



Job Profile Report

**Micro Electrical Mechanical Systems
(MEMS)**

Sandia National Laboratory

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Executive Summary

This job profile report presents the results of an ACT WorkKeys[®] job analysis of the Micro Electrical Mechanical Systems (MEMS) Process Technician job at the Sandia National Laboratory (SNL) in Albuquerque, NM. The profile was conducted by Central New Mexico Community College's ACT authorized job profiler David Licht, to establish a comprehensive list of essential tasks and identify the WorkKeys skill levels necessary for entry level and effective performance of the Process Technician job at SNL.

Mr. Licht toured SNL's semiconductor fab facility and completed required safety training for SNL. Mr. Licht job shadowed Christine Gallardo and Christina Dallo Senior Process Technicians during several visits in 2005.

Mr. Licht met with Ms. Gallardo and Ms. Dallo several times to complete the job profile between January 12, 2006 and April 26, 2006. During the profile sessions, the groups developed task lists that accurately and completely describe the job. The SMEs reviewed all nine WorkKeys skills and determined that eight are required: Applied Mathematics, Business Writing, Listening, Locating Information, Observation, Reading for Information, and Teamwork. The group identified appropriate levels for job entry and for effective performance.

The profile results shown in Table 1 indicates skill requirements for job entry skill level, effective performance skill level, and the number and percentage of tasks that require each skill. Entry into the Process Technician job at SNL was defined as an employee's first day in the job. Employees should be expected to come into the job with the skills shown; they are not expected to learn these skill levels while in the job. Effective performance is the point at which an employee performs competently without continuous supervision. The results shown in Table 1 indicate skill requirements and may be used for identifying training needs.

Table 1. Profile Results

WorkKeys Skill	Skill Level Range	Entry Skill Level	Effective Performance Skill Level	Number of Tasks Requiring This Skill	Percent of Tasks Requiring This Skill
Applied Mathematics	3-7	4	4	19	13%
Applied Technology	3-6	3	3-4	24	16%
Business Writing	1-5	4	4	19	13%
Listening	1-5	3*	5	22	15%
Locating Information	3-6	5	6	64	42%
Observation	3-6	5**	6	135	89%
Reading for Information	3-7	5	5	24	16%
Teamwork	3-6	3***	5	27	18%

* After three months must be up to a four.

** After three months must be up to a six.

*** After two months must be up to a five.

Table 2. Skill Criticality Ranking

	WorkKeys Skill
Most Critical	Observation
	Locating Information
	Listening
	Reading for Information
	Business Writing
	Teamwork
	Applied Technology
Least Critical	Applied Mathematics

Recommendations

In addition to emphasizing the skills, skill levels, and ranking of skills identified in the job profile for SNL, multitasking was also identified as a key skill required. Curriculum for students to develop this skill could also be developed and implemented.

Job Profiling Procedure

WorkKeys job profiling is conducted by job profilers who have been trained and authorized by ACT WorkKeys Industrial/Organizational Psychologists. The profiling procedure is designed to systematically develop accurate profiles through a **task analysis** that is used to select the tasks most critical to a job, and a **skill analysis** that is used to identify the skills and skill levels required at the entry level and for effective performance on that job.

Task Analysis

The first step in conducting the profile was to develop a Final Task List showing the critical tasks of the job. Each group worked to develop one list. To begin the task analysis, Mr. Licht first developed an Initial Task List using the *Dictionary of Occupational Titles* database in the WorkKeys profiling software, SNL job descriptions, resources from similar job profiles, and information gathered from the tour of the facility. The job profiler then met with the SMEs to tailor the Initial Task List to make sure that the resulting Final Task Lists would accurately and completely describe the job. The SMEs deleted any task statements they considered unrelated to the job, revised some task statements, and added tasks they considered critical to the job.

Then the SMEs evaluated each task in terms of its Importance and the time they spend on that task relative to the time they spend on other tasks (Relative Time Spent). The mean Importance rating for each task was multiplied by the mean Relative Time Spent rating for each task to produce the Criticality rating for each task. These ratings represent aggregate information rather than information reached by the consensus of the SMEs. The criticality information was used to sort the task statements, placing the most critical tasks at the beginning of the list. The groups

confirmed that the tasks on their respective lists were critical to the job. The Final Task List can be found in the Final Task List section of this report.

Skill Analysis

The SMEs completed a skill analysis to identify the on-the-job behaviors associated with the WorkKeys skills under consideration and to identify how the skills are used on the job. The skills were reviewed one at a time, and the SMEs finished the analysis for one skill before going on to the next. The job profiler gave each SME a copy of the skill definition, read the definition aloud, and then answered any SME questions. Once the SMEs understood the definition of a WorkKeys skill and had determined its relevance to the job, they independently identified the tasks on their Final Task Lists that require the skill and specified how employees use the skill to perform the tasks.

Mr. Licht presented detailed descriptions of the WorkKeys skill levels to the SMEs and showed them examples of problems or situations employees deal with at each level. The SMEs reviewed nine WorkKeys skills: Applied Mathematics, Applied Technology, Business Writing, Listening, Locating Information, Observation, Reading for Information, Teamwork, and Writing. They determined that eight are most important (all except Writing), and they identified appropriate levels for job entry and for effective performance.

Skill Analysis Documentation

The WorkKeys skills are presented in order, from those most critical to job performance to those least critical.

OBSERVATION

The WorkKeys Observation skill is an employee's skill in paying attention to and remembering work-related instructions, demonstrations, and procedures and in noticing details among distractions.

Observation was ranked as the most critical skill based on SMEs rankings, the fact that 24 of the 25 most critical tasks utilizing this skill, and the fact that 135 (or 89%) of the tasks listed by the SMEs utilized the Observation skill

The SMEs were shown Observation skill Levels four (4) through six (6). In determining the level of skill necessary for the tasks of the job, the SMEs considered the following five characteristics:

- the complexity of the procedures,
- how fast the information is presented,
- the availability of hints or reminders,
- the amount of distractions, and
- the subtlety of the differences in details that they must notice.

The SMEs determined that an entry level person could come into the job with an Observation Skill Level five, but that within three months the employee would have to be up to an Observation Skill Level six. This is the same level that the effective performer must have, and is the highest level of the Observation skill.

LOCATING INFORMATION

The WorkKeys Locating Information skill is an employee's skill in using information taken from workplace graphics such as diagrams, maps, floor plans, tables, forms, graphs (including bar charts, pie charts, and line graphs), flowcharts, and instrument gauges. Employees use this skill

when they find information in a graphic or insert information into a graphic. They also use it when they compare, summarize, and analyze information found in related graphics.

Locating Information was ranked as the second most critical skill based on SME rankings, the fact that 22 of the top 25 most critical tasks required this skill, and the fact that 64 (or 42%) of all tasks required the Locating Information skill. Numerous complex computer menus and wafer databases must be utilized to process the wafers.

The Locating Information skill level required for a job is determined by the complexity of the graphic(s) used to accomplish a task, and the complexity of the task(s) performed. The SMEs compared the tasks of their job to WorkKeys Locating Information skill Levels four through six.

The SMEs determined that an entry level person could come into the job with a Locating Information Skill Level five. An effective performer (i.e., fully trained and experienced) would have to have a Locating Information Skill Level six, which is the highest level of this skill.

LISTENING

The WorkKeys Listening skill is an employee's skill in receiving verbal information and relaying it to another person in writing. Employees must hear a message, write it down, and give it to another person in written form.

Listening was ranked as the second most critical skill based on SME rankings, the importance of accurately utilizing work related verbal instructions and information, and the fact that 22 (or 15%) of all tasks required the Listening skill.

When considering the level of Listening skill necessary for the tasks of the job, the SMEs considered how accurate and detailed their messages are required to be. The SMEs compared their work situation to WorkKeys Listening skill Levels three through five.

The SMEs determined that an entry level person could come into the job with a Listening Skill Level four, but they would have to achieve a Listening Skill Level four within three months. An

effective performer (i.e., fully trained and experienced) would have to have a Listening Skill Level five, which is the highest level of this skill.

READING FOR INFORMATION

The WorkKeys Reading for Information skill is an employee's skill in reading and understanding work-related written texts.

Reading for Information was ranked as the fourth most critical skill based on SME rankings, and the fact that 24 (or 16%) of all tasks required the Reading for Information skill.

When evaluating the level of the Reading for Information skill necessary for the tasks of the job, the SMEs considered the difficulty of the written texts employees must read and how hard it is for employees to find and make use of the information they need in them. The SMEs evaluated their work situation in comparison to WorkKeys Reading for Information Skill Levels four through six.

The SMEs determined that an entry level person could come into the job with a Reading for Information Skill Level five, which is the same level required for the effective performer (i.e., fully trained and experienced). The Reading for Information Skill Levels range from 3-7.

BUSINESS WRITING

The WorkKeys Writing skill is an employee's skill in writing an original response to a work-related situation.

Business Writing was ranked as the fifth most critical skill based on SMEs rankings, the fact that 135 (or 89%) of the tasks listed by the SMEs utilized the Business Writing skill, and the importance of accurately documenting the work they had done on the wafers.

When considering the level of Business Writing skill necessary for the tasks of the job, the SMEs considered the importance of sentence structure, mechanics, grammar, word usage, tone and word choice, organization and focus, and development of ideas prior to using a spell checker,

grammar checker or review by others. The SMEs compared their work situation to WorkKeys Business Writing Skill Levels three through five.

