PUBLIC WORKS INSPECTOR 1 STUDY GUIDE

city of CINCINNATI

HUMAN RESOURCES DEPARTMENT

July 2010

city of CINCINNATI

HUMAN RESOURCES DEPARTMENT

PURPOSE

This Public Works Inspector 1 Study Guide was written to assist employees in becoming familiar with many of the areas that are important for this position.

It should be noted that while most of the exam questions will be taken from this Study Guide, it is **not** possible to cover everything you need to know in this format. Employees should carefully review the exam announcement to become familiar with the knowledge, skills, and abilities that may be sampled/measured/included in this exam and be prepared to answer any related question. Additional reference materials that may be useful to employees are:

- *State of Ohio Construction and Material Specifications*
- *City of Cincinnati, Department of Transportation and Engineering/ Division of Engineering, Standard Drawings*
- *City of Cincinnati, Department of Transportation, Construction Inspection Manual*
- *City of Cincinnati, Supplement to State of Ohio, Department of Transportation Construction and Material Specification*
- *City of Cincinnati, Department of Public Works, Division of Engineering, Street Restoration Book*

Hopefully, by studying this guide, employees will be able to score higher on the eligible list. Even more important, however, employees will learn useful information that can be applied to whatever position they currently hold.

Whatever knowledge is learned is valuable for personal growth as well as for future promotional endeavors.

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July 2010

Public Works Inspector 1 Study Guide
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DUTIES AND RESPONSBILITIES

GENERAL STATEMENT OF DUTIES – PUBLIC WORKS INSPECTOR 1

Under general supervision, this employee performs field and office assignments concerning the inspection of public works projects to help ensure quality work and compliance with the regulations, plans, and specifications. Field work may include monitoring and enforcing construction quality assurance requirements for public works projects such as roadway construction, rehabilitation and restoration, the construction and rehabilitation of structures, walls, sidewalks, sewers, and other public or private facilities; office assignments may include providing appropriate documentation and construction management records. Performs related duties as required.

RECORDKEEPING

The Inspector is solely responsible for daily operations of his/her project. Accurate documentation is just as critical as making sure the work gets done properly. A year or two after completion, the Inspector's daily reports, job photos, and record drawings are the only link to recreate what actually happened. Always remember that the Inspector is the eyes and ears of the Engineer and at times an Inspector's documentation may be used in litigation.

DAILY REPORTS

An Inspector is required to fill out a daily report for each day during the duration of a project. Even days the contractor does not work, a daily report is to be filled out. Think of dailies as a news record of events: who, what, when, where, how, and why.

1. Information Needed: Daily reports should contain the following information:

   - All contractors working and how many people they have working.
   - Activities worked on that day.
   - Any changes made and why.
   - Any unusual happenings, accidents, injuries, conversations, directions to the contractor, etc.
   - Any safety issues.
   - Notes from any meetings and brief description of such.
   - Description of scheduling changes, if appropriate.
   - Record of weather and any unusual circumstances associated with it.

2. Copies: Two copies should be made of the daily report:

   - One copy for the Inspector's records.
   - One copy should be sent to the Project Engineer on a bi-weekly basis.

QUANTITIES

The Inspector is required to keep very accurate and meticulous records of quantities. This is the dollar spending of the contract and is one of the most important element of project records. Quantities need to be accurate, verifiable, and reproducible. Records and notes can be used to recreate all quantities. If there are questions, an Inspector should always ask.

1. Record quantities, location and unusual circumstances on Inspector's daily report for each day of production. List items as bid quantities, description, stations, and either include calculations on daily report or attach separate sheet with calculations. An Inspector should be able to recreate by the description of days worked and condition at any given date. An Inspector will verify work with the contractor on a daily basis.

2. An Inspector will keep a logbook of quantities for daily input that summarizes quantities for a monthly basis. Each item will have an individual page in the Inspector's daily with details. An Inspector will note and document any quantity reconciliation. Finally, total quantities are determined on a monthly basis.

3. Final quantities need to reflect all totals and be clearly marked on the partial as "final." An Inspector will obtain the contractor's signature on the final as proof of agreement.

PROJECT FILES

Inspectors should set up project files including, but not limited to, the following:

1. Meeting minutes and notes (typed and handwritten). Notes should be taken at job meetings by the Inspector.

2. Approved, stamped shop drawings; submittals and transmittals; specifications for special equipment or materials; colors; samples; etc. This should be organized to reflect specification sections as outlined in the contract organized as necessary to keep information clear and concise.

3. All correspondence from Engineer and contractor organized as necessary to keep information clear and concise.

4. Files for daily reports; monthly estimates; bid tabs; tickets (concrete, asphalt, gravel, special items, etc.); time and material work; test results; photos; schedules and updates; proposal requests; safety; survey notes. Upon completion of the project and punchlist items, all files should be boxed in organized folders and sent to the Engineer for permanent storage.

AS-BUILT DRAWINGS

Inspectors are required to keep and maintain a set of "as-built" drawings on the project. This set shall be a neat, clean set of drawings with the following information:

1. Important dates: for example, major concrete pours, sections of the project completed, major demolition, delivery of important material, etc.

2. Drawings are to be updated daily.

3. The "as-built" drawings shall contain the most recent revised drawings and any revised sketches, renderings, or agreements attached to the appropriate page (this includes all corrections, addenda, changes, revisions, notices, and any modifications). Old drawings shall be removed from this set or clearly marked as voided.

4. All things exposed during construction, including utility locations, should be noted.

5. Drawings shall be available at the jobsite for daily review.

PROGRESS PHOTOS

On a regular basis, an Inspector will take, date and label progress photographs of the project. This includes, but is not limited to:

1. Existing conditions before work begins.

2. Progress photos as work proceeds on major aspects of the project. If these photos are a record of production, try to take same location pictures each time. As a minimum, record by photo progress at least once a month with 35mm camera.

3. Any and all unusual circumstances. This includes things underground that will be buried and not seen at a later date. Any problems, design concerns, contractor problems, etc. These can be (and maybe should be) taken with a Polaroid camera for instant viewing.

4. All citizen complaints or right-of-way issues should have pictures for reference and possible future litigation as soon as discovered.

City of Cincinnati
Department of Transportation and Engineering
Construction Management Section
City Hall, Room 430, 801 Plum St.
Cincinnati, Ohio 45202-1980
513-352-3422

Inspector Daily Report

Contractor: A.B.C. CONSTRUCTION CO.
Subcontractors (on site): ELECTRIC CONSTRUCTION

Work Conditions: DRY, Good
Weather Conditions: Sunny
Temperature Range: 60-75

IDR # 1
Date: 5/1/06
Day of Week: Monday
Contract Number: 06/CU99000
Contract Name: STREET REHAB
Inspector: John Doe
Engineer: John Doe

Work Force

Contractor	Craft	No.
ABC	Foreman	1
	LABORER	5
	OPERATOR	2
ELECTRIC	FOREMAN	1
	ELECTRICIAN	4

Equipment

Contractor	Type of Equipment	Hrs in use	Hrs Idle
ABC	FOREMAN TRUCK	8	
	BACK HOE	8	
	DUMP TRUCK	8	
ELECTRIC	FOREMAN TRUCK	8	

Contractor's Work Pay Items

Item	Spec	Description	Street	Location	Quantity	Unit	Is this item complete on this asset? Y/N
4	203	EXCAVATION	FIRST	sta 2+00 to 3+00	100	CY	N
8	254	PAVEMENT PLANNING	Second	sta 1+00 to 8+00	500	SY	N
29	1327	TRAFFIC SIGNAL	THIRT	at MAIN + THIRD	1	EA.	N

Force Account Work (attach Force Account Record sheets) Yes: ☐ No: ☒

Work hours	From	To	Hours
Contractor	7 AM	3:30	8
Inspector	7 AM	3:30	8
Inspector (on site)	7:15	11:00	3.75
	12:00	3:30	3.5

Inspector's Signature: John Doe
Data base entry: ✓
Date:
Engineer review:
Date:

Overtime Explanation: NA
Contractor's Rep. (on site): MR. FOREMAN

Activities inspected and observed: EXCAVATION OF 1ST STREET. MATERIAL HAULED TO DUMP. GRINDING ON SECOND ST. NEW TRAFFIC SIGNAL AT MAIN AND THIRD

Safety observations:

Special remarks:

Law Enforcement Officers

Name of officer	Start time	Finish time	Street	Hours
NA				

Testing Agent

Company name	Technicians name	Description of test	Quantity
NA			

Materials delivered

Description	Ticket or invoice #	Certification y/n	Quantity	Pay item
NONE				

Calculations

ITEM 4. PER PLAN FROM STATION 2+00 + 3+00 = 1000 CY.

ITEM 8 - 450' x 10' ÷ 9 = 500 SY.

CUSTOMER SERVICE

Both public and private businesses and organizations have a customer to serve. For the City of Cincinnati, the citizen paying for and receiving services is the customer. Customers also include supervisors, subordinates, co-workers, other City employees, City Council, community leaders, etc. By being courteous, friendly, and helpful, each employee is helping make the customer's overall experience a good one.

REPRESENTING THE CITY OF CINCINNATI

1. ***You* Are the City of Cincinnati**: To a customer, *you* are the City of Cincinnati no matter what your job. Customers will come away from every encounter with you feeling either happy or dissatisfied, and that is how they will think of the City of Cincinnati until the next time they deal with the City on an issue. A careless word or an indifferent attitude can ruin a customer relationship forever. On the other hand, if you're helpful, enthusiastic, and concerned, people will be impressed with you and the City. Citizens may not like the answers they are given, but they should have no reason to complain about the way the answer is delivered. In some cases, a customer may be misinformed about available City services. In this situation, educating the customer is necessary. He/she must be dealt with positively. Even if the City is not responsible for the service at all, general satisfaction with the City is still an issue.

2. **Supervisor's Role**: Supervisors need to gain commitment from employees to provide the highest quality service by empowering employees with the freedom to make decisions in the interest of providing quality and also gaining customer satisfaction. This can be accomplished by holding departmental meetings to communicate what direction the department is taking and the vehicle needed to take it down the road to better service.

3. **Employee's Responsibility**: None of us are just paid to do a job – all of us are paid to serve, to make a contribution, to create a solution, to save on costs, and to cause an improvement. In virtually all jobs, the contribution we make involves working with others. Success or failure depends upon our ability to work with others; it depends upon our ability to serve customers. Creating customer satisfaction leads to customer loyalty, trust, and confidence.

4. **Service Environment**: Because the public sector is a service driven environment, quality may be more difficult to achieve than in a product driven environment--but it is not impossible. Public sector employees must keep the following points in mind:

    - Service is produced at the instant of delivery and cannot be created in advance and stored in inventory.
    - Service cannot be centrally produced, inspected, or stockpiled.
    - Service cannot be demonstrated, nor can a sample be sent in advance for approval.

- In the absence of tangible products, customers value service on the basis of their own personal experience.
- Faulty service cannot be recalled.
- Customer assessment of service quality tends to decrease in proportion to the number of employees encountered during the delivery of services.
- Customers assessment of service quality are subjective and strongly influenced by expectations.

CUSTOMERS

1. **Who Is a Customer?** Customer service does not mean doing the minimum expected to keep the customer from being upset with the City; positive customer service means doing the maximum you can possibly afford to do. Keep in mind who the customer is:

   - The customer, the user of the service, is the most important person in the organization. The customer is not dependent on the organization; the organization is dependent on the customer.
   - The customer is not an interruption; the customer is the purpose of all our work, and does us a favor when he/she calls. We are not doing the customer a favor by serving him/her.
   - The customer is a partner. The customer is not an outsider or a statistic; the customer is a human being with feelings and emotions just like our own.
   - The customer is not someone with whom to argue or match wits. The customer is a person who brings us his/her wants and needs; furthermore, the customer *pays* us to fulfil them.
   - The customer is deserving of the most courteous and attentive treatment we can give because he/she is the life-blood of this organization.

CUSTOMER SERVICE

1. **Customer Service**: Customer service is the day-to-day treatment of everyone with whom you do business. Good customer service includes:

   - The way problems are resolved.
   - The way people are treated when they receive a service.
   - The appearance of every employee and the surroundings.
   - How customers are treated in a face-to-face situation.
   - How telephone calls and letters are handled.
   - The way employees talk about the City to their friends, neighbors, and family.
   - The overall impression the customer has of the City of Cincinnati.

2. **Representing the City**: Your job success and satisfaction depends on how well you resolve issues and help customers get satisfactory solutions to very real problems and concerns. You are Cincinnati's direct link to the City residents and you are completely in control of the image residents have of City government. In this capacity, you should:

   - Be able to resolve issues.
   - Know you can't always give the customer exactly what he/she wants but can still maintain a positive relationship.
   - Know power strategies to diffuse angry or aggressive customers.
   - Understand the importance of empathy and how to respond to customers.
   - Know the importance of good listening.
   - Be patient in trying to discover the real source of customer dissatisfaction.

DEALING WITH CUSTOMERS

Make each and every customer feel as if he/she is **#1** by:

1. **Personalized Contact**: Personal communications usually mean less potential problems. It is far easier for the customer to be angry with the City than it is for him to be angry with you as a person. Be friendly. People do not want to talk to the "City", they want to talk to other people; specifically, people who care.

2. **Listen Actively**: Listening is hard work. Use interjections such as "I see", "Oh?", "Uh-huh", and "That's interesting" to encourage the customer to talk as well as to control your own speaking. This helps you demonstrate concern.

3. **Interest**: Under no circumstances can interest be faked. You are either interested or not interested, and the customer will certainly know your position; you cannot fake it. Ask questions, show concern, show interest, and get the information right.

4. **Do Not Let the Customer "Get to You"**: Do not be tempted to take satisfaction in showing a customer he/she is wrong, especially when that customer has been bullying or blaming you for the problem. Keep your cool. Later you can be proud of yourself for handling the situation professionally.

5. **Empathy**: Empathy statements are similar to "I understand why you feel that way", "I'm sorry this has happened", or "I can appreciate your position." Using empathy statements carefully and with sincerity is critical to creating high levels of satisfaction -- they are an absolute requirement when dealing with angry customers.

6. **Concentrate on a Solution**: Why something went wrong can be determined later; for now, focus on how to solve the problem with the least cost and maximum benefit to all concerned. Concentrate less on finding fault and more on what can be done right *now* to straighten things out.

7. **Do Not Embarrass the Customer**: Even when it is clear that the customer is in error, be considerate. Focus on how the problem can be avoided in the future in a way that shares responsibility such as "In the future, please call us as soon as you see an error. Then we can correct it and service won't be discontinued because we didn't know why the bill had gone unpaid."

8. **Professionalism**: Use please, thank you, and telephone hold appropriately. Take action by doing something – take a step or find a partial solution. Create a compromise, create a positive change or make a slight improvement. Be a positive asset to your customer and the City.

DEALING WITH CUSTOMERS FACE-TO-FACE

1. **Face-to-Face Contact**: When dealing with customers on a face-to-face basis, keep the following guidelines in mind:

   - Personal appearance is very important. The first impression a customer has is important. This includes more than clothes and hairstyle. If your work area is disorganized, a customer may assume that you are disorganized in your work.
   - Offer a firm handshake.
   - Look the customer directly in the eye.
   - Put aside everything else on your desk or workspace to show the customer that he/she has your full attention.
   - Ignore distractions.
   - Get your whole body involved: smile, nod your head, gesture.
   - Concentrate on what the customer is saying.
   - Ask questions, restate what you have heard. Keep an eye on the customer's expressions.
   - Do not interrupt.
   - Take notes.
   - Avoid forming an opinion until you've heard everything the customer has to say.
   - Do not eating in front of customers. This includes chewing gum and smoking.

CUSTOMER SERVICE OVER THE PHONE

Learning how to create a positive tone on the telephone when serving a customer is vital. The service given the caller must be handled efficiently and completely. When callers have to wait, they are not happy and this creates a negative image for the City.

Take a personal interest in a caller by being courteous and listen carefully to every request. The following points will help develop a positive tone for serving callers:

1. **Answer Promptly**: Answer the phone promptly – preferably within three rings.

2. **Be Courteous**. If a pleasant manner is used when handling a telephone call, it will be easier to convey thoughts.

3. **Use a Pleasant Voice**. Be sure that statements made are grammatically correct and that words are clearly spoken. Sound friendly.

4. **Speak Distinctly, At a Moderate Pace**. Do not mumble, rush, or turn away from the telephone.

5. **Use Everyday Language**. Avoid jargon and explain any words the customer may not understand.

6. **Avoid Putting the Caller on Hold**: Customers do not enjoy being on hold. If you must use hold, ask first and thank the caller for holding.

7. **Make an Effort to Understand the Caller**. Learn the needs of the caller by listening. Provide an opportunity for the customer to explain the purpose of the call.

8. **Give Explanations as Needed**. If it is necessary to give an explanation, be sure it is thorough. Give the explanation in a manner that is sincere and easy to understand.

9. **Repeat Information to the Customer**. That includes the customer's name, address, account number, and the specific terms of the order or complaint.

10. **Be Specific**. Do not allow a customer to rush you and prevent you from relaying information as completely as possible.

11. **Encourage Questions**. Get feedback on what you have discussed.

12. **Display a Positive Attitude**. Always let the caller know that they are important. Remember that you are representing yourself and the City.

13. **Thank Every Caller**: End every call by thanking the caller.

14. **Dealing With An Angry Caller**: Occasionally an angry caller may have to be dealt with. Callers who are annoyed at something often take their anger out on the first person they talk to. While dealing with an angry caller is not pleasant, keep the following in mind:

    - Let the caller vent, but do not take it personally and do not respond back in the same way. Do not interrupt the caller while he/she is venting; the customer may think you're not listening and start over and become more agitated. Once the story has been told, and the angry person peaks, start asking qualifying questions.
    - Do not hang up. Do not be negative; be calm, pleasant and helpful. Focus on the customer's need and how you can meet it.
    - Apologize to the caller on behalf of the City and indicate a desire to help resolve the problem.
    - Get all the information you need to solve the problem.
    - If it is necessary to transfer the call to someone else, reassure the caller that he/she will be connected to the proper person; then make sure the call is connected. Tell the person to whom the call is being transferred what the situation is so that the caller does not have to go through the entire story again.

- If a caller continues to be angry and/or abusive, follow these steps:
  -- Try to ignore the remarks. Take the heat if the caller makes an abusive remark *once*. But if a second comment is made...
  -- Keep your voice low and calm. Keep your cool and demonstrate that you are working to solve the caller's problem. Once customers see that you are working on their behalf, they may calm down and even apologize. Accept their apology and proceed. If abusive remarks continue...
  -- Respond by saying "Mr. Jones, I need to ask you not to talk to me that way. I wouldn't talk to you in this manner. I am trying to help you." If a polite, direct approach fails, you may have to...
  -- Suspend the conversation. Departmental policies dictate when it is OK to cut off a customer. When the time is appropriate, say something like "I know you are upset and I do want to help you, but I can't help you when you are this upset. Can I call you back later today?"

MAKING A CUSTOMER HAPPY

Ways to make unhappy customers happy are:

1. **Hear the Customer Out**: In addition to getting a problem resolved, the customer wants to feel that he/she has been allowed to tell their story to a sympathetic ear. Initially, just let the customer vent; don't take it personally. Listen attentively and responsively, even if you think the problem has nothing to do with the City of Cincinnati.

2. **Do Not Argue**: Customers may be angry and saying things that are not true. Do not fight back; do not return aggression for aggression. By letting the customer sound off, you are creating time for the person to calm down. He/she may not yet be ready to listen to reason.

3. **Show You Are Sorry**: Let the customer know that you are sorry there is a problem, but that you are glad to hear about it. You are not admitting error, but simply letting the customer know you regret the situation, no matter what the reason is or where the fault lies.

4. **Win Them Over With Empathy**: You have calmed the customer down by listening. Now let the customer know you understand how he/she must feel by saying "that must have been frustrating for you. I can see how disappointing it must have been to not have the problem resolved."

5. **Start Your Investigation**: Once the customer has settled down, you should be able to ask questions and get answers that can help you accurately determine the scope and nature of the problem. Use open-ended questions. Words such as who, what, when, where, why, and how help discover causes and help uncover specifics. Try to help the customer understand the real problem. Get all the information needed to solve the problem. Double check the facts.

6. **Clarify**: After you ask a few questions, repeat the information conveyed to you to make sure you understand exactly what the customer perceives as the problem. Continue the discussion; periodically repeat and paraphrase what the customer is saying. Admit error, it necessary.
7.

7. **Find Out What the Customer Wants**: Sometimes a customer simply needs to blow off steam (perhaps justifiably), but does not really expect anything to be done. In this case, you have helped simply by listening and understanding the dissatisfaction. If the customer wants something more, be sure you understand exactly what he/she is asking for. Provide options and consequences for its solution.

8. **Explain What You Can and Cannot Do**: If the customer is asking you to do something that is within your power to carry out, do so at once. If it is not that simple, you may have to involve someone with more authority.

9. **Set Up a Plan**: Once an alternative is decided upon, set up a course of action that is agreeable to the customer. Be specific about what will occur and when such as "I will contact the Accounting Division this afternoon. Refund checks are issued on Fridays, so you should expect to hear from us early next week."

10. **Take Action**: Once you promise action, carry it out. Act promptly before other work gets in the way and distracts you.

11. **Refer the Issue**: In some instances, you will deal with non-City related issues. If that is the case, you may need to refer the customer to another source.

12. **Check Back With the Customer**: Whenever possible, follow through by checking with the customer to see that the implementation of the solution has been satisfactory. Let the customer know that you appreciate the opportunity to make things right.

DELIVERING "BAD NEWS" TO A CUSTOMER

Occasionally it is necessary to deliver "bad news" to a customer. Soften the blow through careful preparation and clear communication. No one likes to hear bad news and no one likes to deliver it, however, your concern, competence, availability, and integrity will be viewed positively – even by a frustrated customer. Keep the following suggestions in mind:

1. **Be Compassionate**: When anticipating a strong negative response from a customer, try to understand the customer's position and empathize.

2. **Be Direct**: Do not hedge or hold out false hope for the customer when presenting bad news. It is better to say "I'm sorry, Mr. Jones, but I've been informed that the problem cannot be corrected until next Thursday" rather than "We're not sure we can get the problem corrected on time, but we're giving it our best shot." The first statement is more direct and reassuring than the latter statement.

3. **Ask for Understanding**: Customers are humans and are usually more than willing to extend their understanding (and even empathy) when they are asked to do so. Asking your customer's understanding and acceptance won't solve the problem, but it can make the solution to the problem a joint effort.

4. **Offer a Realistic Plan for Resolution**: What can you tell the customer about the ultimate resolution of the problem? When can you feasibly offer delivery? Whatever options you bring to the table, even though they are not what the customer really wants, will help bring an end to the issue. Just be sure that you can deliver what you offer.

5. **Do Not Offer Blame or Excuses**: Each employee is a representative of the City of Cincinnati. Do not blame another person or department for the bad news. The City's overall integrity is damaged when employees cast blame on others.

6. **Offer to Explain**: If the bad news will significantly affect the customer's company, offer to explain the situation to the person's supervisor. The customer should not have to take the heat. While the customer may not take you up on the offer, your willingness to stand by his/her side will be appreciated.

7. **Make Amends**: If the bad news has inconvenienced the customer in some way, identify what the City can do to make up for the problem. The closer you come to alleviating any negative effects of bad news, the greater the likelihood that you'll maintain a sound relationship for the future.

REACTING TO DIFFICULT TYPES OF PEOPLE

When dealing with people, be ready to react to the actions of different personalities. Some examples are:

1. **Aggressor**: Intimidates, is hostile, and loves to threaten. *What to do:* Listen to everything the person has to say. Avoid arguments and be formal, calling the person by name. Be concise and clear with your reactions.

2. **Underminer**: Takes pride in criticism and is sarcastic and devious. *What to do:* Focus on the issues and don't acknowledge sarcasm. Do not overreact.

3. **Unresponsive Person**: Difficult to talk to and never reveals his or her ideas. *What to do:* Ask open-ended questions and learn to be silent while waiting for the person to say something. Be patient and friendly.

4. **Egotist**: Knows it all and feels and acts superior. *What to do:* Agree when possible and ask questions and listen. Disagree only when you know you're right.

BE A GOOD LISTENER

To be a good listener, use the following guidelines:

1. **Limit Your Own Talking**: You cannot talk and listen at the same time.

2. **Think Like the Customer**: Your customer's problem and needs are important and you will understand and create greater satisfaction if you listen to his/her point of view. Many people are afraid of City services.

3. **Ask Questions**: If you do not understand something or feel you may have missed a point, clear it up now before it embarrasses you later.

4. **Don't Interrupt**: A pause does not always mean he/she is finished saying everything he/she wants.

5. **Concentrate**: Focus your mind on what the customer is saying. Practice shutting out distractions. Remember, you represent the entire City.

6. **Take Notes**: This will help you remember important points, but be selective. Trying to take down everything can result in being left far behind or in retaining irrelevant details.

7. **Listen for Ideas, Not Just Words**: You want to get the whole picture, not just isolated bits and pieces.

8. **Use Interjections**: An occasional "yes", "I see", etc. shows the customer you are still with him/her, but do not overdo or use as a meaningless comment.

9. **Turn Off Your Own Concerns**: This isn't always easy, but personal fears, worries, and problems not connected with the issue form static that can blank out the customer's message.

10. **Prepare in Advance**: Whenever possible, prepare your remarks and questions in advance. This will free your mind for listening.

11. **React To Ideas, Not the Person**: Do not allow irritation at things he/she may or may not do distract you. Do not be distracted by mannerisms.

12. **Do Not Jump to Conclusions**: Avoid making unwarranted assumptions about what the customer is going to say or mentally trying to complete the sentence for his/her.

13. **Listen for Overtones**: You can learn a great deal about the customer from the way he/she says things and the way he/she reacts to the things you say.

INTEGRITY IN THE WORKPLACE

WHAT IS BUSINESS ETHICS?

Ethics is the process of learning what is right or wrong and then doing the right thing. In other words, doing the right thing because it is the right thing to do. Good ethics are essential to good business. Treating customers ethically helps a business acquire a reputation as an agency worthy of trust.

A business deals with many stakeholders (customers, employees, managers, owners, investors, the public, etc.). Business ethics is about giving fair value *to* all stakeholders in exchange for fair value *from* all stakeholders. Sometimes it is quite a balancing act and takes careful thought to ensure that everyone concerned receives fair value. Ethical business people develop the habit of looking at each and every transaction from multiple perspectives. Become known for high ethical standards and you will probably make many customers.

An organization that is built on integrity will ultimately succeed. When business integrity is present throughout the deepest layers of an organization and not just at the surface, it becomes the heart and soul of the organization's culture. Integrity must be so ingrained within the nature of an individual, the organization and its team members, that it remains steadfast no matter what.

Integrity begins with an organization's leaders who understand the qualities of integrity which then filters down throughout the organization into every department and every member's approach and attitude.

HONESTY

Honesty is the best policy. Honest organizations build trust not only among customers, but among members of the organization. Act ethically, and subordinates and peers will probably do the same. While example is generally the best teacher, do not just rely on others to follow your ethical business behavior. Discuss the role of ethics.

In a climate of trust, people are generally more productive because they are not constrained by hovering micromanager.

PRINCIPLES OF BUSINESS INTEGRITY

1. **Principle #1 – Trust**: Recognize that customers/clients want to do business with a company they can trust. When trust is at the core of an organization, it is easy to recognize. Trust defined is assured reliance on the character, ability, strength, or truth of an organization.

2. **Principle #2 – Feedback**: For continuous improvement of an organization, the leader must be willing to open up to ideas of betterment. Ask for opinions and feedback from both customers and team members.

3. **Principle #3 – Honor Commitments and Obligations**: Regardless of the circumstances, do everything in your power to gain the trust of past customer's and clients, particularly if something has gone awry. Do what you can to reclaim any lost business by honoring all commitments and obligations.

4. **Principle #4 – Do Not Misrepresent or Misinterpret**: Re-evaluate all print materials including advertising, brochures, and other business documents making sure they are clear, precise, and professional. Most important, make sure they do not misrepresent or misinterpret.

5. **Principle #5 – Be Involved**: Remain involved in community-related issues and activities thereby demonstrating that your organization is a responsible community contributor. In other words, stay involved.

6. **Principle #6 – Accountability**: Take a hands-on approach in regard to accounting and record keeping, as a resource for any "questionable" activities. Gaining control of accounting and record keeping allows you to end any dubious activities promptly.

7. **Principle #7 – Respect**: Treat others with the utmost of respect. Regardless of differences, positions, titles, ages, or other types of distinctions, always treat others with professional respect and courtesy.

AN ETHICAL ORGANIZATION

An ethical organization:

1. Treats all stakeholders adequately and fairly.

2. Consistently makes fairness the first priority.

3. Expects individual, rather than vaguely collective, accountability.

4. Defines objectives and goals that all members value.

5. Portrays a clear vision of integrity, exemplified by management.

6. Demands and rewards integrity at all times and in all situations.

An organization is only as ethical as the people who run it and work for it. Individuals need to show strength of character and commitment by giving their best effort to every responsibility of their job, even when they do not want to (called professionalism) or do not feel confident (in

which case they should seek assistance or training). Personal responsibility and accountability is a must at all times. Do not do anything behind someone's back that relates to the organization that you would not do in front of the person.

Ethics is about honest interaction with others, but it begins with the individual employee being honest with himself/herself. Ask yourself the following questions:

1. Do I put in a full day's work for a full day's pay?
2. Do I ever pad my travel expenses or other reimbursables?
3. Do people who know me value my word absolutely?
4. Do I ever "appropriate" office supplies for personal use?
5. Do I value loyalty?
6. Do I believe it is important to set an example of honest behavior?
7. Do I treat others as I want them to treat me?
8. Does the word "honest" honestly describe me?
9. Am I as ethical at work as I am at home with my family?
10. Would an organization staffed with people as honest as I am be a highly ethical organization?

Remember, ethical people are more likely to be successful in business than unethical people.

WHAT IS CHARACTER?

Character describes a cluster of personal qualities each of us can cultivate to help us work ethically and thereby create more ethical businesses.

1. **Trustworthiness**: Being trustworthy means that others do not have to police you to ensure that you will meet your obligations and perform as promised. Behave honestly so that others accept what you say as the truthful expression of your convictions and intentions.
2. **Integrity**: A trait that describes a whole person, one who is undivided and who acts according to his/her convictions, not according to what is easy at any given moment. Behaving with integrity requires acting from principles, which do not change from situation to situation.

3. **Loyalty**: A special allegiance to certain people or organizations. An ethical business person gives loyalty to his organization and the stakeholders associated with it, and he/she expects loyalty in return. Vigilance is required to avoid confusing loyalty with favoritism, friendship, or relationships based on intimidation. Some of the most difficult ethical decisions involve defining loyalty and prioritizing multiple loyalties.

4. **Accountability**: Ethical people take responsibility for their actions. They do not pass the buck. If the organization has a problem, they take ownership of it and make themselves accountable for working the problems toward a solution.

5. **Fairness**: Decision making based on information objectively gathered and impartially evaluated. The processes of gathering and evaluating are open for all to see. Actions taken as a result of fair decisions are both equitable (they apply to everyone in the organization) and proportionate (they do not reward the undeserving, punish the blameless, or impose outrageous penalties).

DETERMINING WHAT IS RIGHT

The following steps can be used to answer ethical questions and resolve ethical dilemmas as they arise. By laying out steps, checking off the points to consider, and asking all the relevant questions, you can reduce the chances of overlooking anything critical to the decision at hand.

1. **Step 1 – Define the Problem**: You cannot solve a problem without first defining it accurately. Often, an accurate description of the problem will reveal its own solution. Avoid responding from motives of expediency, but also resist emotional impulse to act out of anger or to rush into doing what feels right at the moment. Remember, ethical action sets out to treat all stakeholders fairly, which means thinking through how a decision will affect bosses, subordinates, peers, customers, and the community.

2. **Step 2 – Get the Facts**: Make no decision until you are satisfied that you have all relevant facts in the matter at hand. Ethical decisions must be equitable decisions, and it is impossible to achieve balance without having the necessary information from all parties who will be affected by the decision.

3. **Step 3 – Think Long Term**: Formulate ethical decisions not just based on short-term needs and circumstances, but also in relation to long-term goals, policies, and clearly understood principles of ethical conduct. Decisions must respond adequately to the present situation, but this should not require sacrificing values for the long term. Expedient answers that feel okay in the moment may, over time, prove impossible to live with.

4. **Step 4 – List the Options**: Armed with an understanding of policies and principles and having gathered all relevant facts, make a list of possible actions. Ethical decisions making is always about choices, and it is impossible to choose meaningfully without first clearly enumerating the range of available alternatives.

5. **Step 5 – Imagine the Consequences**: For each option that you list, work through the possible consequences for all stakeholders. Depending on the degree of complexity of the issues involved, this may require a special exercise of the imagination as you formulate "what if" scenarios.

6. **Step 6 – Try on Another Pair of Shoes**: Exercise your imagination: What would I decide if I were Joe, Karen, or Lisa? Try to look at the proposed action from a variety of perspectives. Walk the proverbial mile in another person's shoes. If you conclude that others will find the proposed solution unacceptable, rethink and revise. Before you implement an ethical decision, ask: Who could be hurt by this action? Answer the question and, if necessary, take steps to avoid harm or reject the proposed action.

7. **Step 7 – Can You Live with this Decision?**: Consider whether you are 100% comfortable justifying this decision to all stakeholders – boss, colleagues, subordinates, investors, customers, and the community. Do you feel that you have something to hide?

8. **Step 8 – Act**: If this process has yielded a clear choice among the listed options, act. If you are still undecided, consider taking the following steps:

   - How would you like to be treated in this situation? Treat others in this way.
   - Seek advice from those you respect.
   - Seek "virtual" advice. Think of someone you highly respect and whose judgment you trust. Imagine what that person would do in this case.

9. **Step 9 – Do Not Walk Away**: Follow up on the decision you make. Monitor the effects of the decision. Hard as it is to make good choices, few decisions are truly absolute and irreversible. If the decision you have made does not produce good results, the ethical thing to do is rethink the decision and, if necessary, modify it.

COMPUTER TECHNOLOGY

COMPUTER HARDWARE

The typical electronic office workstation consists of a central processing unit, a disk drive, a monitor, a keyboard, a mouse, and a printer – all known as computer hardware.

1. **Central Processing Unit (CPU)**: The central processing unit is the inside of the computer (the "brain") which controls the processing instructions and determines the amount of memory a computer has. The CPU contains the instructions that carry out the input, processing, storage, output, and distribution/communication functions of the computer. It handles the arithmetic-logic calculations as well as the storage of instructions and data in "memory" until they are needed to be called up and used. The computer has two kinds of memory:

    - *ROM (Read-only Memory):* Permanent memory that contains the information to make the computer run. Even when the computer is turned off, ROM is not affected.
    - *RAM (Random-access Memory):* Temporary work space where the computer runs and stores the information on which the user is working. RAM is wiped out as soon as the computer is turned off.

2. **Disk Drives**: The disk drive is a device that reads information from and writes information to a disk. The disk drive is either built into the computer or located in a separate box attached to the computer. Most equipment has two disk drives.

    - *Hard Disk*: Stores data and programs built into the computer. Information can be transferred to and from diskettes. A hard disk can store much more information than a diskette and can retrieve information much faster.
    - *Diskettes:* Diskettes are also called floppy disks or floppies. The floppy disk drive is used to store data on a floppy disk or retrieve data that has been stored previously on a floppy disk.
    - *CD-ROM (Compact Disk, Read-Only Memory)*: Reads information with a laser beam; therefore, it is a read-only drive.

3. **Monitor**: The television-like display screen allows the user to view information about the software being used as well as the material as it is being keyed into the computer. Many monitors have tilt-and swivel bases so the user can position it for comfortable viewing. It is possible to go to any point on the screen by using keys that move a cursor. The document displayed on the screen is known as a *softcopy*.

4. **Keyboard**: The keyboard is the most common method of inputting data into a computer. Most keyboards have four main parts:

    - *Alphanumeric Keypad*: The alphanumeric keypad is a standard keyboard which includes letters, numbers, and basic symbols. Depending on the type of computer, some alphanumeric keys have uses other than those related to typing. There may also be some special keys.
    - *Cursor Control Keypad*: The cursor control keypad (arrows pointing up, down, left and right) enables the user to locate specific portions of a document on the screen; when the cursor is moved to the appropriate point, a specific action can occur.

- *Function Keys*: The function keys (labeled F1 through F12) located across the top of the keyboard act as shortcuts to performing certain operations. Frequently these keys are used in conjunction with keys on the alphanumeric keyboard to perform specific tasks. A template can be placed over the function keys to guide the user.
- *Numeric Keypad*: The numeric keypad has keys for each of the ten Arabic digits and is usually set up like a calculator keypad. This keypad usually has more than one function, i.e., cursor control arrows, page instructions, etc. It is located to the right of the keyboard for more efficient inputting of numbers.

5. **Mouse**: A mouse is a hand-held pointing device, used in conjunction with the keyboard, that takes the place of the cursor control keys and many function keys in performing routine computing tasks. When the cursor is moved, a small arrow or bar-shaped pointer moves on the screen. The mouse can be used to select words, sentences, or paragraphs from the text that need to be manipulated.

6. **Printer**: Printers provide the printed output, known as the *hardcopy*. Printers vary in speed, print, quality, and cost. Laser, inkjet, and dot-matrix are all commonly used types of printers.

COMPUTER-RELATED EQUIPMENT

1. **Modem**: Stands for "modulator-demodulator" which allows the computer to communicate with other computers. The modem translates digital signals into analog signals so they can be sent via telephone lines, and then translates the analog signals back to digital signals for the receiving computer.

2. **Scanner**: Devise that can "read" text and graphics. A copy of the scanned image is stored on magnetic media as it simultaneously reproduces on a monitor. Text, photographs, drawings, and charts can be scanned. Accuracy depends on the quality of the document being scanned so it is imperative to review the scanned image for the occasional error the scanner may have picked up.

3. **Plotter**: Used to print graphics. There are many types of plotters that produce pages or transparencies, and draw curved lines, three-dimensional figures, bar charts, graphs, etc., according to the instructions of the computer. Some plotters are capable of adding text labels to the charts produced.

LOCAL AREA NETWORK (LAN)

A network is a collection of closely grouped PCs wired together to share data, programs, and hardware in an effective cost efficient way. The term local area indicates that the members of the network are in close proximity. A LAN allows users to share software and data files within a building, department, or other limited geographic area. The reason for the growth of LAN environments is that most people do not work alone, but work with others to share information and resources. The heart of the LAN is the file server which is a computer that controls the flow of information between computers and other devices connected to the network. The file server also stores most of the software programs, files, and data that will be accessed by the LAN users.

1. **Advantages of a LAN**: A well-designed LAN can offer a number of advantages:

   - It eliminates an individual having to run around the office delivering and retrieving data--users can do that electronically.
   - Several computers can be hooked up to the same printer, thereby decreasing the cost of many individual printers.
   - Cost savings can also be applied to other hardware that is shared.
   - Users can send e-mail messages to local and remote users.

In addition to an internal communication system, many businesses also need access to external communication systems. Local area networks can tie into a larger network to enable a business to communicate over a greater geographic region--called a wide area network (WAN).

COMPUTER SOFTWARE

A computer cannot do a single thing without programs. A program is essentially a list of instructions to the computer. Programs tell the computer how to process data. *Software* is the term used to refer to the programs and data that instruct the computer to carry out tasks. Software is divided into three distinct categories: programming software, operating systems software and applications software.

1. **Programming Software**: Programming software consists of the instructions of programs that are implanted in the circuits of the CPU. These instructions make the computer operate. The ordinary user does not interact with this software.

2. **Operating Systems Software**: Operating systems software has two major functions: to operate the computer equipment and to translate programs into machine-readable instructions. The operating system for microcomputers (personal computers) is provided on a disk and is referred to as the disk operating system or DOS.

3. **Applications Software**: Applications software consists of programs that instruct computers to execute specific tasks. The software is designed to make the power of a computer available to people who have no programming background and little or no desire to write their own programs. Examples of application software include word processing, spreadsheets, accounting, database management, desktop publishing, graphics, electronic mail, etc.

USES OF A COMPUTER

Most office workers use application programs which are designed for the user to be able to learn to operate the program in a short period of time and with a minimum amount of instruction. These programs are called *user-friendly.* Application programs use menus and commands to carry out their functions. A *menu* is a list of operations that can be performed and are usually listed as options on a separate screen at the beginning of the program or at the top or bottom of the screen containing the data. Application programs also use many *commands* to carry out their functions. These commands are not always displayed on the screen while the program is operating so it is necessary to memorize them in order to operate the program efficiently.

1. **Word Processing**: Word processing can apply to any method of transferring ideas and information into written documents and involves typing and nontyping tasks. Nontyping tasks include setting format specifications, such as those for margins, tab stops, line spacing and positioning of the first line of text. Once these steps are completed, the document is prepared, with all needed corrections. The next step is to proofread and edit the document by use of command keys on the keyboard, called *function keys*. Using the function keys, margins, tabs, and line spacing can be set or changed; text can be adjusted to fit new specifications automatically; words can be added or deleted; and spelling can be checked.

2. **Spreadsheets**: A spreadsheet uses a grid or matrix (similar to an accounting ledger), in the form of columns and rows on the screen, to perform mathematical calculations and analysis. Values are entered in the columns and rows and calculations are performed on them. If a value or formula is changed, everything affected by the change is automatically recalculated. Budgets, balance sheets, and income statements are commonly created with spreadsheets.

3. **Databases**: An electronic database is an organized collection of data on a related subject. This data can be manipulated in many ways to show different aspects of the same information. The data is entered, organized, stored, and retrieved in a format and order specified by the user. A database has the ability to record, manipulate, select, sort, calculate, and retrieve data on the basis of criteria that the user selects.

4. **Graphics**: A computer can make comparisons of all stored data. Software is used to create charts, graphs and other types of pictorial images from numeric data that is entered. This data can be easily retrieved and converted into different formats for easy analysis.

5. **Desktop Publishing**: A desktop publishing program allows the transfer of text created by a word processing program into professional-looking documents such as newsletters, manuals, brochures, and business forms. The software enables the user to experiment with various types of design and layout. The user has the capability of changing print size and appearance, drawing lines and borders, and adding clip art to a document. Typeset-quality copy is then produced on a high-quality printer.

SECURITY CONSIDERATIONS

As the use of microcomputers has increased and more people become knowledgeable of computer systems, security becomes a bigger issue.

1. **Security Procedures**: Information stored on any magnetic media is easy to copy and disks are portable and easy to conceal or steal. In addition, a security problem occurs when only one copy of a document exists and it is erased. Practice the following security procedures:

   - Arrange for a backup of all material that is on magnetic media. This information should be stored in a separate location.
   - Lock up floppy disks when not at your desk and when leaving for the day.
   - Use passwords and do not give anyone else your password.

2. **Computer Viruses**: Computer viruses are a serious threat to computer security. A computer virus is a program introduced into the computer without the permission or knowledge of management. It invades the computer processor and disrupts normal operation of the computer by taking control of the operating system, the program which enables the computer to run application software programs. The virus spreads into other programs and then spreads from one computer to another as users share disks. Computer viruses have the potential to wreak havoc by destroying data or impeding computers that are vital to the City. Antivirus programs have been developed that can check computer software for viruses; this software can eradicate any virus that is found. Guidelines that can be used to help prevent or control viruses include the following:

    - Purchase all software from known, reputable sources.
    - Test new software on an isolated computer before introducing it into a computer system or sharing it with others.
    - Back up all master software and computer data at least once a month so that the backup can be used if current versions are invaded by a virus.
    - Periodically scan hard disk drives on your computer for viruses.

COMPUTER TERMS

In working with computers, the following terms are used:

- **Backup**: A duplicate of an original file or disk, created in case the original is lost or otherwise unusable.

- **Bit**: The smallest unit of information that can be processed by a computer.

- **Byte**: A sequence of bits, usually shorter than a word.

- **Clip Art**: Public domain art, either in books or on disks, that can be used free of charge without credit in a publication. Using clip art is the fastest way to get graphics onto a page.

- **Command**: Instruction to the computer, via the keyboard, to perform a certain function.

- **Cursor:** A lighted indicator on a display screen which marks the current work position (where the next character typed will be displayed).

