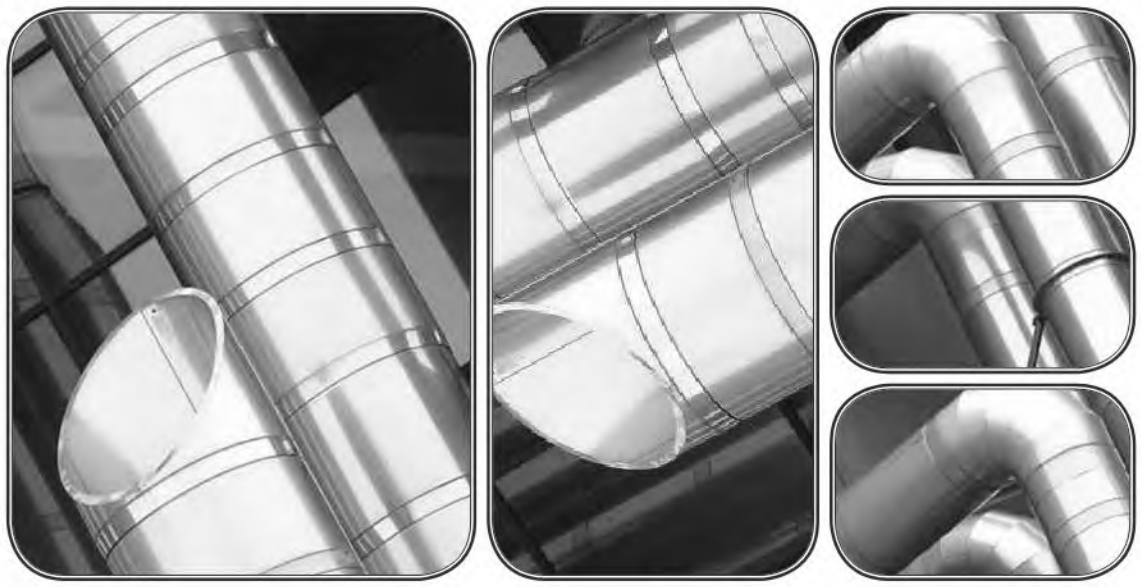
2nd EDITION

PROCESS TECHNOLOGY PLANT OPERATIONS

Michael Speegle

Process Technology Plant Operations



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Michael Speegle

Second Edition

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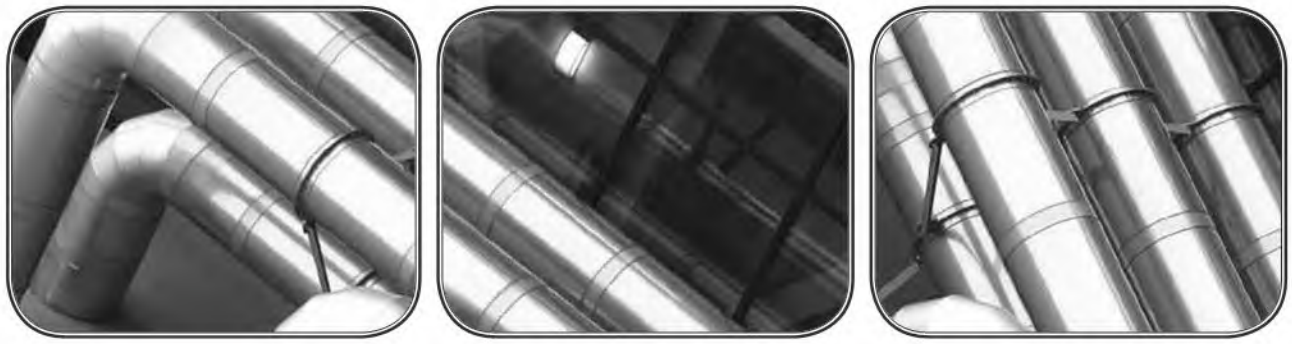
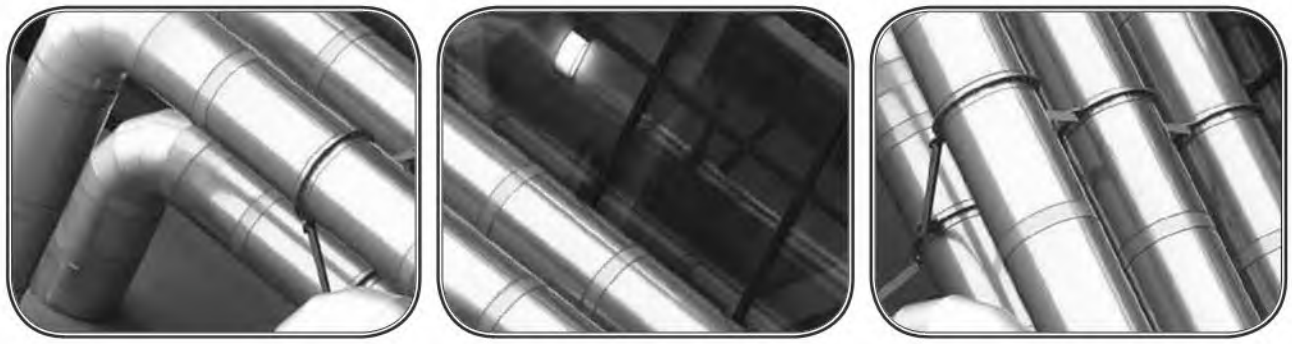