The SMEs determined that an entry level person could come into the job with a Business Writing Skill Level four, which is the same level required for the effective performer (i.e., fully trained and experienced). The Business Writing Skill Levels range from 1-5.

TEAMWORK

The WorkKeys Teamwork skill is an employee's skill in choosing behaviors that support the relationships among team members and lead toward the accomplishment of work tasks. In order for a team to fit the WorkKeys criteria, the team members must have a common goal, share responsibility for achieving that goal, and interact with each other.

Teamwork was ranked as the sixth most critical skill based on SMEs rankings, the fact that 27 (or 18%) of the tasks listed by the SMEs utilized the Teamwork skill, and the importance of effectively working with their peers, lot owners, engineers and other involved personnel..

When considering the level of Teamwork skill necessary for the tasks of the job, the SMEs considered the following: clarity of goals and consequences of the team's actions, availability of resources needed, number of problems and alternative solutions, how challenging it is for team members to work towards the goals. The SMEs compared their work situation to WorkKeys Teamwork skill Levels three through six.

The SMEs determined that an entry level person could come into the job with a Teamwork Skill Level three, but they would have to achieve a Teamwork Skill Level five within two months, the same level required for the effective performer (i.e., fully trained and experienced). The Teamwork Skill Levels range from 3-6.

APPLIED TECHNOLOGY

The WorkKeys Applied Technology skill is an employee's skill in solving problems with machines and equipment found in the workplace. This skill includes four areas of technology: mechanics, electricity, thermodynamics, and fluid dynamics.

Applied Technology was ranked as the seventh most critical skill based on SMEs rankings and the fact that 24 (or 16%) of the tasks listed by the SMEs utilized the Applied Technology skill.

When considering the level of Applied Technology skill necessary for the tasks of the job, the SMEs considered the complexity of the system and the physical principles involved. The SMEs compared their work situation to WorkKeys Applied Technology skill Levels three and four.

The SMEs determined that an entry level person could come into the job with an Applied Technology Skill Level three. The effective performer (i.e., fully trained and experienced) needs an Applied Technology Skill Level 3-4. The Applied Technology Skill Levels range from 3-6.

APPLIED MATHEMATICS

The WorkKeys Applied Mathematics skill is an employee's skill in applying mathematical reasoning and problem-solving techniques to work-related problems. Nineteen (or 13%) of the tasks performed by Process Technicians required the Applied Mathematics skill. Only two of tasks requiring the Applied Mathematics skill were in the top 20 critical tasks required to performing this job. This skill was ranked as least critical by the SMEs due to the few number of tasks requiring this skill.

In evaluating the level of Applied Mathematics skill necessary for the tasks of the job, the SMEs considered the types of mathematical operations (including single-step or multiple-step mathematical operations and conversions either within or between systems of measurement); how the information in the problem is presented (i.e., the information is presented in the order in which it is needed or it must be reordered); and whether all the information employees need for solving problems is provided or if they must derive some necessary information. The SMEs compared the tasks of their job to WorkKeys Applied Mathematics Skill Levels three through five. In setting the skill level required, it is assumed that an employee would have access to a calculator and/or formula sheet if needed to perform calculations.

The SMEs decided that an Applied Mathematics Skill Level four was required for both the entry and effective performer jobs. The Applied Mathematics Skill Level range is 3-7.

Final Task Lists

Tasks are presented in order, from those most critical to job performance to those least critical. . The names of the WorkKeys skills have been abbreviated to save space, as follows: Applied Mathematics (AM), Applied Technology (AT), Business Writing (BW), Listening (L), Reading for Information (LI), Observation (OB), Reading for Information (RI), and Teamwork (TW).

Table 3

SNL Litho/Photo Technologist Task List

	AM	AT	BW	L	LI	OB	RI	TW
<u>Task</u>	Applied Mathematics	Applied Technology	Business Writing	Listening	Locating Information	Observation	Reading for Information	Teamwork
Microscope Inspection – Macro and Micro. (Note: Technologists must be able to multi task – the individual determines how to do this within requirements.)								
Macro look for particles, speedboats.								
Micro: uses microscope to look at reticule ID (Layer ID), Check for gross misalignment and defects.								
If anomaly found, photos acquired and placed in the lot problem data base with location, wafer number etc so that lot owner can find the issue.								
Visual inspection-looking for scrumming and clarity of feature. Verify wafer count and lot ID.								

Operates machines and equipment used in production of semiconductor wafers, Microsystems (MEMS), such as alignment equipment, automatic developer. Tests processed wafers to evaluate performance of machines and equipment.

i. Test Wafers are utilized to check clustered tools

1. Eo, CD monitor
2. Eo-for clearing energy
3. Trend CD data
 - a. Min/Max, Sigma and Mean for CD's
 - b. 9 sites/wafer
 - c. Input into spread sheet
4. Run 12 wafers – check 4 wafers
 - a. Coated/developed on different “chucks”
 - b. Look at trends
 - c. Goal is to run every day on every cluster
5. Interpret and Analyze trend data
6. On New reticule sets and specific layers
 - a. FEM – Focus Exposure Matrix
 - i. Find best Focus – based on Side Wall slope
 - ii. Determine optimum exposure based on CD target.

iii. Strip wafer and run lot with determined focus and exposure.

iv. Use SEM when measuring.

7. Scumming is excess photo resist. Over exposure may clear out scumming.

Inspection consists of: visual inspection, box-in-box, pattern itself, LCF (looks intact, features clear), verify correct reticule used, full visual sweep across wafer, center-bottom-left-right-top, particles on wafer may be difficult to determine if it is this layer or previous layer; sign Traveler, initialing. Look for specific defects including "mouse or shark bites", flares, speedboats. Determine if defect's) are “rework able” or should be sent on.

Data in several different data bases – must be able to find a variety of data and pull together to process lot.

Makes decision: many lot has some problem (scumming, focus, and/or exposure), question is it large enough to require reworking or will reworking cause other more significant problems.

Use multi layered menus in completing computer driven tasks.

AM	AT	LI	OB	
			OB	
			OB	
AM		LI	OB	RI
			OB	
		LI	OB	

Ability to be able to run at a fast pace and then be able to stop, carefully document, or inspect, or receive instructions from engineering.

BW L RI TW

Use Accent Q 200 tool to check alignment, e.g., box in box measurement. Also be able to write recipe

- i. Automated tool
- ii. Write recipe per spec (sample plan)
- iii. Output: Min/Max – if out of spec, take offsets at 70% and re-run lot. Use averages to re-run lot.
- iv. Look at historical data to run current lot.
- v. Lot goes on hold in general for misalignment other than mark shift.
- vi. More experienced can differentiate between scaling, MS, etc.
- vii. Scaling is routine in the MEMS area
- viii. Enter offsets into data base
- ix. WGA, wafer global alignment.
 - 1. On stepper as the lot runs
 - 2. Vary the focus offset and illumination for each failed WGA mark.
 - 3. If it doesn't work – need to abort the tool and recover the wafers from the link. "A nightmare"
 - a. Specific sequence
 - b. Manually fish out the wafers
 - c. Make sure all wafers are accounted for
 - d. Reboot sequence is critical as well as timing
 - e. Takes about 20minutes (patience)
 - 4. If the wafers measure to be out of spec when historically tool trends have been very stable, high probability tool needs maintenance – tool owner is called.

5. Rework run utilizes a different set of marks.

AM LI OB

Use Nano SEM 3 D tool to check exposure, two parts: i. CD's are checked.

AM LI OB

Use Nano SEM 3 D tool to check exposure, two parts: ii. Recipes need to be written

- 1. Creating Wafer Map
- 2. Standard structure and sometimes non-standard (engineer directed).

AM LI OB

Look at wafer under bright light (Macro) then microscope.

OB

Write a recipe from scratch (CD SEM and BioRAD).

LI OB

If stepper cannot find all 16 sites to align masks may not be able to run program. Gets out of program and instructs machine that if it cannot find all 16 to use the ones it can get. May need to relax tolerances. Consultation with engineering – may result in compromised alignment. Need to balance with technology requirements and tool capabilities. Must be proactive in terms of trying to solve problems instead of going to the engineer with everything. Good technical judgment – confidence to take initiative to resolve a problem. Discuss with peers prior to going to engineering. Interpret mask/layer historical data to set up current lot – use at average exposure to better target current lot. After running lot, Metrology done to check LCFs (line width critical feature) and then enters data into computer program. Look for gross misalignment on every wafer – depending on area and technology. Need to check clarity of feature, should be crisp with sharp edge. Looks up lot history and historical data for similar lots. This determines what offset and exposure to use. Particular to Nikon D body – adjust alignment gain to improve signal to noise so that all marks are properly seen by the tool and alignment tolerances are met. Continuous adjustments – intervene when required due to failed run. Requires troubleshooting. Engineers are constantly changing process: different types of photo resist, exposure, and develop which means a lot more processing of wafers trying different combinations to achieve optimal features. – Every lot is customized – with multiple integration schemes even within lot (“split lot”). Child lot and then recombined latter. Be able to split lot in several ways (different reticles resist thicknesses, etc and track physically). Enters and translates appropriate and accurate instructions, information, and data into computer including process tools, lot history and other data bases.

