manufacturing Technician Training Checklist to see how the information for the checklist is recorded.

II. NON-TOOL TRAINING

1. **Tour of Bay**
2. **Safety Items**
3. **Key Contacts**
4. **Housekeeping**
5. **Wafer Handling**
6. **Equipment Owners**
7. **Timesheets**
8. **Special Codes**
9. **Hazardous Waste**

The foil above is a brief overview of items in the second category of the checklist. Please refer to the example of the SEMATECH Manufacturing Technician Training Checklist to see the complete list of Non-Tool Training.

III. TOOL-RELATED SKILLS

1. Process Overview
2. Equipment Overview
3. Locate and Describe Related Hazards
4. Describe Safety Procedures
5. Locate and Describe Controls and Indicators
6. Define Operating Codes or Software Commands
7. Read and Interpret Specifications
8. Process Wafers According to Specifications
9. Apply Principles of SPC to the Tool
10. Preventive Maintenance
11. Qualifications
12. Troubleshooting (optional)
13. Engineering Audit

The foil above shows an overview of the Tool-Related Skills from the third category. Please refer to the SEMATECH Manufacturing Technician Training Checklist for the complete list of tool-related skills.

SKILL TEST

Using a sample job training checklist and a job/task analysis for a specific job in your work area, develop a training checklist.

✐✐✐✐✐

Refer to the example of the SEMATECH Manufacturing Technician Training Checklist as you complete the skill test above. Please ask for assistance if you have any questions.

DL-3

CREATE AN ACTION PLAN FOR PBET IMPLEMENTATION

OBJECTIVE:

At the end of this module, complete an action plan for implementing PBET at your company.

The reasons why companies are willing to implement PBET:

Many companies are eager to implement Performance-Based Equipment Training. In the space above, list the reasons companies are willing to implement PBET. Use the reasons from the flipchart.

Possible solutions or actions for implementing PBET:

Record solutions or actions that may help you overcome PBET objections or obstacles at your company.

PBET IMPLEMENTATION ACTION PLAN

The Action	Who Is Responsible	When It Will Be Completed

Evaluate

EV-1

EVALUATION OF TRAINING

OBJECTIVE:

Given evaluation characteristics, identify all four levels of evaluation correctly.

The Evaluation phase is the seventh and last phase in performance-based training.

The Evaluation Phase of PBET

- **Determines the effectiveness and relevance of the equipment training program**
- **Obtains feedback from customers relating to the appropriateness and effectiveness of the training program**

Evaluation systems are used to determine the relevance and effectiveness of performance-based equipment training programs.

In general, trainers, training managers, instructional developers, students, managers, and administrators need to know the outcomes of a training program to determine the value that it provides and to continuously improve the program.

Donald Kirkpatrick's
Four Levels of Evaluation

Level 1 -- Measures participant's first reactions

Level 2 -- Measures participant's learning

Level 3 -- Measures application of learning at the workplace

Level 4 -- Measures return on investments

We base our PBET evaluation system on Donald Kirkpatrick's four levels of evaluation. (Kirkpatrick is a well-respected former professor and training consultant.)

Level 1 --
Measures Participant's First Reactions

Information is captured in questionnaires:

- **Sometimes referred to as course satisfaction sheets**
- **They gage participant's first reactions to training**

Level 1 is when the participant's first reactions to training are captured. It is usually administered immediately after the completion of a training program. Items such as questionnaires/evaluation sheets ask for feedback on course material and information, the instructor, the setting, etc. This form of Level 1 evaluation is often referred to as "smile sheets" or course satisfaction sheets because they gauge participant reaction.

Refer to the SEMATECH example in Appendix E, page E-1, of your manual. This is a Level 1 evaluation tool. It is a scannable form that can be easily scored; responses can be tabulated by spreadsheet software for ease of reporting course results.

Level 2 -- Measures Participant's Learning

Tests participant's skills and knowledge against the course:

- **Can take the form of simulation, demonstration, or written or hands-on test**
- **Skill tests used in PBET**
- **Sometimes called a test, skill check, evaluation, pretest, posttest, etc.**

Level 2 is an evaluation technique that measures learning. It can be a written test, a demonstration, or a simulation that tests a participant's skills or knowledge against the course objectives.

Level 2 evaluations can be administered for each lesson of a course as well as include a pretest and posttest. How was Level 2 conducted in this course?

Level 3 -- Measures Application of Learning at the Workplace

Conducted a few months after training at workplace:

- **By interviews, observations, or assessments from participants and supervisors**
- **Determine if participants are using their new skills**

A *Level 3* evaluation is conducted at the participants’ work location to determine if the participants are actually using their new skills. Three to four months after the training, a Level 3 evaluation is accomplished either by observation or through interviews/ assessments from the participant, the supervisors, and perhaps the customers.

Level 4 --
Measures Return on Investments

Measures the value of the training activity within the company

What is the impact to the company in terms of:

- **Time saved?**
- **Improved productivity?**
- **Improved efficiency?**
- **$$ saved?**

A *Level 4* evaluation is the most difficult to obtain because it searches for training impact and value. It looks for the cost benefits in terms of business results -- the return on the training investment. In PBET, it requires tracking the cost benefits of having a trained workforce and relating these benefits to improved equipment utilization and improved manufacturing efficiency.

Please refer to the Semitherm Level 4 evaluation in your Participant guide:

- Codes (A-T) are used to represent performance objectives (skills) from the course
- The codes are matched with work done on equipment that requires a specific skill
- The FSE report has a place where the code can be written in
- The FSE report indicates time to repair (TTR)
- TTR is tracked over time to see if training helped reduce it

Skill Test

Level ___

- **Conducted at workplace a few months after training**
- **Determines if participants are using new skills**

Level ___

- **Gages participant’s reactions to training**
- **Questionnaires sometimes referred to as course satisfaction sheets**

Level ___

- **Written test, demonstration, or simulation that measures participant’s skills against course objectives**

Level ___

- **Looks for return in investment of training within the company**

Read the evaluation characteristics in the skill test above and identify the correct evaluation level by writing the appropriate number in the blank.

The skill test should match the requirements of the objective as stated earlier in the module.

Again, if you do not achieve mastery of the intended skill, then you may ask for more practice or assistance, or retake the test until mastery is achieved.

APPENDIX A

PBET Lesson Planning Form Definitions

Instructor's Guide **Class:** Guidelines for Effective Equipment Training

Module Title: Effective Lesson Planning Using Principles of Performance-Based Equipment Training

Target Audience: Who is the targeted audience? **Location:** SEMATECH Tech. Trng. Workshop

Module Objective:
The *performance objective* or *instructional objective* is a clearly written statement that is understood by all performers. The objective is performance based, specific and measurable, and relevant to the requirements of the course or task to be performed. A well-written objective statement contains three important requirements.

1. *Performance* is the action that results from executing the task that's described in the objective.
2. *Condition* describes the environment, location, and/or situation where the performance is to take place, and it tells what materials, supplies, tools, equipment and resources may be used while performing the task.
3. The *standard* gives the acceptable level of performance. It may be stated in terms of how accurate the performance must be, how many times it must be performed, and how much time is allowed.

Prerequisite Skills: The skills that are necessary before the performers may participate in the training.

Skill Test:
Any instructional system that utilizes *well-stated objectives* as a means of informing performers how they are expected to perform at the end of a course or a unit of instruction should have an accompanying *well-matched skill test*. The skill test measures the outcomes of the performance. The test must match the objective in terms of performance, condition, and standard.

Additional Resources:
Given the requirements of the performance objective and the skill test, the instructional designer sets out to evaluate and diagnose the relevance and appropriateness of the material for the targeted audience. The designer determines if the material provides an adequate coverage of the subject matter. For example: Are there adequate examples? Are the skills and concepts adequately covered? Are there assumptions made that a learner might not understand? Is the language or reading level appropriate? Is it too technical--not technical enough? If a performer tried the material what would he or she think? Having examined the material, the designer determines what supplementary material is needed.

Training Aids & Media	Tools & Materials for Practice
Determine additional aids that will be required; for example, written procedures, flipchart, foils, photographs, models, etc. If possible, describe title of each aid and place them in numerical order as they are to be presented. Note: SMEs and other qualified performers may be used as models or subject information.	List equipment, tools, and supplies that are required as part of the practice and final performance.

Relevant Practice Description:
In this space, describe what the performers will be doing when they are practicing the intended *performance* that is stated in an objective.

The more we repeat an activity, the more chances we have of improving the outcomes of subsequent performances. However, the practice must be relevant to the stated objective.

A good relevant practice description contains four important ingredients.

1. *Performance*
2. *Conditions*
3. *Modeling*
4. *Feedback*

Conditions:
Describe how and with what the relevant practice is to be performed. In some cases, a similar activity may be substituted for the real relevant practice.

Type of Modeling:
Provide a way in which the performance can be demonstrated to a performer. The instructor or some other competent performer can model the performance. Various forms of media may also be used to model the performance; for example, pictorials, diagrams, sample practice sheets, videotape, and photographs.

Feedback Mechanism:
Wherever possible, provide indicators, signs, or cues that performers may use to measure their own performance. And if that isn't possible, provide a means for informing the performers how well they are progressing. The instructor can provide feedback, but other methods can also work as effectively; for example, video recording and still photography. Use also checklists, job aids, a list of correct responses, etc.

Summary of Module Content:
Describe the contents of the module so that other instructors can understand it enough to be able to teach it and manage it. In the summary include the following suggestions:

1. A description of relevance -- what benefit will the module provide the participant?
2. Which teaching aids will be used at what time with which concepts?
3. Which skills are to be introduced, modeled, practiced, and tested?
4. The order in which specific concepts and skills are to be introduced.
5. The conditions in which the module is to be performed.

PBET Lesson Planning Form Sample

Astaire Model 1950 Stepper

Instructor's Guide **Class:** Stepper Operator Training

Module Title: Module 4: Perform Daily Checks

Target Audiences: Litho operators with >6 mos. Exp **Location:** Classroom/lab/fab

Objective:
Given an Astaire Stepper and a 14-step checksheet for "daily checks," the performer will perform each daily check accurately and relate any errors or nonstandard conditions to the instructor. The performer must also interpret the nonconforming conditions correctly for the instructor.

Prerequisite Skills: Completion of Modules 1-3

Skill Test:
Given an Astaire Stepper and a checksheet listing all elements to be inspected on a daily basis, the performer will go directly to the designated inspection site, evaluate the conditions that are to be checked, note the conditions on the checksheet, interpret the situation for the instructor, and suggest a correct course of action if necessary. Place a ✓ in the Comment section if an item meets the standard, or a **?** if an item does not meet the requirement. You have 15 minutes to perform this task.

Additional Resources:
Optional: Operator Manual, Chapter 4, pages 1-12.

Teaching Aids & Media	Tools & Materials for Practice
FOILS 1. Daily Checks Locator Map 2. Electronics Cabinet – 1, 2 3. Electronics Cabinet – 3, 4 4. Control Console – 5, 6, 7 5. Stepper Unit– 8, 9 6. Wafer Feed Sys. – 10, 11 7. Merc. Lamp and Laser – 12, 13 8. Pneumatic Gauges – 14 9. Daily Checklist	14-step daily checklist Classroom Overhead projector Astaire Stepper

Relevant Practice Description:

The first assignment requires the performer and a peer to go into the lab/fab, and using the provided checklist, locate and determine the status of all elements listed on the Daily Checklist. The peer will evaluate the responses by using a sheet that has listed, not only the elements, but also the conditions that should be present prior to starting the workday.

Conditions:

The initial orientation will be presented in a classroom setting with an overhead projector, screen, and tables or desks on which to take notes. The relevant practice exercise and the skill test must be conducted at the Astaire Stepper.

Type of Modeling:

The instructor will use the overhead projector to locate the required daily check sites on the locator maps. Since several of the elements have already been located in Modules 3 and 5, the emphasis should be on conditions rather than locations.

Feedback Mechanism:

The instructor will relate the readings, conditions, and indicators to exactly what the performer will see when conducting the inspection. The instructor should also relate the conditions to the process so the performer will understand the importance of conformance to the required specifications.

Summary of Module Content:

The module will require the performer to determine that the Astaire Stepper is in proper operating condition for the day’s production. The locations of the check sites will be noted during the lecture portion of the module and the performer will be given reproductions of the overhead projection graphics. During the practice portion of the module, the performer will identify acceptable conditions from several examples. The performer will also use the Astaire Stepper and a peer-evaluated checksheet to locate and describe the elements relevant to "daily checks." The skill test will consist of the performer identifying, recording, interpreting, and suggesting corrective action if necessary.

PBET Lesson Planning Form

Developer:	**Class:**
Module Title:	
Target Audience:	**Location:**
Module Objective:	
Prerequisite Skills:	
Skill Test:	
Additional Resources:	
Training Aids & Media	**Tools & Materials for Practice**

Relevant Practice Description
• **Conditions:**
• **Type of Modeling:**
• **Feedback Mechanism:**
Module Content Description:

PBET Lesson Planning Form

<table>
<tr><td>Developer:</td><td>Class:</td></tr>
<tr><td colspan="2">Module Title:</td></tr>
<tr><td>Target Audience:</td><td>Location:</td></tr>
<tr><td colspan="2">Module Objective:</td></tr>
<tr><td colspan="2">Prerequisite Skills:</td></tr>
<tr><td colspan="2">Skill Test:</td></tr>
<tr><td colspan="2">Additional Resources:</td></tr>
<tr><td>Training Aids & Media</td><td>Tools & Materials for Practice</td></tr>
<tr><td></td><td></td></tr>
</table>

Relevant Practice Description
• **Conditions:**
• **Type of Modeling:**
• **Feedback Mechanism:**
Module Content Description:

PERFORMANCE-BASED EQUIPMENT TRAINING

TASK ANALYSIS WORKSHEET

ANALYST: ______________________________ DATE: ____________________

SUBJECT MATTER EXPERT: ____

LOCATION: ____

JOB OR COURSE TITLE: ____

TASK: ____

TASK DESCRIPTION: ____

____

____

____

IMPORTANCE STATEMENT: ____

____

____

____

PREREQUISITES: ____

____

____

____

TOOLS & MATERIALS: ____

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____

____

HAZARDS & SAFETY: ____

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____

HIDDEN KNOWLEDGE: ____

____

____

____

CRITICAL CONCEPTS: ____

____

____

____

OTHER RELATED PROCEDURES: ______________________________________

____

____

____

COURSE DESIGN CONSIDERATIONS: __________________________________

____

____

____

TRAINING MEDIA DECISION CHART (DS4)

Media	Advantages	Disadvantages	When To Use
Print	• Self-paced • Easy review/reference • Easy revision • Economical	• Can□t demonstrate motion • Requires audience that likes to read	• Provides factual information • Describes workflow, functions • As an adjunct
Audiographic	• Good for poor reading audience • Easy access of equipment • Self-paced • Economical	• Can□t demonstrate motion • Not suitable for revision	• Recognition/discrimination of audio stimuli • Self-study training
Instructor-Led Workshops	• Dynamic presentation - interaction • Can incorporate all media • Provides coaching and feedback • Flexible	• May involve travel costs • Inconsistent presentation • Scheduling	• When audience is at one site • When teaching interpersonal skills
Videotape	• Addresses visual, audio, color, motion needs • Evokes emotion • Consistent presentation • Good for poor reading audience	• Considerable development time and budget • Needs hardware • Not suitable for revision	• Demonstrating proper performance of complex tasks/role modeling • Promotion • Subjects that have long shelf life • Self-study or instructor-led
Interactive Videodisk	• Addresses visual audio, motion • Highly interactive • Self-paced • Consistent presentation • Eliminates/reduces need for instructor • Easily administered/managed	• Considerable development time and cost • Needs hardware • Not suitable for revision	• Demonstrating proper performance tasks/role modeling • Subjects that have a long shelf life - core curriculum
Multimedia	• Self-paced • Consistent presentation • Interactive • Easily administered/managed • Full audio • Full high quality video	• Considerable development time and cost • Needs hardware • Revisions are costly	• Teaching computer-related knowledge/skills • Audience that uses computers regularly • Subjects that have a long shelf life

OBSERVATION SHEET FOR PBET

Assembly Training Pilot

(PL2)

Observe the performer and your group's pilot assembly training. As you observe, think about what improvements might be necessary, based on the pilot experience, and record them on this sheet.

1. Was the training activity important to you and/or your job? _____ If it could have been improved, tell us how. ____

____

____

2. Was the practice relevant? _____ If it could have been improved, tell us how. _____

____

____

____

3. Was the modeling adequate? _____ If it was not, tell us how it could have been improved.____

____

____

____

4. Was the feedback mechanism appropriate? _____ If it could have been improved, tell how.____

____

____

____

5. Were the training materials effective and appropriate? _____ How could the training materials be improved? ____

____

____

____

Class Performance Record

PBET Modules

Names	IN-1	IN-2	IN-3	ID-1	AN-1	AN-2	AN-3	DS-1	DS-2	DS-3	DS-4	DS-5	DS-6	DV-1	PL-1	PL-2	DL-1	DL-2	DL-3	EV-1
1.																				
2.																				
3.																				
4.																				
5.																				
6.																				
7.																				
8.																				
9.																				
10.																				
11.																				
12.																				