Brief Contents



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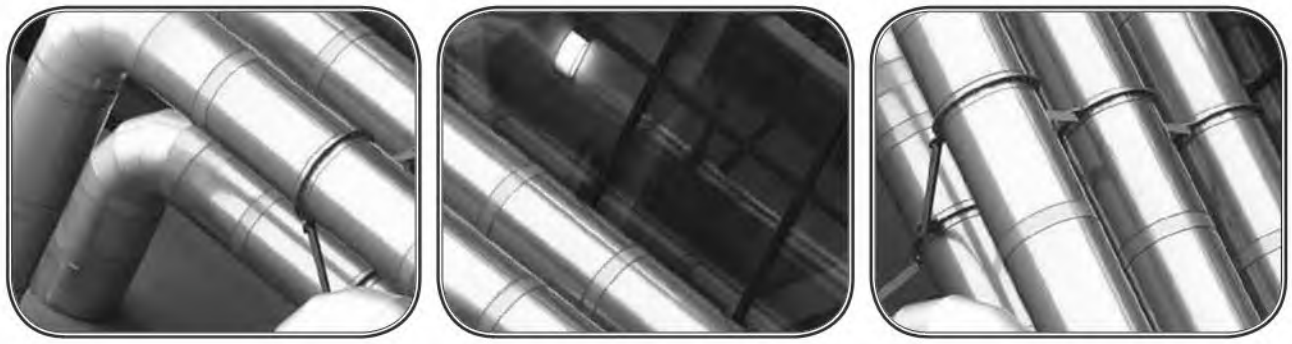

Preface

Operators in the processing industry have been taken for granted for many years, perhaps because at one time all that was required was a high school degree. That opinion and requirement has changed in the last 20 years. Being an operator in the processing industry is not an easy job today because process technology is high tech and because the technology keeps changing and the learning curve never ends. I worked in the process industry for 18 years, almost half of that time as a technician and half as a training coordinator and supervisor. Often, going out to the processing units and talking with operators, I was amazed at what they knew and what they did not know. Most operators were conscientious men with intentions of doing a good job. Some of them pushed buttons and did things because when they were trained that was what they were told to do. Often *why* they push that button and *what if* and *what happens* was not explained. That did not make them bad operators. They were a product of the culture of their plant.

Today, management's expectations of operators, now called *technicians*, are that the workforce must have technical competence. This expectation is verified by most of the processing industries subjecting potential employees to a battery of examinations that test for technical knowledge and interpersonal skills. San Jacinto College, Central Campus, is very fortunate to have a tremendous amount of industry around it. My process technology advisory committee has numerous local industry representatives on it. They are very pleased with the knowledge and skills of the graduates they are hiring with a two-year degree in process technology. In fact, one major integrated oil company presented evidence that a well-trained student with a two-year degree in process technology had the knowledge and skill level of an operator with three years operating experience and no formal schooling in the process technology curriculum. Plus, the company estimated about $15,000 in reduced training expenses per new hire with the Associates of Arts and Science (AAS) degree. This means the colleges teaching this curriculum must be doing a good job.

The first two times I taught *Process Technology III: Operations,* I was frustrated because I did not have a good textbook. Since I have authored several other textbooks, I decided to write *Process Technology Plant Operations* because it would make my job as an instructor easier. This book has been written specifically for the process industries—industries such as refining, petrochemicals, electric power generation, food processing and canning, and pulp and paper. Millions of dollars have been invested and continue to be invested in processing industries. The investment is made with a belief and commitment to a return on that investment, in other words, a profit. If a company is producing the right product at the right time with little competition, profits come easily. However, when a company has a lot of competition, as do refineries and chemical plants, plus strict health, safety,

and environmental constraints, profits do not come easily. Companies strive to protect their investments in people and equipment. Hence, the need for good training and training materials. I hope you find this textbook fulfills the function of a good training resource.

