United States
Environmental Protection
Agency

Solid Waste And
Emergency Response
(OS-420) WF

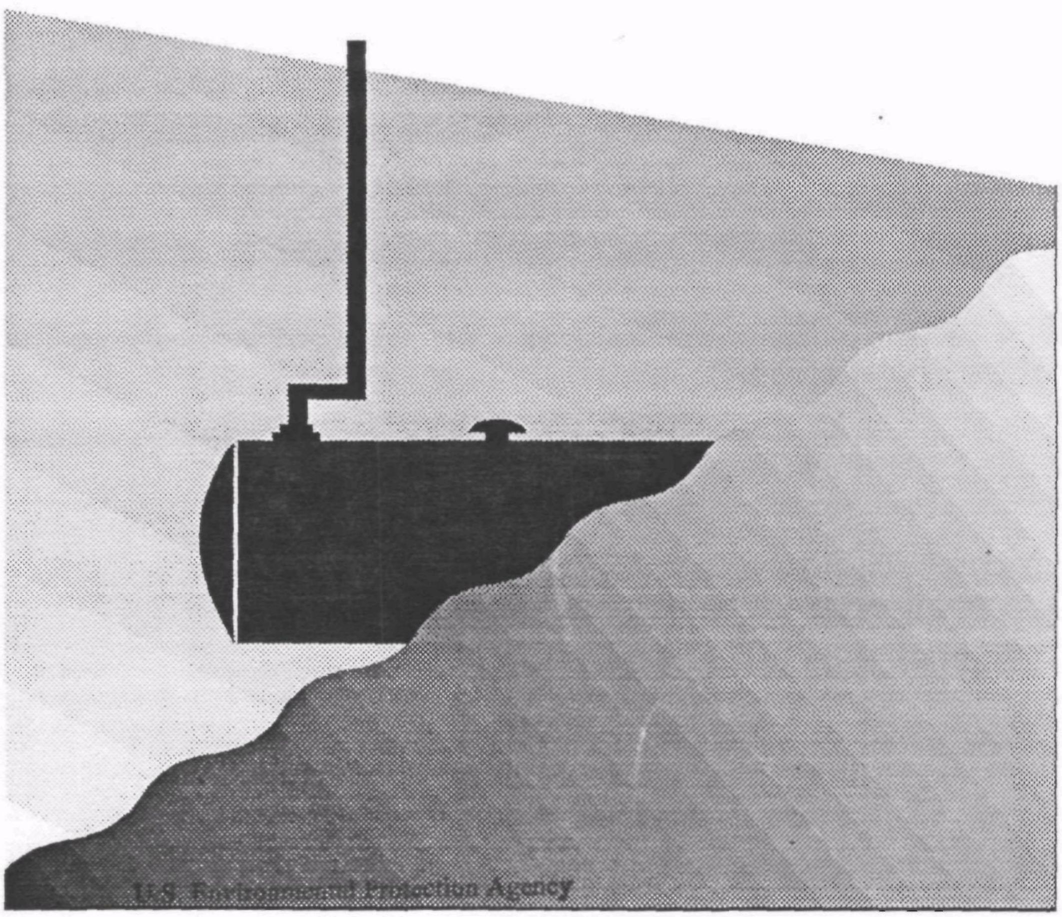
500/B-92/001
April 1992

EPA

Introduction to Leak Detection

Understanding Federal Release Detection Requirements and Acceptable Release Detection Methods

Instructor Manual



Printed on Recycled Paper

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NOTES TO THE INSTRUCTOR

Welcome to "Introduction to Leak Detection." This course presents State and local UST program staff with a review of acceptable methods of release detection. The training should enable them to understand leak detection methods and to help UST owners and operators make an educated choice among leak detection course answers such questions as:

- What are the Federally accepted methods of leak detection?
- What are the requirements for monitoring USTs?
- What methods are used for leak detection in UST piping systems?
- What site characteristics should be considered when deciding on the proper leak detection method for a certain UST?
- What are the advantages and the limitations of the various leak detection methods?
- How do each of the methods compare in operation and maintenance?

These questions will be addressed by means of a variety of instructional methods: class lectures, slide presentations, large and small group discussions, question and answer sessions, and case study exercises. As an instructor, you should be prepared to present the material in the course as well as to answer the questions and address the concerns of your students. The course has been designed to give you numerous opportunities to incorporate scenarios and examples that illustrate your experiences and relate the course material to situations unique to your locale. The more specific the information presented in this course, the more effective the course will be.

Course Materials

The materials in this package are designed to assist the instructor throughout the entire course. Three types of materials are provided: The instructor's manual' a student manual' and visual aids such as text slides, photographic slides, and graphic slides. You will also find a series of illustrative exercises at the end of the manual. These resources will be sufficient for a complete training program, but it is suggested that you incorporate other materials, as appropriate.

The instructor's manual is arranged in a two-column format. The left column contains the text of the student manual. The right column provides space for your notes, as you are encourage to add State-specific material and personal experience anecdotes regarding leak detection. The right column also provides prompts for using the accompanying slides and exercises. (Slide material is described below; see Appendix II for exercises.)

To help you visually present the course, numerous slides are provided in the slide box that is part of this training package. Slides are numbered consecutively for each chapter. Hard copies of each text and graphic slide are provided in the "Slide Section," so you can easily review the slides as you tailor the course to your needs. Text slides act as prompts for both student and instructor by following the content of the course in outline form. Graphic slides and photo slides illustrate concepts and equipment being discussed. (The "Slide Section" does not include hard copies of the photo slides.) You are especially encouraged to supplement the slides or replace them with others that are more appropriate for the situations your students are most likely to encounter.

The student's manual is also arranged in a two-column format. The left column contains the same text found in the left column of the instructor's manual. The right column labeled "Student Notes" indicates only slide numbers; most of the column has been left blank to provide space for notes. The student's manual also provides definitions of terms in a glossary, and hard copies of most graphics.

Preparing to Deliver the Course

Because instructors for this course will have various levels of teaching experience, the following suggestions and teaching hints are provided to make teaching this course a more pleasant and productive experience. Keep in mind that these are suggestions and may be incorporated into the course as you feel necessary.

Effective instruction requires careful preparation by the instructor. The more familiar you are with the course materials, the easier the delivery of the course will be.

- Study the instructor's and student's manuals.
- Review the reference materials, and select slides and other materials to assist you in your presentation. Remember that you are encouraged to incorporate supplemental materials specific to your State. Research for ideas, facts, and anecdotes that will apply to your situation. (Examples of specific situations include coastal areas, where tides affect the water table, or areas with extreme temperature changes that may affect tank testing procedures).
- Practice your presentation and use of the visual aids. Get a feel for the length of time that will be required to cover the material. Remember to include time for questions.
- Make notes to yourself on items you want to cover that are not included in the manuals. It is very easy to forget to include something, once you have begun instruction.
- Contact other instructors who have presented the course to learn from their experiences.
- You may choose to send out an advance registration form to participants requesting information on their work experience. This may help you to shape the course materials for a specific audience.

The following are suggestions you may want to consider just prior to delivery of the course:

- Prepare and check all materials, training aids, and equipment needed for each class. Make sure that you have enough copies of the required materials for the number of students, and include a few extra copies for late registrations.
- Check your meeting facilities for lights, heat, chair set-up, and anything else that might affect the comfort of the students while the course is being conducted.
- Review each chapter for its goals and objectives.

The following are suggestions to consider while giving the presentation:

- Make sure that all students can hear you, and that they can see the slides.

- Try to pace your speaking pattern. A nervous instructor tends to talk too fast. Taking a few deep breaths now and then will help.

- Introduce each new unit with an overview of what the student is going to learn.

- Close each unit with a brief overview of what was presented.

- Make sure to allow time for questions. You may decide to ask students to hold all questions until the end of a unit, or you may tell them that they may ask questions at any time.

Applicability of OUST Publications

EPA's Office of Underground Storage Tanks (OUST) has developed many publications and videos that you may find useful as training tools. You will find a list of these materials at the end of Chapter One.

In addition, you should be aware of an additional resource not included on that list: a series of publications appearing under the general title of "Standard Test Procedures for Evaluating Leak Detection." Each publication in the series presents a detailed, highly technical procedure for testing one of the leak detection methods. Each publication includes a form that can be used to verify that the method being described meets EPA standards. Although tank owners and government regulators are not likely to need the actual, detailed test procedures, you may find some of the information applicable to your training. The series includes the following:

- Automatic Tank Gauging Systems (45A)
- Liquid-Phase Out-of-Tank Product Detectors (45B)
- Non-Volumetric Tank Tightness Test Methods (45C)
- Pipeline Leak Detection Systems (45D)
- Statistical Inventory Reconciliation Methods (45E)
- Vapor-Phase Out-of-Tank Product Detectors (45F)
- Volumetric Tank Tightness Test Methods (45G)
- Entire set of seven titles above (45SET)

The "Standard Test Procedures" series has been available in limited quantities since 1990 and there may already be copies in your office. If you need a copy, you can place an order (at no cost) by using the order numbers indicated above and sending your request to:

U.S. Environmental Protection Agency
Office of Underground Storage Tanks
P.O. Box 6044
Rockville, MD 20850

Questions and Feedback

If you have questions or would like to comment on the contents of the training package, please contact the Office of Underground Storage Tanks, U.S. EPA, at (703) 308-8850.

CHAPTER ONE

BASIC LEAK DETECTION

This chapter will introduce you to the problem of leaking underground storage tanks, leak detection and what it accomplishes, and why leak detection is necessary. It will also provide an overview of several leak detection methods. The chapter will serve as an introduction for some participants, and as a review of the material for others with more experience. This information provides the background necessary for understanding the following chapters.

Lecture Notes	Instructional Aids
I. OVERVIEW OF LEAKING UNDERGROUND STORAGE TANK SYSTEMS (USTs)	**Slide 1:** Chapter One slides. **Note:** Each slide is numbered, and corresponds to a specific section in the manual. **Note:** Text in this column is designed to assist you with talking points. You are encouraged to incorporate scenarios and examples throughout the course.
A. The problem	**Slide 1A (photo):** Leaking tank.
1. Petroleum and chemicals are stored in underground storage tanks, many of which are vulnerable to corrosion.	**Slide 2:** This slide presents the topics to be covered in Chapter One.
-- 84 percent of service station tanks are made of bare (unprotected) steel and are highly susceptible to corrosion.	**Slide 3 (graphic):** This pie graph illustrates the number of tanks that are unprotected, and therefore highly susceptible to corrosion.
-- 15 - 20 percent of petroleum tanks may be leaking, which means that hundreds of thousands of USTs may be leaking.	**Slide 4:** Discuss the problem of leaking USTs. Include specific numbers of the UST universe in your area, and the specific types of health and environmental threats that have resulted.
2. Leaking tanks pose a threat to ground water. Releases from USTs into water supplies used for drinking and other purposes can endanger public health.	
3. The threat of leaking tanks is not limited to ground water. Other considerations are:	**Slide 5:** Discuss other risks associated with leaking USTs.
-- Contamination of surface waters;	**Note:** Although ground-water contamination is a major concern, there are other problems that have to be addressed.

Lecture Notes	Instructional Aids
-- Fires and explosions; and -- Toxic fumes that seep into homes and businesses. 4. Two components of gasoline, benzene and ethyl dibromide, are suspected cancer-causing agents.	
B. Releases 1. Releases result from piping failure, spills and overfills, and tank corrosion.	**Slide 6:** Discuss the three types of releases mentioned. Most of the releases occur due to piping failures.
2. When a release occurs, product can: -- Seep through the soil into the ground water; -- Float on top of the water table; -- Discharge into wells or surface water; and/or -- Seep into underground structures (pipelines, utilities, lines, basements, etc.).	**Slide 7 (graphic):** Use this graphic to point out the ways that released product can travel.
C. Uses and ownership of USTs 1. The largest percentage (39 percent) of regulated USTs are used in retail motor fuel businesses. 2. The second largest user of USTs (38 percent) is the non-retail motor fuel sector, such as rental companies and government agencies.	**Slide 8 (graphic):** Use this pie chart to discuss the uses of regulated USTs. Note that the largest percentage of USTs contain motor fuels. This course will focus on these tanks.
3. Nearly 80 percent of all USTs used to store petroleum are owned and operated by gas stations and industry. Government and farmers each own about half of the remaining 20 percent. Farm tanks with a capacity of 1,100 gallons or less used for storing motor fuel for noncommercial purposes are not subject to Federal UST regulations.	**Slide 9 (graphic):** Use this pie chart to discuss the ownership of the petroleum USTs.

Lecture Notes	Instructional Aids
II. LEAK DETECTION	**Slide 9A (photo):** Current headlines demonstrate the increasing amount of public awareness.
A. What does leak detection accomplish?	
1. Leak detection warns owners and operators of leaks in tanks and piping. Early warning enables owners and operators to take action to stop the escape of large amounts of the product into the environment.	**Slide 10:** Discuss the effects of leak detection: it warns the owner/operator of leaks and prevents environmental contamination and risks to human health.
2. Leak detection can prevent ground-water contamination.	
B. Why is leak detection necessary for owners and operators of USTs?	**Slide 11:** Emphasize the cost benefits of leak detection.
1. Detecting leaks is a good business practice.	**Note:** The average cost of a cleanup now is $150,000.
-- Loss of product costs the owner/operator money.	**Slide 12:** Discuss the four main reasons for leak detection.
-- Extensive releases can be very costly to clean up.	
-- USTs that pollute a community's environment can cause public relations problems.	**Note:** Many service stations want to promote good public relations and avoid bad publicity. Leak detection demonstrates to the community that the owner/operator is concerned about safety.
2. Detecting leaks protects human health and the environment.	
-- Leak detection helps prevent the contamination of ground water that may be used as drinking water. Half of the U.S. population relies on ground water as a source of drinking water.	
-- Petroleum and chemicals stored in USTs can contaminate the soil, air and water with harmful effects to people, plants, and animals, particularly in farm production.	

Lecture Notes	Instructional Aids
-- Leaking tanks also can lead to explosions, fires, toxic fumes, and contaminated surface waters.	
3. Detecting leaks can protect owners and operators against liability suits.	
-- Local residents and communities can take damage claims to court.	
4. Detecting leaks is required by Federal, State, and local laws.	
-- UST regulations require preventing, detecting, and cleaning up leaks and spills.	

Lecture Notes	Instructional Aids

III. LEAK DETECTION METHODS

Three types of methods detect leaks from tanks:

— Internal monitoring:

— Interstitial monitoring; and

— External monitoring.

In addition, piping has special leak detection requirements.

Slide 13: There are three main types of leak detection. Each method will be discussed in detail during the remaining chapters of the course.

Note: A video is available that reviews each type of leak detection except for statistical inventory reconciliation. For information on ordering this 25-minute video, "Straight Talk on Leak Detection with Joe Thursday," see the publication list and order form at the end of this chapter. You may want to show the video in lieu of this portion of the chapter.

A. Internal leak detection methods

These methods monitor inside the tank to check for leaks, and frequently measure volume loss over time of test. There are four types of internal monitoring:

1. Inventory control combined with tightness testing;
2. Manual tank gauging;
3. Automatic tank gauging; and
4. Statistical inventory reconciliation.

Slide 14: Discuss these methods briefly.

Slide 15: Discuss briefly.

B. Interstitial leak detection methods

These methods monitor the area between the tank and a containment barrier.

Slide 16: Discuss briefly.

C. External leak detection methods

These methods use sensors to monitor the environment surrounding the tank for the presence of the leaked product. There are two types of external monitoring:

1. Vapor monitoring; and
2. Ground-water monitoring.

Lecture Notes	Instructional Aids
D. Piping monitoring	
1. Requirements for pressurized piping and suction piping are not the same. -- Compliance deadlines; and -- Testing requirements.	**Slide 17:** Mention the differences between these types of piping systems.
2. Pressurized piping must have automatic line leak detectors to prevent catastrophic releases.	
3. There are three types of leak detection for piping: -- Tightness testing; -- Interstitial monitoring; and -- External monitoring.	**Slide 18:** Mention that the methods of leak detection are generally the same as those for tanks, but piping may be tested either as part of the whole tank system, or separately.

Lecture Notes	Instructional Aids
IV. OTHER SOURCES OF INFORMATION ON THE UST PROGRAM In addition to the materials in this manual, the UST program also has developed handbooks, slide shows, and video tapes on a wide range of topics to inform States, localities and regulated industries about the regulations and program requirements. Many of these materials may be of interest to you. Additional information sources have been provided for you on the next few pages of this manual, including publication and video order forms and a list of UST Regional and State contacts. In addition to these materials, the EPA RCRA/Superfund Hotline (1-800-424-9346) can assist you with specific questions about the UST regulatory requirements.	**Slide 19:** Use this slide to review the chapter. Remind students that each method will be discussed in detail, for both tanks and piping.

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF UNDERGROUND STORAGE TANKS
PUBLICATIONS LIST

General Information

ORDER NO.

Regulations

Technical Reports

ORDER FORM

Name: ____________________ Title: ____________________

Organization: ____________________

Street: ____________________

City: ______________ State: ____________ Zip: __________

Telephone: (_____) _______ - __________

Please return this form to:

U.S. Environmental Protection Agency
Office of Underground Storage Tanks
P.O. Box 6044
Rockville, MD 20850

Please send me the publications I have circled:

3	4A	4B	5	7
10	17	21	26S	32
39	40	42	49	73
74	84	88	92	

Other Publications of Interest

TITLE / STOCK NO.	COST	AVAILABLE FROM
Musts for USTs: A Summary of the Regulations for Underground Storage Tank Systems Stock No. 055-000-00294-1	$2.50	**Superintendent of Documents** U.S. Government Printing Office Washington, D.C. 20402 (202) 783-3238 Visa and MasterCard accepted
Dollars and Sense: A Summary of the Financial Responsibility Regulations for Underground Storage Tank Systems Stock No. 055-000-00293-2	$1.25	
Cleanup of Releases from Petroleum USTs: Selected Technologies Stock No. 055-000-00272-0	$7.50	
Field Measurements: Dependable Data When You Need It Stock No. 055-000-00368-8	$5.50	
Petroleum Tank Releases Under Control: A Compendium of Current Practices for State UST Inspectors Stock No. 055-000-00295-9	$8.50	
Survey of Vendors of External Petroleum Leak Monitoring Devices for Use with USTs Stock No. 055-000-00277-1	$4.25	
Evaluation of Volumetric Leak Detection Methods for Underground Fuel Storage Tanks Volume 1. No. PB89-124333 paper/microfiche Volume 2. No. PB89-124341 paper/microfiche	 $39.00/$8.00 $81.00/$21.50	**National Technical Information Service** 5285 Port Royal Road Springfield, VA 22161 (703) 487-4600
Underground Storage Tank Corrective Action Technologies PB 87-171278 paper/microfiche	$31.00/$8.00	
Soil Gas Sensing for Detection and Mapping of Volatile Organics Catalog No. TO49	$35.00/ member $43.75/ non-member	**National Water Well Association** P.O. Box 182039, Dept. 017 Columbus, OH 43218 (614) 761-1711
Reg-In-A-Box personal computer (PC) software is an aid to understanding and working with the Federal UST regulations. Easy to use and available for PC-compatibles with hard disk drives. Not copy protected.	$5.00 plus shipping and handling	**Public Brand Software** 1-800-426-3475 (24 hours a day) (317) 856-7571 (in Indiana) Visa and MasterCard accepted
Volumetric Tank Testing (Summary of Edison Study on Internal Leak Detectors) Stock No. 625/9-89/009	Free	**Center for Environmental Research Information** 26 West Martin Luther King Drive Cincinnati, OH 45268-1072 (513) 569-7562

6/17/91 SPEC

Audiovisual Programs

IDEOS

AVAILABLE FROM

"Straight Talk on Leak Detection"
(An introductory overview for owners and operators of underground storage tank systems on the leak detection methods available for complying with UST regulations [Total 35 minutes].)
Part 1: Straight Talk From Tank Owners. (Owners address the problems of UST compliance [5 minutes].)
Part 2: Straight Talk on Leak Detection with Joe Thursday (30 minutes).
Cost: $40.00 prepaid

"Doing It Right"
(Proper installation of underground tanks and piping for installation crews.)
Part 1: Tanks (24 minutes)
Part 2: Piping (16 minutes)
Cost: $16.00 prepaid

Environmental Media Center
P.O. Box 30212
Bethesda, MD 20814

OR CALL TOLL FREE:
1-800-522-0362
(301-229-1944 in Maryland)

Visa and MasterCard accepted

"Searching for the Honest Tank: A Guide to UST Facility Compliance Inspections"
(Covers major steps of UST inspections from protocols and equipment to enforcement and followup; from cathodic protection to leak detection. Although it is directed at inspectors, the video is also helpful to owners and operators [illegible]0 minutes].)
Video and Booklet Cost: $40.00 prepaid
Booklet Cost: $5.00 prepaid

"Tank Closure Without Tears: An Inspector's Safety Guide"
(Focuses on problem of explosive vapors and safe tank removal.)
Video and Booklet Cost: $30.00 prepaid
Booklet Cost: $5.00 prepaid

"What Do We Have Here? An Inspector's Guide to Site Assessment at Tank Closure."
(A three-part video on inspecting sites for contamination where tanks have been removed.)
Part 1: Site Assessment Overview (30 minutes)
Part 2: Field Testing Instruments at a Glance (14 minutes)
Part 3: Soil and Water Sampling at a Glance (7 minutes)
Video and Booklet Cost: $45.00 prepaid
Booklet Cost: $5.00 prepaid

New England Interstate Environmental Training Center
Attn: VIDEOS
2 Fort Road
South Portland, ME 04106

"A Question of When: Tank Installation for Inspectors"
(Tank and pipe installation with a checklist for inspectors [28 minutes].)
Cost: $32.85 prepaid

"In Your Own Backyard"
(What tank owners should require from installation contractors [22 minutes].)
Cost: $32.85 prepaid

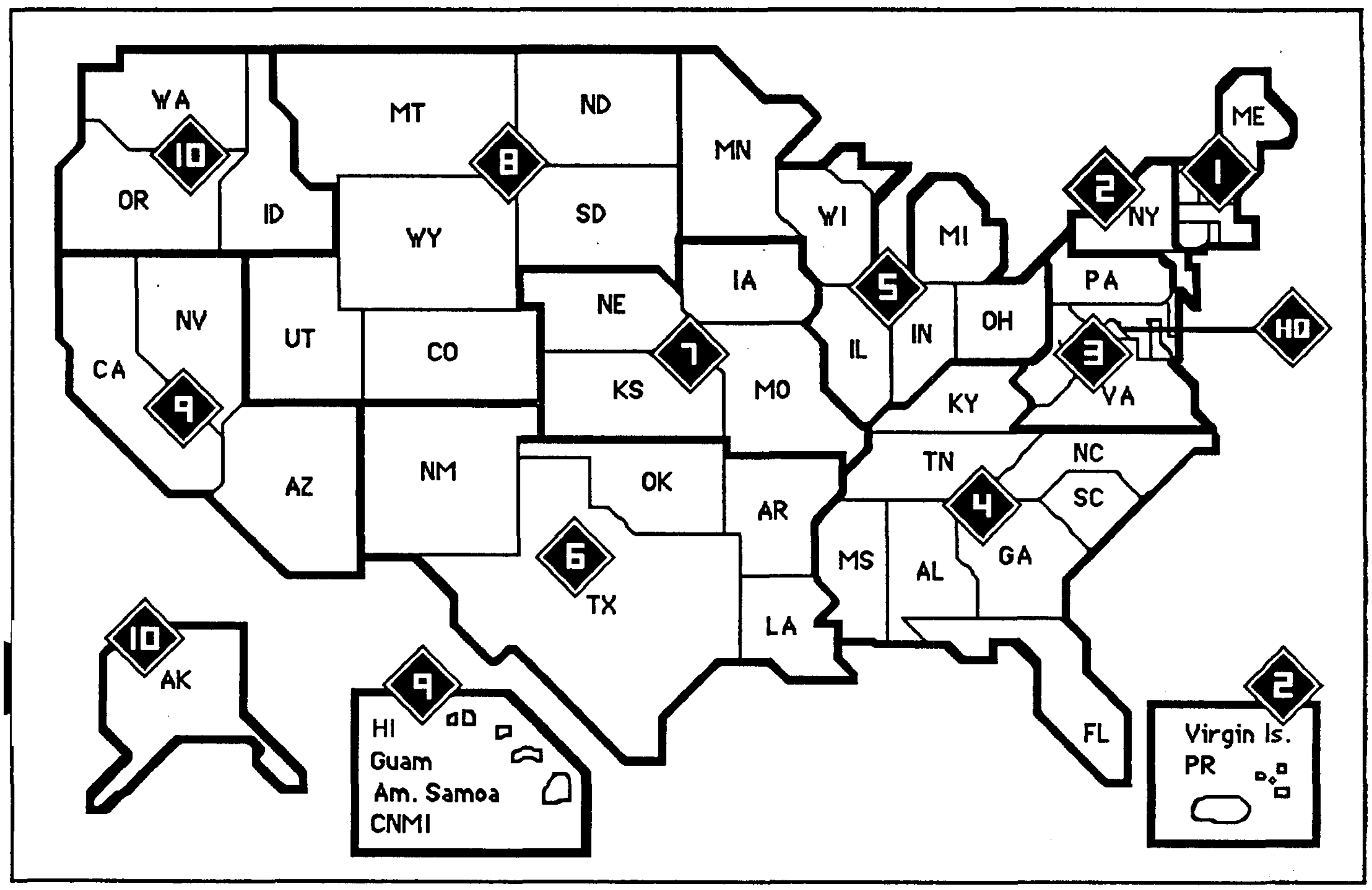
TZ Communications
P.O. Box 332
Holbrook, MA 02343

Audiovisual Programs

SLIDES	AVAILABLE FROM
"Managing Underground Storage Tanks" (Segments on all phases of tank management from inventory and installation to leak detection and clean up.) 185 slides, 27-page script, and 103 pages of graphics. **Cost:** $120.00	**National Audiovisual Center** Customer Services Section/WD 8700 Edgeworth Drive Capitol Heights, MD 20743-3701 (301) 763-1891
"Tank Talk: The New National Rules" (A visual overview of the Federal rules for USTs - - technical standards and financial responsibility.) 70 slides, 20-page script, and 30-minute narrated audio tape. **Cost:** $80.00	**Capital Presentations** 10 Post Office Road - Suite 2N Silver Spring, MD 20910 (301) 588-9540

U.S. Environmental Protection Agency
Office of Underground Storage Tanks

Regional and State UST/LUST Program Contacts



EPA Regional UST Program Managers

William Torrey
U.S. EPA, Region 1
JFK Federal Building
Mailcode: HPU-7
Boston, MA 02203
617-573-9604
FTS 833-1604

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U.S. EPA, Region 2
Hazardous & Solid Waste
Programs Branch
26 Federal Plaza
Code: 2AWM-HSWPB
New York, NY 10278
212-264-3384
FTS 264-3384

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841 Chestnut Building
Mailcode: 3HW63
Philadelphia, PA 19107
215-597-7354
FTS 597-3177

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345 Courtland St., N.E.
Mailcode: 4WM-GWP-15
Atlanta, GA 30365
404-347-3866
FTS 257-3866

Gerald Phillips
U.S. EPA, Region 5
77 W. Jackson Blvd.
Mailcode: HRU-8J
Chicago, IL 60604
312-886-6159
FTS 886-6159

Samuel Coleman, Acting
U.S. EPA, Region 6
1445 Ross Avenue
Mailcode: 6H-A
Dallas, TX 75202-2733
214-655-6755
FTS 255-6755

Lee Daniels
U.S. EPA, Region 7
RCRA/STPG Branch
726 Minnesota Avenue
Kansas City, KS 66101
913-551-7055
FTS 276-7055

Debbie Ehlert
U.S. EPA, Region 8
999 18th Street
Mailcode: 8-HWM-WM
Denver, CO 80202-2466
303-293-1514
FTS 330-1514

Pat Eklund
U.S. EPA, Region 9
75 Hawthorne Street
10th Floor, H-2-1
San Francisco, CA 94105
415-744-2079
FTS 484-2079

Joan Cabreza
U.S. EPA, Region 10
1200 Sixth Avenue
Mailcode: WD-139
Seattle, WA 98101
206-553-1643
FTS 399-1643

State UST/LUST Program Offices

AK UST/LUST CONTACT[2]
AK Dept. of Environmental Conservation
Contaminated Sites
410 Willoughby Avenue, Suite 105
Juneau, AK 99801-1795 907-465-5250

AL UST/LUST CONTACT
AL Dept. of Environmental Management
Ground-Water Section/Water Division
1751 Congressman W. L. Dickinson Dr.
Montgomery, AL 36130
UST: 205-271-7986
LUST: 205-271-7834

AR UST/LUST CONTACT[1]
AR Dept. of Pollution Control & Ecology
Regulated Storage Tank Division
P.O. Box 8913, 72219-8913
8001 National Drive
Little Rock, AR 72219-8913
501-562-6533

AZ UST/LUST CONTACT[2]
AZ Department of Environmental Quality
3033 North Central Avenue
Phoenix, AZ 85004 602-257-6984

CA UST/LUST CONTACT
CA State Water Resources Control Board
Division of Clean Water Program
2014 T Street
(P.O. Box 944212, Zip: 94244-2120)
Sacramento, CA 95814
UST: 916-739-4436
LUST: 916-739-4317

CO UST CONTACT
CO State Oil Inspection Office
1001 East 62nd Avenue, Room A1
Denver, CO 80216 303-289-5643

LUST CONTACT
CO Department of Health
Hazardous Materials & Waste Mgmt. Div.
Underground Storage Tank Program
4210 East 11th Avenue
Denver, CO 80220 303-331-4864

CT UST/LUST CONTACT[2]
CT Dept. of Environmental Protection
Underground Storage Tank Program
165 Capitol Avenue
Hartford, CT 06106 203-566-4630

DC UST/LUST CONTACT[2]
DC Environmental Regulatory Admin.
Underground Storage Tank Branch
2100 Martin Luther King Ave. S.E.
Suite 203
Washington, D.C. 20020
202-404-1167

DE UST/LUST CONTACT[2]
DE Dept. of Natural Resources &
Environmental Control
Underground Storage Tank Branch
715 Grantham Lane
New Castle, DE 19720 302-323-4588

FL UST/LUST CONTACT[2]
FL Dept. of Environmental Regulation
Tank Section
Twin Towers Office Building - Rm 403
2600 Blair Stone Road
Tallahassee, FL 32399-2400
904-488-3935

GA UST/LUST CONTACT[1]
GA Department of Natural Resources
Underground Storage Tank Mgmt. Prog.
4244 International Parkway, Suite 100
Atlanta, GA 30354 404-362-2687

HI UST/LUST CONTACT[1]
HI Department of Health
Solid and Hazardous Waste Branch
500 Ala Moana Blvd., Suite 250
Honolulu, HI 96813-4913 808-586-4230

IA UST/LUST CONTACT[1]
IA Department of Natural Resources
Henry A. Wallace Building
900 East Grand
Des Moines, IA 50319 515-281-8135

ID UST/LUST CONTACT[2]
ID Department of Health & Welfare
ID Division of Environmental Quality
1410 North Hilton
Boise, ID 83706 208-334-5860

IL UST CONTACT
IL Office of State Fire Marshal
Division of Petroleum & Chemical Safety
1035 Stephenson Dr.
Springfield, IL 62703 217-785-5878

LUST CONTACT
IL EPA, Bureau of Land
Div. of Remediation Mgmt., LUST Section
P.O. Box 19276
Springfield, IL 62794-9276 217-782-6760

IN UST CONTACT
IN Dept. of Fire and Services
Office of the State Fire Marshal
402 West Washington Street
Room C241
Indianapolis, IN 46204 317-232-2222

LUST CONTACT
IN Dept. of Environmental Management
Office of Environmental Response
2321 Executive Drive
Indianapolis, IN 46241 317-243-5110

KS UST/LUST CONTACT
KS Department of Health & Environment
Bureau of Environmental Remediation
Underground Storage Tank Section
Forbes Field, Building 740
Topeka, KS 66620-0001
UST: 913-296-1685
LUST: 913-296-1684

KY UST/LUST CONTACT[1]
KY Division of Waste Management
Underground Storage Tank Branch
18 Reilly Road
Frankfort, KY 40601 502-564-6716

LA UST/LUST CONTACT[2]
LA Dept. of Environmental Quality
Underground Storage Tank Division
P.O. Box 82178, 7290 Bluebonnet
Baton Rouge, LA 70884-2178
504-765-0243

MA UST CONTACT
MA Department of Public Safety
Underground Storage Tank Program
P.O. Box 490, East Street, Bldg. #5
Tewksbury, MA 01876 508-851-9813

LUST CONTACT
MA Dept. of Environmental Protection
One Winter Street
Boston, MA 02108 617-556-1044

MD UST/LUST CONTACT[1]
MD Department of Environment
Hazardous & Solid Waste Mgmt. Admin.
Underground Storage Tank Program
2500 Broening Highway
Baltimore, MD 21224 410-631-3442

ME UST/LUST CONTACT[1]
ME Dept. of Environmental Protection
State House - Station 17
Hospital Street, Ray Building
Augusta, ME 04333 207-289-2651

MI UST CONTACT
MI Department of State Police
Fire Marshal Division
P.O. Box 30157
Lansing, MI 48909 517-322-1935

LUST CONTACT
MI Department of Natural Resources
Leaking Underground Storage Tank Unit
P.O. Box 30028
Lansing, MI 48909 517-373-8168

MN UST/LUST CONTACT
MN Pollution Control Agency
Underground Storage Tank Program
520 Lafayette Road North
St. Paul, MN 55155-3898
UST: 612-297-8609
LUST: 612-297-8574

MO UST CONTACT
MO Department of Natural Resources
Water Pollution Control Program
P.O. Box 176
Jefferson City, MO 65102 314-751-6822

LUST CONTACT
MO Department of Natural Resources
Environmental Services Program
P.O. Box 176
Jefferson City, MO 65102 314-526-3349

1 = State has 1 person serving as both the UST and LUST Contact.
2 = State has 1 UST and 1 LUST Contact; both have the same address and telephone number.