- **Data**: An often unorganized group of facts, usually made up of words or figures.

- **Database**: A stored collection of data on a particular subject.

- **Debug**: Remove errors ("bugs") from a software program.

- **Desktop Publishing**: Using the computer to generate text and/or graphics of "publishable" quality.

- **Directory**: A list of documents.
- **Disk or Diskette**: Computer equipment used for recording, transcribing, and storing data.
- **Disk Drive**: A device that contains a small electro-magnetic head capable of reading, writing, or erasing information on a disk.
- **Disk Operating System (DOS)**: A group of programs that control the flow of data between the various components of a computer system.
- **Function Key**: The keys on the keyboard that are labeled F1, F2, F3, etc. These keys perform special functions depending upon the application software being used.
- **Graphics**: Pictorial representation of data, such as graphs or charts, on a computer screen.
- **Hard Copy**: Computer output in a permanent, visually readable form, usually on paper.
- **Hardware**: The physical components of a computer system.
- **Local Area Network (LAN)**: A network of cables and devices interconnecting computers.
- **Menu**: A list of choices displayed on a computer screen.
- **Modem**: An electrical device that converts computer signals into telephone signals (and back again).
- **Mouse**: A hand-operated device which controls the cursor without use of the keyboard.
- **Network**: Collection of closely grouped PCs wired together to share data, programs, and hardware in an effective cost efficient way.
- **Output**: The finished product; hard copy.
- **Password**: A personal code used by an individual to identify himself/herself to a computer.
- **Peripheral Equipment**: Equipment that works with the central unit, such as keyboards and printers.
- **Program**: Set of instructions that enable computers to carry out specific applications.
- **Random Access Memory (RAM)**: Temporary storage place for programs and data; the electronic work space of a computer. The contents of RAM are lost when the power to the system unit is turned off.
- **Soft Copy**: Computer output shown on a screen.

- **Software**: The programs and data that the computer uses to perform tasks.
- **Spreadsheet**: Graphic applications software that presents figures in a grid format on a computer screen.
- **Submenu**: A menu which appears after a choice is made on the main menu.
- **User-friendly**: Relating to applications programs that are easy to use.
- **Word Processing**: The use of a computer to create, edit, revise, format or print text.

SAFETY

It is the policy of the City of Cincinnati that no employee should ever be required or allowed to work in unsafe conditions. City employees are expected to develop and implement safe practices and identify and eliminate all unsafe practices and conditions. All employees, supervisors, and management must support this policy at all times as a condition of employment.

COMMITMENT TO EMPLOYEE SAFETY AND HEALTH

The City's goal is to minimize human injury or illness and property loss or operation interruption caused by accidents, fire, or other hazards. The City believes that safe working conditions for every one of its employees can be attained through the use of safety equipment, proper job instruction, frequent review of safe practices, and proper supervision.

1. **The City's Commitment**: To support and encourage reaching this goal, the City is committed to:

   - Developing processes, designing, building, and maintaining plants and equipment and establishing operating methods with full consideration of safety and health effects.
   - Seeking out the best available information on hazards and risks, and communicating it to all concerned for decision making application.
   - Providing leadership, organization, funds, and other appropriate resources for comprehensive safety and health programs.
   - Fostering safe behavior and initiative, both on and off the job, through education, training, and publicity.
   - Minimizing the undesirable effects of accidents by providing rescue equipment and training, first aid, and medical systems.
   - Recognizing and rewarding achievements in health and safety planning, management, and performance.
   - Requiring all supervisors to consider it an essential part of their job to administer the safety program and to terminate unsafe activities.
   - Informing all employees that they are required, as a condition of their employment, to follow all established safety practices.
   - Having each department/division prepare a definite safety plan by means of which safe working practices will be brought to the attention of every employee.

HEALTH AND SAFETY RESPONSIBILITY

Safety is an integral part of every job. Each employee is responsible for his/her own safety. A person doing a job is usually in the best position to assure the safety of that job. Employees must make themselves aware of the safety and health hazards associated with their jobs and the consequences to themselves and others of unsafe behavior. Employees must become skilled in probing for and recognizing unsafe conditions so they can be reported and corrected.

Employees with organizational responsibilities for others have a special accountability for incorporating safety and health as part of their management or supervisory duties. Supervisors must apply and enforce safety policies and procedures in specific work situations. Through personal example, training, and safety performance rating, supervisors can encourage individuals within their work groups to develop the high level of safety awareness necessary to make safety an integral part of working.

SOURCES OF ACCIDENTS

The cost of an accident can be quite high, even if no one is injured. There may be higher insurance premiums; damage to buildings, equipment, tools, or vehicles; or service delays. There may be time lost as new workers are trained, the work load is rescheduled, the accident is investigated and reports are completed.

There are four sources which can interact to cause an accident. When an accident occurs, the supervisor should consider each of the following sources in determining the cause:

1. **People:** All employees of the City are a potential source of an accident. Motivation, training, and performance evaluation play a big role in preventing accidents. Employees must have the know-how and willingness to work safely.

2. **Equipment**: Equipment can cause an accident. This includes everything from vehicles to hammers. Using faulty equipment or adapting it to perform tasks for which it is not designed can lead to accidents.

3. **Materials:** Materials that employees use can lead to accidents. They may be sharp, heavy, hot, or toxic.

4. **Environment**: This includes the buildings employees work in as well as the air they breathe.

DOMINO EFFECT OF ACCIDENTS

The following outlines a domino effect of accidents and what a supervisor can do to prevent an accident from happening:

1. **Lack of Control By Management**: The first domino in the sequence of events that leads to loss is the "lack of control" by management. A supervisor needs to maintain proper control by making sure that employees receive proper orientation and training and that rules are established and followed. A supervisor should also inspect worksites and equipment, hold safety meetings, and investigate all accidents. The first domino will fall for the supervisor who does not plan and organize the work as well as motivate and lead employees to the proper level of performance.

2. **Basic Causes:** There are two basic causes of accidents:

   - *Personal Factors*: Personal factors that cause poor performance include lack of knowledge or skill, poor motivation, and physical and mental problems.
   - *Job Factors*: Job factors are inadequate work standards, inadequate maintenance or design of equipment or materials, normal wear and tear, and abnormal usage.

   If a supervisor fails to recognize and change or correct these basic causes of accidents, the second domino falls.

3. **Immediate Causes**: When the basic causes exist, they set the stage for unsafe practices and conditions.

   - *Unsafe Practices*: Unsafe practices include operating without authority, operating at improper speed, using defective equipment, using equipment improperly, failing to use personal safety equipment, horseplay, and drinking and/or drug abuse.
   - *Unsafe Conditions*: Unsafe conditions can be inadequate guards or protection, defective tools or equipment, inadequate warning systems, fire and explosive hazards, substandard housekeeping, hazardous conditions (fumes, noise, etc.), and congestion.

   These are only symptoms of the basic causes, but failure to remedy them means failing to keep the third domino from falling.

4. **The Accident**: When unsafe practices or conditions are allowed to exist, then an accident or near-accident is usually the result. The fourth domino has fallen.

5. **The Loss**: Once an accident, whether to people or property, has occurred, the loss could be minor, major, or catastrophic. Long before the last domino falls, there are many things a wise supervisor could do.

MISCELLANEOUS SAFETY ISSUES

All City employees should be familiar with and abide by the policies and procedures established in the City of Cincinnati Employee Safety Instruction Manual (Green Book).

1. **Material Safety Data Sheet (MSDS)**: A MSDS is a chemical hazard and safety sheet which provides information on chemicals in the work environment. A MSDS is important because it provides information on safety handling and how to prevent worker exposure to the chemicals.

2. **Fire Extinguishers**: The most common fire extinguisher used is "ABC." To extinguish a fire, start at the base of the fire and sweep back and forth.

3. **CPR**: The ratio of compressions to breaths on one person CPR is 15:2.

4. **Seat Belts**: When driving or riding in a vehicle, all occupants must wear a seat belt.

SAFETY MANUALS

All City employees should be familiar with and abide by the policies and procedures established in the City of Cincinnati publications: Employee Safety Instruction Manual (Green Book) and the Traffic Safety Handbook (Blue Book).

Employees should also be familiar with the National Manual on Uniform Traffic Control Devices (MUTCD) as well as the Ohio Manual on Uniform Traffic Control Devices and use these manuals for guidance.

PERSONAL PROTECTION

EYE PROTECTION

Employees wearing eye protection have had their vision saved from potential serious and permanent loss. It is, therefore, appropriate that adequate protection be required in the workplace.

1. **Policy**:

   - Approved eye protection shall be worn where danger exists from flying objects or materials.
   - Minimum eye protection shall be suitable for the work to be performed and provide adequate protection against particular hazards for which they are designed. These shall meet ANSI Z87.1-1989 Standards.
   - Persons considered "industrially blind" in one or both eyes (for example, corrected vision of 20/70 or less) shall wear approved eye protection at all times while at work. Contact lenses shall not be worn in areas where chemical contact is a potential hazard to the eyes. Contact lenses may be worn in other areas requiring eye protection provided that approved eye protection is worn over the contact lenses.

2. **Responsibilities**:

   - *Department and Division Management:* Shall determine and clearly identify specific areas and jobs requiring eye protection and communicate eye protection requirements.
   - *Employees:* Shall observe the eye protection requirements for their jobs and work areas and take proper care of their protection equipment.

HEAD PROTECTION

Head protection has been found to be an effective method for the prevention and reduction of injuries which occur commonly in the workplace.

1. **Policy**:

   - Approved hard hats are required to be worn by all City employees when there is a danger of head injuries from impact, flying or falling objects, electrical shock and burns. Class A helmets are required to be worn at all times in all areas except in offices, meeting rooms, restrooms, locker rooms, authorized rest areas, in the driving compartment of vehicle, and other designated areas.
     -- Class A helmets, according to ANSI Standard Z-89.1-1986, are intended to reduce the force of impact of falling objects and to reduce the danger of contact with exposed low-voltage conductors.

2. **Responsibilities**:

- *Department and Division Management:* Shall determine and clearly identify the "other designated areas" and jobs not requiring head protection. Division management and supervision shall enforce requirements where they apply.
- *Employees:* Shall observe the head protection requirements for their jobs and work areas and take proper care of their helmets.
- *Visitors:* Shall comply with the same requirements as employees.

FOOT PROTECTION

A large number of slips, trips, falls, and back injuries could be reduced by the use of appropriate protective footwear.

1. **Policy**:

- Approved safety shoes and/or special foot protection shall be worn by employees whenever job requirements indicate their need. The foot protection made available by the City must be worn by employees handling material which presents a foot hazard, where exposure to machinery or use of equipment presents a foot hazard. Canvas shoes, soft sole shoes, or sandals do not provide adequate foot protection and shall not be worn in operational areas.

2. **Responsibilities**:

- *Department and Division Management:* Shall determine jobs for which safety shoes and special foot protection are required and communicate and enforce foot protection requirements.
- *Employees:* Shall observe the foot protection requirements for their jobs and take proper care of the equipment provided.

3. **Approved Safety Shoes**: Shoes which:

- Have soles and shanks whose design and composition offer an appropriate combination of abrasion, chemical and slip resistance, and cushioning under conditions and anticipated use.
- Have been tested for performance under impact and compression according to the procedures given in ANSI Z41-1991 and meet Class 75 requirements.

HEARING PROTECTION

Prolonged exposure to loud noise can permanently impair one's ability to hear. Certain jobs and areas in City employment are noisy and may present risks.

1. **Policy**:

   - Employees exposed to continuous noise levels of eighty-five or more decibels [(dBA)-slow response] shall be provided with approved ear protection. If variations in noise level involved maxima at intervals of one second or less, the noise is considered continuous.

2. **Responsibility**:

   - *Department and Division Management:* Shall survey workplace noise levels to determine if any employee's exposure is at or above an 8 hour time weighted average (TWA) of 85 dBA; if so, institute corrective action to reduce exposure by administrative or engineering control methods and provide effective employee hearing protection where control methods cannot be used. Assure employee training in use of protective devices supplied. Enforce the use of controls or protective devices where operations dictate use is required.
   - *Employee:* Shall help to identify and eliminate high noise in workplace and use proper controls and protective devices where designated.

RESPIRATORY PROTECTION PROGRAM

Occasionally there is a need to protect individuals from harmful gases, vapors, and dusts with respirators.

1. **Policy**:

   - Respirators shall be provided for and used by employees where personal protection is required to prevent exposure to respiratory hazards.
   - Contact lenses shall not be worn by an employee while using a respirator without the approval of the City's occupational physician.

2. **Responsibilities**:

   - *Division Supervision:* Shall identify locations and conditions having possible respiratory hazards for evaluation by a qualified person. Ensure respirators users are:
     -- Given training in respirator care and use.
     -- Medically approved annually for respirator use.
     -- Provided respirators and accompanying sanitary storage facilities.
   - *Employees*: Shall use and maintain their respirators in accordance with the instructions given in the training program.
   - *Employee Health Services*: Shall provide medical examinations for respirator users to ensure they are physically fit to perform their work while wearing respirators.

3. **Definitions**:

- *Engineering Controls*: Equipment or instrumentation which prevents the evaluation or release of harmful chemical agents into working environment. Examples: process enclosures, exhaust ventilation, high temperature interlocks, and process isolation.
- *Qualified Person*: A person trained and physically qualified to wear the appropriate equipment, operate air sampling instruments, select appropriate respirator, and check the atmosphere in the area of operation.
- *Respirator*: A device (supplied air or filter type) worn by persons for protection against breathing harmful vapors, gases, dust, fumes, or mist.

4. **Procedures**:

- To determine the need for respiratory protection where a potential hazard may exist, the following factors are considered by the Safety Section and/or Qualified Persons:
  - -- Toxic or irritating characteristics of a contaminant.
  - -- Physical state of contaminant (dust, mist, vapor, or gas).
  - -- Concentration of contaminant (determines if protection is needed or whether filter or supplied air).
  - -- Skin absorption of a contaminant, gloves, and protective garb properly selected may provide adequate protection.
  - -- Anticipated exposure time (exposure concentration and time determine respirator type and service life).
  - -- Skin and eye irritation.
  - -- Work location: escape distance to safe atmosphere.
  - -- Possibility of oxygen deficient atmosphere (supplied air required).
  - -- Identity of contaminants (more than one may be present requiring special filters).
- The following situations having workplace exposures to respiratory hazards above permissible levels make the use of respirators necessary:
  - -- During the time necessary to install engineering controls.
  - -- Where engineering controls, work procedures, or process changes are not feasible or sufficient to reduce employee exposure to permissible levels or below.
  - -- For brief, intermittent or non-routine operations.
  - -- In emergencies.
- Implementation: Where it has been determined by an appropriate supervisory level that respirators are required, ensure that operating procedures specify the appropriate type, make, model and canister or cartridge type at each step requiring such protection.
- Medical Testing Requirements:
  - -- Ensure that each person required to wear a supplied air respirator is tested by a competent medical facility before training begins, then annually thereafter. This is to determine if the person can perform the job while subjected to the additional breathing stresses imposed by wearing a respirator.
  - -- Each person designated to wear a filter type respirator shall be physically evaluated and fit tested to determine the size, style, and brand of filter respirator. This evaluation will produce protection factors which dictate adequacy of such devices.

- A respirator training program should include:
  - -- Description of respirators.
  - -- Intended use and limitations of respirators.
  - -- Proper wearing, adjustment, and on site testing for fit by positive and negative seal tests.
  - -- Inspection, maintenance, cleaning, and storage requirements.
  - -- User's responsibilities.
  - -- Limitations.
  - -- Certification for use.
- Use:
  - -- Supervision must ensure that employees wear the prescribed respirator as required.
  - -- Supervisors shall disqualify persons from work assignments requiring filter respirators who have facial hair, which prevents a respirator from sealing properly or who cannot be properly fitted into a filter respirator.
  - -- Supervisor must assure those wearing respirators be certified in their use, supplied air, or filter type.
  - -- Respirators must be used only as described in the training program; misuse constitutes possible disciplinary action.
  - -- Do not wear a respirator assigned to someone else.
  - -- Report a respirator malfunction to your supervisor immediately.
- Inspection, Maintenance and Storage:
  - -- Users must inspect respirator equipment before each use and after cleaning by checking the condition of the facepiece, headbands, valves and hoses, and fit of canister, filter or cartridge.
  - -- Immediately repair or replace respirators failing inspection. Limit any repairs to changing canisters, filters, or cartridges, and replacing head straps. Do not attempt to replace components or make adjustment, modifications or repairs beyond those recommended by the manufacturer.
  - -- Clean and disinfect the respirator as needed. Clean and disinfect a respirator not individually assigned after each use.
  - -- Store respirators as instructed in the training program to protect against dirt, sunlight, temperature extremes, excessive moisture, damaging chemicals and identify mix-ups.
- Availability:
  - -- The stockroom manager shall ensure that an adequate inventory of respirators, cartridges, and spare parts are maintained according to operational needs.
  - -- Individually assigned respirators should be marked with the user's name.
- Inspection of Emergency Respiratory Equipment:
  - -- Ensure the monthly inspection of emergency respiratory equipment, immediately removing units requiring maintenance or repair from service.

PROTECTIVE CLOTHING

The nature of some operations in the City service provides for the possible exposure to acids, alkalis, poisonous plants, insects, or other injurious materials without proper protection.

1. **Policy**: The proper protective clothing shall be worn when working in areas requiring protection. Unless specifically excepted, full leg pants and full shirts with long or short sleeves shall be worn at all times.

2. **Responsibilities**:

   - *Division Management:* Shall ensure availability of the equipment and clothing determined to be needed by the Job Hazard Analysis.
   - *Supervision:*Shall requisition the proper safety gear and enforce the above instruction at the job site.
   - *Employees:* Must use the prescribed equipment and clothing.

3. **Procedures**:

   - While working in areas with traffic, DOT approved traffic vests will be worn.
   - Entry into an area where clothing may become wet with injurious materials, impervious protective wear shall be worn.
   - Provisions for dry, clean, and predominantly cotton clothing, along with rubber shoes, short boots, or other appropriate footwear, shall be considered a satisfactory substitute where job duties preclude clothing getting wet.
   - Working without a shirt, with the sleeves cut off, with shirt tails not tucked into pants, in shorts or cutoff pants is prohibited (unless an exception to this rule is made).

BACK SAFETY

Back injuries account for the City's largest number of accidents. These procedures advise how to minimize or avoid painful serious back injuries. If an employee is asked to lift something he/she cannot handle, **ask for help.**

1. **Lifting and Carrying**: Proper lifting procedures are:

   - Consider the size, weight, and shape of the object to be carried. Do not lift more than can be handled comfortably. If necessary, get help.
   - Set feet solidly; one foot can be slightly ahead of the other for increased effectiveness. Feet should be far enough apart to give good balance and stability (approximately the width of the shoulders).
   - Get as close to the load as practicable. Bend legs about 90 degrees at the knees. Crouch; do not squat. It takes about twice as much effort to get up from a squat.
   - Keep the back as straight as practicable. It may be far from being vertical, but it should not be arched. Bend at the hips, not from the middle of the back.
   - Grip the object firmly. Maintain that grip while lifting and carrying. Before changing or adjusting this grip, set the object down again.

- Straighten the legs to lift the object and, at the same time, bring the back to a vertical position. A good tip is to look up at the sky or ceiling when beginning to lift.
- Never carry a load that cannot be seen over or around. Make sure the path of travel is clear. Carry the object close to the body.
- Never turn at the waist to change direction or to put an object down. Turn the whole body and crouch down to lower the object. Grip the object firmly, keep it close, and keep the back straight (not arched). To keep hands from being pinched against the floor, put one corner of a box or similar object down first, so that the fingers can be removed from under the sides.
- When lifting an object with another person, employees should be sure that both lift at the same time and let the load down together. One person should give the signals or orders.

HAND PROTECTION

The use of proper protection will prevent or lessen the severity of injury to hands.

1. **Policy**: Appropriate hand protection will be worn to protect workers from hazards and potential hazards such as skin absorption of harmful substances, severe cuts or lacerations, abrasions, punctures, chemical burns, thermal burns, harmful temperature extremes, etc.

2. **Responsibilities**:

   - *Department and Division Management:* Shall select hand protection relative to the tasks performed and the performance characteristics of the protective devices (gloves, barrier creams, protective emulsions, thermal insulators, chemical shields, etc.) via job hazard analyses. Assure workers use the protection provided.
   - *Employees:*Shall observe the hand protection requirements for their jobs and take proper care of the supplies provided them.

FALL HAZARDS

Falls from elevations are the leading cause of fatalities in the construction industry. From 1985-1989, 33% of all construction fatalities resulted from a fall. Falls from higher elevations (over 6 feet above the ground) result in injuries ranging from death to fractures; falls from lower elevations (4 to 6 feet above the ground) usually result in lost-time accidents and could even result in a fatality.

Fall prevention systems, such as a standard guardrail system, provide more positive means of protection than bodybelt/harness-lifeline combinations; although, standard guardrail systems are useful when workers are suspended, working on suspended scaffolds, work platforms, etc.

The City of Cincinnati is committed to provide each of its employees a safe and healthy work environment. It is the policy of the City to ensure that all employee are protected from hazards of falling from elevated walking/working surfaces over 6 feet. In order to attain this goal, all employees are not only expected to, but obligated to, protect themselves and their co-workers.

FALL PROTECTION EQUIPMENT, SYSTEMS, AND DEVICES

1. **Guardrails and Guardrail Systems**: A barrier erected to prevent employees from falling to lower levels. The top edge height of toprails must be 42 inches (plus or minus 3 inches) above the walking/working level.

2. **Personal Fall Arrest Systems**: Consist of an anchorage, connectors, and a body belt or body harness and may include a deceleration device, lifeline, or suitable combinations. Effective January 1, 1998, the use of body belts for fall arrest is prohibited.

3. **Types of Fall Hazard Safety Systems**:

   - *Position Device Systems:* Rigged so an employee cannot free fall more than two feet. They shall be secured to an anchorage capable of supporting at least twice the potential impact load of an employee's fall or 3,000 pounds, whichever is greater.
   - *Warning Line Systems*: A barrier erected on a roof to warn employees they are approaching unprotected roof sides or edges. This system designates an area in which roofing work may take place without the use of guardrail, body belt, or safety net systems to protect employees.
   - *Controlled Access Zones:* An area which certain work (for example, overhand bricklaying) may take place without the use of guardrail systems, personal fall arrest systems, or safety net systems; access to the zone is controlled.
   - *Safety Monitoring Systems:* A competent person is responsible for recognizing and warning employees of fall hazards.
   - *Safety Net System*: A net is installed as close to the work surface as possible to protect workers from potential fall hazards as well as to protect workers and people below from falling objects above.

CONFINED SPACE SAFETY

Working safely is *always* important, but in a confined space it is especially important because injuries are likely to be more severe and it is often difficult to rescue an injured person from a confined space.

DEFINITION

1. **What is a Confined Space?** A confined space:

   - Has few ways in or out, and may be difficult to get into or out of.
   - Is not intended to be occupied by human beings, at least not on a regular basis.
   - May contain a hazardous atmosphere or other recognized safety or health hazard.

2. **Typical Confined Spaces**:

   - Types of confined spaces typically encountered include:
     - -- Tanks
     - -- Vats
     - -- Silos
     - -- Manholes
     - -- Storage bins
     - -- Tank cars
     - -- Hoppers
     - -- Trenches
     - -- Pumping or lift stations
     - -- Equipment housings
     - -- Pits
     - -- Tunnels
     - -- Ducts
     - -- Sewers
     - -- Pipelines
     - -- Shafts
     - -- Steam condensers
     - -- Process vessels
     - -- Cisterns
     - -- Degreasers
     - -- Diked areas
     - -- Boilers
     - -- Digestors
     - -- Stacks
     - -- Barges
     - -- Septic tanks
     - -- Holds of ships
     - -- Bunkers
     - -- Underground utility vaults

THE BASICS FOR STAYING ALIVE

1. **Identify**: Be able to recognize a confined space. Some will be posted, but others may not be. If a space could in any way have an atmosphere different from normal air or if it contains anything which could trap you or injure you, take appropriate precautions.

2. **Test**: Testing is the *only* way to find out whether the atmosphere in a confined space is safe to enter. Test equipment must be calibrated, in good working order, and used correctly.

3. **Evaluate**: Know what other precautions are required and take them. Know what hazards are present or what hazards might develop and make certain you know how to keep them from becoming a problem.

4. **Monitor**: Make sure the atmosphere does not change while you are in the space. Monitor continuously or test frequently.

5. **Rescue**: Never enter a confined space without appropriate rescue equipment and personnel available. This includes an observer whose main job is to watch you and make sure you stay safe. Never enter a space to attempt to rescue on your own.

NECESSARY EQUIPMENT/SAFETY PRECAUTIONS

Confined spaces can be very slippery and dark. They are often made of metal and present special electrocution hazards. It is not difficult to be injured in a confined space; and if you are injured, it may be difficult to get help. Even a slight injury can turn out to be serious. *It is extremely important to follow safe work practices at all times in a confined space.*

1. **Equipment Needed**: When there is a potential that an atmosphere can become dangerous to life or health, the following protection is needed:

   - Air supplying respirator.
   - Protective clothing, especially if the hazard can burn skin or be absorbed through the skin.
   - A full body or chest harness.
   - A retrieval system or lifeline.

2. **Personal Protective Equipment**: Whether inside or outside of a confined space, most jobs require the same protective gear:

   - Hardhat.
   - Gloves.
   - Boots.
   - Eye protection.
   - Hearing protection.
   - Protective clothing.

   IMPORTANT *NOTES:*
   - Protective clothing can make movement difficult in a confined space. It might also cause you to become overheated quickly; therefore, it is important to drink plenty of liquids, even in cold weather.
   - Be aware that noise might keep you from hearing an alarm. It could also interfere with communication between you and your observer. Maintain good visual contact or use some other method of communication.

3. **Respirators**: There are times when ventilation cannot completely get rid of a hazard or when ventilation is impossible. The protection of a respirator is then needed. Using a respirator requires extreme care and thorough training. If you have not been given the training, do not attempt to use any type of respirator.

- *Air Purifying Respirators*:
  - -- Are used for additional protection in acceptable atmospheres.
  - -- Filter the existing air and cannot be used in oxygen deficient or IDLH atmospheres.
  - -- Must be fit tested.
  - -- Cannot be used with toxics that have no smell or taste.
  - -- Cannot be used where toxic levels are greater than the filter can handle.
- *Atmosphere Supplying (Air Supplied) Respirators:* These respirators are used when the atmosphere in a confined space cannot be kept at acceptable levels. There are two types:
  - -- *Airline Respirator:* Provides air from an external source like a compressor. It must be used with a five minute emergency escape bottle in case something goes wrong and the air supply is cut off.
  - -- *Self-Contained Breathing Apparatus (SCBA):* Uses an air supply which is carried in a tank on the wearer's back.
- *General Guidelines*: Whichever type is used:
  - -- It must be a positive pressure respirator.
  - -- The air supply must be of breathing quality.
  - -- The unit must be thoroughly inspected before each use.
  - -- The mask must be in place before you enter the space.
  - -- The mask must NEVER be removed while you are in the space.

4. **Ladders**: When using a ladder be sure to:

- Set ladder at the correct angle.
- Tie ladder off at the top.
- Use ladder equipped with safety feet.
- Do not use a metal ladder when working around electricity.
- Use fall arresting devices whenever the potential for a fall exists.

5. **Electrical Equipment**: If a confined space presents an electrocution hazard:

- Use ground fault circuit interrupters or low voltage isolation transformers.
- Use grounded or double insulated tools.
- Make certain that all electrical equipment is in good repair.

ROLE OF THE OBSERVER

Whenever an employee enters a confined space, an observer must be present. The observer maintains contact with the employee during the entire entry in case trouble develops.

1. **Observer**: An observer must:

- Know who is in the space.
- Keep unauthorized people out of the area.
- Maintain voice or visual contact with entrants.

- Recognize early symptoms of danger in the space.
- Watch for hazards outside as well as inside the space.
- Maintain clear access to and from the space.

2. **In Event of a Rescue**: If rescue is necessary, the observer must:

   - Call for rescue personnel.
   - Stay outside the space until his own backup attendant arrives.
   - Perform the rescue from outside the space when possible.
   - Assist the rescuers and victims.

ATMOSPHERIC HAZARDS

Atmospheric hazards kill more people than all other confined space hazards combined. Except for explosive dusts, atmospheric hazards are normally invisible--they can overcome you very quickly.

1. **Types of Atmospheric Hazards**:

   - Oxygen deficiency or excess.
   - Flammable gases or vapors.
   - Toxic gases or vapors.

2. **Testing**: Tests must be performed by a well-trained person who knows the specific test instrument and how to use it properly.

   - *Pre-Entry Testing*: Pre-entry testing for atmospheric hazards are done to:
     - -- Find out what hazards exist.
     - -- Make sure any hazards found have been removed.
     - -- Make sure no new hazards have appeared during pre-entry procedures.
   - *Frequency:* As long as anyone is in the space, it must be tested frequently or monitored continuously to make sure:
     - -- Old hazards do not return.
     - -- No new hazards are created.
   - *Re-Testing:* After a long break, regard going back into a space as a new entry. The space must be tested again.

OXYGEN-DEFICIENT ATMOSPHERES

1. **Oxygen-Deficient**: An oxygen-deficient atmosphere has less than 19.5% available oxygen (O_2). Any atmosphere with less than 19.5% oxygen should **not** be entered without an approved self-contained breathing apparatus (SCBA). The oxygen level in a confined space can decrease because of work being done (such as welding, cutting, or brazing) or it can be decreased by certain chemical reactions (rusting) or through bacterial action (fermentation). The oxygen

level is also decreased if oxygen is displaced by another gas, such as carbon dioxide or nitrogen. Total displacement of oxygen by another gas (such as carbon dioxide) will result in unconsciousness, followed by death.

2. **Key Points about Oxygen**:

   - Oxygen is measured in percent by volume.
   - Air is made up of approximately 21% oxygen at sea level.
   - Oxygen can be used by people, by combustion, and by other natural and man-made processes.
   - Oxygen can be displaced by other gases and vapors.
   - Low or high oxygen concentrations can affect flammability readings so test oxygen first.
   - Lack of oxygen can lead to brain damage or death.
   - Oxygen starvation can bring on a feeling of happiness or well being called "euphoria" causing you to not care that you are in danger.

FLAMMABLE GASES AND VAPORS

1. **Explosive Range**: All combustible gases and vapors have a different explosive range. The lowest concentration (air-fuel mixture) at which a gas can ignite is called its Lower Explosive Limit (LEL). Concentrations below this limit are too lean to burn. The highest concentration that can be ignited is its Upper Explosive Limit (UEL). Above that concentration, the mixture is too rich to burn. A gas is only combustible between its LEL and UEL, but any concentration of combustible gas should be a concern. Lean mixtures can collect in an area and reach a combustible level or rich mixtures can be diluted with air to become combustible.

2. **Organic Matter**: Organic matter can create a hazardous atmosphere in a confined space. Decomposing organic matter, such as domestic waste and plant life, can produce Methane, Carbon Monoxide, Carbon Dioxide, and Hydrogen Sulfide, and consume existing oxygen.

   - *Oxygen Deficiency*: Oxygen can be consumed by bacterial action or displaced by other gases.
   - *Combustible Gases:* The produced Methane, CO or H_2S can reach explosive concentrations.
   - *Toxic Gases:* Both Hydrogen Sulfide and Carbon Monoxide are life threatening gases.

3. **Sample At All Levels**: Some gases are lighter than air and some are heavier. The lack of normal ventilation in a confined space allows gases to collect at one level depending on their vapor density.

CONTROL MEASURES

Anytime there is a potentially flammable atmosphere, all ignition sources must be controlled.

1. **Ignition Sources**: Examples of ignition sources include:

   - Open flames.
   - Heat producing equipment.
   - Spark producing tools.
   - Broken light bulbs.
   - Damaged electrical cords.
   - Ungrounded metal equipment.

2. **Bonding and Grounding**: Eliminates the chance of static spark in a potentially flammable atmosphere. A bond wire connects two conductive objects together. Another wire connects these two objects to ground. Bonding and grounding is required by law in many situations. Some products which produce a lot of static electricity may have internal bonding; but others do not. Read instructions and warning labels and make sure the equipment is used safely.

PURGING AND VENTILATION

Some people think that the terms *purging* and *ventilation* mean the same thing. Sometime the same equipment may be used for both, however, there are differences between the two.

1. **Hazards**: Both natural and man-made processes create atmospheric hazards in confined spaces. Controls vary from good housekeeping to purging and ventilation. Hazards include:

   - Rusting.
   - Welding.
   - Decaying plants and animals.
   - Painting.
   - Cleaning with solvents.
   - Fumigating.
   - Inerting.

2. **Purging**: Purging methods will vary with the hazards of the space and the work to be performed. Purging:

   - Takes place before entering a space.
   - Displaces the air which is in the space to begin with.
   - May be done with air, water, steam, or an inert gas.
     - -- *Air:* The most common purging agent, but there are times when using air to purge a space can be hazardous:
       - ▸ When flammable vapors are present above the upper explosive limit and too rich to burn. Adding air to the space can create an explosive mixture.
       - ▸ When the space contains pyrophorics or other substances that will react with air.
     - -- *Water:* Displaces vapors, but it may also react dangerously with certain substances in the space.

- -- *Steam*: A good purging agent, but special procedures must be used with substances that have low ignition temperatures or flashpoints.
- -- *Inert Gases*: Nitrogen (for example) may be used to get rid of flammable vapors, but the atmosphere in the space will become oxygen deficient.

3. **Ventilation**: Ventilation systems keep hazards away after purging has removed them. Ventilation is critical where the work in the space could create a hazardous atmosphere. A ventilation system may be either a forced air system, an exhaust system, or a combination of the two. The ventilation method and equipment used depends upon the size and shape of the confined space, the work to be performed, the gases to be exhausted (for example, are they flammable?), and the source of makeup air. Mechanical ventilation systems are used to circulate fresh air throughout a confined space. They are also sometimes used to carry any fumes or vapors created by the work you are doing out of the space.

   When the atmosphere in a space contains flammable vapors, an exhaust ventilation system must be explosion-proof and rated for use in that atmosphere. Under certain conditions when flammable gases or vapors have displaced the oxygen level but are too rich to burn, forced air ventilation may dilute them until they are within the explosive range. Also, if inert gases (for example, carbon dioxide, nitrogen, argon) are used in the confined space, the space should be well ventilated and re-tested before a worker may enter. Ventilation:

   - Is used after a space is entered.
   - Supplies fresh air to breathe.
   - Continues to circulate fresh air through the space while people are inside.
   - Must be done with fresh or breathing quality air.
   - Removes potentially hazardous conditions before they become hazardous.
   - Supplies cool air for comfort.
   - Can cause problems:
     - -- *They can feed contaminated air into a space*. Make sure the air supply is clean.
     - -- *They can block exits.* Make certain that people can get out of the space quickly in case of trouble.
     - -- *In an explosive atmosphere, they can be an ignition source.* If the system is exhausting flammable vapors, it must be explosion-proof.
   - *Common Ventilation Method:* A common method of ventilation requires a large hose, one end attached to a fan and the other lowered into a manhole or opening. For example, a manhole would have the ventilating hose run to the bottom to blow out all harmful gases and vapors. The air intake should be placed in an area that will draw in fresh air only. Ventilation should be continuous where possible because in many confined spaces the hazardous atmosphere will form again when the flow of air is stopped.

TEST PROCEDURES

1. **General Guidelines**: Testing procedures can vary according to the type of space being tested, but the following are general guidelines to be followed:

- If possible, begin testing without disturbing the space.
- Test from top to bottom and around ductwork and uneven surfaces.
- Avoid leaning over the space being tested.
- Allow time for the sample to reach the sensors in the equipment.
- If test equipment is lowered into a hazardous atmosphere, make certain it is rated for that environment. (It must be intrinsically safe.)

2. **Remember That Most Equipment Does Not Latch**: This means that it will stop alarming once it is removed from the hazardous environment. If an instrument is lowered into a space, make certain you can see or hear its alarm clearly while it is inside the space.

3. **Never Use Equipment Designed for One Condition to Test for Another**: Each sensor in a piece of equipment works in a different way and is designed for a specific purpose. Do not use an oxygen sensor to test for flammability or a standard flammability sensor to test for toxics.

4. **Do Not Ignore or Not Believe the Equipment**: If a gas detector alarms, **get out**--even if you do not notice any problems. The equipment is designed to detect hazardous conditions long before you can. It can save your life!

GAS DETECTORS

Most of the City of Cincinnati's equipment are direct reading instruments. This means that test results can be read directly from a meter, scale or some other indicator and the employee can tell within minutes or seconds that a hazard exists. Direct reading instruments can be divided into two general groups:

1. **Gas Detector Tube Systems**: Consists of a tube and a pump designed to be used together. If using a gas detector tube, remember:

   - Never mix brands or types.
   - Store tubes properly.
   - Do not use outdated tubes.
   - Test the pump according to the manufacturer's instructions before each use.
   - Follow the manufacturer's instructions included with each tube.
   - Test results must be interpreted by taking into account other substances which have been in the space.

2. **Electronic Gas Detectors**: Available in a wide variety of brands and models. Some will test for one condition only. Some will test for two conditions--usually oxygen and flammability. Some will detect three or more conditions at the same time. Special test equipment is available for less common gases or vapors. It is important to use the equipment as it was designed to be used; never use faulty equipment. Characteristics of electronic gas detectors are:

- They must be calibrated for accuracy.
  - -- Field testing is performed by the operator before each use.
  - -- Factory or laboratory recalibration is done by a trained technician according to the manufacturer's instructions.
- They must be well maintained.
- They must be checked out before each use to make sure they are working properly.
- Those with pumps must be checked for flow and leaks.
- Batteries should be fully charged.

OTHER HAZARDS

There are other hazards that may be encountered in a confined space. Some can be present in the space when you enter:

1. **Engulfment**: If you sink into or get covered by loose material such as fine coal, sawdust, or grains, the material can get into your breathing passages very quickly, suffocating you. *Wear a harness and lifeline and make certain you can be pulled from the space.*

2. **Entrapment or Capture**: People have been trapped in a space and died of exposure or suffocation before anyone even knew they were missing. *Never enter a confined space without an observer watching out for you.*

3. **Mechanical Equipment**: Machinery such as blades, rotors or conveyors can shift because of tensioned springs, hydraulic pressure, or even gravity. *Mechanically disconnected drives and belts when necessary or physically block anything which could move.*

ISOLATION PROCEDURES

1. **Hazards**: You also need protection from the hazards which can enter a confined space while an employee is inside.

   - *Chemical or Physical Hazards*: Can come in through open lines. People have suffocated when a product (like molasses) or a gas (like nitrogen) was mistakenly pumped into a space.
   - *Electrical Energy*: Can enter when someone throws a switch. Machinery can start up, crushing you. You can be electrocuted easily because you are probably standing on grounded metal.

2. **Standard Isolation Procedure**:

   - Disconnect lines entering a space.
   - Insert a blank or blind in a line to block it completely.

- Lock and/or tag valves and install a blank in the line.
- Use a double block and bleed.
- Lock and/or tag out *all* electrical circuits to the space.

CONFINED SPACE ENTRY PERMIT

Preplan work by using the Confined Space Entry Permit as a Guideline. Items to be considered are:

1. **Atmospheric Testing and Monitoring**

2. **Procedures**

   - Initial Plan
   - Standby Person
   - Communications/Observation
   - Rescue
   - Work

3. **Preparation**

   - Isolate/Lockout/Tag
   - Purge and Ventilate
   - Cleaning Processes
   - Requirements for Special Equipment/Tools
   - Labeling and Posting

4. **Safety Equipment and Clothing**

   - Head Protection
   - Hearing Protection
   - Hand Protection
   - Foot Protection
   - Body Protection
   - Respiratory Protection
   - Safety Belts
   - Lifelines, Harness

5. **Rescue Equipment**

HEAT AND COLD STRESS

Physical factors such as heat, humidity, wind, and cold may place added stress on the body through exposure; therefore, these exposures must be recognized, evaluated, and controlled in the workplace.

POLICY

Employee exposures to high heat or extreme cold (or wet) conditions must not exceed the NIOSH Threshold Limit Value without special acclimatization protection and fitness.

RESPONSIBILITIES

1. **Division Management**: Shall evaluate work conditions to determine levels of cold and heat extremes. Assure work schedules allow for adequate warm-up or cool down time periods. Communicate and enforce job site requirements. Provide warm-up areas, cool down areas, water replacement and other appropriate protective equipment.

2. **Employee**: Shall follow the designated work regimen guidelines. Prepare for the work by adapting to prevailing conditions, drinking water and electrolytes in the high heat, and eating high energy food and warm drinks in the extreme cold. Wear work clothing that supports their protection.

HEAT STRESS

The Threshold Limit Value (TLVs) refer to heat stress conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse health effects. The assumption is that nearly all acclimatized, fully clothed workers with adequate water and salt in-take should be able to function effectively under the given working conditions without exceeding a deep body temperature of 38°C.

Since measurement of deep body temperature is impractical for monitoring the worker's heat load, the measurement of environmental factors is required which most nearly correlate with deep body temperature and other physiological responses to heat. At the present time, Wet Bulb Globe Temperature Index (WBGT) is the simplest and most suitable technique to measure the environmental factors. WBGT values are calculated by the following equations:

1. **Outdoors With Solar Load**:

$$WBGT = 0.7\ NWB + 0.2\ GT + 0.1\ DB$$

2. **Indoors or Outdoors With No Solar Load**:

WBGT = 0.7 NWB = 0.3 GT

Where:

WBGT = Wet Bulb Globe Temperature Index
NWB = Natural Wet Bulb Temperature
DB = Dry Bulb Temperature
GT = Globe Temperature

The determination of WBGT requires the use of a black globe thermometer, a natural (static) wet bulb thermometer, and a dry bulb thermometer. Air temperature is actual dry air temperature, while wet bulb measures heat stress to the body.

Permissible Heat Exposure Threshold Limit Values
(Values are given in °C WBGT)

Work-Rest Regimen	Light Work Load	Moderate Work Load	Heavy Work Load
Continuous Work	30.0	26.7	25.0
75% Work - 25% Rest, each hour	30.6	28.0	25.9
50% Work - 50% Rest, each hour	31.4	29.4	27.9
25% Work - 75% Rest, each hour	32.2	31.1	30.0

Higher heat exposures than shown above are permissible if the workers have been undergoing medical surveillance and it has been established that they are more tolerant to work in heat than the average worker. Workers should not be permitted to continue their work when their deep body temperature exceeds 38°C. The most important sign of heat stroke is that the person stops sweating.

COLD STRESS

For work practices at or below -12°C (10°F), the following shall apply:

1. The worker shall be under constant protective observation (buddy system or supervision).

2. The work rate should not be so high as to cause heavy sweating that will result in wet clothing; if heavy work must be done, rest periods must be taken in heated shelters and opportunity for changing into dry clothing shall be provided.

3. New employees shall not be required to work full-time in cold in the first days until they become accustomed to the working conditions and required protective clothing.

4. The weight and bulkiness of clothing shall be included in estimating the required work performance and weights to be lifted by the worker.

5. The work shall be arranged in such a way that sitting still or standing still for long periods is minimized. Unprotected metal chair seats shall not be used. The worker should be protected from drafts to the greatest extent possible.

6. The workers shall be instructed in safety and health procedures. The training program shall include as a minimum instruction in:

   - Proper rewarming procedures and appropriate first aid treatment.
   - Proper clothing practices (dress in layers).
   - Proper eating and drinking habits.
   - Recognition of impending frostbite.
   - Recognition signs and symptoms of impending hypothermia or excessive cooling of the body even when shivering does not occur.
   - Safe work practices.

7. <u>Special Workplace Recommendations</u>: Employees shall be excluded from work in cold at -1°C (30°F) or below if they are suffering from diseases or taking medication which interferes with normal body temperature regulation or reduces tolerance to work in cold environments. Workers who are routinely exposed to temperatures below -24°C (-10°F) with wind speeds less than five miles per hour or air temperature below -18°C (0°F) with wind speeds above five miles per hour, should be medically certified is suitable for such exposures.

   Trauma sustained in freezing or subzero conditions requires special attention because an injured worker is predisposed to secondary cold injury. Special provisions must be made to prevent hypothermia and secondary freezing of damaged tissues, in addition to providing for first aid treatment.