	AT		LI	OB	
	AT	L		OB	TW
AM			LI	OB	
AM			LI	OB	
				OB	
				OB	
AM			LI	OB	
	AT		LI	OB	
			L		OB RI
AM	BW	L	LI	OB	RI

After researching historical data, putting into computer, and printing out Traveler, will input into Stepper to create job.

LI OB

Trains workers in equipment operation and test procedures.

L LI OB TW

Following safety procedures are critical. Need to also be aware of others in fab and verify they have evacuated.

OB TW

Locate reticule, handle properly, 1x inspection look for gross defects.

OB

Determine if problem is tool based or lot based and communicate/consult with appropriate person – supervisor or lot owner (or both).

BW L OB TW

When checking LCF (Line Width Critical Features), checks smallest features first because if smallest feature correct this implies larger features correct. (When a difference between LCF and product is identified – must be able to measure alternate structure per engineering instructions).

OB

After work completed on batch, inputs all data into computer, prints so that information can be reviewed all concerned parties and "Tracks Out" and dispatches to next section. Tools on which lot has run. Also need to dispatch lot through computer system in real time.

BW LI OB

Alternate rework processes are required depending on where the link has crashed. I.e., wafers which have arc already on them require different resist strip than wafers that don't.

OB

MEMS wafers may have correct LCF (Line width Critical Feature). Must compare feature at two different focal planes. Part of inspection.

OB

Example of process problem: Due to trenches of 50um width – resist thickness was not uniform resulting in “shark bites” or resist voids. Found at inspection (therefore, need to be able to identify problem). Show to area owner, (engineering) – team trouble shooting to resolve. Typically will try double dispense – typically engineering will do this.

AT BW OB

Look for abnormalities in the historical data including variations with respect to the current lot requirements and assess whether or not engineering disposition is required.

OB RI

New Reticule System Entry: There are several steps in entering a new reticule into the process flow at Sandia MDL:

New Reticule System Entry: Acquire reticule details from incoming paperwork:		LI	OB	
New Reticule System Entry: Occasionally measure incoming minimum chrome feature; Percent Chrome, Upper/Lower limits, 5x Minimum Feature size		LI	OB	RI
New Reticule System Entry: Calculate wafer minimum feature size depending on whether 4x or 5x stepper is specified (determine inline CD target, minimum and maximum tolerances)		LI		
New Reticule System Entry: Enter data into Excel spread sheet		LI	OB	
New Reticule System Entry: Transfer Excel data to another program to determine lithography process parameters and include:		LI	OB	
New Reticule System Entry: Enter resist thickness		LI	OB	
New Reticule System Entry: Determine and enter exposure		LI	OB	
New Reticule System Entry: Focus offset		LI	OB	
New Reticule System Entry: Data used to bring in a new reticule:		LI	OB	
New Reticule System Entry: Incoming Reticule data		LI	OB	
New Reticule System Entry: Transcribe step size, alignment data (text file, this too is entered into spread sheet)		LI	OB	
New Reticule System Entry: Spread Sheet (Excel file)		LI	OB	
New Reticule System Entry: Historical data base		LI	OB	
New Reticule System Entry: Enter into "Sheets Program"		LI	OB	
New Reticule System Entry: From this data, also create the Stepper Job		LI	OB	
Alignment is checked and offset is determined from BioRAD output (Metrology tune)	AM	LI	OB	
Job input file for Stepper; states which reticule to us; percent of transmission of light through reticule, the alignment, left offset, slight offset and tells Stepper where to go to on wafer to align.	AM		OB	RI
Must make sure of enter correct sequencing of steps into Stepper job.			OB	
When entering recipe into computer make sure to double check each command such as reticule number, exposure and offset.			OB	

Critical aspect of job: proper setup and pass down for following shift when required to complete lot process step.

LI RI

After lot inspection, photograph abnormalities and put in the database for lot owner to review and disposition. Lot is put on hold or reworked. If reworked, usually don't take photos unless problem comes back.

BW LI OB TW

Coats wafers on specific tool, resist, thickness (recipe) as specified by the op code.

AT OB

Load reticule in stepper. (G Line for MEMS).

Choose correct recipe and verify. Other steppers include I line, DUV and step and scan.

OB

Pre-align marks must come up and be acquired – judgment must be made on the mark quality and alternate marks need to be chosen.

OB

Multitasking - While coater purging after current lot run, may enter exposure and offsets into Stepper job file for the next lot.

LI OB

Registration enters measurement for each BLCRT (bottom, left center, right, and top).

AM LI OB

Transcribe instructions received by email or phone onto Traveler for subsequent entry into computer. Critical aspects of job: must be able to prioritize the work.

BW L OB TW

Critical aspect: need to know how to stage lots at proper points for weekend shutdown – i.e., need to plan and time work to meet staging requirements. (Can't leave undeveloped resist on wafer depending on area, technology and layer).

L OB

Hot Lots are lots that have priority and must be worked on immediately. Time management is critical – be flexible, adjust break times to accommodate lots. Make sure tool is available when the lot arrives. Warn the next area that the lot is coming.

L LI OB

MEMS involves a lot more problem solving because more variety in terms of reticules and processes. Also a lot more DOE regulations (CMOS C6, C7 technologies). MEMS do not have as many established procedures and documented parameters – more flexibility allowed.

OB

Check all batches (Wafer Lots) to determine which are Hot Lot, these must be expedited and processed first. WIP management of all lots – to determine

LI OB

iii. Lot history comments are also utilized to note specific problem and disposition.

Lot holds from previous shift reviewed by experienced technologists for disposition if position.

Send email to lot owners when lots are done and passes on to next process. This is done for “black lots” (short loops, process tests, development work)

Another example of Process Problem: Scumming in trenches, CD’s within specifications.

Be able to communicate technically through written means as well as orally.

Periodically check email for special instructions or requests.

Check email to find out if any special messages regarding batches or tools. – Same as pass down see above.

Reads instructions from lot owner that specifies type of resist and depth of resist. Spin speed curves done by engineering.

Three common software programs used in wafer production: Comets & Work Stream (same software), (most widely used in production situations), and now Factory Works (Intelligent Client) and FAB SERVE (data base). Factory Works dispatches lots, Fab serve contains the data – CDs, Reticule info, problem lot info. Factory Works (lot operation tracking, which tools run on, where lot goes next).

- i. To get Traveler report, uses Factory Works.
- ii. Update Traveler sheet after every change so it is current – when engineer makes a change.

Receive verbal and written pass downs and interpret at start of shift.

SVG needs more attention, higher frequency – a. Observe while purging looking for speedboats

SVG needs more attention, higher frequency – b. Request assistance if not successful

SVG needs more attention, higher frequency – c. Clean with Acetone – using proper PPE

	L	LI	OB	RI	TW	
BW			OB			
			OB			
BW	L		OB		TW	
			OB	RI	TW	
			OB	RI		
			OB	RI	TW	
				LI	OB	RI
BW	L		OB	RI	TW	
AT			OB			
AT			OB			
AT			OB			

Uses acetone to strip photo resist (wet) – one way to stripper depending on layer, technology. Specifications must be consulted.

If batch is on "Engineer Hold" will put on engineer hold shelf and leave for engineer to address.

Inserts lot number into CD data base for tracking purposes.

Notifies supervisor and technical maintenance workers of equipment malfunctions. Face to Face, Paging, E-mails

Notifies supervisor, batch owners, and maintenance workers of equipment malfunctions. Determine when it is necessary to notify the lot owner.

Maintenance first – primarily tell the lot owner if the lot will be significantly delayed. (Relative to lot priority).

When barc can't be taken off by acetone, wafer must go to etch to take off bark. Bottom anti reflective coater. The ones baked goes to etch, the ones which haven't been baked can be stripped with acetone. If wafers are wet, may require a different strip.

From Metrology data, determine if changes to exposure is required. This is done by adjusting number of miljoules in recipe.

Write pass downs (where in process lots are) at end of shift so next shift knows what to do with lots in various stages of work.

Select the correct recipe – reticule set, layer, Photo or Etch.

Inserts reticules into photolithography machine.

Inserts reticule into Stepper after retrieving reticule from inventory.

Depending on route, poly or metal route, determines which process recipe to use.

As increased exposure makes line narrower on test wafer, may not be able to obtain the optimal focus; must decide on tradeoff between exposure and focus. For example, in high topology situations may need to offset focus and or exposure to “split the difference”

For problem wafers, uses specifications file created by owner. May give specific instructions for each route or some routes.

Must look for scaling and rotation.

					OB		
				LI	OB		TW
	AT	BW	L		OB		TW
				L	OB		TW
					OB		
AM	AT			LI	OB		
		BW			OB		RI
				LI	OB		
					OB		
					OB		
AM					OB		
					OB		RI
AM				LI	OB		

MEMS wafers are stripped differently than CMOS, the tool uses etch to remove photo resist. Uses microwaves to excite and remove all PR off wafers. Note: sometimes the same technologist may run several bays for a variety of technologies – must be able to keep track of multiple lots/processes and not get them confused.

OB

When emergency alarms go off must be able to distinguish between alarm types and decide whether or not to de-gown prior to leaving fab.

OB

TW

Reset "blower" that keeps temperature and humidity at proper levels at beginning of shift specific to the area. (Humidity and temperature control).

AT

OB

Aligns wafers in boat before putting into microlithography cluster.

OB

Answers questions from workers pertaining to procedures and equipment operation.