Performance-Based Equipment Training

Individual Performance Checklist

Name: ________________________________ **Company:** ____________________

Objectives		Date	Participant	Instructor
IN-1.	Course Orientation	________	________	________
IN-2.	Identify PBET Characteristics	________	________	________
IN-3.	List PBET Design Phases	________	________	________
ID-1.	Perform Needs Analysis	________	________	________
AN-1.	Perform Task Analysis	________	________	________
AN-2.	Write Performance Objectives	________	________	________
AN-3.	Develop a Skills Hierarchy	________	________	________
DS-1.	Develop Skills Tests	________	________	________
DS-2.	Describe Relevant Practice	________	________	________
DS-3.	Analyze Resource Materials	________	________	________
DS-4.	Select Delivery Method	________	________	________
DS-5.	Summarize a PBET Lesson	________	________	________
DS-6.	Complete a Second PBET Lesson Plan	________	________	________
DV-1.	Develop Instructional Materials	________	________	________
PL-1.	Describe Trainer Characteristics	________	________	________
PL-2.	Pilot a PBET Lesson Plan	________	________	________
DL-1.	Describe Trainer Responsibilities	________	________	________
DL-2.	Prepare a Training Curriculum Checklist	________	________	________
DL-3.	Create Action Plan for PBET Implementation	________	________	________
EV-1.	Describe Evaluation Levels	________	________	________

Participant: ________________________ ***Instructor:*** ________________________

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APPENDIX B

Examples of Supporting Instructional and Resource Materials

Target Audience: *Anyone who needs to learn how to use DOS.*

Starting DOS (page 4)

The Enter Key

The Enter key is labeled with a bent left arrow (¿) like the return key on a typewriter, it is used to mark the end of a line. In general, DOS doesn't know what you have typed until you press Enter, so remember: You end a command by pressing Enter.

The Backspace Key

The Backspace key is labeled with a long left arrow (←). It erases the last character you typed; use it to correct typing errors.

STARTING THE SYSTEM

If you're not using a fixed disk, open the latch of drive A (the left-hand drive) and put in the DOS system diskette. The diskette goes in with the label up and away from the machine, as shown in Figure 2-2. When the diskette is all the way in, close the latch.

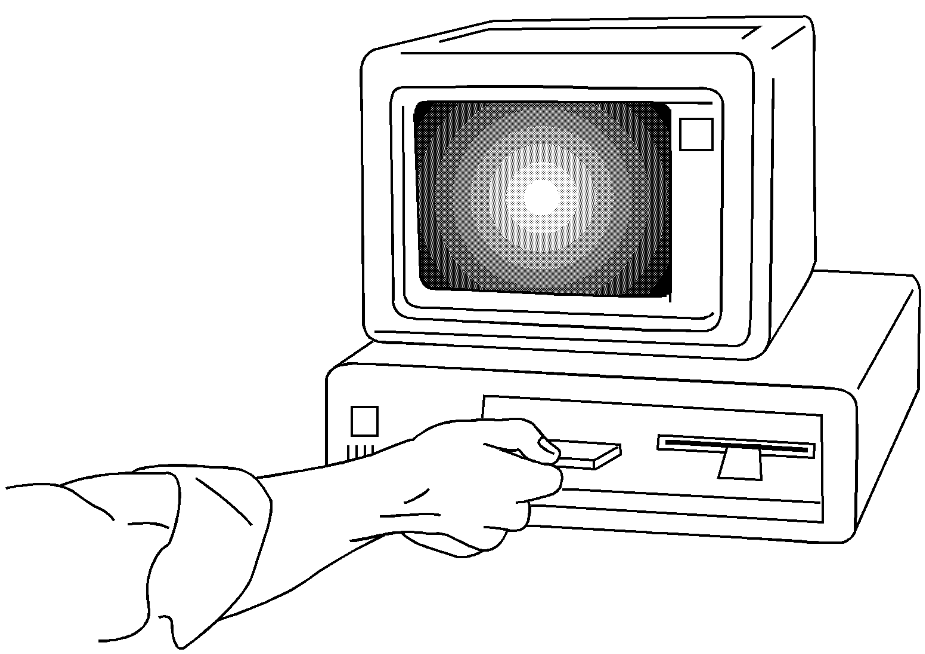

Figure 2-2. Inserting the DOS System Diskette

Target Audience: *Anyone who needs to learn how to use a wordprocessor.*

Word Processing (page 3)

If you're unlucky, the cursor on your word processor may drive you nuts by rapidly flashing on and off.)

As you type, the cursor moves along. Each new letter appears on the space where the cursor was, and the cursor then moves to the next space to the right. (The cursor also indicates the place where text is going to be deleted or changed.)

Memory and Storage

When text appears on a word processor's screen, it's simultaneously stored in the computer's *memory* (actually, it's stored in the memory first, and then displayed on the screen, but both happen virtually simultaneously). The portion of memory you write your text in is called RAM (for "random access memory"), read/write memory or R/W memory.

Since a computer's memory goes blank when you turn the computer off, you must store what you want to keep on floppy disks (also called diskettes or floppies).

Floppies are one of several kinds of storage media. *Storage*–implying a certain amount of permanence–is distinguished from *memory*–which, in computers (unlike elephants), is ephemeral.

Floppies are the word processor's equivalent of filing cabinet drawers. Each will hold several dozen files. A file is any piece of text that you give a name. It can be thousands of words long, or just one word long. You can split long files in two, and combine short files into one. You decide what makes up a file, by giving a chunk of text a distinct name.

A floppy looks sort of like a 45-rpm record in its jacket and is made of essentially the same stuff as recording tape. Floppies are enclosed in square jackets, which are about 1/16" thick and usually measure 8", 5 1/4" or 3 1/2" on each side (these are the common sizes).

Information is **written** onto floppies, and **read** off of them, by devices called **disk drives**. This is done by a **read/write head**, which is mounted at the end of a short arm that moves back and forth over the disks while they spin around at high speed.

Files can also be stored on a cassette tape, or on something called a **hard disk**.

Target Audience: *Semiconductor manufacturing technicians who have worked in the industry at least one year. Most of these technicians are high school graduates. Many will have an AS degree or equivalent education. They should have already met the prerequisite, which is having completed a 2-day class on semiconductor processing overview.*

Introduction to Photolithography (page 4)

Wafer Condition Prior to Lithography

The condition of the wafer upon arrival in the lithography area is very important to know. The surface topography of the wafer has a direct effect on the process specifications required at the resist coating step as well as at the exposure step. The surface condition may affect the ability of the resist to adhere to the wafer and to spread uniformly. Whether the wafer surface is shiny or appears dull has a direct bearing on the subsequent settings of the alignment and exposure systems in the printing equipment.

Wafer Condition After Lithography

Wafers usually flow from lithography into the etch area and occasionally flow into the ion implant area. The pattern printed on a wafer has certain features that will help facilitate the etch and implant processes. The lithography process not only ensures that certain line width requirements (resolution) be met, but also ensures that each masking layer properly overlaps the preceding layer (registration). Another consideration of the resist coating on the wafer is that the resist be able to withstand the environmental conditions of the etch and ion implant processing equipment.

Process Types

There are two types of photolithography processes. These are referred to as the negative and positive lithography processes. The type of process used in any specific application is dependent on various factors, such as: product type, line width requirements, mask design, photoresist type, exposure method (machine type), and other engineering preferences.

Diffraction of Light

Light generally travels in straight lines until obstructed in some way. The results of the interference upon the wave front of light is to cause *interference* patterns or *diffraction* bands. This phenomenon can be easily demonstrated if you hold two fingers in front of your eye in such a way that you look at a light source through the very fine slit between them when they are not pressed together. See Figure 3-19. The experiment works best if the light comes from a long thin lamp, such as a fluorescent tube. You will see alternating dark and light bands as you bring your fingers closer together (Figure 3-20). If you try the same experiment with a white incandescent light, you will see color bands.

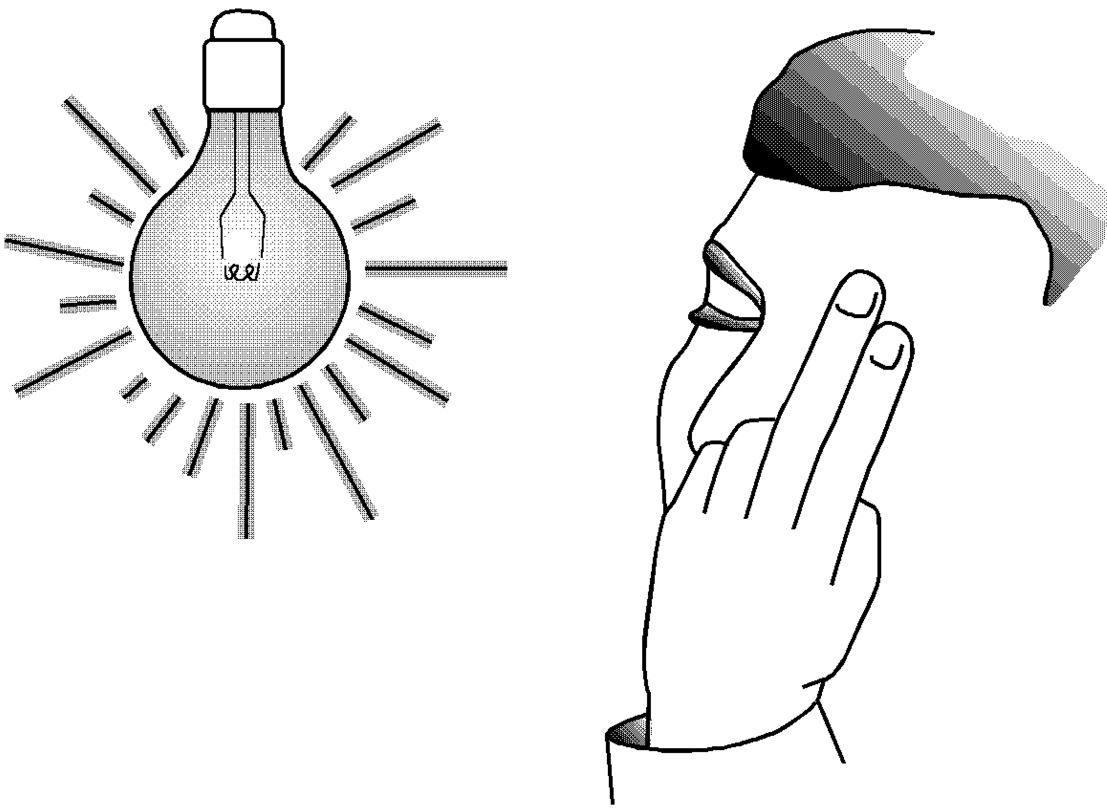

Figure 3-19. A Simple Way to Observe Diffraction

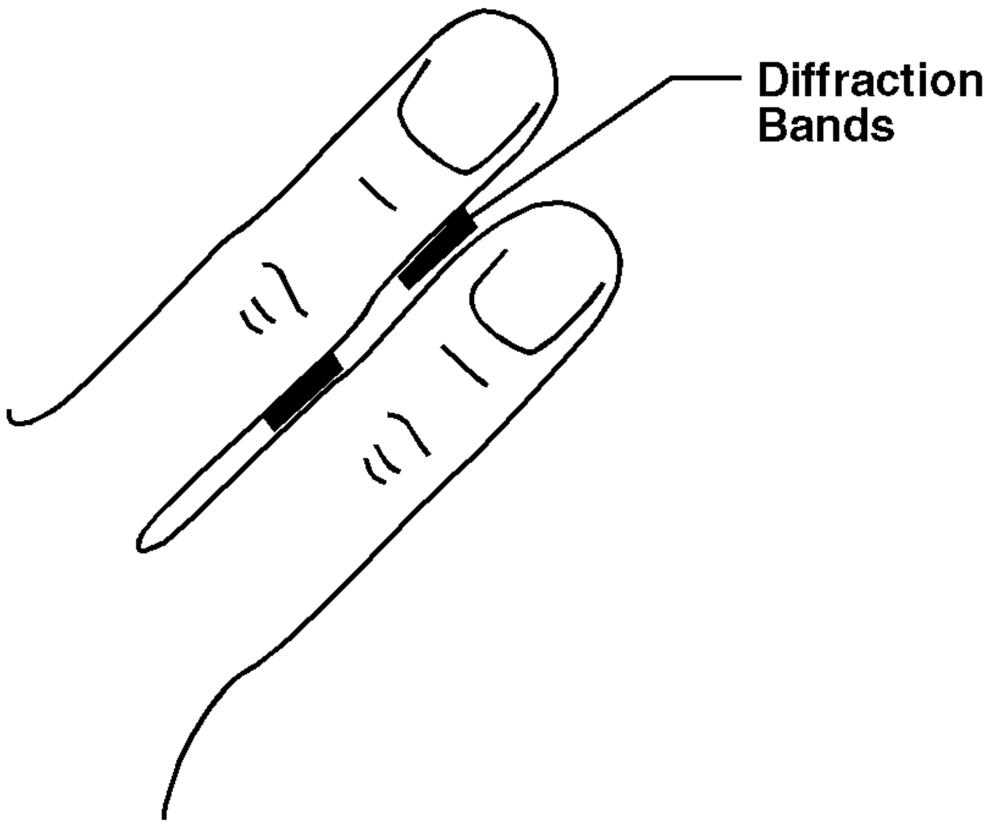

Figure 3-20. Diffraction Bands Between Fingers

When the sources of light are large and the openings through which light passes are large, the effect of diffraction is hardly noticeable. However, when the light sources are either very small or far away and the openings are very small, then the effect of diffraction is of some concern. The latter of the two is of significant importance in the semiconductor industry.

When light comes in contact with the edges of microstructures on masks and reticles, light is scattered from the edges in the form of waves or bands. Diffraction patterns essentially rob exposure energy and scatters it away from the desired field of exposure. The problem is compounded in small holes such as the contacts on the integrated circuit where diffraction patterns are easily generated by the four walls of the small windows in a dark field mask (Figure 3-21). Because of diffraction it is much more difficult to effectively print contact holes than it is to print straight lines through a bright field mask.

SEMATECH

Furnace Processes and Related Issues in Semiconductor Manufacturing

Introduction to Furnace Processes

This manual was developed by the Electronics Training Division of the Texas Engineering Extension Service (TEEX), the Texas A&M University System, under contact from SEMATECH (Requisition No. A 33887)

S-72 PTAB Performance Based Equipment Training Project

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Module Introduction

This module defines a furnace process and shows where the furnace processes fit into the sequence of wafer fabrication. The difference between a grown film and a deposited film is explained. The student is then introduced to the other furnace processes of diffusion, annealing, alloying, ashing, and reflow. A glossary follows the text to help those students who may not be familiar with the terms used in semiconductor processing. A set of evaluation questions is provided at the end of the module to be used by the student to check his or her understanding of the material presented.

Module Outline

List of Figures

List of Tables

MODULE OBJECTIVES

After completing this module, the student will be able to

1. Explain in one sentence the purpose of a furnace process.

2. Identify at least one characteristic of each of the following processes: anneal, alloy, ashing, diffusion, deposition, gettering, oxidation, and reflow.

3. Describe where the furnace processes occur in the overall semiconductor manufacturing process.

4. List at least six semiconductor processes that use a furnace. For each process give a characteristic of the physical effects of the process on the product being manufactured.

COURSE FOCUS AND DIRECTION

This course provides an introductory overview of hardware and processes related to furnaces in semiconductor manufacturing. Anyone assigned to work in the diffusion furnace area or who has an interest in the subject may enroll in this course; however, these individuals must have the prerequisite skills and knowledge as stated in the previously published course description.

A pre-test will be given at the beginning of the course to assess the audience's level of understanding of furnace processes and related topics. A post-test will be administered at the end of the course to determine the amount of improvement students will have gained from the course.

A variety of theoretical and practical topics covering both equipment and process will be presented. This course will help manufacturing personnel solve simple furnace related problems by providing useful and relevant background information. It will also help distinguishing between basic equipment and process related problems.

The course is structured as a series of modules, each covering a topic related to furnace process or equipment. Table 1 is a list of the modules that make up this course. The first three modules (1, 2, and 3) present an overview of furnace processes and equipment. The fourth module covers the properties of gases and gas flow. The fifth module identifies potential hazards and respective safety procedures pertaining to furnaces. The next five modules (6, 7, 8, 9, and 10) each discuss five important sub-systems related to the furnace, namely, temperature measurement/control, mass flow controllers, gas delivery systems, vacuum systems, and wafer handling/transfer systems. The following six modules (11, 12, 13, 14, 15, and 16) each deal with the different types of furnace processes, namely, anneal, alloy, oxidation, deposition, diffusion, ashing, reflow, and gettering processes. This is followed by a module (17) on film thickness and particle measurements. The next two modules (18 and 19) discuss preventive maintenance issues and troubleshooting process/equipment problems. The last module (20) presents a brief discussion of future industry trends in furnace processing.

1. Introduction to Furnace Processes
2. Equipment and Process Parameters
3. Furnace Equipment Overview
4. Properties of Gases and Gas Flow
5. Hazards and Safety
6. Temperature Measurement and Control
7. Mass Flow Controllers
8. Gas Delivery Systems
9. Vacuum Systems
10. Wafer Handling and Transfer Systems
11. Anneal Processes
12. Alloy Processes
13. Oxidation Processes
14. Deposition Processes
15. Diffusion Processes
16. Ashing, Reflow, and Gettering Processes
17. Film Thickness and Particle Measurements
18. Preventive Maintenance Issues
19. Troubleshooting Process and Equipment Problems
20. Future Trends in Furnace Processes

Table 1. List of course modules

WHAT IS A FURNACE PROCESS?

A furnace process is a wafer fabrication process that makes use of temperatures, significantly above room temperature, to aid or enable the desired chemical reaction relative to the fabrication of semiconductor devices. The furnace chamber may contain gases at high, low or atmospheric pressure depending on the specific process.

FURNACE PROCESSES IN SEMICONDUCTOR MANUFACTURING

Figure 1 shows where furnace processes fit into the overall sequence of wafer fabrication. Furnace processes occupy a noble position in wafer fabrication since they are typically performed first. Typically, wafers enter the furnace area from four other fab areas. Newly sliced and polished wafers come from the wafer preparation area. Wafers that have had some processing come from other areas, such as ion implant, metallization, or the etch areas. Wafers almost never come into the furnace area from photolithography (the exception being ashing). This is because photoresist, which is applied in the photolithography process, is an organic material that decomposes when subjected to high temperatures. This could result in the contamination of the process chamber and the production wafers. Some older semiconductor processes utilize furnaces for burning-off or "ashing" photoresist off of the wafers, but this method is not recommended for submicron processing. Wafers leave the furnace area and go to photolithography for further processing. Etch or ion implant processes typically follow photolithography.