OHIO MOTOR VEHICLE LAWS

The following laws should be followed in the State of Ohio and will be a guide to laws in most other states.

LANES

1. **Keep to the Right**: Drive on the right half of a roadway except:

   - When overtaking and passing another vehicle proceeding in the same direction.
   - When driving on a road divided into three or more marked lanes.
   - When driving on a road designed and posted with signs for one-way traffic.
   - When otherwise directed by a police officer or traffic control device.
   - When an obstruction makes it necessary to drive left-of-center. Yield the right of way to all vehicles traveling in the proper direction on an unobstructed portion of the highway.

2. **Multiple Lane Roads**: When a road has been divided into four or more marked lanes or where traffic within municipalities is lawfully moving in two or more continuous lines in the same direction, the following rules apply:

   - A vehicle shall be driven as closely as possible within a single lane of traffic; it shall not be moved from the lane until the driver has first determined that such movement can be made safely. A turn signal must be given before lane changes.
   - On a roadway divided into three lanes, a vehicle shall not be driven in the center lane except where that center lane is devoted exclusively to traffic moving in the direction the driver is proceeding.

3. **Slow Traffic**: Vehicles moving slower than the traffic flow must use the available right lane or as close as possible to the right-hand curb or edge of roadway.

4. **Emergency Vehicles**: Upon the approach of an emergency vehicle displaying flashing lights and an audible signal, the driver must immediately drive to a position parallel to the right edge or curb of the road or highway and stop. Drivers must be careful not to block intersections. All vehicles must remain in this position until the emergency vehicle has passed or when directed otherwise by a law enforcement officer.

   When an emergency vehicle is stopped alongside the roadway with its lights flashing, the drivers of vehicles passing it must reduce their speed. Furthermore, whenever it is possible, the driver should change lanes to pass the emergency vehicle in a lane that is not adjacent to where the emergency vehicle is stopped.

5. **Divided Highway**: A vehicle shall not be driven over, across, or within any dividing space, barrier, or section of a highway, except through an opening or crossover established by authority. Such dividing space, barrier, or section may be occupied for an emergency stop or in compliance with an order of a police officer.

TURNS

1. **Right Turn**: Turn right as close as possible to the right-hand curb or edge of the road.

2. **Right Hand Turn on Red**: In Ohio, it is legal to turn right after stopping at a red traffic signal, but **only when**:

   - There is no sign posted at the intersection forbidding right turns on red;
   - The vehicle has come to a complete stop and has allowed all crossing traffic and all pedestrians to proceed through the intersection; and
   - It can be clearly seen that the turn can be completed safely.

3. **Left Turn**: The driver of a vehicle intending to turn left:

   - At an intersection where traffic is moving in both directions on each road entering the intersection, shall make the approach in the right half of the road nearest the center line. The turn should be made into the lane on the right half of the street nearest the center line.
   - At an intersection where traffic is restricted to one direction on one or more of the roads shall make the approach in the extreme left-hand lane. Turn into the lane farthest left where traffic in that direction is allowed.
   - Is required to yield the right-of-way to any vehicle approaching from the opposite direction. Prior to engaging a left-hand turn, the driver must wait for oncoming traffic to clear the intersection. One may advance into the intersection as a prelude to turning, provided that no other traffic control devices prohibit this action.

4. **Left Turn on Red**: Under limited circumstances, it is legal to make a left turn after stopping at a red traffic signal. A left turn on red may be made only from the extreme left lane of a one-way street to the extreme left lane of another one-way street, providing there is no sign posted forbidding a left turn on red. It is against the law to make a left turn on red except from one, one-way street to another. When making such a turn, the vehicle must come to a complete stop and allow all crossing traffic and all pedestrians to clear the intersection before proceeding.

5. **Signal**: A turn signal must be given at least 100 feet before the intended turn. This may be accomplished by using either a mechanical signal or the appropriate hand/arm signal.

STOPPING

1. **When and Where to Stop**: A driver must stop:

   - Behind the stop line or crosswalk at any stop sign or at a red traffic signal.
   - Behind the stop line or crosswalk at any red traffic signal where right or left turns on red are permitted. The driver may only proceed with a legal turn on red after coming to a full stop and yielding the right of way to all crossing traffic and to all pedestrians crossing the intersection.
   - At a flashing red traffic signal and yield to all traffic that does not have to stop.
   - At a sidewalk, or if there is no sidewalk, at a point prior to entering the roadway, when emerging from an alley, driveway, or private road in a business or residence district. Drivers must yield the right of way to any pedestrian on the sidewalk.
   - Before entering an intersection if there is not sufficient space on the other side to accommodate the vehicle. The law applies whether or not a traffic signal gives a driver the right to proceed.
   - At the approach of a public safety vehicle (such as a police car, fire engine, or ambulance) displaying flashing lights and sounding a warning signal, unless the vehicle is traveling in the opposite direction on a divided highway. Drivers should move as far as possible to the right of the road and remain there until the emergency vehicle has passed.

2. **Stopping for a School Bus**: When a school bus is stopped on a roadway to pick up or drop off passengers, the following regulations apply to other drivers on the roadway:

   - When a school bus driver is preparing to stop the bus, he/she activates four amber lights (two on the front and two on the rear of the bus). These lights continue to flash until the bus is fully stopped. Other vehicles are not required to stop during this preliminary stage of the eight-light warning, but should prepare to stop as soon as the bus comes to a full stop. When the bus comes to a complete stop, the amber lights stop flashing and four red lights (two in front and two in rear) start flashing while the children enter or leave the bus. In addition, a stop arm with flashing red lights is automatically extended beneath the window on the left side of the bus.
   - If the bus is stopped on a street or road which has fewer than four lanes, all traffic approaching the bus from either direction must stop at least 10 feet from the front or rear of the bus and remain stopped until the bus begins to move or the bus driver signals motorists to proceed.
   - If the bus is stopped on a street or road which has four or more lanes, only traffic proceeding in the same direction as the bus must stop.

3. **Stopping Distance**: The distance it takes to stop a vehicle depends on the driver's reaction time, speed being traveled, the condition of the vehicle's brakes, and the condition of the pavement (wet, dry, icy). A driver must maintain sufficient distance between his/her vehicle and the vehicle ahead.

YIELDING

1. **Yielding Right of Way**: A driver must yield the right of way:

   - When directed by a yield sign.
   - When crossing or entering a through highway from a smaller, less traveled road.
   - To a vehicle approaching from the right at an intersection of two similar roads without a traffic control device.
   - To a pedestrian in a marked crosswalk or at an unmarked crosswalk at an intersection.
   - On the approach of a public safety vehicle.
   - For all vehicles which are part of a funeral procession. Each vehicle in the funeral procession must have its headlights lit and must display a purple and white pennant.
   - To oncoming traffic when making a left turn.
   - To traffic approaching an intersection before making a right turn at a red light.

PASSING

Under certain circumstances, vehicle operators are permitted to pass slow-moving traffic that is traveling in the same direction. It is generally safer and more consistent with the law to pass on the left of slower vehicles. Under any circumstance, the law requires that a driver signal the intention to pass by using a turn signal prior to passing.

1. **Passing To the Left**: When passing traffic traveling in the same direction, no vehicle shall be driven to the left of the center of the road unless the left side is clearly visible and is free of oncoming traffic for a sufficient distance ahead. Passing shall be completed without interfering with the safe operation of traffic approaching from the opposite direction or any vehicle being overtaken. Passing is not permitted under the following circumstances:

   - When approaching the crest of a grade or a curve in the roadway where the driver's view is obstructed and the driver cannot see if the pass will interfere with oncoming traffic.
   - Within 100 feet of a bridge, viaduct, or tunnel when the driver's view is obstructed.
   - Within 100 feet of approaching an intersection.
   - Within 100 feet of a railroad grade crossing.

   The limits above do not apply to traffic traveling on a one-way street or on a roadway with two or more lanes for travel in the same direction.

   Additional Regulations: When passing to the left, the law requires that a driver overtaking another vehicle do these things:

   - Sound the horn to warn the driver of the vehicle being overtaken that he/she is about to be passed.
   - Signal the intent to pass.

- Pass to the left of the vehicle being overtaken at a safe distance and return to the right side of the roadway only after the overtaking vehicle is safely clear of the vehicle being overtaken.
- Return to the right lane as soon as the pass has been safely completed and before coming within 200 feet of any approaching vehicle.

When a driver is being passed by another vehicle, the law requires the driver of the slower vehicle to maintain a constant speed and stay to the right until the other driver has safely passed.

2. **Passing To the Right**: A vehicle may pass on the right only under the following conditions:

- When the vehicle being overtaken is about to make a left turn.
- When the payment is wide enough for two or more lines of traffic moving in the same direction as the overtaking vehicle.

Under either circumstance, it is essential that the driver of the passing vehicle first determine that the slower-moving vehicle can be overtaken safely, and the driver must not drive off the roadway in order to overtake the slower vehicle.

SPEED LIMITS

Vehicles may not be driven at speeds greater or less than reasonable, depending on conditions of traffic, road, and weather. A driver must keep the vehicle under control in order to be able to bring it to a stop within assured clear distance ahead.

1. **Unlawful Speeds**: It is unlawful to drive at a speed exceeding:

- 15 mph in all alleys within a municipal corporation.
- 20 mph when passing a school building or grounds (school zones) during school recess and when children are going to or leaving school during the opening and closing hours, and when 20 mph school speed limit signs are erected.
- 25 mph in all other portions of a municipal corporation, except state routes, and through highways outside business districts and alleys.
- 35 mph on all state routes or through highways, except controlled-access highways within municipal corporations outside business districts.
- 50 mph on state routes within municipal corporations outside urban districts, unless a lower speed is established visibly on a sign.
- 55 mph (the maximum speed limit at all times) for vehicles weighing more than 8,000 pounds and non-commercial buses.
- 55 mph (the maximum speed limit) on all other highways.
- 60 and 65 mph on designated highways for vehicles weighing 8,000 pounds or less and commercial buses.
- 65 mph at all times on freeways with paved shoulders inside municipal corporations unless a lower speed is established on a sign.

2. **Minimum Speed Limits**: No person shall operate a vehicle at such a slow speed as to impede or block the normal and reasonable movement of traffic, except when reduced speed is necessary for safe operation or to comply with the law. Minimum speed limits are posted on controlled-access highways.

3. **Racing on Public Roads**: No driver shall participate in a race on a public road. A race consists of two or more vehicles, starting from a point side-by-side and accelerating in a competitive attempt to out-distance each other; or the operation of one or more vehicles over a common course, from the same point to the same point, when the vehicles are timed for the competitive acceleration of speeds. Persons assisting in any manner in such competitive use of vehicles shall be equally charged as participants.

RAILROAD GRADE CROSSINGS

Highway department and railroad companies have clearly marked public highway-rail crossings with warning signs. Advance warning signs advise drivers to look, listen, and slow down.

1. **Warning Devices**:

- *Pavement Markings:* Consists of an "X" and the letters "RR"; may be painted on the pavement of the approach to some crossings.
- *Railroad Crossbuck Signs:* Found at many public crossings, these signs must be obeyed the same as a yield sign. The driver should slow down and be prepared to stop upon seeing or hearing a train. If there is more than one track, a sign below the crossbuck indicates the number of tracks at the crossing.
- *Flashing Red Light Signals:* Used with crossbuck signs at many highway-rail crossings. Drivers must stop no closer than 15 feet and no farther than 50 feet from the crossing when the lights are flashing. Flashing lights mean a train is coming. If there is more than one track, make sure all tracks are clear before crossing.
- *Gates*: Used with flashing red light signals at certain crossings. Stop when the lights begin to flash and before the gate begins to lower across your traffic lane, at no closer than 15 feet and no farther than 50 feet from the crossing. Do not attempt to cross until the gates are raised and the lights have stopped flashing.
- *Stop Signs:* Indicates **all** vehicles **must** stop and yield.

2. **Safety Tips**: The following are safety tips regarding railroad crossings:

- Expect a train on any track at any time. Most trains do not travel on a regular schedule.
- Do not get trapped on a grade crossing. Never drive onto a grade crossing until you are sure you can clear the tracks. Once you have started to cross the tracks, keep going, especially if you see a train approaching.
- Never driver around a lowered gate; it is illegal and deadly.
- Watch for a second train. When at a multiple track crossing, do not proceed until you are sure that no other train is coming on another track, especially from the opposite direction.

- If your vehicle stalls while on the tracks and a train is approaching, unfasten your safety belt, get out of the vehicle, and run as far away from the tracks as you can. Run towards the direction the train is approaching. If you run from the train, you may be hit by debris when the train strikes the vehicle.
- Never shift gears while crossing the tracks. If the vehicle has a manual transmission, shift down before reaching the tracks.
- Never race a train.
- Watch for vehicles that must stop at highway-rail grade crossings (e.g., school buses).
- Do not misjudge the train's speed and distance. Because of the large size of the train, it appears to be moving much slower than it actually is. Trains cannot stop quickly.
- Be alert, especially at night, for rail crossing warning signs. Be sure you can stop within the distance illuminated by your headlights.
- Be careful and reduce your speed when obstructions block your view.

PARKING

A vehicle must be parked facing the direction of traffic on that side of the street, parallel to and not more than 12 inches from the right curb. On one-way streets, vehicles may be parked parallel to and not more than 12 inches from the right or left curb.

1. **Stopping, Parking, or Standing Prohibited**: No person shall stop, park, or stand a vehicle in any of the following places, except when necessary to avoid conflict with other traffic, or in compliance with the directions of a law enforcement officer or traffic control device:

   - On a sidewalk (except a bicyle).
   - In front of a public or private driveway.
   - Within an intersection.
   - Within 10 feet of a fire hydrant.
   - On a crosswalk.
   - Within 20 feet of a crosswalk or intersection.
   - Within 30 feet of a flashing beacon, stop sign, or traffic-control signal.
   - Between a safety zone and the adjacent curb or within 30 feet of points on the curb immediately opposite the ends of a safety zone, unless the traffic authority indicates a different length by signs or markings.
   - Within 50 feet of the nearest rail of a railroad crossing.
   - Beside or opposite a street excavation or obstruction, when such parking would obstruct traffic.
   - Alongside a vehicle stopped or parked at the edge or curb of a street.
   - On a highway bridge or within a highway tunnel.
   - At any place where signs prohibit parking.
   - Within one foot of another parked vehicle.
   - On the roadway portion of a freeway, expressway, or thruway.

2. **Parking for Motorists With Disabilities**: No person shall park any motor vehicle at special parking locations designated with the handicapped symbol unless the motor vehicle is displaying a state-issued parking card or special license plates for those with disabilities. The special license plates and parking cards allow police to identify drivers legitimately using handicapped parking spots. Violators are subject to a citation and fine, on private as well as public property.

SAFETY BELTS

Ohio's mandatory safety belt usage law requires drivers and front-seat occupants of passenger vehicles to wear their safety belts whenever they drive or ride in a motor vehicle on Ohio's roadways.

OPERATING A VEHICLE WHILE IMPAIRED (OVI)

Ohio's legal drinking age for beer and liquor is 21. Driving under the influence of alcohol is against the law in Ohio. Evidence of impaired driving is based on physical findings by the arresting officer and the results of a blood, breath, or urine test. If a driver refuses to submit to a blood-alcohol test or if the results of a test taken within two hours of arrest shows a blood-alcohol concentration at or above the legal limit, the arresting officer will confiscate the driver's license.

Ohio law also forbids driving under the influence of drugs, or a combination of alcohol and drugs. Even prescription or over-the-counter medicines can have detrimental effects on an individual's driving ability.

SPECIAL CONDITIONS

1. **Night Driving**:

   - Maintain a cautious, reasonable speed. By driving at a reasonable speed, the driver will be able to stop in the distance illuminated by the vehicle's headlights.
   - When closely following another vehicle or when another vehicle is approaching, dim the headlights. Use the upper beams only for driving in open country with a clear road ahead.
   - If a vehicle approaches with bright lights on, do not stare at the lights. Steer by the line at the outside edge of the road to prevent being temporarily blinded.
   - Pedestrians walking alongside the roads or crossing streets do not realize that motorists cannot see them. Be sure to watch for pedestrians.
   - Keep windows clean. Glare caused by lights shining on dirty glass reduces visibility at night.
   - Fatigue, which slows down perception and reaction time, is a significant factor in night-time crashes. Be sure to pull off of the road and rest if tired.

2. **Winter Driving**: When roads may be snow-covered or icy, reduce speed. Driving in the winter is much different than driving in any other season of the year. No matter what road or weather conditions are encountered, a slower speed is necessary for safe handling of the vehicle.

- Reduce speed!
- Be sure the vehicle is in excellent operating condition. Lights, brakes, windshield wipers, defroster, radiator, and other parts of the vehicle should be in perfect order, particularly for the winter time. Snow tires are a good precaution. Tire chains can be a big help in severe snow and ice conditions.
- Keep a vent or window slightly open. This will help the windshield remain clear of fog and also guard against possible carbon monoxide buildup.
- Shaded spots on the highway will hold frost and ice while other portions of the pavement are dry. The same is true of bridges, they will hold frost and ice while the rest of the road may be safe.
- In the winter, it is often necessary to stop suddenly. To prevent skidding, intermittently apply light pressure to the brakes. (Anti-Lock Brake Systems do not require pumping.) This pumping action will reduce momentum without losing traction and without locking the brakes. If the vehicle does go into a skid, take your foot off the accelerator and turn the steering wheel in the direction of the skid. Never apply the brakes while skidding!
- When starting a car that is parked on top of ice, move very slowly. The tires will have a better chance to grip if they are turned slowly. Starting in second or low gear will also help. Put a greater distance than usual between other vehicles. This is necessary because cars need a greater stopping distance on slippery roads.

3. **Driving in Fog**: Fog is one of the most hazardous conditions a motorist can drive in. Because most motorists drive slowly in fog, few collisions occur; however, when collisions do occur, there are often chain-reaction crashes on the freeway resulting in fatalities and serious extensive damage. When driving in fog:

   - Slow down! You may have to stop at any time. If the stopping distance for the speed the vehicle is traveling is greater than the distance that can be seen, the driver will be unable to stop if there is an obstruction on the road.
   - Use low-beam headlights, not bright lights.
   - Move with the flow of traffic. Keep a consistent distance behind the car in front of you so the cars behind you may do the same.
   - If a collision occurs, get the vehicles off the road as quickly as possible. If a vehicle cannot be moved, leave the flashers and lights on and set up flares if available. Do not sit in the car waiting for help. Cautiously move as far off the road as possible.
   - Drive with the window open.
   - Shift your gaze instead of staring.

4. **Freeway Driving**:

   - *Getting Onto an Expressway*: If it is necessary to make a left-hand turn onto a freeway entrance ramp, do not wait until the last second to get into the left-hand lane. Move into the turn lane several blocks early. Once entering the on-ramp, **accelerate**. If the vehicle is moving 30 miles per hour, it will be nearly impossible to merge with traffic moving almost twice as fast. When reaching the end of a freeway on-ramp, weather and ramp conditions permitting, a vehicle should be traveling as close as possible to the speed of traffic. Always use a turn signal to let other drivers know the vehicle will be pulling into the stream of

traffic. When reaching the end of the on-ramp, keep a close eye on the car ahead and use the outside mirror to help spot a likely opening. As the driver entering the highway, you are required to yield to motorists already on the freeway; they have the right of way. However, if the vehicle is moving at or near the speed of the surrounding cars, it should be simple to merge with the traffic flow.

- *Traffic Movement*: Once in a lane, stay in it. Do not weave in and out of lanes. Observe and obey signs. Moving at a fast speed means more room is needed between cars in case of an emergency. Follow no closer than one car length for every ten miles of speed. Maintain speed at or just below the posted speed limit. Moving significantly slower than other traffic can cause a hazard. Watch for signs noting changes in speed limits, especially when approaching construction zones or a heavily populated area.
- *To Get Off an Expressway*: Watch for signs, signal for the proper turn-off, and move to the correct exit lane. Use turn signal to indicate when and where you will be exiting. Stay at the speed of traffic until the exit ramp is reached, then slow down. Continue to slow down and stop if required before entering the cross highway or street. If an exit is missed, continue to the next one. It is illegal to stop, to back-up, or to drive into the median or cross-over on an interstate highway.

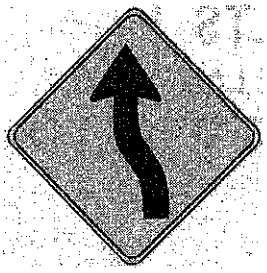
5. **When to Use Lights**: Lights must be displayed:
   - Between sunset and sunrise.
   - During any periods of rain, snow, fog, or other unfavorable atmospheric conditions regardless of the time of day.
   - At any time when natural light conditions do not make it possible to see objects 1,000 feet ahead clearly.

6. **Inoperable Traffic Signals**: At times, power outages can result in non-working traffic signals. This situation can be extremely dangerous, particularly when a law enforcement officer is not present to direct traffic at the disabled traffic light. By law, except when a law enforcement officer is present to direct traffic, drivers must treat the non-working traffic signal as a four-way stop. After stopping, due care should be taken before proceeding through the intersection, as other drivers may wrongfully view the inoperable traffic signal as clearance to proceed without stopping.

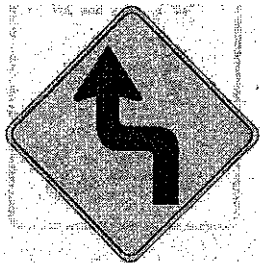
WARNING SIGNS

Warning signs adjacent to the roadways alert motorists to potentially hazardous conditions. Most of these signs retain their traditional yellow color as well as their diamond shape, but on many of the signs, words have been replaced by symbols as illustrated below. The circle is reserved for railroad crossing signs.

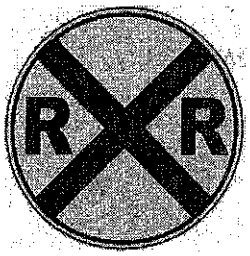
You are approaching a curve to the right, then to the left.



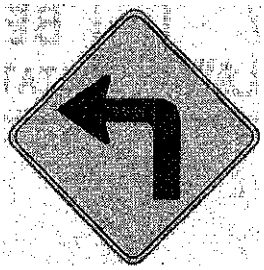
You are approaching a curve to the left, then to the right.



Sharp turn to the left, then to the right.



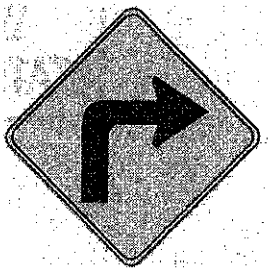
Railroad crossing ahead.



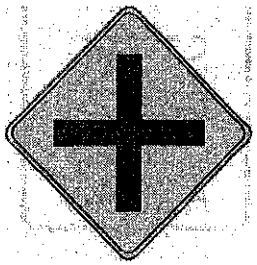
Sharp turn to the left ahead.

Sharp turn to the right, then to the left.

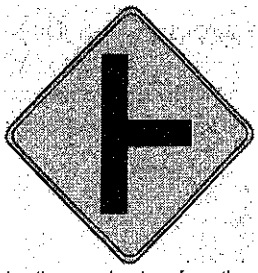
You are approaching a downgrade. May be supplemented with "Trucks Use Low Gear."



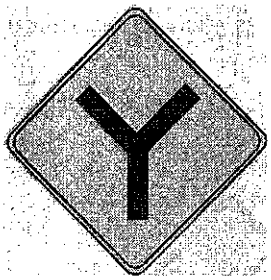
Sharp turn to the right ahead.



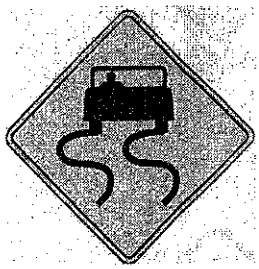
Crossroad ahead. (intersection)



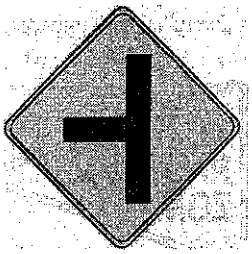
Another road enters from the right.



The road branches to the right and left ahead.

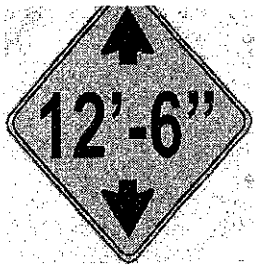


The road ahead is slippery when wet.

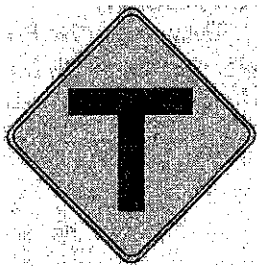


Another road enters from the left.

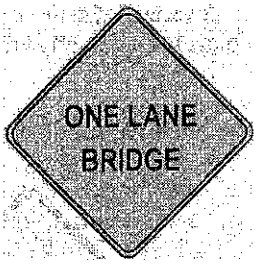
You are approaching a series of curves. Slow down, drive carefully.



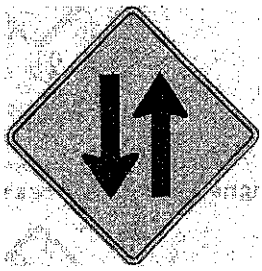
Clearance is limited (by a bridge, overhead crosswalk, etc.).



You are approaching an intersection. Turn right or left.



Proceed with caution. The vehicle closest to the bridge has the right of way.



Traffic is moving in both directions.

TRAFFIC SAFETY

CONSTRUCTION ZONES, SIGNS, AND PENALTIES

1. **Construction Zone**: Construction zone is that lane or portion of street or highway open to vehicular traffic and adjacent to a lane, berm, or shoulder of a street or highway within which lane, berm, or shoulder construction, reconstruction, resurfacing, or any other work or repair of a maintenance nature, including public utility work, is being conducted, commencing with the point where the first worker or piece of equipment is located and ending where the last worker or piece of equipment is located.

2. **Signs**: The Director of Public Works is authorized to erect signs advising motorists that increased penalties apply for violation of moving traffic offenses in construction zones. The increased penalties are in effect when signs are posted and when the violations occur during hours of actual work within the construction zone.

3. **Penalties**: Upon a finding that a person violated a moving traffic offense in a construction zone where a sign was then posted, the court, in addition to all other penalties provided by law, shall impose a minimum fine of at least two times the amount posted on the Hamilton County Municipal Court traffic payout schedule.

TRAFFIC SAFETY APPLICATIONS

1. **Traffic Control Zones**: The traffic control zone is the distance between the first advance warning sign and the point beyond the work area where traffic is no longer affected. Most traffic control zones can be divided into the following parts:

   - *Advance Warning Area:* An advance warning area is necessary for all traffic control zones so drivers know what to expect and in order to have enough time to alter their driving patterns. An advance warning sign should be posted when any problem or conflict with the flow of traffic might occur; an advance warning sign may not be needed when the work area is entirely off the shoulder and the work does not interfere with traffic. The advance warning area should be long enough to give the motorist adequate time to respond to the condition. Generally, the lengths used are:
     -- One-half mile to one mile for freeways or expressways;
     -- 1,500 feet for most other roadways or open highway conditions;
     -- At least one block for urban streets.
   - *Transition Area:* A lane closure is required when work is performed within one or more traveled lanes. In the transition area, traffic is channeled from the normal lanes to the path required to move traffic around the work area.
   - *Buffer Space:* The buffer space is open or unoccupied space between the transition and work areas to provide a margin of safety for both traffic and workers.

- *Work Area:* The work area is that portion of the roadway which contains the work activity and is closed to traffic and set aside for exclusive use by workers, equipment and construction materials.
- *Termination Area:* The termination area provides a short distance for traffic to clear the work area and to return to normal traffic lanes.

2. **Planning for Traffic Control**: A properly installed traffic control zone allows traffic to pass through or around a work zone safely. It requires time and effort for planning, installation and maintenance. Planning for traffic control through construction may be more involved than for maintenance or utility zones because of the difference in traffic disruption and duration of the work. The common goals of all traffic control zones are to:

   - *Minimize Accidents:* Safety should have a high priority through all stages of work.
   - *Minimize Inconvenience:* The traffic control plan should be aimed at reducing inconvenience by inhibiting traffic movement as little as possible.

3. **Traffic Control Devices**: Traffic control devices include signs, signals, lighting units, pavement markings, delineators, channelizing units, hand signaling signs or flags and portable barriers which are used to warn, guide or regulate traffic.

   - *Signs:* Signs are classified as follows:
     -- *Regulatory Signs:* Regulatory signs impose legal restrictions and may not be used without permission from the authority having jurisdiction over the roadway.
     -- *Warning Signs:* Warning signs are used to give notice of conditions that are potentially hazardous to traffic.
     -- *Guide Signs:* Guide signs show destinations, directions, distances, services, points of interest and other geographical or cultural information.
   - *Markings:* Pavement markings are used to guide traffic through work zones. Pavement markings and delineators outline the vehicular path to lead traffic around a work area. Pavement markings include lane stripes, edge stripes, centerline stripes, payment arrows and word messages. Delineators are reflective units, installed about four feet above the roadway on lightweight posts, that can be seen when reflecting a car's headlight.
   - *Channelizing Devices:* Channelizing devices are used to warn and direct traffic away from or around a work area or to control the flow of traffic when separating two directions of travel, i.e., barricades, vertical panels, cones and drums.
   - *Lighting Devices:* Types of light devices include:
     -- *Warning Lights:* Warning lights may be used on channelizing devices, barriers and signs. Types include flashing lights, high intensity lights and steady-burn lights.
     -- *Flashing Vehicle Lights:* Work vehicles in or near the traffic area are hazards and should be equipped with flashing lights. The vehicle warning lights may be emergency flashers, flashing, strobe or rotating beacons.
     -- *Flashing Arrow Panels:* Arrow panels are signs with a matrix of lights that can flash or be a sequential display. Flashing arrow panels are effective day or night, for moving traffic out of a lane to the left or right and may be used for tapered lane closures and moving operations.

- -- *Hazard Identification Beacons:* Flashing hazard identification beacons are used in work areas both day and night to alert drivers of a critical point in the highway.
- -- *Floodlights:* Floodlights are used to light work activities, flagger stations and other restricted or hazardous areas at night when area light is not sufficient.

- *Shadow Vehicles:* Shadow vehicles are used to assist traffic control for moving operations by moving with the work operations.
- *Flagging Operations:* Flagging should only be used when required to control traffic or when all other methods of traffic control are inadequate to warn and direct drivers.

4. **Layouts**: Each traffic control zone is different, with variables such as speed, volume, location of work, pedestrians and intersections, changing the needs for each location. Typical traffic control devices for specific situations are as follows:

- *Work Entirely Beyond Shoulder or Parking Lane:* Traffic control depends primarily on advance warning signs, flashing vehicle lights and flags. An advance warning sign should be used when:
  - -- Work will be performed immediately adjacent to the roadway;
  - -- Equipment may be moved along or across the highway; and
  - -- Motorists may be distracted by the work activity.
- *Work On or Over Shoulder or Parking Lane:*
  - -- *No Encroachment in Traveled Lane:* There is no direct interference with traffic. When the shoulder is occupied or closed, the motorist should be advised and the workers protected; normally a SHOULDER WORK sign is adequate. When an improved shoulder is closed on a high-speed roadway, it should be treated as a closure since motorists expect to be able to use it in an emergency.
  - -- *Minor Encroachment in Traveled Lane:* Types of traffic, speed and capacity should be analyzed to determine whether the affected lane should be closed.
- *Work on Two-Lane Roadway:* When one lane is closed on a two-lane, two-way road, the remaining lane must be used by traffic traveling in both directions. One-way traffic control can be handled by:
  - -- A flagger at each end of the work area.
  - -- One flagger can assign right-of-way at a short work area with low volumes.
  - -- For very short work areas at a spot location where traffic volumes and speed are low, the movements may be self-regulating.
  - -- A pilot car.
  - -- Temporary traffic signals for long-duration projects.
- *Work on Four-Lane, Two-Way Roadway (Undivided):*
  - -- *Right Lane Closed:* If morning and evening peak hourly traffic volumes in the two directions are uneven and the greater volume is on the side where the work is being done, the inside lane for opposing traffic may be closed and made available to the side with heavier traffic. If the heavier traffic changes to the opposite direction, the traffic control can be changed to allow two lanes for opposing traffic by moving the devices from the opposing lane back to the centerline.

- -- *Left Lane Closed:* If the work activity can be contained entirely within the left (or inside lane), it may be appropriate to close that lane only. It may be desirable to close the two center lanes to give traffic and workers additional protection and to provide easier access to the work area.
- -- *Two Lanes Closed:* When the work occupies both lanes for one direction of traffic, the number of lanes remaining open may be reduced to one for each direction.

- *Mobile Operations:* Mobile operations are work activities that make frequent short stops, up to a 15-minute period, such as litter cleanup or pothole patching. Warning signs, flashing vehicle lights, flags and/or channelizing devices should be used.
- *Moving Operations:* Moving operations are work activities where workers and equipment move along the road without stopping, usually at slow speeds. The advance warning area moves with the work area.
- *Short-Term Utility Operations:* The work vehicle may be used for warning if it is equipped with flashing lights, rotating beacons or flags. When entering or leaving a manhole, workers should always face oncoming traffic so they can get out of the way if necessary. Materials or equipment should be stored away from the manhole opening.
- *Pedestrians:* When there is pedestrian traffic in the area, walkway should be provided.
- *Bicycles:* If a bicycle path is closed because of the work being done, an alternate route should be provided and signed if appropriate.
- *Interchanges:*Access to interchange ramps should be maintained whenever possible even if the work area is in the lane adjacent to the ramps. Access to an exit ramp should be clearly marked and outlined with channelizing devices.
- *Intersections:* Use advance warning signs, devices and markings as appropriate on all cross streets.
- *Detours:* Detour signs are used to direct traffic onto another roadway. When the detour is long, signs should be installed periodically to remind and reassure drivers they are still on the detour. The detour should be signed so that traffic can be get back to the original roadway.
- *Portable Concrete Barriers:* Portable concrete barriers are used for added safety.

INSTALLATION, MAINTENANCE AND INSPECTION OF TRAFFIC CONTROL DEVICES

Before work begins, signs, pavement marking materials and channelizing devices should be checked. All devices should be standard in size, shape, color or message; in good condition, not needing repair; and reflectorized.

1. **Installation and Removal**:

- *Order of Placement*: Traffic control devices should be placed in the order that drivers will see them, starting with the sign or device that is farthest from the work area and place the others as the work area is approached.

- *Removal of Devices:* As soon as the work is completed and the devices are no longer needed, they should be removed. Devices should be removed in the opposite order of installation by starting with the devices closest to the work area and continuing away from the area.
- *Pavement Marking Removal:* Any pavement markings that are no longer applicable or that may confuse drivers should be removed as soon as practicable.

2. **Inspection and Maintenance Program**:

- *Purpose*: Once the traffic control zone is established, it is important to ensure that it continues to function as it was intended. Maintenance is needed to service the equipment and make corrections which may be required.
- *Elements of an Inspection Program:* A comprehensive inspection and maintenance program should include the following elements:
  - -- A formalized plan.
  - -- Defined inspection procedures.
  - -- A form on which the findings of the field inspection are recorded.
  - -- A repair program.
  - -- Assurance of an adequate inventory of devices for emergency replacement or repairs.
  - -- Check procedures to assure that specified repairs are made.
  - -- Identify possible causes of accidents or skid marks.
  - -- A review to insure that the travel path clearly marked through the entire work zone, both day and night.
  - -- Formal documentation of inspections and repairs made.
- *Responsibility:* For each project, an individual should be assigned the responsibility for traffic control. Lines of communication and responsibility should be clearly established between individuals in control of routine maintenance activities and those with greater authority so that urgent problems that arise from time to time can be brought promptly to the attention of individuals who are in a position to respond immediately.
- *Frequency:* To determine the frequency with which inspections should be performed, the following factors should be considered:
  - -- Project size and duration.
  - -- Nature of work activity.
  - -- Complexity of traffic control.
  - -- Frequency at which damage is occurring.
  - -- Number of deficiencies observed during previous inspections.
- *Recordkeeping:* To keep good records, the time and location of the installation and removal of traffic control devices should be noted. Major projects require more detailed recordkeeping since they may require greater amounts of funds, outside funding sources (federal or state aid), and longer distances and time of physical exposure to the workers, motorists or pedestrians. When the inspection process reveals a condition that requires correction, the documentation should include:
  - -- Description of the correction needed, when it was noted and by whom.
  - -- Corrections made or deferred and why.
  - -- Replacements made or deferred and why.
  - -- Any other actions needed.

- *Legal Liability:* The likelihood of lawsuits should be anticipated in the event of an accident or other grievance suffered by an injured citizen. To prevent or minimize such litigation, and to help defend lawsuits, the following steps are recommended:
  - -- Know and comply with the traffic control for street and highway construction and maintenance.
  - -- Provide properly working devices at the site, particularly when unattended (night, weekends, etc.)
  - -- Document all actions taken on or related to traffic controls that are placed in effect at the work site.
  - -- Inspect the work site at frequent intervals with a view to detecting and immediately correcting deficiencies in traffic control.
  - -- Remove all materials and equipment not needed at the site as soon as possible.
  - -- Provide warning and protection to motorists, pedestrians and workers for potential conflicts and hazards that may result from the work being done at the site or from a vehicle striking a device.
- *Documentation for Protection:* Careful records of job related activities should be maintained so they document efforts to provide good traffic control at the work site.

GEOMETRY

SPACE

An extent or continuum in which objects can exist and have relative positions and directions.

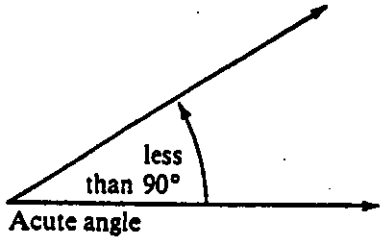
PLANE

A flat surface that extends endlessly in all four directions.

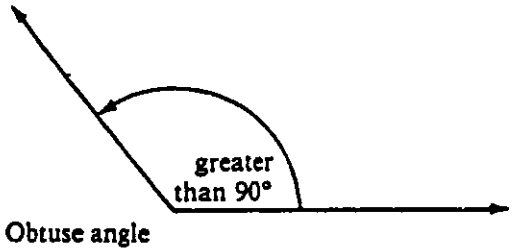
ANGLE

An angle is a figure consisting of two rays with a common endpoint (vertex). A ray starts from a point and extends endlessly in one direction. Angles are measured by degrees with an instrument called a protractor; there are 360° around a vertex. There are four types of angles:

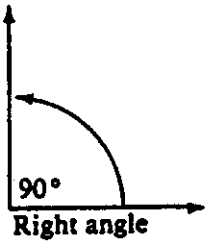
- *Acute Angle*: Angle that is less than 90°.



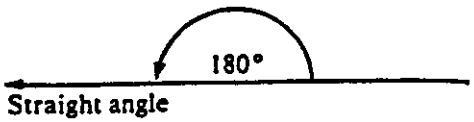
- *Obtuse Angle:* Angle that is greater than 90°.



- *Right Angle:* Angle that is 90°.



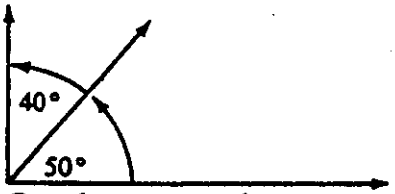
- *Straight Angle:* Angle that is 180°.



Straight angle

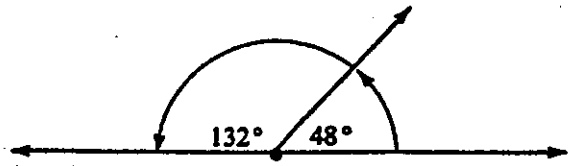
When there are two angles, they are classified as:

- *Complementary Angles:* When the sum of two measures of two angles is 90°.



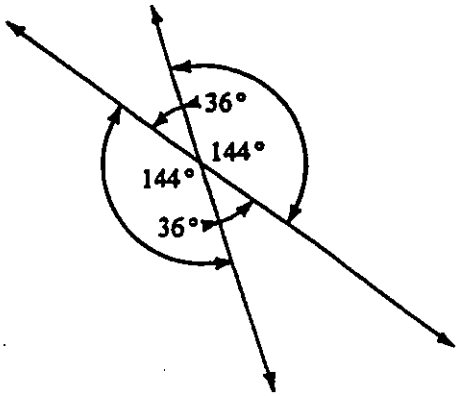
Complementary angles

- *Supplementary Angles:* When the sum of two measures of two angles is 180°.



Supplementary angles

- *Vertical Angles:* Angles that are opposite each other when two straight lines intersect; they are equal in measure.



Vertical angles

LINES

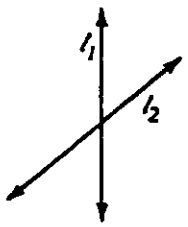
A line is straight and extends indefinitely in two opposite directions. A line segment is a part of a line which consists of two endpoints and all the points between them. A point is a specific, dimensionless location in space having a unique position.

Equations of a Straight Line:

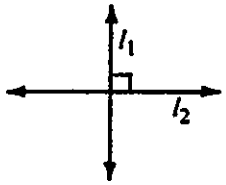
- *General Form:* $Ax + By + C = 0$
- *Slope Form:* $y = mx + b$
- *Point-Slope Form:* $(y-y^*) = m(x-x^*)$
  (x^*, y^*) is any point on the line
- *Intercept Form:* $\frac{x}{a} + \frac{y}{b} = 1$
- *Two-Point Form:* $\frac{y-y^*_1}{x-x^*_1} = \frac{y^*_2-y^*_1}{x^*_2-x^*_1}$

There are three types of lines:

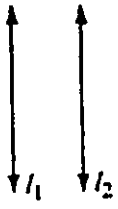
- *Intersecting Lines:* Lines with a point in common.



- *Perpendicular Lines:* Lines that intersect to form four equal angles.



- *Parallel Lines:* Lines that never intersect on a flat surface.



POINTS, LINES AND DISTANCES

The distance d_2 between a point and a line is:

$$d_2 = \frac{|Ax_1 + By_1 + C|}{\sqrt{A^2 + B^2}}$$

The distance between two points is:

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Parallel lines:

$$\frac{A_1}{A_2} = \frac{B_1}{B_2}$$

$$m_1 = m_2$$

Perpendicular lines:

$$A_1A_2 = B_1B_2$$

$$m_1 = -\frac{1}{m_2}$$

Point of intersection of two lines:

$$x_1 = \frac{B_2C_1 - B_1C_2}{A_2B_1 - A_1B_2}$$

$$y_1 = \frac{A_1C_2 - A_2C_1}{A_2B_1 - A_1B_2}$$

Smaller angle between two intersecting lines:

$$\tan\varnothing = \frac{A_1B_2 - A_2B_1}{A_1A_2 + B_1B_2} = \frac{m_2 - m_1}{1 + m_1m_2}$$

$$\varnothing = |\arctan(m_1) - \arctan(m_2)|$$

What is the angle between the lines?

$$y_1 = -0.577x + 2$$
$$y_2 = +0.577x - 5$$

method 1:

$$\arctan\left[\frac{m_2 - m_1}{1 + m_1m_2}\right] = \arctan\left[\frac{0.577 - (-0.577)}{1 + (0.577)(-0.577)}\right] = 60°$$

method 2: Write both equations in general form:

$$-0.577x - y_1 + 2 = 0$$
$$0.577x - y_2 - 5 = 0$$

$$\arctan\left[\frac{A_1B_2 - A_2B_1}{A_1A_2 + B_1B_2}\right] = \arctan\left[\frac{(-0.577)(-1) - (0.577)(-1)}{(-0.577)(0.577) + (-1)(-1)}\right] = 60°$$

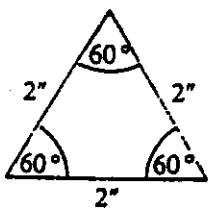
method 3:

$$\varnothing = |\arctan(-0.577) - \arctan(0.577)| = |-30° - 30°| = 60°$$

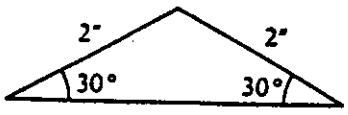
TRIANGLES

A triangle is a three-sided figure which consists of three line segments joined at their endpoints. There are four types of triangles:

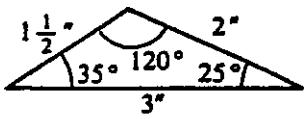
- *Equilateral Triangle:* All three sides are equal in length; because each of the three angles measure 60°, the triangle is also called an *equiangular triangle.*



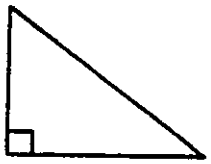
- *Isosceles Triangle:* Two sides are equal in length; the two angles opposite the equal sides are equal and called *base angles*; the third angle is called the *vertex angle.*



- *Scalene Triangle:* All three sides are different in length; all three angles have a different measure.