Process Technology III: Operations is the *capstone* course for the process technology curriculum. This course brings together all the concepts and knowledge the students are supposed to have acquired from approximately 10 other process technology courses. The capstone course integrates concepts from each of those courses and weaves them all together into a mosaic that says, "Young man/woman, you are a technician responsible for expensive equipment, proper operating conditions, quality control, quality improvement, profits and losses, problem solving, community involvement, the environment, and many other things. The company that hires you will not survive without your contributions in all these areas. You endanger your job and the survival of the company if you opt to have no technical expertise and just be a pair of hands that pushes buttons or opens and closes valves." This textbook, likewise, has sought to integrate important concepts from those courses. I have been tempted to incorporate everything, including the kitchen sink, and then realized the book would become too unwieldy and expensive. I have tried to focus on the many daily routines and tasks a technician is required to do, and to give examples of why integrity, attention to detail, attention to quality, and being productive are important attributes of a good technician.

As usual, I struggled with my arrangement of the chapters and after several rearrangements, quit and left them as they appear. The first six chapters could apply to just about any profession. The technical skills and knowledge, safety knowledge, economic savvy, quality consciousness, and effective communications required of workers today are necessities for a vital workforce. These chapters come first to remind the student that they are not going into a process plant to do grunt work. They are being hired as workers with a good overview of the safety, technical, economic, and interpersonal skills required of the job. Chapters 7 through 9 combine process chemistry and physics with safety and health to reveal how they are interrelated. One can directly affect the other. Chapters 10 through 13 discuss the duties of technicians, from making rounds to equipment maintenance responsibilities. Quite a few pages are spent on equipment lubrication because of its importance. Chapters 15 through 17 discuss the material handling of bulk materials, its importance to public and plant safety, and the significant amount of company assets tied up in bulk material storage. Chapters 18 through 20 describe the process, rationale, and duties during unit shutdown, turnaround, and startup, with a good emphasis on safety and economics. The last two chapters fit nicely together: abnormal situations and troubleshooting.

I believe this book meets almost all of the objectives as determined by the North American Process Technology Alliance for the course *Process Technology III: Operations*, especially when labs that require the student operate a process unit and use and monitor instruments are included. As I mentioned earlier, I could have added more chapters, ones on instrumentation and control or reactor and distillation systems but did not because it is assumed that when a student takes this course they have had the other 10 courses in the process technology curriculum (safety and health, systems, physics, chemistry, two instrumentation courses, etc.). As I stated earlier, the intent of this book is to bring all of the previously acquired knowledge together in a general overview to complete the education of the student. This overview should be a final preparation before applying to industry with the knowledge and skills needed to make them a valuable asset to industry.

My writing style is deliberate. I try to communicate with the written word as I would speak in the classroom. It is not my intention to impress people with a didactic style but to convey information with words. And finally, I would like to thank several people for their helpfulness in furnishing their wisdom and some materials to help make this book possible. So, thanks Mark Demark, Glen Johnson, Gaylene Webb, Richard Westerlage, Mickey Pedneau, and Michael Sobbotik. Also, I want to credit the workers and management of Air Products in Deer Park, Sun Products and Kurrary in LaPorte, Odfjell Terminal in Seabrook, and Penreco in Dickinson for allowing me to tour their plants and get a better understanding of some process equipment and operating methods.

Mike Speegle

Process Technology Plant Operations

CHAPTER 1

The Process Technician Today

Learning Objectives

Upon completion of this chapter the student should be able to:

- *Describe the core values needed by process technicians today to meet management's goals and objectives.*
- *List the roles of today's process technician in highly technical industries.*
- *List and discuss three skills or knowledge categories required by technicians today that weren't required 25 years ago.*
- *Explain how an operator participates in site security.*
- *Describe the difference between a fixed and rotating schedule.*
- *Describe two obstacles to being hired as an operator.*

INTRODUCTION

The role of the process technician in the processing industry today has dramatically changed from what it was just 20 years ago. The technician's role will continue to evolve due to changes in technology and competitive pressures both national and international in scope.