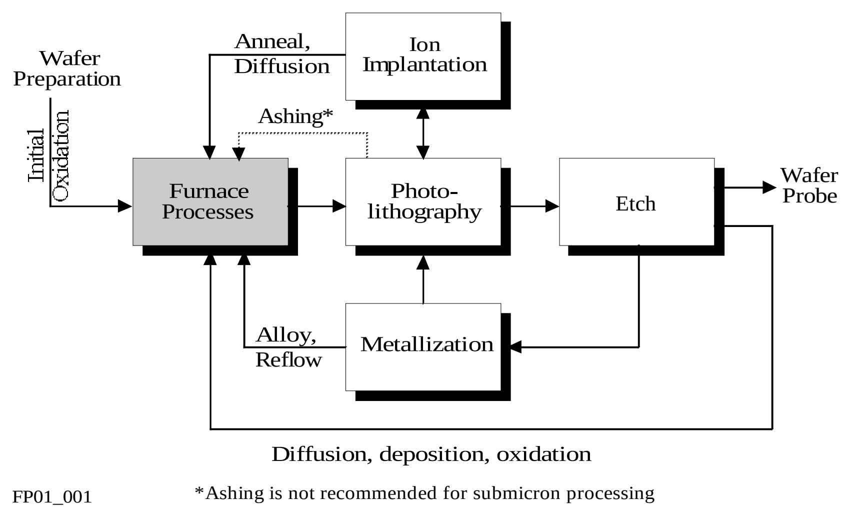


Figure 1. Where common furnace processes fit into wafer fabrication

Furnaces can be used to grow/deposit films, to diffuse dopants into the wafer, to anneal crystal defects after ion implantation, to alloy metal films, and to reflow/planarize doped glass layers. More details on these processes will be provided later in this course.

Growing and Depositing Films

Films are grown or deposited on the wafer surface to form a layer that has different electrical characteristics than the substrate. In general, the growth of a film, such as silicon dioxide, uses and incorporates some of the substrate atoms into the film, resulting in the consumption of part of the substrate, as illustrated in Figure 2.

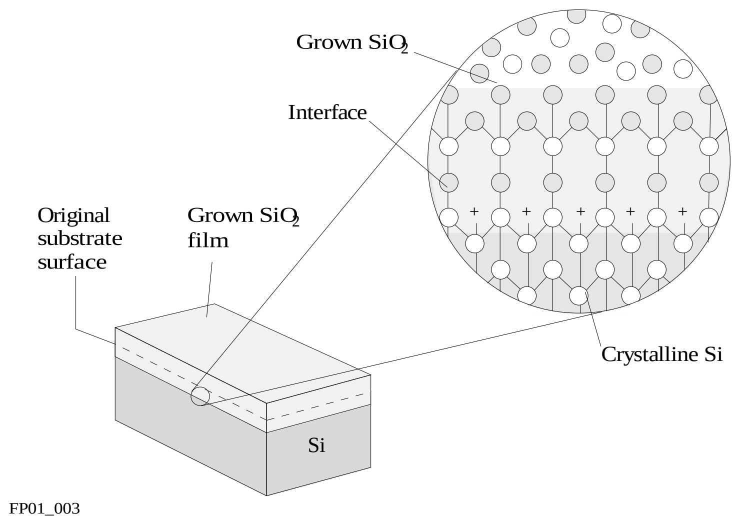


Figure 2. A grown silicon dioxide (SiO_2) film

A deposited film, on the other hand, lies on the surface of the substrate and does not incorporate any of the substrate atoms into the film, as illustrated in Figure 3. All of the materials needed for the film are provided by the process gas mixture.

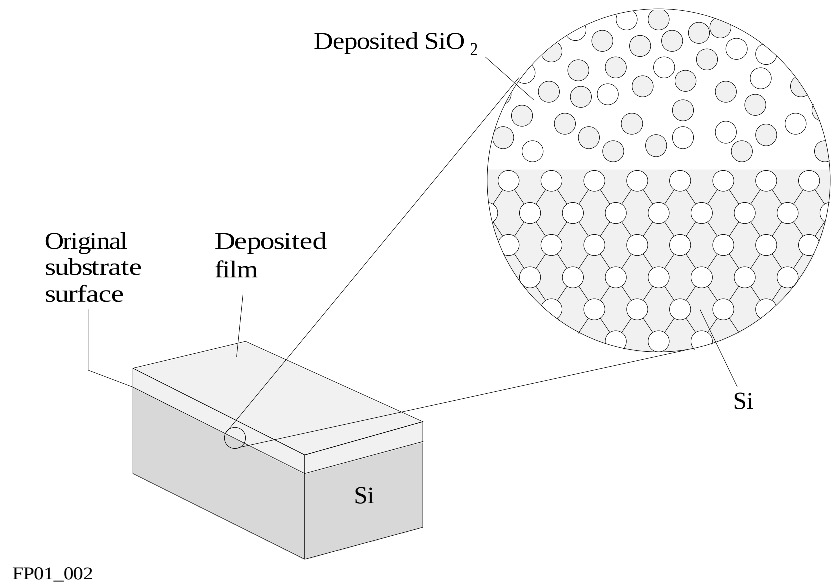


Figure 3. A deposited silicon dioxide (SiO_2) film

Diffusion

Diffusion is the process of introducing the dopant atoms into the crystal lattice structure of the layer. First, a saturated layer of dopants is deposited on or near the surface in a furnace process called predeposition, as in Figure 4(a), or implanted into the surface in an ion implant process. Then, the dopant atoms are driven into the crystal structure where they diffuse (spread out) as shown in Figure 4(b).

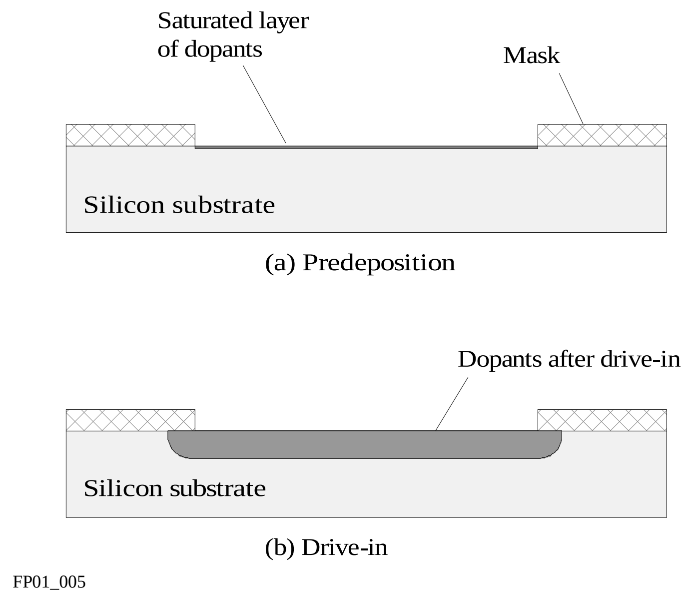


Figure 4. Diffusion of dopants into a silicon substrate

Annealing

Thermal annealing of wafers in a furnace is used to heal the small crystal fractures, especially after an ion implant process as illustrated in Figure 5. During annealing, the silicon atoms move back into their lattice positions and the covalent bonds between the atoms that were broken during the implant process are re-established. Further, the dopant ions are aligned into the lattice structure. The dopant atoms become activated when the bonds are established.

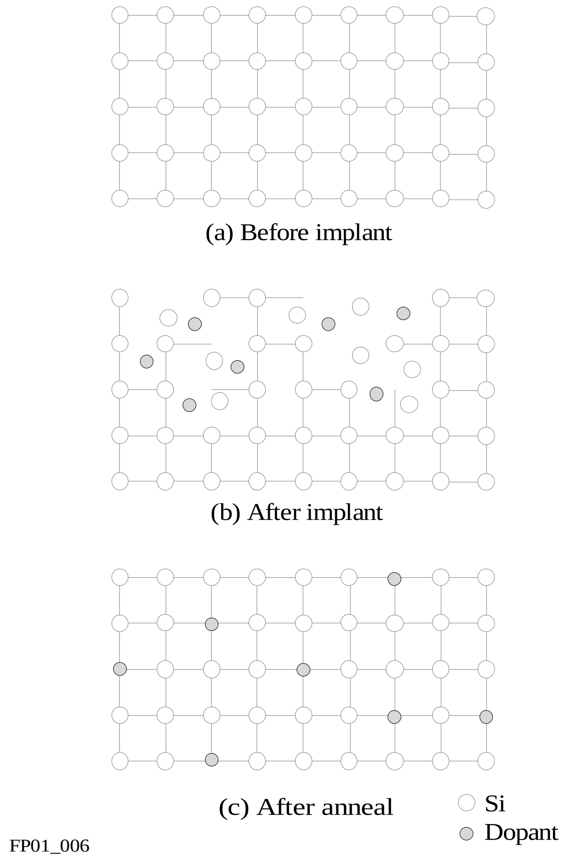


Figure 5. Thermal annealing of ion implant damage

Alloying

Wafers are heated in a furnace after the metallization process, which causes the metal to combine with the silicon in the contact areas, forming an alloy. Alloying (sometimes called sintering) improves the adherence of the metal to the silicon surface and improves the electrical characteristics of the contact.

Ashing

Ashing is a process used to strip photoresist from a wafer, by the application of heat. When this is done in a furnace, the wafers are raised to a high temperature (about 700°C) in the presence of oxygen (O_2). Currently, however, photoresist is ashed with oxygen (O_2) in a plasma reactor usually without adding external heat. High temperature ashing in a furnace is not recommended for submicron processes.

Reflow

Reflow is the process of raising the wafer to a high temperature (about 900°C) to round the sharp corners of the doped oxide insulating layer and slope the sidewalls in the contact areas. This process allows good step coverage of the metallization that follows. Figure 6(a) shows a boron/phosphorus doped oxide layer before reflow. Note the sharp corners and vertical sidewall. After reflow, the corners are rounded and the sidewalls sag a little as in Figure 6(b). Figure 6(c) has the metallization layer added.

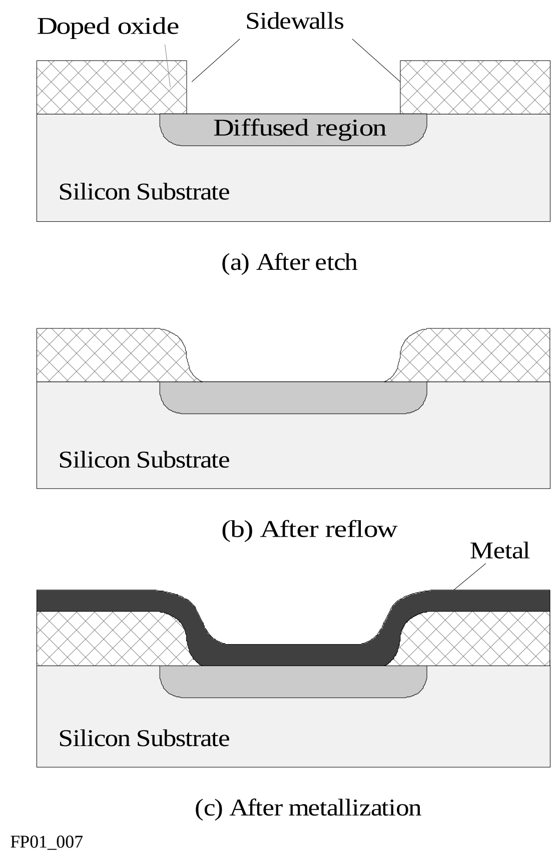


Figure 6. Using the reflow process to round edges and taper sidewalls

Typical Furnace Processes

Table 2 lists many of the common furnace processes that will be covered in this course.

OXIDATION	DEPOSITION	DIFFUSION	ANNEAL	ALLOY	OTHER
Dry	APCVD	Predeposition	Furnace Anneal	Al-Si Alloy	Ashing
Wet	LPCVD	Drive-in	RTA	Pt-Si Alloy	Reflow
HiPOx	PECVD				Gettering

Table 2. Common furnace processes

SUMMARY

This module initially introduces the reader to a list of other modules that comprises the course on "Furnace Processes and Related Issues". The purpose of the furnace process is to aid and enable suitable chemical reactions that are used in semiconductor fabrication. The position occupied by furnace processes in the overall scheme of wafer fabrication is shown with respect to wafer fabrication, ion implantation, photolithography, metallization, and etch processes. Finally, the characteristics of six typical furnace processes, namely, film growth/deposition, diffusion, annealing, alloying, ashing, and reflow, are briefly explored.

GLOSSARY OF TERMS

Al-Si alloying	An alloying process in which the deposited Al metal or Al-Si alloy layer is alloyed to the underlying silicon substrate. Al-Si alloying is used to fabricate ohmic contacts.
alloy	A thermal process in which a metal layer is heat treated with silicon in order to improve contact and electrical characteristics between the two. The two most important alloying processes are Al-Si and Pt-Si
anneal	A thermal process used to heal the small crystal fractures caused primarily by the ion implant process. During annealing, the silicon and dopant atoms move into the crystal lattice positions.
APCVD	Abbreviation for atmospheric pressure chemical vapor deposition. The APCVD process is a chemical vapor deposition (CVD) technique which is performed at or near atmospheric pressure (760 Torr).
ashing	A process in which photoresist is stripped off the wafer surface by the application of heat and in the presence of oxygen (O_2). Modern techniques of ashing use an oxygen plasma reactor to remove the resist layer.
covalent bond	A chemical bond between atoms in which electrons are shared.
diffusion	A thermal process in which dopant atoms at or near the wafer surface are redistributed deeper into the bulk of the wafer. For diffusion to occur, both heat and a concentration gradient are required.
dopant	A chemical element, from the third or fifth group of the periodic table, which is incorporated in trace amounts in a semiconductor crystal, to favorably alter its electrical characteristics. Examples of common dopants used in silicon are boron (B), phosphorus (P), arsenic (As), and antimony (Sb).

doped oxide	Silicon dioxide (SiO_2) containing a few percent of silicon dopants (B, P). Doped oxide has a lower softening (reflow) temperature as compared to undoped oxide.
drive-in	Drive-in is the second stage of the dopant diffusion process in which the saturated dopant on the wafer surface is driven into the wafer to obtain the required junction depth. (The first stage is predeposition.
gettering	Gettering is the process of removal of crystalline defects and metal contaminants from the active region of the substrate.
HiPOx	Abbreviation for high pressure oxidation. HiPOx is the process of oxidation of the wafer by the application of a high pressure (10-20 atms).
LPCVD	Abbreviation for low pressure chemical vapor deposition. The LPCVD process is a chemical vapor deposition (CVD) technique which is performed at a pressure below atmospheric pressure (0.1-1.0 Torr).
metallization	A process usually performed by evaporating or sputtering a thin film of metal or alloy on the surface of a wafer.
organic compound	A chemical compound of carbon (C), hydrogen (H), and one or more other elements, such as oxygen (O) or nitrogen (N).
PECVD	Abbreviation for plasma enhances chemical vapor deposition. The PECVD process is a chemical vapor deposition (CVD) technique which used a plasma to aid in the deposition process.
photolithography	A micropatterning process in which a pattern is transferred from a photomask onto the wafer using a technique similar to photography.

planarization	A process that smooths the contours of the wafer surface by improving surface topography.
plasma	A fourth state of matter composed of charged and uncharged particles which is used in semiconductor processing as a means to energize and drive chemical reactions, such as ashing.
predeposition	Predeposition is the first stage of the dopant diffusion process in which the surface of the wafer is saturated with the dopant. (The second stage is drive-in).
Pt-Si alloying	An alloying process in which the deposited Pt metal layer is alloyed to the underlying silicon substrate. Pt-Si alloying is used to fabricate Schottky-barrier contacts.
reflow	A high temperature process that rounds the corners of the doped oxide insulating layer and slopes the sidewalls. This process allows good step coverage of the metallization that follows.
RTA	Abbreviation for rapid thermal anneal. RTA process is an annealing technique which has a short process time (order of seconds).
substrate	A wafer that is the basis for subsequent processing operations in the fabrication of semiconductor devices or circuits.

EVALUATION QUESTIONS

1. A furnace process in wafer fabrication uses high temperature to

   a. reduce particulate contamination.
   b. increase the gas pressure.
   c. aid/enable the desired chemical reaction.
   d. disable any chemical reaction from occurring.

2. In submicron processing, wafers that enter the furnace area never come from the following fab area:

   a. ion implant
   b. etch
   c. photolithography
   d. metallization

3. The growth of a film, such as silicon dioxide (SiO_2), on a silicon substrate

   a. is a purely physical process.
   b. incorporates some of the substrate atoms into the film.
   c. does not incorporate any substrate atoms into the film.
   d. is called diffusion.

4. The process of depositing a film on a substrate surface

   a. is a purely physical process.
   b. incorporates some of the substrate atoms into the film.
   c. does not incorporate any substrate atoms into the film.
   d. is called diffusion.

5. Diffusion is the process of

   a. raising the wafer temperature to smooth the deposited doped oxide topography.
   b. causing metal to react with silicon in the contact areas.
   c. healing the small surface defects caused by the ion implant process.
   d. introducing dopant atoms into the crystal lattice of the substrate.

6. Thermal annealing is the process of

   a. raising the wafer temperature to smooth the deposited doped oxide topography.
   b. causing metal to react with silicon in the contact areas.
   c. healing the small crystal defects caused by the ion implant process.
   d. introducing dopant atoms into the crystal lattice of the substrate.

7. Alloying is the process of

   a. raising the wafer temperature to smooth the deposited doped oxide topography.
   b. causing metal to react with silicon in the contact areas.
   c. healing the small surface defects caused by the ion implant process.
   d. introducing dopant atoms into the crystal lattice of the substrate.

8. The reflow process consists of

   a. raising the wafer temperature to round the corners of the deposited doped oxide.
   b. causing the metal to react with silicon in the contact areas.
   c. healing the small surface defects caused by the ion implant process.
   d. introducing dopant atoms into the crystal lattice of the substrate.

9. Ashing refers to the process of

   a. removing metal from the wafer surface.
   b. removing photoresist from the wafer surface.
   c. developing photoresist patterns on the wafer surface.
   d. etching oxide after photolithography.