State UST/LUST Program Offices

MS **UST/LUST CONTACT[1]**
MS Department of Environmental Quality
Bureau of Pollution Control
Underground Storage Tank Section
P.O. Box 10385
Jackson, MS 39289-0385
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MT **UST/LUST CONTACT[1]**
MT Dept. of Health & Environ. Science
Solid & Hazardous Waste Bureau
Cogswell Building - UST Program
Helena, MT 59620 406-444-5970

NC **UST/LUST CONTACT[2]**
NC Pollution Control Branch
Division of Environmental Management
Dept. of Env. Health & Natural Resources
441 N. Harrington St.
Raleigh, NC 27603 919-733-8486

ND **UST/LUST CONTACT[1]**
ND Department of Health
Division of Waste Management
Box 5520, 1200 Missouri Ave., Room 302
Bismarck, ND 58502-5520
701-221-5166

NE **UST CONTACT**
NE State Fire Marshal's Office
Flammable Liquid Storage Tank Division
246 South 14th Street
Lincoln, NE 68508 402-471-9465

LUST CONTACT
NE Dept. of Environmental Control
Groundwater Sect., Water Quality Division
301 Centennial Mall South, Box 98922
Lincoln, NE 68509-8922 402-471-4230

NH **UST/LUST CONTACT[1]**
NH Dept. of Environmental Services
Oil Compliance Section
Groundwater Protection Bureau
6 Hazen Drive, P.O. Box 95
Concord, NH 03301 603-271-3644

NJ **UST/LUST CONTACT[2]**
NJ Dept. of Environmental Protection
and Energy
Responsible Party Site Remediation
401 East State Street (CN-029)
Trenton, NJ 08625 609-984-3156

NM **UST/LUST CONTACT[1]**
NM Environment Department
Underground Storage Tank Bureau
P.O. Box 26110
1190 St. Francis Drive
Harold Runnels Building, Room N2150
Santa Fe, NM 87502 505-827-0188

NV **UST/LUST CONTACT[1]**
NV Dept. of Conservation & Natural Res.
Division of Environmental Protection
Capitol Complex
123 W. Nye Lane
Carson City, NV 89710 702-687-5872

NY **UST/LUST CONTACT[1]**
NY Dept. of Environmental Conservation
Bulk Storage Section
50 Wolf Road, Room 326
Albany, NY 12233-3520 518-457-4351

OH **UST/LUST CONTACT[2]**
OH Department of Commerce
8895 East Main Street
P.O. Box 687
Reynoldsburg, OH 43068
614-752-7938

OK **UST/LUST CONTACT**
OK Corporation Commission
Underground Storage Tank Program
Jim Thorpe Building
2101 North Lincoln Blvd.
Oklahoma City, OK 73105
UST: 405-521-3107
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OR **UST CONTACT**
OR Dept. of Environmental Quality
Underground Storage Tanks
811 SW Sixth Avenue, 7th Floor
Portland, OR 97204 503-229-5733

LUST CONTACT
OR Dept. of Environmental Quality
UST Cleanup Program
811 SW Sixth Avenue, 9th Floor
Portland, OR 97204 503-229-6170

PA **UST/LUST CONTACT[2]**
PA Dept. of Environmental Resources
BWQM, Storage Tank Program
3600 Vartan Way, 2nd Floor
P.O. Box 8762
Harrisburg, PA 17105-8762
717-657-4080

RI **UST/LUST CONTACT[1]**
RI Dept. of Environmental Management
Underground Storage Tank Section
291 Promenade St.
Providence, RI 02908 401-277-2234

SC **UST/LUST CONTACT**
SC Dept. of Health and Environ. Control
Ground-Water Protection Division
2600 Bull Street
Columbia, SC 29201
UST: 803-734-5335
LUST: 803-734-5331

SD **UST/LUST CONTACT[1]**
SD Dept. of Environ. & Natural Resources
Division of Environmental Regulation
523 East Capitol
Joe Foss Building
Pierre, SD 57501-3181 605-773-3351

TN **UST/LUST CONTACT[1]**
TN Dept. of Environment & Conservation
200 Doctors Building
706 Church Street
Nashville, TN 37243-1541 615-741-4081

TX **UST/LUST CONTACT[1]**
Texas Water Commission
Petroleum Storage Tank Division
P.O. Box 13087, Capitol Station
1700 North Congress
Austin, TX 78711-3087 512-371-6200

UT **UST/LUST CONTACT[1]**
UT Dept. of Environmental Quality
Bureau of Solid & Hazardous Waste
Division of Environmental Response and
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1950 West North Temple
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VA **UST/LUST CONTACT**
VA State Water Control Board
P.O. Box 11143
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802-244-8702

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Olympia, WA 98504-7655 206-459-

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WA Department of Ecology
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Olympia, WA 98504-7600 206-438-7164

WI **UST CONTACT**
WI Dept. of Industry, Labor & Human
Relations
Bureau of Petroleum Insp. & Fire Protection
P.O. Box 7969
201 East Washington Avenue
Madison, WI 53702 608-266-7605

LUST CONTACT
WI Department of Natural Resources
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Madison, WI 53707-7921 608-267-7560

WV **UST/LUST CONTACT[2]**
WV Division of Natural Resources
Waste Management Section
UST/LUST Office
1356 Hansford Street
Charleston, WV 25301 304-348-6371

WY **UST/LUST CONTACT[1]**
WY Dept. of Environmental Quality
Water Quality Division
Herschler Building, 4th Floor West
122 West 25th Street
Cheyenne, WY 82002 307-777-7781

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State UST/LUST Program Offices

TERRITORIES

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Office of the Governor
American Samoa Government
ATTN: UST/LUST Program
Pago Pago, American Samoa 96799
684-633-2304

CNMI **UST/LUST CONTACT**[1]
Division of Environmental Quality
P.O. Box 1304, Dr. Torres Hospital
Commonwealth of Northern Mariana Ids
Saipan, MP 96950 607-234-6984

GU **UST/LUST CONTACT**[1]
GU Environmental Protection Agency
IT&E
Harmon Plaza, Complex Unit D-107
130 Rojas Street
Harmon, Guam 96911 671-646-8863

PR **UST/LUST CONTACT**[1]
Water Quality Control
Environmental Quality Board
P.O. Box 11488
Commonwealth of Puerto Rico
Santurce, Puerto Rico 00910
809-767-8109

VI **UST/LUST CONTACT**[1]
Environmental Protection Division
Dept. of Planning and Natural Resources
Suite 321, Nisky Center
45A Estate Nisky
Charlotte Amalie
St. Thomas, Virgin Islands 00802
809-774-3320

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CHAPTER TWO

UST WALK-THROUGH

This chapter will walk you through an underground storage tank (UST) system, including the tanks, the piping systems, and the product dispensers. The chapter will also introduce frequently used site terminology, such as excavation zone and water table. This information will serve as a background for following chapters on site characteristics and leak detection methods for tanks and piping systems.

Lecture Notes	Instructional Aids
Understanding the different parts of an UST system allows you to better evaluate the leak detection requirements and the various leak detection methods available. This chapter describes a typical UST system and each of its major components.	Introduce the chapter, describing the material to be covered as it is mentioned in the introduction. **Slide 1:** Chapter Two slides.
I. WHAT IS AN UST? ◂ Underground Storage Tank (UST) refers to a system storing petroleum products or hazardous substances. An UST system for motor fuel includes the tank(s), piping, and product dispensers. At least 10 percent of the combined volume of the tank(s) and associated piping must be underground for the system to be considered an UST system.	**Slide 2:** Define an UST system, including tank, piping, and dispenser. **Slides 3 and 3A (graphic and photo):** Typical Retail Gasoline Station. Shows petroleum tanks, piping, and dispensers. **Note:** (◂) Draws attention to basic Federal requirements for UST systems. You should note that State and local requirements may be more stringent.
Although multi-tank service station USTs are among the most common tank systems, and provide the basis for this course, it is important to recognize that there are several other systems, including used oil tanks, single-tank systems, farm tanks, and tanks without piping.	**Note:** This course focuses on the service station system; however, you should mention that there are other tank types. Mention those which may be most common in your area.
◂ With the following exceptions, underground tanks must comply with Federal UST regulations: -- Farm or residential tanks of 1,100 gallons or less storing motor fuel for noncommercial purposes; -- Tanks storing heating oil for consumptive use on the premises where stored; -- Tanks holding 110 gallons or less;	**Slide 4:** Discuss these exceptions to Federal UST regulations.

Lecture Notes	Instructional Aids
-- Tanks on or above the floor of underground areas, such as basements or tunnels;	
-- Septic tanks and systems for collecting storm water and wastewater;	**Slide 5:** Exceptions to Federal UST regulations.
-- Flow-through process tanks;	
-- Emergency spill and overfill tanks; and	
-- Surface impoundments, ponds, pits, or lagoons.	

Lecture Notes	Instructional Aids
II. UST SYSTEM PARTS	
A. Tanks	**Slide 6:** Use this text slide to discuss characteristics of regulated tanks.
1. Typical retail tanks have a capacity of 2,000 to 12,000 gallons. -- Older tanks typically hold 2,000-6,000 gallons. -- Newer tanks generally hold 6,000-12,000 gallons.	**Slide 6A (photo):** Most older tanks are unprotected; however, regulations require protection. **Note:** There may be some exceptions to the type of tanks encountered, such as partially buried tanks, lift tanks, separators, and older tanks made of concrete. Discuss other tank types that are found in your State.
2. New tanks are generally constructed of cathodically protected coated steel, fiberglass-reinforced plastic (FRP), or a steel-fiberglass composite.	**Slide 6B (photo):** Newer tank types include cathodically protected coated steel, fiberglass, and fiberglass reinforced plastic (FRP) and steel composites. **Slide 6C (photo):** Steel - FRP composite.
B. Piping 1. Product delivery lines connect the tanks and product dispensers. -- Because delivery lines are generally installed near the ground surface and have many connections, leaks often come from delivery lines.	**Slide 6D (photo):** Discuss areas of concern for each type of piping (i.e., where joints commonly leak and which flex connectors and swing joints are susceptible to damage).
2. Manifolded piping typically refers to a fueling system in which two or more dispensers are supplied with product via a piping system that is connected to one or more tanks. Manifolded systems have multiple connections and are thus particularly susceptible to piping failures. -- An example of manifolded piping is a single submersible pump in an UST which supplies three separate dispensers.	

Lecture Notes	Instructional Aids
3. Vent pipes are routed from the tank to the surface as above-ground vents.	**Slide 6E (photo):** Vent pipes.
-- Vent pipes allow product fumes to be vented from the tank into the atmosphere, thus reducing the risk of explosion from volatile fumes under pressure.	
4. Fill pipes usually connect the underground tank to an above-ground fitting where a tank truck connects its transfer hose.	**Slide 6F (photo):** Fill box.
-- These pipes are used to fill the tank with the product.	
-- Remote fills have the potential to leak.	Discuss when remote fills are used. They often pose special problems because they are installed as an "afterthought."
5. Vapor recovery lines are pipes that convey petroleum vapors back to the tank truck during off-loading or back to the UST during dispensing of product. In Stage II vapor recovery, there will be twice as much piping in the UST system because pipes run from dispenser back to tank.	**Slide 7:** Define vapor recovery lines. Discuss vapor recovery lines and Stage II, if it is used in areas of your State.
C. Product dispensers	
1. A pumping system draws or pushes product through the product delivery lines to a delivery hose, which dispenses the product.	
2. At retail stations, meters attached to product dispensers measure the volume of product dispensed from the UST system.	

Lecture Notes	Instructional Aids
D. **The site** 1. Excavation zone is the entire area that must be dug up in order to install an UST.	**Slide 8:** Explain each of these terms and use the following graphic to point them out. **Slide 9 (graphic):** Point out each of the terms discussed in Slide 8.
2. Backfill is any material used to fill in the excavation zone after the tank is in place. -- Manufacturers' suggestions should be followed regarding the proper backfill to be used (generally, crushed rock, pea gravel, or sand).	Explain that ideally the backfill should meet specifications, but may in reality be local soil, contaminated soil, etc. Describe problems you may have seen that resulted from improper backfill.
3. Water table is the level where ground water will rest in porous soil conditions under normal atmospheric pressure.	
	Slide 10 (Review/Wrap Up): This is a repeat of Slide 1, to be used as a review of what you have covered. Mention the main topics discussed. Use this time to answer any questions or to discuss specific UST systems.

CHAPTER THREE

SITE CHARACTERISTICS

What are the important site characteristics that should be considered when selecting the proper leak detection method? This chapter will introduce you to relevant UST system characteristics, product characteristics, soil conditions, climatic factors, and geologic conditions. An understanding of these factors will help you assist UST owners and operators in making a more informed decision about the leak detection methods that can be used with particular UST systems.

Lecture Notes	Instructional Aids
Choosing the appropriate leak detection method for a particular UST system requires understanding how site characteristics can vary. The basic factors to consider when selecting a leak detection method fall into five groups: I. UST system characteristics; II. Product characteristics; III. Soil conditions; IV. Climatic factors; and V. Geologic conditions.	**Slide 1:** Chapter Three slides. **Slide 2:** Use this slide to introduce the chapter, explaining that an understanding of the following site characteristics will assist the UST staff member to work with the owners/operators to determine the most appropriate leak detection method for their UST system. Explain that students will be asked to participate in an exercise at the end of the chapter to review the material and check for understanding.

Lecture Notes	Instructional Aids
I. **UST SYSTEM CHARACTERISTICS**	**Slide 3:** This slide is an overview of UST system characteristics, each of which will be discussed.
A. **Tank age (new vs. existing)**	**Slide 4:** There are different compliance deadlines for existing tanks -- those installed before December 23, 1988, and new tanks -- those installed after December 23, 1988.
1. New tanks are those installed after December 23, 1988. Existing tanks are those installed before December 23, 1988.	
2. Leak detection compliance deadlines differ for new and existing tanks.	**Slide 5 (graphic):** Phase-in schedule for compliance with Federal UST regulations.
3. Some leak detection methods can be used only for 10 years after installation of a new UST or upgrade of an existing UST.	
4. Some leak detection methods are better suited for new tanks, while others easily can be incorporated into existing tank systems.	
B. **Tank size**	**Slide 6:** The size of the tank may limit the selection of leak detection methods involving manual tank gauging, automatic tank gauging systems, and some tank tightness tests.
1. Certain leak detection methods cannot be used with tanks larger than a specified capacity.	
C. **Piping system**	**Slide 7:** Briefly describe the two types of piping. These types will be discussed in detail in Chapter Five.
1. Types of piping systems	
-- Suction piping systems use a vacuum to draw the product from the tank to the dispenser.	
-- Pressurized piping systems use a pump at the bottom of the tank to push the product to the dispenser.	
2. Leak detection requirements for piping differ based on the type of piping system used.	

Lecture Notes	Instructional Aids
D. UST system size	**Slide 8:** Discuss both the numbers of tanks, and the extent of the site area. These variables may be important when selecting a leak detection method.
1. Number of tanks	
-- Some leak detection methods may be better suited or less costly than other methods for systems with many tanks.	
2. Extent of site area	**Slide 9:** (This slide has been deleted.)
-- Some leak detection methods may be more effective or less costly for UST systems that cover a large area.	

Lecture Notes	Instructional Aids
II. PRODUCT CHARACTERISTICS **A. Types of stored product** Stored products fall into two general groups: petroleum products and some hazardous substances. 1. Petroleum products (major types): -- Gasoline and blends; -- Diesel fuel; -- Aviation fuel; -- Kerosene; -- Heating oil; and -- Used oil.	**Slide 10:** Discuss the most common types of stored products, as well as other products that workers may encounter. Mention that this course is geared towards petroleum products; however, other products may be stored. Characteristics of the products are discussed individually below in Section B.
2. Hazardous substances: -- CERCLA (Superfund) hazardous substances are subject to UST regulations. For example, ferric chloride, lead iodide, and zinc nitrate are hazardous substances. -- CERCLA hazardous substances require secondary containment unless it can be proved that another method will work. *This course does not equip you to determine if other methods are sufficient.* -- RCRA hazardous wastes are not subject to UST regulations because they are under different regulations. (See 40 CFR Parts 260-270 for hazardous waste regulations.)	Discuss the hazardous substances that are stored, and which of these are covered by the regulations. **Note:** It is important to stress to students that this course is designed to inform them about leak detection methods, but it will not prepare them to determine if a method is suitable for hazardous substances. *Secondary containment with interstitial monitoring is the only method that is always suitable for hazardous substances.* This will be discussed further in Chapter Four.

Lecture Notes	Instructional Aids
B. Characteristics of stored products	
Traits of different products may render certain leak detection methods inappropriate. Important characteristics include:	**Slide 11:** Product characteristics.
-- Solubility;	
-- Density;	
-- Viscosity;	
-- Volatility;	
-- Thermal effects; and	
-- Compatibility with tank and piping materials.	
1. Solubility	**Slide 12:** Define solubility. Use examples to help clarify. For example, alcohol in water is soluble; oil in water is much less soluble.
-- Solubility is the ability of a substance to dissolve in or mix with another substance. For example, alcohol mixes more easily with water than oil does.	
-- This characteristic is important to know because if the product mixes easily with water, some methods may not easily be able to detect its presence (for example, ground-water monitoring).	
2. Density	**Slide 13:** Define density. The density of a material will determine whether it floats or sinks.
-- Density refers to the mass of a given substance per unit volume.	
-- If the density of the product is higher than that of water, the product may sink beneath the ground-water surface and is not easily detectable. Therefore, ground-water monitoring is not allowed for these substances.	**Slide 14:** Gasoline floats on ground water; dense non-aqueous phase liquids (DNAPLs) do not.

Lecture Notes	Instructional Aids
3. Viscosity -- Viscosity is a measurement of the ease with which a liquid flows (for example, molasses vs. water). -- The degree of viscosity varies with changes in temperature. -- A product's viscosity may affect which method is suitable (for example, whether tank testing can be conducted, ground-water monitoring is effective, automatic tank gauging can be used).	**Slide 15:** Define viscosity. Tell students to imagine water flowing vs. molasses flowing.
4. Volatility -- Volatility refers to how readily a substance will vaporize. -- Volatility of the product may affect the use of certain leak detection methods. For example, a product must vaporize easily if it is to be detected in vapor monitoring wells.	**Slide 16:** Define volatility. Certain materials evaporate much easier than others. Use gasoline vs. heating oil to clarify.
5. Thermal effects -- Thermal effects refer to changes in product characteristics that occur in response to an increase or decrease in temperature.	**Slide 17:** Thermal effects are of particular concern in areas of extreme temperatures, or areas that experience large temperature variations.
-- Density, viscosity, and volatility are product characteristics that are affected by temperature. -- For example, lower temperatures reduce the volatility of a product. As a result, vapor monitoring can be affected at sites storing a product that does not vaporize well at low temperatures.	Discuss how other characteristics change with temperature.

Lecture Notes	Instructional Aids
-- Temperature changes can affect the volume of a product. Monitoring methods that measure volume need to account for changes in volume created by temperature changes.	
6. Compatibility	
-- Compatibility refers to the chemical effects stored products may have on tank materials.	
-- Certain fuel blends (methanol and ethanol) and hazardous substances may not be compatible with the tank and piping material or tank lining, causing them to degrade.	
-- A tank owner storing these materials should check with the manufacturer to ensure that they are compatible with the tank and piping.	

Lecture Notes	Instructional Aids
III. SOIL CONDITIONS: BACKFILL & SURROUNDING SOIL	**Slide 18:** There are three soil characteristics that we will discuss: porosity, hydraulic conductivity, and contamination.
A. Relative porosity	**Slide 19:** Define porosity.
1. Relative porosity refers to a measurement of the extent to which a material (for example, soil or backfill) contains small spaces through which vapors or liquids can pass.	
2. Higher porosity backfill materials allow product vapors and liquids to pass through with greater ease.	
3. Methods that monitor the environment around the tank for signs of the leaked product require higher porosity backfills. New backfill that meets codes would meet porosity requirements. Older backfill needs to be tested for porosity to gauge whether porosity is sufficient for external methods to detect leaks quickly.	**Slide 20 (graphic):** This graph shows the effect of soil conditions (porosity and moisture) on vapor concentrations. Note that the readings were taken the same distance from the free product, at the same time. A low porosity, high moisture soil can mask the vapors detected, so certain detection methods may require greater well spacing.
B. Hydraulic conductivity	**Slide 21:** Define hydraulic conductivity. Explain that this <u>and</u> porosity need to be considered. It is possible to have a high porosity with low conductivity. (The pores may be large, but not connected, so fluid cannot travel through.)
1. Hydraulic conductivity refers to a measurement of the rate at which a liquid (for example, water) can flow through a material such as soil.	
2. Some materials can have high porosities but low hydraulic conductivity; thus, both measurements should be considered.	For example, clay has significant void space (high porosity), but low conductivity.
3. The presence of backfill materials with low hydraulic conductivity (for example, clay) generally precludes the use of leak detection methods that monitor the environment around the tank and piping.	Conductivity may also be affected by karst topography or utility conduits.

Lecture Notes	Instructional Aids
C. Contamination	**Slide 22:** Mention problems that can occur due to previously contaminated soil or backfill. Tests may incorrectly indicate a leak even when there is no problem with the UST system.
1. Soil or backfill may be contaminated by past releases (for example, leaks, spills, or overfills).	
2. Some methods of leak detection would sense this past contamination and inaccurately signal a current leak.	
	Review soil conditions. Answer questions.

Lecture Notes	Instructional Aids
IV. CLIMATIC FACTORS **A. Temperature** 1. Extreme temperatures or dramatic changes in temperature may affect the accuracy of certain leak detection methods, and may render other methods ineffective. **B. Rainfall** 1. Sites subject to heavy rainfall may experience significant changes in ground-water levels. -- Fluctuating ground-water levels may affect the accuracy of ground-water monitoring, and vapor monitoring.	**Slide 23:** Both temperature and amount of rain-fall may affect results obtained by certain leak detection methods. Discuss how these factors may be a problem in your State.

Lecture Notes	Instructional Aids
V. **GEOLOGIC CONDITIONS**	**Slide 24:** There are also ground-water conditions to consider.
A. **Effects of ground water** 1. The level of ground water relative to the tank's product level and the location of the "hole" can affect both the rate and direction of a leak. If ground water is higher than the product level inside a tank, ground water will generally flow into the tank. If the product level is higher than the ground-water level, the product will generally flow out of the tank. By influencing both the rate and direction of a leak, the level and density of ground water relative to the level and density of the product in a tank can mask a leak. To detect leaks in this situation, monitoring devices need to be used that can detect water in the tank.	**Slide 25:** Discuss how the presence of ground water can mask a leak. **Slide 26 (graphic):** Use this diagram to explain how ground water can slow a leak by exerting pressure on the tank, or increase the volume by seeping into the tank.
B. **Important ground-water variables** 1. Depth of water table -- The water table depth may affect the accuracy of vapor and ground-water monitoring. 2. Large fluctuations in the water table levels affect the accuracy of vapor and ground-water monitoring methods.	**Slide 27:** The depth and gradient of the water table may influence the leak detection method used. Stress problems that this causes in your area, especially in areas of a fluctuating water table (e.g., tidal areas).
3. Gradient of ground-water flow -- If the gradient is steep, and the monitoring wells are not properly placed, ground-water flow may bypass the monitoring wells and the release may not be detected.	Explain that with a steep gradient, the free product may flow in a single, narrow path, thus missing a well. With a gentle gradient, the product may flow slower and spread out more horizontally, thus having a greater chance of being detected by the well. (Have students envision water flowing down a steeply versus a slightly sloped pane of glass.)

Lecture Notes	Instructional Aids
	Slide 28: Use this slide as a review to show what material has been covered in the chapter. Ask if there are any questions or specific characteristics that they wish to discuss further. Hand out the exercise on UST Site Characteristics from Appendix II. Have students work either individually or in small groups. Allow 10-15 minutes (or more if necessary). Then go over the questions with students in a group. Make sure that any State-specific questions that might be helpful are covered. A sample list of questions also is included in Appendix II.

CHAPTER FOUR

LEAK DETECTION METHODS FOR TANKS

How can you assist the owner or operator to select the right leak detection method for a specific UST? This chapter describes several methods that meet the Federal requirements for leak detection. This chapter's descriptions, considerations, and limitations noted for each system can help you assist owners and operators in choosing the best leak detection system for their particular facilities. The chapter is divided into three parts: Part I notes some general leak detection requirements, Part II deals with monthly monitoring methods, and Part III treats the temporary leak detection method of tank tightness testing and inventory control.

Lecture Notes	Instructional Aids
I. GENERAL LEAK DETECTION REQUIREMENTS	**Slide 1:** Chapter Four slides.
A. Deadlines ◄ 1. New tanks	**Slide 2:** Use this slide to introduce the chapter. Mention that each method will be discussed in detail in the chapter, including how it works, its applicability, and special considerations. **Slide 2A (graphic photo):** Leak detection alternatives.
-- Tanks installed after December 23, 1988, must comply with UST leak detection requirements **when Installed.**	**Slide 3:** Remind students that deadlines will have to be met according to the date of tank installation. A "new" tank is one installed after December 1988.
◄ 2. Existing tanks	
-- Tanks installed before December 23, 1988, must comply with UST leak detection requirements according to the following timetable:	**Note:** Remind students that the (◄) represents basic Federal regulations.
	Slide 4: Review compliance dates.

Installation Date	Must Comply By
Before 1965*	December 1989
1965 - 1969	December 1990
1970 - 1974	December 1991
1975 - 1979	December 1992
1980 - 1988	December 1993

* Or if installation date is unknown.

Lecture Notes	Instructional Aids
B. Leak detection methods allowed	**Slides 5 and 6:** Discuss new tank requirements. Point out the differences between new tank requirements and those for existing tanks.
1. New tanks require one of the following:	
— Monthly monitoring; or	
— Monthly inventory control with tank tightness testing every five years. This option can be used only for ten years after installation.	
2. Existing tanks require one of the following:	Note that monthly inventory control with tank tightness testing can be used only for ten years after installation or upgrade (or until December 1998 for tanks without upgrade).
— Monthly monitoring; or	
— Monthly inventory control and annual tank tightness testing. This option can be used only until December 1998; or	
— Monthly inventory control and tank tightness testing every five years. This option can be used only for ten years after a tank has been upgraded with spill/overflow prevention devices and corrosion protection.	
C. Requirements for probability of detection/probability of false alarm (PD/PFA)	**Slide 7:** Discuss PD/PFA "95 and 5" requirements.
1. Some leak detection methods (tank or piping tightness testing, automatic tank gauging systems, statistical inventory reconciliation, and automatic line leak detectors) must be capable of detecting the leak rate or quantity specified for that method with a probability of detection (PD) of 0.95 and a probability of false alarm (PFA) of 0.05.	
There are two PD/PFA compliance deadlines:	
— By December 1990, automatic tank gauging systems, statistical inventory reconciliation, and tightness tests for tanks or piping must meet PD/PFA requirements;	
— By September 1991, automatic line leak detectors must meet PD/PFA requirements.	