L

TW

Uses EBR (edge bead removal) to clean photo resist off wafer edge.

At inspection phase verifies features are at correct width or if no EBR is required.

OB

Check centering, width, solvent splash, encroach on the active die.

AT

OB

Reads: manuals, how to manuals for more advanced operations, maintenance manuals, emails. Required company training, a number of online courses required every year, hazcom, radiation training, site specific training, corrosives, safety.

AT

LI

OB

RI

Other areas may be required to assist – detailed communication is therefore required.

OB

TW

Because some wafers are warped, chuck cleaning is required and recalibrating the spindle motor is required.

AT

OB

Works safely to prevent on-the-job injuries by following safety policies and procedures.

TW

Looks for improvement opportunities – and communicate – verbal with coworkers.

OB

TW

Enters gowning dressing room and puts on clean room bunny suit, shoe covering, additional gloves, face mask, head covering, helmet air filter and checks battery, and safety glasses.

OB

MEMS uses totally different photo resist than CMOS. Within MEMS have several types of resist.

Exposure Adjustment may be required to adjust for CD out of control, e.g., line – increase exposure to reduce LCF, space, increase exposure to increase space.

Upon entering pre gowning room puts on gloves, hair net, facial hair cover, and shoe cover.

Changes gloves after entry into chase where gloves may have become contaminated.

Upon completion of work with batch, contacts next station to let them know they will be receiving batch – for hot lots. (Head’s up it is coming to be ready).

Communicate work schedule changes to team and engineering staff and coordinate coverage.

Record work schedule deviations, overtime to time keeper.

Review white board for facilities issues.

Multi-tasking is critical when handling several batches simultaneously.

Multitasking essential aspect of job given number of batches working on at one time; i.e., where is each batch in production process, what needs to be done next for each batch, and in what sequence to maximize output.

Mathematics used: line/space relationships to exposure; figure out mean and range of CDs; other equations $(1.3400 \cdot .5) / 2$.

Number of tasks using specified skill:

AM	AT			LI	OB			
					OB			
					OB			
					OB			
		BW	L	LI	OB	RI	TW	
		BW		LI		RI	TW	
					OB	RI	TW	
					OB			
AM				LI				
19	24	19	19	64	135	24	27	

Subject Matter Expert Demographics

Two Process Technicians from SNL participated in this profile.

Job Status	
Incumbent	2
Years in Profiled Job	
Average	11
Highest	13
Lowest	9
Years with Company	
Average	6.5
Highest	6.5
Lowest	6.5
Age	
Average	37
Gender	
Female	2
Male	0

WorkKeys Terminology

This information is presented in the order that it typically appears during a job profile.

WorkKeys Skills	Applied Mathematics Applied Technology Business Writing Listening Reading for Information	Observation Reading for Information Teamwork Writing
Job Profiling	A procedure to determine the most critical tasks for a job and to determine the WorkKeys skills and skill levels required to perform these tasks.	
Job Profile	The result of conducting one or more job profiling sessions which shows the most critical tasks for a job and the WorkKeys skills and skill levels required to perform a job.	
Profiler	An individual who has completed ACT's WorkKeys Job Profiling training program successfully. An ACT authorized profiler has been trained to: (1) Facilitate the job profiling process while using the SkillPro software (2) Generate a report of the profile results	
SME	Subject matter experts are employees currently performing the job or people knowledgeable about the job being profiled (e.g., supervisors or people who have been recently promoted from the job).	
Profiling Session	A focus group meeting facilitated by an ACT authorized job profiler. The job profiler meets with SMEs to perform a task analysis and skill analysis.	
Initial Task List	Prior to the profiling session, the profiler develops an Initial Task List using information compiled from databases (e.g., <i>Dictionary of Occupational Titles</i> and O*NET), job-related documentation (e.g., job descriptions, resources from similar job profiles, training materials), and information gathered from the tour of the facility.	

Task Analysis	<p>A task analysis consists of three parts:</p> <ol style="list-style-type: none"> (1) The job profiler meets with the SME group to tailor (i.e., add, edit, and delete tasks) the Initial Task List, making sure that the Final Task List accurately and completely describes the job. (2) The SMEs independently rate each task for Importance and Relative Time Spent. (Definitions are shown below.) (3) The profiler calculates the criticality of each task using the SME ratings, and sorts the task statements by placing the most critical tasks at the beginning of the list. The SMEs review and confirm the order of the tasks. The product of the task analysis is the Final Task List.
Importance	The importance of the task to the job.
Relative Time Spent	The amount of time spent performing a task relative to the amount of time spent on all the other tasks.
Criticality	The extent to which a task is critical to the job. To calculate Criticality, the profiler multiplies the mean Relative Time Spent rating by the mean Importance rating for each task. These ratings represent aggregate information rather than information reached by the consensus of the SMEs.
Final Task List	A list specifying the critical tasks for a job in statements that have been reviewed and edited by SMEs and then placed in criticality order using SME ratings.
Skill Analysis	<p>A skill analysis occurs after a task analysis is completed and consists of two parts:</p> <ol style="list-style-type: none"> (1) The SME group identifies the on-the-job behaviors (i.e., tasks from the Final Task List) that are associated with the WorkKeys skills under consideration. (2) The SME group compares detailed descriptions of the WorkKeys skill levels to the tasks that require the specified skill. The job profiler seeks to bring the group to a consensus regarding the skill levels required at job entry and for effective performance.

Entry-Level	Following the <i>Uniform Guidelines on Employee Selection Procedures (1978)</i> , WorkKeys defines entry as an employee’s first day performing the job. The entry-level skill requirements are recommended for use as cutoff scores on the related WorkKeys assessments.
Effective Performance Level	Effective performance is the point at which an employee performs competently without continuous supervision. Effective performance levels are provided for use as training goals.
Replication	Replication sessions are additional profiling sessions with different groups of SMEs. Replication sessions are used to make sure that the results are consistent from one group to another, especially when there are a large number of incumbents on the job.
Reconciliation	When SME groups do not agree on skill requirements (generally for job entry) the profiler meets with representative SMEs from each group to resolve the differences in a reconciliation session.
Profile Report	A summary generated by the profiler that includes the Final Task List, detailed descriptions of the session discussions of each skill, and recommendations for using the results.
Assessment	A test used to evaluate individuals' performance in a skill area. Scores on the WorkKeys assessments can be compared to the WorkKeys skill levels identified in a profile. The difference between the profiled level and a score indicates the need for training.
Skill Gap	When the profiled skill level is higher than the assessment score, the difference is referred to as a “skill gap.”
Value-Added Reseller (VAR)	A WorkKeys Value-Added Reseller provides a variety of workforce development services including profiling, assessment, and training to support employers in the local area.
ACT Center™ Network	ACT Centers support workforce development through a comprehensive set of distance-delivered and site-based services such as guidance, testing, and training. An ACT Center may also be a WorkKeys Value-Added Reseller.

Relationship Between WorkKeys and the Job

The WorkKeys system employs the content validation strategy to show the WorkKeys assessments reflect the content of the job. First, WorkKeys test items are developed from samples of a variety of work situations so items on the assessment reflect situations that might be found on the job. Next, the job profiling process establishes a link between tasks performed on the job, the WorkKeys skills needed to perform the tasks, and the skills and skill levels measured with the WorkKeys assessments.

During job profiling, groups of subject matter experts are convened to describe the tasks performed on the job and the skills required for completing the tasks. SMEs are knowledgeable about the job and are representative of the job incumbents in terms of such characteristics as age, race, gender, national origin, and religion. Using definitions and sample items that match the specifications of the assessment, they then match the levels of skill needed for the job with the levels of skill measured by the WorkKeys assessments.

Skill Descriptions

APPLIED MATHEMATICS SKILL

WorkKeys Applied Mathematics is the skill people use when they use mathematical reasoning and problem-solving techniques to solve work-related problems. Employees may use calculators and conversion tables to help with the problems, but they still need to use math skills to think them through.

There are five levels of difficulty. Level 3 is the least complex and Level 7 is the most complex. The levels build on each other, each incorporating the skills assessed at the previous levels. For example, at Level 5 employees need the skills from Levels 3, 4, and 5. Examples are included with each level description.

When deciding what level of the Applied Mathematics skill employees need for the tasks they do at work, consider the following questions:

How is the information presented? That is:

- Is it presented in the same order that it is needed?
- Is it necessary to change the order that the information is in before the math can be performed?

Is all the information needed for solving the problems provided? That is:

- Is all the information presented in the right form?
- Is it necessary to do some calculations to get some of the important information?
- Does the problem require a formula?
- Does the information need to be taken from a graphic?

What kind of mathematical operations do employees perform? That is:

- Can the math problem be completed in one step?
- Does the problem need to be done in several steps?
- Is it necessary to convert measurements from one form to another, either within or between systems of measurement?

Applied Mathematics Level 3

Level 3 problems can easily be translated from a word problem to a math equation. All the needed information is presented in a logical order and there is no extra information given.

When employees use Level 3 Applied Mathematics skills on the job, they can:

- Solve problems that require a single type of mathematical operation. They add or subtract either positive or negative numbers (such as 10 or -2). They multiply or divide using only positive numbers (such as 10).
- Change numbers from one form to another. For this they use whole numbers (such as 10), fractions (such as $\frac{1}{2}$), decimals (such as 0.75), or percentages (such as 12%). For example, they can convert $\frac{4}{5}$ to 80%.
- Convert simple money and time units (for example, hours to minutes and vice versa).