10. Typical furnace processes include:

    a. oxidation, photolithography, diffusion, anneal/alloy
    b. oxidation, deposition, diffusion, anneal/alloy, reflow
    c. wet/dry etch, deposition, metallization, anneal/alloy
    d. oxidation, metallization, diffusion, anneal/alloy

APPENDIX C

SEMATECH MANUFACTURING TECHNICIAN TRAINING AND CERTIFICATION PROCESS

Purpose

The purpose of Manufacturing Technician Training and Certification is to document the demonstration of the skills required for safe operating, process monitoring and/or maintaining of process equipment according to SEMATECH specification.

How it Works

1. Communications and Ownership

   The manufacturing technician's manager issues a Training Request form including a description of the MT's background and experience, training needs, and job expectations.

   The form is routed to the following for signatures:

   a. ATDF Shift Manager - The manager has responsibility over the employee's career development and to support production in the ATDF.

   b. Document Control - The document control center inputs training related data:
      - trainee's name,
      - course(s)
      - date training was requested
      - training completion date
      - certification date
      - recertification date.

   c. Peer Trainer (lead technician) - The peer trainer is anyone who is already certified in the specific job that the MT is to be trained to do. Or, the trainer can be someone who is recognized to have outstanding expertise, such as:
      - experienced MTs
      - process engineers
      - equipment engineers
      - field service engineers
      - training specialists.

   d. Process Engineer - The process engineer, or tool owner, plays a major role in contributing to the content of the training and certification program. The engineer is responsible for defining the operating specs as well as the process specs for the assigned tool; thus, the engineer may be directly involved in the actual certification process as well as the training.

   e. Equipment Engineer - The equipment maintenance technician or engineer may also be involved in the MT training and certification process.

f. MT Trainee - The MT trainee signs the training request to show his/her commitment to the training program. The trainee will receive a training and certification checklist. This serves as the individual's preliminary career development roadmap.

2. Prepare an Individualized Roadmap

After the training request has been received and signed by all affected parties, the peer trainer prepares the standard SEMATECH MT Training and Certification Checklist for the assigned work area. The peer trainer reviews the training goals and objectives with all affected parties. An individualized roadmap is determined and the peer trainer is given permission to start the training process.

Major Events There are several steps to the certification process.

Step 1 Kickoff Meeting. The manager meets with the trainee and peer trainer and explains why the training is important and what will be expected from the MT on the job after the training is completed. Any additional expectations will also be covered at this time, such as length of time to complete training, number of hours dedicated to training, etc.

Step 2 Roadmap Explanation. The trainer will begin by explaining the trainee's training and certification roadmap. The trainer will explain what will be done, how long it will take, and how performance will be evaluated.

Step 3 Four-Step Training Process. While following the individualized roadmap to guide the training process, the trainer will apply four basic steps in the training process.

a. Trainer tells the trainee what the trainee is expected to do.
b. Trainer demonstrates the required skill and answers the trainee's questions.
c. Trainee practices the skill while the trainer coaches the trainee. Trainee practices until the desired level of competency is achieved.
d. Trainee explains, demonstrates, and answers the trainer's questions.

Step 4 Record Keeping. When both the trainer and the trainee agree a skill has been mastered, the trainer initials and dates the training checklist. The process in steps 3 and 4 is repeated until the MT performs all skills related to a task or job with acceptable competence.

Step 5 Certification Test. During the certification test the MT must complete the task according to specification with no assistance or errors. In addition to the performance portion of the certification test, a written test will also be administered for each level of certification. Only after achieving a perfect score on both the performance tests and the written tests will a MT be certified.

Successful Completion. If the engineer or person responsible for the certifying is satisfied with the performance, the engineer will sign the certificate and inform the trainer and the MT's manager that the MT is certified and ready to be assigned to the job the MT has been trained to perform.

Remedial Action. If the MT did not perform according to the specification or made errors, the engineer will notify the manager and trainer that the MT will need additional supervised practice or training.

Step 6 Recognition. After receiving the certification documentation from the trainer and the person accountable for the certification, the Level 3 manager will sign the certificate and present it to the MT.

Step 7 Recertification. The same procedure applies for MTs requiring recertification.

GUIDELINES FOR WRITING CERTIFICATION TESTS

Introduction These guidelines describe what a trainer will need to do to develop written tests for a manufacturing technician certification program.

Basic Rules Follow these basic rules when preparing written tests for certifying manufacturing technicians:

1. Early Warning. Prior to the start of the training program, the trainer should explain to the MT the objectives of the course and the test that will be used to evaluate his performance. A MT should know in advance the topics to be covered on the test. This information will help steer the MT's learning.
2. Test Styles. Select a test style that fits the target audiences' learning preferences. The method of testing should be easy to administer, manage, and maintain as well as easy for the MT to understand how to perform the test.
3. Open Book. In most cases, MTs should be allowed to use the same resources they would have available when performing the tasks and job they have been trained to do. This includes specifications, manuals, checklists, etc.
4. Objective-Driven. Tests should match the objectives of the training and certification program. A test should not be subjective and open to scrutiny. If the training program has a strong foundation of sound performance objectives, and if the test is based on the objectives, then there is a stronger probability that the MT's performance will be measured in an objective manner.
5. Specifications. Ultimately, it is the SEMATECH operating specifications that determine the specific content of the certification tests. Objectives are derived from the specifications. The performance objectives provide the means for measuring a MT's ability to perform according to the specification.
6. Test the Test. Tests are only as good as the people who design them. Written tests have to be carefully designed to prevent ambiguity, inferences, and misinterpretations. The author of the test must remain open-minded and flexible. The test should be administered several times. After each test session, MTs should be allowed to critique the test to determine if unfair, irrelevant, or confusing questions need to be revised.
7. Update the Test. Ensure that the test is kept up to date as specifications are updated. The continuous improvement concept also applies to designing effective tests.

8. Pretest or Sample Test. A prerequisite test, or "pretest," may be helpful in assessing entry level skills for new or prospective MTs. This test usually includes a sampling of questions from the actual certification test.

Required Resources

Training and Certification Checklists containing Performance Objectives

Specifications for the Designated Work Area and for Related Process Tool(s)

Relevant Resource Materials considered Necessary for the Performance of a Task

Test Styles

Tests can be written in various styles. The test style should fit the specific application for which a test is designed to serve. In general, the test developer should use the simplest method that will provide a fair means of evaluating a MT's skills.

Matching Tests

- Match words
  - Match words to statements
  - Match names and/or statements to objects
  - Combination of all of the above
- Multiple-Choice
  - A statement followed by two or more choices
  - Two or more choices within a statement
- Fill in the blank
  - Word statements with missing words
  - Tables with missing information
- Complete the statement
- True or False tests
- Tests requiring a written response

Locate & Describe Items

Verbal Style. Have the list of parts, components, systems, or objects available on paper or computer and verbally test the MT at the actual workstation.

Written Style. Matching test - match names, objects, and descriptions. The same skill can be accurately tested by using photographs, drawings, or video of the equipment when the actual machine is not available.

Explain Steps in a Process

Verbal Style. Given an actual SEMATECH specification, the MT can be asked direct questions regarding the process at the actual work location.

Written Style. Practically any test style can be used to test for an understanding of a process flow. Even flash cards containing word descriptions of the process or actual photographs can be used as a means of testing for the correct order of all steps in the process.

Recall Parameters in a Process

Verbal Style. Having available an actual SEMATECH specification, the MT can be asked direct questions regarding the process at the actual work location.

Written Style. Any test style can be used to test for recall of specific information contained within a specification.

EXAMPLES OF TEST STYLES

Matching Test

Matching Words to Statements

A. Wafer
B. Die
C. Scribe lines
D. Notch
E. Flat
F. Test die

1. ____ A single isolated product device on a wafer.

2. ____ These run vertically and horizontally on a wafer to isolate individual dice.

3. ____ Special devices on the wafer that help engineers tell the results of the process.

4. ____ A small alignment hole on the edge of a wafer.

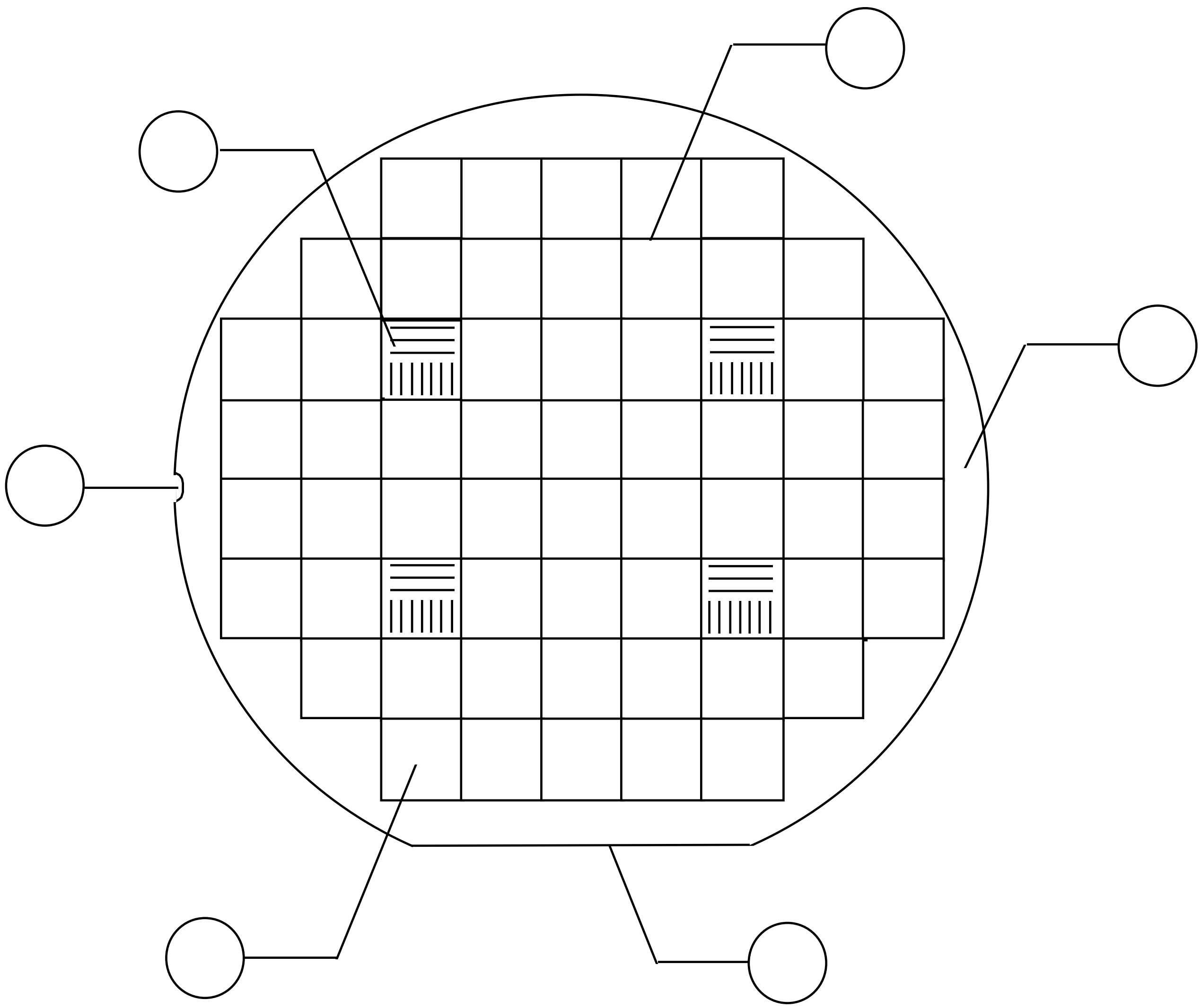
5. ____ A straight alignment indentation on a wafer’s edge.

6. ____ A flat circular slice of silicon on which many semiconductor ICs are built.

Matching Test

Matching Words and Statements to Objects

Match the items on the facing page with the objects in the figure on this page.



Multiple Choice

1. Proper airflow in critical areas serves two functions -
   A. cooling and heating.
   B. cooling and contamination control.
   C. barometric pressure and contamination control.
   D. humidity and contamination control.

2. Humidity interferes with the ability of:
   A. the vacuum in wafer handling systems.
   B. resist to adhere to the wafer surface.
   C. MTs to perform their jobs.
   D. lens focus system.
   E. all of the above.
   F. none of the above.

3. Select the statement that best describes the term "through-the-lens."
   A. A point of view outside the plane of the projection lens.
   B. Light rays that pass through the same plane as the projection lens.
   C. Same as enhanced global alignment.
   D. TTL refers to the type of alignment used when dark field lighting is
   used.

4. Given a list of tools, which are used to measure critical dimensions? (Circle all that apply.)
   A. Optical microscope
   B. Confocal microscope
   C. Scanning slit microscope
   D. Scanning electron microscope
   E. Interference microscope
   F. Ellipsometer

5. In microlithography, the (NA, resolution, depth of focus) is defined as the smallest isolated feature which is repeatedly printed by a photolithography process.

Fill in the Blank

Word Statements with Missing Words

1. In microlithography, the _ _ _ _ _ _ _ _ _ _ _ is defined as the smallest isolated feature that is repeatedly printed by a _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ process.

Tables with Missing Information

Use this table to test your troubleshooting skills. Place an "X" in the appropriate place to a specific "Defect ID" to some "Possible Causes due to Process Variations." The first one has been done for you as an example.

True or False Tests

Indicate whether a statement is correct or incorrect by writing the word "true" or "false" next to each statement.

1. ____ Mercury can be found in the stepper within the high intensity lamp.

2. ____ Commonly used cleaning slovents, IPA and acetone are highly flammable.

3. ____ Most develop solutions are acidic.

Indicate which statement is true by placing a checkmark next to the statement.

1. ____ As a precautionary, one should avoid breathing in the yellow room.

2. ____ HMDS is considered highly explosive at room temperature.

3. ____ Wafers brought to the stepper will have been coated with photoresist.

GUIDELINES FOR DEVELOPING TRAINING AND CERTIFICATION CHECKLISTS

Introduction

These guidelines describe what a trainer will need to do to develop certification training materials. What is described here is the minimum requirement.

Required Materials

Training Request Form
Course Prerequisites
Task Analysis
List of Training Objectives
Relevant Documentation
Training Checklist
Estimated Time for Completion
Certification Test
Certification Form

Training Request Form

The first step in the training and certification process requires that the manufacturing technician's (MT) manager submit a training request to the respective peer trainer in the MT's work area. The form contains important information that will help you strategize the learning roadmap for the MT trainee.

Course Prerequisites

The course prerequisites describe the knowledge and/or skills that the MT needs to have before beginning a training program. Here are some examples of prerequisites:

Courses:

- E-Mail Training
- Site Safety Orientation
- Chemical Safety
- Workstream
- Cleanroom Entry
- IC Process Overview
- Digital Circuits
- DC and AC Electronics
- Physics 101

Skills:

- Typing Speed (30 wpm)
- Soldering using pencil tip soldering iron
- Wafer handling
- Microscope usage
- Practical oscilloscope applications
- Use of basic hand tools
- Operate leak detector

Task Analysis In general, SEMATECH engineers have written operating, process, and maintenance specifications to ensure that processes and tasks are done on schedule or when required and with some desired result in mind. There may be some instances where segments of a MT's job has not been documented. If this should occur, a task analysis (TA) should be performed. The TA identifies when a task must be done and describes how the task is done step-by-step. The TA can then be used as part of the MT's training checklist.

Training Objectives Training objectives state what the MT will be able to do as a result of the training. Objectives describe a performance that is clearly visible and measurable.

<Example> Given a cassette containing 25 200mm wafers, the MT will use the vacuum wand to transfer all 25 wafers to a quartz boat without dropping, scraping or contaminating the wafers.

<Example> Given a 20-question test, the MT will correctly answer at least 85% of the questions.

<Example> Given a list of 35 major components, the MT will locate and describe each component on the ion implanter within a time period of 60 minutes.

<Example> Walk thru the etch area with your trainer, identify all possible hazards and describe the proper safety procedure for dealing with each hazard.

Training objectives should follow an order of hierarchy depending on their level of complexity. The order of performance should be from the simplest to the most complex. Additional knowledge and skills, sometimes hidden and not observable, may also be required before an objective can be achieved. These objectives must also be included in the list of training objectives.

<Example> Recall from memory the action to take when a XXX-XX error is noted on the tool.

<Example> State the difference between Kev and ma.

<Example> Explain the difference between Charles's Law and Boyle's Law.

<Example> List at least 3 items that are needed for ionizing a gas in a plasma etch reactor.

Relevant Documentation

Ensure that all necessary reference documentation including videos and other applicable resources will be available when you need them for the training process. Here are some items to consider:

Safety Module
Standard Operating Procedures (SOPs)
Specifications
Supplier Manuals and Schematics
Theory of Operation
Text Books
Other Suggested Resources

On the training checklist indicate the pages or sections of the document that the MT should read to support the performance of a specific objective on the training checklist.

Training Checklist

The training checklist is a form that the trainer and MT use to track their progress. It lists all the objectives that the MT will achieve or be able to do so as a result of the training course. Next to each task are two underlined spaces. When the trainer and the MT agree that the activity has been mastered, they initial and date the appropriate objective. When all the objectives have been initialed, a certification test can be scheduled.

Estimated Time for Completion

The time estimate includes the number of hours of on-the-job training as well as the number of additional hours needed for reading assignments or for doing homework. The time estimate should also state the approximate duration of the course. For example, a training course may include several four-hour sessions that will be completed over a two-month period.

Certification Test

To become certified, the MT must demonstrate the ability to perform the tasks learned in training to the person accountable for the respective work area. The person doing the certification could be a process engineer, equipment engineer, field service engineer, Level 3 manager, or another qualified MT. In order to ensure the integrity of the certification program, the individual doing certification must have demonstrated competence in the specific area and/or tool where the trainee is to be tested.

Performance Test	The MT will demonstrate the tasks to the person doing the certifying without any errors.
Written Test	The MT will complete the written test without errors.