- *Right Triangle:* Has one right angle.



Similar Triangles have the same shape, but are different sizes; *corresponding angles* are equal; *corresponding sides* are proportional to each other (these are the sides opposite equal angles); triangles may be turned and still be similar. The sum of the three angles in any triangle is always the same.

Pythagorean (Right Triangle) Theorem

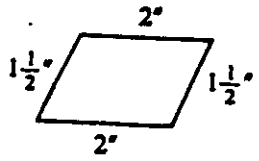
The sides of a right triangle are related in a special way: *the sum of the squares of the lengths of the two shortest sides equals the square of the length of the longest side.* The two shorter sides are called *legs* and the longest side (always opposite the right angle) is called the *hypotenuse.* This fact, called the Pythagorean theorem, can also be stated as *the sum of the squares of the legs equals the square of the hypotenuse* or $a^2 + b^2 = c^2$

An exponent is a small figure written to the upper right of a number to be raised to a power (how many times the number is multiplied by itself); the factor to be raised to a power is called the base. To find the square root of a number means to find the number that was multiplied by itself to get the number; a *perfect square* means that the square root is a whole number.

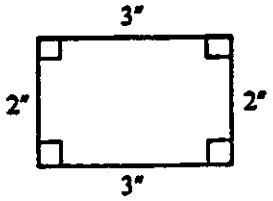
POLYGON

A geometric shape formed by three or more connecting line segments is a polygon. Types of polygons include:

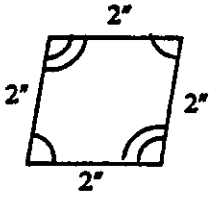
- Parallelogram



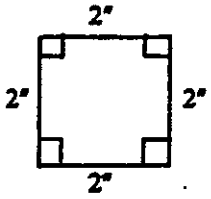
- Rectangle



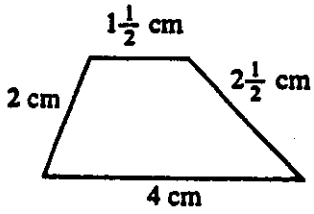
- Rhombus



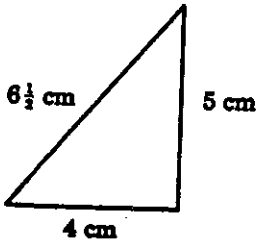
- Square



- Trapezoid



- Triangle



Finding the Areas of Polygons

The *perimeter* of a polygon is the distance around it; to find the perimeter of a polygon, *add the length of all its sides.*

Area is the measure of the surface of a polygon. It is written in *square units*. There is a formula, where letters replace words, for finding the area of each kind of polygon.

A = area
s = side
L or l = length
W or s = width

b = base
b_1 = top base
b_2 = bottom base
h = height (height is measured perpendicular to the base)

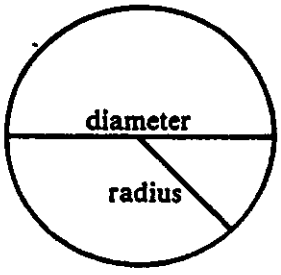
Formulas

Rectangle	$A = LW$
Square	$A = s \times s = s^2$
Triangle	$A = \frac{1}{2} bh$
Parallelogram	$A = bh$
Trapezoid	$A = \frac{1}{2}(b_1 + b_2)h$

CIRCLES

A circle is a curve that starts and ends at the same point and does not cross itself. All points on the curve are the same distance from the center. The *diameter* is a straight line that passes through the center of the circle and connects two points on the circle. The *radius* is a straight line that connects the center of the circle to a point on the circle. The radius is one-half the length of the diameter. The *circumference* is the distance around a circle; it is like the perimeter of a polygon.

C = circumference
d = diameter
r = radius
π = 3.14 (This Greek letter, pronounced "pi" stands for the ratio between the circumference and the diameter of every circle.)



The formula for finding circumference of a circle is:

$C = \pi d$

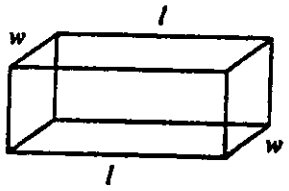
The formula for finding the area of a circle (the surface inside the circle which is always written in square units) is:

$A = \pi r^2$

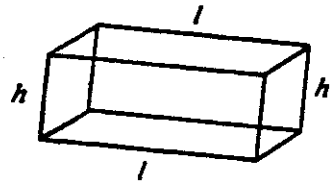
FINDING SURFACE AREAS AND VOLUMES OF RECTANGULAR SOLIDS

A box is an example of a rectangular solid. It has three dimensions: length (l), width (w) and height (h). The *surface area* is the sum of all of the areas.

The top and bottom are rectangles with sides *l* and *w*. The area of each is *lw*.



The front and back are rectangles with sides *l* and *h*. The area of each is *lh*.



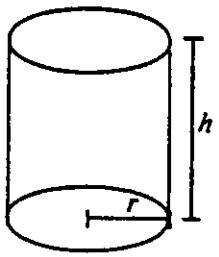
The right and left sides are rectangles with sides *w* and *h*. The area of each is *wh*.

Volume is the measure of capacity; this is how much an object can hold or how much space it takes up. Volume is written as cubic units. The formula is: $V = lwh$

FINDING THE VOLUME OF A CYLINDER AND COMBINED VOLUMES

A cylinder has the shape of a tin can; volume is equal to the area of the base multiplied by the height:

$V = \pi r^2 h$



MATHEMATICS AND RELATED SUBJECTS

CONVERSION FACTORS

To Convert	Into	Multiply by
Acres	hectares	0.4047
Acres	square feet	43,560.0
Acres	square miles	1.562 EE−3
Ampere hours	coulombs	3,600.0
Angstrom units	inches	3.937 EE−9
Angstrom units	microns	1 EE−4
Astronomical units	kilometers	1.495 EE8
Atmospheres	cms of mercury	76.0
BTU's	horsepower-hrs	3.931 EE−4
BTU's	kilowatt-hrs	2.928 EE−4
BTU/hr	watts	0.2931
Bushels	cubic inches	2,150.4
Calories, gram (mean)	BTU (mean)	3.9685 EE−3
Centares	square meters	1.0
Centimeters	kilometers	1 EE−5
Centimeters	meters	1 EE−2
Centimeters	millimeters	10.0
Centimeters	feet	3.281 EE−2
Centimeters	inches	0.3937
Chains	inches	792.0
Coulombs	faradays	1.036 EE−5
Cubic centimeters	cubic inches	0.06102
Cubic centimeters	pints (U.S. liq.)	2.113 EE−3
Cubic feet	cubic meters	0.02832
Cubic feet/min.	pounds water/min.	62.43
Cubic feet/sec.	gallons/min.	448.831
Cubits	inches	18.0
Days	seconds	86,400.0
Degrees (angle)	radians	1.745 EE−2
Degrees/sec.	revolutions/min.	0.1667
Dynes	grams	1.020 EE−3
Dynes	joules/meter (newtons)	1 EE−5
Ells	inches	45.0
Ergs	BTU's	9.480 EE−11
Ergs	foot-pounds	7.3670 EE−8
Ergs	kilowatt-hours	2.778 EE−14
Faradays/sec.	amperes (absolute)	96,500
Fathoms	feet	6.0
Feet	centimeters	30.48
Feet	meters	0.3048
Feet	miles (nautical)	1.645 EE−4
Feet	miles (statute)	1.894 EE−4
Feet/min.	centimeters/sec.	0.5080
Feet/sec.	knots	0.5921
Feet/sec.	miles/hour	0.6818
Foot-pounds	BTU's	1.286 EE−3
Foot-pounds	kilowatt-hours	3.766 EE−7
Furlongs	miles (U.S.)	0.125
Furlongs	feet	660.0
Gallons	liters	3.785
Gallons of water	pounds of water	8.3453
Gallons/min.	cubic feet/hour	8.0208
Grams	ounces (avoirdupois)	3.527 EE−2
Grams	ounces (troy)	3.215 EE−2
Grams	pounds	2.205 EE−3
Hectares	acres	2.471
Hectares	square feet	1.076 EE5

To Convert	Into	Multiply by
Horsepower	BTU/min.	42.44
Horsepower	kilowatts	0.7457
Horsepower	watts	745.7
Hours	days	4.167 EE−2
Hours	weeks	5.952 EE−3
Inches	centimeters	2.540
Inches	miles	1.578 EE−5
Joules	BTU's	9.480 EE−4
Joules	ergs	1 EE7
Kilograms	pounds	2.205
Kilometers	feet	3,281.0
Kilometers	meters	1,000.0
Kilometers	miles	0.6214
Kilometers/hr.	knots	0.5396
Kilowatts	horsepower	1.341
Kilowatt-hours	BTU'S	3,413.0
Knots	feet/hour	6,080.0
Knots	nautical miles/hr.	1.0
Knots	statute miles/hr.	1.151
Light years	miles	5.9 EE12
Links (surveyor's)	inches	7.92
Liters	cubic centimeters	1,000.0
Liters	cubic inches	61.02
Liters	gallons (U.S. liq.)	0.2642
Liters	milliliters	1,000.0
Liters	pints (U.S. liq.)	2.113
Meters	centimeters	100.0
Meters	feet	3.281
Meters	kilometers	1 EE−3
Meters	miles (nautical)	5.396 EE−4
Meters	miles (statute)	6.214 EE−4
Meters	millimeters	1,000.0
Microns	meters	1 EE−6
Miles (nautical)	feet	6,080.27
Miles (statute)	feet	5,280.0
Miles (nautical)	kilometers	1.853
Miles (statute)	kilometers	1.609
Miles (nautical)	miles (statute)	1.1516
Miles (statute)	miles (nautical)	0.8684
Miles/hour	feet/min.	88.0
Milligrams/liter	parts/million	1.0
Milliliters	liters	1 EE−3
Millimeters	inches	3.937 EE−2
Newtons	dynes	1 EE5
Ohms (international)	ohms (absolute)	1.0005
Ounces	grams	28.349527
Ounces	pounds	6.25 EE−2
Ounces (troy)	ounces (avoirdupois)	1.09714
Parsecs	miles	19 EE12
Parsecs	kilometers	3.084 EE13
Pints (liq.)	cubic centimeters	473.2
Pints (liq.)	cubic inches	28.87
Pints (liq.)	gallons	0.125
Pints (liq.)	quarts (liq.)	0.5
Pounds	kilograms	0.4536
Pounds	ounces	16.0
Pounds	ounces (troy)	14.5833
Pounds	pounds (troy)	1.21528
Quarts (dry)	cubic inches	67.20

To Convert	Into	Multiply by
Quarts (liq.)	cubic inches	57.75
Quarts (liq.)	gallons	0.25
Quarts (liq.)	liters	0.9463
Radians	degrees	57.30
Radians	minutes	3,438.0
Revolutions	degrees	360.0
Revolutions/min.	degrees/sec.	6.0
Rods	meters	5.029
Rods	feet	16.5
Rods (surveyor's measure)	yards	5.5
Seconds	minutes	1.667 EE−2
Slugs	pounds	32.17
Tons (long)	kilograms	1,016.0
Tons (short)	kilograms	907.1848
Tons (long)	pounds	2,240.0
Tons (short)	pounds	2,000.0
Tons (long)	tons (short)	1.120
Tons (short)	tons (long)	0.89287
Volt (absolute)	statvolts	3.336 EE−3
Watts	BTU/hour	3.4129
Watts	horsepower	1.341 EE−3
Yards	meters	0.9144
Yards	miles (nautical)	4.934 EE−4
Yards	miles (statute)	5.682 EE−4

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PRE-CONSTRUCTION PREPARATION

Some preparation must be accomplished before actual work can be undertaken on a construction project. To begin, the survey party establishes the centerlines, offset lines, construction limits, reference points, bench marks (for elevations), and a host of other pins, nails, and stakes to witness what and where everything goes. A photo log of the site to record "before" conditions is a useful measure to forestall potential disputes in the future.

SITE PREPARATION ITEMS

1. **Clearing and Grubbing**: Removing material readily visible on the ground surface such as trees, stumps, logs, debris, and rubbish falls under the category of clearing. Grubbing consists of removing and properly disposing of roots, buried debris, and other obstructive materials not readily visible on the ground surface. Work of this nature should not go outside the bounds needed for the actual construction operations. It usually includes selective thinning, rather than complete removal, of trees and woody vegetation.

2. **Salvaging Topsoil**: The stripping and storing of topsoil takes place before, during, or immediately after clearing and grubbing. Topsoil should not be stripped if doing so could cause erosion problems.

EXCAVATION

Excavation problems can be tricky. Placing the excavated materials in fills can be checked, observed, tested, and controlled.

1. **Weather**: Hot weather, cold weather, and wet weather all have detrimental potential for placing fills. Construction should be avoided during bad weather because unfavorable conditions can occur such as drying out of soil moisture, frozen chunks of dirt, and muddy conditions.

2. **Equipment**: Choice of equipment for moving dirt is one of the more critical economic considerations. Terrain and anticipated weather conditions play a part in selecting the appropriate earth moving equipment. Using the correct equipment can help obtain the desired aesthetics of the final project.

3. **Types of Excavation**:

   - *Unclassified Excavation:* Used on most projects. Traditional practice states that a contract price bid for unclassified excavation includes its transport to and placement in fills, along with appropriate site finishing or trimming.

- *Rock Excavation:* Considerably more difficult than ordinary dirt digging. Most of the time rock excavation necessitates blasting or ripping the rock and then cleaning up the rubble.
  - *Presplitting:* A technique to obtain a fairly even backslope is known as presplitting, where charges are placed in equally spaced drilled holes at the top of the rock cut. The charges are simultaneously detonated; a fracture line is created from which all remaining rock in the cut can be removed by ripping, additional blasting, or other methods.
- *Trench Excavation:* Used for drainage pipes, utility lines, and similar appurtenances. This type of excavation requires more specialized equipment and greater care, especially during placement of backfill.
- *Structure Excavation:* Has unique concerns because the soil or rock that remains must have the ability to support considerable weight. Quantities excavated must allow for forms and working room around the footings.

4. **Embankments**: Compaction of embankments plays its part in assuring that a roadway pavement or structure holds up through the expected life of the project. For this reason, embankments of any size are built up in layers and the water content is closely monitored so that it remains close to the optimum (not maximum) value, so as to achieve adequate soil density after compaction. It is prudent when designing a highway embankment to allow for slightly flatter slopes than required so that slides and uncertain angles or repose do not cause unnecessary problems for those who must cope with construction contingencies. If right-of-way is tight, consideration of retaining walls to contain fill within the flatter slopes, rather than attempting to economize with marginally steep slopes, would be suggested.

DRAINAGE AND EROSION CONTROL

Each different type of culvert or drain pipe has different properties and specifications, and they come in many sizes and shapes. Channel linings, splash pads, catch basins, drop inlets, leaching basins, headwalls, and similar appurtenances may be standardized, precast, or job-tailored. Erosion control may involve a great deal of measures and materials. Installing drainage and erosion control items in accordance with plans and specifications should satisfy these essentials at the time when construction operations are complete.

PAVEMENTS

1. **Subgrade**: No matter how sturdy the design and construction of the pavement itself, it will not last long if there is no support beneath it. Quality of the subgrade must be consistently high throughout the project. The potential for inconsistency exists when:

   - Various parts of the subgrade are prepared at different times or different seasons.
   - Half the road prism is in cut and half is in fill.

- Treatments such as soil-cement, PCC-treated-aggregates, or calcium chloride are applied to fortify segments of weak base material.
- Adequate inspection and testing do not occur on a regular and continuing regimen.

2. **Portland Cement Concrete**: Specifications for pouring Portland Cement Concrete (PCC) pavements are well defined by all major highway agencies.

   - Joints in PCC pavements are sawed-in shortly after the concrete has achieved its initial set. In most jurisdictions, the joint is then filled with a sealer which prevents moisture from entering the joint and working its way down to the subgrade. Some places have determined that these joint sealers are not cost-effective, so then joints are sawed and left unsealed.
   - Roller-compacted concrete has been used primarily for heavy-duty transfer aprons, large parking lots, and other locations that do not require a smooth riding surface for high-speed vehicles. It does away with slip forms and employs a paver with vibrating screed and tamper. Compacting is then accomplished in three steps:
     -- Vibrating smooth-wheel roller.
     -- Pneumatic roller.
     -- Non-vibrating steel drum roller.
   - Diamond grinding is applied to a rough PCC pavement to restore rideability.

3. **Asphalt**: Joints are rarely placed in flexible pavements. When an asphalt overlay is placed atop a PCC base, joints are usually sawed directly above the PCC joints so that expansions and contractions from the PCC slabs reflecting upwards do not appear as cracks in the surface.

CONSTRUCTION MATERIALS AND FOUNDATIONS

SOILS

Soil contains not only solids, but liquid and gas as well. The solid portion is comprised of various size particles arranged in randomly diversified distribution; the liquid portion is mainly water filling some of the voids between solid particles; the gaseous portion (air) occupies voids not filled by liquid. All three play critical roles in highway and structure design.

1. **Use of Soil**: Soil (dirt and rocks) forms two important components of highways:

   - Support for pavements and structures.
   - Materials for building pavements and structures.

SUBSURFACE INVESTIGATION

In order to identify soil properties in a specific location, a subsurface investigation is necessary. The steps involved in this investigation are:

1. **"Armchairing"**: Look at materials already in place and contact information sources for available soils and geologic information such as:

   - Agricultural maps
   - Oil, gas, and water logs
   - University geography departments
   - Local construction history

2. **Sampling**: Obtaining soil samples is subject to certain protocols. The ultimate objective of boring (and drilling) is to obtain information on subsurface conditions. Number and spacing of borings are usually based on educated guesses which are modified according to field conditions.

   - An investigation should provide much of the following:
     -- Water levels.
     -- Depth and thickness of each stratum.
     -- Permeability.
     -- Field tests of other soil parameters.
     -- Samples for determining soil properties in the laboratory.
   - Once obtained, samples can be divided into:
     -- *Disturbed Samples:* These samples are relatively complete, but contain significant structural derangement. They are suitable for classification tests, such as by penetration methods.

- -- *Undisturbed Samples:* Samples in which the structural disturbance has been kept to a minimum are more difficult to obtain. Although impossible to extract a perfectly undisturbed sample, it is feasible to keep disturbance minimal with skillful and careful effort.

3. **Testing**:

- *Density*: Density is the most important soil physical characteristic in highway architecture; is primarily affected by moisture content. Laboratory tests set standards for density, while field tests measure density of soils in place. Supporting power (strength) under one moisture condition may become quite different should the percentage of moisture change--and soils supporting subgrades are constantly subject to moisture changes. A 1% variation (measured as part of the total weight) in the moisture content of granular layers may cause pavement damage to increase by a very significant margin. Testing for optimum moisture content is a must for any soils that are used for supporting loads.
- *Classification Tests*: Determine the index properties of soil, including mechanical analysis, density, grain size, and sensitivity. Laboratory tests indicate soil makeup, texture, and consistency. Knowledge of these properties allow for the prediction of types and approximate magnitude of potential soil problems.
- *On-Site Soil Tests*: Some of the common tests include:
  - -- Penetration Tests
    - ▸ Standard
    - ▸ Cone
    - ▸ Piezocone
  - -- Plate Load Test
  - -- Pressuremeter Tests
    - ▸ Full displacement
    - ▸ Prebored
    - ▸ Self-boring
  - -- Dilatometer Test
  - -- Spectral Analysis of Surface Waves (seismic)
  - -- Vane Shear Test
- *Consolidated/Over-Consolidated Soil*: Normally consolidated soil is in equilibrium with its present overburden pressure and has not been stressed to a higher pressure than it is presently undergoing; an over-consolidated soil has been stressed sometime in its geologic past to a higher pressure than it is now experiencing from the overburden. An over-consolidated soil usually contains a natural moisture content well below its liquid limit, whereas a normally consolidated sedimentary soil is characterized by:
  - -- Natural moisture content approximating its liquid limit.
  - -- Increasing cohesion with depth.
  - -- Decreasing void ratio (along with concomitant lower water and gas content), with depth.
- *Stress:* Effective stress determined from field and/or laboratory tests can aid in effective design, since it correlates directly with soil behavior. By increasing the effective stress of a soil, the particles come closer together with an added densification and an increase in shear strength.

4. **Geotechniques**:

   - *Seismic Method:* Uses the principle of travel speed of shock waves being different for different materials. Used mostly for determining the depth to rock.
   - *Resistivity*: Variation in the electrical conductance between different subsurface materials requires a direct current to be passed through the soil between two electrodes. Used to locate sand and gravel deposits.

5. **Results**: At the completion of a soil investigation, the results will include:

   - Problem areas regarding support for pavements and structures.
   - Locations of desirable borrow and/or disposal sites.
   - Recommended design of subbase.
   - Tentative inputs for pavement designs.
   - Slope stability.
   - Depth to rock.
   - Limitations on type of drainage pipe.
   - Depth to groundwater and frostline.
   - Compaction factors.

AGGREGATES

Sorting and remixing aggregates (derived mostly from soils) for use in base courses, asphaltic concrete and portland cement concrete (PCC) is necessary. They are segregated into coarse aggregate (stones and gravel), fine aggregate (sand), and mineral filler. Where the aggregates are not cemented, they are usually structured so that there are sufficient voids to allow moisture to drain away. In concretes, the larger aggregates provide the strength and bulk, medium aggregates fill in the voids of the larger aggregates, fine aggregates fill in the voids of the medium aggregates, and the cements fills in that which is left and holds the entire mass together.

Graduation and hardness are two prime factors in the proper use of aggregates. Particle shape (sharpness) is important in concretes. Rounded aggregates (such as beach sand) are unsatisfactory because they do not lock onto each other to form a strong bond. Crushed (fractured) gravel is more satisfactory than round gravel.

PAVEMENTS

The most essential component of a modern highway is the pavement. Pavements vary in their makeup based on the expectations placed upon them. The pavement structure should be designed based on the anticipated loadings and expected life span.

Street pavements must be designed for the volume and characteristics of traffic expected to use the street. For example, residential streets would have a lower volume of traffic than collector streets which are more likely to carry heavy loads, including buses. The design of all streets must account for the soil (subgrade), the available range of paving materials, and the behavior of those materials under load and in all probable climatic conditions. The components of a street pavement include the subgrade, the base, and the wearing surface.

CLASSIFICATIONS

Pavements are generally divided into unimproved and improved. Improved pavements can be classified as:

1. **Flexible**: A flexible pavement maintains direct contact with and distributes loads to the subgrade, depending upon aggregate interlock, particle friction, and cohesion for stability. Such pavement is composed of a layer or layers of aggregate that provide the aggregate interlock and particle friction; this is topped by a layer or layers of aggregate bound together with asphalt, which provide the necessary cohesion. The generic term for dense pre-mix aggregates and bituminous materials is now equated with asphalt concrete. Asphalt concrete pavements are the most common used for all degrees of traffic, from light to very heavy. Most often they consist of several layers (or courses):

    - Wearing surface.
    - Base.
    - Sub-Base atop a prepared subgrade.

2. **Rigid**: A pavement is classified as rigid if it includes at least one course of portland cement concrete (PCC) thick enough to provide a high bending resistance. Rigid pavement, because of its rigidity and degree of elasticity, tends to distribute the load over a relatively wide area of soil; therefore, a major portion of the structural capacity is supplied by the slab itself. The chief factor in the design of rigid pavement is the structural strength of the concrete. As a result, minor variations in subgrade strength have little influence on the structural capacity of the pavement. PCC pavements have the highest value in situations where considerable heavy trucking is anticipated.

3. **Which to Use?** Things to keep in mind when deciding on the type of pavement to use:

    - In dry climates, the compacting action of traffic tends to strengthen pavement sub-base, while the opposite occurs in wet climates.

- A climate with small daily and seasonal temperature changes favors the use of portland cement in concrete pavements.
- Those regions having climates with large temperature changes produce excessive thermal expansion and contraction in portland cement concrete, therefore, favoring asphalt concrete.
- On roads with bituminous cover, periodic sealing of this cover is required.
- The initial cost for a rigid pavement is somewhat higher than for a comparable flexible pavement, but over the first few years the maintenance costs are low.

SUBGRADE

Without adequate support, no pavement can perform satisfactorily for long. All pavements derive their ultimate support from the underlying subgrade. The subgrade is the foundation layer for the street. It may simply be the natural earth surface or compacted soil or may include additives for stabilizing the soil. Preparation of the subgrade is one of the most important steps in street construction. The subgrade soil must be of sufficient load-bearing capacity.

If the subgrade is of such character that it cannot be properly compacted, it may have to be partly replaced with different material or may need to be stablized with bituminous materials, portland cement, selected granular barrow membrances or geo-textiles, or a combination of the before stated materials. Substandard soils can be stablized by incorporating an additive such as lime into the soil, especially for clay soils. In addition, either cement or fly-ash can be mixed with a substandard soil to stablize it or a layer of crushed stone or equivalent can be placed to improve the load-carrying capabilities of poor subgrades.

1. Need for Consistency: Quality of the subgrade must be consistently high throughout the project. The potential for inconsistency occurs when:

   - Various parts of the subgrade are prepared at different times or different seasons.
   - Half the road prism is in cut and half is in fill.
   - Treatments such as soil-cement, PCC-treated-aggregates, or calcium chloride are applied to fortify segments of weak base material.
   - Adequate inspection and testing do not occur on a regular and continuing regimen.

BASE

A base course is defined as the layer of material that lies immediately below the wearing surface of a pavement, while the subbase is a layer of material between the base and the subgrade. Base courses may be constructed of bituminous-aggregate mix, gravel, stone, slag, soil-cement, old recycled pavement, or similar construction material. The base course is important to transmit loads from pavement surface to the subgrade as well as to act as a purveyor to allow water to escape from underneath the wearing surface.

1. **Function of the Base**: The function of the base course varies according to the type of pavement, but generally base courses are used for:

   - Protection against frost action.
   - Drainage.
   - Prevention of volume change of the subgrade.
   - Increased structural capacity.
   - Expedition of construction.

ASPHALT

Liquid asphalt is obtained as a residue during the petroleum refining process.

1. **Types of Asphalt**: In road building, asphalt is sorted into:

   - *Cutbacks*: Uses diluents, such as naphtha, gasoline, or kerosene; classified into:
     -- Rapid Curing (RC)
     -- Medium Curing (MC)
     -- Slow Curing (SC)
   - *Emulsions:* Dispersed in a mixture of water and emulsifier (soap or similar product); designated as:
     -- Rapid Setting (RS)
     -- Medium Setting (MS)
     -- Slow Setting (SS)

2. **Emulsified Asphalt**: Depending on the emulsifying agent, emulsified asphalt is one of the following:

   - *Anionic Emulsions*: Have a negative charge; more effective in coating electropositive materials such as limestone.
   - *Cationic Emulsions*: Have a positive charge; more effective with siliceous materials, such as sand and gravel.

3. **Hot Mix Asphalt**: The most common pavement material is Hot Mix Asphalt. It is made in a plant under controlled conditions by mixing liquid asphalt cement with accurately proportioned aggregates. After the material is transported to the site, specially designed paving machines place the mixture while still hot to the required thicknesses and grade specification, overlaying the prepared subgrade. After the mixture has been rolled to desired compaction, the surface is ready for immediate use by traffic.

PORTLAND CEMENT CONCRETE

The most common form of concrete used in street construction is portland cement concrete. Portland cement is an extremely fine powder manufactured in a cement plant. When mixed with water, it forms a paste that binds such materials as sand and gravel or crushed stone into concrete.

1. **Types of Portland Cement**: The following types of portland cement are used in highway construction:

   - *Type I:* Basic standard.
   - *Type II*: Sulfate resistant.
   - *Type III*: Provides high early strength.
   - *Type IV:* Low heat of hydration.
   - *Type V:* High sulfate resistant.
   - *Type K*: Shrinkage compensating properties.

2. **Most Common Type Used**: The most commonly used cement in construction is Type IIA. The letter A is often found following each type and designates an air entrainment additive to trap small, uniformly distributed bubbles of air when mixed into concrete. The purpose of air entrainment is to enhance durability.

3. **Slip-Form Paving**: The most common method of construction of concrete streets is slip-form paving with integral curb. The slip-form paver is set to line and grade and the concrete is spread, consolidated, screeded, and finished in one pass. Contraction joints are then sawed at transverse intervals not to exceed in feet twice the thickness in inches.

METALS

Metals that show up on major road building jobs are:

1. **Steel**: Used extensively for bridge girders, reinforcing in portland cement concrete, guardrails, and corrugated drainage pipes.

2. **Aluminum**: May be specified for railings, corrugated drainage pipes, and pipe arches (small bridges) where harsh climates or soils deteriorate steel.

BRIDGE DECK ASSESSMENT

Bridge deck deterioration is a major problem for highway agencies and is one of the leading contributors to the number of deficient bridges in the United States. Inspection methods are generally slow, labor intensive, and require lane closures. They can only be applied to a limited number of decks, usually those in the worst condition.

INSPECTION METHODS

1. **Visual Inspection**: The first step is usually a visual inspection. All visible defects on both top and bottom deck surfaces are categorized and recorded. The size, location, extent, and depth of spalling and scaling are noted. The location, length, width, and orientation of cracks are observed, and if possible, the cause of cracking determined. Visual inspection is complicated if an asphalt overlay hides the deck. If the underside of the deck is accessible, it is examined for signs of leakage and deterioration.

2. **Detection of Delamination by Sound**: Delamination mechanically separates the upper layer of the concrete from the bulk of the deck. When a delaminated area of the deck is struck with a tool (usually hammers, rods and chains), this separation makes the noise sound dull and hollow in comparison to the more highly pitched ringing noise of an intact portion of deck. Sounding techniques accurately detect delamination on bare decks. This approach is inexpensive and not weather dependent, but it is tedious, dependent on the operator's skill, and time consuming. It is difficult to use on a bridge only partly closed to traffic, due to interference from traffic noise. Sounding methods have difficulty in differentiating between debonding and delamination.

3. **Chloride Content Chemical Testing**: Chemical analysis of a sample of concrete from the level of the top reinforcing mat can be used to determine whether the deck is contaminated with chlorides. The number of samples that must be taken to obtain a data set representative of the overall deck condition is dependent on the deck's variation in chloride content. Six samples are commonly recommended as a minimum set. Different approaches are taken to locate samples. Samples can be randomly located, located in an attempt to maximize variation, or located in areas of ambiguous results from other test methods. Samples may be taken in either cored or pulverized form for laboratory analysis.

4. **Core Drilling and Testing**: On exposed decks one core is usually taken for every 2000 square feet of deck, with a minimum of three cores. For an asphalt overlaid deck this amount would be increased three or four fold. In this case, sections of the overlay are usually removed in rectangular patches to allow visual inspection of the deck at sample locations. Cores are usually taken in these stripped areas. The cores are examined in the laboratory to determine: visual signs of deterioration, aggregate and cement paste condition, air voids, density, strength, and chloride content.

5. **Corrosion Potentials**: As the reinforcing rusts, a voltmeter can be used to measure the corrosion potential against a reference potential. The standard version of this test uses a copper/copper-sulfate cell to provide reference voltage. This method detects only the likelihood of corrosion and does not detect the rate of corrosion. When used on asphalt-covered decks, it is desirable, if no membrane is present, and essential if a membrane is present, to drill through the paving to ensure contact with the concrete.

6. **Pachometer Surveys of Cover Depth**: The thickness of the concrete cover over the top layer of reinforcement can be measured by a magnetic device called a pachometer. The pachometer generates a magnetic field between two poles on a probe. This field is distorted by ferromagnetic materials, such as steel. The pachometer detects the magnitude of this field distortion, which is proportional to the size of the bar and its distance from the probe. If the size of the bar is known from construction drawings, the cover thickness can be determined directly, otherwise cores can be used to determine bar size at several points. Cover measurements are used to: establish the depth of the top steel for taking chloride samples, determine if low cover is the cause of observed deterioration, and locate areas with insufficient cover to allow scarifying. Pachometer surveys of cover depth do not provide direct information about deterioration, but instead identify areas of low cover which are likely to experience distress. If an overlay is in place, the pachometer identifies the distance from the probe to the bar through both overlay and over, not the desired measure of concrete cover.

CONCRETE REPAIRS

DAMAGE CLASSIFICATION AND METHODS OF REPAIR

1. **Failure Mode**: Concrete damage can be classified by the failure mode. Each of the categories listed below can range from minor to catastrophic. Major failure modes include:

   - *Flexure:* Compression zone crushing and tension zone cracks.
   - *Shear:* Diagonal cracking.
   - *Spalling:* Surface pockets.
   - *Delamination:* Separation surfaces.
   - *Rebar Corrosion:* Reduced rebar cross section.
   - *Rebar Fracture:* Effective cross section reduced to zero.
   - *Disintegration:* Paste/aggregate bond failure.
   - *Brittle Cracking:* Alligator cracking from impact.

2. **Repairs**: Depending on the level of damage, there are several means available for repair:

   - *Epoxy Injection:* Pressure grouting of a low viscosity bonding agent into cracks.
   - *Patching:* Use of concrete or latex modified concrete to fill surface voids.
   - *External Steel Reinforcing:* Bonding of steel to external portion of member.
   - *Internal Steel Reinforcing:* Drilling and bonding steel to interior sections of member.
   - *Addition of External Concrete:* Bonding new concrete to existing concrete.
   - *Removal and Replacement of Concrete:* Removal of major portions of concrete and replacing with concrete or shotcrete.

3. **Matrix**: The below matrix matches the damage to possible repair procedures.

	Epoxy Injection	Patching	External Steel Reinf.	Internal Steel Reinf.	Addition External Concrete	Remove/ Replace Concrete
Flexure	X	X			X	X
Shear	X	X		X	X	X
Spalling		X				
Delamination	X			X		
Rebar Corrosion			X	X		
Rebar Fracture			X	X		
Disintegration		X			X	X
Brittle Cracking	X	X			X	X

DRAINAGE AND EROSION CONTROL

Potential downstream flooding, maintaining water quality and enhancing visual aspects are considerations that must be considered in draining methods.

MAJOR STEPS IN DRAINAGE DESIGN

The major steps in a drainage design system are:

1. **Hydrology**: Determine quality and rate of runoff water to be handled. The results of a hydrological study would be the flow of water that is expected to run off each drainage area upstream from the highway location.

2. **Underground Water**: Ascertain if groundwater conditions are pertinent and significant. Less visible than runoff, but potentially significant, is groundwater.

3. **Hydraulics**: Design a system to accommodate runoff and, when necessary, groundwater. Effort is needed to get water from one side of a highway to the other through culverts. Size, type, inlet and outlet conditions are the design commodities. On city streets, drop inlets or catch basins should be provided upstream at virtually every intersection, to intercept surface water before it has a chance to enter the intersection. The storm drain system for the street must be provided with an outlet. A typical drainage scheme should take into account the following:

   - *Ditches*: Lines, grades, cross sections.
   - *Channels:* Lines, grades, cross sections, lining materials.
   - *Inlets:* Catch basins, drop inlets, culvert inlets.
   - *Pipes:* Sizes, materials, invert (flowline) elevations.
   - *Junctions:* Manholes, junction boxes.
   - *Outlets*: End sections, rip rap, leaching basins.

4. **Legal and Environmental Aspects**: Consider upstream and downstream consequences of the proposed hydraulic design.

5. **Review**: Once completed, it is imperative that all aspects of the drainage problems, as well as design of appurtenances to address these problems, are reviewed and checked. Protection of the highway investment both upstream and downstream effects potentially created by the new or modified highway deserve consideration in the review. Basic factors the reviewer should recognize include:

   - Adequacy of the drainage plan in coping with expected conditions.
   - Cost-effectiveness of drainage components with relation to the highway investment.
   - Suitable harmony with the natural and human environment.

EROSION CONTROL

In dealing with highway drainage, the prevention of washouts is important during construction, after the highway is opened to traffic, and in material sites (borrow pits).

1. **Slopes**: Almost all erosion conditions are related to slopes exposed or created by construction activity. Moisture in the soil, moisture moving on the ground surface, and moisture moving through the subsoil are vital factors in designing cut slopes, and to a lesser extent, in fill slopes. Formations from which cut slopes are made and material obtained for fill slopes vary greatly in size, shape, texture, color, moisture content, and material composition. Natural soil conditions can be described as:

    - *Loose Material*: Loose material is composed of soil particles of various sizes that have been bonded together by compaction or cementing. Sand, gravel, and diffused rock are the most common loose materials because they can be bonded only by cementing, a slow natural process. Loose material will shift and move when pressure is applied and will not usually repose on a slope steeper than one-on-two; it may not be stable on flatter slopes.
    - *Compressed Material:* Compressed material is composed primarily of clay and silt that have been lightly bonded together by compression when moist. Larger sand and rock particles can also be included if there are enough fine particles to act as a bonding agent. Compressed materials will repose nearly vertical but becomes subject to very rapid breakdown, and, because any material that breaks down becomes loose, cut slopes steeper than one-on-one-and-one-half are not recommended.
    - *Cemented Material:* Cemented material is stable when cut vertically and not subject to rapid deterioration. Rock belongs in this group. Because rock is stable and does not deteriorate, about the only way it breaks down is by jarring or by water freezing in the cleavage cracks.

2. **Contour Grading**: Modification of the landscape is necessary to construct a modern highway with its requirements for size, vehicle quantities, and speed. Usually, highway construction is divided into three phases:

    - *Earthwork*: Earthwork may be considered the portion of the highway construction necessary to provide a strip of terrain in the landscape on which the structures and road (surfacing) can be placed.
    - *Structures (Including Drainage):* The reshaped strip of land will have the width, grades, compaction, drainage, etc., to accommodate the highway.
    - *Surfacing:* Natural ground surface tends to be irregular, random, and continually changing, while a highway has smooth parallel edges and remains the same for long distances. Contour grading is a means to locate, design, and construct cut and fill slopes.

3. **Rills, Gullies, and Crown Ditches**: Even with the best slope design, there will be some continual soil loss on cuts and fills. Development of rills (small eroded channels) and gullies (slightly larger erosion channels) do occur. Crown ditches at the tops of slopes are often

required to intercept flows coming down the hillsides before the flows have a chance to form gullies and erode slopes. The crown ditches convey the water either to the ends of the cut slopes or to channels leading down the slopes.

4. **Vegetative Cover**: Vegetation is important for erosion control and slope stability. Grass is the quickest natural means to provide erosion control, but it might not be compatible with other vegetation. Trees can be very effective for screening, delineating, accenting, and bordering, but they are often restricted because of narrow right-of-way and safety clearance. Shrubs are very effective for roadside planting and have versatility around other objects. Availability of adequate water is essential.

COMPLETION OF DRAINAGE AND EROSION CONTROL

1. **Completion**: Design of the drainage scheme can be considered to be complete when the following have been accomplished:

   - All hydraulic calculations and results in an understandable format. It may be necessary for some future adjustments in the field, and the original design might have to be altered.
   - Mapping of the entire drainage scheme. Stations, invert elevations, pipe schedules, connections to existing systems, box culverts, stream rechanneling, ditches, irrigation, and sundry other items necessary for the satisfactory installation and operation of the complete drainage scheme.
   - Specifications for nonstandard items.
   - Estimates (usually tabulated) of lengths, quantities, etc., of all components of the drainage requirements for the proposed highway segment.
   - Upstream and downstream consequences that may be anticipated.
   - Schematics where appropriate.
   - All aspects of the erosion control measures, with adequate descriptions for field installation. This would include estimates of quantities, specifications for speciality items, locations, mapping, stationing, and cross sections.
   - Checking everything stated or implied in the above items.

STRUCTURES

BRIDGE CLASSIFICATIONS

The bridge classifications system is broken down into:

1. **Small Bridges**: Small bridges rarely exceed a span of 80 feet.

   - *Box Culverts:* Box culverts made of concrete poured in place as a single unit and capable of supporting heavy loads are constructed as short spans around drainage channels and farm road crossings. Typical length would be 40 feet with a span of 12 feet.
   - *Pipe Arches:* Pipe arches are metal pipe culverts. They can also be used in the same situations as box culverts.
   - *Slabs:* Slabs (deck units), either precast or poured in place, are designed so that they are capable of carrying large volumes of traffic (and even heavy loads) to span short distances, usually less than 30 feet. Support for the decks is provided by abutments and, if more than one span is required, by standard bents or piers.
   - *Rigid Frames:* Rigid frames are different from slabs in that the deck and supports are poured in place as a single piece; may be prefabricated and precast structures. Comprised of corrugated steel or corrugated aluminum or reinforced concrete, they range in span up to 40 feet and have the advantage of quick installation so that maintenance of traffic becomes less of a problem.

2. **Medium Bridges**:

   - *Girder:* Girders are used widely in the United States and come in a number of styles using one or more of three different materials for the span: timber, concrete, and steel.
     - -- *Timber Girders*: Used sparingly for unique situations.
     - -- *Concrete Girders:* Concrete can be incorporated into girders by two methods:
       - ▸ *Box Girders:* Capable of carrying large volumes of traffic and are most appropriate where curved roadway alignment is used.
       - ▸ *Pre-stressed Girders:* Gaining in popularity are segmental, posttensioned box girders. Concrete modules are precast and erected and the reinforcing steel cables are placed in tension. Pre-stressed and posttensioned concrete girders take advantage of the principle that concrete is at peak performance while in compression and steel is at peak while in tension.
     - -- *Steel Girders:* Steel girders are used for spans longer than optimum for concrete. Steel members can be connected to form a continuous beam; longer span structures of steel beams tend to be more economical and more easily constructed than those of concrete.
   - *Trusses:* Trusses are not used very often in today's world. They are constructed as a framework of members set in triangles. Since each member is dependent upon the compression or tension of all the others, one weakened member can result in the complete collapse of the structure. Truss bridges have been replaced by other types of structures for safety reasons; primarily because the members cause obstruction above the road level.

3. **Large Bridges**:

- *Arches:* Arches come in all sizes and may be built of masonry, concrete, or steel.
  - -- *Masonry:* Not usually used for new bridges.
  - -- *Concrete:* Since concrete is at peak performance while in compression, the structure stands by itself, requiring minimum reinforcement. Capable of carrying large volumes and heavy loads, concrete arches are constructed over washes or rivers; they are not generally practical over roadways because of tight clearance through the arch. Typical span is not likely to be much over 100 feet.
  - -- *Steel:* A steel arch may be constructed as a hinged arch that is later (at the completion of the arch) fixed by rigidly anchoring the joints to abutments and adjacent members. Capable of carrying large volumes and heavy loads, steel arch bridges are used where a long span for crossing canyons, gorges, or rivers is required. Typical spans may reach more than 500 feet. Three varieties of steel arch construction include:
    - *Spandrel or Standard Arch:* Roadway is supported above arch by spandrel columns.
    - *Suspension Arch:* Roadway deck is suspended from the arch by steel cables.
    - *Through Arch:* Roadway deck is positioned halfway between the top and the bottom of the arch; a combination of suspension cables and spandrel columns support the roadway deck.
- *Suspensions:* Holds record for longest span. They are generally an entire highway segment in themselves.
- *Steel-framed Cantilevers:* Are becoming obsolete. Used where access to the ground or waterway below the structure is difficult.
- *Cable-Stayed:* Used for spans greater than 700 feet.

ADDITIONAL STRUCTURAL ELEMENTS

1. **Temporary Bridges**: There are times when temporary spans or crossings must be provided while a replacement bridge is under construction. Modular systems, pontoon bridges, and prefabricated types can be dismantled, moved, or disassembled after they have served their purpose and be used again at some other location (a consideration that allows for lower costs for each temporary installment).

2. **Tunnels**: If a tunnel must be used, there are several undesirable operational and maintenance features that must be addressed:

- Forced ventilation.
- Continuous dewatering.
- Potential fire danger.
- Lighting.
- Inability to move motorists to adjust rapidly to the difference in light intensities during daytime.