Lecture Notes	Instructional Aids

However, methods permanently installed before the applicable compliance deadline are not required to meet the PD/PFA requirements.

D. Standard test procedures

EPA has developed standard test procedures (also known as protocols) that enable manufacturers of release detection methods and third-party evaluators of those methods to demonstrate that the methods can meet the Federal release detection requirements. Results form these highly technical testing procedures can be summarized on a short form provided with each test procedure. Having summarized test results, manufacturers can distribute the forms to tank owners and State and local regulators, who can use them to verify that the method being described meets EPA's release detection standards.

As of January 1992, EPA has published seven standard test procedures:

— Volumetric tank tightness test methods;

— Non-volumentric tank tightness test methods;

— Automatic tank gauging systems;

— Liquid-phase out-of-tank product detectors;

— Vapor-phase out-of-tank product detectors;

— Statistical inventory reconciliation methods; and

— Pipeline leak detection systems.

Your course instructor can tell you more about these published standard test procedures and how to get copies of them.

Lecture Notes	Instructional Aids
II. LEAK DETECTION METHODS: MONTHLY MONITORING	**Slide 8:** Each of these methods will be discussed in this chapter.
Federal regulations describe five acceptable monthly monitoring methods:	**Note:** Place emphasis on the methods that are most commonly used in your area.
-- Automatic tank gauging systems; -- Manual tank gauging; -- Secondary containment with interstitial monitoring; -- Ground-water monitoring; and -- Vapor monitoring.	**Note:** Remind students that these methods are conducted at least monthly.
The following sections briefly describe each method, discuss the conditions suitable for a method's application, and point out the major factors owners and operators should consider when selecting a method.	**Slide 9:** Each method is discussed within the following structure: how the method works; when the method is appropriate; and considerations for owners/operators.
A. Automatic tank gauging systems (ATGS)	**Slide 9A (graphic photo):** ATGS introduction.
1. How ATGS work	**Slide 10:** The first method is ATGS.
Automatic tank gauging systems continuously measure and record product level and temperature within the tank to determine the change in volume over time. If there is a significant loss of volume, then there may be a leak.	ATGS continuously measure product level, water level, and temperature in the tank. **Slide 10A (graphic photo):** Facility layout showing ATGS.
-- Each tank is equipped with a probe to measure product level and temperature.	The sensors continuously measure the product in the tank. If there is a significant loss of volume that cannot be accounted for due to temperature change, a leak may be indicated.
-- Underground wiring connects the tank with a monitor and microprocessor to record data read by probe:	**Slide 11 (graphic):** Use this graphic to point out the various parts of an ATGS. Point out that the probe is inside the tank.
- Product level; - Water level; and - Temperature.	**Slide 11A (photo):** ATGS probe installed into a tank. **Slide 11B (photo):** ATGS remote monitor. Point out readings that can be obtained from the monitor. **Slide 11C (photo):** ATGS remote monitor.

Lecture Notes	Instructional Aids
-- A leak is indicated if recorded temperature changes cannot account for the measured volume change.	
-- ATGS must be able to detect 0.2 gal/h release from any portion of the tank that routinely contains product.	
-- ATGS have two modes, and the same equipment performs both operations:	**Slide 12:** There are two modes of operation of an ATGS.
- Inventory control; and - Leak testing.	**Slide 13 (graphic):** Based on this flow chart, discuss activities and procedures for setting up, monitoring, and analyzing data with an ATGS.
a. Inventory control mode -- This mode automatically records activities of an in-service tank, including deliveries.	**Slide 14:** Discuss how an ATGS works; that the tank has a dedicated opening for the ATGS and measurements are automatically taken and converted into volume.
- Product level and temperature readings are taken automatically and computer converts them to volume measurements.	
- ATGS operate in this mode whenever leak test mode is not being performed.	
-- In most systems, a probe measures water levels in the bottom of the tank and converts to a volume, which is used in inventory control. The probe can also indicate a leak of ground water into the tank.	Mention that these are typical characteristics of ATGS, and that systems will vary according to manufacturer.
-- For most ATGS, on-site staff must manually record dispenser information.	

Lecture Notes	Instructional Aids
-- Many systems have alarms to alert on-site staff of:	**Slide 15:** Discuss ATGS Alarm Systems.
- High and low product levels;	
- High water levels inside tank; and	
- Theft.	
b. Leak testing mode	**Slide 16:** Discuss how the leak testing mode works. The longer the test is conducted, the more accurate the results will be.
-- Product level and temperature are measured generally at least two hours a month in out-of-service tanks, usually at night. The test can be set to last a given length of time.	
- The frequency of measurements and length of test is determined by the manufacturer to meet PD/PFA requirements and the regulatory performance standard of 0.2 gal/hr, and are programmed into ATGS. Generally, the longer the test is conducted, the higher the performance level of the test.	
- Test can be run with any level of product in the tank.	
- The temperature and product level readings are taken automatically.	
2. When automatic tank gauging systems are appropriate	**Slides 17 and 18:** Discuss when ATGS are appropriate.
a. UST system characteristics	
-- ATGS are used primarily on tanks smaller than 15,000 gallons.	

Lecture Notes	Instructional Aids
-- ATGS cannot be used for piping.	
b. Product characteristics	**Note:** For each leak detection method the discussion will go through each of the site characteristics from Chapter Three.
-- To date ATGS used mostly with gasoline or diesel tanks because service stations have been the primary ATGS users.	
-- If other products are to be tested, owner/operator should ascertain that ATGS meets regulatory performance standards when used with that product.	
c. Soil conditions	
-- Use of ATGS is not restricted by soil type.	
d. Climatic factors	
-- Wait at least six hours between delivery and testing to stabilize temperature differences between added product and product already in tank. The wait time may vary due to climate.	**Slide 19 (graphic):** This graphic helps explain why at least a six-hour waiting period is necessary. Newly added product causes chaos within the normal tank product stratification (layering). Once the product has re-stratified, tests can be conducted, achieving more accurate results. The left side of the graph represents temperature. The horizontal axis represents the number of hours. Note how the temperature layers "calm down."
e. Geologic conditions	
-- If the ground water is high enough to cover a hole in a leaking tank, a leak may be masked and water may enter the tank.	**Slide 20 (graphic):** Use this graphic to explain how changing levels in ground water can affect test results. High ground water can mask a leak or allow water into the tank.
-- Therefore, ATGS should have water sensors with alarms, so that they can monitor for an increase in water as well as a decrease in the level of product.	**Slide 20A (graphic photo):** Sample results from an ATGS.

Lecture Notes	Instructional Aids
3. Considerations	**Slides 21 and 22:** Discuss the other considerations for the use of ATGS.
-- No product should be delivered to the tank for at least six hours before the monthly test, to allow the temperature to stabilize.	
-- No withdrawal should be made from the tank for a few hours prior to testing. Withdrawals disturb the stratified layers in the tank, which can lead to inaccurate test results.	
-- No product withdrawals or deliveries can be made during the monthly test which lasts one to six hours or more, depending on the manufacturers' recommendation.	
-- ATGS automation reduces time that employees must spend in monitoring leak detection.	
-- Inventory control and potential off-site monitoring features are attractive to some owners and operators.	
-- Tanks require a dedicated opening for the ATGS probe, making retrofit difficult in some cases.	Hand out exercise on ATGS from Appendix II. Discuss as a group once students have had the opportunity to work through the problem.
B. Manual tank gauging (MTG)	**Slide 23:** Note that MTG can be used only on small tanks (under 2001 gallons). Describe MTG and explain that this method must be conducted in a static tank, and must last 36 to 58 hours, depending on the size of the tank.
1. How MTG works	
MTG is a short-term test in a static (i.e., closed) tank. It cannot be used for tanks larger than 2,000 gallons.	
a. It differs from inventory control, which requires daily recording of volume in an active tank, and keeping track of additions and withdrawals.	

Lecture Notes	Instructional Aids
b. With MTG, weekly measurements of product levels are taken with a gauge stick inserted in the tank through the fill pipe.	**Slide 23A (photo):** Person using a gauge stick.
c. A test is conducted once each week and lasts at least 36 hours.	**Slide 24:** Discuss each requirement for MTG. Emphasize those required by the regulations.
d. The UST must not be in use between measurements (no product can be added or withdrawn during this test period).	
e. Four measurements must be taken:	
-- Two at beginning of the weekly test; and	
-- Two at end of the weekly test.	
f. A calibration chart specific to the tank is used to convert product level measurement into product volume.	**Slide 25 (graphic):** Enlarged sample calibration chart. Point out the depth (in inches), tank capacity, and how to find the product volume. Emphasize that the owner/operator should have the calibration chart for his or her tank from the tank's manufacturer.
g. The average of the final two measurements is subtracted from the average of the first two to obtain the change in product volume over time.	**Slide 26:** Discuss how MTG works.
h. The calculated product volume change is compared to weekly and monthly standards (below, in gallons). If the volume change exceeds these standards, the tank may be leaking. (The monthly figure is a simple average of the weekly measurements.)	**Slide 27:** Discuss the chart of weekly and monthly standards for volume change.

Lecture Notes	Instructional Aids

Tank Capacity (gal.)	Weekly Change (gal.)	Monthly Change (gal.)	Test Duration (hrs.)
Up to 550	10	5	36
551-1,000(64"x73")	9	4	44
1,000(48"x128")	12	6	58
If MTG is combined with TTT:			
1,001 - 2,000	26	13	36

2. When MTG is appropriate

   a. UST system characteristics

   -- Only tanks of 1,000 gallons or less can use MTG as the only leak detection method for the life of the tank.

   Slide 28: Discuss tank size and the restrictions that apply.

   -- Tanks between 1,001 and 2,000 gallons must combine MTG with tank tightness testing. This combined method can be used only for ten years following new tank installation or upgrade of existing USTs. Tank tightness tests must be performed annually for existing, non-upgraded USTs, and every five years for upgraded and new USTs. (USTs that have not been upgraded cannot use this combined method after December 1998.)

   -- Tanks larger than 2,000 gallons cannot use MTG.

   -- MTG cannot be used for piping.

   b. Product characteristics

   -- Not restricted to particular fuel types.

   Slide 29: This method is not restricted to fuel types. However, a heavier fuel, such as used oil, will be easier to measure. (Imagine using a dip stick to measure alcohol vs. measuring used oil. The alcohol level would be difficult to read due to evaporation.)

Lecture Notes	Instructional Aids
-- Works best with heavier fluids (such as used oil and diesel) because they don't evaporate easily, are less sensitive to temperature changes, and can be seen more easily on the gauge stick.	
c. Soil conditions	
-- Use is not restricted by soil type.	
d. Climatic factors	**Slide 30:** Mention that the testing period can be extended so that the tests are conducted at the same time of day. This may be important in areas where the temperature varies greatly between day and night.
-- Ambient (surrounding) temperature changes may affect volume of stored product due to expansion and contraction of liquid. This is one of the reasons the test must last so long.	
-- If temperature change is great, the testing period can be lengthened so that the beginning and ending gauge measurements can be taken at the same time of day.	
-- Because this method does not account for temperature change, false alarms may occur in areas of extreme temperature variation.	
e. Geologic conditions	**Slide 31:** Once again, ground water may mask a leak.
-- If the ground water is higher than product level in a leaking tank, it can exert pressure that can hide a leak from MTG.	
-- Permanently high ground water may render this method inappropriate.	

Lecture Notes	Instructional Aids
3. Considerations	**Slide 32:** Tanks must be taken out of service for at least 36 hours a week.
◂ -- UST system must be removed from service at least 36 hours every week.	
-- Equipment costs are very low.	Answer any questions pertaining to MTG.
C. Secondary containment with interstitial monitoring	**Slide 32A (graphic photo):** Interstitial monitoring.
1. How secondary containment with interstitial monitoring works Secondary containment involves placing a barrier between the tank and its surrounding environment. The barrier may fully or only partially enclose the UST. Leaks are contained in the space between the tank and its secondary barrier. In addition, interstitial monitoring systems test for presence of released product in the space (interstice) between the tank and its outer containment barrier.	**Slide 33:** Discuss how secondary containment provides a barrier between the tank and the surrounding environment. The interstitial monitor tests for leaks in the space between the tank and the barrier.
a. Secondary containment may include: -- Concrete vault;	**Slide 34 (graphic):** Shows tanks within a concrete vault. They are on supports, as shown, with or without backfill. Notice the sump installed for detecting leaks.
-- Double-walled tank;	**Slide 35 (graphic):** Shows double-walled tanks.
-- Tank with excavation liner; and	**Slide 36 (graphic):** Shows a diagram of a tank with a liner installed.
	Slide 36A (photo): Excavation liner.
	Slide 36B (photo): Spread out liner.
	Slide 36C (photo): Tank and observation wells installed.
	Slide 36D (photo): Backfill.
-- Internal bladder.	**Slide 36E (photo):** Internal bladder.
	Slide 36F (photo): Internal bladder installed in tank.
	Slide 36G (photo): Interstitial space monitor for internal bladder.

Lecture Notes	Instructional Aids
b. Fully enclosed systems include:	
-- Concrete vaults,	
-- Double-walled tanks, and	
-- Internal bladders.	
c. Partially enclosed systems may include:	
-- Excavation liners.	
-- In areas of heavy rainfall, liners should fully enclose the tank to prevent rainwater from sitting in the backfill and interfering with the monitoring equipment.	
d. Interstitial monitoring methods include:	**Slide 37:** Discuss each monitoring method. Which are most common in your State?
-- Electrical conductivity methods monitor changes in conductivity by differentiating between petroleum (nonpolar) and water (polar).	**Slide 38 (graphic):** Shows where sensors for two types of interstitial monitoring are placed. Mention that the system would normally use only either vapor or liquid sensors, not both.
-- Pressure sensing methods apply either vacuum or pressure to the interstitial space. A leak is detected by changes in pressure.	
-- Liquid sensors detect the presence of a liquid by use of coated fibers or other materials that respond preferentially to liquid in the tank. Alternatively, there may be a pressure switch at the bottom of the interstitial space.	
-- Hydrostatic sensors monitor changes in the level of liquid in the interstitial space.	
-- Manual detection methods use product-finding paste on a dipstick to find liquid product in the interstitial space.	

Lecture Notes	Instructional Aids
-- Vapor monitoring checks for presence of product fumes in the interstitial space.	
2. When secondary containment with interstitial monitoring is appropriate	
a. UST system characteristics	**Slide 39:** Discuss each point on the slide.
-- This method can be used for both tanks and piping.	
- Containment system for piping involves placing liner underneath or around piping to establish interstitial space, assembling a pipe within a larger diameter pipe, and double-walled piping.	
-- Double-walled tanks are seldom larger than 20,000 gallons.	
- Larger tanks are very heavy and difficult to ship.	
-- Excavation liners may be used around any size tank.	
-- Secondary containment is impractical for existing tanks and piping, except when internal bladders are available for existing tanks.	
- Installation for existing tanks and piping requires substantial retrofitting.	
b. Product characteristics	**Slide 40:** Note that this is the only method that can always be used for hazardous substances, as long as interstitial monitoring is appropriate for the stored substance. Other methods can be used with hazardous substances if the manufacturer can demonstrate that the method is effective. This course does not prepare the student to determine if the other methods are appropriate for specific hazardous substances.
-- Use of this method is unrestricted for all fuel types.	
c. Soil conditions	
-- Use of this method is not restricted by soil type.	

Lecture Notes	Instructional Aids
d. Climatic factors -- This method can be used in all climatic conditions. However, in areas with heavy rainfall, a barrier system which fully encloses the tank should be used to prevent rain from interfering with the monitoring system. A tank liner that only partially encloses the tank may collect water, and therefore is not appropriate.	**Slide 41:** Areas where there is high annual rainfall or a high water table will need to install fully enclosed containment systems to prevent water from interfering with the monitoring system.
e. Geologic conditions -- Tanks located in areas with high ground water should use a fully enclosed containment system.	
3. Considerations a. Installation of secondary containment using liners requires even more careful attention by professional installers than other leak detection methods. b. Containment barrier used must be compatible with product stored. -- Exposure to product should not result in deterioration of barrier, which would release product into the environment. -- For standard petroleum products, such as gasoline and diesel fuel, most liners sold by reputable firms are compatible with product. -- For other products, nature of product and type of barrier must be considered to ensure an appropriate match.	**Slides 42, 43, and 44:** Discuss other points to consider when using secondary containment with interstitial monitoring. What are other considerations or problems that you have encountered?

Lecture Notes	Instructional Aids
c. If a leak occurs, the barrier provides a degree of protection for surrounding environment against exposure.	
– This aspect differentiates this method from others, which detect leaks but do not contain them.	
– Lower corrective action costs associated with this method than with other leak detection methods.	
D. Ground-water monitoring	**Slide 44A (graphic photo):** Introduction to ground-water monitoring.
1. How ground-water monitoring works	
Ground-water monitoring detects free product in monitoring wells. The monitoring wells extend from the ground surface to several feet below the lowest water table level. The leaked product travels through the soil and reaches ground-water wells and detection equipment.	**Slide 45:** Discuss structure of ground-water monitoring wells and how ground-water monitoring works.
a. Monitoring wells	
– Generally one to four wells per UST system will adequately detect leaks.	
– Wells must be placed in, or near, backfill so that they can detect leaks rapidly.	**Slide 46 (graphic):** Shows components of a typical ground-water monitoring well. **Note:** It may be beneficial to bring in sections of screening and other well materials.
– To intercept free product the well screen must extend from the bottom of well to the highest point of the water table surface.	**Slide 47 (graphic):** Shows placement of a monitoring well, and how it will detect free product.
– On-site staff must check wells at least monthly for presence of free product.	**Slide 48 (graphic):** Shows that the screen must cover the entire range of ground-water fluctuation.

Lecture Notes	Instructional Aids
b. Manual devices for detecting free product	**Slide 49:** Discuss manual sample collection, such as use of bailers, and automated systems.
-- Grab samplers (bailers or buckets) collect liquid samples for visual inspection or on-site electronic analysis.	**Slide 50:** Bring in examples of bailers and paste, if possible. **Slide 50A (photo)**: Person using bailer. **Slide 50B (photo)**: Person using bailer.
-- Chemical-sensitive pastes, attached to a weighted tape measure, are lowered into the well and change color when hydrocarbons are present.	**Slide 50C (photo)**: Drop stick with paste.
-- Manual devices must be used at least once a month. Additional measurements need to be taken during the month.	
-- Manual devices need to be able to detect 1/8 inch of free product.	
c. Automatic devices for detecting free product	**Slide 51:** Describe how these detection devices work.
-- These devices need to be able to detect 1/8 inch of free product.	
-- Differential float devices contain two floats:	
- One float reacts only to liquids with density similar to water.	**Slide 52 (graphic):** Shows cross-section of differential float devices. Note that graphic illustrates a monitoring well contaminated by a considerable amount of product.
- One float responds only to liquids lighter than water.	
- Different float levels will trigger an alarm.	
-- Product soluble devices:	**Slide 53 (graphic):** Cross-section of product-soluble device.
- These devices are coated with material that degrades when exposed to hydrocarbons.	

Lecture Notes	Instructional Aids
-- Thermal conductivity devices: - These devices measure heat loss when a floating probe contacts certain liquids.	**Slide 54 (graphic):** Cross-section of thermal conductivity device.
-- Electrical conductivity devices: - These devices measure changes in electrical resistance that trigger alarms.	
-- Automatic monitoring devices must be operated at least once a month.	
-- Automatic monitoring devices are either permanently installed or placed in the well during each test.	
2. When ground-water monitoring is appropriate	
a. UST system characteristics	**Slide 55:** Discuss these and other factors that could affect applicability.
-- This method can be used to detect leaks from tanks and piping.	
-- This method may be used on any size tank. For larger systems, more wells are added.	
-- This method may be retrofitted, but installer must be careful not to puncture tanks or piping.	
b. Product characteristics	**Slide 56:** Product characteristics.
-- Product density must be lower than that of water. (Product must float on top of water.)	

Lecture Notes	Instructional Aids
-- The product should not mix easily with water. (If it mixes, no free product layer will form.)	**Note:** Product must be a "floater" vs. a "sinker," i.e., must not mix readily with water. Method is most commonly used with gasoline and diesel fuels.
-- This method is most commonly used for gasoline and diesel fuels. (Alcohols and water-soluble chemicals are not appropriate.)	
c. Soil conditions	
-- If this method is used alone, soil and backfill material between well and UST must be coarse and permeable (for example, sand or gravel) to allow released product to travel to wells.	**Slide 57:** Explain the terms "porosity" and "hydraulic conductivity." (Review from Chapter Three) **Slide 57A (photo):** Drilling. **Slide 57B (photo):** Taking a soil core sample.
-- Hydraulic conductivity of backfill material and soil between tank and monitoring well should be more than 0.01 cm/sec.	**Slide 57C (photo):** Workers installing backfill.
-- If national codes are followed for installation, the above requirements and conditions will have been met.	
d. Climatic factors	**Slide 58:** Discuss climatic problems relating to ground-water monitoring as they pertain to your State (e.g., high annual rainfall, low rainfall or extreme temperatures).
-- Very low temperatures may interfere with some monitoring devices. Ice can freeze monitors and interfere with product-soluble devices.	
e. Geologic conditions	**Slide 59:** Discuss these requirements.
-- Level of ground-water table	
- If this method is used alone, ground water must not be more than 20 feet below the surface.	

Lecture Notes	Instructional Aids
- Ideally, the ground water should be between 2 and 10 feet from the surface.	Mention that it is essential to know the water table level and gradient in order to have an effective ground-water monitoring program.
-- Fluctuations in water table level	
- If water level falls below or rises above the well screen, this method alone becomes insufficient to detect released product.	
-- Gradient of ground-water flow	
- If the gradient is steep, the product may bypass the monitoring wells. The most complete coverage would have wells installed on all sides of the site to intercept product and ensure release detection.	**Note:** Describe liquid flowing down a steep hill vs. a gentle hill. The steep grade will cause the liquid to travel in a narrow path, vs. a gentle slope where the liquid might spread out more. Similarly, a steep gradient may mean that the release may flow past the well without being detected.
-- Fractures and cavities	
- Because free product tends to flow through fractures and cavities in the soil, wells that do not intercept these fractures and cavities will not detect free product.	**Slide 60 (graphic):** This graphic shows how the well can be installed in a seemingly good place, but due to the geology, will still not detect a release.
3. Considerations	
a. Site assessment is required before installation. This involves:	**Slide 61:** Discuss these considerations, and any others you may have. Is ground-water monitoring used frequently in your State? What specific problems prevent the use of ground-water monitoring?
-- Identification of soil type, ground-water depth and flow direction, and general geology of site.	

Lecture Notes	Instructional Aids
– Identification of evidence of previous leaks that would falsely indicate a current release.	
b. Simple operation of detection devices.	
– On-site staff must take samples at least once a month.	
c. When installing monitoring wells, it is essential to avoid puncturing tanks or piping for UST or utility lines (such as gas, sewer, water, and electric).	Review ground-water monitoring. Hand out the ground-water monitoring exercise from Appendix II. Discuss as a group once students have had the opportunity to work through the problem.
E. Vapor monitoring systems	
1. How vapor monitoring works Vapor monitoring systems check for presence of product fumes in the soil or backfill around tank. After a leaked material evaporates, its vapors travel through porous soil, and may be detected by vapor monitoring equipment located in monitoring wells.	**Slide 62:** Describe how vapor monitoring systems work; they monitor for presence of vapor from product near the UST system. Mention both automatic and manual systems.
a. This method is operated either automatically or manually.	**Slide 63 (graphic):** (This slide has been removed.)
– Automatic systems incorporate a network of sensors that test for presence of vapors in monitoring wells.	**Slide 64 (graphic):** A schematic diagram of an UST system with vapor monitoring.
– Manual monitoring systems collect air samples from wells surrounding tank to determine presence of vapors.	**Slide 65 (graphic):** A map view of an UST system with vapor monitoring. Note location of the three types of vapor wells: background, tank, and product line vapor wells.

Lecture Notes	Instructional Aids
2. When vapor monitoring is appropriate	**Slide 65A (graphic photo):** Vapor monitoring system. **Slide 65B (graphic photo):** Vapor monitor.
a. UST system characteristics -- This method can be used for both tanks and piping. -- This method can be installed as part of new or existing tanks and piping.	**Slide 66:** Discuss applicability of vapor monitoring. **Slide 66A (graphic photo):** Vapor monitoring trends upon start-up. **Slide 66B (graphic photo):** Vapor monitoring detecting a spill.
b. Product characteristics	**Slide 66C (graphic photo):** Soil Sentry data.
-- Vapor monitoring must be used with products that vaporize readily. For example, gasoline, diesel fuel, and aviation fuels are appropriate, but fuel oils No. 4 or No. 6 are not.	**Slide 67:** Give examples of fuels that are most appropriate for vapor monitoring due to their high volatility (e.g., gasoline).
c. Soil conditions -- The backfill and soil around the tank must be porous enough to allow the vapors to reach the monitoring wells. -- For example, sand and gravel are porous materials. Clay is not porous and should not be used as backfill.	**Slide 68:** Discuss how backfills can distort results, such as previous soil contamination. Soil type can affect how the vapor can travel.
-- Backfill and nearby soil must be clean and should not contain substances that will produce vapors. -- Previously contaminated soil may lead to false readings, indicating releases. d. Climatic factors	**Slide 69 (graphic):** This graph demonstrates the effects of soil conditions on vapor concentrations at a vapor monitoring well. The vertical axis is gasoline in ppm, the horizontal axis represents time in days. Note that the vapor concentrations are much lower in wet sand or clay vs. the dry backfill. These are all readings taken from the same release, at the same distance from the source.
-- Temperature affects the volatility of released product. Sensors may need to be adjusted for extreme temperatures.	**Slide 70:** Climate.

Lecture Notes		Instructional Aids
—	This method should not be used in areas with heavy annual rainfall or extremely moist climates.	
—	The water fills spaces between the soil particles, preventing vapor from travelling through the soil. Vapors may also dissolve in the mositure before reaching the monitors.	
—	Heavy rains may fill monitoring wells with water and drown sensors, if not properly capped and sealed.	
e.	Geologic conditions	**Slide 71:** Discuss slide.
—	This method should not be used in areas with high ground water because water interferes with vapor detection (as explained above).	
3.	Considerations	**Slide 72:** Discuss these and other considerations that are appropriate for your area.
a.	Manual monitoring systems require monthly time investment to obtain samples and have results analyzed.	
—	The time required increases for each tank included in system.	
—	Large sites require considerable time each month.	Hand out the vapor monitoring exercise from Appendix II. Discuss as a group once students have had the opportunity to work through the problem.
—	Samples are often sent offsite for analysis.	
b.	Owners and operators of existing USTs that have not been upgraded should consider using spill and overfill protection when using vapor monitoring.	
		Slide 73: (This slide has been removed.)

Lecture Notes	Instructional Aids
F. Statistical Inventory Reconciliation (SIR)	
The five monthly monitoring methods described so far were all identified in the Federal regulations that became effective in December 1988. The regulations provided, however, that other release detection methods could be approved in the future if those methods could meet EPA's performance standards for release detection. In June 1990, EPA published a standard test procedure for an additional release detection method that is known as Statistical Inventory Reconciliation (SIR). SIR methods must be evaluated using EPA's standard test procedure or an equivalent procedure to prove they can meet EPA's release detection performance standards.	
1. How SIR works	**Slide 73A:** Discuss basic SIR operation.
Statistical inventory reconciliation (SIR) analyzes inventory, delivery, and dispensing data collected over a period of time to determine whether or not a tank system is leaking.	
a. Each operating day the operator measures the product level using a gauge stick or other tank level gauge. A calibration chart specific to the tank is used to convert product level into product volume.	
— The operator also keeps complete records of all withdrawals from the UST and of deliveries to the UST.	
— After data have been collected for the period of time required by the SIR vendor, this information is provided to the SIR vendor.	
b. The SIR vendor uses sophisticated statistical software to conduct a computerized analysis of the data that can identify if the UST is leaking.	
c. Every month, the SIR vendor reports the results of the analysis to the operator, who keeps monthly reports on file for at least 12 months.	

Lecture Notes	Instructional Aids
d. The Federal requirements for monthly release detection are met if the SIR analysis is performed every month, is capable of detecting release rates of at least 0.2 gallons per hour (with a probability of detection of 0.95 and a probability of false alarm of 0.05), and the monthly results are available at the UST facility. State and local requirements can be more restrictive.	**Slide 73B:** Discuss Federal requirements, noting that tank tightness testing will be described in next section.
e. Also, SIR can qualify as a tank tightness test if it meets the Federal requirements of detecting release rates of at least 0.1 gallons per hour with a probability of detection of 0.95 and a probability of false alarm of 0.05. (Tank tightness testing is discussed in section III.B below.) State and local requirements can be more restrictive.	
2. When SIR is appropriate	
a. UST system characteristics	**Slide 73C:** Discuss these characteristics.
— SIR procedures apply to fueling sites where the required measurements can be taken every operating day. It is not appropriate for unattended facilities, unless the required data can be retrieved remotely.	
— SIR systems may be used on tanks up to the capacity for which an individual SIR system is evaluated. SIR systems are generally not certified for use on tanks larger than 18,000 gallons.	
b. Product characteristics	
— SIR is generally not restricted by product type.	
c. Soil conditions	
— SIR is not affected by soil type.	
d. Climatic factors	**Slide 73D:** Note that SIR vendors must be able to account for variables introduced by climatic factors and geologic conditions.
— Changes in climate, especially temperature, affect the data used in SIR, so SIR vendors must take climatic factors into consideration in their procedures.	