Recertification may be required if an individual's performance drops below standard or if the MT has not performed the task for a specified period of time.

Certification Form

Once all the criteria for certification have been met, the trainer, Level 3 manager, and the person doing the certifying will sign the certification form. The Level 3 manager will present the certification to the MT. The trainer will report the completion of the training program to the training department.

MANUFACTURING TECHNICIAN TRAINING CHECKLIST

As trainee completes each class or procedure, trainee and trainer (or instructor) should initial and date each section.

I.	CORE COURSES	TIME	TRAINEE	TRAINER	DATE
WEEK ONE – ORIENTATION To include:	PC/Windows E-Mail HAZCOM Site Safety Orientation Chemical Safety Cleanroom Entry Certification	28			
2.	WorkStream Training				
3.	Semiconductor Processing Overview	8			
4.	Electrical Safety	6			
5.	Lockout/Tagout	1			
6.	RS1/Quickstart	7			
7.	Intro to Statistical Methods	7.5			
8.	Passive Data Collection	7.5			

II.	NON-TOOL ATDF TRAINING	TIME	TRAINEE	TRAINER	DATE
1.	Tour of bay including familiarization of all equipment in the bay.				
2.	Safety Items a. Demonstrate proper evacuation routes b. Demonstrate the correct use of personal protective equipment c. Identify the different types of alarms d. Identify the emergency phone numbers e. Identify the hazards in the bay f. Demonstrate how to contact security and the reasons for contacting them				
3.	Key Contacts a. Demonstrate how to use the paging system b. Demonstrate how to contact management c. Demonstrate how and why to contact fab stores				
4.	Housekeeping a. Demonstrate the proper housekeeping policies in the ATDF				
5.	Wafer Handling a. Demonstrate the correct way to handle wafers and the use of the transfer tool b. Demonstrate the correct way to use the notch finder c. Demonstrate the correct way to use the wafer sleuth tool				
6.	Equipment Owners a. Identify the equipment owners for your area				
7.	Timesheets a. Demonstrate how to correctly fill out a timesheet and where to send it				
8.	Special Codes a. Identify the special codes and nonmenclatures used in the ATDF				
9.	Hazardous Wastes a. Identify and/or demonstrate the proper procedure for the removal/exit of hazardous wastes				

III.	TOOL RELATED SKILLS	TIME	TRAINEE	TRAINER	DATE
1.	Process Overview a. Describe product before and after the process b. List major process parameters c. List major process steps d. Briefly describe process equipment				
2.	Equipment Overview a. Locate and descibe major systems, subsystems, and components				
3.	Locate and Describe Related Hazards a. Chemical b. Electrical c. Thermal d. Optical e. Mechanical f. Radiation				
4.	Describe Safety Procedures for Items in #3				
5.	Locate and Describe Controls and Indicators a. Control panels, keyboards, etc... b. Information displays, CRT, etc... c. Switches, gauges, joysticks, etc... d. Describe relationships between items in 2 and 5				
6.	Define Operating Codes or Software Commands				
7.	Read and Interpret Specifications a. Process specifications b. Operating specifications c. Station maintenance specifications				
8.	Process Wafers According to Spec a. ID lot number and select appropriate recipe b. Load and unload wafers c. Setup stations d. Operate station e. Monitor process f. Interpret alarms and take appropriate corrective action				
9.	Apply Principles of SPC to the Tool a. Interpret process data b. Plot data on control charts c. Make appropriate decisions regarding corrective action d. Troubleshoot the tool and the process to the subsystem level				
10.	Preventative Maintenance a. Shiftly b. Daily c. Weekly				
11.	Qualifications				
12.	Troubleshooting (optional)				
13.	Engineering Audit				

APPENDIX D

Examples of Completed Lesson Plans Courtesy of Semitherm

Instructor Guide: #01	**Class:** Semitherm VTP-1500 Operations
Module Title: VTP-1500 Vertical Furnace Course Introduction	
Target Audience: Operators, Technicians, Engineers -- anyone responsible for operating the VTP-1500	**Location:** Classroom
Prerequisite Skills: Basic computer skills, basic electronics, mechanical skills	

Module Objective: Upon completion of this module, the participant will be able to

- List expectations regarding the course
- Follow the course format and schedule
- Understand the purpose of the performance objectives
- Understand the course completion criteria
- Complete the course pretest
- Tour the facilities and learn evacuation procedures for the site of the class

Skill Pretest: The pretest will be administered during this module. Two functions are served by this test: (1) The pretest is designed to measure each participant's competency level regarding the contents of the course. (2) The instructor can tailor the pace and contents of the course based on the results of the pretest. There is no passing grade requirement for this test.

Additional Resources: The instructor will require an assistant. This person can take the participants on a tour of the facilities while the instructor grades the pretest.

Training Aids & Media	Tools & Materials for Practice
1. Overhead projector and screen 2. Transparency of the facility layout 3. Pointer and transparency markers 4. Flipchart and markers to take notes 5. Name tents and markers 6. Class roster 7. Registration forms 8 Transparency of course outline or map 9. Transparency of Individual Progress Chart 10. Transparency of Class Progress Chart	None required

Relevant Practice Description: Not applicable

Conditions: Not applicable

Type of Modeling: Not applicable

Feedback Mechanism: Not applicable

Module Content Description: The purpose of this module is to welcome the participants to the class and to allow them and the instructor time to get acquainted before starting the class. Participants should fill out the registration form if they have not already done so. Participants are asked to write their names on the name tents using the markers provided. Then everyone is allowed to introduce themselves. During the introductions, the instructor can check the attendance for the day.

The instructor will explain the location and procedures for: accessing the break areas, cafeteria, restrooms, telephones, health services, etc. Safety is of a major concern, so hazards are pointed out and safety procedures are explained including emergency procedures and the evacuation routes.

Class schedules are announced, including meeting times, breaks, lunch, and specific times when equipment will be available for demonstrations, practice, and testing sessions.

The instructor will explain the course format including the purpose of the course and the individual module objectives. Participants will learn that the course is based on performance objectives that are derived from careful front-end analysis. Skill tests are administered in each module to determine each participant's understanding of concepts and level of skill competency. The tests are graded individually and appropriate feedback is provided by the instructor or the course materials to ensure participants know how well they are doing at all times.

Participants are informed that the course is a performance-based equipment training (PBET) course, and as such, it allows for plenty of relevant practice to support the concepts and performance of skills demonstrated by the instructor. Wherever possible, participants will receive as much "hands-on" practice on the VTP-1500 Vertical Furnace System as is possible.

The course outline or course map is explained. If a course map is available, the instructor can point out the logical sequencing of individual units of instruction (modules). The instructor can explain the specific order of modules for the specific class based on current needs.

Satisfactory completion of the VTP-1500 Operations course by each participant requires satisfactory performance of each skill test attempted. The pretest and posttest must be taken by each participant; however, the results are not used to rank the participants against each other. Instead, the results of the posttest are compared to the pretest to determine the extent of individual improvement in learning the VTP-1500. Each participant will have an "Individual Performance Chart" where the participant can record performance on the pretest, posttest, and individual learning modules. Both the instructor and the participant are required to sign the IPC as an indication of agreement between the two that all or specific instructional modules have been completed. The instructor will have a "Class Performance Chart" to track the completion of modules as they are completed by each participant.

The instructor asks the audience if they have any specific needs or expectations from this class that have not already been mentioned. The instructor writes the list on flipchart paper and will continue to use the paper to record issues and questions that might arise during the course. The instructor will check off the items as the expectations are met or as issues and questions are resolved.

When the class has completed taking the pretest, a training assistant arrives to escort the class on a tour of the facility. During this time, the instructor can grade the pretest and tally the scores. The instructor may or may not be able to establish a baseline from the results unless there is a noticeable pattern of scores in certain areas of the test which the instructor can identify as being either strong or weak competencies.

The instructor passes out the participant guides along with the results of the pretest. The instructor will review the results of the pretest with the class when the participants return from the tour. The instructor explains any modifications in the course from the original course map. The participant guide is explained and the first module begins.

Instructor Guide: #02	**Class:** Semitherm VTP-1500 Operations
Module Title: VTP-1500 Vertical Furnace Overview	
Target Audience: Operators, Technicians, Engineers -- anyone responsible for operating the VTP-1500	**Location:** Classroom and/or at the VTP-1500
Prerequisite Skills: Basic computer skills, basic electronics, mechanical skills	

Module Objectives:

1. Given a functional block diagram and pictorial drawings, the student will be able to locate and describe the function of the nine specific major subsystems in the VTP-1500 Vertical Furnace with at least 90% accuracy.

2. Using an operational VTP-1500 Vertical Furnace and a checklist, the student will be able to locate and describe the components of each of the following major subsystems to items on the checklist with 90% accuracy: (a) process chamber/heater element system, (b) temperature control system, (c) gas delivery system, (d) exhaust/pressure control system, (e) computer control system, (f) water flow control system, (g) interlock system, (h) wafer transfer system, and (i) power distribution system.

3. Using available documentation the student will be able to identify wafer transfer movement designations and wafer station designations of the VTP-1500 Vertical Furnace with 90% accuracy.

Skill Test: (1) The instructor will provide a checklist of nine major subsystems of the VTP-1500 Vertical Furnace. At the VTP-1500 the student will locate each item on the checklist and describe to the instructor the purpose of each subsystem. Acceptable performance on this test is 90% or better. (2) On the reverse side of the checklist will be a pictorial diagram of the wafer transfer station. The student will be asked to name the major components of the wafer transfer system and to identify the wafer transfer movement designations -- direct load, load, unload, preload, and post load

Additional Resources: None

Training Aids & Media	Tools & Materials for Practice
1. Overhead projector and screen 2. Pointer and transparency markers 3. Flipchart and markers to take notes 4. Transparencies: (1) course outline or map (2) Fig. 1 (3) Fig. 2.2 (4) Fig. 2.3 (5) Fig. 2.4 (6) Fig. 2.5 (7) Fig. 2.6 (8) Fig. 2.7 (9) Fig. 2.8 (10) Fig. 2.9 (11) Fig. 2.3 without callouts (12) Fig. 2.4 without callouts (13) Fig. 2.5 without callouts (14) Fig. 2.6 without callouts (15) Fig. 2.8 without callouts	1. VTP-1500 Vertical Furnace (if available) 2. Videotape of VTP-1500 (if tool is not available)

Relevant Practice Checklist

Relevant Practice Description:
Type of Modeling: The instructor will use the overhead projector and transparencies 7 - 9 to point out the major subsystems of the VTP-1500. He will show the location of the nine major subsystems and describe the function of each item with respect to the overall function of the VTP-1500. The instructor will create an interactive environment and will answer all questions provided by the audience.
Conditions: The practice session can be done in the classroom using the overhead and transparencies 14 - 18. After the preliminary practice session in the classroom, the instructor will take the participants to the location of an actual VTP-1500 where he will point out the actual location of the subsystems on the tool.
Feedback Mechanism: When he feels that the participants are ready for relevant practice, the instructor will use transparencies 14-18 to quiz the class on the location of the nine major subsystems. The instructor will allow each student to respond to his questions as he points at the location of each subsystem. Another way to practice locating the subsystems would be to provide the class with a set of illustrations and then ask students to locate the components on the graphics. On another sheet of paper, students could be asked to write a statement describing the function of each subsystem. Students can check their own work by comparing it with the information in the participant guide.

Module Content Description: This module introduces participants to the location and function of nine major subsystems of the VTP-1500 Vertical Furnace. Participants will be expected to know the location of these items directly on the tool; however, plenty of classroom practice will be provided before participants are tested directly on the tool. It is also a requirement for participants to be able to describe the basic function of each of the nine major subsystems.

In addition, participants will learn the names of the major components of the wafer transfer system and be able to identify the wafer transfer movement designations -- direct load, load, unload, preload, and post load

Instructor Guide: #03	**Class:** Semitherm VTP-1500 Operations
Module Title: Process Characteristics	
Target Audience: Operators, Technicians, Engineers -- anyone responsible for operating the VTP-1500	**Location:** Classroom
Prerequisite Skills: Completion of the following courses: Module 2 of the VTP-1500 Operations course, completion of the SEMATECH Furnace Processes course or equivalent, and basic college chemistry.	
Module Objective: Given a list of processes available on the VTP-1500 Vertical Furnace and a list of specific process characteristics, the student will be able to match the characteristics to the process with at least 90% accuracy.	
Skill Test: Participants will be given a list of processes which are available on the VTP-1500 and a list of hardware and process characteristics. Participants are required to match each process to its relevant hardware and process characteristics.	
Additional Resources: None	
Training Aids & Media	**Tools & Materials for Practice**
1. Overhead projector and screen 2. Pointer and transparency markers 3. Flipchart and markers to take notes 4. Transparencies: (1) course outline or map (2) block diagram 3.1 (3) atmospheric system vs. LPCVD (4) polysilicon deposition bullets (5) silicon nitride deposition bullets (6) dry ox process bullets (7) pyrogenic process bullets (8) H2 anneal process bullets (9) POCl3 dep. proc. bullets (10) HTO process bullets (11) TEOS process bullets (12) block diagram 3.2 (13) Fig. 3.3 Process Characteristics table	None required

Relevant Practice Checklist

Relevant Practice Description:
Conditions: The relevant practice for this module will take place entirely in the classroom.
Type of Modeling: The instructor will use the transparencies provided for this module to describe the versatility of the VTP-1500 in handling a variety of furnace processes. When the instructor has completed presenting the process and hardware characteristics of each configuration, the instructor will verbally quiz the audience to give them practice in associating process characteristics to hardware requirements. The flipchart can be used for this activity.
Feedback Mechanism: The instructor will provide appropriate feedback during the practice session. The instructor can also refer students to their participant guides or reference the transparencies as needed. These materials can also serve as feedback mechanisms.
Module Content Description: This module introduces participants to the various process configurations that can be performed in the Semitherm VTP-1500 Vertical Furnace. At this point it is very important that participants have previously completed the prerequisite courses listed on the front cover of this instructor guide. Or, participants should have equivalent work experience. In summary, it is assumed that participants will already have the necessary chemistry and general furnace process background to be able to understand the applications of the VTP-1500. For a refresher of the process concepts mentioned in this module, consult the SEMATECH Furnace Processes participant guide. Block diagram 3.1 is used to list and categorize the different process configurations of the VTP-1500. Each process is summarized briefly by using the bullet transparencies listed on the front page of this instructor guide. The instructor will describe the equipment requirements for each process and explain the function of the process configuration. The purpose of the module is to ensure that the participants in the course are able to discriminate between one process and another in terms of hardware requirements and process characteristics.

Instructor Guide: #04	**Class:** Semitherm VTP-1500 Operations
Module Title: Safety	
Target Audience: Operators, Technicians, Engineers -- anyone responsible for operating the VTP-1500	**Location:** Classroom and/or at the VTP-1500
Prerequisite Skills: Completion of the following courses: Modules 2 & 3 of the VTP-1500 Operations course, completion of the SEMATECH Furnace Processes course or equivalent, and basic college chemistry.	
Module Objective: (1) From memory, the student will be able to identify the four classifications of safety hazards associated with working on or around the VTP-1500 Vertical Furnace with 100% accuracy. (2) Given a list of the nine major functional subsystems described in Module 2, the student will be able to identify which of the four classifications of hazards are associated with each of the subsystems and cite at least one example of each with 100% accuracy. (3) Given a safety violation scenario by the instructor, the student will be able to describe what consequences may/will occur due to the safety violation. (4) Using a functional VTP-1500 Vertical Furnace, the student will be able to locate and operate all EPO and EMO switches and give an example of a scenario in which the switches might be used. (5) From memory, the student will be able to list the possible consequences of activating the EPO button with at least 90% accuracy.	
Skill Test: The skill test for this module will be performed directly at the VTP-1500 Vertical Furnace. The participant will have a checklist of hazards that can be found in the VTP-1500. The participant must be able to locate each item on the VTP-1500, indicate the type of hazard (thermal, electrical, mechanical or chemical), and explain the safety procedure for working in the area of the potential hazard.	
Additional Resources: MSDS information for typical chemicals that are used in the processes and maintenance of semiconductor furnaces.	

Training Aids & Media	Tools & Materials for Practice
1. Overhead projector and screen 2. Pointer and transparency markers 3. Flipchart and markers to take notes 4. Transparencies: (1) course outline or map (2) list of four hazard categories (3) illustrations or picture of VTP-1500 (4) list of thermal hazards (5) list of electrical hazards types (6) list of mechanical hazards (7) table of chemical hazards, Fig. 4.1 (8) subystem hazard chart, Fig. 4.2 (9) process chamber hazards (10) gas delivery system hazards (11) water flow system hazards (12) exhaust pressure control hazards (13) wafer transfer system hazards (14) temp. control system hazards (15) computer, interlock, and power distribution system hazards	1. VTP-1500 Vertical Furnace or videotape of the VTP-1500 2. Safety glasses 3. Gloves (3 types)

Relevant Practice Checklist

Relevant Practice Description:
Conditions: The relevant practice for this module will take place in the classroom and at the location of the VTP-1500 Vertical Furnace.
Type of Modeling: The instructor will use the transparencies provided for this module to explain the types of possible hazards that can be found in the VTP-1500 Vertical Furnace depending on process characteristics and hardware configuration. When the instructor has completed pointing out the hazards and explaining safety procedures, the instructor will verbally quiz the audience to give them practice in associating the types of hazards with hardware and process requirements. The overhead transparencies and the flipchart can be used for this type of activity.
Feedback Mechanism: The instructor will provide appropriate feedback during the practice session. The instructor can also refer students to their participant guides or reference the transparencies as needed. These materials can also serve as feedback mechanisms.

Module Content Description: This module introduces participants to the various potential hazards that can be found in the Semitherm VTP-1500 Vertical Furnace. It is very important that participants complete the prerequisite courses or lessons listed on the front cover of this instructor guide before attempting this module. Or, participants should have equivalent work experience.