RETAINING WALLS AND SYSTEMS

Right-of-way requirements, stream encroachments, embankment instability, and several other conditions often require that retaining walls or surrogate measures be employed to contain and/or protect the highway. Retaining walls can also be used as rock catchers at the base of an unstable slope or utilized as slide suppressors embedded in failed slopes. There are several concepts that can be used:

1. **Cantilever Walls**: Resists earth pressures via the bending moments within the wall. Placement of the footing to resist overturning usually requires a considerable amount of extra excavation.

2. **Mechanically Stabilized and Reinforced Embankments**: Reinforcing strips attached to the facing are laid in the soil so that the backfill holds them in place. Geo-textiles and certain recyclable materials, such as discarded automobile tires, are often used in these types of retaining structures. Tie backs are protected steel cables connected to ground anchors that are anchored in stable soil behind the backfill.

3. **Gravity Systems**: Use the weight of the wall itself, sometimes accompanied by beveling or leaning the wall back.

4. **Reinforced Slopes**: While not actually retaining earthwork, they permit use of steeper slopes that may accomplish the goals stated above.

5. **Root Piles**: Occasionally used to widen existing roads on fills, root piling consists of a series of small diameter holes drilled 30-60 feet deep and filled with grout around reinforcing rods. Interlaced by angling, they are tied together at the top with a concrete cap.

INITIAL DATA REQUIRED BEFORE A STRUCTURE IS DESIGNED

1. **Typical Cross Sections**: Geometrics would determine the following:

   - Cross section of roadway carried by structure.
   - Cross section of roadway, stream, railroad, or other facility being crossed.
   - Location of control and profile lines, as they relate to cross sections.
   - Design speeds for each alignment.
   - Clear zone under structure.

2. **Plan Sheet**: Completion of final geometrics precedes establishment of the following:

   - Station ties to control lines at points of intersection.
   - Horizontal alignment for roadway carried by the structure (if applicable): bearings, curve data, coordinates of PI's, and stationing.
   - Horizontal alignment for roadway or facility to be crossed; bearings, curve data, coordinates of PI's, and stationing. (Ties to existing roadways, railroads, or streams and

any physical characteristics that may have an effect on the geometry of the structure and the approach fills may require field surveys to obtain adequate information.)
- Skew (crossing angle) of facilities crossed, unless one of the alignments is on a curve.

3. **Profile Sheet**: These elements furnish the necessary third dimension:

   - Profiles of facility carried by structure.
   - Profiles of facility being crossed.
   - Vertical curve lengths (checked to make sure they are adequate for stopping sight distance requirements).

4. **Stream Crossings**: A major structure may require most, or all, of the following information on a hydraulics data sheet:

   - Drainage area.
   - Design flood (Q_d).
   - 100-yr. flood (Q_{100}).
   - Normal depth (dn) for Q_d.
   - Normal water surface elevation for Q_d.
   - Backwater for Q_d.
   - Backwater elevation for Q_d.
   - Velocity through bridge opening for Q_d.
   - Normal water surface elevation for Q_{100}.
   - Backwater for Q_{100}.
   - Backwater for elevation for Q_{100}.
   - Overtopping flood frequency.
   - Magnitude of overtopping flood ($Q_{overtopping}$).
   - Water surface elevation for $Q_{overtopping}$.

5. **Retaining Walls**:

   - Profiles of the top and bottom of the walls.
   - Offsets and stations from the control line to the walls.
   - Location, elevation, and size of pipes, sleeves, and other items that go through the walls.
   - Cross sections at wall locations.
   - Soils investigations that are applicable.

BRIDGE TERMS

- **Abutment**: The end support for a structure, usually placed in earth or rock, consisting of a footing with earth-retaining backwall and wingwalls.

- **Bent**: Another term for pier.

- **Clear Span**: The distance, face to face, between two adjacent supports.
- **Deck**: The roadway surface of a bridge.
- **Joint**: Connection point between two structural members, with or without provision to accommodate differential movement due to thermal expansion and contraction.
- **Parapet**: The low wall placed along the sides of a bridge roadway to prevent vehicles from running off the edge.
- **Pier**: An intermediate support for a structure, usually consisting of a footing, column(s), and a cap to provide support for main structural members.
- **Span**: The distance, center to center, of supports for a beam, slab, truss, or girder.
- **Spandrel**: That portion of an arch bridge above the arch and below the deck.
- **Stringer**: A longitudinal member carrying the deck of a bridge between supports.
- **Wingwall**: The retaining wall extending back from the abutment.

INTERSECTIONS AND INTERCHANGES

INTERSECTIONS

More conflicts, more capacity constraints, and more accidents occur at intersections than anywhere else in the highway network. The alignment and grade of intersecting streets should afford drivers a complete and unobstructed view of approaching traffic and enable them to make the necessary maneuvers to pass through the intersection safely, with a minimum of conflict between vehicles.

1. **Conflicts**: Vehicles, pedestrians, bicyclists, and sometimes trains, all trying to occupy the same space (preferably not at the same time), cause the intersection to be the highway component where the greatest potential for conflict occurs. Conflicts can be divided into:

   - *Crossing Conflicts:* Contributes to the most severe accidents and capacity constraints.
   - *Diverging and Merging Conflicts:* Creates the rash of fender benders.

2. **Capacity Constraints**: When a group of vehicles comes to a stop at a traffic light or a stop sign, efficient passage of the procession is slowed. Even after stopping and then proceeding, the constraints of left- and right-turning vehicles tend to slow the procession. Operational aspects can also slow down the system. Whenever work or repairs are performed, the intersection becomes dysfunctional.

3. **Accidents**: Multiple contributors cause accidents. People not paying attention is a major factor. Traffic signals, prohibition signing, directional signing, and channelization, while necessary, do not always contribute to a safe driving environment.

4. **Layout**: In most cases, streets should intersect one another at 90-degree angles. Right-angle intersections are the most comfortable for drivers and provide the most direct view of traffic; acute angles create awkward turning movements. It is important for there to be adequate sight distance at an intersection. Vertical alignment also plays a role in the selection of measures to accommodate the anticipated traffic.

INTERCHANGES

It must be determined which type of interchange would be most beneficial within the traffic/ financial/right-of-way constraints at a location.

1. **Types of Interchanges**:

   - *Diamond Interchanges:* A simple diamond has ramps that are fairly well spaced apart so as to create two separate interchanges on the minor crossroad. This works well in a rural location where a wide right-of-way is normally available.

- *Compressed Diamond Interchange (CDI):* Used in more congested areas. The ramps are brought closer together--200 to 300 feet on each side of the grade separation. This could create a problem whereby intersections are closer together than desirable with vehicles backing into one of the intersections while waiting at the traffic signal in the other intersection.
- *Tight Urban Diamond Interchange (TUDI):* The two ramps are brought as close together as possible and the signals interconnected so that they are able to prevent gridlock on the minor crossroad. A potential problem with this design is if traffic coming off the major crossroad has to stop for lengthy periods and gets backed up onto the traveled way.
- *Single Point Urban Interchange (SPUI):* Places the two intersection movements of the TUDI at a single point under or over the major crossroad. The single point operates with traffic movements equivalent to those of a large intersection. The SPUI is reasonably successful where there are lots of interchanging (left turns) between the two crossroads.
- *Stacked Diamond:* Separates the single point intersection from both crossroads, creating in the process three, rather than two, levels. Additional structure and associated earthwork raise costs to sometime unacceptable figures in spite of the increase in efficiency offered by the stacked diamond.

PLANS, SPECIFICATIONS, AND ESTIMATES

Highway work is done by contractors who specialize in construction. They get a set of plans and specifications and then complete the work accordingly. The low bid from those submitted by contractors is usually selected. Consequently, all activities performed by the low-bid contractor must be closely monitored because the contractor (desiring to make a profit on the work) tries to keep costs down by providing the minimum acceptable work.

PLANS

1. **Plan Requirements**: Plans provide a picture for the work to be done on a project. Plans will usually include the following:

   - Title page.
   - Sheet layout.
   - Index maps.
   - Page sequence (for example, plan views, drainage, structures, etc.)
   - Extent of detailed drawings.
   - Summary sheet arrangement.
   - Use of standard drawings.
   - Applicable schedules.
   - Descriptions of traffic phasing and control.
   - Scales and legends normally used.
   - Structure sheet organization.
   - Traffic signal specialities.

2. **Safety Review**: On most large projects involving federal aid highway funds, a safety report is required. Whether or not required, a review of the plans to check safety angles is a good idea. There are several key items that require attention on almost every project:

   - Consistency of layout within intersections.
   - Compliance with application provisions of federal, state and local requirements.
   - Appropriateness in level of striping and traffic control devices.
   - Assurance that existing dangerous conditions at high-hazard locations have been removed or lessened.
   - Determination that no new hazard sites have been introduced.

3. **Quality of Plans**: A good set of plans does a lot toward obtaining lower bid prices, reducing legal liabilities, completing the design concept, and having the project built in a timely manner. A good set of plans should be clean, complete, consistent, clear, compliant (with applicable regulations), coherent, credible, correct, and coordinated.

SPECIFICATIONS

Specifications provide the narrative or captions that go with the plans. Highway construction contracts are usually bid on a per-item basis. Each item, therefore, requires a corresponding specification. A specification will almost always describe the material(s) to be used, the method of incorporating the material, and how the completed work will be measured and paid for.

1. **Standard Specifications**: A standard highway construction specification book should be used. Standard specifications should be used whenever feasible.

2. **Special Provisions**: Supplementing the references to the items contained in the standard specifications, most projects also have a number of unique specs or special provisions. If a speciality item (or method of construction) is required and is not covered in the standard specs, it is advisable to locate another highway agency spec book and see if the speciality item is listed there. If not, it may be necessary to go to a supplier, distributor, or manufacturer who handles the item in question.

ESTIMATES

Average bid prices are readily available (most often on a data base at the state highway agency) for the previous year on all standard items. An inflation factor can be added on by adapting the Consumer Price Index (CPI). Nonstandard items can be estimated in a number of ways; the most common practice being through suppliers and manufacturers.

CONSTRUCTION CONTRACTS

CONTRACTS

1. Typical Contract: Each agency formats and words its documents in its own distinct manner, but there are many points that run through all construction contracts. A typical contract is likely to include:

   - Copy of a published notice or advertisement announcing the request for bids from the highway agency.
   - The proposal submitted by the selected bidder, which lists the bid items, estimated quantities, price per unit, total contract price, firm name and address, together with the principals of the firm.
   - Errata sheet.
   - Various agency requirements directed towards disadvantaged business enterprises, equal employment opportunities, affirmative action, and nondiscrimination.
   - Other agency requirements involving non-collusion, debarment, compliance, and certifications.
   - Applicable environmental regulations dealing with air and water quality.
   - Listing of the minimum wage rates for various trades.
   - Supplemental agency specifications that have been adopted subsequent to the last-published standard specification book.
   - Special provisions that are unique to the project.
   - Performance bonding certificate.
   - Payment bonding certificate.
   - Requisite methods of record keeping.
   - Project plans.
   - Signature page.

COST OVERRUNS

Cost overruns on some items can sometimes be balanced against underruns on other items to assure that the total contract price remains within bounds. What needs to be addressed is when many more items overrun than underrun. These matters are usually negotiated at the time when it becomes evident that a significant quantity change in one or more items will be necessary. When it becomes necessary to modify contract provisions in the middle of a project, a change-in-work order or supplemental agreement is drafted and, if satisfactory to both parties, signed and executed. If not satisfactory to both parties, the adversary approach takes over and a previously established claims process is started. Should the claims process not satisfy both parties, the matter has a good chance of winding up in the court system.

1. **Reasons for Overruns**: Factors that usually contribute to overruns are:

   - Time constraints placed on the contractor that are too restrictive.
   - Lengthy spells of bad weather that cause excessive time delays.
   - Ambiguous contract provisions.
   - Underground utility locations inadequately or incorrectly plotted or flagged.
   - Design of a rehabilitation project relying too much on as-built plans from the last construction improvement on the site; subsequent maintenance activities might have changed highway characteristics and were not logged on the as-builts.
   - Use by the contractor of wrong equipment for the job.

2. **Reducing Cost Overruns**: There are actions that can be taken to reduce unnecessary cost overruns:

   - Time resolution of questions or disputes may do much to avert a contractor from resorting to the claims process.
   - Having clear and accurate records places the highway agency in good negotiating posture.
   - More complete sampling and testing of materials during the design phase may be beneficial, although a trade-off between the added cost of testing versus the anticipated benefits during construction should be considered.
   - A report on the final project should be documented and kept as a reference for future projects.

INSPECTION

CONSTRUCTION PROJECT

1. **Basic Tasks**: On all projects, big and small, there are several basic tasks which must be performed:

   - Locating control points and limits of work.
   - Assuring that safety precautions are adequate.
   - Inspecting work.
   - Testing (or certification) of materials.
   - Maintaining accurate records.
   - Preparing estimates of progress payments due the contractor.
   - Responding in a timely fashion to questions regarding interpretation of plans and specs.

SITE PREPARATION

Inspectors often find themselves involved with the survey party at the beginning of work on a project. This is beneficial because the inspector gains a knowledge first hand of what the project limits are and where many of the control points are located.

1. **Clearing and Grubbing**: Where payment for some work (for example, undercutting unstable material) is by volume, the Inspector should assure that preliminary cross sections (or other survey measurements) are taken prior to removal of material. Anything that requires before and after documentation must be logged in before work commences. This is the best time for the Inspector to set up a field book/diary rather than waiting for the first concrete pour.

2. **Topsoil**: If topsoil is to remain on-site through the duration of the contract, it must be adequately nurtured, drained, and protected from erosion. Inspectors should also be alert to contractors stripping off high quality topsoil and replacing it with lesser quality topsoil.

EXCAVATION, BACKFILL, AND EMBANKMENT

1. **Compaction**: Compacting trenches, particularly the ones that cross transversely (90 degrees) under the proposed pavement, must be controlled and checked. Although the specifications probably cite many provisions relating to method of tamping and thickness of backfill layers and quality of backfill material, the Inspector on the job must have a good feel for the adequacy of the work performed.

   Use of the correct compaction equipment enhances the prospect of achieving the best results. In narrow and hard-to-reach places, tampers are more useful than rollers; rollers are more beneficial when larger masses of fill are to be compacted, but each soil classification responds

best to a specific type or types of roller. Rock fills and gravel seem to be the most difficult to compact properly. Sandy and silty soils can be compacted with a smooth drum vibratory roller. When considerable clay is encountered, a padded drum obtains the best compaction.

Method of compaction can and should be subject to an Inspector's judgment. Visual observations of how well compactors and earth moving equipment behave when traveling back and forth over successive layers of fill material is a pivotal reason for having an Inspector on-site. The Inspector can also see to it that hauling and leveling equipment is routed over the entire width of an embankment rather than being confined to one path.

Where excavating for structure footings that must support great weights, it is important for the contractor to excavate just to the elevation of the bottom of the footing so that it is not necessary to bring fill back in (presuming that the consolidated soil is stable and has the essential strength). The fill is not likely to have the same bearing capacity as the undisturbed earth.

2. **Testing**: Testing during construction operations is essential. Density of the soil below a pavement subgrade or a structure foundation is critical. Testing for density in the field is now done by nuclear gauges more often than by time-consuming laboratory methods. Under bridge footings, soil strength is another important characteristic. Laboratory testing is performed on undisturbed field samples to assure that the load carrying capacity of the soil is equal to the task.

DRAINAGE AND EROSION

Natural erosion is vital to sustain healthy waterways and is not considered pollution. Excessive erosion, however, which often occurs on larger earthwork undertakings is the single greatest pollutant by volume in the nation's waterways.

1. **Drainage and Culvert Pipes**: Inspection of pipelines includes certification that the size, class, type, and manufacture of each pipe length is in accordance with the specifications. Before pipe laying, the bed must be checked for proper grade, compaction, and shape. Tongues of each pipe length should be in the direction of flow, which means that pipe laying is to proceed from outlet to inlet (working upstream). Joints are to be snug and the pipe aligned as straight as possible--particularly vertically so that there are no dips that could catch and hold stagnant water. Invert (flowline) elevations must be checked at every junction of drainage pipes with drainage structures and at each end of the culvert. Backfilling pipelines is difficult because tamping of each layer must be vigorous enough to consolidate the soil, yet gentle enough so that the operation does not damage the pipe beneath. Near the time of completion for all contract work, culvert and drainage pipes should be checked (from inside) to make sure that they are clean, clear of obstructions, and undamaged and that the flowlines have not been altered by settlement, backfilling, or other nearby construction activities.

2. **Drainage Structures**: Some of the items in this category come precast, some must be constructed on the jobsite, and some built in-place. Plans, specifications, and special provisions outline most of the Inspector's responsibilities. The Inspector needs access to the appropriate documents.

3. **Erosion Control Measures**: Changing jobsite conditions require that timely placement of both temporary and permanent erosion controls are undertaken. Since temporary measures are mostly a contractor's option, unless otherwise stated, the Inspector's primary responsibility is to take notes of what temporary controls are implemented and when the contractor installs them.

4. **Geo-textiles**: If fabrics are able to withstand the stresses of being placed (and having construction machinery run over them), they will probably hold up quite well during their expected life with the exception of ultraviolet light. Direct sunlight can destroy exposed geo-textile materials. Fabrics should be lapped so that water flows over not into the laps. Woven and interwoven materials are not interchangeable. Geo-textile attributes tensile strength, puncture strength, burst strength, permeability, elongation, and resistance to abrasion. If it is possible to certify the correctness and applicability of these various properties before and during placement. When this is not feasible, the best test is to examine how well the material stands up while being placed and covered (and repaired).

PAVEMENTS

1. **Subgrade**: No pavement will stand up for long if the subgrade collapses. Inspection of the subgrade immediately before placing of the subbase or base course or concrete slab is the most critical time to do so. (This presumes that preparation of the subgrade was watched over properly.) With crack/break-and-seat and rubblized base courses, however, the subgrade is not visible. Certain initiatives may have to be exercised by the Inspector to assure that the subgrade is adequate and consistent. Having heavy equipment (not the compactor) run back-and-forth over questionable areas, watching closely as the wheels pass to observe any noticeable deflections in the broken concrete may be one method of assurance.

2. **Portland Cement Concrete**: Just before placing PCC on a subgrade, the subgrade is usually dampened so that the subgrade soil does not draw moisture out of the concrete. Besides observing the operation, verifying adequate mixing times, assuring that line and grade are correct, recording deliveries, and reminding the construction personnel that PCC pavements are to be poured and finished as a continuing on-interrupted operation, the Inspector may also be required to take air-entrainment readings, slump tests, and prepare cylinders.

   The two most essential components in a PCC mix are adequate cement and not too much water. Checking these are two of the Inspector's prime responsibilities. Another responsibility is the proper finishing of the pavement surface. Timing of texturing, timing of joint sawing, and application of curing compound are very sensitive. Both temperature and humidity are important factors in determining the optimum times to perform the finishing touches. Specifications for concrete finishing tend to leave a lot to the Inspector's best judgment.

3. **Asphalt:** Construction projects rely on plant mix bituminous concrete or a combination of plant mix and recycled materials. An Inspector should watch out for:

- Correct percentage of bituminous material (too much will bleed; too little will not provide adequate bonding).
- Proper temperature at delivery and lay down.
- Thorough tacking (where required) to the course below.
- Careful rolling and compacting (the drive wheels of the rollers are usually required to be nearest the paver).

STRUCTURES

Bridges or other major structures (including foundation piles) must be checked to make sure they are laid out in the correct place and that nearby survey bench marks have been checked for accuracy. Formwork, reinforcing bars, and any observable damage to beams and girders that may have occurred during transit or unloading, concrete placement, and normal testing procedures all lend themselves to complying with plans, standard specifications, and commons sense.

ROADSIDE

The Inspector must assure that the utilities companies have been given adequate notice by the contractor prior to any work that might affect installations, and that changes in locations of utility lines and appurtenances have been adequately charted, recorded, and provide to the utility.

STREET OPENING PERMITS

The Department of Transportation and Engineering issues Street Opening permits in response to written applications filed in the Right of Way Section.

"Street" shall mean every public way set apart for travel, by whatever word designated, including the area from property line to property line which may include a roadway, sidewalk, curb, grassy area, utilities, facilities, all or any combination of the above.

A street opening shall be considered an excavation in a street or work in a City street that may cause damage to a street pavement or surface or any work in the opinion of the City Engineer that will place the City street in jeopardy.

Permits are issued to be valid for enough time to perform the specified work and to make permanent restorations to the street and public facilities that have been disturbed.

The Department of Transportation and Engineering Inspectors are responsible for the field administration of all Street Opening permits that include, but not limited to, the enforcement of traffic maintenance requirements, facility installation, backfill, temporary restoration and subsequent permanent restoration of the affected City street right-of-way.

SIDEWALK SAFETY PROGRAM

CRITERIA FOR CONDEMNING SIDEWALKS

1. Any block having a crack or cracks in it more than 5/8" wide.

2. Adjoining blocks or portions thereof whose edges differ vertically by more than 5/8".

3. Blocks that have holes in them 5/8" or more in diameter or are cracked and broken so that pieces are missing or loose.

4. Blocks having depressions, reverse cross-slope (sloping away from the street) or below curb grade so as to impound mud or water.

5. Blocks having a cross-slope in excess of ¾" vertical per one foot horizontal.

6. Blocks that cause an abrupt change in the longitudinal grade of the sidewalk.

7. Blocks that are raveled: i.e. the surface has spalled leaving it very rough with the coarse aggregate protruding.

8. Cellar doors and coal hole covers that are not flush with the sidewalk, or have a smooth surface, or projecting hinges, or are structurally unsafe and which project more than 15" into the public right-of-way. The exceptions to this rule are:

    a. All non-conforming coal hole covers must be replaced when located in a narrow full-width sidewalk.

    b. Neither cellar door or coal hole covers, provided they are structurally sound, need be replaced if protected by steps projecting into the sidewalk.

9. Cellar gratings that have openings measuring more than 5/8", or project above the sidewalk, or are structurally unsafe and which project more than 15" into the public right-of-way. The exceptions to this rule are:

    a. All non-conforming cellar gratings must be replace when located in a narrow full-width sidewalk.

    b. Cellar gratings need not be replaced if protected by steps projecting into the sidewalk provided they are structurally sound.

10. Any natural stone slabs, steel plates (other than approved covers over cellar openings), or prismatic lights used as sidewalk over of sub-grade.

11. Defective columns or beams supporting a sidewalk slab over a sub-grade.

12. Sidewalk material placed without prior approval through the granting of a revocable minor street privilege.

13. Sod area between the sidewalk and the street that protrudes above the sidewalk and impounds water or causes it to drain along the sidewalk, in such cases the condition should be corrected by lowering the sod. In cases where the sod area on either side of the sidewalk is below the grade of the sidewalk, a fill should be made and the either sodded or seeded.

14. Stumps, stones, private sign posts or any other unauthorized obstruction in the sidewalk space.

15. Trees, bushes, or shrubs that overhang the sidewalk. Tree limbs should be trimmed to at least eight feet above the sidewalk after obtaining a permit from the Urban Forest Manager. Bushes or shrubs should be trimmed so as not to overhang the sidewalk even after a rain.

16. Water stop-boxes, gas stop-boxes, etc., that are not to proper grade.

CRITERIA FOR CONDEMNING DRIVEWAYS

1. Any driveway having a crack or cracks in it more than 5/8" wide.

2. Driveways that differ vertically by more than 5/8" either above or below the sidewalk.

3. Driveways that are cracked or broken or have holes larger than 5/8" in diameter.

4. Driveway entrances within the street right-of-way constructed of materials other than concrete on an improved street, (a street with curbs), that have been placed without prior approval through the granting of a revocable minor street privilege.

5. Driveway entrances within the street right-of-way constructed of materials other than concrete or bituminous concrete on an unimproved street, (streets not having curbs), that have been placed without prior approval through the granting of a revocable minor street privilege.

6. Step-down driveways; i.e., having vertical curbs so that the construction is similar to an improved alley intersection.

7. Driveways that are dipped across the sidewalk so as to create an abrupt change in grade. This condition normally exists where the driveway street at edge of the sidewalk has been held several inches below the grade of the sidewalk and the transition from the driveway to sidewalk grade is accomplished in a very short distance.

8. Abandoned driveways. Curb to be restored only if sidewalk abuts curb or if abandoned or unimproved driveway is being used illegally.

TERMS

GLOSSARY OF TERMS

- **Abutment**: A retaining wall which also supports a vertical load.
- **Admixture**: A material other than water, aggregates, and portland cement that is used as an ingredient in concrete and is added to the batch immediately before or during its mixing.
- **Aggregate**: Irregular shaped gravel suspended in cement. A mixture of various soil components (for example, sand, gravel, silt).
- **Backfill**: Process of placing granular material or earth against foundation, pipes, and walls after all necessary treatments have been performed.
- **Base Course**: The bottom portion of a pavement where the top and bottom portions are not of the same composition.
- **Batter Pile**: A pile inclined from the vertical.
- **Battered Curb**: Curb with upper part leaning away from street pavement.
- **Beam**: Supports loads that are applied at right angles to the longitudinal axis of the member. Carries the load to its supports, which may consist of the bearing walls, columns, or other beams into which it frames.
- **Bend**: Any change in direction of a utility line.
- **Berm**: Built-up mound of dirt for drainage and landscaping.
- **Bituminous Concrete**: Asphaltic paving material.
- **Butt Joint**: A joint formed by two abutting surfaces placed squarely together.
- **Cap**: Hardware used to terminate any utility line.
- **Column**: A vertical member used to support main beams, roofs, etc.
- **Concrete**: A mixture of portland cement, sand, gravel, and water used for foundations, walls, floors, footings, etc.
- **Conduit**: A pipe used to carry electricity, water, sewage, stormwater, etc., to a designated area.

- **Contracts**: An agreement between two or more parties; especially one that is written and enforceable by law.

- **Curing**: Process of maintaining proper moisture level and temperature until the design strength is achieved. Curing methods include adding moisture and retaining moisture.

- **Dead Load**: The total weight of walls, floors, and roof bearing on the structure. An invert, inactive load, primarily due to the structure's own weight.

- **Drop-Manhole**: Manhole with vertical water way outside of manhole.

- **Easement**: Gives rights of traverse on property to others such as local governments.

- **Encroachment**: A structure that extends beyond its building line or projects onto another individual's property.

- **Expansion Joint**: A joint or gap between concrete structures to allow for expansion and contraction of the structures without cracking.

- **Feathering**: To thin, reduce, or fringe the edge of by cutting, shaving, or wearing away.

- **Fill Dirt**: Loose dirt. Normally dirt brought in from another location to fill a void.

- **Finish Grade**: Process of leveling and smoothing topsoil into final position prior to final paving, landscaping, etc.

- **Flexible Pavement**: A pavement having sufficiently low bending resistance to maintain intimate contact with the underlying structure.

- **Flow Line**: Position of normal flow in sewer.

- **Footing**: Lowest perimeter portion of a structure resting on firm soil or rock that supports the weight of the structure.

- **Frostline**: The depth to which frost penetrates the soil.

- **Grading**: Process of shaping the surface of a lot to give it the desired contours.

- **Grate**: A type of screen made from sets of bars used to allow the interception of flow and also to cover an area for pedestrian or vehicle traffic.

- **Gravity Wall**: Wall retaining pressure by mass.

- **Headwall**: The structural appurtenances placed at the end of a culvert to control an adjacent highway embankment and protect the culvert end from undercutting.

- **Inlet**: A structure for capturing concentrated surface water.
- **Invoice**: A detail list of goods shipped or services rendered with an account of all costs.
- **Lamp Hole**: Opening for sewer inspection.
- **Lateral**: A sewer line which goes off at right angles to another.
- **Live Load**: The weight of all non-permanent objects in a structure, including people and furniture.
- **Load Bearing Wall**: Any wall that supports the weight of other structural members.
- **Lug Curb**: Curb integral with sidewalk.
- **Main**: A large sewer from which all other branches originate.
- **Manhole**: A structure by which one may access a closed drainage system.
- **Pier Shaft**: The part of a pier structure which is supported by the pier foundation.
- **Plumb**: The condition when something is exactly vertical to the ground.
- **PVC (Poly Vinyl Chloride) Line**: A form of plastic line used primarily for sewer and cold water supply.
- **Re-Bar**: Metal rods used to improve the strength of concrete structures.
- **Rip Rap**: Pieces of broken stone used to protect the sides of waterways from erosion.
- **Riser**: The vertical section of a step in a staircase.
- **Rough Grade**: First grading effort used to level terrain to approximate shape for drainage, roadway, landscaping, etc.
- **Sanitary Sewer**: The conduit or pipe system which carries human excrement or household and industrial wastes.
- **Seal Coat**: A bituminous coating, with or without aggregate, applied to the surface of a pavement for the purpose of waterproofing and preserving the surface.
- **Settling**: Movement of unstable dirt over time.
- **Sewer Invert**: Bottom inside of sewer pipe.

- **Silt Fence**: A barrier of burlap, plastic, or bales of hay used to prevent the washing away of mud and silt from a cleared lot onto street or adjacent lots.
- **Slump**: The decrease in height of wet concrete when a supporting mold is removed.
- **Staking**: To lay out the portion of a proposed project, excavation lines, and depths.
- **Strip Walk**: Walk not joined to building or curb.
- **Street Opening Permit**: To give consent and provisions to a permittee to excavate a street where work may cause damage to the pavement, surface, or surroundings with directions to restore to permanent use.
- **Subbase**: A layer of a layer of aggregate of planned thickness and quality placed on the basement soil as a foundation for the base.
- **Subgrade**: The portion of a roadbed surface, which has been prepared as specified, upon which a subbase, base, base course, or pavement is to be placed.
- **Surface Runoff**: Water flow over the surface which reaches a stream after a storm.
- **Tack Coat**: The initial application of bituminous material to an existing surface to provide bond between the existing surface and the new material.
- **Topsoil**: Two or three inch layer of rich, loose soil.
- **Transit**: A surveying instrument that measures horizontal and vertical angles.
- **Tread**: The horizontal part of the staircase on which a person steps to ascend or descend the stairs.
- **Valley Inlet**: Sewer appurtenance.
- **Weep Hole**: Small holes in a wall that permits water to drain from behind.

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DRAFTING INTRODUCTION

Drawing is a universal language. Ideas can be graphically drawn, whether by hand or computer. Drafting requires multiview drawings, dimensioning, section drawings, etc. Engineering drawings communicate and document ideas. Engineering drawings present technical information to all the individuals who need the drawings to complete their tasks; therefore, the drawings must conform to *exacting standards* for their presentation and understanding.

Engineering drawings are documents that change. During the life of a drawing, there may be changes in the design, materials, suppliers and uses of the product. These changes must be noted and recorded.

An engineer thinks about the way that a system operates and how it can be built or improved and directs the drafter in the preparation of final drawings. The final drawings follow preliminary sketches the engineer has made. A drafter must be able to assemble written, numeric and graphic information and make final drawings. These drawings are called "working drawings" because they are drawings from which the improvement is made. The drawings must convey shape, size and manufacturing information needed to fabricate the parts and assemble the structure. Civil drafting is the field of making drawings which describe land terrain, road systems and utility systems.

LETTERING

To present a complete shape description of a machine or structure, the drawing must be accompanied by size description: dimensions, notes and text. On traditional engineering drawings, dimensions and notes are lettered in a plain, legible style that can be rapidly executed. Poor lettering detracts from the appearance of a drawing and often impairs its usefulness, regardless of the quality of the line work.

1. **Technical Lettering, Single-Stroke Letters**: Single-stroke means that the straight and curved lines that form the letters are the same width as the stroke of the pen or pencil. Single-stroke letters are used universally for technical drawings. This style is suitable for most purposes because it is legible and can be written quickly.

2. **Uniformity and Composition in Lettering**: Uniformity in height, inclination, spacing and strength of line are essential for good lettering. The professional appearance depends as much on uniformity as on the correctness of the proportion and shape of individual letters. Uniformity in height and inclination is assured by the use of guide and slope lines; uniformity of weight and darkness is controlled by the type of pencil used and the pressure of its point on the paper. In combining letters into words, the spaces for the various combinations of letters are arranged so that the areas appear to be equal. The space between words should be equal to or greater than the height of a letter, but not more than twice the height. The space between sentences should be somewhat greater. Devices for drawing guide lines are available in a variety of forms, with the most popular being the Braddock lettering triangle and the Ames lettering guide.

3. **Technique of Freehand Lettering**: Freehand lettering can be learned with practice. The necessary muscular control, which must accompany the knowledge of lettering, can only be developed through constant repetition. Pencil letters should be formed with strokes that are dark and sharp, never with strokes that are grey and indistinct.

   - *Large and Small Caps in Combination:* Generally a combination of large and small capital letters are used in forming words. When this style is used, the height of the small caps should be approximately three-fifths the height of the standard capital letter.
   - *Fractions:*The height of each of the numbers in the numerator and denominator is equal to three-fourths the height of a non-fractional number and the total height of the fraction is twice the height of this number. The division bar should be horizontal and centered between the fraction numerals and is parallel to the axis of the whole number.
   - *Titles:*Every drawing, sketch, graph, chart or diagram has some form of descriptive title to impart certain necessary information and to identify it. On machine drawings, where speed and legibility are prime requirements, titles are usually single stroke. On display drawings, maps, etc., which call for artistic effect, the titles are usually composed of "built-up" ornate letters.

4. **Mechanical Lettering Devices and Templates**: There are several mechanical aids available which improve the legibility of manually produced letters. Mechanical aids are categorized as:

   - *Lettering Templates:* Lettering templates are an inexpensive alternative to freehand lettering. These plastic templates are held in place and moved along a straight edge while the inside of each letterform is traced.
   - *Mechanical Guides With Scribes:* The Leroy letter guide is a mechanical guide which uses a tracer and precision-cut guide to form each letter. As with lettering templates, the user must space each letter, but generally the results are better.
   - *Electronic Lettering Guides:* An electronic lettering guide works very much like the Leroy guide except that text is lettered as a complete note and the machine takes care of letter spacing and alignment.

EQUIPMENT AND MATERIALS

There is basic equipment and materials necessary for drawing.

1. **Basic Equipment and Materials**: Items needed are:

   - Case of drawing instruments, including small bow compass and a set of fractional dividers
   - Protractor
   - Drafting templates
   - Drafting edge (T-square, parallel edge, drafting machine)
   - Triangles (30°, 45° or adjustable)
   - French curve
   - Scales

- Drawing pencils
- Lead pointer
- Drafting tape
- Eraser
- Dry cleaning pad
- Erasing shield
- Dusting brush

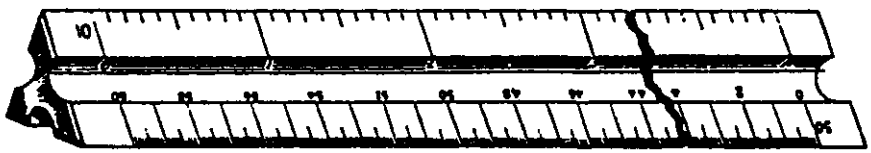
TYPES OF SCALES

Any graduated instrument or measuring stick used to measure distance or length may be called a scale, however, technically the graduations themselves are the scale. Scales are made in a wide variety of shapes, sizes and materials and for many purposes.

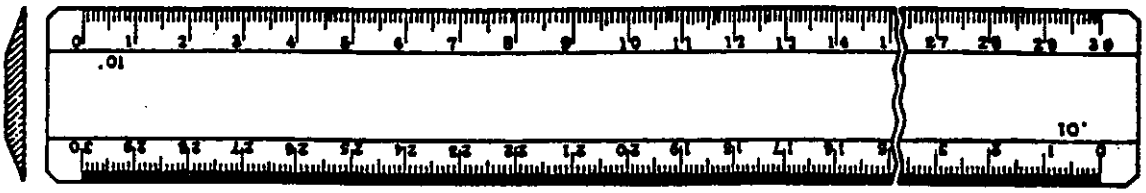
Because the space of a drawing sheet does not permit the object to be shown in its actual dimensions (true size), dimensions in accurate proportion to actual dimensions of the objects are used. Large objects must be drawn to a reduced size or very small objects must be drawn to an enlarged size. The scale provides the instrument to lay out the proportional dimensions quickly and easily.

1. **Architects' Scale**: Architects' Scales are divided into proportional feet and inches and are generally used in scaling drawings for machine and structural work. The triangular architects' scale usually contains 11 scales, each subdivided differently. Six scales read from the left end, while five scales read from the right end.

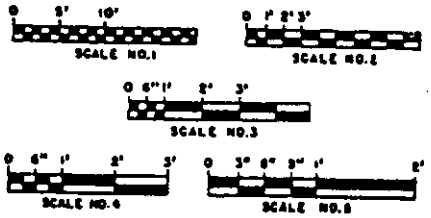
2. **Engineers' Scale**: Engineers' Scales are divided into decimal graduations (10, 20, 30, 40, 50 and 60 divisions to the inch). These scales are used for plotting and map drawing and in the graphic solution of problems.



3. **Metric Scales**: Metric Scales are used in conjunction with drawings, maps, etc., made in countries using the metric system. The scale is divided into centimeters and millimeters.



4. **Graphic Scales**: Graphic Scales are lines subdivided into distances corresponding to convenient units of length on the ground or of the object represented by the blueprint. They are placed in or near the title block of the drawing and their relative lengths to the scales of the drawing are not affected if the print is reduced or enlarged.



BLUEPRINTS

Drawing is the universal language used by engineers, technicians and skilled craftsmen. Drawings are needed to convey all necessary information to the individual who will construct the improvements. If many people are involved in the construction, copies will be made of the original drawing so that all persons involved will have the same information. Drawings (prints) are also used to illustrate how objects are operated, maintained, repaired or lubricated. More than one view of an object may be required to furnish all the required information.

BASIC FUNDAMENTALS OF BLUEPRINTS

1. **How Blueprints Are Made**: Blueprints are reproduced copies of mechanical or other types of technical drawings. A mechanical drawing is drawn with instruments such as compasses, technical drawing pens, circle templates, triangles and french curves or a computer can be used to produce drawings. Prints are reproduced from original drawings in much the same manner as photographic prints are reproduced from negatives.

   The original drawings for prints are made by drawing directly on, or tracing a drawing on, a translucent tracing paper or mylar, using black waterproof (india) ink or a special pencil. This original drawing is normally referred to as a tracing (master copy). Reproductions of these tracings are made and distributed to persons or offices where needed. These tracings can be used over and over indefinitely if properly handled and stored.

   From these tracings, blueprints are made. The term blueprint is a rather loosely used term in dealing with reproductions of original drawings. One of the first processes devised to reproduce or duplicate tracings produced white lines on a blue background, hence the term "blueprint". Other methods of reproduction have been developed producing prints of black lines on a white background.

2. **Handling Blueprints**: Blueprints are valuable permanent records that can be used over and over again if they are handled with care. In order to preserve these prints:

   - Keep them out of strong sunlight; they will fade.
   - Don't allow them to get wet or smudged with oil or grease; these ingredients seldom dry out completely, making the prints practically useless.
   - Don't make notations on a print without proper authority. When marking a print, use an appropriate colored pencil and make the markings a permanent part of the print.
   - Keep prints stored in their proper place so they can be readily located the next time they are needed.

3. **Folding Blueprints**: A standardized, accurate system of filing blueprints is necessary in order to have them readily available when necessary. The method of folding prints depends upon the type and size of the filing cabinet and the location of the identifying marks on the print.

It is preferable to place identifying marks at the bottom right corner. In some cases, construction prints are stored in rolls in which case the identifying marks are placed on the outside of the roll.

PARTS OF A BLUEPRINT

A blueprint has the following parts:

1. **Title Block**: The name of the object or the location on the blueprint is given in the title block which is usually located in the lower right corner of a drawing. The title block contains the drawing number and all the information required to identify the part or assembly that the blueprint represents. The title block also includes the Department and Division preparing the drawing, the scale, and the date. Additional space should be provided for placement of the engineer's stamp adjacent to the title block.

2. **Revision Block**: A revision block is located at the right side of the print. Changes to the drawing are noted in this block and are dated and identified by a number or a letter. If, for some reason, a revision block is not used, a revised drawing may be shown by the addition of a letter to the original drawing number, i.e., 143-A.

3. **Drawing Number**: All drawings are identified by a drawing number, which appears in a circle in the upper right corner. It may be shown in other places also, i.e., in the title block or on the reverse side at both ends so that it will be visible when a drawing is rolled up. Its purpose is to permit quick identification of a blueprint number. If a blueprint has more than one sheet, and each sheet has the same number, this information is included in the number block indicating the sheet number and the number of sheets in the series, i.e., page 2 of 8.

4. **Scale**: The scale of the blueprint is indicated in one of the spaces within the title block. It indicates the size of the drawing as compared with the actual size. The scale is usually shown as 1" = 2", 1" = 10", etc. Very small parts are enlarged to show the views clearly and large objects are normally reduced in size to fit on a standard size drawing paper. The scale is selected to fit the object being drawn and space available on a sheet of drawing paper. It is important to NEVER MEASURE A DRAWING - USE DIMENSIONS. This is because the print may have been reduced in size from the original drawing. Dimensions on a drawing will always remain the same. Graphic scales are often placed on maps and plot plans. These scales indicate the number of feet or miles represented by an inch.

5. **Material Specifications**: Always use the material specified; never make a substitution without proper authorization. The material indicated was selected by an engineer because it meets the requirements of the job and is the best material for that job. Only an engineer or other authorized person can approve substitutions of materials when the kind specified is not available.

6. **Notes**: Blueprints contain the information about an object or part which can be presented graphically or by drawing. Additional information is required that cannot be adapted to the graphic form of presentation. This type of information is given on the drawing as notes. Notes are generally placed on drawings to give additional information to clarify the object on the blueprint. Leader lines are used to indicate the precise item being notated.

7. **Legends or Symbols**: The legend is generally placed in the upper right corner of a blueprint if space permits. The legend is used to explain or define a symbol or special mark placed on a blueprint.