The role of a process technician is to assist the operations division to assess, adapt, and coordinate process manufacturing and maintenance activities to meet the business production schedules and product specifications. In the past, management assumed all those

responsibilities and *technicians were not asked to think* but simply *to do as they were told.* Management—usually the first-line supervisor—was responsible for making decisions and many tasks now assigned to process technicians. Hiring managers today *hire a person from the neck up*; they *require* their operators to think and to take charge. Today, unlike in the past, it is important for all operators to:

- Proactively identify opportunities to improve process operations.
- Detect and remove threats to steady-state operations.
- Seek continuous operating improvements.
- Compensate and correct abnormal operations.

Many processing units are highly automated and once they are lined out they literally run themselves; however, things can still go wrong. An important function of today's process technician is to detect and correct abnormal situations before the situations become very expensive or threatening to life and equipment. Part of competent equipment control requires the operator to have the ability to recognize deficiencies or symptoms of abnormal equipment performance. The technician today has become or is in the process of becoming a highly skilled jack-of-all-trades. However, skills and knowledge alone are not sufficient; they must be accompanied by strong personal values and integrity, which we will discuss later in this chapter. These values are sought to be revealed during interviews.

There is a strong demand for more women in the processing industries. Many women are not aware of the good paying jobs or are afraid they may not be physically strong enough to do the jobs or feel threatened by a male-dominated environment. These are wrongly grounded fears and misconceptions. The jobs do not depend on brute strength but on integrity and intelligence. The penalty for sexual harassment usually results in termination.

CORE VALUES AND COMPETENCIES OF TODAY'S WORKERS

All companies in any business want their employees to have certain core values and competencies. The company's success is dependent on this.

Core Values

Core values are essential values. They are not nice to have values, *they are essential*. Companies cannot survive in today's fiercely competitive environment unless their workforce possesses these core values. Individuals without these core values are often termed *high maintenance* individuals, which is management's way of saying you have to keep looking over the individual's shoulders to ensure they are working and doing their work correctly. Literally, they cannot be trusted. They always have to be told what to do and how to do it, plus they are constantly filing complaints against the company or fellow workers are filing complaints against them. In today's business environment, management does not have the time or resources for these types of workers.

Certain technician core values required for a process unit to meet its established goals are:

- Integrity—technicians perform their duties ethically and responsibly. They do not falsify data or leave work for the oncoming shift that they could have completed.

- Safety—individuals are proactive in creating and maintaining a safe, healthy, and incident- or accident-free environment.
- Environmental awareness—technicians are knowledgeable and vigilant about understanding threats to the environment and their surrounding community.
- Diversity—technicians embrace and nurture an inclusive work environment.
- Responsibility—technicians accept responsibility for their actions and consider the impact of their actions on team members and the site organization.
- Performance—individuals are committed to excellence in all tasks.

Many individuals have some or all of these core values to some degree. What core values or degrees of values an individual lacks will not magically occur when they are hired. These core values do not just happen. These are formed during childhood and young adulthood. Management must foster and nurture a culture that promotes these values through acknowledgment, awards, bonuses or promotions, and training. Management must also have a screening process for new hires that detects if most of these values already exist in potential employees and can be nurtured and encouraged. One way management screens for these core values before hiring is through the use of behavioral questions in its testing and interviewing process. These types of questions reveal a lot about the personality and values of the individual.

Technician Competencies

A competency is something that someone is very good at. A good list of general competencies for today's process technician would consist of:

- Business basics—understand the economics of their process unit and the corporate vision and operating philosophy. They are part of a business unit and should understand the business.
- Systems thinking (understanding the Big Picture)—understand how people, equipment, material, and technology interact to affect their unit operations and downstream and upstream operations.
- Loss prevention—understand the critical role of preventive maintenance and mechanical integrity to successful and profitable business operations. When an individual takes a car to a shop for engine repairs it is expensive; when a process unit shuts down pumps and/or compressors for repairs due to a lack of preventive maintenance it is very expensive.
- Continuous improvement—realize things can always be done more efficiently and waste can be reduced. Continuous improvement is necessary for operational survival.
- Problem solving—use a systematic process to solve operational problems rather than guessing and jumping to conclusions. Production problems quickly become very expensive.

In response to the economic pressures of world-wide competition, process technicians have assumed a multifaceted role. Today's technicians no longer confine themselves to just production work; they are active in safety committees, health and safety issues, public relations, quality and environmental concerns, process unit continuous improvement, preventative maintenance, and problem solving. This is a huge difference from 20 or 30 years ago when technicians were rarely delegated responsibilities outside of production.