The instructor will use transparency #2 to introduce the four types of potential hazards that can be found in the VTP-1500. Transparency #3 is used throughout this lesson to help locate the areas in the VTP-1500 where the hazards may exist. The remaining transparencies are used to summarize the types of hazards.

The types of hazards may vary depending on the type of process and equipment configuration that has been designed into the specific furnace system. For example, a pyrogenic torch would only be found on wet oxidation systems and a bubbler can be found in a POCl3 deposition system.
Prior to the skill test students will have ample time in the classroom and at the VTP-1500 to ask pertinent questions related to hardware, processes, hazards and safety procedures.

Instructor Guide: #05	**Class:** Semitherm VTP-1500 Operations
Module Title: Computer Screen Interpretation	
Target Audience: Operators, Technicians, Engineers -- anyone responsible for operating the VTP-1500	**Location:** Classroom, and/or at the VTP-1500
Prerequisite Skills: Completion of the following courses: Modules 2 - 4 of the VTP-1500 Operations course and the SEMATECH Furnace Processes course or equivalent. Basic computer keyboarding skills is required and proficiency in the use of DOS and Windows user interfaces is helpful.	
Module Objective: (1) Using a diagram of the Main screen, the RUN screen, the wafer handling screen, and the MAINT screen, the student will be able to locate and describe the different fields, icons, boxes, and drawings with an accuracy of 90%. (2) Given an Intouch TM Software Main Screen, the student will be able to describe the resultant machine/software action of touching the different fields, icons, boxes, and drawings with at least 90% accuracy.	
Skill Test:	
Additional Resources:	
Training Aids & Media	
1. Overhead projector (2ea) and screen (2ea) or one InTouch remote video display and one overhead projector 2. Pointer and transparency markers 3. Flipchart and markers to take notes 4. Transparencies: (1) Main screen (2) bullets for Main screen (3) Main screen soft key definitions (4) bullets for Main screen soft keys (pages) (5) Run screen (6) bullets for Run screen (7) Recipe Edit screen (#1) (8) bullets for Recipe Edit screen (9) clear/cut/copy/paste functions (10) Deviation Parameters screen (#2) (11) bullets for Deviation Parameters screen (12) Temp and PID Parameters screen (#3) (13) bullets for Temp/PID Parameters screen	Transparencies (continued) (14) Load Pattern Edit screen (15) bullets for Load Pattern Edit screen (16) Wafer Handling screen (17) bullets for Wafer Handling screen (18) Furnace Charts screen (19) bullets for Furnace Charts screen (20) Datalog screen (21) bullets for Datalog screen (22) Change Pens screen (23) bullets for Change Pens screen (24) Change Scales screen (25) Maint screen (26) bullets for Maint screen (27) Digital Inputs screen (29) Digital Outputs screen (30) Alarm Screen (31) bullets for Alarm screen

Tools & Materials for Practice
1. VTP-1500 Vertical Furnace or videotape of the VTP-1500 2. InTouch remote monitor (if available) 3. Safety glasses 4. Gloves (3 types)

Relevant Practice Checklist

Relevant Practice Description:
Conditions: The relevant practice for this module will take place in the classroom using the InTouch remote computer system, or at the location of the VTP-1500 Vertical Furnace.
Type of Modeling: The instructor will access the InTouch software screens via the remote system. Or, if the remote is not available, the instructor may use an overhead projector and the listed transparencies to describe the screens. A second overhead projector can be used to display the bullets summarizing individual screen functions. The instructor will explain screens and related soft keys.
Feedback Mechanism: The instructor can call up specific screens on the remote system or use the available screen transparencies to verbally quiz the audience on their knowledge of the screens. The instructor will provide the immediate feedback to inform participants how well they are doing.
Module Content Description: This module describes the functions of 15 screens of the Semitherm VTP-1500 operator interface software. The module also describes the various soft keys associated with these screens. Operators will be able to interpret the information represented by these specific screens. The instructor can use two methods to present the information from this module; (1) the best way is to have available the InTouch remote software computer station. The overhead projector can be used to display the bullets summarizing each of the related screens. (2) If the InTouch remote station is not available, use screen transparencies on one overhead projector and use a second projector to display related bullets for the screen.

Instructor Guide: #06	**Class:** Semitherm VTP-1500 Operations
Module Title: Alarm Screen Interpretation	
Target Audience: Operators, Technicians, Engineers -- anyone responsible for operating the VTP-1500	**Location:** Classroom, and/or at the VTP-1500
Prerequisite Skills: Completion of the following courses: Modules 2 - 5 of the VTP-1500 Operations course and the SEMATECH Furnace Processes course or equivalent. Basic computer keyboarding skills is required and proficiency in the use of DOS and Windows user interfaces is helpful.	
Module Objective: (1) Given a VTP-1500 Vertical Furnace in a random alarm state, the student will be able to use the alarm screen display and a list of alarm definitions provided by the instructor to describe the effect the alarm will have on the operation of the tool. The student's responses must be within 90% accuracy. (2) Given an active alarm scenario, the student will be able to describe the correct procedure/action to take at an operations level in order to prevent damage to the tool or product or injury to personnel.	
Skill Test: The instructor will induce a random alarm scenario on the VTP-1500. The student must be able to call up the Alarm Screen and interpret the alarm type and locate the alarm definition in the alarm message list. The student must be able to describe the correct procedure/action to take at an operations level in order to prevent damage to the tool or product or injury to personnel.	
Additional Resources: None required	
Training Aids & Media	**Tools & Materials for Practice**
1. Overhead projector (2ea) and screen (2ea) or one InTouch remote video display and one overhead projector 2. Pointer and transparency markers 3. Flipchart and markers to take notes 4. Transparencies: (1) Course map or course outline (2) Alarm screen (3) Alarm soft key definitions (4) Table of Alarm warnings (sample) (5) Practice alarm scenario exercises	1. VTP-1500 Vertical Furnace or videotape of the VTP-1500 2. InTouch remote monitor (if available)

Relevant Practice Checklist

Relevant Practice Description:
Conditions: The relevant practice for this module can be accomplished by three possible methods: (1) by using the InTouch software (SIC) at the location of the VTP-1500 Vertical Furnace, (2) by using the InTouch remote computer system in the classroom, or (3) by simply creating alarm condition scenarios on paper, transparencies, or by other means.
Feedback Mechanism: The instructor can call up specific screens on the remote system or use the available screen transparencies to verbally quiz the audience on their knowledge of the alarm screens and relevant remedial action. The instructor will provide the immediate feedback to inform participants how well they are doing.
Module Content Description: This module describes the functions of the alarm screen of the Semitherm VTP-1500 operator interface software. Operators will be able to interpret the information represented by these specific alarm screens. The instructor can use one or a combination of three methods to present the information from this module; (1) the best way is to have available the InTouch remote software computer station. The overhead projector can be used to display the transparency tables summarizing the alarm messages, (2) if the InTouch remote station is not available, use screen transparencies on one overhead projector and use a second projector to display related bullets for the screen, and (3) if the VTP-1500 is available, use the furnace computer interface (SIC).

Instructor Guide: #07	**Class:** Semitherm VTP-1500 Operations
Module Title: External Controls and Indicators	
Target Audience: Operators, Technicians, Engineers -- anyone responsible for operating the VTP-1500	**Location:** Classroom, and/or at the VTP-1500

Prerequisite Skills: Completion of the following courses: Modules 2 - 6 of the VTP-1500 Operations course and the SEMATECH Furnace Processes course or equivalent. Basic computer keyboarding skills is required and proficiency in the use of DOS and Windows user interfaces is helpful.

Module Objective:
(1) Using system drawings, photos, and a list of external controls and indicators, the student will be able to locate and explain the purpose of all external controls and indicators on the VTP-1500 Vertical Furnace to at least 90% accuracy.

(2) Using an operational VTP-1500 Vertical Furnace, the student will be able to locate all external controls and indicators and describe to the instructor their purpose and/or operation with at least 90% accuracy.

Skill Test: The instructor will provide the student with a checklist of controls and indicators to be located. The student will point at each control and indicator according to the list provided. The student must then explain the purpose of each respective control and indicator. The student must respond with a minimum of 90% accuracy.

Additional Resources: None required

Training Aids & Media

1. Overhead projector (2ea) and screen (2ea) or one InTouch remote video display and one overhead projector
2. Pointer and transparency markers
3. Flipchart and markers to take notes
4. Transparencies:
   (1) Course map or course outline
   (2) Fig. 7.1 location of controls & indicators
   (3) Fig. 7.2 watchdog/temp. control drawer
   (4) Fig. 7.3 power distribution drawer panel
   (5) Fig. 7.4 SIC drawer front panel

Transparencies (continued)
   (6) Fig. 7.5 SFC drawer front panel
   (7) Fig. 7.6 EPO button
   (8) Fig. 7.7 robot EMO, Enable, Front door enable/disable switch
   (9) Fig. 7.8 Ampstack front panel
   (10) Fig. 7.9 Patlite™ signal tower
   (11) Fig. 7.10 CAL 9000 temp controller
   (12) Fig. 7.11 lift speed control needle valves

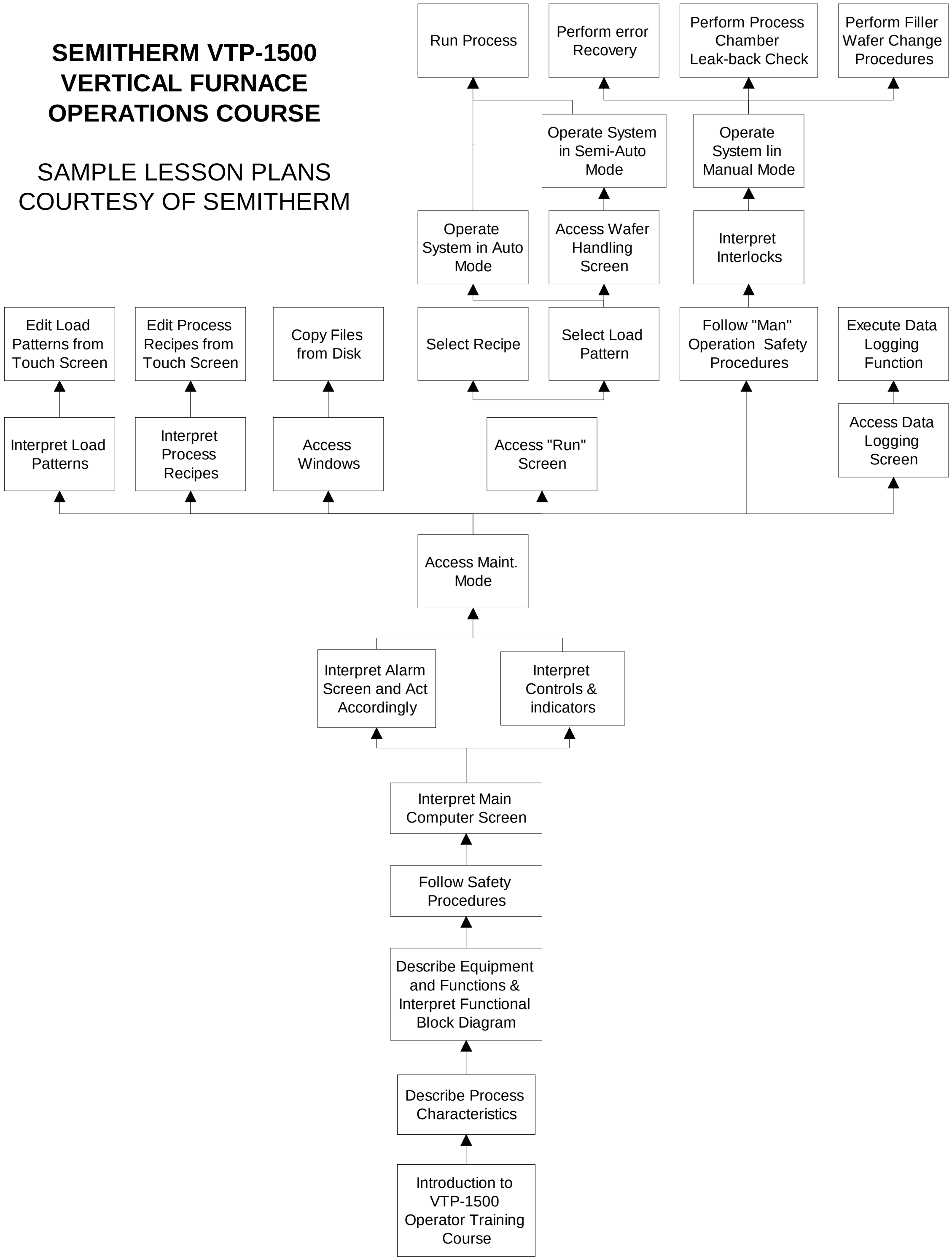
Training Aids & Media
1. VTP-1500 Vertical Furnace or videotape of the VTP-1500 2. InTouch remote monitor (if available)

Relevant Practice Checklist

Relevant Practice Description:
Conditions: The practice session can be accomplished very easily in the classroom with transparencies that can be displayed via the overhead projector.
Modeling Methods: The instructor will use overhead transparencies in the classroom to point our the location and purpose of specific controls and indicators on the VTP-1500. The participants will have a list of the controls and indicators they will be responsible for locating and describing.
Feedback Mechanism: The instructor can provide the feedback indicating correct or incorrect responses on the part of the participants or they can refer to their student guides for the appropriate responses.
Module Content Description: The instructor can use overhead transparencies to show the location of the controls and indicators that the participants are responsible for locating and describing. The modeling and practice can be done in the classroom, but the skill test should be performed on the actual VTP-1500.

SEMITHERM VTP-1500 VERTICAL FURNACE OPERATIONS COURSE

SAMPLE LESSON PLANS
COURTESY OF SEMITHERM



APPENDIX E

Examples of Evaluation Systems

SEMATECH COURSE EVALUATION

Course ________________

Instructor ________________

Date ________________

AFFILIATION / CATEGORY

- ▭ Member Co.
- ▭ Supplier
- ▭ Assignee
- ▭ Direct Hire
- ▭ Other
- ▭ Contractor
- ▭ Temp.
- ▭ Exempt
- ▭ Non-exempt

Rev. 01.05

DEPARTMENT CODE

	0	1	2	3	4	5	6	7	8	9
	0	1	2	3	4	5	6	7	8	9
	0	1	2	3	4	5	6	7	8	9

COURSE DESIGN:

This section determines the effectiveness of the course structure and design:

1. The title and course description match the course content.
   - ❍ Yes ❍ No
2. I understood the course objectives as they were presented.
   - ❍ Agree ❍ Strongly Agree
   - ❍ Disagree ❍ Strongly Disagree (please explain)
3. The content matched the course objectives.
   - ❍ Agree ❍ Strongly Agree
   - ❍ Disagree ❍ Strongly Disagree (please explain)
4. The topics presented in this course are relevant to my job.
   - ❍ Agree ❍ Strongly Agree
   - ❍ Disagree ❍ Strongly Disagree (please explain)
5. The course was organized in an "easy to learn" sequence.
   - ❍ Agree ❍ Strongly Agree
   - ❍ Disagree ❍ Strongly Disagree (please explain)
6. The pace of the course was...
   - ❍ Just right ❍ Too fast ❍ Too slow
7. The length of the course was...
   - ❍ Just right ❍ Too short ❍ Too long
8. I had enough opportunity to practice my new skills.
   - ❍ Always ❍ Usually
   - ❍ Seldom ❍ Not at all (please explain)
9. The course examples, activities, simulations, or demonstrations enhanced my learning.
   - ❍ Agree ❍ Strongly Agree
   - ❍ Disagree ❍ Strongly Disagree (please explain)

COMMENTS

COURSE MATERIALS:

This section addresses the participant's satisfaction with the WRITTEN materials used in the course.

10. The participant materials consistently supported the course.
    - ❍ Always ❍ Usually ❍ Seldom
    - ❍ Not at all ❍ No materials provided
11. The appearance and format of the participant materials were...
    - ❍ Outstanding ❍ Good
    - ❍ Needs Improvement ❍ No materials provided
12. The participant materials were easy to read.
    - ❍ Agree ❍ Strongly Agree
    - ❍ Diasgree ❍ Strongly Disagree
    - ❍ No materials provided
13. The participant materials will be useful to me on the job.
    - ❍ Agree ❍ Strongly Agree
    - ❍ Disagree ❍ Strongly Disagree
    - ❍ No materials provided
14. The audio/visual aids (foils, flipcharts, video, music, etc.) enhanced the course.
    - ❍ Agree ❍ Strongly Agree
    - ❍ Disagree ❍ Strongly Disagree
    - ❍ No audio/visual aids

COMMENTS

INSTRUCTOR:

In this section, the participants rate the instructor(s) effectiveness in leading this course.

15. The instructor was knowledgeable about the topics.
    - ❍ Agree ❍ Strongly Agree
    - ❍ Disagree ❍ Strongly Disagree
    - ❍ This was a self-study course
16. The instructor consistently presented information to support the course objectives.
    - ❍ Always ❍ Usually
    - ❍ Seldom ❍ Not at all

INSTRUCTOR, Cont.:

17. The instructor effectively used examples relevant to SEMATECH and the semiconductor industry.
    - ❍ Always ❍ Usually
    - ❍ Seldom ❍ Not at all

18. The instructor(s) ability to communicate the material was
    - ❍ Outstanding ❍ Good
    - ❍ Needs Improvement ❍ This was a self-study course

19. The instuctor's ability to encourage participation, provide clear feedback, and summarize the main points was...
    - ❍ Outstanding ❍ Good
    - ❍ Needs Improvement

20. The instructor(s) ability to organize and manage the class was...
    - ❍ Outstanding ❍ Good
    - ❍ Needs Improvement ❍ No materials provided

COMMENTS

PARTICIPANT READINESS:
This section deals with the participant's readiness to take the course.