STANDARD SYMBOLS

ITEM	SYMBOL
State Line	(Indiana) / (Ohio)
County Line	(Hamilton County) / (Butler County)
Township Line	(Miami Township) / (Green Township)
Corporation Line	(City of Cincinnati) / (County of Hamilton, Amberley Village, Etc.)
Section Line	(Section 25) / (Section 24)
Prop. Fence Line	Prop. Fence
Ex. Fence Line	Ex. Fence
Ex. Center Line	
Prop. Center Line	
Existing Curb Line	(Always Face of Curb)
Proposed Curb Line	
Future Curb Line	
Existing Conc. Wall	
Existing Stone Wall	(Width Drawn To Scale)
Existing Brick Wall	
Proposed Wall	
Edge of Conc. Walk, Asph. Covered Conc. Pav't., Brick, & Granite Pav't.	
Edge of Macadam, Gravel, & Crushed Stone Pav't	

STANDARD SYMBOLS

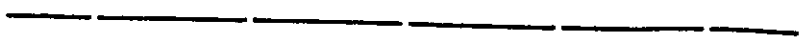
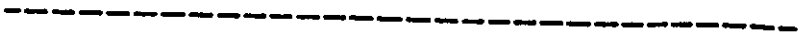
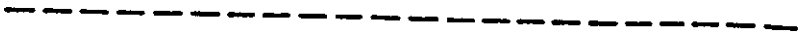
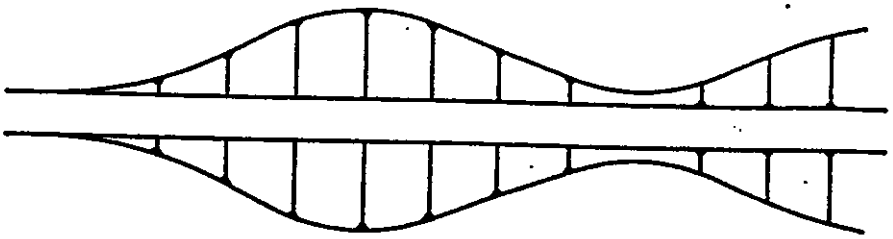
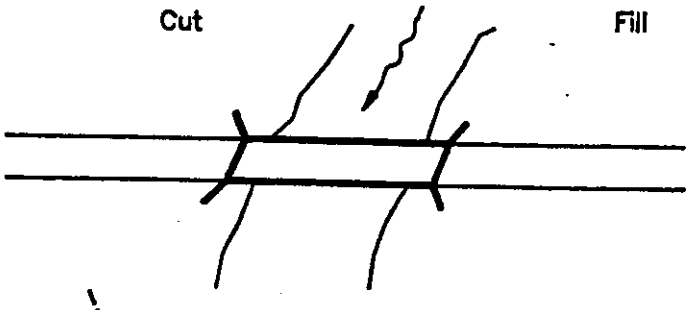
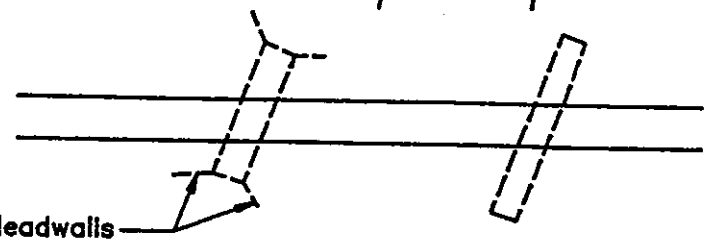
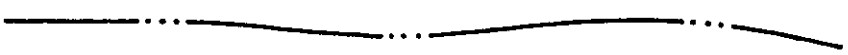
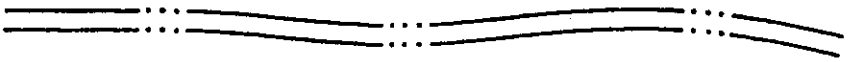
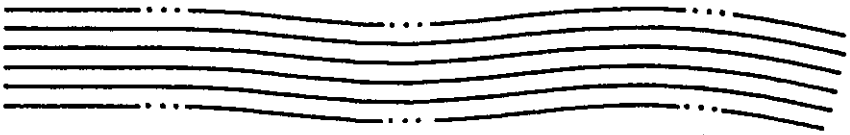
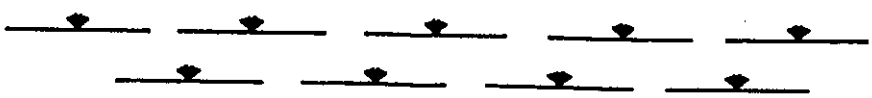
ITEM	SYMBOL
Profile of Property Line Closest to Bottom of Plan	
Profile of Centerline of Street	
Profile of Property Line Closest to Top of Plan	
Ex. Sewer & Manholes	Ex. ____ P.S. (Indicates Direction of Flow) (12" & Over. to Scale)
Prop. Conduit & Manhole	Prop. ____ Conduit
Water Line	W W W
Gas Line	G G G
Telephone Line	T T T
Electric Line	E E E
House Connection	HC HC HC HC
Existing Guard Rail	
Prop. Guard Rail	
Dumped Rock	
Buildings	#2113 2 St. Frame D.S. = 62.52 — House No.s, etc., for illustration Only; P. Fl.= 2.40 (Porch)

Label Size, Type, Direction of Flow (if applicable), and if line is existing or proposed.

STANDARD SYMBOLS

ITEM	SYMBOL
Limited Access Line	L/A — L/A
Ex. R–O–W Line	R/W — R/W
Prop. R–O–W Line	R/W — R/W
Property Line	℄ — ℄
Survey Line	℄
Construction Line	℄
Base Line	℄
Point of Intersection	△
Curve Points	P.C. — P.T.
Station Indication	10
Existing Flow Arrow	
Prop. Flow Arrow	
Railroads	For 1"=10' to 1"=40'; For 1'=50' and Over
Prop. Curb Grade Line (Unless Otherwise Marked)	89.21, 25', 89.35, 20', 89.24, 0.5%–120; Elev's., Dist's., Etc. for illustration only (4)

STANDARD SYMBOLS

ITEM	SYMBOL
Toe of Fill	
Top of Cut	
Construction Limits	
Slopes	
Bridges	
Culverts	
Streams — Intermittent	
Streams — Creek	
Streams — River	
Marsh or Swamp Land	
Top of Ground	

STANDARD SYMBOLS

Ex. Manhole

Manhole To Be Adjusted/Reconstructed

Prop. Manhole

Ex. Water Valve Chamber

Water Valve Chamber To Be Adjusted/Reconstructed

Prop. Water Valve Chamber

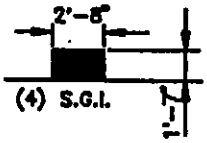
Gasoline Pump Island

Underground Tank Caps

Ex. Single Gutter Inlet

Single Gutter Inlet To Be Adjusted/Reconstructed

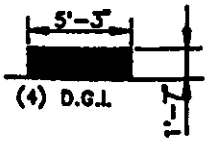
Prop. Single Gutter Inlet



Ex. Double Gutter Inlet

Double Gutter Inlet To Be Adjusted/Reconstructed

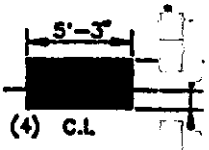
Prop. Double Gutter Inlet



Ex. Combination Inlet

Combination Inlet To Be Adjusted/Reconstructed

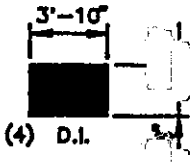
Prop. Combination Inlet



Ex. Ditch Inlet

Ditch Inlet To Be Adjusted/Reconstructed

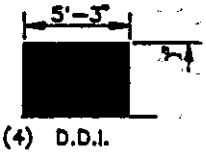
Prop. Ditch Inlet



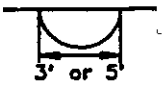
Ex. Double Ditch Inlet

Double Ditch Inlet To Be Adjusted/Reconstructed

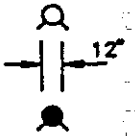
Prop. Double Ditch Inlet



Ex. Curb Inlet



Ex. Fire Hydrant



Prop. Fire Hydrant

STANDARD SYMBOLS

Coal Hole — C.H.

Cellar Door — Size From F.N.'s — C.D.

Window Well & Grating

Sign — Label or Use a "Key" for the description

Yard Drain, Drives, Etc. — Dr.

Tree (Dia. in Inches) — 1.0' — (Dia. From F.N.'s)

Hedge

Bush

Guy Wire

Ex. Traffic Signal — (Arrows are placed according to the number and position of the faces. Label if a Flashing Signal) — 12"

Prop. Traffic Signal

General Pole — 12"

Light Pole

Power or Electric Pole

Telephone Pole

Ex. Water Box — W.B. — 12"

Ex. Water Meter — W.M.

Gas Box — G.B.

Parking Meter — P.M.

Police Call Box — P.C.B.

Fire Alarm Box — F.A.B.

Mail Box — M.B.

Stump

NOTE:
Symbols should be drawn to scale on all plans drawn to a scale 1" = 20' or larger. On smaller scale drawings, symbols should be drawn to a scale of 1" = 20'. Size of lettering used to indicate existing features shall be No. 3 size obtained with Ames Lettering Guide or equal. Figures in parentheses, such as (4), indicate size of lettering to be used with proposed work.
Notes, etc. shown in parentheses with symbols are for illustration and information only. Dimensions are for information only.

Z (To Left or Top of Drawing)

MAPPING

All engineering construction projects require maps or site plans. A map is a report of a survey in the form of a drawing. Maps were developed as a communication aid. Most maps are made for a definite reason: to show topography, boundaries of property, precise location of traverse points, routes of highways or railroads, etc.

The drawings of surveying consists of maps, profiles and cross sections; their usefulness depends largely upon the accuracy with which points and lines are projected on paper. Few dimensions are shown.

MAP SCALES

1. Size: Map scales are generally classified as follows:

   - *Large Scale:* 1 in. = 100 ft. or less
   - *Intermediate Scale:* 1 in. = 100 ft. to 1000 ft.
   - *Small Scale:* 1 in. = 1000 ft. or more

2. Representation: Map scales are given in three ways:

   - *Ratio or Representative Fraction*: such as 1/2000.
   - *Equality:* such as 1 in. = 200 ft.
   - *Graphically.*

MAP DRAFTING

Map drafting can be divided into four parts:

1. Plotting the Transverse: Measurements of lengths and angles are used to plot a traverse. Distances are plotted from the field data to a selected scale using an engineer's scale. Angles for traverse are plotted by:

   - *Tangent Method:* To lay off an angle by the tangent method, a convenient distance is measured along the reference line to serve as a base. The tangent method is used extensively for plotting deflection angles.
   - *Protractor Method:* The protractor is centered at the vertex of the angle, with the zero line along one side, and the proper angle point is marked along the edge.

2. **Plotting Details**: Boundary corners and important points are plotted by the tangent method, while the protractor is used for most details. Angles are marked along the edge of the protractor and distances are scaled from the vertex to plot the detail. Points to be used for plotting contours are located in the same manner as those for details.

3. **Drawing the Topography and Special Data**: Standard symbols are used to represent topographic features thereby making it possible to show many details on a single sheet.

4. **Finishing the Map**: The final touches that make a map look professional including being appropriately arranged and carefully lettered with a heavy border line outlining the map.

INFORMATION ON A MAP

In general, specific information should appear on a map that is to become a part of public records of land division.

1. **Items on a Map**: Items which a map should contain include the following:

   - A neat and explicit title showing the name of the tract, or its owner's name, its location, the scale of the drawing (unless it is shown elsewhere), the surveyor's name, the draftsman's name and the date.
   - A north arrow for orientation purposes.
   - Length of each line.
   - The bearing of each line or the angle between intersecting lines.
   - The location of the tract with reference to established coordinate axes.
   - The number of each formal subdivision, such as a section, block, or lot.
   - The location and kind of each monument set, with distances to reference marks.
   - The location and name of each road, waterway, railroad, cemetery, landmark, etc.
   - The location of utility lines (above or below ground).
   - The names of all property owners, including owners of property adjacent to the tract mapped.
   - A graphical scale with a corresponding note stating the scale at which the map was drawn.
   - A full and continuous description of the boundaries of the tract by bearing and length of sides; and the area of the tract.
   - The witnessed signatures of those possessing title to the tract mapped; and, if the tract is to be an addition to a town or city, a dedication of all streets and alleys to the use of the public.
   - A certificate by the surveyor that the plat is correct to the best of his knowledge.

2. **Additional Environmental Information**: Additional information dealing with environmental concerns can be added, often by applying a different color or by clear film overlays using computer-aided drafting and design (CADD). Basic environmental concerns may include:

- Ecologically sensitive locales.
- Wooded areas.
- Major classes of land use (farms, airports, and industrial sites, residential and commercial zones).

CONTOUR LINES

1. **Contour Lines and Their Characteristics**: The vertical distance chosen between contours (the contour intervals) depends on the scale of the map and on the character of the terrain. For larger scale maps of flat country, the interval may be as small as 1 foot; for smaller scale maps of flat country, the interval may be 40 feet. For intermediate scale maps, the interval is usually 2, 5, or 10 feet. Basic principles for reading contours:

   - Since each contour line follows a specified ground elevation, it will not merge or cross another (except in the case of overhanging rocks).
   - Areas within contours are equivalent to "islands" about sea level; therefore, contour lines always close (sometimes outside the borders of the map). A contour line containing no other contours within its closed area indicates either a summit or a depression. If elevations of adjacent contour lines or aquatic boundaries do not show which applies, a depression may be labeled using a hatched area within the contour line.
   - A single contour line had better not lie between two contour lines of higher (or lower) elevation.
   - Since contours represent level lines, they are perpendicular to steep slopes as well as to ridges or valleys.
   - Horizontal distance between contour lines becomes inversely proportional to the slope so that steep slopes cause contour lines to be closer together.
   - On uniform slopes, contour lines space themselves uniformly.
   - Throughout plane surfaces, contour lines tend to be straight and parallel.

TOPOGRAPHIC MAPS

A topographic map shows detail and relief. Topographic maps indicate the relief of the ground in such a manner that elevations may be determined by inspection. The relief is usually shown by irregular lines, called contour lines, drawn through points of equal elevation. One of the first considerations of topography is the intended use of the map. If the map is to be used for preliminary planning, the map scale may be small (i.e., 1" = 200'); if the map is to be used for design purposes, the scale will usually be quite large (i.e., 1" = 10').

1. **Detail and Relief**: Topographic maps show detail and relief:

   - *Detail:* Detail is usually classified as natural or artificial. Natural detail consists of features such as trees, rivers, lakes, boulders, etc. Artificial detail consists of man-made features

such as building, roads, dams, etc. Detail is drawn on the map to scale or shown by symbols.

- *Relief:* Relief is the configuration or shape of the terrain being mapped. It is shown by the use of contour lines. A contour line is a line drawn on a map that represents an imaginary line on the surface of the earth along which all points have the same elevation. The vertical distance between contour lines is the contour interval.

2. **Items on a Topographic Map**: On topographic maps, and on maps that represent natural and artificial features, the following should always appear:

   - The direction of the meridian.
   - A legend or key to symbols used, if they are other than the common conventional signs.
   - A graphic scale of the map with a corresponding note stating the scale at which the map was drawn.
   - A neat and appropriate title generally stating the kind or purpose of the map, the name of the tract mapped or the name of the project for which the map is to be used, the location of the tract, the scale of the drawing (unless it is shown elsewhere), the contour interval, the name of the engineer or draftsman (or both) and the date.
   - A statement of the contour interval.
   - The hub locations and traverse lines are omitted from the finished drawing.

VERTICAL ALINEMENT

In road, sewer, water and airfield construction, one of the most important parts of the design is the plotting of profiles. From the profile, the proposed finished grade is developed. In road and airfield construction, if a vertical curve is needed it is computed and plotted.

PROFILE PLOTTING

Usually the profile is plotted on a roll of cross section paper which is ruled with horizontal and vertical lines. The profile is plotted from Profile-Cross-Section Survey notes or from elevations taken from a topographic map. This ground line is formed by drawing a line through the plotted points. This ground line is usually the survey baseline or centerline. Additional profiles may be plotted along existing and/or proposed sewers, water lines, gutter lines and driveways. The profile is a succession of straight lines between adjacent points. Generally, the profile begins at the end of the sheet with the lowest station number and progressed through the higher stations. The horizontal and vertical scales to be employed depend on the purpose of the profile.

1. **Vertical Scale**: Vertical scale must be exaggerated if the amount of relief is small. It is always selected to show the highest and lowest elevations given in the field notes for any specific project.

2. **Horizontal Scale**: The horizontal scale depends on the length of the project and is selected to correspond with the vertical grid lines on the profile sheet.

3. **Station Numbers**: Even stations (0+00, 1+00, etc.) are written vertically; plus stations are written horizontally using the + to indicate exact station location on the sheet.

4. **Gradelines**: A gradeline is a line on the profile paper marking the ascent or descent of the existing elevations. After a profile of the existing ground has been plotted in ink, a gradeline is superimposed over it to represent the proposed elevations of the surface. The location of the proposed gradeline will determine the volume of earthwork required for the project. Gradelines for roads should be kept within the limits of a maximum of 10% and a minimum of .5%.

5. **Grades**: Proposed grades should be shown every 25 feet unless a break in grade occurs in between two 25 foot grades. If a continuous tangent is used for over 100 feet, proposed grades need only be shown at the beginning and end of the tangent. Between these two grades the distance and the proposed percent of grade are shown.

6. **Utilities/Vertical Crossings**: Many times a profile includes existing utilities. The simplest way to indicate on a drawing the vertical alignment of these facilities is to obtain depths from various sources of the facility and then translate them to the profile view. A straight line relationship from each of these points is commonly used, but generally data is received from

the utility company verifying this assumption. In the case of proposed utilities, the proposed conduit is normally shown at a predetermined depth below grade (existing or proposed as defined by project scope) to the top of the conduit -- pipe sewers typically refer to flow line or invert (bottom of pipe) elevations. All specials, fittings, etc., are labeled with names, dimensions, and depths. Stationing of facility features from plan to profile must remain consistent. There will be times when other existing utilities will cross the proposed conduit. These existing utilities are plotted in the same fashion; however, the existing utility will be viewed cross sectionally in the profile since the utility is crossing the gradeline perpendicularly and not running longitudinally to the gradeline. When the proposed utility encounters the existing facility, a vertical clearance of 18 inches is normally maintained. Some special fittings/bends may be required in order to accommodate this clearance. Again, these items' relationship between plan and profile must remain consistent.

VERTICAL CURVE

A vertical curve is a parabolic arc connecting two gradelines. Parabolic arcs are used for forming vertical curves instead of simple arcs because the parabola is better adapted to gradual change in direction, the elevations can be computed more easily and this type of curve provides safe and comfortable travel.

1. **Types of Vertical Curves**:

   - *Summit Curve:* A summit curve is convex in shape and used when an ascending grade (positive) is followed by a descending grade (negative) or when an ascending grade is followed by one ascending less sharply.
   - *Sag Curve:* A sag curve is concave in shape and connects gradelines when a descending grade is followed by an ascending grade or when a descending grade is followed by one descending less sharply.

   Summit or sag curves may be further divided according to their tangents. When the tangents are equal, the curve is symmetrical and described as an *equal tangent curve*; when the tangents are not equal, the curve is unsymmetrical and expressed as an *unequal tangent curve*.

2. **Elements of a Vertical Curve**:

   - Point of vertical intersection (PVI) is the point where grades intersect. Computations and field work are simplified when the PVI is located on a full station.
   - Point of vertical curvature (PVC) is the beginning of the curve. It is always on the 0+00 side and its location is fixed by the length of the curve.
   - Point of vertical tangency (PVT) is the end of the curve. It is always on the end of project (E.O.P.) side of the curve.
   - Tangent (T) is the horizontal distance between the PVI and PVC or between the PVI and PVT. Do not confuse the tangent with the gradeline which is tangent to the curve. In an equal tangent curve, the value of T is always one-half the length of the curve.

- Length of curve (L) is the horizontal distance from the PVC to the PVT. To ensure adequate stopping, sight distance, comfort and appearance, the minimum length of a summit curve is 125 feet per 4% algebraic difference in grades and the minimum length of a sag curve is 100 feet per 4% algebraic difference in grades.
- Tangent offset (0) is the *vertical* distance from the gradeline to the curve. The offset is below the gradeline on the summit curve and above the gradeline on a sag curve.
- Maximum Vertical Offset (Vm) is the *vertical* distance from the PVI to the mid-point of the curve. This is the largest offset on the curve.
- Grade (G) is the ascent or descent of the road centerline.
- Chord (C) is the *straight line* distance between the PVC and PVT. The chord should not be confused with the curve length.
- A is the algebraic difference in grade (G_2 - G_1).
- Station Interval (SI) is the horizontal distance between stations on the curve. The interval should always be in multiples which can be divided into 100; this simplifies computations and reduces the field work.

METHODS OF COMPUTING VERTICAL CURVES

There are two common methods of computing vertical curves:

1. **Chord Gradient**: Using the chord gradient method, the known elements are plotted on graph paper; the unknown values are read from the graph.

2. **Tangent Offset**: The tangent offset method is a mathematical solution. Advantages include a check of the curve computations by using the characteristics of a parabola.

EARTHWORK COMPUTATIONS

The planning, scheduling and supervision of earthwork operations are of major importance in managing an efficiently operated construction project. In order to plan a schedule, the quantities of clearing, grubbing and stripping, as well as the quantities and position of cuts and fills, must be known so that the most efficient type and number of pieces of earth-moving equipment can be chosen, the proper number of personnel assigned and the appropriate time allotted.

Earthwork computations involve the calculations of volumes or quantities, the determination of final grades, the balancing of cuts and fills, and the planning of the most economical haul of materials. Field notes and established grades are used to plot the cross sections at regular stations and at any plus stations which may have been established at critical intermediate points. The line representing the existing ground surface, and those representing the proposed cut or fill, enclose cross section areas. These areas and the measured distances along the centerline are used to compute earthwork volumes.

CROSS SECTIONS

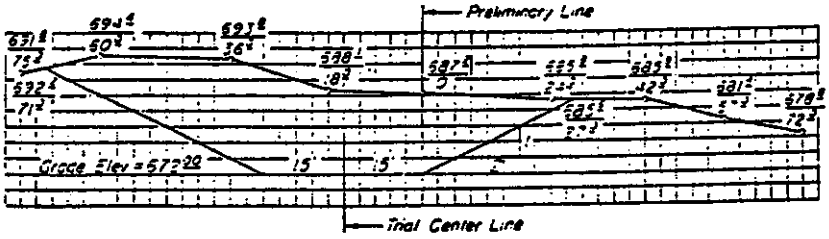
The cross section used in earthwork computations is a vertical section, perpendicular to the centerline at full and plus stations, which represents the boundaries of a proposed cut or fill. Determination of cross section areas is simplified when the sections are plotted on cross section paper. They are usually plotted to the same vertical and horizontal scale, standard practice being one inch equals 10 feet; however, if the vertical cut or fill is small in comparisons with the width, an exaggerated vertical scale may be used to gain additional precision in plotting such sections. The side slopes of a cross section are expressed by a ratio of horizontal distance to vertical distance. The slope is usually determined by the design specifications based on the stability of the soil in cut or fill.

1. **Preliminary Cross Section**: In making a preliminary estimate and in determining the location of a facility, such as a highway, a preliminary line is located in the field as close to the final location of the facility as can be determined from a study of the terrain supplemented by maps or aerial photographs of the area. The preliminary line is stationed, and profile levels are taken. The configuration of the ground normal to the line is obtained by determining the elevations of points along sections at right angles to the line.

   The values of the elevations and the corresponding distances out to the right or left of the line are plotted. When the location and grade of a trial line representing a tentative location of the center line of the facility have been established, the offset distance from the preliminary line to the trial line is plotted, and the grade elevation of this trial line is plotted in relation to the terrain cross section.

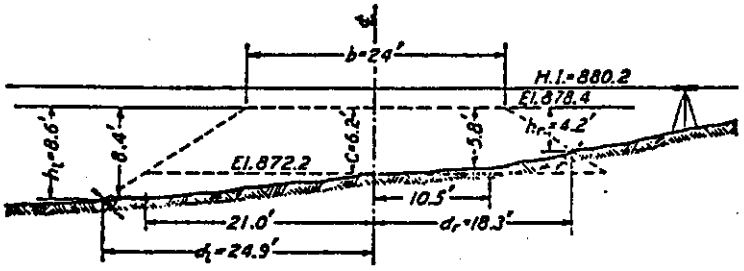
   The cross-sectional area bounded by the base, the side slopes, and the ground line of each trail cross section along the trial line is determined from the plotted cross section by using a planimeter or by computation based on the formulas used for area. The volumes of excavation

and embankment for this trial line are computed from the successive areas and the distances between the areas. The volumes for various trial lines are compared. The necessary changes in line and grade are then made to locate the final line and establish the final grade. This location will require a minimum of earthwork and, in the case of a highway project, will at the same time meet the criteria of curvature, maximum grade, and safe sight distances.



2. **Final Cross Sections**: The line representing the adopted center line of a facility is staked out in the field and stationed. This line is located by computing and running tie lines from the preliminary line. Deflection angles are measured between successive tangents, and horizontal curves are computed and staked out. Reference stakes are sometimes set opposite each station on both sides of the center line at distances of 25, 50, or 100 ft from the center line. These stakes are used to relocate the center line after grading operations are begun. Stakes at a distance on either side equal to half the base width are sometimes driven to facilitate taking final cross sections and setting construction on slope stakes. The center line and the reference lines are then profiled.

   When the final line has been located and profiled, a cross section is taken at each station to determine the area of the cross section and, at the same time, to locate the limits of excavation or embankment. These limits are defined on the ground by stakes. The process of setting these stakes is called *slope-staking*.



   The grade rod may be determined from the center-line cut or fill and the rod reading at the center line by the following relationship:

$$\text{Grade rod} = \text{ground rod} + \text{center cut}$$

or

$$\text{Grade rod} = \text{ground rod} - \text{center fill}$$

   where the ground rod is the rod reading at the center line. In the example above, the ground rod is 8.0 ft; so the grade rod is 8.0 - 6.2 = 1.8 ft.

With the grade rod established for the cross section, the amount of cut or fill at any point in the section can be determined by reading the rod held at the point and applying the following relationship:

$$\text{Cut or fill} = \text{grade rod} - \text{ground rod}$$

If the result is plus, the point is above grade, indicating cut (+); if the result is minus, the point is below grade, indicating fill (-). The location, on the ground, of the slope stake is determined by trial. When the ground surface is horizontal, the position of the slope stake is at a distance from the center line equal to one-half the base width plus the product of the side-slope ratio and the center cut or fill.

In the field notes, these two dimensions are recorded in fractional form, the numerator representing the fill and the denominator representing the distance out from the center. To distinguish between cut and fill, either the letters *C* or *F* or the signs + and – are used to designate them. As the point is located with respect to the finished grade, a point below grade indicates a fill and is designated by a – sign. The amount of cut or fill is marked on the side of the stake toward the center stake, and the distance out is marked on the opposite side. The stake is usually driven slantingly to distinguish it from a center-line stake and to prevent it from being disturbed during the grading operations.

3. **Cross-Sectioning With Slope Tape and Automatic Leveling Rod**: The task of locating the edges of the side slopes can be simplified by the use of a slope tape and an automatic or lightning leveling rod. When this rod is used, the rod reading can be changed to any desired value by shifting the movable band on which the graduations are painted. The edge of the side slope can be located by holding the zero of the tape at a distance equal to one-half the width of the roadbed from the center stake, and finding the point where the rod reading and the tape reading, on that side which has divisions 1½ tenths long, are identical. The horizontal distance from the center line will be half the width of the roadbed plus the distance read on the side of the tape with the regular divisions. The vertical distance below grade will be the reading on the reverse side of the tape, which is the same as the reading on the rod.

4. **Distance Between Cross Sections**: The horizontal distance between cross sections is dependent on the precision required, which in turn is dependent on the price per cubic yard paid for excavation. In addition to the cross sections taken at regular intervals, other sections are taken at the P.C. and the P.T. of each curve, at all breaks in the ground surface, and at all grade points. A *grade point* is a point where the ground elevation coincides with the grade elevation. In passing from cut to fill, or from fill to cut, as many as five sections may be needed in computing the volume when the change occurs on a side hill.

END AREAS

There are various methods of computing end areas of cross sections, including:

1. **Counting Squares**: To approximate a cross section area plotted on cross section paper, count the number of squares enclosed by the boundary lines of the section. Then multiply the total number of counted squares by the number of square feet represented by a single square.

2. **Stripper Method**: To determine the area of a plotted cross section by strip measurements, subdivide the area into strips by vertical lines spaced at regular intervals. Measure the total length of these lines by cumulatively marking the length of each line along the edge of a stripper, which is made of paper or plastic. Then multiply the cumulative total of the average base lengths by the width of the strip. Regular intervals of 3, 5 or 10 feet, depending upon the roughness of the ground, give satisfactory results for strip widths. Due regard must be given to the horizontal and vertical scales of the cross section.

3. **Area by Planimeter**: A polar planimeter is an instrument which can be used to measure the area of a plotted figure by tracing its perimeter. The planimeter touches the paper at three points: the anchor point (P), the tracing point (T) and the roller (R). The adjustable arm (A) is graduated to permit adjustment to the scale of the plot. This adjustment provides a direct ratio between the area traced by the tracing point and the revolutions of the roller. As the tracing point is moved over the paper, the drum (D) and the disk (F) revolve. The disk records the revolutions of the roller in tens; the drum in units and tenths; and the vernier (V) in hundredths. The planimeter is used as follows:

   - Always measure cut and fill areas separately.
   - Check the accuracy of the planimeter as a measuring device to guard against errors due to temperature changes and other noncompensating factors.
   - Before measuring a specific area, determine the scale of the plot and set the adjustable arm of the planimeter according to the chart in the planimeter case.
   - To measure an area, set the anchor point of the adjusted planimeter at a convenient position outside the plotted area; place the tracing point on a selected point on the perimeter of the cross section; take an initial reading from the disk, drum and vernier; continue by tracing the perimeter clockwise, keeping the tracing point carefully on the line being followed; when the tracing point closes on the initial point, again take a reading from the disk, drum and vernier. The difference between the initial reading and the final reading gives a value proportional to the area being measured.

   To measure plotted areas larger than the capacity of the planimeter, divide the area into sections and measure each separately as outlined above.

4. **Geometric Method**: To compute the area of a cross section by the geometric method (also called the trapezoidal method), subdivide the area into simple geometrical figures, calculate each area according to its geometry and total the results.

   There is no set rule for performing the subdivision; judgment must be used in selecting those subdivisions which will produce the most direct and accurate results. The basic formulas used for applying the geometric method are:

$$A = \frac{bh}{2} \quad \textit{for the area of a triangle}$$

$$A = \frac{h(b_1 + b_2)}{2} \quad \textit{for the area of a trapezoid}$$

A = Area
b = Lengths of the bases
b_1 = Lengths of the bases
b_2 = Lengths of the bases
h = Perpendicular distance, or height, between parallel bases, for a trapezoid and from base to vertex for a triangle

5. **Double-Meridian Method**: The double-meridian method is based on the theory that the area of a right triangle equals one-half the product of the two sides. Since latitudes and departures are at right angles to each other (the area bounded by the distance) the latitude and the departure is a right triangle. This area can be determined by taking one-half of the product of the latitude and the departure. The triangle may add or subtract from the total area of the irregular figure, depending on its location.

   To avoid determining a plus or minus area for each triangle, a slight refinement is made. The departure is added twice; first in determining the DMD of the course and then when the next course's DMD is determined. Multiplying the DMD of each course by its latitude results in twice the area, but the sign of the product illustrates whether the area adds to or subtracts from the figure area.

EARTHWORK VOLUMES

The computation of earthwork volumes uses solid geometry. Earthwork volumes are determined by the following methods:

1. **Average End Area**: The average end area method is the most commonly used method of determining the volume of earthwork required between stations along a route. Computations of volume are divided into the categories of like areas and unlike areas.

   - *Like Areas:* The formula for computing volumes of like areas is based on the equation used for computing volume of a prism.

$$V = \frac{(A_1 + A_2)}{2} (L)$$

V = Volume in cubic feet
A_1 = Area in square feet of one cross-section
A_2 = Area in square feet of the other cross-section
2 = Constant for averaging the areas
L = Horizontal distance between cross-sections (stations)

- *Unlike Areas:* To determine the volume of earthwork between unlike areas, the formula used is indicated below. This formula is based on the equation used for computing the volume of a pyramid.

$$V = (A/3)\,(L)$$

V = Volume in cubic feet
A = Area of cross section from which volume is to be computed
3 = Constant
L = Horizontal distance from cross section to point of zero earthwork

-- *Horizontal Distance to the Point of Zero Earthwork:* This distance may be estimated using a proportion between the horizontal distance that separates the two stations and the difference between the existing and proposed elevations at each station. The proportion is:

$$\frac{de}{total\ de} = \frac{L}{total\ L}$$

de = Difference between existing and proposed elevation at some convenient point on cross section from which volume is found
total de = de plus difference in elevation at same relative location on other station
L = Unknown
total L = Horizontal distance between the two stations

2. **Earthwork Tables**: Earthwork tables are used to determine volumes between end areas in lieu of mathematical computations. Results are equal to those computed by average end area method.

3. **Prismoidal**: When more exact values for earthwork volumes are required, the prismoidal formula is used:

$$V = \frac{A_1 + 4A_m + A_2}{6} (L)$$

V = Volume in cubic feet
A_1 = End areas in square feet
A_2 = End areas in square feet
A_m = Area in square feet of a constructed section midway between A_1 and A_2
L = Horizontal distance between A_1 and A_2

SURVEYING INTRODUCTION

Surveying is the science or act of making the measurements necessary to determine the relative position of points, above, on or beneath the surface of the earth, or to establish such points. Surveying is indispensable in all branches of engineering. Engineers must know the limits of accuracy possible in surveying so that the concept of the theory of errors can be understood.

DUTIES OF THE SURVEY CREW

A survey crew normally consists of the Survey Crew Leader, the Instrument Person, the Rodperson and the Recorder.

1. **Survey Crew Leader**: The Crew Leader is in charge of the survey party and trains and assigns work to members of the crew. The Crew Leader is responsible for supervising survey party personnel, seeing that records are kept in proper format, equipment is properly maintained and all other duties and responsibilities are carried out to the job specification. The Crew Leader may read prints; take field notes; make calculations to solve curves, closures and other problems; establish lines and grades necessary for construction work and for topographic cross-section and boundary surveys; investigate property records.

2. **Instrument Person**: The Instrument Person operates the transit and level in various kinds of survey work. The Instrument Person determines lines, angles, distances, elevations and keeps notes on readings and observations as well as cleans and adjusts transits, levels and other survey instruments. The Instrument Person may obtain survey data from public records. Assists in the supervising and training of the Rodperson; may take charge of the crew at times; assists the Crew Leader in checking calculations, reading prints, etc.

3. **Rodperson**: The Rodperson carries a stadia rod and holds it vertically at detail points and at critical terrain points; measures with tape; operates the level rods; responsible for preventing the loss, breakage and abuse of the equipment; carry instruments; look up records; assist in computations; drive stakes; obtain depths of pipes in manholes, etc.

4. **Recorder**: The Recorder reduces stadia readings to horizontal and vertical distances and computes the ground elevations for rod observations.

SURVEYING

Field parties are most often employed to set controls for aerial photography, to establish baselines through heavily wooded areas, to define exact positions of items to be incorporated into final design plans, and to locate points and elevations during construction. Preliminary field surveying has been superseded by mapping and by obtaining information already collected for other purposes.

1. **Waterways, Wetlands, and Floodplains**: Each state has an agency that measures and records rivers and major stream flows at critical locations. High quality maps showing floodplains are available for the entire country through the Federal Emergency Management Agency.

2. **Geologic Hazards**: Geological records can pinpoint potentially unstable ground: landslide susceptible areas, older landslide masses, and active landslide masses; debris flows and areas with potential for debris flows; land mass creep; rock falls; fault lines; avalanche hazards; problem soil units; and areas subject to flooding or high ground water problems.

3. **Controls and Baselines**: Setting a baseline for any section of new alignment, to be used as a reference, is usually done at the beginning of preliminary design. Horizontal and vertical controls (coordinate points and elevations) are established concurrently with the baseline.

4. **State Plane Coordinate System**: Since many surveys are conducted at elevations somewhat higher than sea level, datum adjustments are made to ground level measurements in hilly country, high plains, and plateaus. Most states have a coordinate adjustment system.

5. **Global Positioning System (GPS)**: The *Navigation Satellite Timing and Ranging System (NAVSTAR),* commonly known as *Global Positioning System (GPS),* is a space satellite chain developed by the Department of Defense. The satellite constellation will provide precise three-dimensional information on a continuous basis. The advantage of this system is accuracy and lower projected costs.

6. **Geographic Information Systems (GIS)**: Computerized mapping, combined with a managed database, can be used for plotting topography.

TYPES OF SURVEYS

The different types of surveys include:

1. **Plane Surveying**: Surveying in which the curvature of the earth is neglected; used for small areas.

2. **Geodetic Surveying**: Surveying in which the curvature of the earth is considered; used for large areas and long lines, used to precisely locate basic points suitable for controlling other surveys.

3. **Land or Boundary Surveys**: Surveys to establish property corners and land lines; usually closed surveys (start at one corner and end at the same corner).

4. **Topographic Surveys**: Surveys made for the purpose of preparing maps showing location of natural and artificial features and elevations of points on the ground.

5. **Route Surveys**: Surveys of and for highways, railroads, pipelines, transmission lines and other projects which do not close upon the starting point.

6. **Hydrographic Surveys**: Surveys of lakes, streams, reservoirs and other bodies of water.

7. **Construction Surveys**: Surveys providing locations and elevation of structures.

8. **Photogrammetric Surveys**: Surveys in which photographs are used.

MEASUREMENTS AND ERRORS

MEASUREMENTS

The process of making measurements in surveying requires a combination of human skill and mechanical equipment applied with the utmost judgment. Measuring is an inexact science, therefore, even the finest of measurement is only an estimate. Measuring is typically dependent upon the comparison of the thing being measured to a standard or known value. Variations in the accuracy of the standard value, the precision of the limits as well as other factors, introduce variables into the measurement process. These variables are called "errors".

1. **Kinds of Measurements**: Five kinds of measurements form the basis for all surveying:

   - Horizontal angles.
   - Horizontal distances.
   - Vertical angles.
   - Vertical distances.
   - Slope distances.

2. **Units of Measurement**: The units of measurement in surveying are those for *length, angle, area,* and *volume*. The *English system* length unit of *yard, foot* and *inch* are most commonly used in the United States. It bears a relation to the *metric system*. Distances are measured in feet, tenths and hundredths of feet; and surveyor's tapes are usually graduated in these units. Units of length used in past and present surveys in the United States include the following:

   1 foot = 12 inches
   1 yard = 3 feet
   1 meter = 39.37 inches = 3.2808 feet
   1 rod = 1 pole = 1 perch = 16 1/2 feet
   1 Gunter's Chain = 66 feet = 100 links = 4 rods
   1 engineer's chain = 100 feet = 100 links
   1 mile = 5280 feet = 80 Gunter's chains
   1 nautical mile = 6076.10 feet

   The *Gunter's chain*, the unit of length for public-land surveying, is 66 feet long and is divided into 100 links each 7.92 inches long. The unit of area commonly used are the *square foot* and the *acre* (1 acre = 43,560 sq. ft.) The units of volumetric measurement are the *cubic foot* and the *cubic yard*. The unit of angle used in surveying is the *degree*, defined as 1/360th of a circle.

3. **Precision of Measurements and Significant Figures**: It is the duty of the surveyor to maintain a degree of precision as high as is justified by the purpose of the particular survey, but not higher. Measured quantities are not exact and the number of digits that have meaning is limited strictly by the precision with which the measurement has been made. In calculations

involving multiplication or division, the precision is governed by the number of *significant figures*; in addition or subtraction, by the number of *decimal places*. The number of significant figures in any value includes the positive (certain) digits plus one (*only one*) digit which is estimated and, therefore, questionable. In order to be consistent with the theory of errors, it is essential that data be recorded with the correct number of significant figures. In surveying, three types of problems relating to significant figures are encountered.

- The field measurements are given to some specific number of significant figures, dictating that a corresponding number should be shown in a computed value. In an intermediate calculation, it is common practice to carry at least one more digit than required; then round off the answer to the correct number of significant figures. If logarithms or natural trigonometric functions are used, they should always have one more place than the number of significant figures desired held in the answer.
- There may be an implied number of significant figures. For example, a football field might be specified as 100 yards, but in laying out the field the distance would probably be measured to the nearest hundredth of a foot, not the nearest half yard.
- Each factor may not cause an equal variation. For example, if a steel tape 100.00 ft long is to be corrected for a change in temperature of 15°F, one of these numbers has five significant figures while the other has only two. A 15° variation in temperature changes the tape length by only 0.01 ft, therefore, an adjusted tape length to five significant figures is warranted for this type of data.

4. **Rounding Off Numbers**: Rounding off numbers is the process of dropping one or more digits so that the answer contains only those digits which are significant or necessary in subsequent computations. To round off numbers to a required degree of accuracy, the procedure to follow is:

   - When the digit to be dropped is less than 5, the number is written *without* the digit, i.e., 78.374 becomes 78.37.
   - When the digit to be dropped is greater than 5, the number is written with the preceding digit *increased* by one, i.e., 78.376 becomes 78.38.
   - When the digit to be dropped is exactly 5, the nearest *even* number is used for the preceding digit, i.e., 78.375 becomes 78.38; 78.385 is also rounded to 78.38.

5. **Methods of Measurement**: Direct measurements may be obtained by:

   - *Odometer Reading:* Distances measured by an odometer on a vehicle can be used for preliminary surveys in route-location work and can be used to do a rough check on measurements taken by other methods.
   - *Pacing:* The process of pacing consists of counting the number of steps or paces in a required distance. A pedometer can be used to register the number of paces.
   - *Taping:*Taping is the most common method of measuring lengths in surveying. Different types of tapes can be used.
   - *Tachymetry:* Tachymetry is a surveying method used to quickly determine the distance, direction and relative elevation of a point with respect to the instrument station by a single

observation on a rod or other object at the point. An example of tachymetry is the stadia method.

- *Subtense Bar:* Method by which an angle is read over the known distance between endmarks intercepted on a horizontal bar by means of a precise transit or theodolite.
- *Electronic Devices:* Electronic measuring devices use the process of determining the time required for an induced wave to reach a reflector and return to the sender; this time interval is converted to distance. Types of electronic devices include:
  - *Tellurometer:*A tellurometer system consists of two portable instruments which can be mounted on ordinary tripods and set up on the usual survey points. The "master" unit transmits a series of microwaves towards the "receiver"; the impulses are received, run through the circuitry of the receiver, and retransmitted to the original sending unit.
  - *Geodimeter:* The geodimeter consists of an electrical unit and a reflecting unit mounted on tripods. The electrical unit directs a modulated light beam to a prism reflector at the other end of the line.
  - *Electrotape:*The electrotape consists of an interrogator unit which transmits a radio-frequency signal to the responder, the responder then transmits it back to the interrogator unit.

An indirect measurement is secured when it is not possible to apply the measuring instrument directly to the distance or angle to be measured. The answer is determined by its relation to some other known value. Indirect measurements involve a knowledge of geometry and trigonometry.

ERRORS

Errors in measurement occur because no measurement is exact, every measurement contains error and the true value of a measurement is never known; therefore, the exact error present is always unknown. *Mistakes* are caused by a misunderstanding of the problem, carelessness or poor judgment. It is difficult to detect small mistakes because they merge with errors.

1. **Sources of Errors**: Errors in measurements fall into three categories:

   - *Instrumental Errors:* Instrumental errors result from imperfections or faulty adjustments of the devices with which measurements are taken or from movement of individual parts. The tape may be different in length from its nominal length because of defects in its manufacture, repair or as a result of kinks.
   - *Natural Errors:* Natural errors occur from variations in the phenomena of nature such as temperature, humidity, wind, gravity, refraction and magnetic declination.
   - *Personal Errors:* Personal errors occur through the observer's inability to read the instruments exactly due to limitations of the human senses of sight, touch and hearing.

2. **Types of Errors**: Errors in measurement can be categorized as followed:

   - *Systematic Error:* So long as conditions remain unchanged, always has the same magnitude and the same algebraic sign (either positive or negative). Inaccuracies occur in the same direction every time that a measurement takes places. A systematic error always follows some definite mathematical or physical law and a correction can be determined and applied. The error may be instrumental, personal or natural.
     -- If conditions do not change during a series of measurements, the error is termed a *constant* systematic error, i.e., a line may be measured with a tape that is too short.
     -- If conditions change, resulting in corresponding changes in the magnitude of the error, it is termed a *variable* systematic error; i.e., a line may be chained during a period in which the temperature varies.
   - *Accidental Error:* Accidental errors are those errors which remain after mistakes and systematic errors have been eliminated. They are due to a combination of causes beyond the ability of the observer to control and it is impossible to eliminate them. Accidental errors are sometimes called "compensating errors" because they tend to partially conceal themselves in a series of measurements. According to the mathematical theory of probability, accidental errors tend to increase in proportion to the square root of the number of opportunities for error.
   - *Random Error:* These are the errors which remain after mistakes and systematic errors have been eliminated. Random errors are measurement inaccuracies that occur in varying directions and magnitudes. Random errors tend to cancel one another out when measurements are repeated several times.

3. **Magnitude of Errors**: To determine the magnitude of errors, the following terms must be understood:

   - *Discrepancy:* A discrepancy is the difference between two measured values of the same quantity. It is also the difference between the measured value and the known value of a quantity.
   - *Precision:*Precision denotes relative or apparent nearness to the truth and is based upon the refinement of the measurements and the size of the discrepancies. The degree of precision is dependent upon the sensitiveness of the equipment and the skill of the observer. Precision should not be confused with *accuracy* which denotes absolute nearness to the truth.
   - *Agreement:* Agreement between two measured values for the same quantity implies precision but does not assure accuracy.

4. **Probable Value**: Errors must be eliminated or reduced, however mistakes can only be corrected if discovered. If systematic errors are so far eliminated as to be a negligible factor, the *most probable value* is the adjusted value of a quantity that according to the principles of least squares, has more chances of being correct than has any other. For a series of measurements of the same quantity made under identical conditions, the most probable value is the mean of the measurements.

5. **Occurrence of Random Errors**: When making physical measurements, it is necessary to record values read from scales, dials, gauges or similar equipment. It is characteristic of a measurement that *it cannot be made exactly*, so will always contain random error. The size of the error can be reduced by refining the equipment and procedures used.