Lecture Notes	Instructional Aids
e. Geologic conditions	
— Ground water around a tank may hide a hole or distort the data to be analyzed by temporarily reducing or preventing the product from leaving the tank. To detect a leak in this situation, the UST operator must check for water at least once a month.	
3. Considerations	**Slide 73E**: Emphasize that SIR should not be confused with other inventory methods, because SIR depends on extremely sophisticated statistical analysis that requires a competent SIR vendor using software and computers effectively.
— SIR can be used for tank and piping systems.	
— SIR should not be confused with other release detection methods that also rely on periodic reconciliation of inventory, withdrawal, or delivery data. Unlike manual tank gauging and automatic tank gauging systems (described earlier) or inventory control (described in the following section), SIR uses a sophisticated statistical analysis of data to detect releases. This statistical analysis can only be done by competent vendors of SIR systems.	
— The procedures used by the SIR vendor must be evaluated against EPA's standard test procedures (or an equivalent protocol) to confirm that the procedures are capable of meeting the Federal regulatory requirements regarding the detection of minimum release rates and the probabilities of detection and false alarm.	
— Tank level and meter readings should be taken carefully at the same time each operating day, at a time when no product is being delivered or dispensed. SIR does not require that the tank be out of service for extended periods.	
— Data can be transmitted to the SIR vendor on paper or by using computer modems or diskettes.	**Slide 73F:** Discuss these considerations.
— SIR can identify problems other than leaking systems, such as miscalibrated meters, tilted tanks, and loss resulting from theft.	

Lecture Notes	Instructional Aids
— SIR requires minimal investment of staff time and equipment costs (usually involving a gauge stick and pastes that help identify product and water levels). The cost of services provided by SIR vendors compares favorably with the cost of other leak detection methods. — State and local governments can place restrictions on the use of SIR for compliance purposes.	

Lecture Notes	Instructional Aids
III. LEAK DETECTION METHOD: INVENTORY CONTROL & TANK TIGHTNESS TESTING	**Slide 74:** Discuss slide.
Inventory control must be combined with tank tightness testing to meet the leak detection requirements. This combined method can be used only during the first ten years following the installation of a new UST or the upgrade of an existing UST. Existing USTs without upgrade cannot use this combined method after December 1998.	**Slide 74A (graphic photo):** Inventory Control with tank tightness testing.
A. Inventory control 1. How inventory control works	**Slide 75:** Explain that inventory control is a <u>daily</u> accounting system (vs. manual tank gauging which is performed weekly).
Inventory control is a daily accounting system in which records of input and output of a product are compared to the measured product volume in an UST.	
-- Inventory control is only acceptable as a leak detection method when used with periodic tank tightness testing.	
-- Volume of product in the tank, deliveries, and sales are recorded daily.	
-- Each month the owner or operator balances accounts of deliveries and product sold from the tank with daily volume measurements.	
-- This method must be able to detect a monthly loss of 1.0 percent of flowthrough plus 130 gallons.	
-- If overage or shortage equals or exceeds 1.0 percent of the tank's flowthrough volume plus 130 gallons of product, the UST may be leaking.	Leak is indicated if there is an overage or shortage in tank volumes. Shortages could be due to leaks and release into the environment; overages could be the result of a hole into which water is seeping.

Lecture Notes	Instructional Aids
a. Daily tank gauging and reconciling	**Slide 76:** Describe the method of record-keeping.
-- Each morning and evening (or after each shift) product level is measured with a gauge stick marked to one-eighth of an inch. This procedure should be conducted at regular intervals.	**Slide 76A (photo):** Person using gauge to measure tank volume.
-- A gauge stick is inserted vertically through the fill pipe until it touches the tank's bottom.	**Slide 77:** Mention that it is essential that gauging be performed accurately.
- Product-finding paste can be used to highlight the level on the gauge stick.	
-- A calibration chart specific to the tank is used to convert product level into product volume. Similarly, water at the bottom of the tank is measured and accounted for in the reconciliation.	**Slide 78 (graphic):** Part of a sample calibration chart. Note that appropriate tank size column must be used to convert measured depth in inches into product volume in gallons.
-- Every day, product volume, withdrawals, and deliveries are recorded.	
b. Monthly reconciliation	
-- At least monthly, daily data on product volume, and the amounts of product delivered to and withdrawn from the UST are reconciled.	**Slide 79 (graphic):** Shows part of a monthly reconciliation form.
-- Daily overages and shortages that fluctuate randomly around zero are common for USTs without a leak.	

Lecture Notes	Instructional Aids
◄ – If monthly overage or shortage is greater than or equal to 1.0 percent of tank's flow-through volume plus 130 gallons of product, the UST may be leaking.	**Slide 80:** Review monthly procedures.
◄ - If this overage or shortage occurs over two consecutive months, the owner or operator must report results to local implementing agency as a possible leak.	
c. Tank stock control	**Slide 81:** It is very important to recognize and account for inaccurate meters and dispensers in the inventory.
◄ -- Dispensing meters must be correctly calibrated to local weights and measure standards to ensure accuracy of inventory control.	
-- Product delivery volumes must be verified.	
-- Unaccounted for additions and withdrawals (such as spillage or thefts) must be included in the reconciliation.	**Slide 82 (graphic):** Shows a flow chart of the inventory control procedure. Talk through this.
2. When inventory control is appropriate	
a. UST system characteristics	
-- Any size tank is appropriate as long as inventory control can meet the performance standard of 1.0 percent of flow-through plus 130 gallons.	**Slide 83:** Explain this performance standard.
– If the tank is not level you will need to create your own tank chart by adding increments of product and reading the corresponding level.	**Slide 83A (photo):** Instrument used to measure if tank is level.

Lecture Notes		Instructional Aids
b.	Product characteristics	**Slide 84:** Discuss slide.
--	This method is effective for gasoline and diesel fuel and products that have similar viscosities and thermal properties.	
--	If other products are stored, owner/operator should ensure that this method can be used satisfactorily with those substances.	
c.	Soil conditions	
--	Use is not restricted by soil type.	
d.	Climatic factors	
--	The ambient temperature should be noted when taking gauge readings. Inventory control is most accurate when performed at same time each day.	**Slide 85:** Discuss climate vulnerability as it applies to your State.
--	The temperature difference between newly-delivered product and product in tank limits accuracy of inventory control.	
--	Temperature increase or decrease causes expansion or contraction of product, and may mask or imitate a leak.	
e.	Geologic conditions	**Slide 86:** Ground water poses the problem of masking a leak.
--	High ground water may interfere with measurement. If water level fluctuates, testing will be able to catch leak only during low water levels.	
--	Inventory control may be inappropriate for areas with permanent high ground water.	

Lecture Notes	Instructional Aids
- If water level is high enough to cover a hole in the leaking tank, it can counteract outward pressure of stored product and mask a leak.	
-- A monthly measurement using a gauge covered with water-finding paste must be taken to identify any water at bottom of tank.	Mention this monthly requirement to determine water level in the tank.
- If water level in the tank is over one-half inch, water must be removed.	
- Water volume should be accounted for in the reconciliation.	
3. Considerations	
a. Inventory control must be combined with periodic tank tightness tests. This combined method can be used for only ten years following installation of new USTs or upgrade of existing USTs.	**Slide 87:** Discuss these considerations for inventory control. **Slide 88:** (This slide has been removed.)
b. This method requires:	
-- Daily product gauging;	
-- Calibration of meters; and	
-- Recording and monthly calculation of overage or shortage compared to total flow-through.	
c. Staff time is required every day, but doesn't require much time. Also, many facilities already practice inventory control.	
d. Small leaks may go undetected for a long period.	

Lecture Notes	Instructional Aids
e. This method is applicable only to metered storage tanks.	
f. Deliveries must be made through a drop tube that extends to within one foot of the tank's bottom.	
g. Inventory control results can be affected by variation in temperature, theft, tank tilt, and discrepancies in meter calibration, the tank calibration chart used, and delivery overages or shortages.	**Slide 89:** This slide discusses possible sources of error in interpreting inventory control results. **Slide 90:** (This slide has been removed.)
B. Tank tightness testing Tank tightness testing identifies leaks in closed tank systems and must be performed annually in existing non-upgraded tanks and every five years in new or upgraded tanks. Tank tightness testing must be performed along with inventory control, but this combined method can be used only during the first ten years following installation of a new UST or upgrade of an existing UST. Neither method alone is an acceptable method of leak detection. The two types of tank tightness testing are volumetric and non-volumetric testing.	**Slide 91:** Tank tightness testing (TTT) identifies leaks in a closed system. There are both volumetric and non-volumetric tests.
1. How tank tightness testing works	
a. Volumetric testing	**Slide 92:** Discuss volumetric testing.
-- Changes in product level or volume in tank over several hours are measured precisely (in milliliters or thousandths of an inch).	**Slide 93 (graphic):** Discuss level and temperature gauges. Product level is measured over a period of several hours.
-- Changes in product temperature must also be measured in some methods to account for temperature-induced changes in product volume.	**Slide 93A (graphic photo):** Petrotite. **Slide 93B (photo):** Test site overview (petrotite). **Slide 93C (photo):** Standpipe (petrotite). **Slide 93D (photo):** Petrotite van and stand pipe.

Lecture Notes	Instructional Aids
	Slide 93E (photo): Reading results.
	Slide 93F (photo): Sample chart.
	Slide 94 (graphic): (This slide has been removed.)
-- Tests are conducted either on partially filled or overfilled tanks.	**Slide 95 (graphic):** Partially filled and overfilled tanks.
- In a partially filled tank, test is conducted with the product level below the top of the tank. Because product level changes occur in a large surface area, small changes in volume create very small changes in product level.	
- In an overfilled tank test, the tank is filled until the product level reaches the fill tube or a standpipe located above grade. Because product level changes occur in a small surface area, small changes in volume cause large changes in level.	
-- A net decrease in product volume during testing indicates a leak.	
b. Non-volumetric testing	**Slide 96:** There are several methods of non-volumetric testing. An "acoustic" test detects small bubbles that may indicate a leak.
-- Instead of monitoring for changes in product level or volume, these methods look for some other evidence of a leaking tank.	
-- Acoustic testing methods use equipment that "listens" for the sound of air bubbling through a hole or the sound of turbulent product at a hole. This method may not work well where the water table is high or where the tank sits in mud.	

Lecture Notes	Instructional Aids
-- Tracer methods add an easily detected liquid or vapor to the tank. The backfill surrounding the tank is monitored to see if the tracer escapes.	**Slide 96A (photo):** Tanks holding a tracer gas, helium.
c. General details	
-- The test equipment is temporarily installed in the tank, usually through the fill pipe.	
-- The tank must be taken out of service for duration of test. Tests may last 6-12 hours.	
-- Test must be able to detect loss of 0.1 gallon per hour from any portion of tank that routinely contains product.	
-- Some methods require that product in the tank be at a certain level before testing.	
- The owner or operator may have to add product from another tank on-site or purchase additional product.	
-- If new product is added to tank to prepare it for testing, the test cannot be conducted until the temperature of the tank contents has stabilized.	**Slides 97 and 98 (graphics):** These graphics of tanks show how changes in product temperature, and structural deformation of the tank can be mistaken for a leak. These graphics help to explain why a wait period is suggested before tests are conducted.
-- Tank deformation and temperature in tank must be allowed to stabilize.	
-- If product is added during the test to make fine adjustments in tank volume, tank contents must again be allowed to stabilize before the test can continue.	

Lecture Notes	Instructional Aids
d. Application of test	
-- A testing company performs tests. -- Some methods require tester to make measurements and calculations by hand.	Note that tests are conducted by private companies, not the owner or operator. Testing is conducted annually or every five years depending on whether the tank is unimproved or has been upgraded or is new. The tester temporarily installs equipment into the tanks.
-- Some methods are highly automated and have computerized measurements and analysis.	
2. When tank tightness testing is appropriate	
a. UST system characteristics	**Slide 99:** Discuss applicability.
-- Tightness tests can be used for both tanks and piping.	
-- Tightness testing is primarily used for tanks smaller than 15,000 gallons.	
-- If tank tightness testing is used for larger tanks, the owner/operator should make sure that the manufacturer or vendor has proof that it will meet the performance standard when used on larger tanks.	
-- With automated tank tightness test methods, up to four tanks may be tested at one time.	
b. Product characteristics	
-- To date this method has been used primarily in tanks containing gasoline, diesel, and light heating oils.	
-- If other products are stored, the owner or operator should ensure that this method can be used satisfactorily with those substances.	

Lecture Notes	Instructional Aids
c. Soil conditions	
-- In volumetric testing, if the backfill allows the tank to "bulge," one may have to wait longer for tank to stabilize between filling the tank and beginning the test.	**Slide 100:** The wait time may have to be lengthened if the backfill is such that it allows the tank to bulge.
d. Climatic factors	
-- In volumetric testing, wait at least six hours between delivery and testing to stabilize temperature differences between added product and product already in tank. The wait time may vary due to climate.	
- Temperature differences could cause differences in densities, which would result in different product capacitances.	
Very cold weather will cool product in fill pipe. This cooler product drops into the tank, cooling the product below the fill pipe, and creates erroneous readings.	
e. Geologic conditions	
-- Ground-water level must be determined before this method is applied.	
-- Presence of ground water may mask an actual leak or slow the rate at which product is leaking.	The presence of ground water is particularly important with this method due to the infrequent testing that takes place. If a leak is masked, it is possible that it may not be detected for one or five years when the next test is conducted.
-- If water table is higher than location of hole in leaking tank, ground water exerts pressure on hole.	

Lecture Notes	Instructional Aids
-- Water counteracts pressure exerted on hole by fluid in tank. This condition may mask or slow a leak.	
-- This is particularly important with tank tightness testing due to the length of time between tests. A false reading may not be caught until the next test is performed.	
-- The best methods can compensate for high groundwater levels if these levels are known prior to tank testing.	
3. Considerations	**Slide 101:** Discuss these considerations and limitations.
a. Tightness tests must be used with inventory control method. This combined method can only be used for ten years following new UST installation or upgrade of existing USTs.	
b. Tank must be taken out of service during a test.	
c. Access problems may make it difficult to set up test equipment. Tester should be aware of layout of site beforehand.	
d. Permanent installation of equipment is unnecessary.	
e. Many different commercial methods are available.	
f. It is vital that tester follows proper testing methods.	**Slide 102:** Review of Chapter Four. Answer questions.

CHAPTER FIVE

LEAK DETECTION METHODS FOR UST PIPING

How can you assist the owner or operator to meet the leak detection requirements for piping? This chapter presents detailed information about the two types of UST piping systems, pressurized and suction, and the requirements for piping monitoring and leak detection methods. This chapter covers types of line devices, line testing methods, and monthly monitoring methods.

Lecture Notes	Instructional Aids
I. UST PIPING	**Slide 1:** Chapter Five slides.
The majority of UST leaks occur in the piping system. Two varieties of piping systems for product delivery are pressurized piping and suction piping.	**Slide 2:** Introduce the chapter on leak detection methods for piping. **Slide 2A (photo):** Leaking pipe.
A. Pressurized piping systems	**Slide 3:** There are two varieties of piping. The first is pressurized piping.
1. A pump at the bottom of the tank pushes product through the delivery piping to the dispenser at positive pressure, usually around 28 to 32 pounds per square inch (psi).	Explain that with pressurized piping releases can occur very quickly, posing a threat to the environment.
2. Very large releases can occur quickly because pumps continue to operate when piping is broken and force product through the hole or break.	
3. These systems are usually chosen for high volume sites because they deliver product quickly.	
B. Suction piping systems	**Slide 4:** The second variety of piping is suction piping.
1. A positive displacement pump, at or near the point of end use, reduces the pressure at the dispensing unit, and atmospheric pressure pushes the product through delivery lines.	**Slide 4A (photo):** Suction pump dispensers. **Slide 4B (photo):** Suction pump dispensers.

Lecture Notes	Instructional Aids
2. When the pump is shut off or a leak in the lines occurs, suction is interrupted, and product flows back through the piping toward the tank.	Explain that when the pump is shut off, the suction is interrupted. If there is a leak, the product will flow back toward the tank. The volume of the release is much less for suction piping than for pressurized piping because no pressure forces product from the lines.
-- Some product remains contained in the lines by one or more check valves within the pipe system.	
-- At the point of a line failure, some product can not drain back into the tank and escapes into the environment.	**Slide 4C (graphic photo):** Suction piping.
3. Two general types of suction systems exist:	Mention the "European" and "American" systems.
-- In the "European" system, the location of the check valve is immediately below the pump. Also, the slope of the piping will allow product in the piping to drain back into the tank when suction is released.	**Slide 5 (graphic):** This diagram shows the differences between the "American" and "European" systems. Both are used in the United States.
-- In the "American" system, the check valve is located at the top of the tank (angle check) or at the bottom of the suction line (foot valve).	
Both systems are used in the United States.	
4. Suction piping systems deliver product slowly, so they are only used where speed of delivery is not a factor. These systems also require that the dispenser and tank are near each other.	Discuss when suction piping is used. Limitations of this system are the slow delivery rate, and the short distance allowed between the tank and the dispenser.

Lecture Notes	Instructional Aids
II. LEAK DETECTION FOR UST PIPING	**Slide 6:** Introduce this section on deadlines and requirements for leak detection.
Federal regulations require that all UST piping systems that routinely contain product be tested for leaks. This may or may not include the vent lines, depending on the State requirements. Depending on the test method, piping may be tested separately or in conjunction with the tank.	**Note:** Much of the information is the same for tanks and piping. You may not wish to repeat those parts of this section that are redundant with earlier material.
A. Deadlines	
1. Pressurized piping ◂ -- New piping must comply with UST leak detection requirements **when installed**. ◂ -- Existing piping must comply with UST leak detection requirements by **December 1990**.	**Slide 7:** Discuss regulations. You may want to repeat that "new piping" refers to piping installed after **December 1988.**
2. Suction piping -- Leak detection is not required for either new or existing piping of the "European" type described earlier. -- Other "American" suction piping types need to meet the following deadlines. - New piping must comply with UST leak detection requirements **when installed**. - Existing piping must comply with UST leak detection requirements according to the following timetable:	**Slide 8:** Discuss suction piping deadlines, emphasizing difference between "American" and "European" style systems and their differing compliance requirements.

Lecture Notes	Instructional Aids

Installation Date	Must Comply By
Before 1965*	December 1989
1965 - 1969	December 1990
1970 - 1974	December 1991
1975 - 1979	December 1992
1980 - 1988	December 1993

* Or if installation date is unknown.

Slide 9: Review chart.

B. Requirements

1. Pressurized piping (new and existing)

Slide 10 (graphic): Pressurized piping system. Note piping extending to bottom of tank.

- Each pressurized piping run must have an automatic line leak detector (LLD).

Slide 11: Requirements for pressurized piping.

- Pressurized piping must also have one of the following:
    - Monthly ground-water monitoring; or
    - Monthly vapor monitoring; or
    - Monthly interstitial monitoring; or monthly SIR;
    - Annual tightness test.

2. Suction piping

Slide 12: Discuss the leak detection requirements for suction piping. Note that the requirements are for systems that do not meet the design requirements for exemption from leak detection.

- No leak detection is required if the suction piping is designed with:
    - Enough slope so that the product in the pipe can drain back into the tank when suction is released; and
    - Only one check valve, which is as close as possible beneath the pump in the dispensing unit.

Lecture Notes	Instructional Aids
— If a suction line does not meet all of these design criteria, one of the following leak detection methods must be used:	
— A line tightness test at least every three years; or	
— Monthly vapor monitoring; or	
— Monthly SIR;	
— Monthly ground-water monitoring; or	
— Monthly interstitial monitoring.	
C. Methods	**Slide 13:** Introduce the acceptable methods of leak detection or piping. Each method will be discussed later in this chapter.
1. Automatic line leak detectors	
— Two types are currently available:	
- Automatic flow restrictor; and	
- Automatic shutoff device.	
2. Line tightness testing methods	**Slide14:** Leak detection methods.
— Two general approaches are currently used:	
- Direct volumetric testing; and	
- Indirect tightness testing.	
3. Monthly monitoring methods	
— Four types exist:	
- Interstitial monitoring;	
- Ground-water monitoring;	
- SIR monitoring; and	
- Vapor monitoring.	

Lecture Notes	Instructional Aids
D. Requirements for PD/PFA	**Slide 15:** Discuss PD/PFA "95 and 5" requirements.

1. Line tightness testing and automatic line leak detectors must be capable of detecting the leak rate or quantity specified for that method with a probability of detection (PD) of 0.95 and a probability of false alarm (PFA) of 0.05.

There are two PD/PFA compliance deadlines:

— By December 1990, tightness testing for piping must meet PD/PFA requirements;

— By September 1991, automatic line leak detectors must meet PD/PFA requirements.

However, methods permanently installed before the applicable compliance deadline are not required to meet the PD/PFA requirements.

E. Standard test procedures

As discussed earlier in Chapter Four, Section I.D., EPA has developed standard test procedures (also known as protocols) that enable manufacturers of release detection methods and third-party evaluators of those methods to demonstrate that the methods can meet the Federal release detection requirements. EPA published standard test procedures for evaluating pipeline leak detection systems in September 1990.

Lecture Notes	Instructional Aids
III. AUTOMATIC LINE LEAK DETECTORS	
A. Automatic flow restrictors	
1. How automatic flow restrictors work	
-- Restrictors, located at the pumps, monitor the line pressure and restrict flow if a possible leak is indicated.	**Slide 16:** Describe how automatic flow restrictors work and how they are set up. Discuss the devices that are particularly common in your State.
-- When pressure in the pump delivery system drops below a preset threshold, commonly 1 to 2 psi, a test is automatically performed.	**Slide 17:** Continue the discussion of automatic flow restrictors.
-- During the test product flows through line at 1.5 to 3 gal/h.	
-- Line leak detectors must detect 3 gal/h release at 10 psi pressure, within 1 hour.	
-- Leaks greater than 3 gal/h are indicated if more than 2 seconds are required to fully pressurize the line.	
-- If test does not indicate a leak, normal flow is resumed.	
-- Restrictors do not shut the system off entirely, but limit product flow to 3 gal/h.	
2. When automatic flow restrictors are appropriate	**Slide 18:** Discuss when automatic flow restrictors are appropriate.
-- This method is used only in pressurized piping.	
-- Most gas station USTs already have automatic flow restrictors (Red Jackets).	**Slide 18A (photo):** Red Jacket.

Lecture Notes	Instructional Aids
3. Considerations -- This method causes a slight lag in product delivery even when there is no leak. -- At high altitudes or high temperatures, vapors are more likely to form in piping. This increases the amount of time required for product to reach operating pressure and may falsely indicate a leak. - If additional time is spent pressurizing the line, vapors will usually be reabsorbed into the liquid. -- On-site staff may tamper with system to avoid delays in product delivery. -- Requires little owner or operator involvement. -- Tests can not be run while dispensers are in use. About five minutes between dispensings at the UST are needed for accurate testing. -- Typical time between dispensings should be considered when selecting a method of piping leak detection.	**Slide 19:** Discuss these and other factors that may need to be considered before using automatic flow restrictors.
B. Automatic flow shutoff devices 1. How automatic flow shutoff devices work There are two different types of automatic flow shutoff devices: one system monitors for an increase in line pressure; the other monitors for a decrease in line pressure.	**Slide 20:** There are two types of automatic flow shutoff devices that will be discussed: pressure increase monitors and pressure decrease monitors.

Lecture Notes	Instructional Aids
a. Pressure increase monitor -- The normal rate of pressurization in pipes is calculated when the testing system is set up. -- When the pump is activated, the rate of increase in line pressure is measured. -- It will take longer than usual for the piping to become fully pressurized if there is a leak. -- If pressure does not rise quickly enough, the system automatically shuts down. -- The level of automation varies from system to system. -- Automatic flow shutoff systems are permanently installed.	**Slide 21:** In this method the amount of time it takes to fully pressurize a line is measured. Automatic shutoff occurs when the length of time for full pressurization is longer than usual, indicating a possible leak.
b. Pressure decrease monitor -- System monitors line pressure over several minutes when dispenser is not in use. -- If constant pressure can not be maintained or if pressure decreases more quickly than its normal rate, a leak is indicated, and the pump is shut down. -- Generally, more than one test which indicates a leak is required before system shuts down. -- The level of automation varies from system to system. -- Such systems are permanently installed.	**Slide 22:** This method measures decreasing pressure in the lines over a period of time when the lines are inactive. The inability to maintain normal pressure may indicate a leak.

Lecture Notes	Instructional Aids
2. When automatic flow shutoff devices are appropriate -- This method is used for pressurized piping only. -- Typical time between dispensings should be considered when selecting a method of piping leak detection.	**Slide 23:** Discuss slide. Mention when the devices are appropriate, and that they allow for only minimum product loss.
3. Considerations -- Flow shutoff devices are subject to tampering if they are not locked or tamper-proofed in some way. -- As with flow restrictors, tests cannot be run while dispensers are in use. At a minimum, about five minutes between dispensing at the UST are needed for accurate testing. - A longer interval between dispensings (up to one hour) is necessary to detect small leaks. -- Automatic flow shutoff devices provide nearly continuous leak detection and require little time from staff.	**Slide 24:** Discuss these and other factors that should be considered when using automatic flow shutoff devices.

Lecture Notes	Instructional Aids
IV. LINE TIGHTNESS TESTS **A. Direct volumetric line tightness test**	**Slide 25:** There are two line tightness testing methods -- direct volume and an indirect line tightness test. Each method will be discussed in this chapter.
1. How direct volumetric line tightness tests work -- The line is isolated from the tank, and is tested for its ability to maintain pressure. - A pressure loss indicates a potential leak. - The test must be able to detect a leak of 0.1 gal/h at 1.5 times the normal line operating pressure.	**Slide 26:** Describe how a volumetric line tightness test is conducted. Describe the methods that are common in your State.
-- A hand pump or a dispenser and submerged pump is used to pressurize the piping leading back to the tank.	The piping between the tank and dispenser is pressurized. The ability to maintain pressure is measured in several ways. If a predetermined volume is lost, a leak in the piping is indicated.
-- The amount of volume lost is determined in one of several ways: - If pressure decreases in the piping system, product is added to return pressure to original test level. The leak rate is estimated by measuring the amount of product added.	Mention that few of these devices are currently available.
- The volume of product lost over time is observed in an above-ground tube that is connected to pressurized piping.	**Slide 26A (photo):** Line tightness testing equipment. **Slide 26B (photo):** Line tightness testing equipment. **Slide 26C (photo):** Line tightness testing equipment.

Lecture Notes	Instructional Aids
- A pressure gauge on the hand pump, or temporarily installed on the dispenser, can be used to indicate pressure change, which is converted to a leak rate.	
-- If a 0.1 gal/h per hour leak rate is found, a leak is indicated.	
2. When the direct volumetric line tightness test is appropriate	**Slide 27:** Can be used in conjunction with tank tightness testing.
-- This method can be performed alone or in conjunction with other monitoring methods.	
-- With certain variations on tests, line tightness testing may be performed on both pressurized and suction systems.	
3. Considerations	**Slide 28:** Discuss these and other considerations as they apply to your State.
-- The line must be shut down for several hours for the test.	
-- This method requires no permanent equipment and can be performed along with tank tightness testing.	
-- Test needs to be performed only once every three years for suction piping. Line tightness testing can be used as the only method of line leak detection for suction piping.	
-- There are generally more problems with line tightness testing than with tank tightness testing. These problems are difficult to resolve due to poor fittings and gaskets, vapor pockets, bad check valves, etc.	

Lecture Notes	Instructional Aids
B. Indirect line tightness test	**Slide 29:** This method tests piping and the tank as one system. If a leak is suspected, then a systematic method of locating the leak is used, testing each system part until the leak is isolated.
1. How the indirect line tightness test works	
a. In an indirect line tightness test, piping is tested as a part of a full tank system test. Fluid loss over time in a closed tank and piping system is examined to determine presence of a leak. Procedures are the same as for tank tightness test with the following additions:	
-- Overfill method must be used, so that piping as well as tank is full of product.	
-- If test indicates a leak, tank is tested alone.	Discuss this procedure.
-- If no leak is found in tank, piping is assumed to be leaking.	
-- If tank is leaking, separate test of piping must be conducted.	
2. When the indirect line tightness test is appropriate	**Slide 30:** This method must be done along with tank testing, and can be used on both pressurized and suction piping.
-- This method must be done in conjunction with tank testing; tanks and piping might be on different test schedules, making an indirect test impractical.	
-- With certain variations on tests, line tightness testing may be performed on both pressurized and suction systems.	
-- If low pressure is put on piping, it is necessary to detect very small leaks to pass the pressure piping 0.1 gal/h test requirement.	

Lecture Notes	Instructional Aids
3. Considerations -- This method must be performed as part of tank test; therefore, UST system must be shut down for at least several hours. -- Requires no permanent equipment, and can conveniently be performed along with tank tightness testing. -- Test must be performed only once every three years for suction piping. Line tightness testing can be used as the only method of line leak detection for suction piping. -- There are generally more problems with line tightness testing than with tank tightness testing. These problems are difficult to resolve and are due to poor fittings and gaskets, vapor pockets, bad check valves, etc. -- Indirect tests can only show that the entire UST system is leaking. Tanks and piping will have to be tested separately to identify the source of the leak.	**Slide 31:** Discuss these considerations for indirect line tightness tests.

Lecture Notes	Instructional Aids
V. MONTHLY MONITORING METHODS	
A. Secondary containment with interstitial monitoring Methods, applications, and considerations of interstitial monitoring with secondary containment for piping systems are similar to those for tanks.	**Slide 32:** Discuss the use of interstitial monitoring with piping. It is very similar to that used with tank systems; however, some differences will be discussed.
1. How interstitial monitoring works	**Slide 33:** Discuss trench liners.
a. Trench liners	
-- Backfill and piping are placed in a lined trench.	
-- The trench should be sloped away from the tank excavation to differentiate between tank leaks and piping leaks.	Note that the system can be arranged such that leaks in piping and tanks can be differentiated.
-- An interstitial monitor is placed between piping and the trench liner.	
b. Double-walled piping	**Slide 34:** Discuss double-walled piping.
-- Piping that carries the product is contained within a larger outer pipe.	
-- The outer pipe usually drains to a sump that can be monitored for leaks. Other methods use an interstitial monitor placed between inner and outer piping.	
2. When secondary containment with interstitial monitoring is appropriate	The same applications of tank interstitial monitoring apply to piping. There are few restrictions.
a. UST system characteristics	**Slide 35:** Discuss when secondary containment is appropriate.
-- Can be used for both tanks and piping.	