21. This course is in my Development Plan.
    - ❍ Yes ❍ No
    - ❍ No Development Plan yet

22. I had the prerequisite knowledge and skills for this course.
    - ❍ Strongly Agree ❍ Agree
    - ❍ Disagree ❍ Strongly Disagree (please explain)

23. With respect to my current or future job needs, this course was available to me...
    - ❍ Too early ❍ Just in time
    - ❍ Too late

24. I am a member of the target audience for this course as stated in the course description.
    - ❍ Yes ❍ No

COMMENTS

SKILL/KNOWLEDGE IMPROVEMENT:
This section addresses the participant's own perception of competence with the knowledge and skills learned in the class.

25. I will be able to apply what I learned in this course.
    - ❍ Right away ❍ Within 90 days
    - ❍ After 90 days ❍ Not at all (please explain)

26. The course improved my skills and/or my understanding of the course concepts.
    - ❍ Strongly Agree ❍ Agree
    - ❍ Disagree ❍ Strongly Disagree (please explain)

COMMENTS

OVERALL SATISFACTION:
This category determines the participant's level of satisfaction associated with their learning experience and their registration process.

27. I received the correct course information in a timely manner after registering for the course.
    - ❍ Yes ❍ No
    - ❍ Did not register for this class

28. The registration process was easy to use.
    - ❍ Yes ❍ No
    - ❍ Did not register for this class

29. Overall, I was satisfied with this course.
    - ❍ Yes ❍ No (please explain)

30. I would recommend this course to others.
    - ❍ Yes ❍ No (please explain)

31. I learned about this course through (select all that apply)
    - ❍ SEMATECH Learning resource Guide (SLeRG)
    - ❍ VTX System on the computer
    - ❍ Learning by Design Quarterly Newsletter
    - ❍ All-hands Information Items
    - ❍ My manager
    - ❍ Co-workers
    - ❍ Others (please specify)

COMMENTS

Thank you for completing this form. Your information will be used to measure the level of satisfaction with this course and to determine areas for improvement.

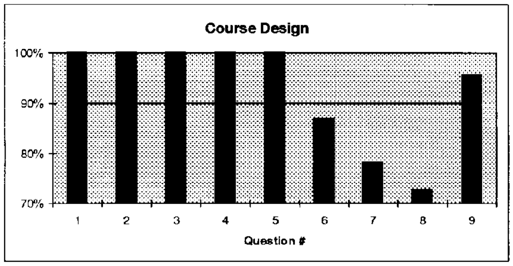
Level 1

COURSE EVALUATION SUMMARY

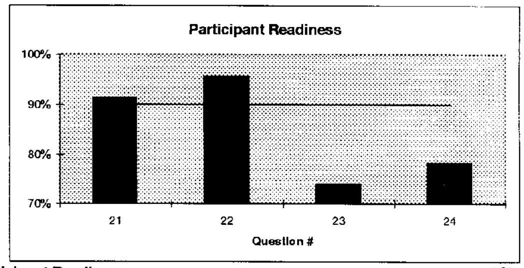
Acceptable levels: 90% and above; bars below 70% are not shown

Attendance= 29 Evaluations= 23

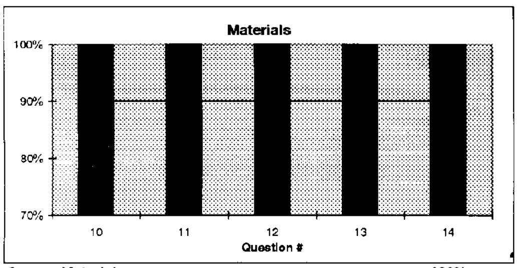
Start Date:	8/30/94	78% were members of the target audience
Class:	Furnace Processes & Related Issues	91% had this course in their development plan
Instructor:	Dennis Villar	9% had no development plan



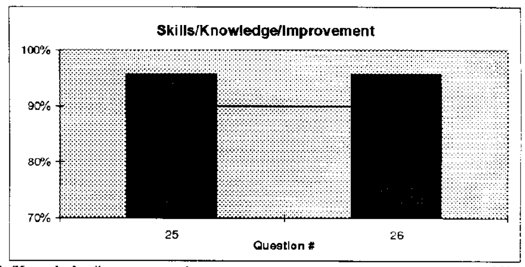
Course Design: **93%**



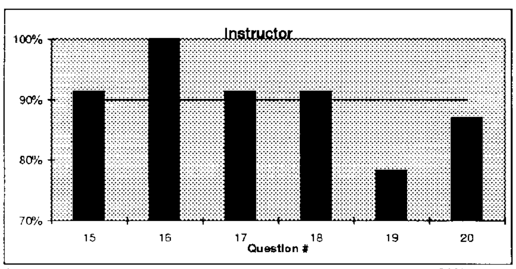
Participant Readiness **85%**



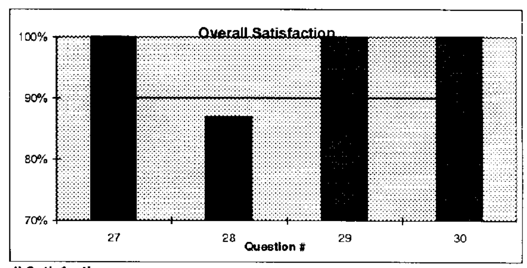
Course Materials: **100%**



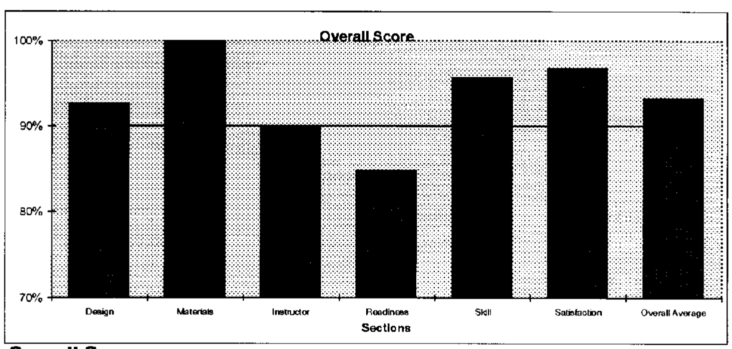
Skills/Knowledge/Improvement **96%**



Instructor **90%**



Overall Satisfaction: **97%**



Overall Score: **93%**

Level 3

Evaluation Flow

1. Write performance-based objectives for the whole course.
2. Determine the metrics that the performance-based objectives should influence.
3. Integrate the performance-based objectives into a matrix to show the relationships between the objectives and the metrics.
4. Get customer agreement regarding the metrics and the training's relationship to influence
the metrics.
5. Develop the course to support the objectives.
6. Utilize Level 3 check sheet for customer indication of level of importance, i.e., H, M, L.
7. Perform Level 2 evaluation to check students' mastery of skills as stated in the course objectives.
8. Utilize Level 3 check sheet for follow-up evaluation of supervisor's and students' perception of whether student is applying learned skills on the job after 3-4 months.
9. For skills being applied, cross-reference to original level of importance rating.
10. For skills being applied, cross-reference the matrix to see which of the metrics should have been affected.
11. Gather the data on the metrics and look for delta on pre-training data vs. post-training data.
12. Report the findings.

MATRIX SHOWING RELATIONSHIP BETWEEN LEARNING OBJECTIVES AND PERFORMANCE METRICS

PERFORMANCE OBJECTIVES	REDUCTION IN # OF ON-SITE FOLLOW-UP CALLS	REDUCTION IN # OF FIELD SERVICE LABOR HOURS	REDUCTION IN TYPE OF FIELD SERVICE CALLS	REDUCTION IN PARTS REPLACEMENT SCHEDULED/ REPAIR
SECTION 3 PM's				
Daily - Perform all daily preventive maintenance tasks using a checklist provided by SEMITHERM				
Weekly - Perform all Weekly preventive maintenance tasks using a checklist provided by SEMITHERM				
Monthly - Perform all Monthly preventive maintenance tasks using a checklist provided by SEMITHERM				
Semi-annual - Perform all Semi-annual preventive maintenance tasks using a checklist provided by SEMITHERM				
Module 7 - Quartz install/removal				
Using specialty tools and knowledge gained in this course, perform a complete quartz install on any configuration of the VTP-1500 Vertical Furnace when furnace is cold				
Using specialty tools and knowledge gained in this course, perform a process tube change with the furnace at standby temperature (400C - 600C)				
Perform an external torch installation and test on a VTP-1500 set up for wet oxidation				
Module 8 - Cassette stand removal and installation				
Completely remove and install the cassette stand of the VTP-1500 Vertical Furnace Load Station				
Module 9 - Genmark Robot Teaching				
Perform a complete robot teaching that allows wafers to be transferred between all stations without rubbing, mis-picks, or dropping of wafers				
Module 10 - VTP-1500 Calibrations and Adjustments				
Perform all necessary calibrations or adjustments on the following areas: Manometers, Butterfly valve, Needle valves, Wafer Transfer Robot				
Module 11 - Process Chamber Leak-back Check Techniques				
Using the Touch screen of the VTP-1500 Vertical Furnace in manual mode, Perform a process chamber leak-back check.				
Module 12 - Vacuum Tree Breakdown and Reassembly				
Completely disassemble, clean, reassemble, and leak check a VTP-1500 Vertical Furnace vacuum system				

Semitherm VPT-1500 Operations Course
Level III Evaluation

Major Course Objectives	Is objective important? (High, Medium, Low) (Supv)	Student Evaluation - Was objective achieved? (Instructor/ Student)	Did supervisor provide opportunity for student to perform objective (Supv)	Did supervisor provide opportunity for student to perform objective (Student)	Did student perform objective (Supv)
	H M L	N\Y I N\Y	N \ *Y	N \ *Y	N \ *Y
2.1) Given a functional block diagram and pictorial drawings, the student will be able to locate and describe the function of the eight specific major subsystems in the VTP-1500 Vertical Furnace to 90% accuracy.					
2.2) Using a normally operating VTP-1500 Vertical Furnace and an instructor provided checklist, the student will be able to locate and describe the components of each of the following major subsystems to items on the checklist to 90% accuracy:					
a) Process Chamber/Heater Element System					
b) Temperature Control System					
c) Gas Delivery System					
d) Exhaust/Pressure Control System					
e) Computer Control System					
f) Water flow Control System					
g) Interlock System					
h) Wafer Transfer System					
2.3) Using instructor provided documentation, the student will be able to identify wafer transfer movement designations and wafer station designations of the VTP-1500 Vertical Furnace to 90% accuracy.					

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Semitherm VPT-1500 Operations Course
Level III Evaluation

Major Course Objectives	Is objective important? (High, Medium, Low) (Supv)	Student Evaluation - Was objective achieved? (Instructor/ Student)	Did supervisor provide opportunity for student to perform objective (Supv)	Did supervisor provide opportunity for student to perform objective (Student)	Did student perform objective (Supv)
	H M L	N \ Y I N \ Y	N \ *Y	N \ *Y	N \ *Y
3.1) Given a list of processes available on the VTP-1500 Vertical Furnace and a list of specific process characteristics, the student will be able to match the characteristics to the process to 90% accuracy.					
4.1) From memory, the student will be able to identify the four classifications of safety hazards associated with working on or around the VTP-1500 Vertical Furnace to 100% accuracy.					
4.2) Given a list of the 8 major functional subsystems described in Module 2, the student will be able to identify which of the 4 classifications of hazards are associated with each of the subsystems and cite at least one example of each to 100% accuracy					
4.3) Given a safety violation scenario by the instructor, the student will be able to describe what consequences may/will occur due to the safety violation.					
4.4) Using a normally operating VTP-1500 Vertical furnace, the student will be able to locate and operate all EPO and EMO switches and give an example of a scenario in which they might be used.					

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LEVEL 4 EVALUATION STRATEGY

A. What will be measured:

Reduction in installation time
Reduction in number of on-site follow-up calls
Reduction in number of emergency requests
Reduction in Field Service labor hours
Reduction in type of Field Service calls
Reduction in damaged warranteed part replacement

B. Sources of Data:

Field Service reports (and Database?)

199_ - 199_ Reduction in installation time
199_ - 199_ Reduction in number of on-site follow-up calls
199_ - 199_ Reduction in number of emergency requests
199_ - 199_ Reduction in Field Service labor hours
199_ - 199_ Reduction in type of Field Service calls
199_ - 199_ Reduction in damaged warranteed part replacement

C. Accounting system to be used:

Excel spreadsheet

D. How data will be analyzed:

Reduction in installation time will be *measured in hours*
Reduction in *number* of on-site follow-up calls
Reduction in *number* of emergency requests
Reduction in Field Service labor *hours*
Reduction in *type* of Field Service calls
Reduction in *damaged warranteed part replacement*

E. When and how results will be reported and to whom:

A formal written report will be generated and an information briefing will be held to communicate results of the study to:

R. Thompson
S. Thompson
T. Manley

F. Collect and reduce the data:

Cost of Training system (actual or projected)
Benefits accruing from Training (actual or projected)

G. Analyze the data:

Compare costs and benefits
Develop conclusions and recommendations

H. Report findings:

Prepare a formal written report
Present an information briefing

NOTES FOR MATRIX/TECHNICAL SERVICE SUMMARY REPORT

The purpose of the matrix is to show correlation of course/module learning objectives to the metrics which have been selected as indicators of performance.

> Subject matter experts should complete the matrix by marking the DOWNTIME CODE SHEET associated with the objective in the respective column <u>only</u> if a student's mastery of the given performance objective would favorably impact the metric.

This information will be used in conjunction with the Level 3 evaluation check sheet for those performance objectives (skills/behaviors) which have transferred from training to "on-the-job" application. Pre and post training data from the Technical Service Monthly Summary Report
will be compared. This data will be collected by the Field Service Representative at the time of repair and reported on the "Technical Service Summary Report."

NOTE: The "Reason for Downtime" should be selected from those which are most common and which are related to the course performance objectives from the matrix. Again, the subject matter experts should be the persons to select these.

DOWNTIME CODE SHEET

REASON FOR DOWNTIME	CODE
SYSTEM WILL NOT PUMP DOWN TO SETPOINT	A
PROCESS GAS WILL NOT FLOW / INCORRECT FLOW	B
ROBOT WILL NOT LOAD WAFERS	C
ROBOT WILL NOT PREALIGN WAFERS	D
SYSTEM WILL NOT CONTROL PROCESS PRESSURE	E
QUARTZ REMOVAL & REPLACEMENT	F
PYRO TORCH REMOVAL & REPLACEMENT	G
ELEMENT WILL NOT RAISE & LOWER	H
JAR WILL NOT RAISE & LOWER	I
FURNACE WILL NOT MAINTAIN TEMPERATURE SETPOINT	J
ELEMENT WILL NOT ENABLE	K
PROCESS GAS VALVE WILL NOT OPEN	L
CASSETTE NOT IN POSITION	M
COOLING WATER FAILURE	N
BASEPLATE TEMPERATURE CONTROL FAILURE	O
THERMOCOUPLE FAILURE	P
WEEKLY PM	Q
MONTHLY PM	R
SEMIANNUAL PM	S
OTHER	T

14/9/94

MATRIX SHOWING RELATIONSHIP BETWEEN LEARNING OBJECTIVES, PERFORMANCE METRICS AND DOWNTIME CODES

PERFORMANCE OBJECTIVES		REDUCTION IN # OF FIELD SERVICE LABOR HOURS TO PERFORM TASK	REDUCTION IN FIELD SERVICE CALLS	REDUCTION IN PARTS REPLACEMENT (SCHEDULED/ REPAIR)
MAINTENANCE COURSE: Module xx				
7.4	Using documentation provided by the instructor and a normally operating VTP-1500 Vertical Furnace Wafer Transfer System, the student will be able to calibrate (teach) the Genmark Gencobot IV robot to transfer wafers between all wafer stations without damage to the stations, furnace, or the wafers.	C, D	C, D	C, D
8.1	Given a written procedure from Genmark, the student will be able to perform all preventative maintenance procedures on the Gencobot IV Robot to 100% accuracy.	C, D	C, D	C, D
9.2	Using a normally operating VTP-1500 Vertical Furnace and knowledge gained in the class, the student will be able to check the operation of the element shroud seal and confirm correct operation.	H	H	H
9.3	Using a normally operating VTP-1500 Vertical Furnace and documentation outlining jar/element lift speed adjustment, the student will be able to adjust the vertical speed of the jar or element up or down so the element travels at a speed between 30~60 seconds from top to bottom and the jar travels between 15~30 seconds from top to bottom.	H, I	H, I	
11.2	Using an instructor provided procedure and a normally operating VTP-1500 Vertical Furnace, the student will be able to remove, check, and replace any O-ring in the system without damage to the O-ring or injury to personnel.	A, E	A, E	A, E
12.2	Using an instructor provided procedure and a normally operating VTP-1500 Vertical Furnace, the student will be able to locate, remove and replace the process chamber thermocouples (three spike, one profile) without damage to the thermocouples, furnace, or wafers, and without injury to personnel.	J, O, P	J, O, P	J, O, P

14/9/94

13.3 Using specialty tools, a normally operating VTP-1500 Vertical Furnace at room temperature, and an instructor provided procedure, the student will be able to perform a complete quartz removal and installation on the VTP-1500 Vertical Furnace without damage to the quartz or furnace, or without injury to personnel.	F	F	F
15.3 Using an instructor provided procedure and a normally operating VTP-1500 Vertical Furnace configured for steam oxidation, the student will be able to perform a complete pyrogenic torch install, set-up, and test so the torch operates normally without damage to any furnace components or injury to any personnel.	G	G	G
17.2 Using knowledge gained in Module 13 and instructor provided specifications, the student will be able to set the base plate cooling water flow rate, the base plate temperature setpoint, and baseplate overtemp setpoint so the baseplate temperature control system operates correctly.	N, O	N, O	N, O
18.2 Using an instructor provided procedure, knowledge gained in Module 13 , and a normally operating VTP-1500 Vertical Furnace, the student will be able to set and test the process chamber over temperature setpoints so the proper sequence of events occurs when an individual zone overtemp condition occurs.	K	K	
20.1 Using an instructor provided procedure and a normally operating VTP-1500 Vertical Furnace, the student will be able to calibrate the vacuum system throttle valve so the process chamber pressure is within spec. when the throttle valve is used to control pressure.	E	E	E
23.1 Using gas pressure specs, a procedure provided by the instructor, and a normally operating VTP-1500 Vertical Furnace, the student will be able to correctly set all process and non-process gas pressures so the furnace operates correctly.	B, L	B, L	B, L
23.2 Using an instructor provided procedure, the student will be able to locate, check, and adjust the H_2:O_2 Ratio Board so the board generates an alarm whenever the H_2 to O_2 gas flow ratio exceeds 1.85:1.	B	B	B, F