6. **General Law of Probability**: Some general laws of probability can be stated as follows:

   - Small errors occur more often than large ones; that is, they are more probable.
   - Large errors happen infrequently and are, therefore, less probable; for normally distributed errors, unusually large ones may be *mistakes* rather than random errors.
   - Positive and negative errors of the same size happen with equal frequency; that is, they are equally probable.

7. **The Most Probable Value: The Mean**: In physical measurements the true value of any measurement is never known and, therefore, it is not possible to say what error does exist in any measurement. According to one of the general laws of probability, positive and negative errors of a certain magnitude happen with equal frequency so that *the most probable value of a group of repeated measurements is the average (arithmetic mean)*. The detectable error of any particular measurement is the amount by which it deviates from the mean. This error, or deviation, is known as the *residual*.

8. **Measures of Precision**: *Standard deviation* (often interchangeably called *standard error*) and *variance* are statistical terms commonly used for expressing precisions of groups of measurements. The equation for standard deviation is:

$$\sigma = \pm \sqrt{\frac{\Sigma v^2}{n - 1}}$$

σ = standard deviation of a group of measurements of the same quantity
v = residual of an individual observation
Σv^2 = sum of the squares of the individual residuals
n = number of observations

Variance is equal to σ^2, *the square of standard deviation*. In surveying, a deviation is thought of as an error and, therefore, the term *standard error* will be used instead of standard deviation.

SURVEYING TERMS

TERMS

Abstract of Title (or Deed): Summary of conveyances, exchanges, easements or other legal instruments affecting property rights in a particular parcel.

Accessories to a Corner: Natural physical objects, such as trees, rock formations, ledges and other features, that are at a known distance and/or direction from a corner; accessories are part of the corner monumentation.

Adjoiner: That parcel of land that shares a common boundary with another.

Adjusted Value: Value assigned to a measured quantity after the application of corrections designed to account for measurement errors.

Astronomic: In surveying, values assigned to direction or position based upon measurements made of the relative positions of heavenly bodies.

Azimuth: Definition of the direction of a line based upon the clockwise angle formed between that line and a certain pole of a meridian.

Backsight (BS): A rod reading taken on a point of known elevation.

Balancing a Traverse: Procedure(s) for distributing the accumulated measurement errors of a traverse among the observed values to obtain computational consistency.

Base Line: A series of points established for the express purpose of locating other features or lines.

Bearing: Direction of a line based upon the clockwise or counterclockwise angle formed between that line and either pole of a meridian.

Beginning Point: The first point encountered in the narrative portion of a deed description, especially a metes and bounds description, that is a part of the real property boundary itself.

Bench Mark (BM): An object, natural or artificial, in a relatively stable location, which is at a definite point of known elevation relative to a particular vertical datum.

Blunder: A mistake or incorrect assessment of a measured value associated with a gross misinterpretation of facts.

Boundary Line: An imaginary line of demarcation between two adjoining land parcels which may or may not be physically marked, which distinguishes a separation of real property rights.

Chain: (1) A length of measure equal to 66 U.S. survey feet; (2) a surveyor's measuring tape; (3) the act of measuring a linear distance.

Compass: (1) Device for detecting the earth's magnetic field and aligning with the lines of force; (2) a device for laying out a specific distance or marking an arc.

Contour: Series of lines on a map connecting points of equal elevation.

Corner: In real property, point of intersection of real property boundary lines which may or may not be monumented.

Datum: A basis or measurement foundation on which a location can be defined or referenced either vertically, horizontally or both.

Deed: A written instrument that conveys rights or interests in real property.

Design Survey: A collection of information to produce a final design and plans. Collection of physical information to show field conditions on paper. Locate pavements, horizontal and vertical location of underground items, etc.

Easement: A right held by one party in the land of another.

Elevation: Distance above or below a vertical datum.

Error: Difference between the measured and actual values for a certain quantity.

Field Notes: Written notes, sketches and computations of a surveyor taken during and at the site of a survey.

Foresight (FS): (1) A rod reading taken on a point the elevation of which is to be determined; (2) a point sighted so as to measure a horizontal angle.

Grade: The slope of a surface or structure.

Height of Instrument (HI): Elevation of the line of sight of the telescope when the instrument is leveled, such that the axis of the telescope is perpendicular to the axis of the earth.

Horizon: A plane, perpendicular to the plumb line at a particular point.

Horizontal Control: Establishing a point or points by direction and distance from some known point. To say that a point is "known" means that its distance and direction from some other point is documented.

Latitude: Set of parallel imaginary lines going around the earth from east to west. The equator is zero latitude; 90 degrees north or south latitude designates the poles.

Level: (1) A curved surface which is at every point perpendicular to the plumbline; (2) instrument for measuring differences in elevation.

Longitude: Imaginary lines going around the earth passing through the poles. Greenwich, England is the zero point for longitude; longitude is designated from 0 to 180 degrees, both east and west from Greenwich.

Maps: Graphic, two-dimensional representation of the surface of the earth; report of a survey in the form of a drawing.

Meridian: A north-south line used to reference lines of a survey.

Monument: Physical object that indicates the location of a real property corner or datum.

Plat: A map, prepared by a land surveyor, usually for a specific legal purpose.

Plumb: Aligned with the pull of gravity.

Preliminary Survey: Used when extreme precision is not required. Often a map (topographic preferably) can be used. The main purpose of a preliminary survey is to study the feasibility of an overall plan.

Station: (1) A point established or measured to by survey products; (2) a point on an alignment described by the horizontal distance along the alignment from the beginning point.

Theodolite: Instrument designed to precisely measure vertical and horizontal angles.

Traverse: Systematic series of linear measurements during which the direction and length of consecutive line segments is made. The most common method for establishing horizontal control in a small area on construction surveys.

Turning Point (TP): An intermediate point between two bench marks, on which point both foresight and backsight rod readings are taken. No record is made of its location.

Vertical Control: Points of known elevation, usually relative to sea level datum for the purpose of propogating and establishing new points with elevations.

ROAD LAYOUT

To layout a road of any length, the best route must be chosen as well as the many curves along the course considered. Each of these "horizontal" curves must be surveyed and staked out accurately to produce a smooth transition from one line to the other.

SURVEY DATA

The surveyor must gather all survey data needed to make the necessary decisions concerning the particular project. Survey data includes:

1. **Existing Facilities**: Consider the existing facilities and how they can be used to minimize or aid in construction.

2. **Soil Characteristics**: The location of a road on terrain that already possesses adequate soil characteristics, or that can easily and rapidly be compacted to the desired standards, will minimize the construction effort and result in a better road.

3. **Drainage**: For good drainage, roads should be located along ridge lines. Unless the soil is free draining, long stretches of flat ground should be avoided because of the difficulty of providing adequate drainage. The bottoms of valleys or other depressed areas should be avoided because they tend to be a focal point for water collection.

4. **Geology**: The existence of rock in sizable quantities anywhere along a construction project will present a removal problem. In areas where preliminary design indicates that cutting is required to reach final grade, sufficient borings should be made to determine the location of rock.

5. **Topography**: Roads must be constructed within maximum grade specifications. The normal maximum grade is 10%, the desirable maximum on gentle horizontal curves is 6% and on sharp horizontal curves the desirable maximum is 4%. The location of routes should avoid excessive grades and steep hills should be bypassed when possible. If excessively steep hills must be negotiated, the route should run along the side of the hill rather than going directly over it.

6. **Earthwork**: Earthmoving operations are the largest single work item on any road project. Since roads are a series of straight grades, earthwork in some quantity must be accomplished at most points in the project. The amount to be done at any one point can be minimized by taking advantage of all prevailing grades that fall within specifications and by following contour lines. When there is a need for both cutting and filling along a project, the material excavated should be used for filling if the haul capabilities will permit it and the material is acceptable.

7. **Alinement**: Routes should be laid out with a minimum of horizontal curves by making tangent lines as long as possible. The desirable minimum radius for a horizontal curve is 150 feet; the absolute minimum is 80 feet.

8. **Obstacle Crossing**: When a route crosses a river, ravine, etc., extensive construction of bridges or other structures is required.

9. **Ground Cover**: If the road is to extend through a wooded area, it must be cleared before actual construction can begin.

10. **Accessibility to Materials and Utilities**: The construction of a road requires different types of materials including aggregate for concrete and bituminous pavements, load bearing soil for embankments, water for all construction phases, etc. The location of the road should take into consideration the availability of these materials to the construction site.

11. **Sunny Slopes**: If tactical concealment is not a consideration, roads should be located on the sunny and exposed sides of valleys or hills to permit more rapid drying of the road surface and subgrade to minimize the possibility of freezing.

ROAD DESIGN TERMS

Common terms used to designate features and components of a road include:

1. **Surface Course**: The surface course is the smooth hard surface on which traffic moves. It should be all-weather, provide for rapid runoff of water and constructed of asphalt or tar products, concrete, gravel or specially compacted earth with certain types of binders.

2. **Base Course**: The base course is the layer of material immediately beneath the surface course. Its purpose is to distribute the induced stresses from the wheel load so that they will not exceed the strength of the subgrade. It may be composed of crushed stone, crushed slag, crushed or uncrushed gravel and sand or a combination of these materials.

3. **Subgrade**: The subgrade is the natural soil which is compacted or otherwise treated to receive the base and wearing courses.

4. **Traffic Lane**: A traffic lane consists of that portion of the road surface over which a single line of traffic traveling in the same direction will pass.

5. **Traveled Way**: The traveled way is that portion of the road surface upon which all vehicles move or travel. For a single lane road, the traveled way is the same as one traffic lane; for a multilane road, it is the sum of the traffic lanes.

6. **Shoulders**: The shoulder of a road is the additional width provided beyond the traveled way which must be at least four feet wide on each side and slope at least 0.75 inch per foot. Shoulders provide a space for emergency parking, assist in the removal of surface water and provide a safety zone along the edge of the traveled way.

7. **Roadbed**: The roadbed is the entire width of the surface on which a vehicle may stand or move; it consists of the traveled way and the shoulder.

8. **Slopes**: There are three types of slopes referred to in road construction:

   - *Cut Slope:* Cut slope or back slope is the slope from the top of a cut to the ditch line or bottom of ditch.
   - *Ditch Slope:* The ditch slope is the slope of a ditch which extends from the outside edge of the shoulder to the bottom of the ditch.
   - *Fill Slope:* The fill slope is the incline extending from the outside edge of the shoulder to the toe or bottom of a fill.

9. **Measurement of Slope**: Slopes are commonly specified in terms of a slope ratio which is a measure of the relative steepness of the slope expressed as the ratio of horizontal distance to vertical distance. The value of the slope ratio is dependent largely upon the properties of the soil involved. Ditch slopes may also be governed by the quantity of water to be passed and the possibility of erosion.

10. **Roadway**: The roadway is the entire width which lies within the limits of earthwork construction and is measured between the outside edges of cut or fill slopes, but does not include interceptor ditches if these ditches fall outside of the slopes.

11. **Crown**: The crown of a road is the difference in elevation between the centerline and the edge of the traveled way. The crown on paved roads is 1/4- to 1/2-inch per foot and 1/2- to 3/4-inch per foot on gravel and dirt roads. The crown should be sufficient to provide adequate runoff of surface water.

12. **Superelevation**: The superelevation is the downward slope from the outside to inside of the traveled way on a curve which is expressed in inches of drop per horizontal foot.

SURVEYING FOR ROAD CONSTRUCTION

Road construction requires several surveys. These surveys include:

1. **Reconnaissance Survey**: The purpose of a reconnaissance survey is to find a route most nearly meeting all requirements, to recommend a general layout and construction plan, to estimate the work required to construct the road and to obtain data needed to determine possible completion date and detailed construction schedules. The following elements are essential to good reconnaissance:

- The overall reconnaissance plan must be coordinated to prevent a duplication or omission.
- Factors to be considered include road net, general nature of the terrain and the weather. Such factors also influence the equipment used. Soil samples should be taken for later analysis.
- In order to successfully complete the survey, the reconnaissance party must know:
  - -- The area to be included in the reconnaissance.
  - -- The nature of the proposed route; what type of vehicles are scheduled to use it; minimum requirements concerning dimensions, grades and clearance.
  - -- The proposed vehicle traffic to be accommodated initially.
  - -- Pertinent information which preliminary planning groups have obtained about the project.
  - -- The details concerning the reconnaissance report; when, how and to whom the report should be made.
- The ground reconnaissance should determine the following:
  - -- Estimated grades to be encountered.
  - -- Estimation of the amount of clearing involved; this normally involves trees, tree stumps and boulders, but can include buildings, concrete foundations, etc. Disposal of debris must also be considered.
  - -- Nature of the soil encountered including field determination of gradation, percentage of fines and plasticity characteristics.
  - -- Stream conditions at crossing sites including width, depth and velocity of the stream; condition of the banks and streambed; and indication of high water level.
  - -- Presence or lack of local construction materials and sources including quarries, gravel pits, cement, tar and asphalt.
  - -- Estimate of the amount of earthwork necessary and approximate state of balance between cut and fill.
  - -- Any error or discrepancies on the maps from which the route was tentatively selected.
  - -- Local rainfall data and other pertinent information on seasons and weather.
  - -- Other information or observations which may affect the final route location.

2. **Preliminary Survey**: The preliminary survey is a detailed study of a route tentatively selected on the basis of reconnaissance survey information and recommendations. It is used as a reference for obtaining topographic information and other data concerning the terrain within the proposed route.

   A typical preliminary survey is an open traverse consisting of a series of straight lines called tangents. The beginning point of the survey is designated by a station labeled 0+00. From this point the survey proceeds down the proposed route, stopping only at points where tangent lines intersect. At each point of intersection (PI) a station is established, a deflection angle is turned, and the horizontal distance is measured from the last station established. Then the survey continues down the route until all points of intersection have been measured. The last tangent to be measured will be the one connecting the last PI to the end-of-project (EOP).

The angles measured during a preliminary survey must be doubled to prevent a blunder and to improve the results when computing the horizontal curves for the route. The horizontal distances are accurately measured (0.01 foot) to insure proper placement of the horizontal curves.

3. **Final Location Survey**: This survey establishes final location of centerline, horizontal curves, makes profile and cross section levels, establishes grades and determines earthwork volumes.

- *Centerline Location:* The centerline is started at station 0+00 and proceeds towards the end of project. "Full" or "even" stations are set every 100 feet except in rough terrain and on horizontal curve where they are set as required. They are hubs set flush with the ground. A guard stake is set to aid in finding the hub and has the station number written on it, i.e., 1+00, 2+00, etc. Those stations that are set closer than 100-foot intervals are called "plus" stations and are 1" x 2" stakes which are marked with the station number, i.e., 1+25, 2+50, etc. Stations on a horizontal curve are set and marked in the same manner as full stations.
- *Horizontal Curves:* There are four types of horizontal curves:
  - -- *Simple Curve:* Most commonly used curve and is that part of a circle known as the arc. The size of the circle (radius) defines the sharpness of the curve.
  - -- *Compound Curve:* Often used when the road is confined to following the sides of rolling hills. It consists of two simple curves which are adjacent to one another with a common point of tangency and with their radii on the same side of the centerline, but of different lengths.
  - -- *Reverse Curve:* Often used like a compound curve and also to avoid obstructions. It consists of two simple curves which are adjacent and have a common point of tangency, but whose radii are on opposite sides of the centerline.
  - -- *Spiral or Easement Curve:* Used when a much smoother transition from tangent to curve is desired. The spiral curve has many radii and common points of tangency all on the same side of the centerline.

  Elements of the horizontal curve are:
  - -- *Point of Intersection (PI):* Point where two tangents intersect.
  - -- *Point of Curvature (PC):* Point where the straight line of the road begins to curve.
  - -- *Point of Tangency (PT):* Point where the curve is tangent to the succeeding straight line.
  - -- *I or Delta Angle:* The deflection angle or change in direction between the two tangents at the PI is called the intersection angle (I) or Delta angle (Δ).
  - -- *Length of Curve:* The length of curve on the arc between the PC and the PT.
  - -- *Length of Tangent:* The tangent (T) is the distance along the tangent line from the PC to the PI or from the PI to the PT.
  - -- *Length of the Long Chord:* The long chord (LC) is the length of the straight line from the PC to the PT.
  - -- *Radius:* The radius (R) is the actual radius of the curve or arc.
  - -- *Middle Ordinate:* This is the distance from the midpoint of the LC to the midpoint of the arc and is noted as (M).

- -- *External Distance:* This distance (E) is from the PI to the midpoint of the curve.
- -- *Degree of Curvature:* Is the sharpness of a horizontal curve; the curve becomes sharper as the degree of curvature increases. The degree of curvature (D) is defined as *arc definition* whereby the degree of curvature is the central angle subtended by a 100-foot arc or *chord definition* whereby the degree of curvature is the center angle subtended by a 100-foot chord.

- *Profile and Cross Section Levels:* The profile and cross section levels are run using the centerline stations as a guide. This information obtained is used for designing grades and computing earthwork volumes.
- *Establishing Grades:* Vertical alignment is an important phase of road construction. It is accomplished by using a drawing of the profile, to design vertical curves and the gradelines that connect them.
- *Earthwork Volumes:* Earthwork volumes are determined using cross-section drawings.

PROFILE AND CROSS SECTION SURVEYS

Every operation in construction costs time and money. The amount of earthwork to be accomplished is one of the primary cost items in any type of construction. Before any earthwork can be computed, a profile and cross section survey must be performed in order to provide the data necessary for the computation.

PROFILE SURVEY

A profile is a vertical section of the earth measured along a predetermined or fixed line. The profiles may be used to determine the final grade or alignment in the construction of roads, railroads or sewers. A series of parallel profiles taken at a fixed distance apart can be used to compute volumes of earth for areas to be cut or filled.

Profiles are a series of ground elevations determined by some method of leveling. Differences in elevations are measured and elevations are computed for each station and for each definite change in the slope of the ground. The elevations when plotted to scale on a sheet of cross section (or profile) paper becomes the profile along the centerline.

Profiles may be drawn for finished structures to check the final grades against the design specifications. These profiles may or may not be plotted on paper.

The measurement of horizontal distance is started at the beginning of a project, with station number 0 + 00. Stations are numbered consecutively and are set at the full 100 foot stations or 1 + 00, 2 + 00, 3 + 00, etc., except when major breaks in elevation occur which require a plus station, such as 1 + 50 or any distance(s) between full stations or change in direction.

Elevations will be taken at each full station and plus station along the centerline.

1. **Procedures for a Profile Survey**: After all stations, both full and plus, have been established, the elevation of each station is determined. All backsights taken on control points or turning points are read to the nearest .01 of a foot. All other ground shots are read to the nearest .1 of a foot. After setting up the instrument, a number of foresights can be taken before the instrument is moved. A foresight is taken at each station to determine the ground elevation. Before moving the instrument, a turning point must be established and a foresight read and recorded to the nearest .01'. If the top of a station hub is to be used as a turning point, it will not be confused with the ground elevation of the station. To avoid confusion, the hub should be identified as a T.P., not by station number, or the top of the hub may be set flush with the ground before making a foresight. A backsight is only taken when the instrument has been moved, then a control or turning point is used.

CROSS SECTION SURVEY

A cross section is a vertical section of a project taken at right angles to the centerline. Cross section leveling furnishes data for final location studies and for estimating volumes of earthwork. The cross section lines are established at regular stations, at any plus station, and at intermediate breaks in the ground. Long crosslines are laid out at a 90° angle to the centerline with a transit. All elevations at abrupt changes or breaks in the ground are measured with rod and level. Distances are measured from the centerline with a metallic tape. In rough terrain, the hand level is best for obtaining cross sections, if the centerline elevations have been determined by use of the engineer's level. Ground shots are read and recorded to the nearest .1 foot along the cross section line at major breaks in elevation and critical points.

GRADE STAKES

STAKES

1. **Types of Stakes**:

   - *Blue Top:* Finish stakes are placed to show the actual finish elevations or grades required for such items as asphalt, concrete, subgrades, rails and ballast used in construction projects of roads, buildings, runways and railroads. For accuracy, the stakes are driven into the ground until the top of the stake is at the finish elevation. When the top of the stake is at the desired finished grade elevations, its top is colored blue to identify it as a finish grade stake. A "blue top" usually requires a guard stake for protection and to assist in locating the finish grade stake.
   - *Rough Grade:* Rough grade stakes are placed on the centerline, shoulder lines or along the slope lines. They are marked on one side with the amount of cut or fill needed at that point to bring the grade to the required elevation, together with the horizontal distance to the centerline, if applicable. The station number is marked on the other side of the stake. During grading operations, it is advisable to offset these stakes to prevent their destruction or disturbance by construction equipment.

2. **Stake Markings**:

   - *Centerline:* When marking centerline stakes, the front of the stake is the broad side that faces the beginning of the project and the back is the reverse side. The front of the stake indicates the station number and the type of station, i.e., PC, PT, etc. The back of the stake indicates the amount of cut or fill that is required at that station. Cut is symbolized by the letter "C" and fill by the letter "F". Fractional portions of a foot in tenths are indicated by placing a line under the decimal digit.
   - *Shoulder:* Shoulder stakes are set along the edge of the roadbed, showing the beginning of the sideslope, which indicates cut or fill at that point. Stakes are set facing the beginning of project. The marking on the front side indicates cut or fill and distance from centerline; the station number is shown on the back of the stake.
   - *Sideslope:* Sideslope stakes are grade stakes set at the intersection of cut or fill with the existing natural ground line. They indicate the earthwork limits on each side of the centerline stakes. Slope stakes are set sloping away from the centerline at a 45° angle with the front side facing the centerline of the road.

BUILDING LAYOUT AND UTILITIES SURVEYS

When surveying for building construction, the proposed structure must be laid out according to the prepared plans and the controlling points of the structure marked in the manner most useful for the construction. This marking consists of indicating the corners of the building and other horizontal and vertical positions by means of stakes, batter boards with stringlines and cut and fill notations. The actual layout of the building is usually preceded by some form of reconnaissance and location survey.

By laying out utility systems, their location is made a matter of record and future construction may be planned accordingly. Utility surveys include water, power and sewerage systems.

BUILDING LAYOUT

A typical building layout is accomplished by using the following procedure:

1. **Baseline**: A baseline (AB) must be conveniently established near the work area, but far enough away that the construction will not destroy the control points A and B. Two points (CD) are then measured to the proper building length.

2. **Corner Stakes**: At point C set up and level transit, then turn a 90° angle from point B and locate corner points E and F with 2" x 2" hubs. Locate the actual corner with a tack set on line with the transit and measured exactly from the baseline. Set up at point D and establish points H and G in the same manner.

3. **Diagonal Check**: To check the accuracy of the work, measure the two diagonals EH and FG using the formula:

$$c = a\sqrt{a^2 + b^2}$$

   with c being the diagonal; a and b being the sides. When the computed value equals the measured value, the work is accurate.

4. **Elevations**: Carry forward to the baseline, the elevation from an established BM or control point.

5. **Batter Boards**: After the corners have been staked and elevations established, the general rough grading will disturb the previously set stakes; therefore, a more suitable mark must be placed to continue construction. These suitable markers are called batter boards, and are temporary devices which mark the outline and grade of the structure.

UTILITIES

1. Sewer Lines: The proper location of sewer lines depends on the extent of the area to be serviced and the location of disposal points. Profiles are run and extended to cover the area within which the sewers may be needed. Topographic notes of elevations along the centerline and both sides of the sewer are taken for plotting a map with contours at intervals of from 1 to 10 feet, depending on the configuration on the ground. The elevations of the beds of streams, ditches, canals and culverts are found and the maximum and minimum flow is determined as accurately as is practicable. The profile of the sewer line is plotted on profile sheets, which also show information obtained from borings and soundings, and the location of all existing utilities intersecting the proposed sewer trench. Once the line and grade are determined, they must be transferred into the trench. This is done as follows:

   - Batter boards for sewer alinement are usually placed at intervals of 25 feet and set on edge across the trench. After a number of batter boards have been set, their stationing is determined. The centerline of the sewer is determined by the plans and is transferred to the batter boards, usually by transit and marked by notches or nails on the top edge of the board. The elevation of the sewer grade at each batter board is computed or obtained directly by the shooting-in method.
   - Battens (small pieces of wood) are nailed to the batter boards to indicate sewer alinement. All battens are set vertically on the same side of the batter boards and with the same edges directly over the centerline of the sewer. The alinement of these battens is checked frequently as work progresses. This is done by sighting past the edges marking the centerline. Any batten that has been moved or disturbed will be visible immediately.
   - A sighting cord stretched parallel to the centerline of the sewer at a uniform distance above the invert grade will be used to transfer line and grade into the trench. After computing the invert elevation, some even number of feet is added to establish the elevation of the top of the batter board. The sighting cord is then placed in the notches or next to the nail, which establishes the alignment of the sewer. The centerline will be directly below the cord and the sewer invert grade will be at the selected distance below the cord.
   - A rod or stick, called a grade pole, with a mark at a distance from the footpiece equal to the distance between the sighting cord and the invert grade, is normally used to transfer the grade (usually in feet) from the sighting cord to the pipe. In practice, the footpiece end is then raised or lowered until the mark on the grade pole is on the horizontal line with the cord. A plumbline is held tightly against the cord and the pipe shifted sideways until its crown is directly below the point of the plumb bob. The grade pole is again placed in position, held plumb and its mark checked against the cord.

CONSTRUCTION SURVEYS

Surveying is extremely important to the construction industry. An accurate topographic survey and site map are the first requirements in designing streets, sewer and water lines, and structures. Surveyors then lay out and position these elements for construction according to the design plan. A final "as built" map, incorporating any modification made to the design plans, is prepared during and after construction and filed. Such maps are extremely important, especially where underground utilities are involved, to assure that they can be located quickly if trouble develops and will not be disturbed by later improvements.

STAKING OUT A PIPELINE

Flow in water lines is generally under pressure; most sewers have gravity flow, therefore, alignment and grade must be more accurate. Larger water lines also have definite grades because "blowoffs" are needed at low points and "air releases" at high spots. Grades are fixed by existing conditions, such as topography, which affects excavation depth of connecting lines, manholes, outfalls and catch basins.

Construction stakes disappear on the first pass of a ditcher or bulldozer, so parallel *offset lines* are necessary. Marks should be closer together on horizontal and vertical curves than on straight segments. For pipes of large diameter on horizontal curves, stakes may be placed for each pipe length, i.e., 6 or 8 ft.

When inflexible pipe lengths are laid as *chords*, they may not follow the trench properly. By installing big-diameter pipes (i.e., only 4-ft lengths) on relatively sharp-radius curves as *tangents*, tight joints and close adherence to desired alignment can be secured. Half of the first length should then precede the beginning of the curve, and one-half of the last piece extend beyond the end of the curve.

Batter boards are used for a sewer line. Batter boards are usually 1" x 6" boards nailed to 2" x 4" posts which have been pointed and driven into the ground. The top of the batter board is placed a full number of feet above the invert (lower inside surface) or above the flow line of the pipe. Nails are driven into the tops of the boards so that a string stretched tight between them will define the pipe center line. A graduated stick or special rod is used to measure the required distance from the string to the pipe invert or to the flow line. The string gives both line and grade.

Instead of a fixed batter board, a 2" x 4" carrying a level vial can be placed on top of the offset-line stake whose elevation is known. Measurement is made from the underside of a leveled 2" x 4" with a tape or graduated stick to establish the flow line. On jobs having a deep wide cut, a level or laser instrument is set up in the ditch to give the line and grade. Grades for trenches are designed to avoid excessive cut and fill.

STAKING PIPELINE GRADES

Staking grades is the reverse of running profiles, although in both operations the new center line should first be marked and stationed in horizontal control. The actual profiling and staking are on an offset line with cut and fill values given from the offset hubs to pipe invert or flow line.

Grade elevations are computed, then fixed on the ground by a leveling process summarized below:

1. Stake and profile stations on the pipelines.

2. Calculate pipeline grade, if not previously determined.

3. Compute flow line or invert elevation at each station.

4. Subtract grade elevations from ground elevations to get cut or fill and mark the offset stake with keel facing the center line; the station on the other side.

A level-rod target can be set at the proper elevation to put the rod base at grade, or an even number of feet above or below it. Stakes are then driven until the level's horizontal line of sight coincides with the target center line as the rod is held on top of each stake.

Staking lines having 1/2% or 1% grades is easy. Since the usual stadia interval factor is 100 to 1, sight lines through the middle and upper, or middle and lower, cross hairs of a level, transit or theodolite differ by 1/2 ft in 100 ft and define a 1/2% grade. Between the upper and lower wires there is a 1% grade. After setting one cross wire on the grade-rod reading for any station, either 1/2% or 1% grade is readily established for succeeding points from that position even though the telescope is not level.

STAKING OUT A BUILDING

The first task in staking out a building is to locate it properly on the correct lot by making measurements from the property lines. Stakes may be set initially at the exact building corners as a visible check on positioning the structure, but such points are lost immediately when work is begun on the footings. A set of *batter boards* and reference stakes, are erected near each corner but out of the way of construction. The boards are nailed a full number of feet above the bottom of the footing or the at the first floor elevation. Corner stakes and batter-board points for rectangular buildings are checked by measuring the diagonals for comparison with each other and the computed values. A bench mark (two or more on large projects) beyond the construction area but within easy sight distance is necessary to control elevations. Nails are driven into the batter-board tops so that strings stretched tightly between them define the outside wall or form line of the building. The boards give line and grade.

Permanent foresights are helpful in establishing principal lines of the structure. Targets or marks on nearby existing buildings can be used if movement due to thermal effects or settlement is considered negligible. On formed concrete structures such as retaining walls, offset lines are necessary because the outside wall face is obstructed.

STAKING OUT A HIGHWAY

After suitable control has been instituted, the construction area limits are staked so the contractor can clear them. Some contractors may want points set on the right-of-way with subgrade elevations showing cut or fill to a given elevation for use in performing rough grading and preliminary excavation of excess material.

Location stakes for the highway are then placed on the center line or an offset line at full stations, the beginning and end of horizontal and vertical curves, and other critical points. A profile run on the center line determines the elevation at each stake.

To guide the contractor in making final excavations and embankment, *slope stakes* are driven at the intersection of the ground and each side slope, or offset a short distance, i.e., 4 ft. The cut or fill at each location is marked on the slope stake. Slope stakes are located by a trial-and-error method based upon mental calculations involving the HI, grade rod, ground rod, half-roadway width, and side slopes. One or two trials are generally sufficient to fix the stake positions within an allowable error or 0.3 to 0.5 ft for rough grading. The infinite number of ground variations prohibits use of a standard formula in slope staking.

Grade stakes are set at points having the same ground and grade elevation. Three transition sections occur in passing from cut to fill and a grade stake is set at each one. A line connecting grade stakes, perhaps scratched out on the ground, defines the change from cut to fill. Earthwork quantities *cannot* be correctly calculated going directly from cut to fill or vice versa -- there *must* be one or more grade-point sections in between.

Steps to be taken in slope staking are:

1. Compute the cut at the center line stake from profile and grade elevations; check in field by grade rod minus ground rod; mark the stake.

2. Estimate the difference in elevation between the left-side slope stake point and the center stake; apply the difference to the center cut and get an estimated cut.

3. Mentally calculate the distance out to the slope stake.

4. Hold zero end of a cloth tape at the center stake while the rodperson goes out at right angles with the other end and holds the rod.

5. *Forget all previous calculations to avoid confusion of too many numbers and remember only the grade-rod value.*

6. Read the rod with a level set anywhere or by hand level while standing at center stake.

7. Compute required distance out for this cut.

8. Check tape to see what is actually being held.

9. If distance is within a few tenths of a foot, it is close enough. If ground is level, move out a few feet and drive stake; move out further if the ground slopes up since a greater cut would result and the slope stake must be beyond the computed distance or not so far if the ground has begun to slop down which gives a smaller cut.

10. If the distance has been missed badly, make a better estimate of cut, compute a new distance out, take a reading and repeat procedure.

11. In going out on the other side, the rodperson lines up the center and lefthand slope stake to get his/her right-angle direction.

12. To locate grade stakes at road edge, one person carries the zero end of the tape along the center line while the rodperson walks parallel with him/her holding the 20-ft mark until the required ground-rod reading is found by trial. Note that the grade rod changes during the movement but can be computed at 5- or 10-ft intervals. The notekeeper should have the grade rod listed in the book for quick reference at full station and other points where slope stakes are to be set.

13. Grade points on the center line are located using a starting guess determined by comparing the cut and fill at back and forward stations.

On transition sections, a peg may be set at the slope stake point. A marker stake is also driven perhaps 1/2 ft beyond, with the cut or fill distance out from the center line to the slope-stake point, side-slope ratio, and base half-width noted on the side facing the center line. Stationing is given on the back side. A reference stake placed 6 ft or more farther out of the way of clearing and grading has the same information repeated on it.

Slope staking using an EDM and vertical angles is now being carried out since the slope distance to a stake is readily measured. Slope-stake locations (and earthwork quantities) are also obtained from large-scale maps having small contour intervals.

After rough grading has shaped cuts and embankments to near final elevations, finished grade is set more accurately from *blue tops* (stakes whose tops are marked with blue keel and driven to grade elevation). These are not normally offset, but rather driven directly on center line. A tight string line stretched through notches to the blue tops can provide close control of the grading.

Drainage profiles, prepared to verify or construct drainage cross sections, can be used to accurately locate drainage structures and easements. Utility relocation surveys may be necessary in connecting with highway construction; for example, manhole or valve-box covers have to be set at correct grade before earthwork begins to fit the center-line finished grade and differential elevation resulting from transverse surface slope. They are located by center-line station and offset distance.

VOLUMES

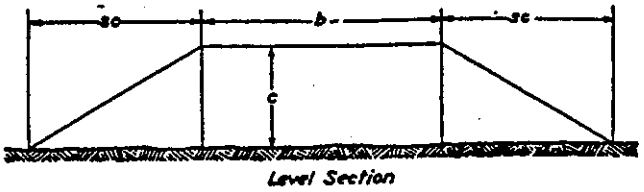
Surveyors are called upon to measure volumes of earthwork and concrete for various types of construction projects. Volume computations are also required to determine the capacity of bins, tanks, reservoirs and buildings. The field work includes the measurements of the dimensions of the various geometrical solids which make up the volumes, the setting of grade stakes and the keeping of the field notes. The office work involves the computation of the measured volumes and the determination of the most economical manner of performing the work.

CALCULATION OF AREAS

Volumes of prismoids are obtained from tables or diagrams, or the areas of the cross sections are determined and the volumes are computed by averaging end areas or by applying the prismoidal formula. When the cross sections are very irregular or when the route traverses land that is badly cut up, the areas can be found by planimetering the plotted cross sections.

When the sections are more regular, the areas can be calculated directly from the field notes. Four classes of sections are encountered:

1. **Level Section**:

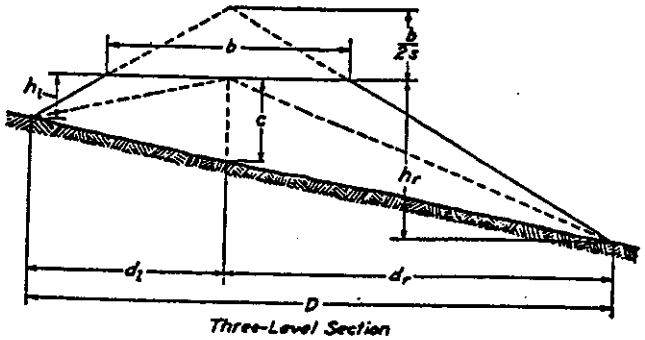


Level Section

$$Area = \tfrac{1}{2}(b + sc + b + sc)\,c = (b + sc)\,c$$

where b = width of the roadbed; c = center fill or cut; s = side-slope ratio

2. **Three-Level Section**:



Three-Level Section

$$Area = \tfrac{1}{2}h_l \times \tfrac{1}{2}b + \tfrac{1}{2}c \times d_l + \tfrac{1}{2}c \times d_r + \tfrac{1}{2}h_r \times \tfrac{1}{2}b$$

$$= \tfrac{1}{2}\left[\tfrac{1}{2}b\,(h_r + h_l) + c(d_r + d_l)\right]$$

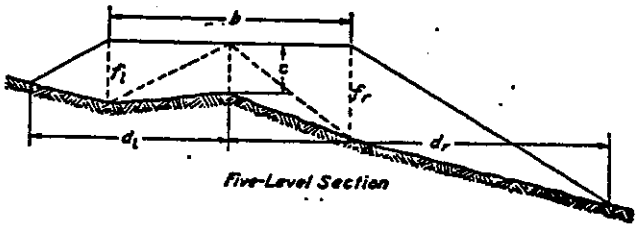
A second method, which reduces the computation to a single multiplication, is to calculate the area of the figure formed by extending the side slopes to an intersection and subtracting from this area the portion that is above roadbed:

$$Area = \frac{1}{2}\left(c + \frac{b}{2s}\right) \times (d_r + d_l) - \frac{1}{2}\left(b \times \frac{b}{2s}\right)$$

$$= \frac{1}{2}\left(c + \frac{b}{2s}\right) \times D - \frac{b^2}{4s}$$

where $D = d_r + d_l$. The area above the roadbed and b/(2s) are constants, as long as the width of the roadbed and the side slopes remain constant.

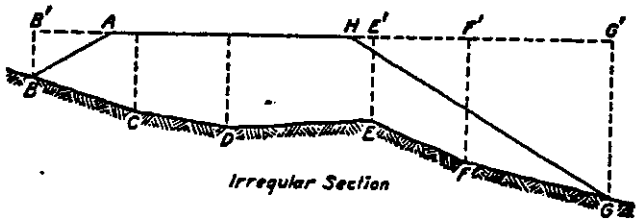
3. **Five-Level Section**: If triangles that have common vertical sides are combined:



Five-Level Section

$$Area = \tfrac{1}{2}(f_l \times d_l + c \times b + f_r \times d_r)$$

4. **Irregular Section**: The area of the section may be obtained by computing the area of the trapezoids forming the figure and subtracting from their sum the areas of the two triangles. Another method is to consider the cross section as a traverse. The field notes provide the coordinates of the corners with respect to the finished grade and the center line as coordinate axes, the horizontal distances from the center line being the x-coordinates, and the vertical cuts or fills the y-coordinates. For an 8-sided traverse, the area can be expressed by one of the following equations:



Irregular Section

$$Area = \tfrac{1}{2}[X_1(Y_2 - Y_8) + X_2(Y_3 - Y_1) + X_3(Y_4 - Y_2) + \ldots]$$

or

$$Area = \tfrac{1}{2}[Y_1(X_2 - X_8) + Y_2(X_3 - X_1) + Y_3(X_4 - X_2) + \ldots]$$

Since, for a cross section in earthwork, the y-coordinates of two of the points are zero, the computations will be shortened if the second equation is used.

METHODS OF MEASUREMENTS

Direct measurements of volumes is rarely made in surveying since it is difficult to actually apply a unit of the material involved. Indirect measurements are obtained by measuring lines and areas which have a relation to the volume desired. The principal methods used are:

1. **The Cross-Section Method**: When the cross-section method is used for computing volumes, ground profiles called cross sections are taken (at right angles to the center line) usually at intervals of 50 or 100 ft. In addition to the cross sections taken at regular intervals, other sections are taken at the P.C. and the P.T. of each curve, at all breaks in the ground surface, and at all grade points. A *grade point* is a point where the ground elevation coincides with the grade elevation. In passing from cut to fill, or from fill to cut, as many as five sections may be needed in computing the volume when the change occurs on a side of a hill. Volume is computed by the:

   - *Average End-Area Formula:* According to this formula, the volume, in cubic feet, between two cross sections having areas A_0 and A_1 is:

$$V_e = \tfrac{1}{2}(A_0 + A_1)\,L$$

   where L is the distance between the sections. The volume, in cubic yards, is:

$$V_e = \frac{1}{2}(A_0 + A_1)\frac{L}{27} = \frac{L}{54}(A_0 + A_1)$$

   Although this relationship is not exact when applied to many earthwork sections, it is commonly used because of the ease of its application and because of the fact that the computed volumes are generally too great and thus the error is in the favor of the contractor.

   - *Prismoidal Formula*: The prismoidal formula applies to volumes of all geometric solids which can be considered prismoids. Most earthwork volumes fit this classification, but relatively few of them warrant the precision of the prismoidal formula. The ground is not uniform from cross section to cross section, and right angles turned from the center line using a pentagonal prism introduce errors. When the more exact volume must be known, the prismoidal formal can be used:

$$V_p = \frac{L}{6}(A_0 + 4M + A_1)$$

where M is the area of the middle section and V_p is the volume, in cubic feet. In general, M will *not* be the mean of the two end areas. It can be shown that this formula is correct for determining the volumes of prisms, pyramids, wedges and prismoids that have triangular end sections and sides which are warped surfaces. To use this formula, it is necessary to know the area of the section half-way between stations. This area is found by the usual computations *after averaging the heights and widths of the cross sections.* The middle area is *not* the average of the end areas, since there would then be no differences between the results of the end-area formula and the prismoidal formula.

2. **Unit-Area or Borrow-Pit Method**: Greater accuracy can be obtained in rough terrain by using triangular areas instead of rectangular blocks. The volume is then equal to A, the area of each triangle times the average of its three corner heights.

$$V = \frac{A(a + b + c)}{3} \; ft^3$$

3. **Contour-Area Method**: Volumes based on contours can be obtained from contour maps by planimetering the area enclosed by each contour and multiplying the average of areas for adjacent contours by the contour interval.

TABLE FOR COMPUTING EARTHWORK VOLUMES

Base: 16 ft — Side Slopes: 1½:1

	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9	
e	L	K	L	K	L	K	L	K	L	K	L	K	L	K	L	K	L	K	L	K
0	0.0	7.4	3.0	7.5	6.0	7.7	9.1	7.8	12.3	8.0	15.5	8.1	18.8	8.2	22.1	8.4	25.5	8.5	28.9	8.7
1	32.4	8.8	36.0	8.9	39.6	9.1	43.2	9.2	46.9	9.4	50.7	9.5	54.5	9.6	58.4	9.8	62.3	9.9	66.3	10.0
2	70.4	10.2	74.5	10.3	78.6	10.5	82.8	10.6	87.1	10.7	91.4	10.9	95.8	11.0	100.2	11.2	104.7	11.3	109.3	11.4
3	113.9	11.6	118.5	11.7	123.3	11.9	128.0	12.0	132.9	12.1	137.7	12.3	142.7	12.4	147.7	12.5	152.7	12.7	157.8	12.8
4	163.0	13.0	168.2	13.1	173.4	13.2	178.8	13.4	184.1	13.5	189.6	13.7	195.1	13.8	200.6	13.9	206.2	14.1	211.9	14.2
5	217.6	14.4	223.4	14.5	229.2	14.6	235.1	14.8	241.0	14.9	247.0	15.0	253.0	15.2	259.1	15.3	265.3	15.5	271.5	15.6
6	277.8	15.7	284.1	15.9	290.5	16.0	296.9	16.2	303.4	16.3	310.0	16.4	316.6	16.6	323.2	16.7	329.9	16.9	336.7	17.0
7	343.5	17.1	350.4	17.3	357.3	17.4	364.3	17.5	371.4	17.7	378.5	17.8	385.6	18.0	392.8	18.1	400.1	18.2	407.4	18.4
8	414.8	18.5	422.2	18.7	429.7	18.8	437.3	18.9	444.9	19.1	452.5	19.2	460.3	19.4	468.0	19.5	475.9	19.6	483.7	19.8
9	491.7	19.9	499.7	20.0	507.7	20.2	515.8	20.3	524.0	20.5	532.2	20.6	540.4	20.7	548.8	20.9	557.1	21.0	565.6	21.2

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Administrative Regulation No. 22

City of Cincinnati

February 3, 1998

Office of the City Manager

AFFIRMATIVE ACTION POLICY STATEMENT **** REVISED ****

Equal employment opportunity is the law. Discrimination is banned in all terms and conditions of employment on the basis of: race, color, sex, religion, age, national or ethnic origin, HIV status, marital status, sexual orientation, regional Appalachian ancestry or disability. (Definitions of terms are found in the Affirmative Action Plan.)

Banning discriminatory practices is not enough. An affirmative action plan is necessary to guarantee that equal employment opportunity will happen for all protected groups.