For example, at this level employees can add the prices of several products to reach a total, and they can make the correct change for a customer.

Applied Mathematics Level 4

At Level 4, tasks may present information out of order and may include extra, unnecessary information. A simple chart, diagram, or graph may be included.

When employees use Level 4 Applied Mathematics skills on the job, they can use the skills described at Level 3, and they can:

- Solve problems that require one or two operations. They may add, subtract, or multiply using several positive or negative numbers (such as 10, -2), and they may divide positive numbers (such as 10).
- Figure out averages (such as $\frac{(10+11+12)}{3}$), simple ratios (such as $\frac{3}{4}$), simple proportions (such as $\frac{10}{100}$ cases), or rates (such as 10 mph). For this they use whole numbers and decimals.
- Add commonly known fractions, decimals, or percentages (such as $\frac{1}{2}$, .75, or 25%).
- Add three fractions that share a common denominator (such as $\frac{1}{8} + \frac{3}{8} + \frac{7}{8}$).
- Multiply a mixed number (such as $12\frac{1}{8}$) by a whole number or decimal.
- Put the information in the right order before they perform calculations.

For example, at this level, employees can figure out sales tax or a sales commission on a previously calculated total, and they can find out rates of use or business flow.

Applied Mathematics Level 5

Level 5 tasks require several steps of logic and calculation. For example, at this level employees may complete an order form by totaling an order and then computing tax.

When employees use Level 5 Applied Mathematics skills on the job, they can use the skills described at Levels 3 and 4, and they can:

- Decide what information, calculations, or unit conversions to use to find the answer to a problem.

- Look up a formula and change from one unit to another in a single step within a system of measurement (for example, converting from ounces to pounds).
- Look up a formula and change from one unit to another in a single step between systems of measurement (for example, converting from centimeters to inches).
- Calculate using mixed units, such as adding 3.50 hours and 4 hour 30 minutes.
- Divide negative numbers (such as -10).
- Identify the best deal by doing one- and two-step calculations and then comparing the results to determine the solution that meets the stated conditions.
- Calculate perimeters and areas of basic shapes like rectangles and circles.
- Calculate percent discounts or markups.

Applied Mathematics Level 6

Level 6 tasks may require considerable translation from verbal form to mathematical expression. They generally require considerable setup and involve multiple-step calculations.

When employees use Level 6 Applied Mathematics skills on the job, they can use the skills described at Levels 3, 4, and 5, and they can:

- Use fractions with unlike denominators, reverse percentages, or multiply two mixed numbers.
- Rearrange a formula before solving a problem (for example, $8X = 20 \Rightarrow X = \frac{20}{8}$).
- Look up and use two formulas to change from one unit to another unit within the same system of measurement (for example, 1 cup = 8 fluid ounces; 1 quart = 4 cups).
- Look up and use two formulas to change from one unit in a system of measurement to a unit in another system of measurement (for example, 1 mile = 1.61 kilometers; 1 liter = 0.264 gallons).
- Find mistakes in problems that belong at Levels 3, 4, and 5.
- Find the best deal and use the result for another calculation.
- Find the area of basic shapes (rectangles and circles) when it may be necessary to rearrange the formula, convert units of measurement in the calculations, or use the result in further calculations.
- Find the volume of rectangular solids.
- Calculate multiple rates (such as by comparing production rates or pricing plans).

Applied Mathematics Level 7

At Level 7, the task may be presented in an unusual format and the information presented may be incomplete or implicit. Tasks often involve multiple steps of logic and calculation.

When employees use Level 7 Applied Mathematics skills on the job, they can use the skills described at Levels 3, 4, 5, and 6, and they can:

- Solve problems that include nonlinear functions (such as rate of change) and/or that involve more than one unknown.
- Find mistakes in Level 6 problems.
- Convert between systems of measurement that involve fractions, mixed numbers, decimals, or percentages.
- Calculate multiple areas.
- Calculate volumes of spheres, cylinders, or cones.
- Set up and manipulate complex ratios or proportions.
- Determine the better economic value of several alternatives by using graphics or by finding a percentage difference or a unit cost.
- Apply basic statistical concepts such as measures of central tendency (e.g., mode, median, and weighted mean).

APPLIED TECHNOLOGY SKILL

WorkKeys Applied Technology is the skill people use when they solve problems with machines and equipment found in the workplace. This skill includes four areas of technology: electricity, mechanics, fluid dynamics, and thermodynamics. Employees need to know the basic principles of each area, as described below.

Electricity involves the flow of electrons. Employees need to know how electrical current moves through a circuit or a system and how electricity affects a circuit or system. For example, they need to know how to control current and resistance.

Mechanics involves the way solid things move and how leverage, force, friction, and momentum affect that motion. Employees need to solve problems with simple machines, complex machines, and mechanical systems.

Fluid dynamics involves the way fluids (liquids and gases such as water and air) move through systems. Employees need to use this knowledge to solve problems with plumbing, hydraulics, or pneumatics (compressed gas).

Thermodynamics involves the movement of heat. Employees need to know which substances warm up quickly when heated and which ones warm up more slowly. For example, air heats faster than water. They also need to know how specific heat works. That is, they need to know how different materials hold heat for different amounts of time. They need to solve problems with refrigeration, heating, air conditioning, and phase changes.

The Applied Technology skill focuses on reasoning, not math. Therefore, employees do not need to make calculations or use formulas to solve problems.

When employees use the Applied Technology skill, they may:

- Analyze a problem by identifying the problem and its parts.
- Decide which parts of a problem are important.
- Decide on the order to follow when dealing with the parts of the problem.
- Apply existing tools, materials, or methods to new situations.

There are four levels of difficulty. Level 3 is the least complex and Level 6 is the most complex. The levels build on each other, each incorporating the skills assessed at previous levels. For example, Level 5 includes the skills used at Levels 3, 4, and 5. Individual situations may involve only one area of technology, but each skill level requires employees to know the basic principles of all four areas at that skill level.

When considering the level of Applied Technology skill needed for the tasks employees complete on the job, you should think about the complexity of the system and the physical principles involved. You might consider the following questions:

How complex is the system? That is:

- Is the system one simple object or several objects working together?
- Are tools or test equipment involved?
- How much extra information is included?

How complicated is the troubleshooting task? That is:

- How many components of the system are involved?
- Are the underlying principles elementary or complex?
- Is more than one area of technology involved?

Applied Technology Level 3

Level 3 tasks are straightforward because the situations include the following characteristics:

- They involve one simple system (such as a sprinkler) that generally has two to five components.
- They show clear physical symptoms and usually have only one variable.
- They include all the needed information.
- They use only basic technical terms (such as *loosen*, *temperature*, and *flow*).

When employees use Level 3 Applied Technology skills on the job, they can:

- Identify how basic tools (such as hammers and wrenches) work.
- Identify how simple machine parts work (such as how turning a screw clockwise drives it into wood).
- Apply basic principles to solve problems involving a simple system (for example, friction creates heat).

- Solve basic problems (for example, using heat to loosen a metal nut stuck to a bolt or using a rubber washer to stop a leak at a hose connection).
- Identify the clear physical symptom (such as an oil leak, a stopped shaft, or warm coils) that points to the potential source of a problem.
- Identify the best solution after getting rid of clearly unsuitable options.

Applied Technology Level 4

Level 4 tasks are moderately complex because the situations include the following characteristics:

- They can involve two or more simple systems that work together (such as a timer and sprinkler) or one moderately complex system (such as plumbing for a sink). These systems have up to ten components.
- They can involve one or two variables.
- They present all the information that is needed but may contain extra information.
- They include less common technical terms that are defined (such as *heat exchanger* and *circuit breaker*).

When employees use Level 4 Applied Technology skills on the job, in addition to the skills at Level 3, they can:

- Understand the operation of moderately complex tools (such as gear pullers) and diagnostic equipment (such as continuity testers).
- Understand the operation of moderately complex machines and systems. These can include appliances, pulley-driven equipment, or piping systems that carry more than one fluid. For example, they can find the drive wheel shown on a diagram of a tape player.
- Apply less obvious basic principles to solve problems within physical systems (moving air cools a warm object).
- Solve moderate problems such as installing a valve to manage oil flow or using a block to improve the leverage of a pry bar.
- Eliminate physical symptoms that do not point to the source of a problem by choosing which information is important and ignoring information that is clearly extra.
- Identify the best solution after getting rid of other unsuitable options.

Applied Technology Level 5

Level 5 tasks can be moderately complex or of advanced difficulty because the situations include the following characteristics:

- They can involve two or more simple tools or systems that affect each other or a complex system (such as the plumbing in a house) that includes several components (such as drains, hot and cold water lines, and valves). These systems perform somewhat complex operations and generally have more than ten components.

- They can involve two or three variables.
- They may require the use of technical knowledge (for example, condensing coils should be warm and evaporating coils should be cool) and often include extra information.
- They use technical terms, which may be clearly defined or whose meaning may be implied in the context and illustrations.