TECHNICAL SERVICE SUMMARY REPORT

#	DOWN TIME CODE	DATE OF REPAIR/ SERVICE	# HOURS TO REPAIR/ SERVICE	$ PARTS SCHEDULED P/M	$ PARTS FAILED OR DAMAGED	NAME OF FSE	COMMENTS (include symptoms & corrective action)
1	E	1/3/94	2			John Doe	Cleaned butterfly valve and leak checked
2	C	1/4/94	2			John Doe	Mispick wafer #25 re-leveled cassette stage m3 & m4
3	T	1/5/94	1			John Doe	Uniformity has been high the last 5 runs. Found the DCS injector loose
4	T	1/6/94	2			John Doe	High particles. Found that night shift had 2 fillers break from thermal. Replaced fillers and vac.d FS area
5	O	1/7/94	1			John Doe	Baseplate overtemp repeatedly. Found TC to Cal 9900 loose connection
6	E	1/7/94	4			John Doe	Jar overpressure. House exhaust fluctuation. Installed Tee inline exhaust for a venturi on exhaust line
7	Q	1/7/94	2			John Doe	Weekly pm. Cleaned butterfly valve & foreline
8	T	3/29/94	10			John Doe	Dep rate per min jump up 2 Ang. Checked temp., manometer, Tws and metrology. Also refractive index, found old manometer 1Torr span drifted high. Replaced 1 Torr.
9	A	3/15/94	2.5			John Doe	Vacuum vent alarm. Nitride build-up around bellows/base of Hi Vac valve.
10	A	3/11/94	2.5			John Doe	Pump down failure. Soft needle valve clogged up cleaned/leak checked
11	A	3/4/94	2.5			John Doe	Pump down failure. Nitride buildup around bellows/base of High Vac valve
12	O	3/3/94	1			John Doe	Base plate overtemp. Increased water flow
13	A	1/9/94	4			John Doe	Abort for pump failure. Pump silencer clogged up. Cleaned muffler
14	E	1/11/94	5			John Doe	Aborted for pressure control. Cleaned butterfly valve, rebuilt exhaust valve V2 leak
15	T	1/17/94	1.5			John Doe	Front door would not close. Chain broke. Replaced
16	B	1/18/94	3			John Doe	Aborted for no gas flow. Replaced gate valv+H36e
17	C	1/19/94	14			John Doe	Prealigner would turn 1/4 turn and servo off. Bad prealigner motor. Replaced robot and controller
18	T	1/23/94	0.5			John Doe	SIC/SFC not communicating. Reset SFC & SIC

TECHNICAL SERVICE SUMMARY REPORT

MONTH ______________

CUSTOMER/LOCATION ______________

DOWN TIME CODE	DATE OF SERVICE/ REPAIR	# HOURS TO REPAIR/ COMPLETE	$ PARTS		FRACUS CODE	NAME OF FSE	COMMENTS (Include corrective action)
			SCHEDULED P/M	FAILED/ DAMAGED			

APPENDIX F

SEMATECH Learning Resource Guide

Chapter 5: Transfer of SEMATECH Courses

Technology Transfer #92061162D-TRG

Introduction to Course Transfers

Purpose

The SEMATECH technology transfer process makes technology and knowledge available to SEMATECH and SEMI/SEMATECH member companies. Materials for many courses developed or acquired by SEMATECH are available through this process. Course materials are provided for internal review or for internal instruction to employees, suppliers, and customers.

SEMATECH and SEMI/SEMATECH members may realize substantial savings in course development costs when they are able to apply the materials as designed.

Non-Transferable Courses

SEMATECH contracts with a number of training providers to develop responses to training needs. Many of the courses described in this document are owned by external providers and are not available through Technology Transfer.

The descriptions of those courses include a notation that the course is contracted with a training provider. Chapter 7 contains a comprehensive listing of training suppliers currently providing services to support the SEMATECH curriculum.

Ordering Documents

To request SEMATECH technology transfer documents, use the form on page 5-6.

Intent to Course Transfers

Introduction

The technology transfer document for a given course contains the materials necessary to support the intended purpose of the transfer. The intent may be to support instruction of the course, or it may be to provide materials for benchmarking or course development.

Course Instruction

When the materials transfer includes the participant guide, instructor guide, and visual aids, the purpose of the transfer is to support instruction of the course.

Support materials or equipment such as videos, catapults, or calculators are not included in the transfer package. Information about the equipment and materials required, along with a source for purchasing, is included in the instructor guide provided with the course materials.

Course Benchmarking Development

When the transfer document includes only the participant guide, the material may be useful in benchmarking or in course development.

In these cases, SEMATECH does not intend to transfer instructional capability.

Conditions of Transfer

To protect SEMATECH and the copyright/license agreements with our training suppliers, some restrictions may apply to the use of the materials. The restrictions will be clearly outlined in the introductory letter that accompanies the technology transfer document.

Materials Currently Available for Transfers

List of Courses

The following courses are currently available for transfer.

Capacitance-Voltage Measurements
Participant guide, visual aids
Transfer Number: 93021492A-TRG

Continuous Process Improvement*
Participant guide, instructor guide, visual aids
Transfer Number: 93031543A-TRG

Cost of Ownership
Participant guide
Transfer Number: 91020473B-GEN

Cycle Time Improvement*
Participant guide, instructor guide, visual aids
Transfer Number: 93011457A-TRG

Design of Experiments
Participant guide, instructor guide, visual aids
Transfer Number: 91120781A-ENG
Note: Course design is based on RS/1 software.

Design Practices for Higher Equipment Reliability
Participant guide, instructor guide, visual aids
Transfer Number: 93102065A-TRG

Introduction to Contamination Control in Semiconductor Manufacturing Equipment
Participant guide, instructor guide, visual aids
Transfer Number: 92101317A-TRG

Introduction to Statistical Methods
Participant guide, instructor guide, visual aids
Transfer Number: 91110769A-ENG
Note: Course design is based on RS/1 software.

Introduction to Measurement Capability Analysis
Participant guide, instructor guide, visual aids
Transfer Number: 91090709A-ENG
Note: Course design is based on RS/1 software.

Introduction to Total Quality*
Participant guide, instructor guide, visual aids
Transfer Number: 92041045B-TRG

*From the *Partnering for Total Quality* curriculum

Materials Currently Available for Transfers, continued

List of Courses, continued

Mass Flow Control in a Semiconductor Process
Participant guide, instructor guide, visual aids
Transfer Number: 93021493A-TRG

Partnering*
Participant guide, instructor guide, visual aids
Transfer Number: 92081241A-TRG

Passive Data Collection
Participant Guide, Instructor Guide, Visual Aids
Transfer Number: 91090684A-ENG
Note: Course design is based on RS/1 software.

Problem Solving*
Participant Guide, Instructor Guide, Visual Aids
Transfer Number: 91060578B-TRG

Reliability Overview
Participant guide, instructor guide, visual aids
Transfer Number: 93102064A-TRG

Software Inspections*
Participant guide
Transfer Number: 92061180A-TRG

Software Quality Engineering*
Participant guide
Transfer Number: 92101312A-TRG

Software Quality Engineering for Managers*
Participant guide
Transfer Number: 92111389A-TRG

Statistical Methods I
Participant guide, instructor guide, visual aids
Transfer
Number: 92101344B-TRG

Statistical Methods for Efficient Management
Participant Guide and 5 videos
Transfer Numbers: 92041040A-TRG 90050253A-TRG
91060558A-TRG 91060559A-TRG
91060560A-TRG 91060561A-TRG

Team Member Skills*
Participant Guide, Instructor Guide, Visual Aids
Transfer Number: 92041100A-TRG

*From the *Partnering for Total Quality* curriculum

Transfers Planned for 1995

List of Courses

The following courses will become available for transfer in 1995.

Capacity Utilization Bottleneck Efficiency System (CUBES)
Participant guide

Failure Mode and Effect Analysis (FMEA)
Participant guide
Transfer Number: 93102063A-TRG

Instructor guide and visual aids
Transfer Number: 94122657A-TRG

Failure Reporting, Analysis, and Corrective Action System (FRACAS)
Participant guide
Transfer Number: 94022236A-TRG

Instructor guide and visual aids
Transfer Number: 94122656A-TRG

Furnace Processes in Semiconductor Manufacturing
Participant guide, instructor guide, visual aids

Performance-Based Equipment Training
Participant guide, instructor guide, visual aids

Tactical Software Reliability
Participant guide
Transfer Number: 94092525A-TRG

Tactical Software Reliability
Instructor guide and visual aids
Transfer Number: 94122658A-TRG

*From the *Partnering for Total Quality* curriculum

Technology Transfer Distribution Requisition

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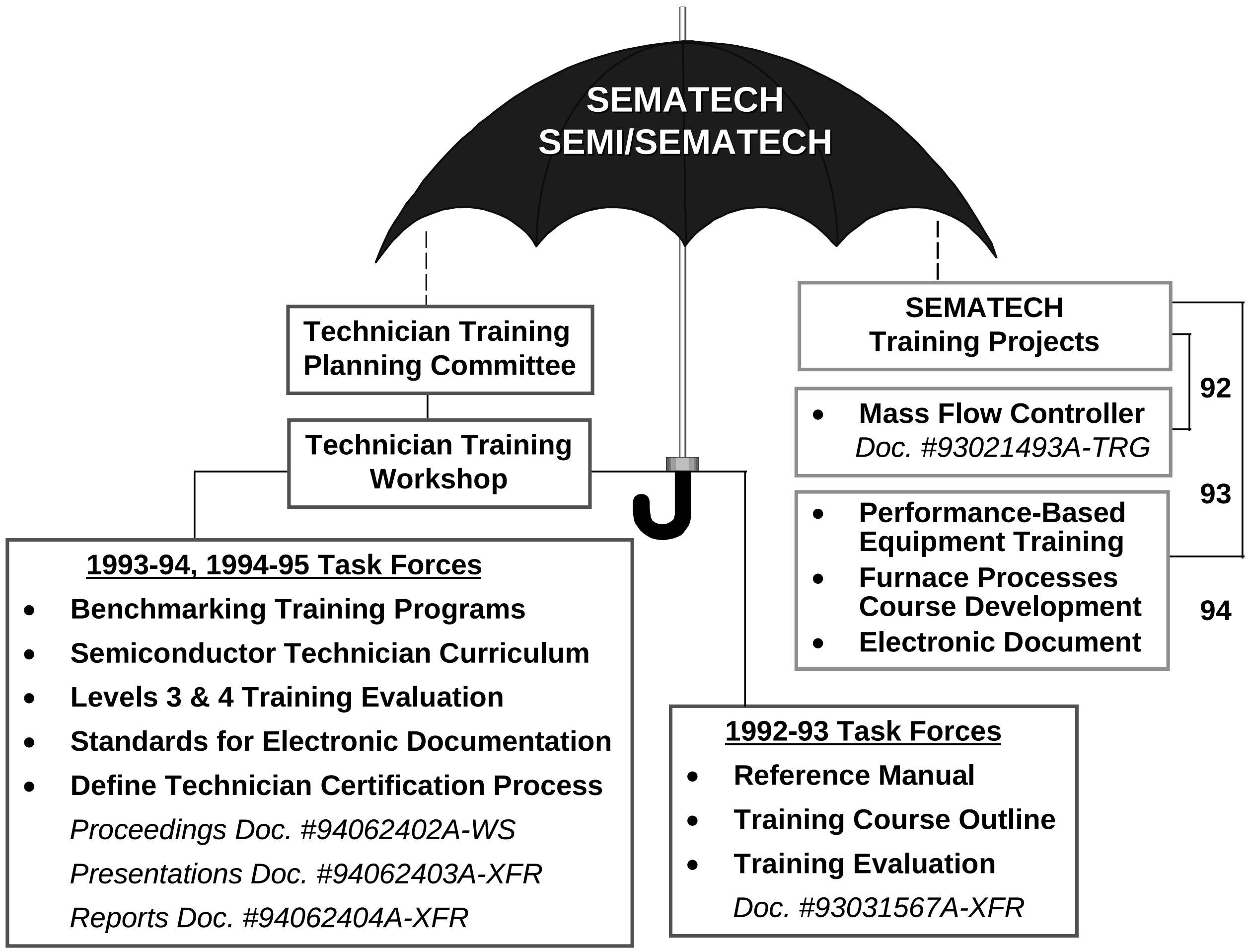
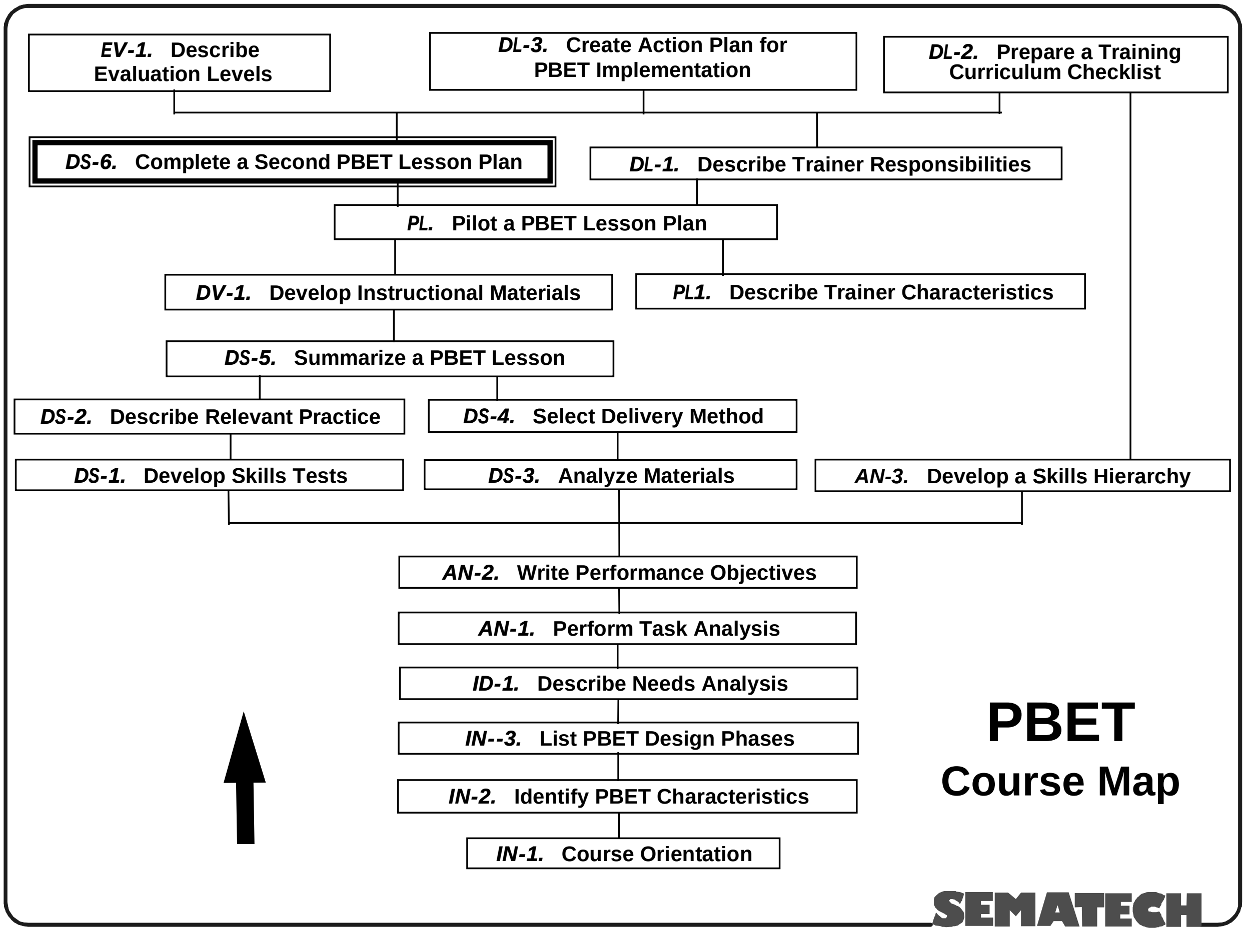

SEMATECH
SEMI/SEMATECH
Technician Training Planning Committee
Technician Training Workshop
1993-94, 1994-95 Task Forces
• Benchmarking Training Programs
• Semiconductor Technician Curriculum
• Levels 3 & 4 Training Evaluation
• Standards for Electronic Documentation
• Define Technician Certification Process
Proceedings Doc. #94062402A-WS
Presentations Doc. #94062403A-XFR
Reports Doc. #94062404A-XFR
1992-93 Task Forces
• Reference Manual
• Training Course Outline
• Training Evaluation
Doc. #93031567A-XFR
SEMATECH Training Projects
• Mass Flow Controller
Doc. #93021493A-TRG
• Performance-Based Equipment Training
• Furnace Processes Course Development
• Electronic Document
92
93
94



EV-1. Describe Evaluation Levels
DL-3. Create Action Plan for PBET Implementation
DL-2. Prepare a Training Curriculum Checklist
DS-6. Complete a Second PBET Lesson Plan
DL-1. Describe Trainer Responsibilities
PL. Pilot a PBET Lesson Plan
DV-1. Develop Instructional Materials
PL1. Describe Trainer Characteristics
DS-5. Summarize a PBET Lesson
DS-2. Describe Relevant Practice
DS-4. Select Delivery Method
DS-1. Develop Skills Tests
DS-3. Analyze Materials
AN-3. Develop a Skills Hierarchy
AN-2. Write Performance Objectives
AN-1. Perform Task Analysis
ID-1. Describe Needs Analysis
IN--3. List PBET Design Phases
IN-2. Identify PBET Characteristics
IN-1. Course Orientation
PBET
Course Map
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