An affirmative action plan is defined as a set of specific and results-oriented procedures to which an employer commits itself to apply every good faith effort. The objective of these procedures plus efforts is equal employment opportunity. Procedures without effort to make them work are meaningless, and efforts, undirected by specific and meaningful procedures, are inadequate. Therefore, there shall be a yearly goal for each EEO job category and city job group as a guideline for hiring and promotion toward meeting the yearly goals.

Each agency head is directed to take affirmative action to assure that all personnel actions have fair treatment to both applicants and employees. Agency heads should carefully analyze their utilization of women, minorities, and the persons with disabilities in all employment categories. They should then evaluate their recruitment, examination, selection, promotion, training, and other operations in order to determine what actions can rectify underutilization of women, minorities and persons with disabilities in any EEO job group.

Each agency head will, on a yearly basis, report to the City Manager what affirmative actions, as of December 31, have been taken to:

(1) Hire persons from underutilized classes;

(2) Utilize and/or develop skills of present employees;

(3) Provide opportunity for advancement of all employees;

(4) Train management and supervisory personnel to implement affirmative action;

(5) Correct inadequate performance of all employees.

These reports will be delivered to the City Manager no later than February 28 of each year.

The City Manager shall assure the existence of an effective system for processing complaints of discrimination because or race, color, sex, religion, age, national or ethnic origin, HIV status, marital status, sexual orientation, Regional Appalachian ancestry, or disability. Specific City policies relating to sexual harassment and reasonable

accommodation for persons with disabilities are covered in the City's Affirmative Action Plan.

The City Manager is responsible for the overall success of the Affirmative Action Program. Each agency head is personally responsible and accountable for the success of the Affirmative Action Plan in his/her agency. Each manager and supervisor is responsible and accountable for the success of the Affirmative Action Program as it relates to his/her employees.

The City Manager shall evaluate affirmative actions taken and shall consider that evaluation when determining "salary adjustments" for directors and agency heads. Acts of discrimination and/or violation of EEO/AA policies or procedures will result in written reprimands, salary reductions, suspensions, and/or any combination of corrective actions, including termination.

The Director of Personnel and the EEO Division will audit personnel actions in City agencies and will provide assistance to agency heads in determining what affirmative actions should be taken. All reports generated by this policy and the City Council ordinance will be made available to the Affirmative Action Advisory Committee and the public upon request.

As authorized by ordinance, the City Manager shall appoint members of the Affirmative Action Advisory Committee. The Director of Personnel shall designate staff support of the Committee.

Administrative Regulation No. 25

City of Cincinnati

Office of the City Manager

February 3, 1997

POLICY STATEMENT ON SEXUAL HARASSMENT - **Revised 5/4/1998**

Sexual harassment is against the law.

Sexual harassment is a prohibited personnel practice when it results in discrimination for or against an employee on the basis of conduct not related to performance, such as the taking or refusal to take a personnel action, including promotion of employees who submit to sexual overtures.

Sexual harassment also includes the display of sexually suggestive objects or pictures, deliberate or repeated verbal comments, gestures, or physical contact of a sexual nature which are unwelcome.

It is a form of employee misconduct which undermines the integrity of the employment relationship. Harassment on the basis of sex is a violation of Section 703 of Title VII of the Civil Rights Act of 1964, and therefore illegal. All City employees must be allowed to work in an environment free from unsolicited and unwelcome sexual overtures. Sexual harassment debilitates morale and interferes in the work productivity of its victims, as well as the work productivity of other employees present in the workforce.

Within the City of Cincinnati, a supervisor who uses implicit or explicit coercive sexual behavior to control, influence, or affect the career, salary, or job of an employee or applicant for employment is engaging in sexual harassment. Also, the appearance of doing the above could also lead to a charge of sexual harassment. For example, a supervisor who is having an affair with a subordinate could be viewed by other employees as granting special privileges to that employee, and thus, charged with sexual harassment. Similarly, an employee of a department who behaves in this manner in the process of conducting departmental business is engaging in sexual harassment.

Finally, any employee who participates in deliberate or repeated verbal comments, gestures, or physical contact of a sexual nature which are unwelcome and interfere with work productivity or create an intimidating, hostile, or offensive working environment is also engaging in sexual harassment.

An employee who subjects a non-employee to sexual harassment in the workplace is subject to this regulation.

A non-employee who subjects an employee to sexual harassment in the workplace will be informed of the harassment policy by the employee's supervisors or manager. Other more severe action may be taken as appropriate, including informing the non-employee's supervisor of the unacceptable conduct.

Complaints of harassment shall be examined impartially and resolved promptly. Employees with sexual harassment complaints should contact their supervisor, EEO Counselor, and/or the City's EEO Officer.

Employees who have been determined to have violated this policy will be subject to the disciplinary process.

Federal law, as well as Section 308-79 of the Cincinnati Municipal Code, prohibits employers from retaliating against

any employee who files a complaint of sexual harassment or who provides information relative to a complaint of sexual harassment.

In addition to sexual harassment, it is also a prohibited employment practice to engage in any verbal or physical conduct that denigrates or shows hostility or aversion toward an individual because of his or her race, color, religion, gender, national origin, age, disability, marital status, HIV status, or Appalachian regional ancestry, or that of his or her relatives, friends, or associates, and that:

1) has the purpose or effect of creating an intimidating, hostile, or offensive working environment;
2) has the purpose or effect of unreasonably interfering with an individual's work performance; or,
3) otherwise adversely affects an individual's employment opportunities.

It is the responsibility of every employee to prevent the existence of a climate in the workplace that promotes, condones, tolerates, or ignores any form of harassment including sexual harassment.

Copies of this regulation are to be prominently displayed on bulletin boards in all City of Cincinnati work sites.

Administrative Regulation No. 41

City of Cincinnati

Date: February 3, 1997

Office of the City Manager

Approved: Dtty H. Rindler

Subject: THE AMERICANS WITH DISABILITIES ACT OF 1990 – **Revised 1/31/02**

It is the intention and policy of the City of Cincinnati to comply with Title I of the Americans with Disabilities Act of 1990 (ADA), which will allow individuals with disabilities to have equal access to employment in a supportive work environment. Decisions regarding an individual's disability and potential reasonable accommodations will be made on a case-by-case basis, utilizing a structured, consistent process for making such assessments.

The City of Cincinnati intends to be a champion for recruiting, hiring and retaining employees at the utmost of their potential and capabilities. The City recognizes that adherence to the letter and spirit of the ADA is not only good business, but also enhances the quality of life for all City employees.

Copies of this regulation are to be prominently displayed on bulletin boards in all City of Cincinnati offices and work sites.

Purpose of the ADA

The ADA is a federal anti-discrimination statute designed to remove barriers which prevent qualified individuals with disabilities from enjoying the same employment opportunities that are available to persons without disabilities. The ADA is applicable to state and local governments, private employers, employment agencies, labor unions, joint labor-management committees, and persons who are "agents" of the employer, such as managers, supervisors and others who act for the employer.

Title I of the ADA prohibits discrimination against qualified individuals with disabilities in regard to any employment practices or terms, conditions, and privileges of employment. The ADA is therefore applicable to employment decisions involving application, promotion, testing, medical examinations, hiring, layoffs, recalls, disciplinary actions and terminations as well as to employment decisions regarding assignments, evaluation, compensation, leave, training and benefits.

The ADA is intended to ensure access to equal employment opportunities based on an individual's merit, and requires disabled persons to compete and function in the workplace based on the same performance standards and job requirements that employers expect of persons who are not disabled. When an individual's disability creates a barrier to employment opportunities, the ADA requires an employer to work with the disabled person to attempt to find a reasonable accommodation which would remove the barrier in a manner which would not create an undue hardship for the employer.

Frequently Used Terms of the ADA

The following terms and definitions are from the Americans with Disabilities Act (Title I of the ADA) and the EEOC Technical Assistance Manual on the Employment Provisions (Title I) of the Americans with Disabilities Act.

Disability:

A disability according to the ADA is 1) a physical or mental impairment that substantially limits one or more of a person's major life activities; 2) the status of having a record of such an impairment; or 3) the status of being regarded by one's employer as having such an impairment. Major life activities are functions such as caring for oneself, performing manual tasks, walking, seeing, hearing, speaking, breathing, learning, working, sitting, standing, lifting, etc.

"Substantially Limits":

An impairment will be considered a disability under the ADA if it "substantially limits" one or more major life activities, which an average person can perform with little or no difficulty. An individual must therefore be unable to perform, or be significantly limited in the ability to perform, a major life activity compared to an average person in the general population. Three factors are considered in determining whether a person's impairment substantially limits a major life activity: 1) the nature and severity of the impairment; 2) the expected duration of the impairment and 3) the permanent or long-term impact, or expected impact. These factors must be considered because, generally, it is not the name of an impairment or condition that determines whether a person is protected by the ADA, but rather the effect of an impairment or condition on the life of a particular individual.

Qualified Individual with a Disability:

A qualified individaul with a disability is a person with a disability who: 1) satisfies the requisite skill, experience, education and other job-related requirements of the employment position that the individual currently holds or desires to obtain; and 2) who, with or without reasonable accommodation, can perform the essential functions of the position.

Essential Function:

Essential functions are the fundamental job duties that the individual who holds the position must be able to perform unaided or with the assistance of a reasonable accommodation. Factors to be considered in determining whether a function is essential include: 1) whether the position exists to perform that particular function; 2) the number of other employees available to perform that job function or among whom the performance of that job function can be distributed; and/or 3) the degree of expertise or skill required to perform the function. Under the ADA, an employer is permitted to establish production standards for a position, setting the quantity and quality of work that must be performed by a person holding a particular job, regardless of whether or not that person has a disability.

Reasonable Accommodation:

Reasonable accommodation is a modification or adjustment to a job, the work environment, or the way things are usually done that enables a qualified individual with a disability to enjoy an equal employment opportunity. An equal employment opportunity means an opportunity to attain the same level of performance or to enjoy equal benefits and privileges of employment as are available to an average, similarly-situated employee without a disability. A reasonable accommodation must be an effective accommodation, but it does not have to ensure equal results or provide exactly the same benefits or privileges.

A reasonable accommodation must be determined on a case-by-case basis, and must take into account two unique factors: 1) the specific abilities and functional limitations of a particular applicant or employee with a disability and 2) the specific functional requirements of a particular job. Depending on the circumstances of a particular case, a reasonable accommodation might include:

- making facilities readily accessible to and usable by an individual with a disability
- restructuring a job by reallocating or redistributing marginal job functions
- altering when or how an essential job function is performed
- part-time or modified work schedules
- obtaining or modifying equipment or devices
- reassignment to a vacant position

and other potential accommodations which would be appropriate in a particular case.

Undue Hardship:

An employer is not required to make a reasonable accommodation if it would impose an undue hardship on the operation of the business. An undue hardship is an action that requires "significant difficulty or expense" in relation to the size of the employer, the number of employees, the resources and facilities available, and the nature of the operation. An undue hardship would therefore include any action which is unduly costly, extensive, substantial, disruptive or that would fundamentally alter the nature or operation of the business. If a particular accommodation would indeed impose an undue hardship, an employer must consider whether there are alternative accommodations that would not impose such a hardship.

City Resources

In order to implement the provisions of the ADA and to streamline the City's ADA procedures, the City of Cincinnati has established a Citywide ADA Coordinator, EEO and affirmative action procedures, a reasonable accommodation request and review procedure, and an ADA Reasonable Accommodation Review Committee. The Human Resources Department will inform employees and applicants of their rights under the ADA, will provide technical assistance to City departments, provide ADA training for City employees and management, and monitor compliance standards for reports to the City Administration and regulatory agencies.

City departments will be required to establish and regularly review the essential functions of all departmental positions, and to address and attempt to resolve reasonable accommodation requests from both employees and applicants for employment. Additional departmental

requirements will be distributed as applicable. Any questions regarding the feasibility of a requested accommodation should be referred to the Citywide or departmental ADA Coordinators.

The City of Cincinnati will continue to informally accommodate, at management's discretion within existing policies, the accommodation needs of City employees for a variety of personal reasons, including some physical or mental limitations that might not otherwise qualify for accommodation under the ADA. The fact that an employee is informally accommodated does not necessarily establish a continuing right to the particular accommodation. Likewise, an informal accommodation does not imply that the City regards such an individual as being disabled in that regard. Disabled individuals who seek accommodations under the ADA are required to make a written request for such an accommodation to their departmental ADA coordinator or the Citywide ADA Coordinator.

Conclusion

The process of identifying whether, and to what extent, a reasonable accommodation is required should be flexible and should incorporate common sense solutions. In order to be effective, the process should involve both management and the individual with a disability. The determination of whether an individual is qualified for a particular job must necessarily be made on a case-by-case basis, and any accommodations must be designed to match the needs of the disabled individual within the requirements of the job's essential functions. Such an approach will allow qualified individuals with varying abilities to attain equal employment opportunities within the City of Cincinnati.

Administrative Regulation No. 46

City of Cincinnati

February 3, 1997

Office of the City Manager

CITY VEHICULAR SAFETY POLICY

City policy provides the safest possible working conditions for all of its employees. All City workers, supervision and management must support this concept as a condition of employment. The use of vehicles in City workplaces presents a potential significant risk to worker safety and therefore is subject to certain control.

All City employees are required to wear safety belts while driving or riding in City vehicles, or in a private vehicle on City business, with exceptions as described below.

All vehicular accidents must be reported immediately to the employee's supervisor and City vehicles taken to Fleet Services within 24 hours of the "accident." This is in addition to the required notification of the Police Division.

If the incident results in a fatality or serious injury requiring hospitalization of an employee or a third party, the Employee Safety/Environmental Compliance Division and Risk Management Division must be notified immediately by telephone. Ohio OSHA must be notified within 8 hours of a fatality or the hospitalization of three or more employees.

The employee's supervisor must immediately begin an investigation into the causative factors of the incident.

Completed forms, with appropriate corrective action noted, shall be forwarded to the Department's reviewing authority the same work day.

The reviewing authority shall, within 24 hours, forward completed 91-S reports to the Employee Safety Division.

The Superintendent of Fleet Services will determine the amount and type of damage and repairs to vehicles involved and, if needed, impound for purposes of evidence in cases of a fatality or serious injury.

The following forms, or their equivalent, will be part of the incident investigation:

Form 30-S Attending Physician's Report

Form 90-S Supervisor's Investigation Report: Vehicle Accident

Form 91-S Supervisor's Investigation of Employee Injury/Illness (to include notation on whether a seat belt was in use)

Form 92-S Driver's Report of Vehicle Accident

Form OH-1 State Accident Report

The City's Employee Safety Instructional Manual ("Green Book"), Section 107, describes details in filling out all but the State form.

Exceptions to mandatory safety belt usage would include:

Operators and other employees while at a job site in some trucks, mowers and heavy equipment operating at low speeds and not equipped with roll bars and seat belts.

Sanitation Division truck drivers and helpers, while performing collection of waste and operating at low speeds (less than 15mph).

Other persons where their job hazard analysis determined seat belt use is not appropriate.

The Green Book, Section 610, includes many other specific requirements for vehicular operation by City employees and further clarifies these exceptions.

Safety belt use is mandated on Ohio roadways by State Regulation in addition to this City policy and Federal Occupational Safety and Health regulations.

Administrative Regulation No 49

City of Cincinnati

Date: April 7, 1997

Office of the City Manager

Approved: _____

Subject: **POLICY ON VIOLENCE IN THE WORKPLACE – Revised 4/14/04**

POLICY - The City of Cincinnati will not tolerate workplace violence, or the threat of violence, by any of its employees, customers, the general public, and/or anyone who conducts business with the City. The City will provide a workplace which is free from intimidation, threats, or violent acts.

DEFINITIONS - Workplace violence includes, but is not limited to, harassment, threats, physical attack, intentional property damage, or the carrying of weapons on City property. A threat is the expression of an intent to cause physical or mental harm regardless of whether the person communicating the threat has the present ability to carry out the threat and regardless of whether the threat is contingent, conditional, or future. Physical attack is unwanted or hostile physical contact with another person such as hitting, fighting, pushing, shoving or throwing objects. Property damage is intentional damage to property which includes property owned by the City, employees, or others (the public, other agencies, companies, or vendors). The possession of weapons of any kind, unless specifically authorized by a department/division manager for use in the line of duty (e.g. security guards), or the brandishing of any object that could reasonably be perceived as a weapon is a violent act.

PREVENTION OF VIOLENCE IN THE WORKPLACE - The City subscribes to the concept of a safe work environment and the prevention of workplace violence. Prevention efforts include, but are not limited to, informing employees of this policy, instructing employees regarding the dangers of workplace violence, communicating the sanctions imposed for violating this policy, and providing a reporting system to report incidents of violence without fear of reprisal.

REPORTING THREATS - INTERNAL AND EXTERNAL -- Each incident of violent behavior, whether the incident is committed by another employee or a member of the public, must be reported to department/division management. Management will assess and investigate the incident and determine the appropriate action to be taken - both to address the immediate situation and, subsequently, to investigate and take further action. Management should also notify the Police Division of all perceived violations of criminal statutes and ordinances. Department/division management will inform the Personnel Department of all reported incidents of workplace violence for evaluation to prevent future occurrences.

In critical incidents in which a serious threat or injury occurs, emergency responders such as Police, Fire, and/or ambulance personnel must be immediately notified. As necessitated by the seriousness of the incident, the Personnel Department may

assemble a Threat Management Team consisting of representatives from the City Manager's Office, Personnel Department, Law Department, PEAP, Employee Safety, Police Division, Fire Division, and others as deemed necessary to assess the situation and recommend a plan of action.

Any employee who acts in good faith by reporting real or implied violent behavior will not be subject to any form of retaliation or harassment. Any retaliation or harassment must be reported by the employee to their supervisor or the next level of supervision for investigation and disposition.

PROHIBITED ACTIONS AND SANCTIONS - It is a violation of this policy to engage in any act of workplace violence. Any employee who has been determined to be in violation will be subject to disciplinary action up to and including dismissal and, depending upon the violent act, may be subject to criminal sanctions.

CONCEALED FIREARM - The possession of a concealed firearm/weapon of any kind by a City employee while working for the City or acting as a representative of the City, on or in City property, including city owned parking lots, city owned or leased vehicles, buildings or property or privately owned vehicles used for City business, or in the field, during the normal course of their duties is prohibited. Police Officers and Arson Investigators are exempt from this rule because they are authorized and may be required to possess concealed weapons in carrying out their assigned duties. The prohibition against possession of a concealed firearm/weapon while in the performance of an employee's duties applies even if an employee has a license or permit to carry a firearm/concealed weapon.

Employees not authorized to carry a firearm/concealed weapon as part of their job who are found to either possess or use a concealed firearm/weapon shall be subject to disciplinary action.

PUBLIC EMPLOYEES ASSISTANCE PROGRAM (PEAP) - Should an employee become the victim of an incident of workplace violence, the department/division manager may offer the assistance of PEAP to help in coping with any effects of the incident. Should an employee commit an act of violence, he or she may be referred to PEAP by the department/division manager.

DEPARTMENT/DIVISION SECURITY AUDIT - On an annual basis or whenever the physical layout of the work space is significantly altered, the deparment/division manager will examine the escape routes of the work area and communicate any changes to all department/division employees. On an as needed basis, the department/division manager may request a security audit from the Police Division to determine whether security measures, such as panic alarms, are necessary and effective. All employees should openly communicate with each other to be aware of any unusual activity that may identify the potential for or actual occurrence of a violent incident

OFF-THE-JOB - An employee may be involved in a personal non-criminal dispute with family members or neighbors. If the situation escalates, individuals sometimes secure "Restraining Orders," "Protective Orders," "Injunctive Orders," or other court orders. When an employee requests a court order, he or she should include the work location

as well as the place of residence in the order. The employee should inform the supervisor of the issuance of such an order and provide a description of the individual(s) cited in the order. Even in the case where an employee has not secured a court order but fears for his or her safety, the employee should notify the Police Division immediately and inform his or her supervisor.

EMPLOYEE TRAINING - The department/division manager or his or her designee will orient all new employees to departmental/divisional procedures regarding reporting incidents of violence, what to do if the employee is threatened and/or if an incident of violence actually takes place, and dealing with the after-effects of an act of violence.

Administrative Regulation No. 52

City of Cincinnati

Office of the City Manager

Date: 12/97, Rev. 9/99, 11/05, 6/07
Current Revision: July 2007

Approved: Milton Dohoney Jr
City Manager

Approved: 7/24/07
HR Director

Subject: **SUBSTANCE ABUSE POLICY**

1. PURPOSE

Alcohol and drugs in employees' systems impair their ability to perform their duties in a safe and efficient manner. The purpose of this administrative regulation is:

- To deter alcohol and drug abuse.
- To provide a consistent and fair policy to deal with City employees who abuse alcohol and drugs.

2. DEFINITIONS (See Appendix A)

3. TRAINING

The City will develop an ongoing training program which will at a minimum provide all employees with one hour of training for the recognition of the signs of alcohol abuse and one hour of training for the recognition of the signs of drug abuse.

4. COMPLIANCE

Failure to comply with the provisions of this Administrative Regulation will result in corrective action. Prior to any corrective action, a pre-disciplinary hearing will be scheduled as dictated by current contractual or administrative procedures.

5. VALIDITY

The results of blood or breath tests for alcohol detection or urine tests for drug detection which are conducted by federal, state, or local officials having independent authority for the test shall be considered to meet the requirements of this regulation, provided such tests conform to applicable federal, state, or local requirements, and the results are obtained by the City.

A certified laboratory report from the City's official testing laboratory shall be deemed prima-facie evidence of a positive result. The certified laboratory report shall be provided to the employee upon his/her request.

Split Specimen Testing:
Applicants and employees who have received a positive test result reported by the Medical Review Officer (MRO) may request to have an additional test beyond the confirmation test performed by a National Institute on Drug Abuse certified lab.

Applicants and employees that request a split specimen to be tested must contact the MRO. The MRO will contact the testing laboratory to order the split specimen test. The initial laboratory will only send the split

specimen to another NIDA certified laboratory for testing. The party requesting the retest shall bear the cost of the slit specimen test(s).

6. EXPECTATIONS; REQUIREMENTS; PROHIBITIONS

This substance abuse policy applies to all City employees, regardless of title or classification, and to individuals seeking employment with the City.

A. City employees shall not report to work or remain on duty under the influence of drugs or alcohol, that would result in a positive drug and/or alcohol screen.

B. Employees shall not possess, store, or use drugs or alcohol while on duty, in uniform, or on City property.

C. City employees shall not possess drug paraphernalia while on duty, in uniform, or on city property.

D. City employees shall not possess any substances or devices intended to alter the results of a drug or alcohol screen while on duty, in uniform, on city property or at a screening facility.

E. Employees shall not sell or provide drugs or alcohol to any person while on duty, in uniform or on City property.

F. Any employee who is arrested for a drug-related or alcohol-related statute violation shall notify his/her supervisor at the start of the employee's next working day.

G. A supervisor having actual knowledge that a Commercial Driver's License (CDL) covered or non-CDL covered employee who is likely to operate a vehicle, heavy equipment or dangerous machinery is using or has used alcohol within four hours shall not permit them to remain on the job.

H. All employees are responsible for the consistent enforcement of this policy. A supervisor or employee who knowingly permits a violation of this policy shall be subject to corrective action. An employee who suspects that a supervisor is in violation of this policy shall report their suspicions to the next higher level of supervision. An employee who suspects that another employee is in violation of this policy shall report their suspicions to a supervisor ("supervisor" as defined in this policy).

I. No City employee shall refuse to take any of the following required tests:

   1. Post-Accident Testing
   2. Reasonable-Suspicion Testing
   3. Return-to-Duty Testing
   4. Unannounced Follow-up Testing as determined by the Substance Abuse Professional (SAP) and scheduled by Department
   5. Random Testing (CDL employees only)
   6. Intra-Inter Agency Transfer or Demotion (CDL employees only)

J. Records pertaining to the administration of this policy including but not limited to records of drug and alcohol testing procedures, results, referrals, treatment and follow-up, and/or refusals to comply with the policy, are to be retained permanently in the employee's medical personnel file. Records of corrective actions related to positive drug/alcohol screens are retained permanently in the employee's personnel file, unless a relevant collective bargaining agreement provides otherwise. *See Section 13 – RECORDS* for additional information.

7. REFUSAL TO SUBMIT TO TESTING

A. Refusal To Test
Refusal to submit to a legally, properly ordered drug and/or alcohol test shall result in consequences that are the same as those for a positive drug/alcohol test result. The employee will be subject to corrective action up to and including dismissal.

(7. REFUSAL TO SUBMIT TO TESTING, continued)

B. Shy Bladder
When an employee fails to provide a urine sample after being subjected to standard laboratory procedures, the employee shall immediately undergo a medical evaluation, by the Employee Health Service (EHS) during standard working hours (or by the physician at the designated collection site during hours EHS is closed). If both EHS and the designated collecting site's physician are unavailable, the employee can be evaluated the next business day by EHS as long as the employee does not report back to work. If the EHS physician or collection site physician reports that no physical condition exists that would have prevented the employee from providing a specimen, the employee shall be deemed to have refused the test.

C. Shy Lung
When an employee fails to provide an adequate breath sample after being subjected to standard laboratory procedures, the employee shall immediately undergo a medical evaluation, by the EHS during standard working hours (or by the physician at the designated collection site during hours EHS is closed). If both EHS and the designated collecting site's physician are unavailable, the employee can be evaluated the next day as long as the employee does not report back to work.

If EHS physician (or collection site physician) reports that no physical condition exists that would have prevented the employee from providing a specimen, the employee shall be deemed to have refused the test.

D. Invalid or Diluted Specimen
The validity of a specimen will be initially determined by the Laboratory. The Medical Review Officer (MRO) will be notified of the invalid or diluted specimen and will determine if there is a valid explanation for the status of the specimen.

8. REQUIRED TESTS

Employees who are scheduled for drug/alcohol test appointments with the laboratory must keep the scheduled appointments when directed by the City to report to the laboratory to submit to drug and/or alcohol testing.

A. Post Accident
An employee driving on duty who is involved in a vehicular accident, or an employee driving a city vehicle whether on or off duty, shall be tested for drugs and alcohol as soon as practical following the accident, if any of the following occurs:

- The accident involves the loss of human life or bodily injury to any person who, as a result of the injury, receives immediate medical treatment away from the scene of the accident; or
- The driver receives a citation under state or local law for a moving traffic violation arising from the accident; or
- One or more motor vehicles incurring disabling damage as a result of the accident, requiring the motor vehicle to be towed away from the scene;
- The accident causes damage to property other than a motor vehicle and the investigating supervisor reasonably believes that the property damage is of an amount greater than $2,000.00.

Notwithstanding the above, when the investigating supervisor determines immediately after the accident that the accident was not caused by negligence on the part of the employee, (e.g., the employee is stopped and gets rear-ended by another driver), the employee will not be required to submit to post-accident testing.

1. Testing Procedures - General
A driver who is subject to post-accident testing shall remain readily available for such testing or the employee may be deemed to have refused to submit to testing. Nothing in this section shall be construed to require the delay of necessary medical attention for injured people following an accident or

to prohibit a driver from leaving the scene of an accident for the period necessary to obtain assistance in responding to the accident or to obtain necessary medical care.

2. Alcohol Test Procedures
   Any employee required to take a post-accident alcohol test shall not use alcohol for eight hours following the accident or until the employee undergoes a post-accident test, whichever comes first.

If an alcohol test is not administered to the City employee within two hours following the accident, the supervisor shall prepare and maintain on file a written record stating the reason(s) the test was not administered but will proceed with required testing.

If an alcohol test is not administered within eight hours following the accident, attempts to administer an alcohol test shall cease, and the supervisor shall prepare a written record stating the reasons the test was not administered.

3. Drug Test Procedures
If a drug test is not administered to the City employee within 32 hours following the accident, attempts to administer a drug test shall cease, and the supervisor shall prepare and maintain on file a written record stating the reasons the test was not administered.

B. Reasonable Suspicion
An employee shall submit to an alcohol/drug test when a supervisor believes there is a reasonable suspicion that the employee is under the influence of alcohol/drugs.

1. Reasonable Suspicion
Reasonable suspicion must be based on specific, contemporaneous, articulable observations concerning the appearance, behavior, speech, or body odors of the employee. The observations may include indications of chronic and/or withdrawal effects of alcohol/drugs. The supervisor shall record, in writing, his observations which created a reasonable suspicion. In the case of a non-CDL employee, the supervisor shall immediately seek a second supervisor to confirm such suspicion. The second supervisor shall also record, in writing, his observations which confirm reasonable suspicion.

2. Reasonable Suspicion – Procedures
When reasonable suspicion that an employee is under the influence of drugs/alcohol is documented, the employee will be immediately removed from duty. The employee shall be immediately transported to the City's designated collection site for drug/alcohol testing by a supervisor.

The Department shall take all reasonable steps to prevent the employee from driving, up to and including transporting the employee home if necessary. If it is not possible to prevent the employee from driving, the Department shall notify Police

After drug/alcohol testing, the employee will be placed in a SWP status or SWOP and transported home. The employee will remain in a SWP or SWOP status until the drug/alcohol test results are known.

3. Test Administration Timeframes
If a reasonable-suspicion alcohol test is not administered within two hours following the determination that the employee should be tested, the supervisor shall prepare and maintain on file a written record stating the reasons the test was not administered.

If an alcohol test or drug test is not administered within eight hours of the determination, attempts to administer an alcohol test shall cease, and the supervisor shall state in the written record the reasons for not administering the test.

C. Return-To-Duty
Prior to returning to duty after testing positive for drugs/alcohol:

1. The employee shall submit to a drug/alcohol test before the employee's return to duty. The employee may return to duty once a negative drug/alcohol test has been obtained.

(8. REQUIRED TESTS, continued)

2. The employee shall be administered the same screen(s) (drug and/or alcohol) that was used in obtaining the original positive result.

3. Before a CDL employee or any employee who is likely to operate a city-owned vehicle, heavy equipment, or dangerous machinery returns to duty requiring the performance of safety-sensitive functions after receiving an alcohol test of 0.04 BAC or greater, the employee shall undergo a return-to-duty alcohol test. The alcohol screen must have an indication of less than 0.02 and a return-to-duty drug screen of a verified negative result.

4. An original level of .02 BAC to .039 BAC does not require a Return to Work screen. The department/division will obtain a recommendation from the SAP that the employee is capable of returning to duty. The department/division cannot consider returning an employee to duty until the SAP's release is secured. The City will determine the actual date of return of an employee to duty. This decision is to be based on the SAP's assessment that the employee has demonstrated compliance with treatment.

D. Unannounced Follow-Up

After being returned to duty following a positive test, the employee shall be subject to unannounced intermittent follow-up alcohol/drug testing for up to five years.

The Substance Abuse Professional shall determine the number of the follow-up tests for up to five years. However, there shall be a minimum of six tests in the 12-month period following the employee's return to duty.

Department Responsibilities:

1. Departments must carry out the SAP's follow-up testing requirements. Departments may not allow the employee to continue to perform safety-sensitive functions unless follow-up testing is conducted as directed by the SAP.
2. The Department must schedule follow-up tests on dates of their choice, but must ensure that the tests are unannounced with no discernable pattern as to their timing, and that the employee is given no advance notice.
3. Departments cannot substitute any other tests (e.g. those carried out under the random testing program) conducted on the employee for this follow-up testing requirement.
4. Departments cannot count a follow-up test that has been cancelled as a completed test. A cancelled follow-up test must be rescheduled.
5. A supervisor must accompany and remain with an employee at the testing facility.

E. Random (Applicable to CDL Covered Employees Only)

Pursuant to federal guidelines, at unannounced times and dates throughout the calendar year, a specific percentage of the average number of CDL covered employee positions will be randomly tested for drugs/alcohol.

No CDL licensed employee is permitted to drive a City vehicle requiring CDL licensing unless they are included in the random testing pool, regardless of the infrequency of driving such vehicles.

CDL covered employee names will be randomly selected through a scientifically valid method as defined in the federal regulations. The "pool" of CDL covered employees may be randomly selected for both a drug and alcohol test at the same point in time. Whenever an employee becomes a "CDL covered employee" their name shall be placed in the pool regardless of the number of times they have been randomly selected for testing or otherwise tested.

(8. REQUIRED TESTS continued)

Upon notification of selection for random alcohol and/or drug testing, the CDL covered employee will be transported to the test site immediately. If an employee is performing a safety-sensitive function, the supervisor will ensure that the employee ceases performing such duties and is transported to the test site as soon as possible.

If an employee is selected for a random alcohol and/or drug testing and is not on duty (vacation, SWP, etc.), the employee must be tested upon his/her return to duty.

F. New Hire/Pre-Placement/Reinstatement/CDL Transfer or Demotion

1. Disqualification
Applicants for City employment or reinstatement who test positive for drugs/alcohol or who have refused to take a drug/alcohol test will be disqualified on the basis that they have failed the medical examination. Individuals may appeal the medical disqualification to the Civil Service Commission.

2. CDL Promotion, Inter/Intra Departmental Transfer or Demotion
Current employees eligible for promotion, transfer (inter/intra departmental) or demotion into a CDL "safety sensitive" classification must undergo a drug/alcohol screen with a verified negative result before the promotion, transfer or demotion can be implemented.

9. TEST CATEGORIES AND PARAMETERS

A. Alcohol - a reported test result .02 BAC to .039 BAC is considered positive to the extent that the employee must be removed from work for a minimum of 24 hours. Time off work during the 24 hours shall be designated SWP or SWOP. The supervisor shall make a management referral to the Public Employees Assistance Program (PEAP) for evaluation. Employees are strongly urged to comply with any PEAP recommendations.

A reported test result of .04 BAC or more is considered positive and a violation of this policy, and must be acted upon in accordance with the requirements in this policy.

B. Drugs - a test result reported by the MRO of verified positive is considered positive and in violation of this policy and must be acted upon in accordance with the requirements in this policy.

C. Drug Groups
The drug screening for CDL covered and non-covered employees will include the following drug groups: Marijuana, Cocaine, Amphetamines, Opiates, and PCP.

10. TEST RESULT CATEGORIES AND PROCEDURES

A. Negative: Upon receipt of negative test results following a Reasonable Suspicion screening, the department will notify the employee. An employee on SWP or SWOP due to Reasonable Suspicion procedures will be returned to duty immediately and the employee's time restored.

B. Positive: When a drug/alcohol test is reported positive:
1. The employee shall not return to duty until receiving a recommendation from the SAP and approval from the department.
2. The Department shall take all reasonable steps to prevent the employee from driving, up to and including transporting the employee home, if necessary. If it is not possible to prevent the employee from driving, the Department shall notify Police.

(10. TEST RESULT CATEGORIES AND PROCEDURES, continued)

3. When a drug/alcohol test is reported positive, the employee will be placed and remain in SWP or SWOP status until the Department returns the employee to duty or the employee is officially dismissed.
4. SWP or SWOP used due to a positive test result cannot be used by an employee to serve a suspension.
5. The employee shall be referred to PEAP by the division head/superintendent / director of the division/department for the first positive result. No PEAP referral shall be given for second positive.
6. A pre-disciplinary hearing shall be scheduled as dictated by current contractual or administrative procedures.
7. Corrective action will be taken in accordance with this policy and administrative procedures.
8. Return to Duty - An employee subject to return to duty testing is required to test negative.

C. Refusal to Test: Refusal will be considered as a positive screen result.

D. Dilute-Negative: In the event that a test result is reported by the MRO as Negative – Dilute, the employee shall be taken immediately to a testing facility and shall submit to another test. The MRO will advise the employer if direct observation is required.

E. Diluted-Positive: See *Positive* in this Section.

F. Invalid: If there is a valid explanation, the MRO reports a cancelled test, invalid result, with no request for a directly observed specimen collection. If there is no valid explanation, the MRO reports a cancelled test, invalid result, and a second collection must take place immediately under direct observation.

G. Cancelled: Cancelled tests need to be recollected only when ordered by the MRO, or when a negative test result is required, such as pre-employment, return to duty, follow-up testing, etc.

11. VIOLATIONS OF POLICY; PENALTIES

Violation of this policy will result in any or all of the following charges: Substance abuse, Neglect of Duty, Failure of Good Behavior and/or Insubordination. Due to the nature of their job, police officers violating this policy may be subject to more severe and punitive discipline than is provided for herein.

For Substance Abuse, the penalty shall be:

A. First violation –
   1. Minimum suspension of 40 hours.
   2. A mandatory PEAP referral (listed under "Other " on the Form 32).
   3. Unannounced Follow-up Testing for up to five years as determined by the SAP.

   Prior corrective action and circumstances surrounding the positive test will be considered as aggravating factors in determination of actual penalty. A mandatory referral to PEAP does not preclude the appointing authority from rendering a final decision of dismissal.

B. Second violation (within three years of first violation) – Dismissal. No referral to PEAP.

C. Treatment Compliance – Failure to comply with the evaluation and/or treatment recommendations until successful completion, as determined by the SAP, shall result in dismissal.

(11. VIOLATIONS OF POLICY; PENALTIES, continued)

D. Represented Employees – If corrective action as a result of a violation of this policy is dismissed due to procedural defects such as failure to meet contractual timelines, the employee will not be charged with violation of this policy for disciplinary purposes, but must still be subject to the remaining provisions of this policy, including clearance by the SAP, return to duty testing and intermittent testing.

12. TREATMENT PROGRAM

The SAP establishes the scope and duration of any treatment program as well as compliance with a treatment/rehabilitation program.

13. SELF-IDENTIFICATION OF DRUG/ALCOHOL PROBLEM

Employees with drug/alcohol problems are encouraged to seek help before the problem impacts upon their employment. Employees who identify themselves to their supervisor as having a substance abuse problem AND enroll in a rehabilitation program approved by PEAP will be given the opportunity to seek recovery treatment. The employee will be required to sign a release of information that will enable the City to receive the results of PEAP's assessment and to receive subsequent reports related to the assessment and the employee's successful completion of all recommended treatment. The employee shall be placed on sick leave and shall not permitted to return to work until cleared by PEAP.

An employee who self-identifies to their supervisor and complies with the PEAP counselor's recommendation is NOT subject to disciplinary action for self-identifying. However, they will be subject to return-to-duty and follow-up testing. An employee who self-identifies but does not comply with the PEAP counselors' recommendation will be considered in violation of this policy and subject to the disciplinary consequences in this policy.

Employees will NOT be permitted to self-identify in any of the following circumstances:

- The employee selected for testing prior to enrolling in the rehabilitation program.
- Reasonable suspicion exists that the employee is under the influence of drugs/alcohol.
- The employee attempts to self-identify during their work shift.

Once an employee falls into one of the above categories, any attempts to self-identify and enroll in PEAP will not preclude corrective action.

An employee cannot use self-identification to avoid corrective action for other misconduct.

14. RECORDS

A. Mandated Record Requests

Departments must, after obtaining an employee/applicant written consent, request the information listed below from DOT-regulated employers who have employed the employee/applicant during any period during the two years before the date of the employee's application or transfer. An employee/applicant who refuses to give such consent will be deemed ineligible for employment, promotion, transfer, demotion, etc.

- Alcohol Tests with a result of 0.04 or higher alcohol concentration.
- Verified positive drug tests.
- Refusals to be tested (including verified adulterated or substituted drug test results).
- Other violations of DOT agency drug and alcohol testing regulations
- With respect to any employee who violated a DOT drug and alcohol regulation, documentation of the employee's successful completion of DOT return-to-duty process.

(14. RECORDS, continued)

B. Content
Records pertaining to the administration of this policy including but not limited to records of drug and alcohol testing procedures, results, referrals, treatment and follow-up, and/or refusals to comply with the policy, are retained permanently in the employee's medical file.

C. Transfers
In the event that an employee transfers from one City department to another, all employee records regarding the violation of this policy shall follow the employee to any other City department to which the employee may be transferred.

D. Retention
Records of corrective actions related to positive drug/alcohol screens are to be retained in the employee's personnel file according to relevant collective bargaining agreement or the Personnel, Policies and Procedures.

Records listed in Section *8.REQUIRED TESTS*- Section F, Part 3, are to be retained permanently in the employee's medical file. However, these records are not to be considered as medical information and will be released in accordance with federal DOT, CDL regulations and the aforementioned Section of this Policy

15. CLARIFICATION

It is not the intent of this policy to inappropriately modify the Department of Transportation federal regulations on drug and alcohol testing for CDL covered employees. If there are errors or omissions discovered in this policy, the federal regulations must be enforced.

Appendix A
DEFINITIONS

Alcohol. The intoxicating agent in beverage alcohol, ethyl alcohol, or other low molecular weight alcohols including methyl and isopropyl alcohol medications.

Alcohol concentration (or content). The alcohol in a volume of breath expressed in terms of grams of alcohol per 210 liters of breath as indicated by an evidential breath test.

BAC. Blood Alcohol Content.

CDL (Commercial Drivers License) Covered Employees. Employees who are required to possess a CDL to perform their job and who operate or are available to operate a commercial motor vehicle weighing 26,001 pound GVW or greater. Licensure administration regulated by the federal Department of Transportation.

Drug. A controlled substance, compound, mixture, preparation, or substance listed in *Section* 9. *Test Categories and Parameters* or in the federal regulations governing alcohol and drug testing for CDL Drivers.

Invalid Drug Test The result reported by the MRO of a drug test of a urine specimen that contains an unidentified adulterant or an unidentified interfering substance, has abnormal physical characteristics, or has an endogenous substance at an abnormal concentration that prevents the laboratory from completing or obtaining a valid drug test result.

Diluted Drug Test. A specimen with creatinine and specific gravity values that are lower than expected for human urine.

Medical Review Officer (MRO) A person who is a licensed physician and who is responsible for receiving and reviewing laboratory results generated by an employer's drug testing program and evaluating medical explanations for certain drug test results.

Safety-Sensitive Function. Any on-duty time for a CDL required function including, but not limited to, driving, inspecting, loading or unloading, supervising, repairing or obtaining assistance. The CDL employee is performing a safety sensitive function during any period in which he/she is actually performing, ready to perform, or immediately available to perform any safety-sensitive function.

Substance Abuse Professional (SAP). A person who evaluates employees who have violated drug and alcohol program regulations and makes recommendations concerning education, treatment, follow-up testing, return-to-duty and aftercare. The designated SAP for the City of Cincinnati is the Public Employees Assistance Program (PEAP).

Supervisor. For purposes of this policy and pertinent to reasonable suspicion, a "supervisor" means:

a. Employees included in Division D0, D0C, 5, 7, 8, or 9 of the Salary Schedule, or employees in Divisions 1 or 4 who serve in a supervisory capacity.
b. A city employee whose title is listed in Division POL of the Salary Schedule, whose title is Police Sergeant or higher;
c. A city employee whose title is listed in Division F40 or F48 of the Salary Schedule, whose title is Fire Lieutenant or higher.

For the purposes of this policy, a "supervisor" may or may not be in the line of supervision of an employee suspected under reasonable suspicion.

Shy Bladder. The failure to produce a urine sample in sufficient quantity for a required test to be conducted.
Shy Lung. The failure to produce an adequate breath sample for a required test to be conducted.

Appendix B
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Administrative Regulation No. 55

City of Cincinnati

Date: March 24, 2004

Office of the City Manager

Approved:

Subject: Prohibiting Offensive or Derogatory Comments

The purpose of this policy is to prohibit the making of offensive or derogatory comments by City employees based on race, color, sex, religion, age, national or ethnic origin, HIV status, marital status, regional Appalachian ancestry or disability. As a public employer, the City of Cincinnati will not tolerate any action by an employee which constitues derogatory or offensive comments made on the basis of race, color, sex, religion, age, national or ethnic origin, HIV status, marital status, regional Appalachian ancestry or disability. It is the policy of the City that every employee is entitled to a diverse and respectful workforce, and City employees are therefore strictly prohibited from making offensive or derogatory comments based on an individual's race, color, sex, religion, age, national or ethnic origin, HIV status, marital status, regional Appalachian ancestry or disability.

Slurs or comments based on an individual's race, sex or other above-listed criteria create an intimidating hostile or offensive working environment and interfere with other employees' work performance. Violations of this policy will result in the imposition of the strictest discipline permissable under local, state and federal law. For a first offense, an individual will be penalized with a forty-hour suspension. For a second offense, an individual will be penalized with an eighty--hour suspension. For a third offense, an individual will be dismissed from City employment.