Lecture Notes	Instructional Aids
-- Secondary containment is impractical for existing piping, because it involves either excavating all piping runs and installing trench liners, or replacing existing piping with double-walled piping.	
b. Product characteristics	**Slide 36:** This method can be used for all fuel types.
-- This method can be used for all types of fuels.	
c. Soil conditions	
-- Use is not restricted by soil type.	
d. Climatic factors	**Slide 37:** Discuss climatic and geologic considerations.
-- This method can be used in all climatic conditions; however, in areas with heavy rainfall, a fully enclosed containment system should be used to prevent rain from interfering with monitoring system.	
e. Geologic conditions	
-- In areas with high ground water, a fully-enclosed containment system should be used to prevent ground water from interfering with the monitoring devices.	
3. Considerations	**Slide 38:** Discuss these considerations and any others that apply to your State.
-- Correct installation of trench liners is essential because piping trenches are narrow and long. To cover these areas requires piecing together small pieces of liner. Trained and experienced professionals can minimize the number of seams in the liner and ensure correct installation.	Installing liners in trenches can be very difficult due to the number of seams required to line a piping system.

Lecture Notes	Instructional Aids
-- Proper installation of double-walled piping is also very important, and requires a professional.	
-- Piping monitoring can often be integrated with the tank monitoring system.	
-- This is the only leak detection method that prevents product from entering the environment, thus reducing potential for cleanup costs.	
B. Ground-water monitoring	**Slide 39:** Discuss ground-water monitoring as it applies to piping. Note that additional wells may be added approximately every 10 to 20 feet of piping run to monitor the piping system.
1. How ground-water monitoring works	
a. Use of this method for piping is the same as its use for tanks, with the following exception:	
-- Additional wells will be needed to monitor the area affected by piping.	
2. When is ground-water monitoring appropriate	**Slide 40:** Mention ground-water monitoring as it applies to piping. Ground-water monitoring's applicability for piping is the same as it is for tanks.
a. UST system characteristics	
-- Can be used to detect leaks from tanks and piping.	
-- May be used on any size piping run. For larger systems, more wells are added.	
-- May be retrofitted. When retrofitting, installer must be cautious not to puncture piping.	
b. Product characteristics	
-- Density must be lower than that of water. (Product must float on top of water.)	

Lecture Notes	Instructional Aids
-- Product should not mix easily with water. (If it mixes, no free product layer will form.)	**Slide 41:** Product must be a "floater" vs. a "sinker," and must not mix readily with water. Most commonly used with gasoline and diesel fuels.
-- Most commonly used for gasoline and diesel fuels. (Alcohols and water-soluble chemicals are not appropriate.)	
c. Soil conditions	**Slide 42:** Explain the terms "porosity" and "hydraulic conductivity." (Review these terms from Chapter Three.)
-- If this method is used alone, soil between well and piping must be coarse and permeable (for example sand or gravel).	Soil analysis may have to be conducted.
d. Climatic factors	**Slide 43:** Discuss climatic problems relating to ground-water monitoring as they pertain to your State (e.g., areas with high or low annual rainfall, or extreme temperatures).
-- Very low temperatures may interfere with some monitoring devices. Ice can freeze monitors and interfere with product-soluble devices.	
e. Geologic conditions	**Slide 44:** Discuss geologic considerations.
-- Level of ground-water table must not be more than 20 feet below the surface.	
- Ideally, the ground water should be between 2 and 10 feet from the surface.	Mention that it is essential to know the water table level and gradient in order to have an effective ground-water monitoring program.
-- Fluctuations in water table level	
- If water level falls below bottom of, or rises above the top of, the well screen, this method alone becomes insufficient to detect released product.	
-- If there is a steep gradient of ground-water flow, the product may bypass the monitoring wells.	

Lecture Notes	Instructional Aids
-- Because free product tends to flow through fractures and cavities in the soil, wells that do not intercept these fractures and cavities will not detect free product.	**Slide 45 (graphic):** This graphic shows how the well can be installed in what seems to be a good place, but will still not detect a release due to the geology.
3. Considerations -- Ground-water monitoring of underground piping can easily be integrated with a tank ground-water monitoring system.	**Slide 46:** Discuss site assessments, detection devices, and how to avoid damage to pipes during installation.
C. Vapor monitoring	
1. How vapor monitoring works a. Use of this method for piping is same as its use for tanks, with the following exceptions: -- Monitoring wells do not need to be as deep as those used for tank monitoring. -- When used for interstitial monitoring, horizontal slotted tubes at or below piping level may be used rather than conventional vertical wells.	**Slide 47:** Discuss vapor monitoring as it applies to piping. Shallower wells than those used for tanks may be used. Applicability is the same for a tank system. This method is easily integrated with an UST vapor monitoring system.
2. When vapor monitoring is appropriate	
a. UST system characteristics -- This method can be used for both tanks and piping. -- This method can be installed as part of new or existing tanks and piping. -- May be retrofitted. When retrofitting, installer must be cautious not to puncture piping.	**Slide 48:** General applicability.

Lecture Notes	Instructional Aids
b. Product characteristics	
-- Vapor monitoring must be used with products that vaporize readily. For example, gasoline, diesel fuel, and aviation fuels are appropriate, but residual oil No. 6 (used oil) is not.	**Slide 49:** Give examples of fuels that are most appropriate for vapor monitoring due to their high volatility (e.g., alcohol, jet fuels).
c. Soil conditions	
-- The backfill around the pipes must be porous enough to allow the vapors to reach the monitoring wells.	**Slide 50:** Discuss how backfills can distort results, such as previous soil contamination. Soil type can affect how the vapor can travel.
-- Backfill and nearby soil must be clean and should not contain substances that will produce vapors. - Previously contaminated soil may lead to false readings, indicating releases.	**Slide 51 (graphic):** This graph demonstrates the effects of soil conditions on vapor concentrations at a vapor monitoring well. The vertical axis is gasoline in ppm, the horizontal axis represents time in days. Note that the vapor concentrations are much lower in wet sand or clay vs. the dry backfill. These are all readings taken from the same release, at the same distance from the source.
d. Climatic factors	**Slide 52:** Discuss slide.
-- Temperature affects the volatility of released product. Sensors may need to be adjusted for extreme temperatures.	
e. Geologic conditions	
-- This method cannot be used in areas with heavy annual rainfall, extremely moist climates or high ground water.	**Slide 53:** Moisture-related considerations.

Lecture Notes	Instructional Aids
— The water fills spaces between the soil particles, preventing vapor from travelling through the soil. Vapors may also dissolve in the moisture before reaching the monitors.	
3. Considerations — Vapor monitoring for underground piping can easily be integrated with a tank vapor monitoring system.	**Slide 54:** Can easily be integrated with tank vapor monitoring system. Discuss any other considerations relevant to your State.
D. Statistical Inventory Reconciliation (SIR) The three monthly monitoring methods described so far were all identified in the Federal regulations that became effective in December 1988. The regulations provided, however, that other release detection methods could be approved in the future if those methods could meet EPA's performance standards for release detection. In June 1990, EPA published a standard test procedure for an additional release detection method that is known as Statistical Inventory Reconciliation (SIR). SIR methods must be evaluated using EPA's standard test procedure or an equivalent procedure to prove they can meet EPA's release detection performance standards. Chapter Four described the applicability of SIR to leak detection for tanks. Methods, applications, and considerations of SIR for piping systems are similar to those for tanks. 1. How SIR works	
Statistical inventory reconciliation (SIR) analyzes inventory, delivery, and dispensing data collected over a period of time to determine whether or not a tank system is leaking. a. Each operating day the operator measures the product level using a gauge stick or other tank level gauge. A calibration chart specific to the tank is used to convert product level into product volume. — The operator also keeps complete records of all withdrawals from the UST and of deliveries to the UST.	**Slide 55:** Discuss basic SIR operation.

Lecture Notes	Instructional Aids
— After data have been collected for the period of time required by the SIR vendor, this information is provided to the SIR vendor.	
b. The SIR vendor uses sophisticated statistical software to conduct an analysis of the data that can identify if the UST is leaking.	
c. Every month, the SIR vendor reports the results of the analysis to the operator, who keeps monthly reports on file for at least 12 months.	
d. The Federal requirements for monthly release detection are met if the SIR analysis is performed every month, is capable of detecting release rates of at least 0.2 gallons per hour (with a probability of detection of 0.95 and a probability of false alarm of 0.05), and the results are available at the UST facility on a monthly basis. State and local requirements can be more restrictive.	
2. When SIR is appropriate	**Slide 56:** Discuss these characteristics.
a. UST system characteristics	
— SIR procedures apply to fueling sites where the required measurements can be taken every operating day. It is not appropriate for unattended facilities, unless the required data can be retrieved remotely.	
b. Product characteristics	
— SIR is generally not restricted by product type.	
c. Soil conditions	
— SIR is not affected by soil type.	
d. Climatic factors	
— Changes in climate, especially temperature, affect the data used in SIR, so SIR providers must take climatic factors into consideration in their procedures.	

Lecture Notes	Instructional Aids
e. Geologic conditions	
— SIR for piping is not affected by geologic conditions.	
3. Considerations	
— SIR can be used for tank and piping systems.	**Slide 57:** Discuss these considerations.
— SIR should not be confused with other release detection methods that also rely on periodic reconciliation of inventory, withdrawal, or delivery data. Unlike manual tank gauging, automatic tank gauging systems, and inventory control (described earlier in Chapter Four), SIR uses a sophisticated statistical analysis of data to detect releases. This statistical analysis can only be done by competent vendors of SIR systems.	
— The procedures used by the SIR vendor must be evaluated against EPA's standard test procedures (or an equivalent protocol) to confirm that the procedures are capable of meeting the Federal regulatory requirements regarding the detection of minimum release rates and the probabilities of detection and false alarm.	
— Tank level and meter readings should be taken carefully at the same time each operating day, at a time when no product is being delivered or dispensed. SIR does not require that the tank be out of service for extended periods.	
— Data can be transmitted to the SIR vendor on paper or by using computer modems or diskettes.	**Slide 58:** Discuss these considerations.
— SIR can identify problems other than leaking systems, such as miscalibrated meters, tilted tanks, and loss resulting from theft.	

Lecture Notes	Instructional Aids
— SIR requires minimal investment of staff time and equipment costs (usually involving gauge stick and pastes that help identify product and water levels). The cost of services provided by SIR vendors compares favorably with the cost of other leak detection methods.	
— State and local governments can place restrictions on the use of SIR for compliance purposes.	
	Slide 59: Review UST piping. Answer questions.

GLOSSARY OF LEAK DETECTION TERMS

Ambient temperature -- Temperature of areas surrounding the tank site.

Atmospheric pressure -- The weight of overlying air at any given location.

Backfill -- The material used to fill in the excavation zone after the tank is in place. The best installation practice is to use sand or gravel as specified.

Check valve -- The valve found in suction piping systems that closes when product begins to flow backwards through the pipe.

Compatibility -- The ability of a tank and piping to be unaffected by stored product.

Contamination -- The remains, liquid or vapor, in soil or backfill of releases at a site.

Density -- The mass of a given substance per unit volume.

DNAPLs -- Dense non-aqueous phase liquids.

Excavation liners -- Flexible sheets of relatively impermeable substances (possibly made of various synthetic materials, such as high-density polyethylene, polyester elastomers, epichlorohydrin, and polyurethane) that separate the UST system and backfill from the native soil of the site.

Excavation zone -- The entire area that must be dug up in order to install an UST.

Fill pipes -- The pipes connecting the underground tank to an aboveground fitting where a tank truck connects its transfer hose.

Free product -- The leaked product floating on the water table surface.

Grab samplers -- The bucket or bailer used to obtain ground-water samples, from monitoring wells.

Hydraulic conductivity -- The measurement of the rate at which a liquid can flow through a particular material, such as soil.

Interstitial space -- The space between the wall of the tank or pipe and the secondary container or lining.

Inventory control -- A comparison of what is actually in the tank, based on measurement, to what should be in the tank, based on records.

Overages -- The amount by which volume measurement exceeds what is expected.

Overfill method -- A method used on tank tightness testing during which the tank is filled until the level of the product reaches the fill tube or a standpipe located above grade.

Performance standard -- The minimum sensitivity of a method as specified in the regulation.

Permeability -- A measurement of the ability of backfill or soil to permit liquids or gases to pass through.

Porosity -- The measurement of the extent to which a material contains small spaces through which vapors or liquid can pass.

Positive displacement pump -- The pump placed at or near the point of end use on suction piping systems; this pump creates a vacuum which draws product from the tank to the pump.

Pressurized piping systems -- These systems use a pump at the bottom of the tank to push the product to the dispenser.

Product delivery lines -- The piping that connects tanks and product dispensers (pumps).

Product-finding paste -- Paste applied over a gauge stick to improve adherency of the product to the stick and prevent creepage. The pastes change color in the presence of product, and are applied in the area where one expects to see the product line, not on the entire stick.

Remote fill - Piping runs leading to a storage area for wastes, such as used oil, that are generally installed as an afterthought, which therefore, are prone to leaks.

Restrictors -- Devices that keep the flow of product from the pump to the point of use below a certain gal/h rate.

Retrofit -- The process of upgrading an UST system with new technologies and/or products.

Shortage -- The amount that the volume measurement is below what is expected.

Solubility -- The ability of a substance to dissolve in or mix with another substance.

Static tank system -- A tank that is not in use; no product is added or removed.

Suction piping -- The system uses a vacuum to draw the product from the tank to the pump.

Tank deformation -- Expansions and contractions of the tank resulting from fluctuating temperatures of product within the tank and from the addition of product to the tank.

Thermal properties -- Changes in product characteristics that occur in response to an increase or decrease in temperature.

Underground storage tank (UST) -- A system used to store and dispense petroleum products. An UST system includes the tank(s), piping, and product dispensers. At least 10 percent of the combined volume of the tank(s) and associated piping must be underground for the system to be considered an UST system.

Vapor pockets -- Vapor that becomes trapped in the manways, deadend piping, etc., after a tank has been filled to or above the top of the tank.

Vapor recovery lines -- Pipes that carry vapors back to the tank truck during off-loading, or back to the UST during product dispensing.

Vent pipes -- Pipes routed to the surface as aboveground vents.

Viscosity -- The measurement of the ease with which a liquid flows.

Volatility -- The measurement indicating how readily a substance will vaporize.

Water table -- The level where ground water will rest in porous soil conditions under normal atmospheric pressure.

Well screen -- The perforated or slotted area of a well that allows product to enter the well.

CASE STUDY GUIDELINE

I. INTRODUCTION

The following guideline has been provided to help you develop a case study tailored to the specific needs of each training session that can be used by participants to increase their understanding of the leak detection requirements. This course is designed to be flexible, allowing you to include your own "designer" case study exercise in place of or in addition to the other exercises provided in Appendix II. The goal of the case study is to apply the UST system characteristics and regulatory information presented throughout the course to an actual or fictitious UST facility.

II. GUIDELINE FOR DEVELOPING A CASE STUDY

A. Identify the purpose of the case study.

1. What specific topics do you want to cover?

2. How much time are you allowing for the case study?

3. Have you considered your audience carefully (for example, their level of prior knowledge in their field or their expectations for the training)?

B. Select an UST site.

1. Do you want an actual site or a fictitious site?

2. What characteristics are important about the site: UST system characteristics, product characteristics, soil conditions, climatic factors, and geologic conditions?

3. Locate or create slides and maps of the site.

C. Develop a list of pertinent information that participants will need in order to make decisions about the leak detection method at the site.

1. Have list ready prior to presentation of case study, or

2. Incorporate this task into the presentation of the case study as a group discussion. You may want to use the "UST Site Characteristics" exercise found on pages 3 and 4 of this Appendix.

D. Break students into small groups. Provide a list of questions or issues to be addressed based on the topics that you have chosen for the case study. Discussion topics may include:

- Determining the important site characteristics at the case study's site.

- Comparing UST leak detection methods in terms of suitability to the site, cost, ease of use, and amount of time required for operation or maintenance.

- Determining the appropriate leak detection method for the site.

Each group can discuss all questions, or each group can be assigned a specific question/issue. Groups can prepare to present and justify their decisions to the whole class based on regulations and materials presented in the course. Remind students that the student manual should be used to check for the regulatory requirements.

E. Evaluate group decisions, making sure that all regulations and measures have been addressed for the UST site being considered. This would be an appropriate time for open group discussion and other suggestions.

EXERCISE -- UST SITE CHARACTERISTICS

You are the UST "hotline" person for your State. UST owners and operators call you for information on leak detection methods. The UST systems range from a single tank and large service station systems to military installations. In order to make decisions and answer questions correctly, you will need to know some information about the UST in question.

Develop a list of questions that you will use to obtain necessary information about the UST. Consider the site characteristics discussed in the training manual, as well as logistical information that you may want for your records.

SAMPLE LIST OF "UST SITE CHARACTERISTICS" QUESTIONS

1. Name of owner/operator. Are you the owner or operator?

2. What is the purpose of the UST? (Service station, city installment.) Site location? (State, county, city; for specific local regulations).

3. How many tanks are in question?

4. What is the date of tank installation? (May have to be approximate.)

5. Types of tanks. (May be more than one type.)

6. Size of tanks. (May be more than one size; therefore, different regulations may apply.)

7. Types of piping system in the UST. (Where is the pump located?)

8. What types of product are handled?

9. What is the backfill around the tanks? (Describe. Was it local fill or specifically delivered for the UST?)

10. What is the soil type and ground-water level (if known)?

11. Is there any leak detection system used now? Describe.

12. If a leak is suspected, what indications do you have?

EXERCISE - ATGS

Review the scenario described in the following situation. You should decide individually, and then as a group, what could be causing the described problem.

Scenario

Sal Robinson owns a small tank facility in southern Louisiana. The tanks range from 7,000 to 15,000 gallons in size, and contain heating oil and diesel fuel. Sal purchased the facility in 1988. At that time, manual inventory control was the leak detection method used. No leaks had been detected using this method. Two months ago Sal installed an ATGS into the tank system. His records now indicate substantial leaks in the UST system. In your discussion you have found out that his area is suffering a severe drought, a real shock for an area with such a high annual rainfall. Sal is concerned and confused about the new leak detection method and the results that are being obtained.

What suggestions do you have that may explain the results? (Consider that the results may be either true or false.)

EXERCISE - ATGS
(Instructor's Copy)

Review the scenario described in the following situation. Students should decide individually, and then as a group, what could be causing the described problem. Lead a group discussion, making sure that all relevant points are considered, and that the students fully understand the reasoning upon which decisions were made.

Scenario

Sal Robinson owns a small tank facility in southern Louisiana. The tanks range from 7,000 to 15,000 gallons in size, and contain heating oil and diesel fuel. Sal purchased the facility in 1988. At that time manual inventory control was the leak detection method used. No leaks had been detected using this method. Two months ago Sal installed an ATGS into the tank system. His records now indicate substantial leaks in the UST system. In your discussion you have found out that his area is suffering a severe drought, a real shock for an area with such a high annual rainfall. Sal is concerned and confused about the new leak detection method and the results that are being obtained.

What suggestions do you have that may explain the results? (Consider that the results may be either true or false.)

Points to emphasize

- The tanks may have been leaking for some time, but they were not being properly tested previously.
- The tanks were leaking all along. However, due to the usually high amount of rainfall, the ground-water levels were high enough to mask the leaks. The area is now suffering from a drought, which may affect the level of ground water.
- Staff may be making errors with the use of the new system.
- Wiring of the ATGS may be improperly installed.
- The temperature and volume calibrations may not be correct in the ATGS, giving false data.

EXERCISE -- GROUND-WATER MONITORING

Review the scenario described in the following situation. You should decide individually, and then as a group, whether ground-water monitoring is appropriate. Review the site characteristics mentioned in Chapters Two and Three.

Scenario

Frank Lee has owned a small service station near Lathrop Wells, Nevada, since 1958. All four of the station's underground storage tanks were installed at the time he bought the site. The only products Frank stores in the tanks are gasoline (both leaded and unleaded) and diesel fuel. The tanks are located in soil that consists of welded volcanic ash (or tuff) that extends for several hundred feet below the surface. The climate at the site (not far from Death Valley) is generally arid, and temperatures can exceed 110 degrees fahrenheit during summer days. On the other hand, sub-freezing temperatures at night are not uncommon during winter months.

Is ground-water monitoring an appropriate leak detection method in Frank's case? Why or why not?

What further information, if any, do you need from Frank, to determine this?

EXERCISE -- GROUND-WATER MONITORING
(Instructor's Copy)

Review the scenario described in the following situation. Students should decide individually, and then as a group, whether ground-water monitoring is appropriate. Review the site characteristics mentioned in Chapters Two and Three.

Scenario

Frank Lee has owned a small service station near Lathrop Wells, Nevada, since 1958. All four of the station's underground storage tanks were installed at the time he bought the site. The only products Frank stores in the tanks are gasoline (both leaded and unleaded) and diesel fuel. The tanks are located in soil that consists of welded volcanic ash (or tuff) that extends for several hundred feet below the surface. The climate at the site (not far from Death Valley) is generally arid, and temperatures can exceed 110 degrees fahrenheit during summer days. On the other hand, sub-freezing temperatures at night are not uncommon during winter months.

Is ground-water monitoring an appropriate leak detection method in Frank's case? Why or why not?

What further information, if any, do you need from Frank, to determine this?

Points to emphasize

- Is Frank required to have leak detection for his tanks now?

  [Yes, the tanks are 30 years old.]

- Are the types of products Frank stores appropriate for a ground-water monitoring system?

  [Yes, both gasoline and diesel fuel have lower density than water, and do not mix easily with water.]

- Is the geology at Frank's site appropriate for ground-water monitoring?

  [No, the water table is several hundred feet below the surface.]

- Is the soil appropriate?

  [Unknown. Need to inquire about conductivity of tuff.]

- Is the climate appropriate?

  [Yes. Short-term temperature changes are not a problem.]

- Is ground-water monitoring appropriate for Frank?

  [No. The water table is too low to allow floating free product to be detected.]

- Is more information needed?

  [No. Low water table rules out ground-water monitoring.]

EXERCISE -- VAPOR MONITORING

Review the scenario described in the following situation. You should decide individually, and then as a group, whether vapor monitoring is appropriate for this situation. Review the site characteristics mentioned in Chapters Two and Three, along with the considerations for vapor monitoring.

Scenario

Joe Carlisle has owned a small airfield in Green Lake, Wisconsin for 20 years. He has four USTs for various types of airplane fuels that are all near the airfield. Near the hangers are diesel, unleaded and leaded gasoline tanks, and near the maintenance shop is one 750-gallon storage tank for used oil. The tanks are installed in a glacial outwash area, which consists of unsorted sands and gravels. The depth of the water table averages 15 feet, and remains fairly constant. An airplane owner has suggested that instead of the time consuming method of manual tank gauging, that Joe consider vapor monitoring for the entire area.

Is vapor monitoring appropriate for this case?

Is there any other information that you might need to make your decision?

EXERCISE - VAPOR MONITORING
(Instructor's Copy)

Review the scenario described in the following situation. Students should decide individually, and then as a group, whether vapor monitoring is appropriate for this situation. Review the site characteristics mentioned in Chapters Two and Three, along with the considerations for vapor monitoring. Lead the group discussion, making sure that all of the relevant points are considered.

Scenario

Joe Carlisle has owned a small airfield in Green Lake, Wisconsin for 20 years. He has four USTs for various types of airplane fuels that are all near the airfield. Near the hangers are diesel, unleaded and leaded gasoline tanks, and near the maintenance shop is one 750-gallon storage tank for used oil. The tanks are installed in a glacial outwash area, which consists of unsorted sands and gravels. The depth of the water table averages 15 feet, and remains fairly constant. An airplane owner has suggested that instead of the time consuming method of manual tank gauging, that Joe consider vapor monitoring for the entire area.

Is vapor monitoring appropriate for this case?

Is there any other information that you might need to make your decision?

Points to emphasize

- The stored product: While the airplane fuel, gasoline, and diesel fuels are appropriate for vapor monitoring, the used oil is not, due to its low volatility.
- Soil conditions: The glacial outwash provides adequate porosity for vapor travel, and is therefore appropriate for vapor monitoring.
- Ground water: The level of ground water is appropriate, and does not fluctuate greatly, and is therefore appropriate for vapor monitoring.

Slide Section

CHAPTER I-1

BASIC LEAK DETECTION

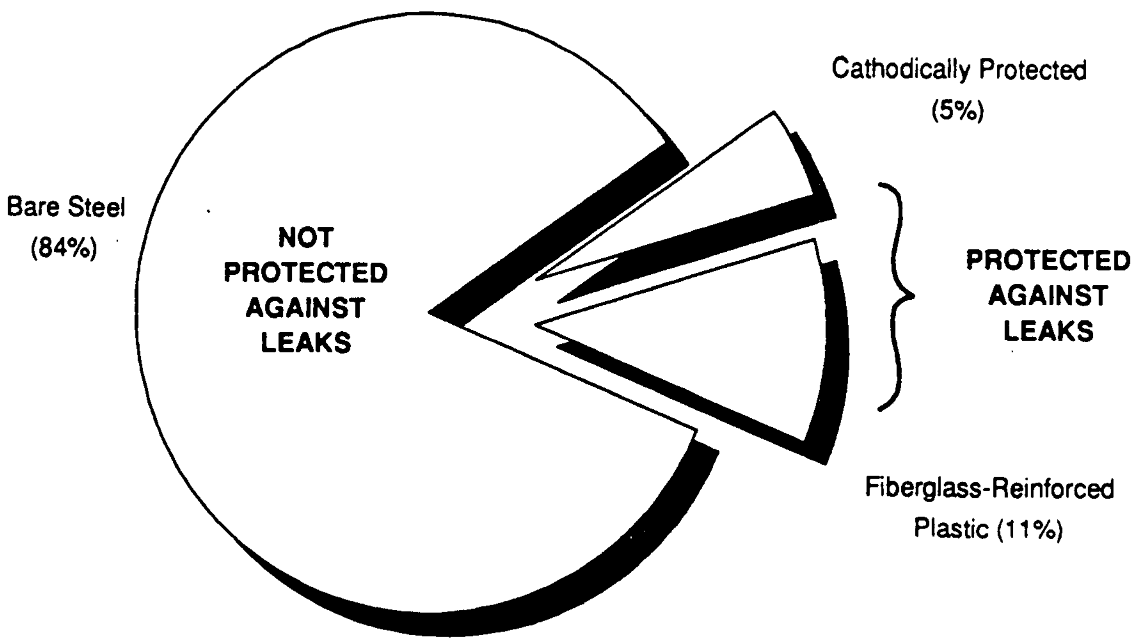
SLIDE I-2

BASIC LEAK DETECTION

- Overview of leaking USTs
- The need for leak detection
- Leak detection methods

SLIDE I-3

DISTRIBUTION OF TANK TYPES AT GASOLINE SERVICE STATIONS



Source: *Regulatory Impact Analysis. August 24, 1988.*

SLIDE I-4

OVERVIEW OF LEAKING USTs

The Problem

- 15-20 percent of petroleum tanks may be leaking
- Leaking tanks pose a threat to ground water and surface water

SLIDE I-5

THE PROBLEM OF LEAKING USTs

The threat of leaking tanks also applies to

- Contamination of surface waters
- Fires and explosions
- Toxic fumes
- Cancer causing agents