Being an operator is no longer a blue-collar job. Process technology has become high technology and most processing companies no longer hire blue-collar workers, they hire para-professionals called process technicians who possess an associate of applied science degree.

NEW ROLES FOR TODAY'S PROCESS TECHNICIAN

Major changes have occurred in the processing industry over the last 20 to 30 years that affect operator roles (Figure 1-1). The North American Process Technology Alliance (NAPTA), an alliance of industry representatives, trade associations, and educational institutions, has identified some of the changes. Process technicians today must:

- Accept a much more diverse workforce because America is a melting pot of all races, colors, creeds, and nationalities. You may work on a crew with a female of Hispanic descent, a naturalized Nigerian, a Yankee from Maine, a southerner from Mississippi, a Sioux Indian, and a homosexual. That's diversity.
- Train themselves using computer-based training materials. Seventy percent of operator training is computer-based and requires good reading comprehension.
- Understand computerized controls and automation. More and more equipment is controlled and monitored by computers that require human interaction, needing an operator to monitor and adjust some parameters.
- Understand and comply with safety and environmental regulations. Operators will be trained on these and it is their job to know the regulations and comply with them.
- Function as a team member with good interpersonal skills. Operators work as a team. A team is no stronger than its weakest member. Operators cannot go to Human Resources and complain that their team members don't like them and

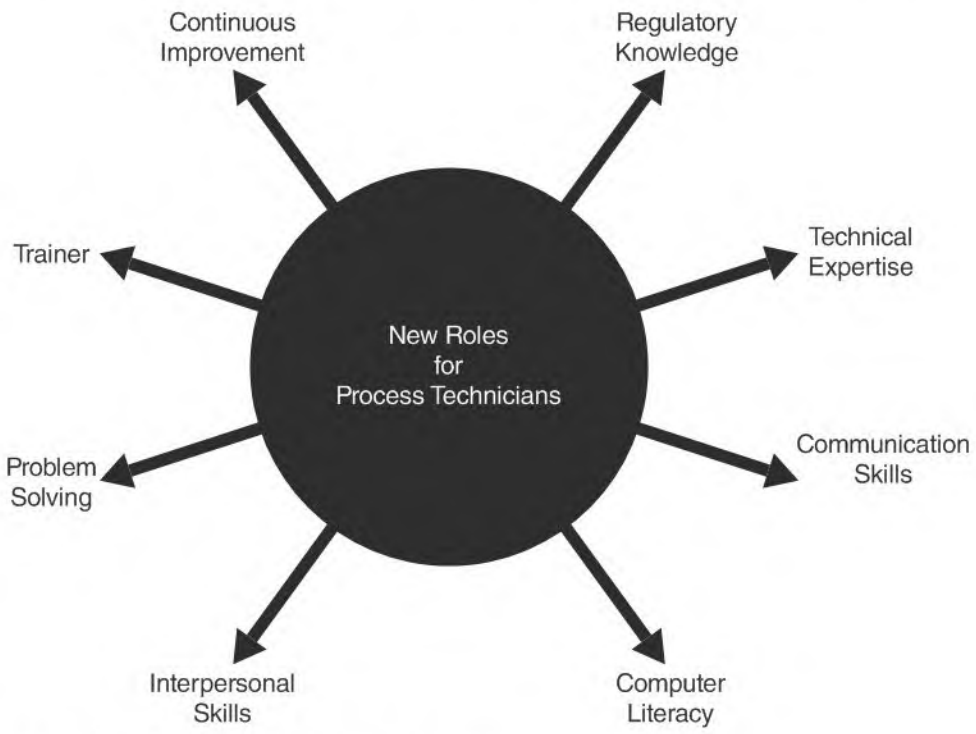

Figure 1-1 New Roles for Process Technicians

they want to be moved to another unit. They are on that team until they retire so they better learn to play nice.

- Support and contribute to process quality and a quality improvement process. Continuous improvement is everyone's job, not just management's. Make improvements, make the unit more profitable, and receive larger year-end bonuses.
- Become involved with process hazard analysis. It's your unit, wouldn't you want to find and eliminate or reduce the hazards on it?
- Apply analytical skills to process troubleshooting. It's the operator's unit and they know it better than the engineers and superintendents. When things go wrong its operators and their intimate knowledge of the unit that resolves most problems.
- Assist in site security. Operators know who should be on their unit, what is occurring on their unit, and what seems odd or suspicious. They are the eyes and ears of the plant.