When employees use Level 5 Applied Technology skills on the job, in addition to the skills at Levels 3 and 4, they can:

- Understand the operation of moderately complex tools (such as cutting torches and drill presses) and diagnostic equipment (such as ohmmeters, micrometers, or thermometers) and choose the best tool for the task.
- Understand the operation of complex machines and systems, such as gasoline engines, dishwashers, freezers, and building electrical systems.
- Apply two or more principles of technology (within one area or in two or more areas) as they interact in moderately complex systems (heat from friction causes components to expand).
- Solve moderate and advanced problems, such as how to change the speed of pulley-driven machines, protect electric circuits from overload, place fans in the best position, or find a problem in a hydraulic cylinder.
- Eliminate physical symptoms that do not lead to the source of a problem by choosing which information is important and ignoring extra information. To do this, it is necessary to use clues to find the source of a problem. For example, the smell of hot rubber near a conveyor might indicate a loose drive belt.
- Identify the best solution after getting rid of other suitable options.

Applied Technology Level 6

Level 6 tasks are advanced because the situations include the following characteristics:

- They involve complex tools or systems (such as the water system of a new subdivision) with more than ten components and they include large amounts of information.
- They present a variety of possible sources of problems that are subtle and difficult to diagnose.
- They may involve many variables at the same time.
- They require the use of technical, although not job-specific, knowledge (for example, how an electromagnetic relay operates) and contain considerable extra information.
- They use technical terms, which may be clearly defined or whose meaning may be implied in a complex context and illustrations.

When employees use Level 6 Applied Technology skills on the job, in addition to using the skill at Levels 3, 4, and 5, they can:

- Understand the operation of complex tools (such as an arc welder or compound miter saw) and diagnostic equipment (such as an oscilloscope) and choose the best tool for the task.
- Understand the operation of complex machines and their components (for example, hydraulic lifts, automobiles, and water treatment facilities).
- Apply two or more principles of technology (within one area or in two or more areas) as they interact in complex systems. For example, fluids, like refrigerant, are often subjected to phase changes in order to move greater amounts of heat.
- Solve advanced problems where a variety of mechanical, electrical, thermal, or fluid faults could be the reason for the problem.
- Eliminate physical symptoms that do not lead to the source of a problem by choosing which information is important and ignoring extra information. To do this, it is necessary to use less obvious clues to find the source of a problem. For example, discolored oil may mean a faulty gasket is allowing moisture into an engine.
- Test possible hypotheses to ensure the problem is diagnosed correctly and the best solution is found. This is necessary when systems have difficult problems that could be caused by a variety of mechanical, electrical, thermal, or flow faults.

BUSINESS WRITING SKILL

WorkKeys Business Writing is the skill people use when they write an original response to a work-related situation. Components of the Business Writing skill include sentence structure, mechanics, grammar, word usage, tone and word choice, organization and focus, and development of ideas.

The main requirement of workplace writing is clarity. Employers want their employees' written communications to be direct, grammatically correct, and easy to read. Careless errors may lead the reader to believe there are also errors in the facts, and the writer loses credibility and trustworthiness. WorkKeys Business Writing requires standard business English, defined as writing that is direct, courteous, grammatically correct, and not overly casual.

There are five skill levels. Level 1 is the least complex and Level 5 is the most complex. At each new level, employees demonstrate more competent writing skills than those used at the previous levels. For example, Level 3 builds upon the skills used at Levels 1 and 2. With the increased skills at each level, the writing that employees produce communicates more clearly and smoothly as they move to Level 5. At the same time, errors become less frequent and less serious.

When you evaluate a job to see what skill level employees need for completing their tasks, consider the following questions:

- To what extent do the ideas need to be developed? Should the writing include relevant supporting examples and details, or should there just be a focus on the main ideas themselves?

- How important is the writing style? Does the writing have to flow smoothly, or can it be choppy as long as the writer's thoughts are successfully communicated?
- Is it necessary to have a professional tone? Does the writing need to be formal, or is it all right to be casual?
- How important are the writing mechanics and grammar? Is it important for all the grammar, punctuation, and spelling to be correct, or are errors acceptable as long as the ideas get across?

When measuring the WorkKeys Business Writing skill, we focus on the writing a person can produce without help from a dictionary, a spelling or grammar checker, another person, or any other aids. As you decide which writing skills employees need on the job, you need to consider what kind of writing they must produce.

- The assigned skill level will be higher if the writing must be polished and well developed, but the writer does not have the chance to get help from a dictionary, a spelling or grammar checker, another person, or any other aids.
- The assigned skill level will be lower if the final product must be polished and well developed, but the writer has the chance to use writing aids.
- The assigned level will also be lower if the important thing is to convey the information, and what the writing looks like is not as important.

After this skill description, the skill levels are described individually. Sample responses are also provided, and each sample is followed by an explanation of why the response is at the specified level.

Business Writing Level 1

Employees with Level 1 skills can write responses in English. However, a large number of errors make the response very difficult to understand.

When employees use Level 1 Business Writing skills on the job, they produce writing:

- That consists of incomplete sentences the majority of the time.
- That includes a large number of major grammatical, mechanical, and word usage errors that interfere with communication.
- That has rude or overly casual language, tone, and style that may be inconsistent with standard business English.
- That has no organization.
- That attempts to communicate their ideas but provides little or no development or support.

Business Writing Level 2

Employees with Level 2 skills can write responses that are generally understandable. When employees use Level 2 Business Writing skills on the job, they can produce writing:

- That has some complete sentences, although some sentences may be simple or repetitive.
- With enough correct mechanics, word usage, and grammar to convey an idea, although many errors may somewhat interfere with comprehension.
- That has rude or overly casual language, tone, and style that may be inconsistent with standard business English.
- With some organization, but with an unclear focus. They use few or no transitions.
- With ideas that are generally understandable but that are not expanded.

Business Writing Level 3

Employees with Level 3 skills can write clear responses. The writing may include incorrect structure, some errors in grammar and punctuation, and adequate development, although the ideas may be limited.

When employees have Level 3 Business Writing skills on the job, they produce writing:

- With most of the sentences complete. Some variety and complexity are attempted.
- With few mechanical, grammatical, and word usage errors so that the response is adequately conveyed, but may be repetitive. Spelling is generally correct.
- With style and tone that are generally consistent with standard business English. The writing may have somewhat casual language, but does not contain rude language.
- That exhibits some organization but that may lose focus at some point. Transitions are simple.
- That has adequate development of ideas, but which may be limited in depth and thoroughness. Supporting examples tend to be general and details are relevant, but they may be repetitive.

Business Writing Level 4

At Level 4, employees write responses that are clear, with almost no errors. When employees have Level 4 Business Writing skills on the job, they produce writing:

- With all sentences complete and generally varied in length and complexity.
- With very few mechanical, grammatical, and/or word usage errors. These do not interfere with communication. Word usage is precise and varied.
- With style, tone, and language that are consistent with standard business English (the writing contains no rude or overly casual language).
- That is organized and maintains consistent focus. Transitions are effective, if not especially varied.
- That has most of the ideas developed well with relevant supporting examples and details.

Business Writing Level 5

At Level 5, employees write responses that are clear, precise, and generally free of errors. The writing communicates in a professional, courteous manner.

When employees have Level 5 Business Writing skills on the job, they produce writing:

- That uses complete sentences that are varied in length and complexity.
- With few or no errors in grammar and/or mechanics. Any errors present do not interfere with communication. They write with word usage that shows considerable precision and variety.
- With style, tone, and language that are consistent with standard business English (the writing contains no rude or overly casual language).
- That is smoothly organized and that maintains clear and consistent focus from beginning to end. Transitions are varied and effective, creating a seamless flow of ideas.
- That has well-developed ideas elaborated on with relevant supporting examples and specific details. The writing shows insight, perception, and depth.

LISTENING SKILL

WorkKeys Listening is the skill people use when they receive verbal information in the workplace to relay to another person. To require the Listening skill, tasks must include the following:

- Work-related information is given verbally to an employee.
- The employee writes down the information.
- The written information is given to another person, who must be able to act upon it as required.

There are 5 levels of difficulty. Level 1 is the least complex and Level 5 is the most complex. At each new level, employees need to demonstrate more competency than at previous levels. For example, at Level 1, employees need to write down a few pieces of straightforward information. As the individuals' skills move toward Level 5, the messages they relay will include:

- Primary information, so the person who receives the message can act on it.
- Supporting information that further explains the message.
- The correct relationships among the pieces of information.

At Level 5, additional information about the speaker's tone or attitude may also be included.

When you evaluate a job to see what skill level employees need for completing their tasks, consider the following questions:

How difficult is the message to understand?

- How many people are talking?
- Is the message short and straightforward?
- Does the message include a lot of information?
- Are there many subtle cues?

How complicated is the task?

- How much information do employees have to include in one message?
- How important is it for employees to provide complete and accurate information?
- Do employees need to provide information about the tone or attitude of the speaker?

Listening Level 1

When employees use Level 1 Listening skills on the job, they can:

- Write down at least one piece of primary information that is correct.
- Write down the gist of the situation (a minimal grasp of the message) or include clues to sources of further information.

Listening Level 2

When employees use Level 2 Listening skills on the job, they can:

- Write down one or more pieces of primary information that are correct, but they may also include primary information that is incorrect.
- Write down a correct sketch of the situation, including both the gist of the situation and clues to sources of further information.

Listening Level 3

When employees use Level 3 Listening skills on the job, they can:

- Write down most of the primary information and what is present is correct, but the message may be missing one or two pieces of primary information.
- Correctly show the relationships among the pieces of primary information so that the reader can take appropriate action without getting more information.