SLIDE I-6

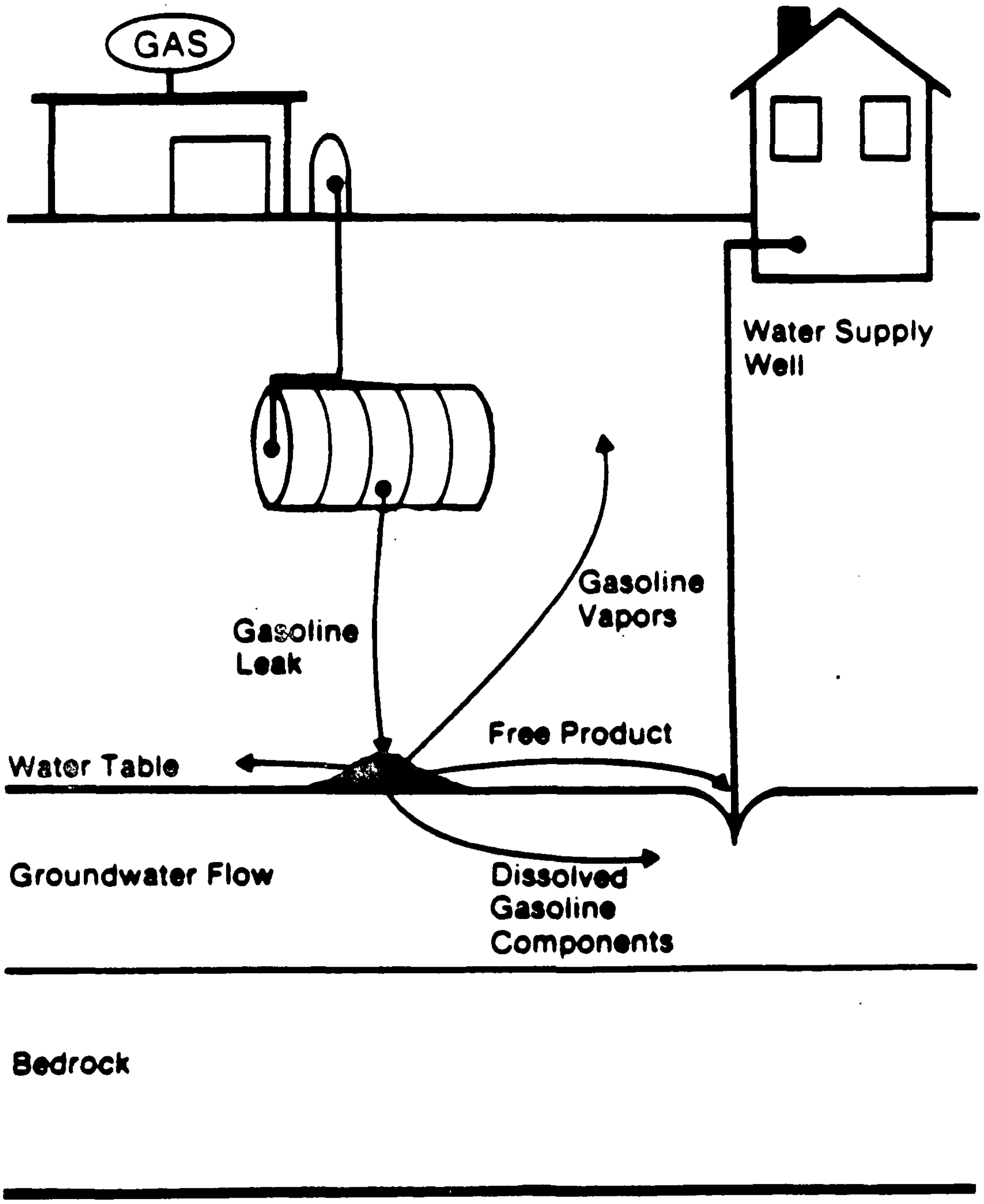
CAUSES OF RELEASES

Releases result from

- Piping failures
- Spills and overfills
- Tank corrosion

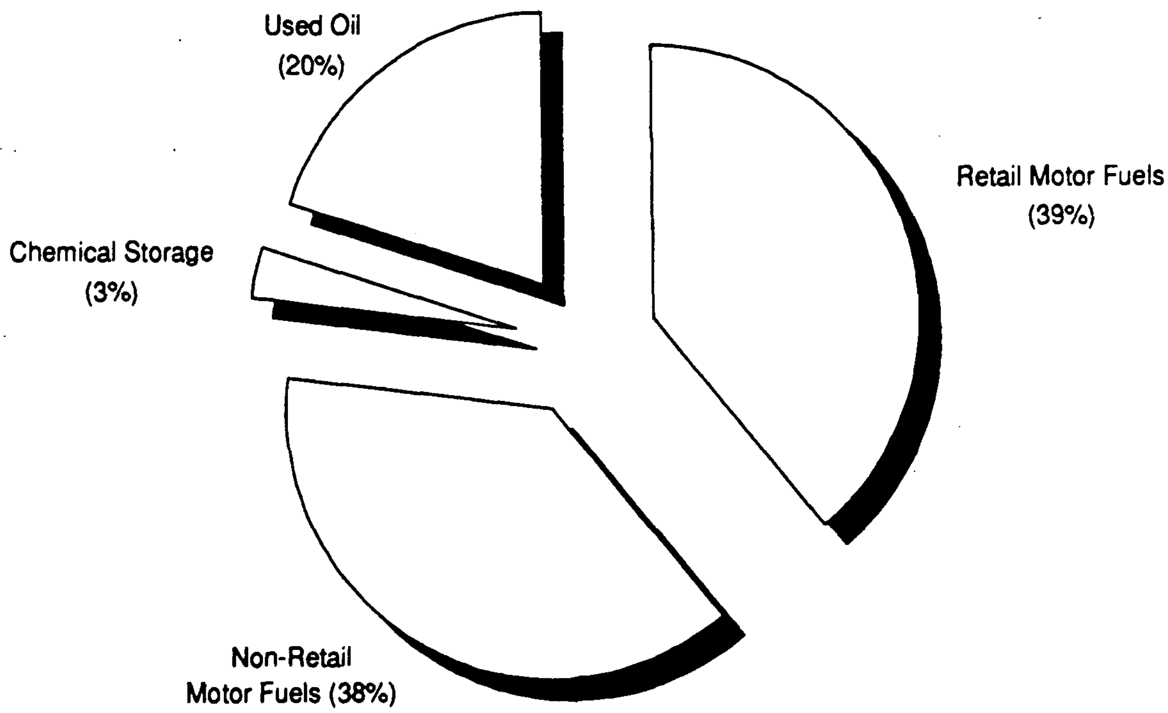
SLIDE I-7

WHERE RELEASED PRODUCT TRAVELS



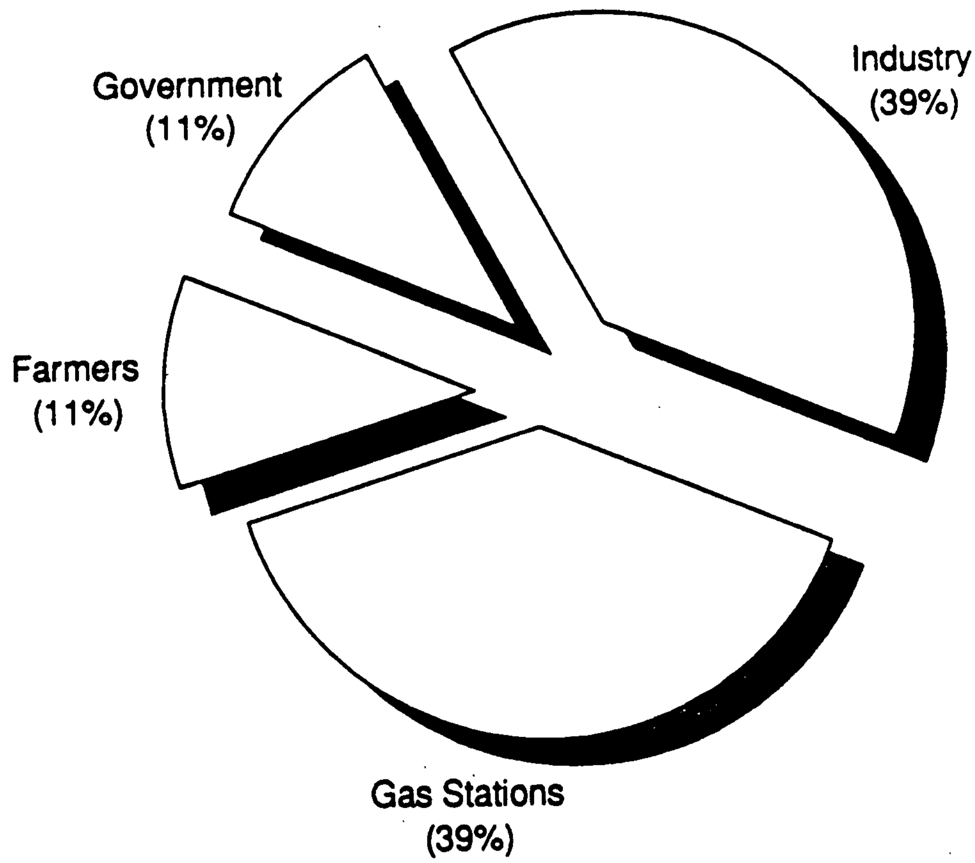
SLIDE I-8

USES OF REGULATED USTs



SLIDE I-9

OWNERSHIP OF USTs USED TO STORE PETROLEUM



SLIDE I-10

WHAT CAN LEAK DETECTION ACCOMPLISH?

Leak detection

- Warns owner or operator of leaks
- Prevents contamination of the environment and risks to human health

SLIDE I-11

WHY IS LEAK DETECTION NECESSARY?

- Leak detection can help save money in the long run
- The average cleanup now costs $150,000

SLIDE I-12

WHY IS LEAK DETECTION NECESSARY?

Leak detection

- Is a good business practice
- Protects human health and the environment
- Protects against liability suits
- Is required by Federal, State, and local laws

SLIDE I-13

LEAK DETECTION METHODS

Three main types of leak detection

- Internal Monitoring
- Interstitial Monitoring
- External Monitoring

SLIDE I-14

INTERNAL MONITORING

Internal monitoring methods

- Inventory control combined with tightness testing
- Manual tank gauging
- Automatic tank gauging
- Statistical inventory reconciliation

SLIDE I-15

INTERSTITIAL MONITORING

Interstitial monitoring method

- Secondary containment with interstitial monitoring

SLIDE I-16

EXTERNAL MONITORING

External monitoring methods

- Vapor monitoring
- Ground-water monitoring

SLIDE I-17

PIPING MONITORING

- Pressurized and suction piping have different compliance time tables and testing requirements
- Pressurized piping must have automatic line leak detectors

SLIDE I-18

LEAK DETECTION METHODS FOR PIPING

Leak detection methods for piping operate on the same principles as those for tanks

- Tightness testing
- Interstitial monitoring
- External monitoring

SLIDE I-19

BASIC LEAK DETECTION

- Overview of leaking USTs
- The need for leak detection
- Leak detection methods

CHAPTER II-1

UST WALK-THROUGH

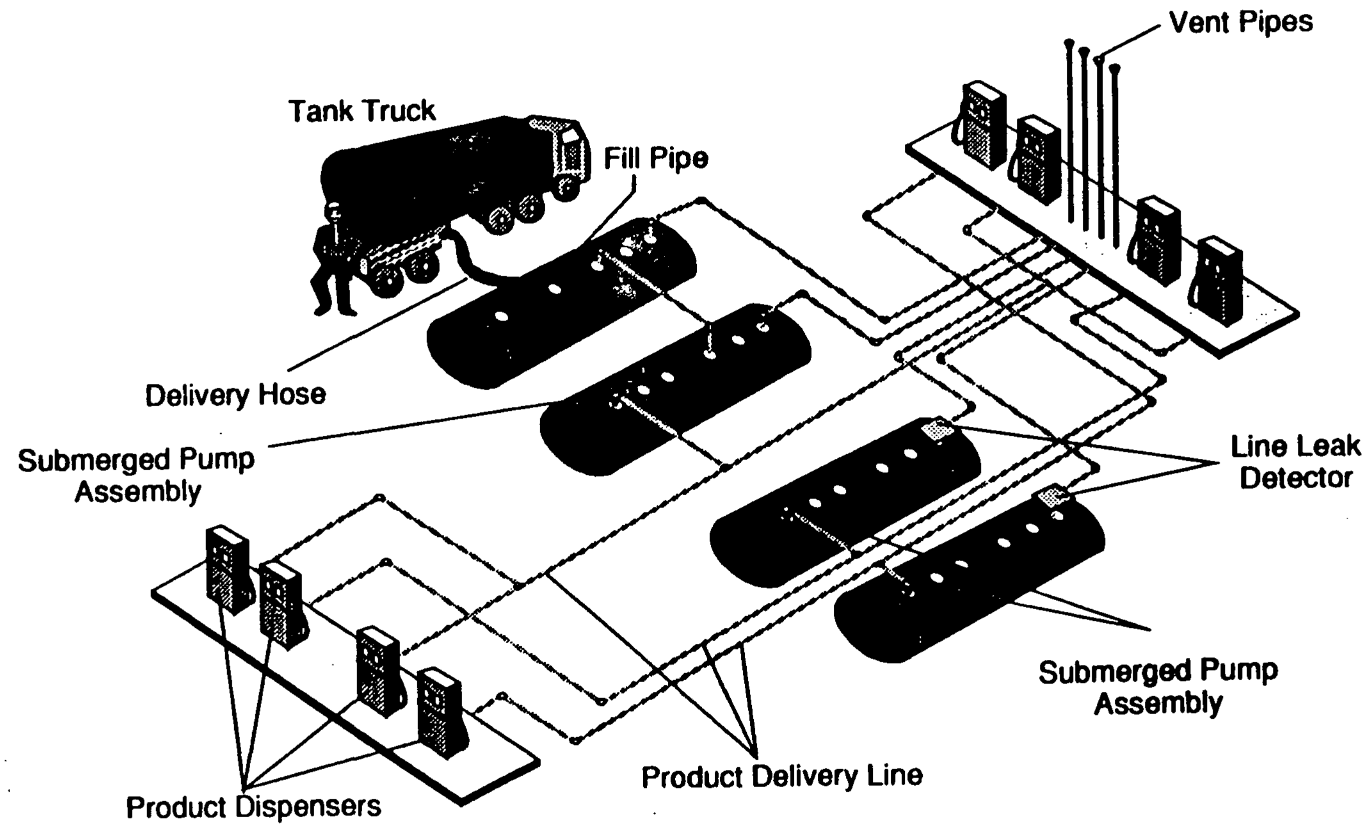
SLIDE II-2

WHAT IS AN UNDERGROUND STORAGE TANK (UST)?

- A system used to store petroleum products
- Includes the tank, piping, and product dispensers

SLIDE II-3

TYPICAL RETAIL GASOLINE STATION



SLIDE II-4

USE EXCEPTIONS

Certain USTs are not required to comply with Federal UST regulations.

- Farm or residential tanks 1,100 gallons or less storing motor fuel for noncommercial purposes
- Tanks storing heating oil for consumptive use on the premises where stored
- Tanks holding 110 gallons or less
- Tanks on or above the floor of underground areas
- Septic tanks and systems for collecting storm water and waste water

SLIDE II-5

UST EXCEPTIONS

- **Flow-through process tanks**
- **Emergency spill and overfill tanks**
- **Surface impoundments, ponds, pits, or lagoons**

SLIDE II-6

UST SYSTEM PARTS

TANKS

- Typical tanks hold between 2,000 and 12,000 gallons
- New tanks are generally constructed of:
  - -- Cathodically protected coated steel
  - -- Fiberglass-reinforced plastic (FRP)
  - -- Steel/fiberglass composite

SLIDE II-7

VAPOR RECOVERY LINES

- Pipes that convey petroleum vapors back to the tank trucks during off-loading or back to the UST during dispensing of product

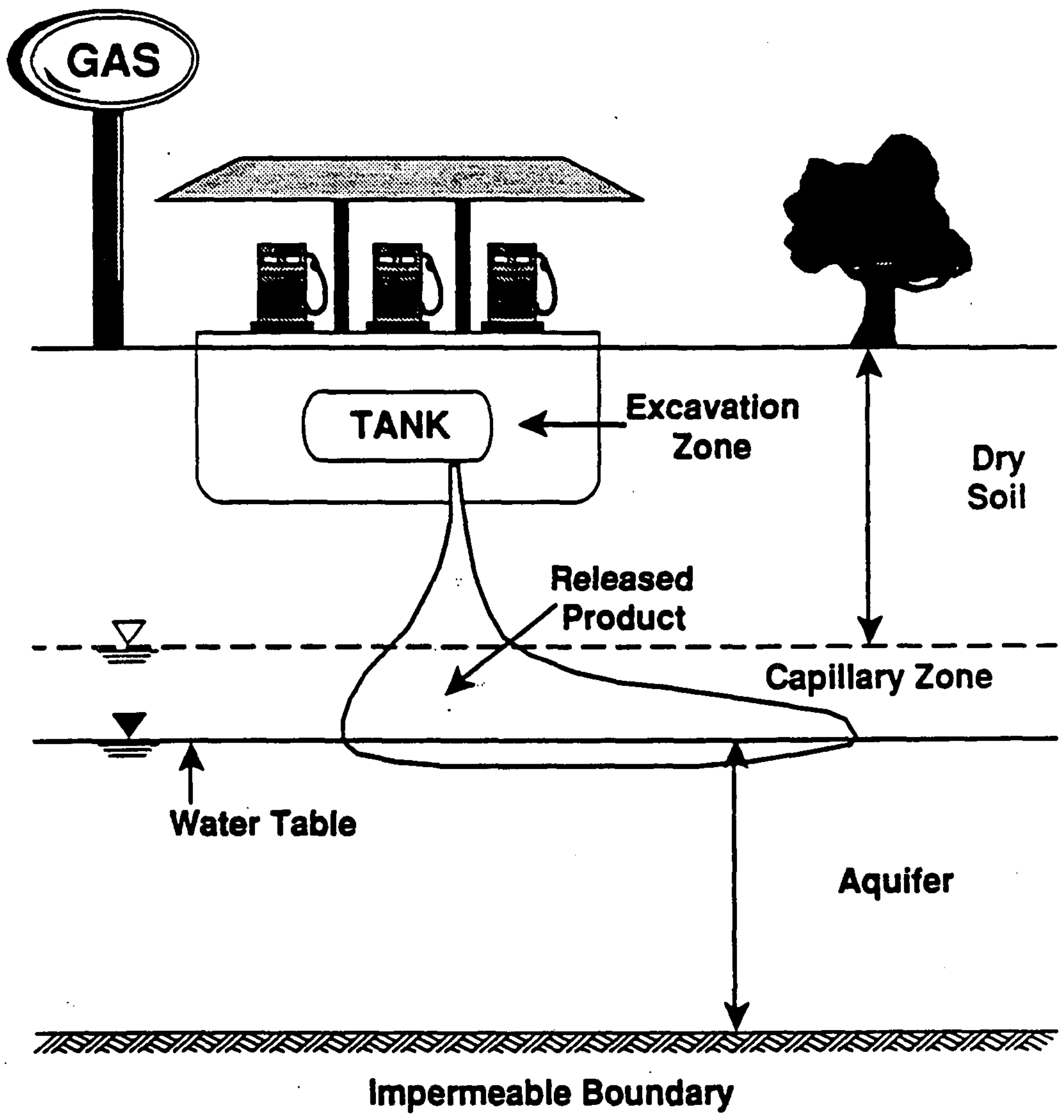
SLIDE II-8

SITE TERMINOLOGY

- Excavation zone
  - -- Area that must be dug up to install an UST
- Backfill
  - -- Substance (usually clean sand, crushed rock, or pea gravel) used to fill in excavation zone after tank is installed
- Water Table
  - -- Level where ground water will rest in porous soil conditions under normal atmospheric pressure

SLIDE II-9

SCHEMATIC OF A SUBSURFACE ENVIRONMENT



SLIDE II-10

WHAT IS AN UST?

- A system used to store and dispense petroleum products
- Includes the tank, piping, and product dispensers

CHAPTER III-1

SITE CHARACTERISTICS

SLIDE III-2

Important site characteristics that should be considered when selecting the proper leak detection method

- UST system characteristics
- Product characteristics
- Soil conditions
- Climatic factors
- Geologic conditions

SLIDE III-3

UST SYSTEM CHARACTERISTICS

- Tank age (new vs. existing)
- Tank size
- Piping system
- UST system size

SLIDE III-4

TANK AGE

- New tanks and piping are those installed after December 23, 1988
- Existing tanks and piping are those installed before December 23, 1988

SLIDE III-5

AGE OF TANK	LEAK DETECTION
Existing Tanks Installed:	Must have leak detection by:
Before 1965 or unknown	December 1989
1965-1969	December 1990
1970-1974	December 1991
1975-1979	December 1992
1980-1988	December 1993

SLIDE III-6

TANK SIZE

- Check tank size -- some tanks may be too large to use certain detection methods

SLIDE III-7

PIPING SYSTEM

- Suction systems use a vacuum to draw the product to the dispenser
- Pressurized systems use a pump to push the product to the dispenser

SLIDE III-8

UST SYSTEM SIZE

- Number of tanks
- Extent of site area

SLIDE III-10

TYPES OF STORED PRODUCTS

- Petroleum
- Hazardous substances
  - -- Include CERCLA hazardous substances
  - -- Do not include hazardous wastes regulated under 40 CFR Parts 260-270
  - -- Use secondary containment for hazardous substances

SLIDE III-11

PRODUCT CHARACTERISTICS IMPORTANT IN LEAK DETECTION

- Solubility
- Density
- Viscosity
- Volatility
- Thermal effects
- Compatibility with tank and piping materials

SLIDE III-12

CHARACTERISTICS OF STORED PRODUCTS

Solubility

- The ability of a substance to dissolve in or mix with another substance

SLIDE III-13

CHARACTERISTICS OF STORED PRODUCTS

Density

- Refers to the mass of a given substance per unit of volume

SLIDE III-14

CHARACTERISTICS OF STORED PRODUCTS

- Gasoline floats on water; DNAPLs do not float

SLIDE III-15

CHARACTERISTICS OF STORED PRODUCTS

Viscosity

- **A measurement of the ease with which a liquid flows**

SLIDE III-16

CHARACTERISTICS OF STORED PRODUCTS

Volatility

- **A measurement indicating how readily a substance will vaporize**

SLIDE III-17

CHARACTERISTICS OF STORED PRODUCTS

Thermal effects

- Refers to changes in product characteristics that occur in response to an increase or decrease in temperature

Compatibility

- The ability of a tank and piping to be unaffected by a stored product

SLIDE III-18

SOIL CONDITIONS

- Relative porosity
- Hydraulic conductivity
- Contamination

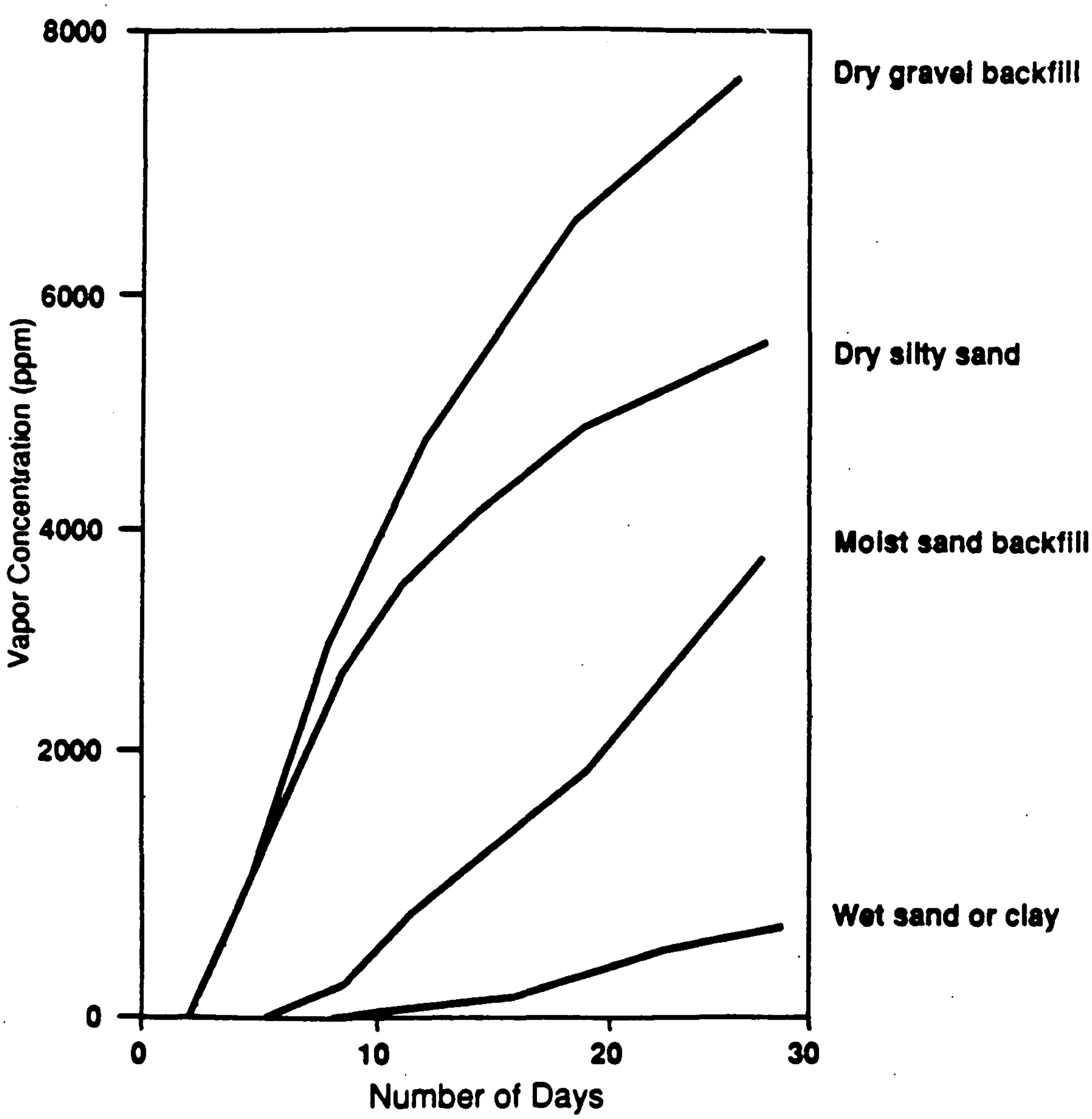
SLIDE III-19

RELATIVE POROSITY

- A measurement of the extent to which a material (e.g., soil or backfill) contains small spaces through which vapors or liquids can pass

SLIDE III-20

THE EFFECT OF SOIL CONDITIONS ON VAPOR CONCENTRATIONS AT A WELL



SLIDE III-21

HYDRAULIC CONDUCTIVITY

- A measurement of the rate at which a liquid (e.g., water) can flow through a particular material such as soil

SLIDE III-22

CONTAMINATION

- **Soil or backfill may be contaminated by past releases**

SLIDE III-23

CLIMATIC FACTORS

- Temperature
- Rainfall

SLIDE III-24

GEOLOGIC CONDITIONS

- Effects of ground water
- Important ground-water variables

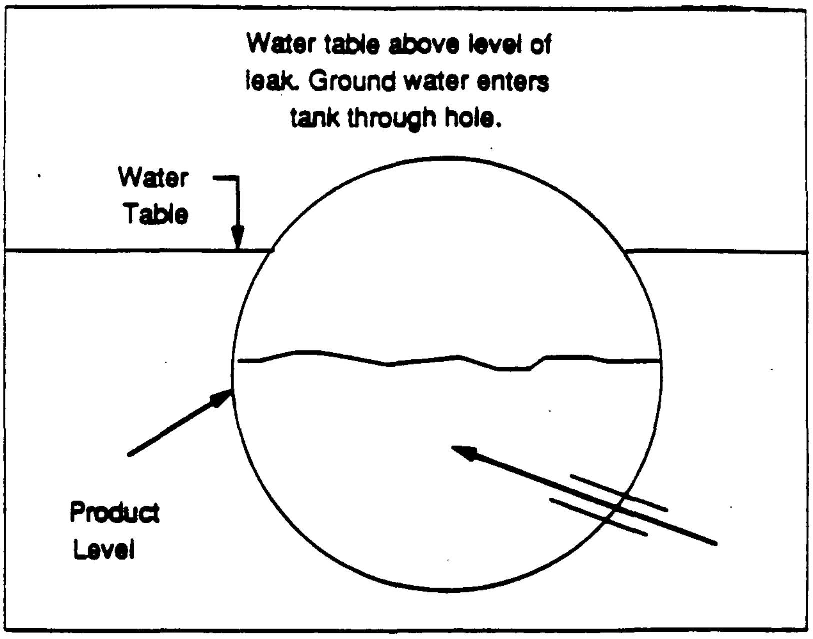
SLIDE III-25

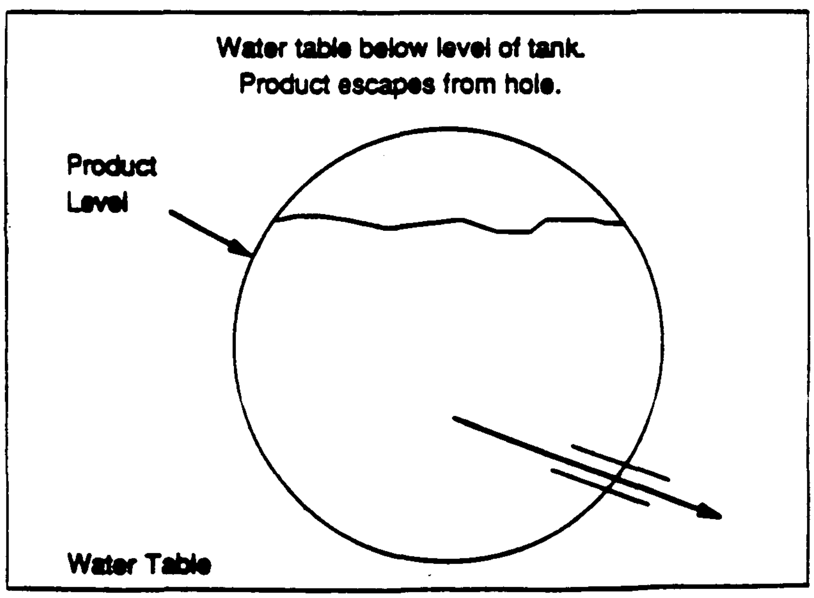
PRESENCE OF GROUND WATER

- Presence of ground water may mask an actual leak or slow the rate of the leak

SLIDE III-26

THE EFFECT OF GROUND WATER ON THE RATE AND FLOW THROUGH A HOLE IN AN UST





SLIDE III-27

GROUND-WATER TABLE

- Depth of water table
- Large fluctuations in water table levels
- Gradient of ground-water flow

SLIDE III-28

SITE CHARACTERISTICS TO CONSIDER WHEN SELECTING A LEAK DETECTION METHOD

- UST system characteristics
- Product characteristics
- Soil conditions
- Climatic factors
- Geologic conditions

CHAPTER IV-1

LEAK DETECTION METHODS FOR TANKS

SLIDE IV-2

ALLOWABLE LEAK DETECTION METHODS

- Monthly leak detection methods

  -- Automatic tank gauging
  -- Manual tank gauging
  -- Secondary containment with interstitial monitoring
  -- Ground-water monitoring
  -- Vapor monitoring

- Inventory control and tank tightness testing

SLIDE IV-3

REQUIREMENTS FOR LEAK DETECTION FOR UST TANKS

There are different leak detection deadlines for new and existing UST tanks:

- New tank deadlines
  - -- MUST comply with UST leak detection when installed
- Existing tank deadlines
  - -- must comply with the requirements according to the following timetable (next slide):

SLIDE IV-4

AGE OF TANK	LEAK DETECTION
Existing Tanks Installed:	Must have leak detection by:
Before 1965 or unknown	December 1989
1965-1969	December 1990
1970-1974	December 1991
1975-1979	December 1992
1980-1988	December 1993

SLIDE IV-5

LEAK DETECTION FOR NEW TANKS

- Monthly monitoring (ATGS, manual tank gauging, secondary containment with interstitial monitoring, ground-water monitoring, vapor monitoring)

- Monthly inventory control and tank tightness testing every five years. (This choice can be used only for ten years after installation)

SLIDE IV-6

LEAK DETECTION FOR EXISTING TANKS

- Monthly monitoring
- Monthly inventory control and tank tightness testing every five years. (Can be used for only ten years after adding corrosion protection and spill/overfill prevention or until December 1998, whichever date is later)
- Monthly inventory control and annual tank tightness testing (this can be used only until December 1998)

SLIDE IV-7

PD/PFA REQUIREMENTS

- Some methods must be capable of detecting a specified leak rate or quantity with a probability of detection (PD) of 0.95 and a probability of false alarm (PFA) of 0.05
- By December 1990, automatic tank gauging systems and tightness tests for tanks or piping must meet PD/PFA requirements
- By September 1991, automatic line leak detectors must meet PD/PFA requirements

SLIDE IV-8

LEAK DETECTION METHODS -- MONTHLY MONITORING

Five monthly monitoring methods:

- Automatic tank gauging
- Manual tank gauging
- Secondary containment with interstitial monitoring
- Ground-water monitoring
- Vapor monitoring

SLIDE IV-9

FOR EACH RELEASE DETECTION METHOD

- Brief description of how the method works
- When the method is appropriate
- Considerations for owners/operators

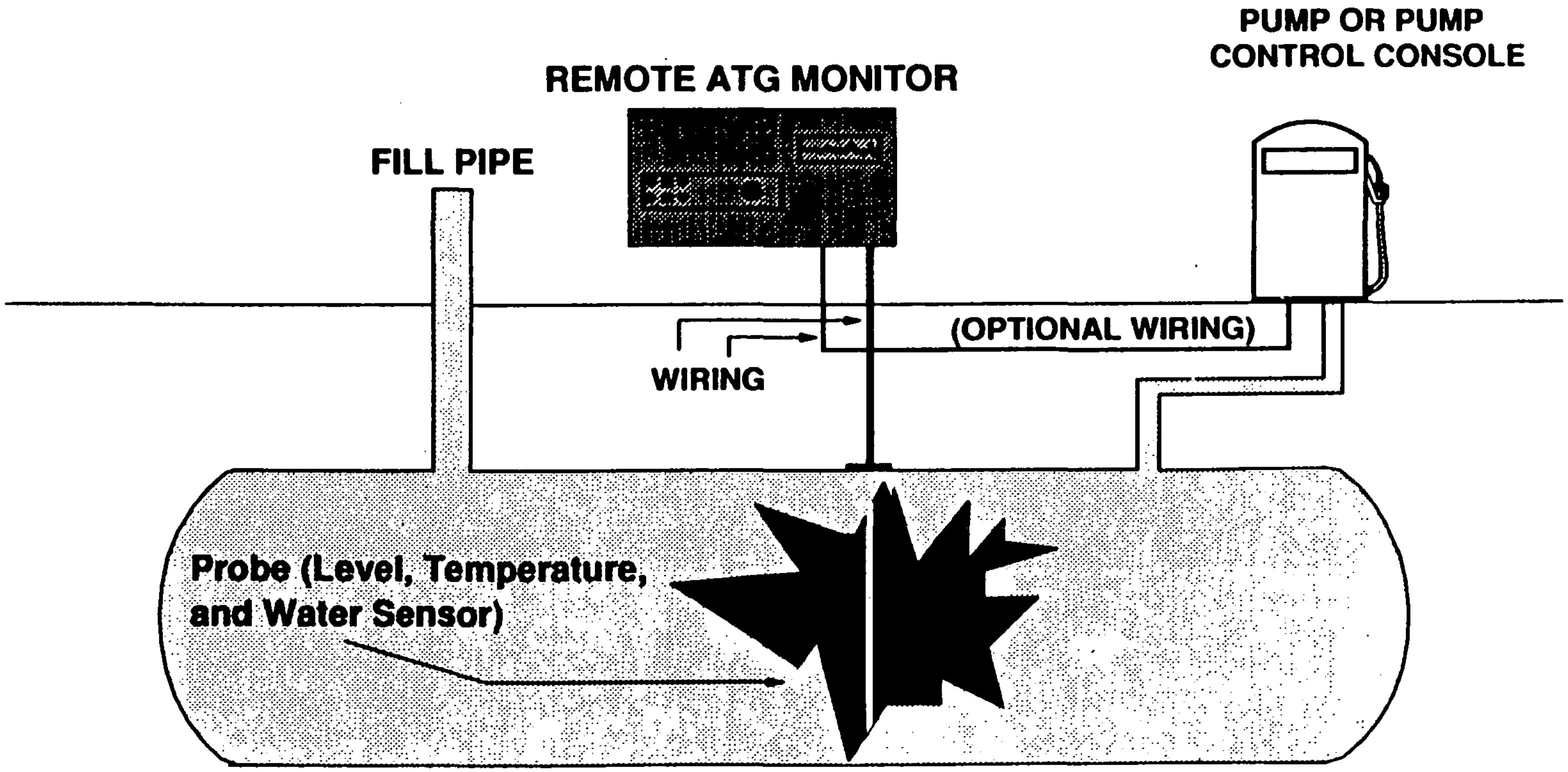
SLIDE IV-10

HOW AUTOMATIC TANK GAUGING SYSTEMS WORK

- Continuously measure and record product level and temperature in tank
- Measure volume change over time. If it decreases significantly, there may be a leak

SLIDE IV-11

SCHEMATIC OF AN AUTOMATIC TANK GAUGING SYSTEM



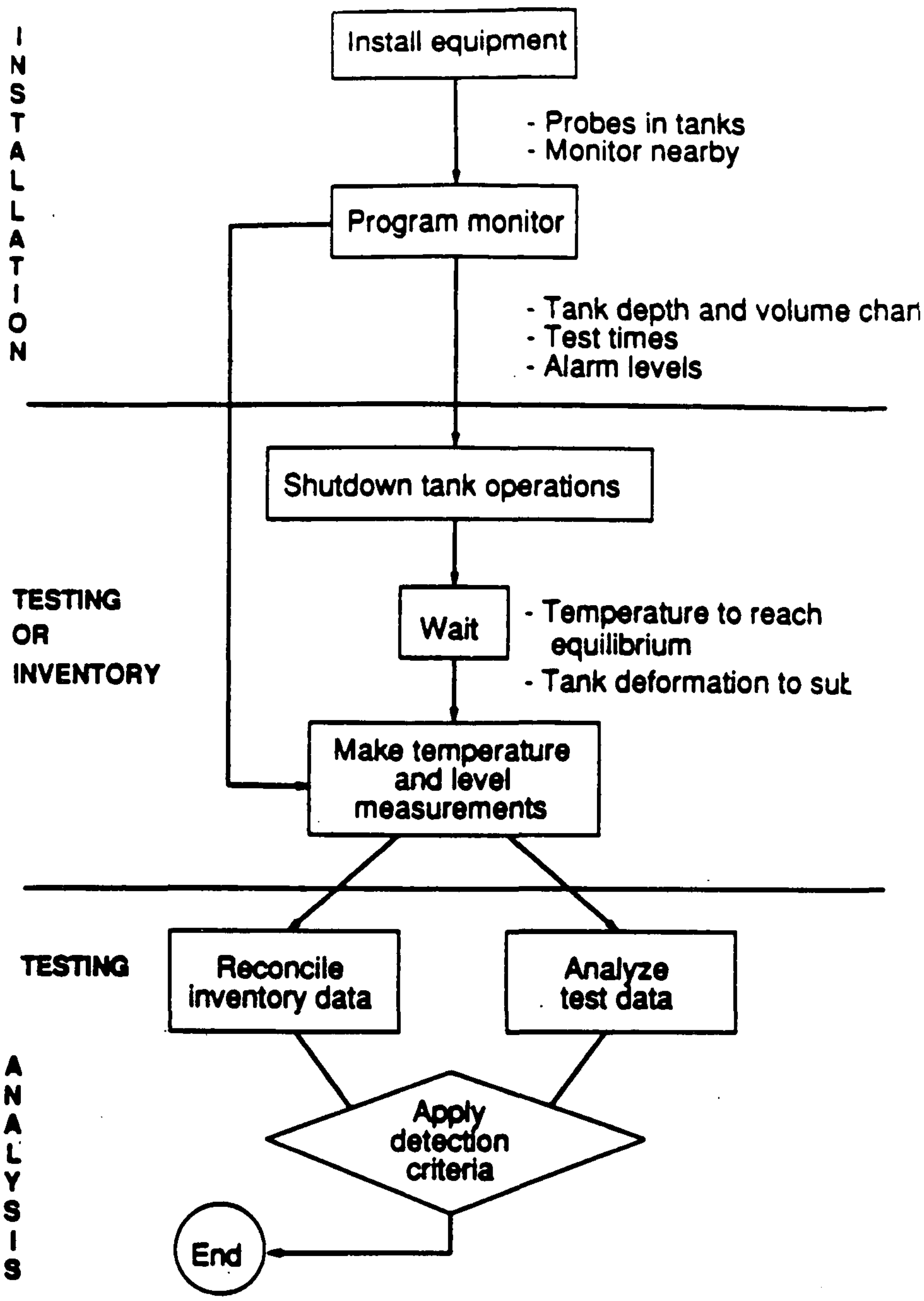
SLIDE IV-12

HOW AUTOMATIC TANK GAUGING SYSTEMS WORK

- Inventory control mode
- Leak testing mode

SLIDE IV-13

GENERAL PROCEDURE FOR ATGS



SLIDE IV-14

HOW AUTOMATIC TANK GAUGING SYSTEMS WORK

Inventory control mode

- Automatically records activities of an in-service tank, including deliveries
  - -- Product level and temperature readings are automatically taken and are converted to volume measurements. Data used in inventory control
  - -- ATGS operate in this mode when leak test is not being performed

SLIDE IV-15

ATGS ALARM SYSTEMS

- ATGS alarms notify owners/operators of:
  - -- High and low product levels
  - -- High water level
  - -- Theft of product

SLIDE IV-16

HOW AUTOMATIC TANK GAUGING SYSTEMS WORK

Leak testing mode

- Product level and temperature measured generally at least two hours a month while tank not in use
- Determines change in volume per hour, compares that value to an internal standard, and determines if UST is leaking or not
- Test can be run at any level of product in tank
- Tank must be out of service during the test

SLIDE IV-17

WHEN ATGS ARE APPROPRIATE

- UST system characteristics
  - -- Primarily used for tanks with capacity less than 15,000 gallons and cannot be used for piping
- Product characteristics
  - -- Primarily used with gasoline or diesel
  - -- If used with larger size or other fuels, ask vendor for proof that the method is effective
- Soil conditions
  - -- No restrictions exist

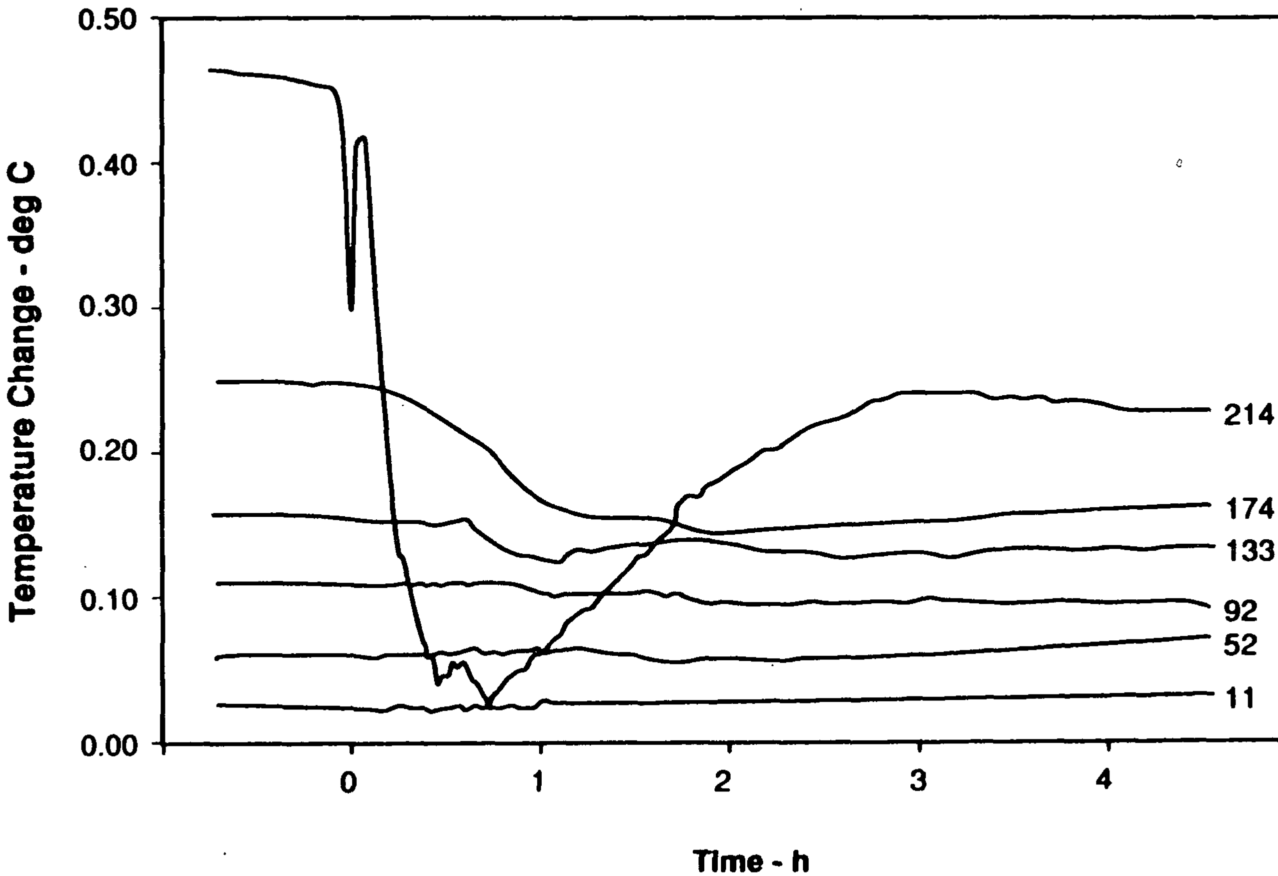
SLIDE IV-18

WHEN ATGS ARE APPROPRIATE

- Climatic factors
  - -- Following delivery of fuel there is a six-hour waiting period (or longer, depending on climate)
- Geologic conditions
  - -- Ground water covering all or part of a tank may mask a leak

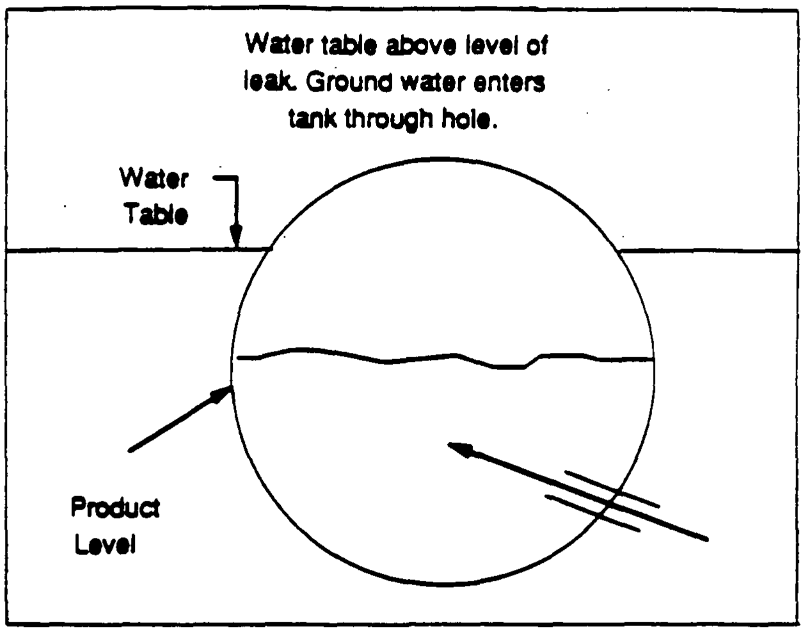
SLIDE IV-19

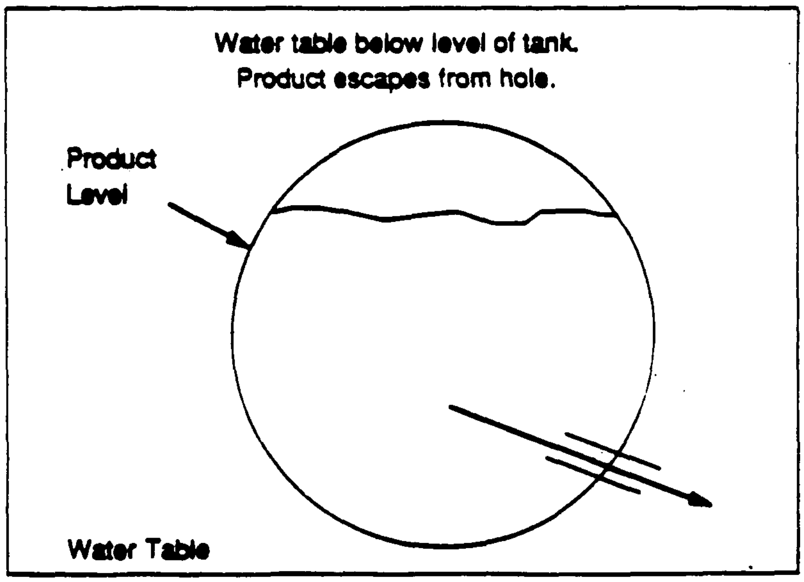
EFFECT OVER TIME OF TOPPING THE TANK WITH COLDER PRODUCT



SLIDE IV-20

THE EFFECT OF GROUND WATER ON THE RATE OF FLOW THROUGH A HOLE IN AN UST





SLIDE IV-21

CONSIDERATIONS

Tank level

- No product should be delivered to tank for at least six hours before the monthly test
- No product should be withdrawn from the tank for a few hours before the monthly test
- No product can be withdrawn from or added to an UST during the monthly test, which lasts one to six hours

SLIDE IV-22

CONSIDERATIONS

- ATGS requires little staff time
- Some owners/operators find inventory control and optional off-site monitoring features attractive
- Tanks require a dedicated opening for the ATGS probe, making retrofit difficult in some cases

SLIDE IV-23

HOW MANUAL TANK GAUGING WORKS

Short-term test in a static UST system

- This test differs from inventory control, which requires daily recording volume in an active tank
- Method cannot be used on tanks larger than 2,000 gallons

SLIDE IV-24

HOW MANUAL TANK GAUGING WORKS

Product measured weekly with gauge stick

- Test lasts up to 58 hours, depending on tank size
- UST must be out-of-service during the test
- Four measurements taken each week
  - -- Two at beginning of the test
  - -- Two at end of the test

SLIDE IV-25

SAMPLE CALIBRATION CHART CONVERTING PRODUCT DEPTH TO GALLONS*

Tank Size / Depth in Inches	550 Gal. 49½" x 5'5"	1000 Gal. 49½" x 10'	1000 Gal. 64" x 6'	1500 Gal. 64" x 9'	2000 Gal. 64" x 12'
1	2	4	3	4	6
2	7	13	9	13	18
3	13	24	17	25	34
4	20	38	26	39	52
5	29	52	36	54	75
6	37	68	47	71	94
7	47	86	59	89	119
8	57	104	72	108	144
9	68	124	85	128	171
10	79	144	100	150	200
11	90	165	114	172	229
12	102	187	130	195	260
13	115	209	145	218	291
14	127	232	162	243	324
15	140	255	178	268	357

* Note that product depth in left column converts to gallons in the other columns.

SLIDE IV-26

HOW MANUAL TANK GAUGING WORKS

- Calibrations converted to product volume
- Average of first two measurements - Average of final two measurements = Change in product volume over time
- Compare calculated tank volume change to weekly and monthly standards to determine whether discrepancy indicates leak

SLIDE IV-27

WEEKLY AND MONTHLY STANDARDS FOR VOLUME CHANGE

Tank Capacity (gal.)	Weekly Change (gal.)	Monthly Standard (gal.)	Test Duration (hrs.)
Up to 550	10	5	36
551 - 1,000 (64"x73")	9	4	44
1,000 (48"x128")	12	6	58
If MTG is combined with TTT:			
1,001 - 2,000	26	13	36

SLIDE IV-28

WHEN MANUAL TANK GAUGING IS APPROPRIATE

UST system characteristics

- Used only with tanks with capacity less than 2,001 gallons

  -- Tanks smaller than 1,001 gallons may use this method alone for the life of the tank

  -- Tanks between 1,001 and 2,000 gallons must <u>also</u> use periodic tank tightness testing. Combined method can be used only for ten years following installation or upgrade. Not allowed after 1998 for existing, non-upgraded tanks

SLIDE IV-29

WHEN MANUAL TANK GAUGING IS APPROPRIATE

Product characteristics

- Not restricted
- Works best with heavier fluids (e.g., used oil)

Soil conditions

- Not restricted

SLIDE IV-30

WHEN MANUAL TANK GAUGING IS APPROPRIATE

Climatic factors

- Ambient temperature changes may affect volume of stored product
- If temperature change is great, testing period can be lengthened

SLIDE IV-31

WHEN MANUAL TANK GAUGING IS APPROPRIATE

Geologic conditions

- Ground water may mask leak
- Should not be used in areas with permanent high water table

SLIDE IV-32

CONSIDERATIONS

- Frequency and length of test
  - -- Test must be performed at least once a week
  - -- Testing period must last at least 36 hours
  - -- Owner/operator must remove UST system from service during test
- Equipment costs are very low

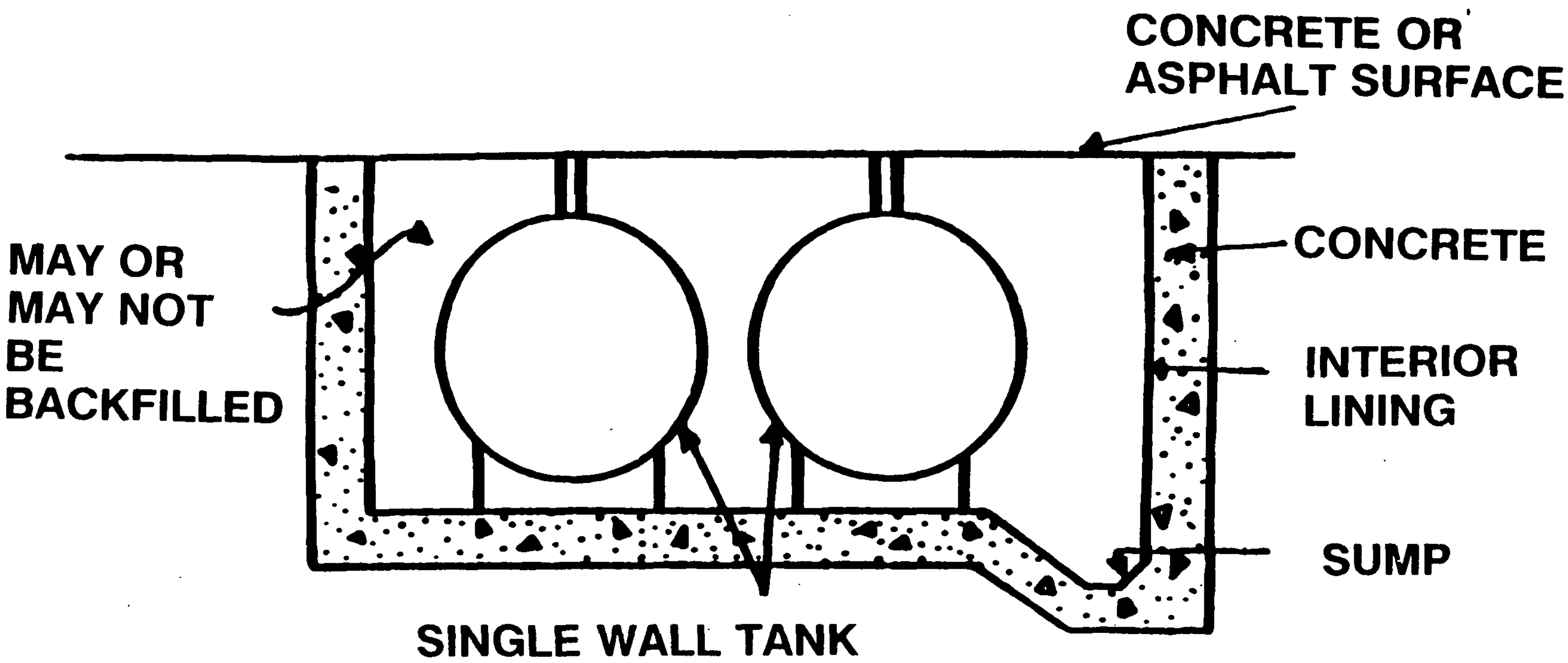
SLIDE IV-33

HOW SECONDARY CONTAINMENT WITH INTERSTITIAL MONITORING WORKS

- Secondary containment provides a barrier between tank and surrounding environment
- Interstitial monitors test for product in space between tank and outer containment barrier

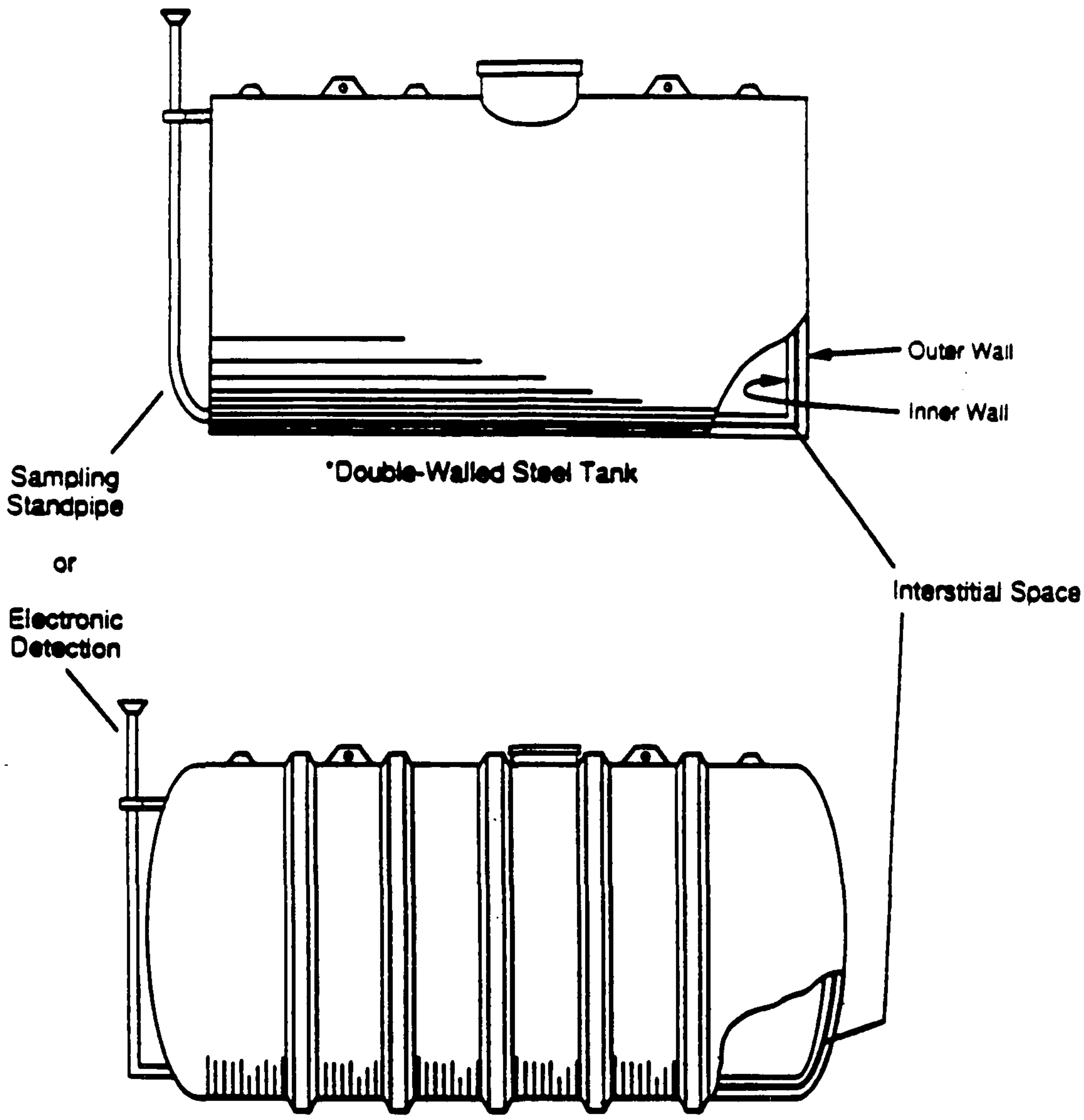
SLIDE IV-34

TANKS IN A CONCRETE VAULT



SLIDE IV-35

TWO DOUBLE-WALLED TANK CONFIGURATIONS

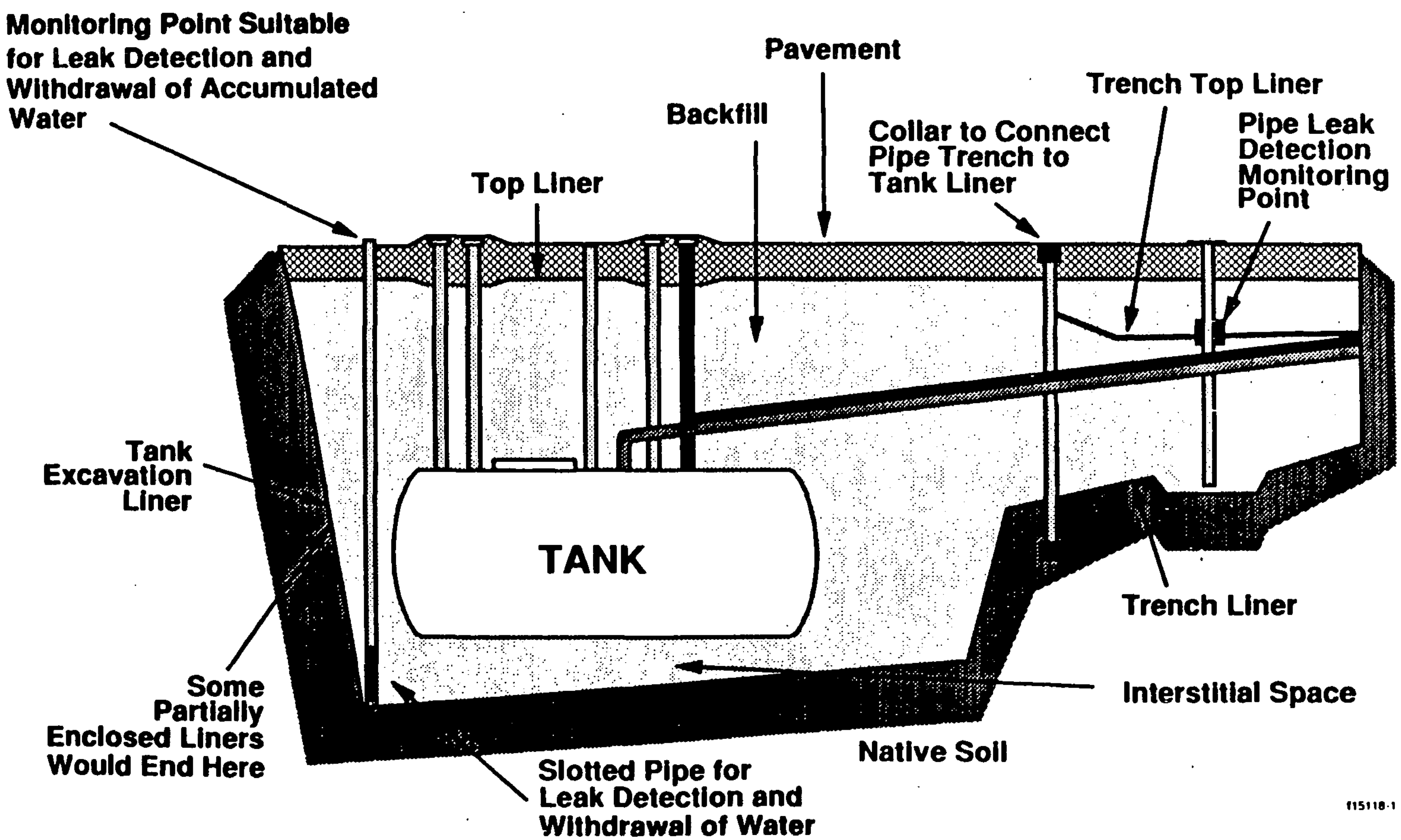


*Double-Walled Steel Tank

*Double-Walled FRP Tank

SLIDE IV-36

TANK WITH EXCAVATION LINER



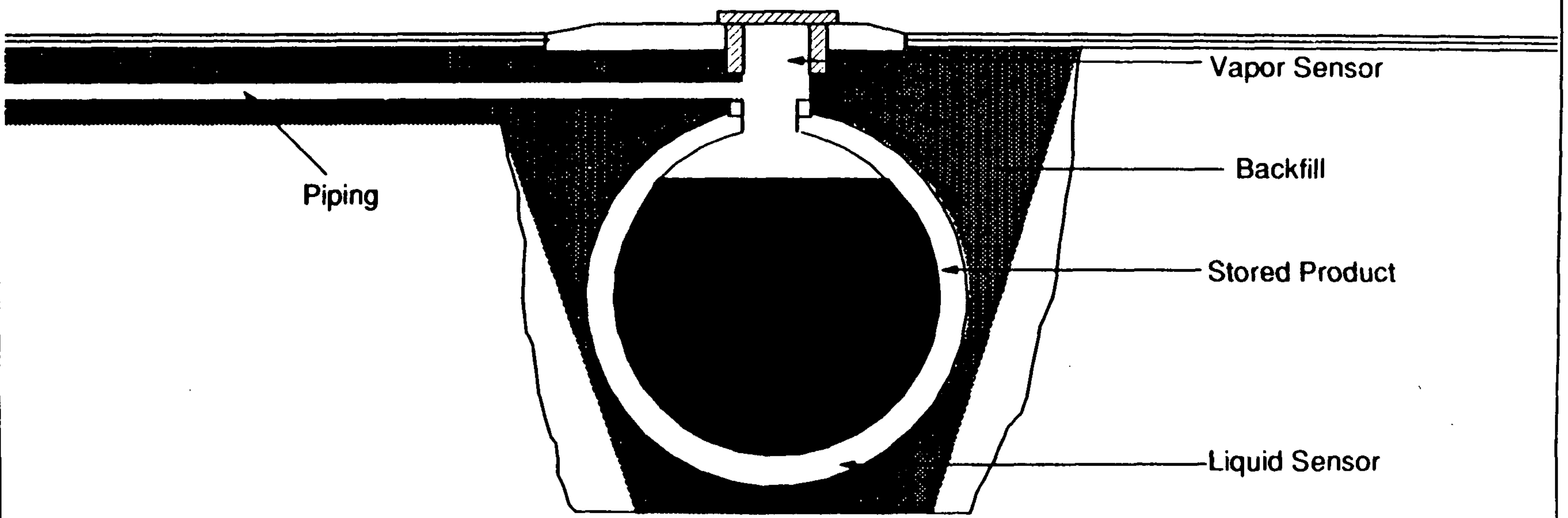
SLIDE IV-37

INTERSTITIAL MONITORING METHODS INCLUDE

- Electrical conductivity
- Pressure sensing
- Liquid sensors
- Hydrostatic sensing
- Manual detection (dipstick)
- Vapor monitoring