The skill and knowledge requirements for a process technician changed because of the sophistication of new automated control systems and the complexity of the growing list of responsibilities required of workers in the industry for their companies to remain competitive plus meet the requirements of OSHA, the EPA, Homeland Security, and the U.S. Coast Guard. Process technicians can no longer be people who could come in off the street without a core of critical knowledge and be trained for the job in a few weeks. The fact that operators are now more frequently referred to as process technicians implies a change in the role of the operator. The definition of *technical* is:

> **Having special or practical knowledge of a mechanical or scientific subject.**

Process technicians today are required to have *special or practical knowledge and skills of a mechanical or scientific nature* in addition to interpersonal skills. They are being hired for *knowledge*. Part of the reason for that is because of their increased responsibilities involving production, quality, safety, and the environment. America is a highly technical society, one of the most high-tech nations in the world. The better jobs in such a society require an educated workforce with the ability to learn quickly and keep learning. The ability to learn is critical because technology keeps evolving. Things change and as they change learning is required to keep up with the changes.

Physical strength is no longer a major requirement of technicians today because plants are highly automated (Figure 1-2). Plants now seek employees who can think, analyze, solve problems, and respond in correct ways with minimal supervision. Companies hire technicians capable of understanding the chemistry used in their process and who have some college math, analytical skills, and communication skills. Technicians must also be familiar with computers and some computer programs. They must understand the economics of their process. They are required to continually improve their knowledge and skills because of changing technology and federal and state regulations. After receiving training, process technicians are responsible for running their unit economically, safely, and efficiently. It is *their* unit, its proper operation is *their responsibility*.

Figure 1-2 Strength Worker versus Knowledge Worker

MORE SKILLS, MORE KNOWLEDGE, MORE RESPONSIBILITY

Earlier we said that the refining and petrochemical industry was largely responsible for changing the process technician's job from one that required a manual laborer to one that required a skilled technician. Historically, batch distillation units that produced only kerosene were replaced by more complex batch units that produced everything from fuel gases to heavy tars. These more complex batch units gave way to continuous processes that were mostly manually controlled units producing the simpler petrochemical derivatives. Because the continuous flow process could operate around the clock and around the calendar, it instituted shift work and rotating shift schedules.

As more complex operations such as catalytic cracking and reforming were introduced, more complex instrumentation and controls were needed to operate the plants safely and economically. As operations became more complex pneumatic controllers were replaced by computerized systems. Each change required the process technician to have more technical training to understand the new controls and how they affected the process operation. An evolutionary process occurred and the operator of yesterday who was originally hired for strength and stamina evolved into a process technician of sophisticated skills and knowledge. The increasing technical and regulatory environment require a process

technician to possess varied skills. Some of the more important ones are discussed in the following paragraphs.

Technical Expertise—Process technicians today must possess technical expertise. In the past they were not expected to design process improvements, be involved in quality, understand instrumentation and control systems, be aware of environmental issues, or be involved in visits by governmental agencies. They are now. Their value to the company is in terms of their ability to continue to learn new technical knowledge and skills.

Regulatory Knowledge—With new requirements, laws, and regulations being enacted the technician must be aware of these regulations and adhere to them in their daily work. In the past a small chemical spill may not have been considered a serious concern. Today, process technicians must document spills, classify them, and report them to the proper agencies. Failure to do so can result in the company and/or technician being fined, imprisoned, or both, by a regulatory agency.

Communication Skills—Lack of communication and poor communication are constant complaints in all businesses. Process technicians must communicate effectively with fellow team members and other plant personnel. They should be capable of good verbal and written communication skills. Information should be clear, concise, and easily understood so that it can be acted on without error. The written report technicians prepare at the end of their shift should summarize their activities in a way that others can easily understand. The procedures and guidelines that they help write should be written so that misunderstandings and mistakes are eliminated. Many reports and logbooks are legal documents that can be referred to in case of accidents that result in lawsuits or audits by regulatory agencies.

Computer Literacy—The technician must also be very familiar with computers and several types of computer programs. They use computers for issuing maintenance work orders, tabulating records and data from the unit and the laboratory, and for maintaining personnel records such as timesheets, payroll, and vacation schedules. Plus, much of a technician's training takes place via computers. And more importantly, technicians must understand the control schemes for their units, many of which will be on computers or local microprocessors. Plants today have much of their operations controlled by computers using sophisticated programs on their distributive control systems (DCS) for this purpose.

Problem Solver—Process technicians must be able to troubleshoot problems in operating equipment and process systems and determine if the equipment is running properly or if maintenance is needed. They must become so familiar with their unit that they should quickly recognize when an operating or mechanical problem occurs and adjust unit conditions to correct for quality and yield loss problems. They should be able to recognize hazardous conditions that require corrective action.