Listening Level 4

When employees use Level 4 Listening skills on the job, they can:

- Write down all the primary information and it is correct.

- Include some supporting information that is correct or, if incorrect, does not interfere with the central message.
- Correctly show the relationships among the pieces of primary information.

Listening Level 5

When employees use Level 5 Listening skills on the job, they can:

- Correctly write down all of the pieces of primary information.
- Use accurate and relevant supporting information to convey insight into the particular situation that the message represents. This may include information regarding the speaker's tone or attitude.
- Accurately show the relationships among pieces of information in the message.

READING FOR INFORMATION SKILL

The WorkKeys Reading for Information skill is the skill people use when they work with workplace graphics such as charts, graphs, tables, forms, flowcharts, diagrams, floor plans, maps, and instrument gauges. Employees use this skill when they find information in a graphic or insert information into a graphic. They also use it when they compare, summarize, and analyze information found in related graphics.

There are four levels. Level 3 is the least complex and Level 6 is the most complex. At each new level, employees need more demanding skills in addition to the skills used at the previous levels. For example, Level 5 includes the skills used at Levels 3, 4, and 5. At Level 3, employees look for information in simple graphics and fill in information that is missing from simple graphics. At Level 6, employees may use the information in one or more complex graphics to draw conclusions and make decisions. The complexity can also increase as the quantity and/or density of the information increases.

When considering the level of Reading for Information skill needed for the tasks employees complete on the job, you should think about the difficulty of both the graphics and the task. You might consider the following questions:

How difficult are the graphics? That is:

- How many graphics are used?
- Are the graphics simple or complicated?
- Do the graphics use elementary, common language or do they include unfamiliar, technical terms or symbols?
- How many extra details are included?

How complicated is the employee's task when using the graphics? That is:

- Is it only necessary to use information that is stated clearly?

- Does the information in the graphics need to be summarized or compared?
- Is the information in the graphics used to draw conclusions or make decisions?

Reading for Information Level 3

Level 3 workplace graphics are elementary. They may be simple order forms, bar graphs, tables, flowcharts, maps, instrument gauges, or floor plans. At Level 3, employees use one graphic at a time.

When employees use Level 3 Reading for Information skills on the job, they can:

- Find one or two pieces of information in a graphic.
- Fill in one or two pieces of information that are missing from a graphic (for example, they might fill in a bill number on a form).

Reading for Information Level 4

Level 4 workplace graphics are straightforward. They may be basic order forms, diagrams, line graphs, tables, flowcharts, instrument gauges, or maps. At Level 4, employees may work with one or two graphics at a time.

When employees use Level 4 Reading for Information skills on the job, they can use the skills described at Level 3, and they can:

- Find several pieces of information in one or more graphics.
- Understand how graphics are related to each other (for example, they might use a parts table and shipping ticket together).
- Summarize information from one or more straightforward graphics (for example, they might find how many oak trees in an inventory table are taller than four feet).
- Identify trends shown in one or more straightforward graphics (for example, they might use a line graph to find how sales of a product change from one month to another).
- Compare information and trends shown in one or more straightforward graphics.

Reading for Information Level 5

Level 5 workplace graphics are complicated. The graphics are sometimes in a less common format (such as a three-dimensional bar graph). They may be detailed forms, tables, graphs, diagrams, maps, or instrument gauges. At Level 5, employees may work with one or more graphics at a time.

When employees use Level 5 Reading for Information skills on the job, they can use the skills described at Levels 3 and 4, and they can:

- Sort through distracting information (that is, information in a graphic that may not be useful for the current task).
- Summarize information from one or more detailed graphics (for example, they might find the maple trees in an inventory table that are taller than four feet, are less than \$50, and are in the sales region).

- Identify trends shown in one or more detailed or complicated graphics (for example, they might use a detailed line graph to find how sales of five separate products changed from March to July).
- Compare information and trends from one or more complicated graphics.

Reading for Information Level 6

Level 6 workplace graphics are very complicated. They contain large amounts of information and may have challenging formats (such as a wiring diagram, airplane control chart, or contour map). They may be very detailed graphs, charts, tables, forms, maps, and diagrams. At Level 6, employees may work with one or more graphics at a time, and connections between the graphics may be subtle.

When employees use Level 6 Reading for Information skills on the job, they can use the skills described at Levels 3, 4, and 5, and they can:

- Draw conclusions based on one complicated graphic or several related graphics.
- Apply information from one or more complicated graphics to specific situations (for example, using multiple schedule forms and clinic maps, they might find times for several people to visit doctors, clinicians, and labs in various parts of a large hospital).
- Use the information to make decisions (for example, they might use handling forms, facility maps, and storage guidelines to figure out where to put a product that is highly flammable and/or corrosive).

OBSERVATION SKILL

WorkKeys Observation is the skill people use when they pay attention to and remember work-related instructions, demonstrations, and procedures. There may be distractions or other information competing for the employees' attention. The details observed will differ depending on the job, the task, and the situation.

There are four levels. Level 3 is the least complex and Level 6 is the most complex. The levels build on each other, each incorporating the skills assessed at the previous levels. For example, Level 5 includes the skills used at Levels 3, 4, and 5. The skill level is determined by the complexity of the procedure(s) being observed and the task(s) that employees are asked to do based on their observations. At Level 3, employees must notice and recall straightforward information, which moves slowly, with very strong hints or reminders. There are few distractions, and differences are obvious. At Level 6, employees remember details after they have been shown a complex situation with many distractions. The information moves quickly, and hints or reminders are minimal. Details are subtle, and differences are not easy to notice.

A videotape shows examples of situations that belong at each skill level. When you consider what skill level is needed for the tasks that employees complete on the job, think about the following things:

How complex is the procedure being observed and remembered?

- Is it logical or illogical, familiar or new, commonplace or unique, straightforward or complicated?
- How much information is involved, and are the procedure's parts independent or interactive?
- How fast is the information presented? Does it move quickly or slowly? Can the employee control the speed, or does the employee have to keep up with a set pace?
- How much distracting information is there?

How difficult is the task that employees are asked to do?

- Is it clear what employees must pay attention to, or must they work hard to pay special attention to important details (selective attention)?
- Are there obvious hints or reminders that the task needs to be done; how to complete the task; when the task should be completed; or whether the task was done correctly?
- How subtle are the details or differences in the procedure to be noticed by employees? Are these differences significant?

Observation Level 3

At Level 3, employees watch a straightforward procedure and remember it. The task is performed at a slow pace, generally under the employees' control, and in a routine, predictable manner. There are no extra details or distractions. Obvious hints or reminders prompt employees that the task needs to be done, how and when it should be completed, and whether it is done correctly.

When employees use Level 3 Observation skills on the job, they can:

- Pay attention to the basic parts of a straightforward procedure that is done at a slow pace.
- Remember a few strongly prompted details.
- Remember instructions and reminders that give them strong cues.
- Remain focused on the important parts of a procedure shown without distractions or irrelevant information.
- Notice clear differences.

Observation Level 4

At Level 4, employees pay attention to and remember a straightforward procedure that involves more than one part. The tasks are performed at a moderate pace, and some extra details and distractions are present. The procedure is normally routine and somewhat under the employees' control, but employees must watch for important details and use their judgment to decide which information to pay attention to. The employees' attention is directed toward important details.

When employees use Level 4 Observation skills on the job, they can use the skills described at Level 3, and they can:

- Select and pay attention to parts of a straightforward procedure with some details that are hard to notice.
- Pay attention to details that are shown at a moderate pace.
- Remember a few important details that are reinforced.
- Remain focused on the important details when there are some extra details or distractions.
- Notice less obvious differences.

Observation Level 5

At Level 5, employees pay attention to and remember work procedures that include several tasks that may occur at the same time and that may be outside of their control. The tasks, which are performed at a moderate pace, often interact with each other and may change from one situation to another. Several important details are presented, most of which are not strongly prompted. The employee must examine differences and figure out if the differences are important to note (for example, detect differences from standards and figure out if the differences are big enough to report). There are often several extra details or distractions that make it difficult for the employee to pay attention to the important points.

When employees use Level 5 Observation skills on the job, they can use the skills described at Levels 3 and 4, and they can:

- Focus their attention on and remember several important details from a work procedure that includes several tasks that may occur at the same time and at a moderate pace.
- Maintain attention to important details with little prompting.
- Remember relevant aspects of the information presented.
- Remember several important details about unfamiliar material.
- Ignore irrelevant background information or distractions and pay attention only to important points.
- Recognize several differences that are presented at the same time.
- Examine a subtle difference and decide whether or not it is acceptable.

Observation Level 6

At Level 6, employees pay attention to complicated work procedures and remember them. Tasks are performed at a quick pace that is usually outside of the employees' control. The tasks contain a number of extra details and often involve unusual elements. The tasks performed have a number of steps, but none of them is highlighted and only some of them are discussed directly or explained. There are strong distractions that must be ignored. Employees must understand if-then and cause-and-effect relationships involved in the tasks so they can make predictions, comparisons, and evaluations, visualize how a detail fits into a procedure, and detect differences that are hard to notice.