Trainer—Process technicians may be asked to train newly hired technicians in their roles and responsibilities, which includes safety and environmental training. Much of the training on a specific process unit is done one-on-one using experienced technicians.

Quality and Continuous Improvement—Quality and continuous improvement are requirements for survival in today's highly competitive markets. In recent years, continuous

improvement has become a relentless goal for all organizations. The process technician knows every valve, pipe, vessel, and the ins and outs of their unit better than anyone else. They are the most qualified for defining the large and small pathways that lead to continuous incremental improvements and higher profitability.

Interpersonal Skills—The technician must develop the interpersonal skills needed to work as an effective team member. Each crew must function as a team to do its job effectively. The operations and support groups must work together as a team to resolve process or equipment problems. Technicians may also be asked to work on special teams to troubleshoot or upgrade equipment, to review safety or environmental issues, or to write operating or maintenance procedures. Getting along with all types of personalities is a necessary attribute. Teamwork is an important part of the technician's job today. Individuals that have poor interpersonal skills and personality conflicts hamper teamwork and will eventually be terminated.

THE PROCESS TECHNICIAN AND PRODUCTION

The primary role of a process unit is to safely and effectively achieve daily production schedules. The unit was built to make a profit and that profit is dependent on meeting production schedules on time and producing product as efficiently as possible. Assume Plant A and Plant B are both producing polypropylene and the market price is 15 cents a pound. Plant A has a better trained workforce dedicated to core values and efficient production and can produce polypropylene for 11 cents a pound, whereas Plant B produces its polypropylene for 14 cents a pound. Which plant is more competitive, and hence, more profitable?

Processing industries are seeing and will continue to see a fundamental change in the roles, responsibility, and authority of technicians. In the near future all operations personnel will proactively collaborate to set targets, initiate work orders, identify opportunities to improve process operations, identify and compensate for process disturbances, avoid critical process situations or mitigate the consequences if the situations are unavoidable. Technicians will also be responsible for monitoring the condition of manufacturing assets (equipment) and performing light maintenance to ensure the day-to-day operation of their equipment. Ultimately, technicians will proactively manage their units to maximize safety and minimize environmental impact while driving the process to optimal production. There will be a commitment to the concept of collaborative knowledge workers and individual empowerment that makes optimal production possible. Peter Drucker, a famous management scientist and consultant, had it right when he stated, "Managing the productivity of equipment and of knowledge workers will be the main challenge of the 21st century."

PROCESS TECHNICIANS AND SITE SECURITY

Process technicians play a critical role in site security. They are on the frontline manning the foxholes against potential terrorists, doing this with their knowledge, skills, and alertness as they make their rounds. They are the first to notice something different about their equipment, to notice a stranger on their unit or a neighbor's unit, or to detect a hole cut in the perimeter's fence. They do not defend their unit with guns, rather they defend it with alertness and unit knowledge as they go about their normal tasks. A major release of a site's hazardous material can injure people, harm the environment, and seriously damage a company by disrupting operations, inviting lawsuits, requiring expensive remediation and injuring the company's image. Process technicians receive training on perimeter security, the security of equipment, access to control rooms, and important process control software.

THE PROCESS TECHNICIAN AS A SHIFT WORKER

Shift work in the process industry has been around for decades. It is nothing new, but it does have a major impact on a technician's life. It is discussed here briefly because readers who are planning to become technicians should have a clear understanding of shift work, the demands it places on their body, the demands it places on their social life, and how to follow a shift schedule.

Shift work originated because continuous operations, as occurs at refineries and petrochemical plants, and many other types of manufacturing sites run 24 hours a day, 365 days a year to maintain maximum efficiency. Shift work offers advantages not found with straight day schedules, but it can also be the cause of problems and conflicts. Depending on the particular shift schedule, the shift worker can be off for a week of continuous time each month. This permits more flexibility in scheduling vacation activities. But work takes precedence when the shift worker is scheduled to work. Though it may be Christmas or their daughter's graduation from high school if they have been scheduled to work they must report to work. This is especially a problem when special occasions with their young children are involved.

In the processing industry most shifts are 12-hour shifts, though a few places still have 8-hour shifts. A person working on a 12-hour shift has little time after their shift ends to do much of anything after they drive home and bathe. Maybe they can work in a couple of hours at the gym or grocery shopping. In addition, the worker's schedule is always at odds with his body's biological clock and frequent schedule changes can desynchronize these rhythms. Shift work can cause physical and emotional problems if the worker is not successful in adapting to such a schedule.