When employees use Level 6 Observation skills on the job, they can use the skills described at Levels 3, 4, and 5, and they can:

- Focus their attention on and remember a number of steps and details from a complicated work procedure that includes unusual elements and is presented at a quick pace.
- Notice and remember a number of steps when none of them are discussed directly or explained.
- Visualize how a step fits into the procedure even if there are not many hints or reminders.
- Disregard irrelevant information.
- Interpret if-then and cause-and-effect relationships that affect their tasks.
- Make predictions, comparisons, and evaluations.
- Examine a subtle detail to judge if there is a significant difference.

READING FOR INFORMATION SKILL

WorkKeys Reading for Information is the skill people use when they read and use written text in order to do a job. The written texts include memos, letters, directions, notices, bulletins, policies, and regulations. It is often the case that these workplace communications are not necessarily well written or targeted to the appropriate audience. Reading for Information materials do not include information that is presented graphically, such as in charts, forms, or blueprints.

There are five levels of difficulty. Level 3 is the least complex and Level 7 is the most complex. The levels build on each other, each incorporating the skills assessed at the preceding levels. For example, at Level 5, employees need the skills from Levels 3, 4, and 5. The reading materials at Level 3 are short and direct. The material becomes longer, denser, and more difficult to use as readers move toward Level 7. The tasks also become more complex as readers move from Level 3 to Level 7. At Level 3, readers begin by finding very obvious details and following short instructions. At the more complex levels, tasks can also involve more application and interpretation.

When you consider what level of Reading for Information skill is needed for the tasks employees complete on the job, you might consider the following questions:

How difficult are the materials? For example:

- Are the sentences short, simple, and clear; or are they complex and possibly even confusing?
- Do the materials use only common words; or do they include difficult words, jargon, and words used in unfamiliar ways?
- How much extra information is included?

How complicated is the task? For example:

- Is it only necessary to use information that is stated clearly?
- Is it necessary to draw conclusions based on the reading materials before using the information?
- Do the employees need to apply the information to a situation exactly like the one described in the materials or to one that is quite different?

Reading for Information Level 3

Level 3 reading materials include basic company policies, procedures, and announcements. They are short and simple, with no extra information. Employees read the materials to find out what they should do. All the information they need is stated clearly and directly, using easy words and straightforward sentences.

When employees use Level 3 Reading for Information skills on the job, they can:

- Pick out the main ideas and clearly stated details.
- Choose the correct meaning of a word when the word is clearly defined in the reading.
- Choose the correct meaning of common everyday and workplace words (such as *employee, timecard, office*).
- Choose when to perform each step in a short series of steps.
- Apply instructions to a situation that is the same as the one they are reading about (such as knowing what button to push first after reading instructions on how to run a copy machine).

Reading for Information Level 4

Level 4 reading materials include company policies, procedures, and notices. They are straightforward, but have longer sentences and contain a number of details. These materials use common words, but do have some harder words, too. They describe procedures that include several steps. When following the procedures, employees must think about changing conditions that affect what they should do.

When employees use Level 4 Reading for Information skills on the job, in addition to using Level 3 skills, they can:

- Identify important details that may not be clearly stated.
- Use the reading material to figure out the meaning of words that are not defined for them.
- Apply instructions with several steps to a situation that is the same as the situation in the reading materials.
- Choose what to do when changing conditions call for a different action. For example, they can follow directions that include “if-then” statements.

Reading for Information Level 5

At Level 5, policies, procedures, and announcements have many details. The information that employees need to finish a task is stated directly, but it is hard to understand because of the way it is worded. The materials include jargon, technical terms, and acronyms or words that have several meanings. The employee must consider several factors in order to identify a course of action that will accomplish their goals.

When employees use Level 5 Reading for Information skills on the job, in addition to using the skills described at Levels 3 and 4, they can:

- Figure out the correct meaning of a word based on how the word is used.
- Identify the correct meaning of an acronym that is defined in the document.
- Identify the meaning of a technical term or of jargon that is defined in the document.
- Apply technical terms and jargon and relate them to stated situations.
- Apply straightforward instructions to a new situation that is similar to the one described in the material.
- Apply complex instructions that include conditionals to situations described in the materials.

Reading for Information Level 6

Level 6 materials include elaborate procedures, complicated information, and legal regulations found in all kinds of workplace documents. They use complicated sentences with difficult words, jargon, and technical terms. Most of the information is not clearly stated.

When employees use Level 6 Reading for Information skills on the job, in addition to using the skills described at Levels 3, 4, and 5, they can:

- Identify implied details.
- Use technical terms and jargon in new situations.
- Figure out the less common meaning of a word based on the context.
- Apply complicated instructions to new situations.
- Figure out the principles behind policies, rules, and procedures.
- Apply general principles from the materials to similar and new situations.
- Explain the rationale behind a procedure, policy, or communication.

Reading for Information Level 7

At Level 7, the reading materials are very complex. The information includes a lot of details, and the concepts are complicated. The vocabulary is difficult. Unusual jargon and technical terms are used, but they are not defined. The writing often lacks clarity and direction. Readers must draw conclusions from some parts of the reading and apply them to other parts.

When employees use Level 7 Reading for Information skills on the job, in addition to using the skills at Levels 3, 4, 5, and 6, they can:

- Figure out definitions of difficult, uncommon words based on how they are used.
- Figure out the meaning of jargon or technical terms based on how they are used.
- Figure out the general principles behind the policies and apply them to situations that are quite different from any described in the materials.

TEAMWORK SKILL

WorkKeys Teamwork is the skill people use for choosing behaviors and actions that both lead toward the accomplishment of work tasks and support the relationships between team members. A team is defined as **any workplace group** with a **common goal** and ownership of **shared responsibility** in achieving that goal.

There are four levels of difficulty. Level 3 is the least complex and Level 6 is the most complex. At Level 3, employees have a number of teamwork-related skills already in place. The levels build on each other, each incorporating the skills assessed at the preceding levels. For example, Level 5 includes the skills used at Levels 3, 4, and 5.

Skill levels depend on two things: the complexity of the work situation and the task that the employee is asked to perform. When you think about what level of Teamwork skill is needed for the tasks that employees complete on the job, consider the following:

- How clear are the goals and consequences of the team's actions?
- How available are the resources needed (e.g., time, people, and supplies)?
- How many problems and alternative solutions exist?
- How challenging is it for team members to work toward the goals?

Teamwork Level 3

At Level 3, the employee is faced with simple work situations involving a single, recognizable problem, goals and consequences are clear, resources are readily available, and the team members get along well.

When employees use Level 3 Teamwork skills on the job, they can:

- Recognize team goals that are clear.
- Show acceptance of team goals by working cooperatively with other team members.
- Identify recognizable problems and their causes.
- Persist in solving problems, seeing them through until completion.
- Accept membership in the team, such as by supporting and soliciting the input of others.

- Demonstrate a positive attitude, respond appropriately to praise, and give positive feedback.
- Display trust in other team members by asking for help or showing confidence that the team will complete the task.
- Be dependable in completing their tasks correctly and on time

Teamwork Level 4

At Level 4, the employee must deal with work situations that involve several problems or sources of difficulty. The goals and consequences are not altogether clear, some resources may not be available, and/or team members have competing concerns.

When employees use Level 4 Teamwork skills on the job, they can:

- Use the skills described at Level 3.
- Organize and schedule tasks.
- Generate alternatives to solve problems or accomplish tasks.
- Show a commitment to quality by their desire to do a good job.
- Be sensitive to customer needs by effectively interpreting both verbal and nonverbal communication.
- Take direction from team members and respond to feedback in a way that furthers team relations and task accomplishment.
- Demonstrate respect for other team members by asking honest questions and accepting feedback appropriately.
- Show an appreciation for the diversity among team members by recognizing and respecting individual differences.

Teamwork Level 5

At Level 5, the work situations involve many subtle and competing problems, team goals and consequences are unclear, resources are limited, and/or team relationships are uncertain due to team members' competing concerns and needs.

When employees use Level 5 Teamwork skills on the job, they can:

- Use the skills described at Levels 3 and 4.
- Exhibit good decision making and analyzing skills that indicate an ongoing process of identifying problems, proposing alternatives, examining the likely consequences of reasonable alternatives, selecting the best course of action, and monitoring the operation.
- Delegate responsibility by weighing opinions and ideas and assigning responsibilities in ways that reflect the talents and needs of each team member.
- Show leadership by both giving direction to other team members and taking direction from them as the situation demands.

- Empower other team members by making each other responsible for reaching the goal and considering all points of view.
- Display initiative by doing what is required and showing willingness to try new tasks or methods.
- Be properly assertive in explaining personal beliefs honestly and with sincerity.

Teamwork Level 6

At Level 6, the work situations involve complex problems and sources of difficulty, team goals and/or consequences conflict, resources are limited or not available, and/or team relationships are changeable due to team members' varying levels of commitment, cooperation, or disagreement.

When employees use Level 6 Teamwork skills on the job, they can:

- Use the skills described at Levels 3, 4, and 5.
- Identify and organize the various parts of a problem or task, order them, and determine who will be responsible for them.
- Create and revise team goals by moving from one objective to another, depending on the situation.
- Coordinate multiple parts of a task (which include materials, staffing, transportation, time, and different types of personalities) to help the team meet its goals.
- Be flexible in the roles they play on the team using active listening, questioning, and directing behaviors.
- Resolve conflict among team members by using supportive behavior and language, and by giving negative feedback in a constructive manner.
- Build team cohesiveness by helping to create a feeling of unity within the team.

WRITING SKILL

The Writing skill was not profiled because it was determined the Business Writing skill was most appropriate.