The human body's "biological" clock helps maintain complex internal functions throughout a 24-hour day. A number of physiological functions show distinct rhythmic changes (called **circadian rhythms**) in the course of a 24-hour period. For example, a person's heart rate and body temperature change throughout a 24-hour period and are typically lowest around 4:00 A.M. and peak in mid-afternoon. The body's various circadian rhythms are "reset" every 24 hours by environmental cues, such as light and darkness. For example, body temperature increases with daylight and decreases at night. The human body is meant to be active during daytime hours, while during nighttime hours it is meant to sleep, which allows it to recover and replace energy. Working at night and sleeping during the day is opposite to the body's "biological" clock and what the body naturally wants to do. This may make sleeping difficult; it may also mean that the body cannot recover as quickly from physical and mental exertions and demands.

A shift worker should ensure that family and friends are aware of and considerate of the worker's sleep hours and needs. They should create a comfortable, quiet place to sleep during the day. Foam ear plugs and good window darkening blinds that block all light are examples of devices that may improve the shift worker's sleep.

Some of the negative health effects of shift work are:

- Reduction in the quality and quantity of sleep.
- Widespread complaints of "fatigue."
- Anxiety, depression, and increased neuroticism.
- Increased evidence of adverse cardiovascular effects.

- Possible increase in gastrointestinal disorders.
- Increased risk of spontaneous abortion, having low birth weight infants, and premature births.

Fixed and Rotating Schedules

A fixed-shift schedule assigns a worker to one shift indefinitely, while a rotating-shift schedule moves the worker through all shifts on a rotating basis. Each shift schedule has its merits and disadvantages. Manufacturing industries, which can easily shut down their processes, tend toward fixed-shift schedules. The process industries that have large continuous operations that are difficult to shut down favor the rotating shift. The rotating schedule rotates workers through all shifts—days, evenings, and graveyards.

The 12-hour shift has become the standard for shift workers in the process industries. This means that in a normal workday the operator will work 12 hours and be off 12 hours. Starting and ending times vary with each facility. Work schedules starting at 6:00 A.M. and ending at 6:00 P.M. are common, but some facilities work from 7 A.M. to 7 P.M. There are some advantages to such a schedule, such as workers get more days off, they work fewer weekends and it requires less commuting time. However, the 12-hour shift raises concerns about worker fatigue affecting quality, safety, and worker health. Plus, such a schedule also leaves little time for family and friends when the technician is working.

A common 12-hour schedule is shown in Figure 1-3. The schedule has the workers working four days, then having four days off. This schedule uses four crews of workers (A, B, C, and D crews), with two crews working and two crews off. One of the crews working is on the night shift, the other on the day shift. Essentially, this schedule has a technician

HOUSTON OPERATIONS

12-HOUR SHIFT SCHEDULE 2003

	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
1 Jan			(1)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
2 Jan–Feb	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
3 Feb–Mar	24	25	26	27	28	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
4 Mar–Apr	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	(18)	19	20
1 Apr–May	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2 May–Jun	19	20	21	22	23	24	25	(26)	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3 Jun–Jul	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	(4)	5	6	7	8	9	10	11	12	13
4 Jul–Aug	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10
1 Aug–Sep	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	(1)	2	3	4	5	6	7
2 Sep–Oct	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5
3 Oct–Nov	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2
4 Nov	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	(27)	(28)	29	30
1 Dec	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	(25)	26	27	28
2 Dec	29	30	31																									

1 0630–1830	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	A	A	A	A	B	B	B	B	C	C	C	C	Day:
1830–0630	C	C	C	C	D	D	D	D	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	A	A	A	A	Ngt:
2 0630–1830	D	D	D	D	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	A	A	A	A	B	B	B	B	Day:
1830–0630	B	B	B	B	C	C	C	C	D	D	D	D	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	Ngt:
3 0630–1830	C	C	C	C	D	D	D	D	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	A	A	A	A	Day:
1830–0630	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	A	A	A	A	B	B	B	B	C	C	C	C	Ngt:
4 0630–1830	B	B	B	B	C	C	C	C	D	D	D	D	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	Day:
1830–0630	D	D	D	D	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	A	A	A	A	B	B	B	B	Ngt:

NOTE: CIRCLED DATES ARE SCHEDULED HOLIDAYS

Figure 1-3 Shift Schedule