SLIDE IV-38

DOUBLE-WALLED TANK SHOWING PLACEMENT OF BOTH VAPOR AND LIQUID SENSORS



SLIDE IV-39

WHEN SECONDARY CONTAINMENT WITH INTERSTITIAL MONITORING IS APPROPRIATE

UST system characteristics

- Can be used for both tanks and piping
- Double-walled tanks are seldom larger than 20,000 gallons
- Excavation liners may be used around any size tank
- Secondary containment is not practical for existing tanks and piping, except when an internal bladder is used for existing tanks

SLIDE IV-40

WHEN SECONDARY CONTAINMENT WITH INTERSTITIAL MONITORING IS APPROPRIATE

Product characteristics

- Methods may be used for all fuel types, including hazardous substances

Soil conditions

- No restrictions exist

SLIDE IV-41

WHEN SECONDARY CONTAINMENT WITH INTERSTITIAL MONITORING IS APPROPRIATE

Climatic factors

- No restrictions. However, in areas with heavy rainfall a fully enclosed containment system should be used

Geologic conditions

- In areas of high ground water, a fully enclosed containment system should be used

SLIDE IV-42

CONSIDERATIONS

Difficult installation

- Installation of secondary containment using liners requires even more careful attention by professional installers than other leak detection methods
- With the exception of internal bladders, retrofitting is basically impractical because it requires removing tank and piping entirely, installing a liner, and reinstalling tank

SLIDE IV-43

CONSIDERATIONS

Compatibility of barrier with stored product

- Exposure to product should not result in deterioration of barrier
- For standard petroleum products such as gasoline and diesel fuel, most liners sold are compatible with product
- For products other than petroleum, nature of product and type of barrier must be considered to ensure an appropriate match

SLIDE IV-44

CONSIDERATIONS

Barrier may protect environment if leak occurs.

- **Low, if any, corrective action costs associated with this method. This aspect differentiates this method from others by detecting leaks and containing them**

SLIDE IV-45

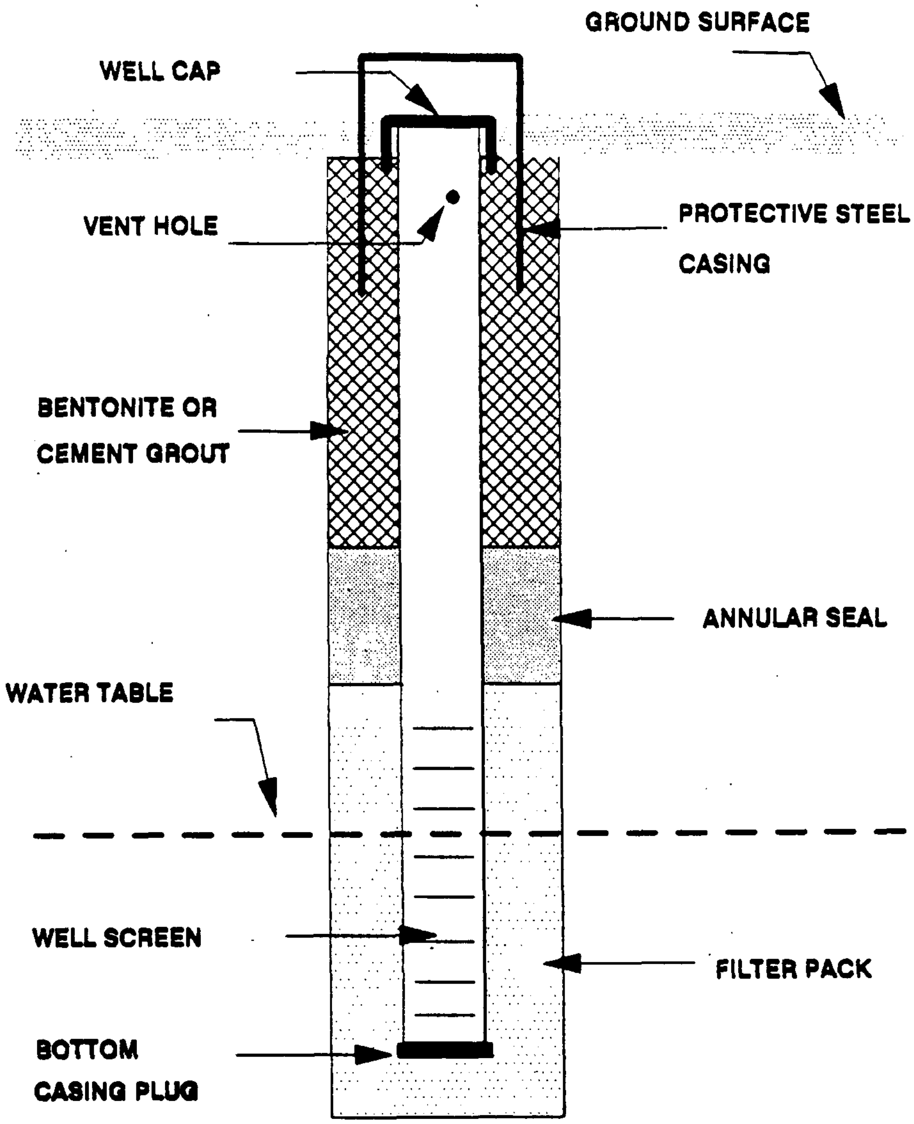
HOW GROUND-WATER MONITORING WORKS

Monitoring wells

- There are generally one to four wells per UST
- Wells must be placed in, or near, backfill so that they can detect leaks rapidly
- Well screen extends from the bottom of well to the highest water table level
- On-site staff must check wells at least monthly for presence of leaked product floating on ground-water surface

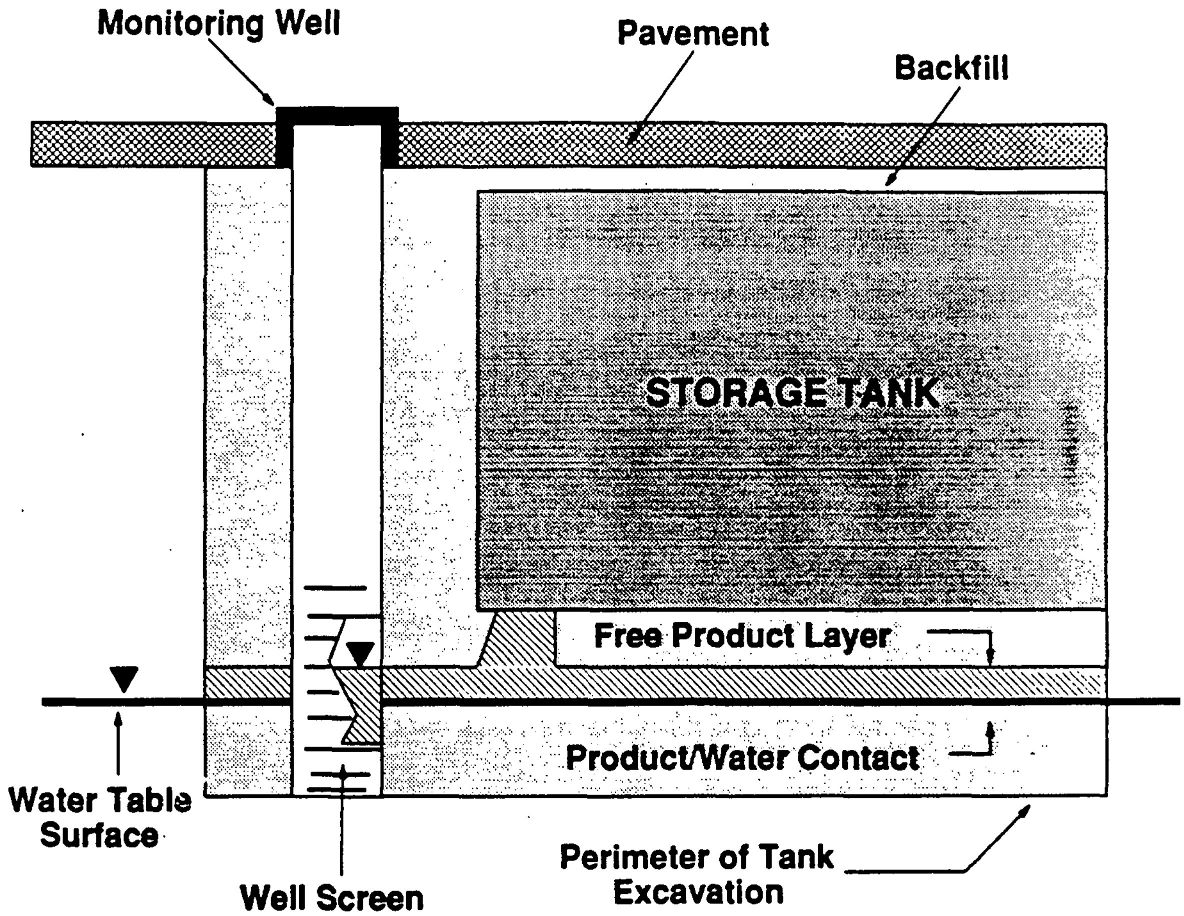
SLIDE IV-46

MONITORING WELLS WITH FILTER PACK



SLIDE IV-47

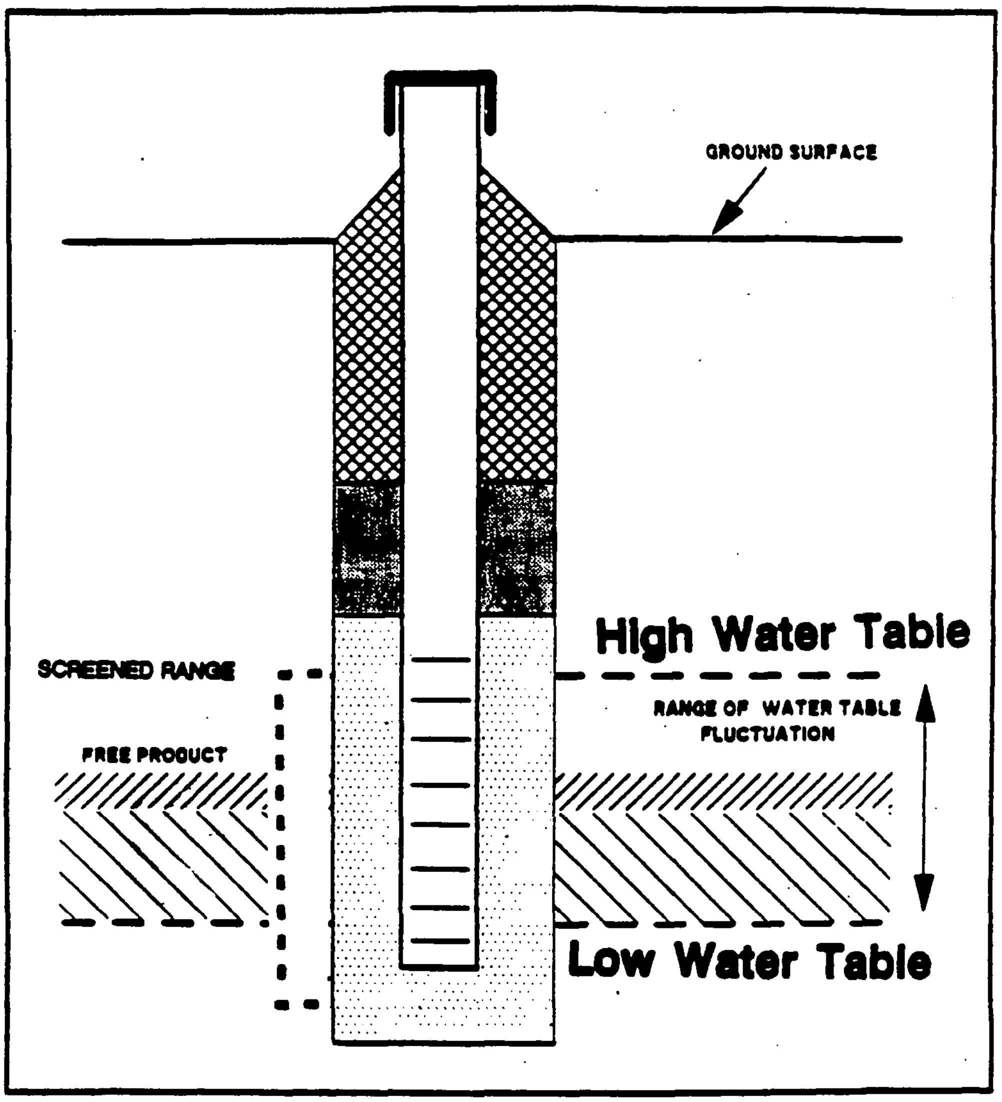
MONITORING WELL IN EXCAVATION ZONE



Monitoring wells installed in the excavation zone will quickly detect a release when the ground water table is within the tank excavation.

SLIDE IV-48

THE WELL SCREEN IS PLACED TO EXTEND OVER THE ENTIRE RANGE OF WATER TABLE FLUCTUATION



SLIDE IV-49

MONITORING WELLS

- In manual systems, ground-water samples must be collected from the well by hand with a bailer at least once a month
- In automatic systems, the detector operates by itself and sounds an alarm. This system is used at least once per month

SLIDE IV-50

HOW GROUND-WATER MONITORING WORKS

Manual Devices

- Grab samplers
- Chemical-sensitive pastes

SLIDE IV-51

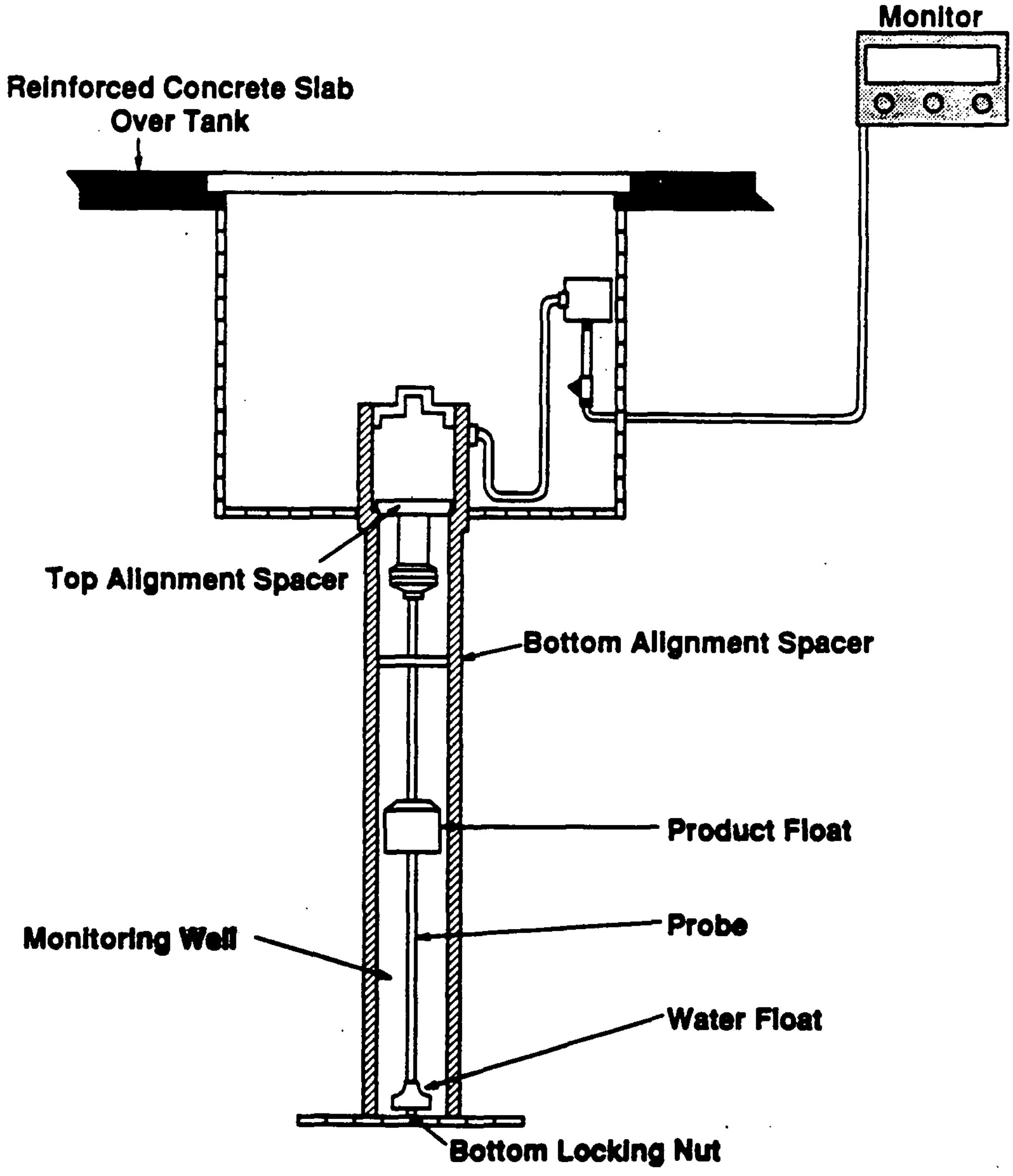
HOW GROUND-WATER MONITORING WORKS

Types of automatic devices

- Differential float devices
- Product soluble devices
- Thermal conductivity devices
- Electrical conductivity devices

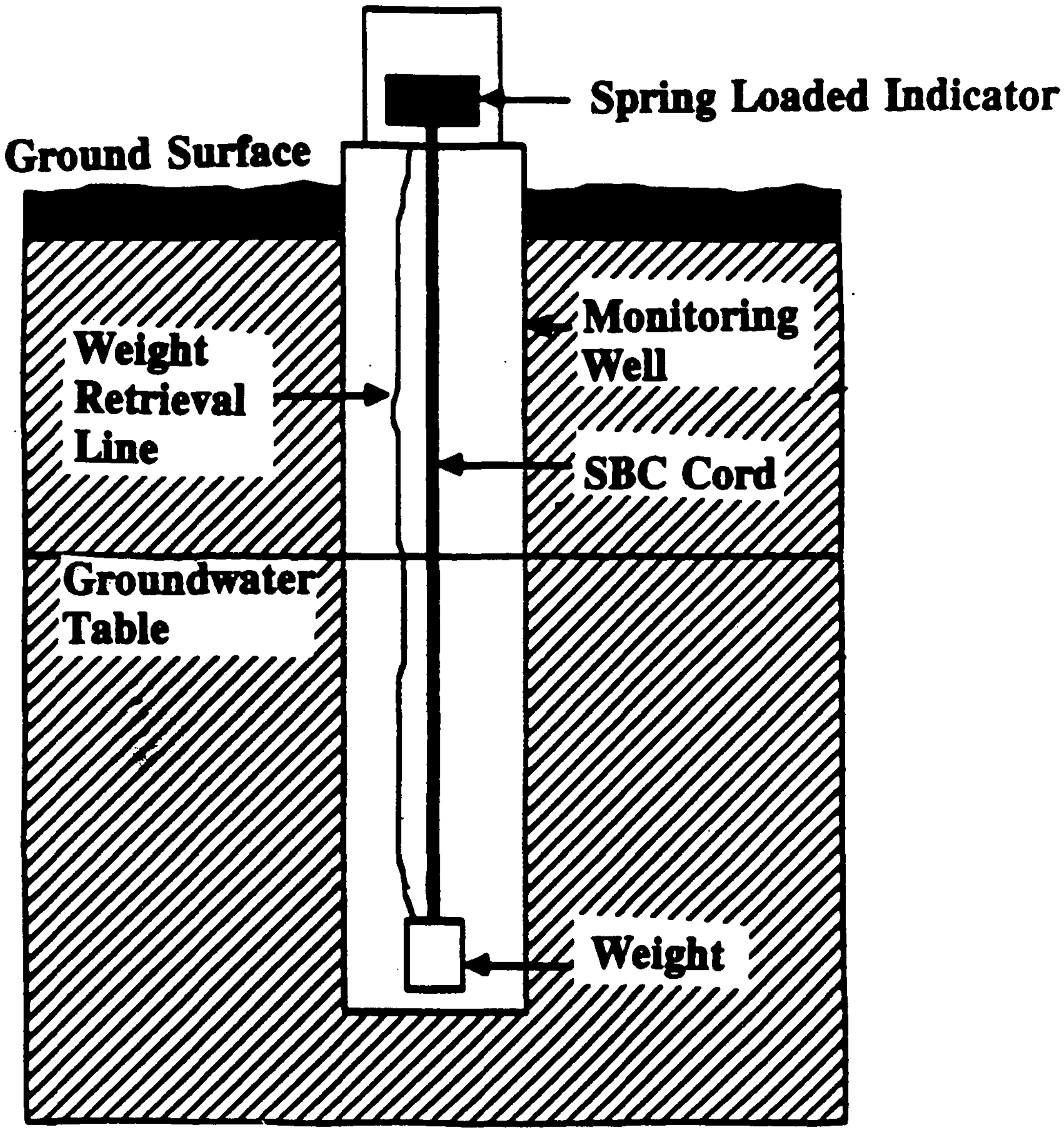
SLIDE IV-52

SCHEMATIC OF A DIFFERENTIAL FLOAT DEVICE



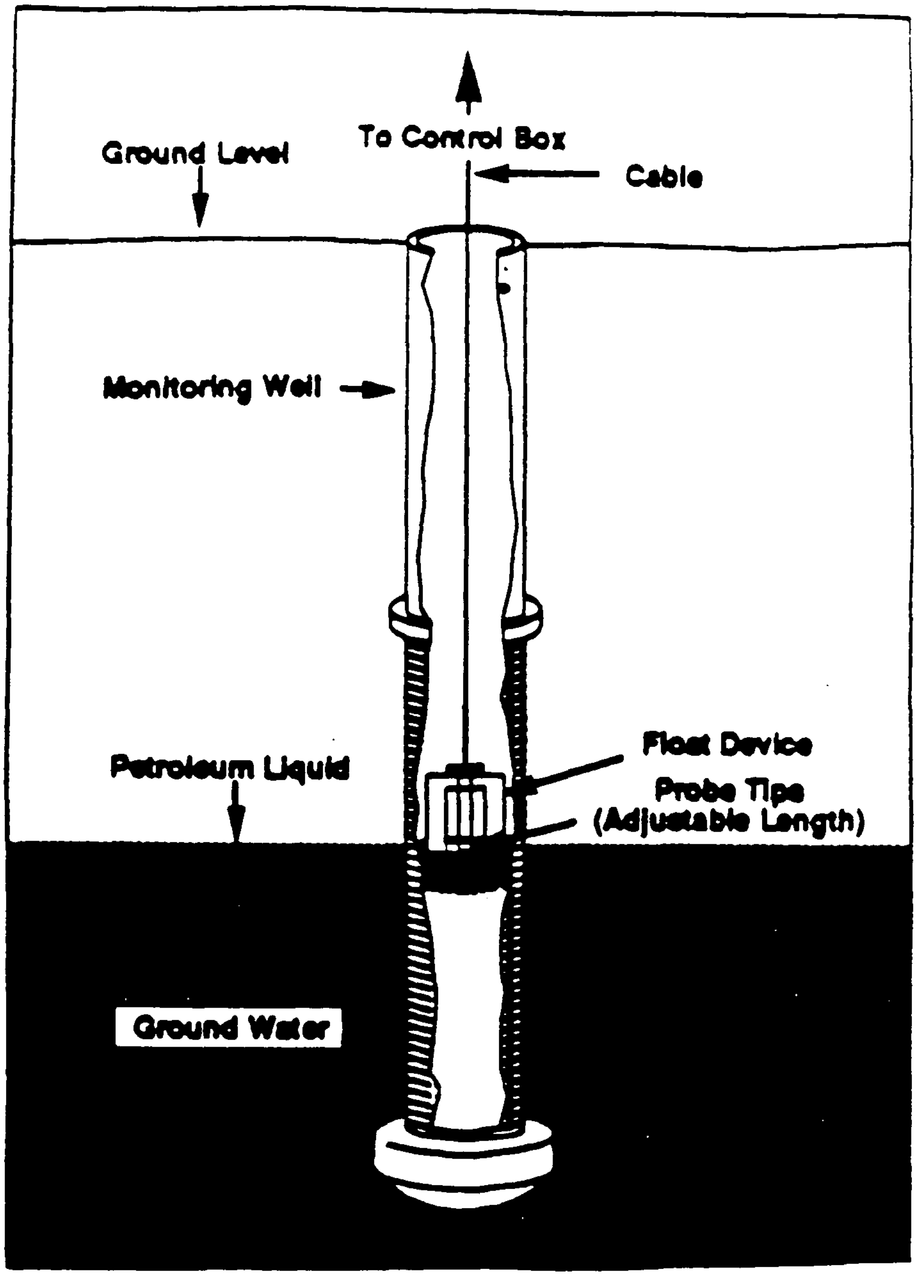
SLIDE IV-53

SCHEMATIC OF A MECHANICALLY ACTIVATED PRODUCT SOLUBLE DEVICE



SLIDE IV-54

SCHEMATIC OF THERMAL CONDUCTIVITY DEVICE



SLIDE IV-55

WHEN GROUND-WATER MONITORING IS APPROPRIATE

UST system characteristics

- Can be used to detect leaks from both tanks and pipes
- May be used on any size tank. For larger systems, more wells are added
- May be retrofitted

SLIDE IV-56

WHEN GROUND-WATER MONITORING IS APPROPRIATE

Product characteristics

- Density must be lower than that of water
- Product should not mix easily with water
- Two examples are gasoline and diesel fuel

SLIDE IV-57

WHEN GROUND-WATER MONITORING IS APPROPRIATE

Soil conditions

- Soil or backfill between well and UST must be permeable
- Soil or backfill must be porous enough to allow released product to travel to wells
- Hydraulic conductivity should be > 0.01 cm/sec

SLIDE IV-58

WHEN GROUND-WATER MONITORING IS APPROPRIATE

Climatic factors

- Very low temperatures can cause incorrect test results. Ice can freeze monitors and interfere with product-soluble devices

SLIDE IV-59

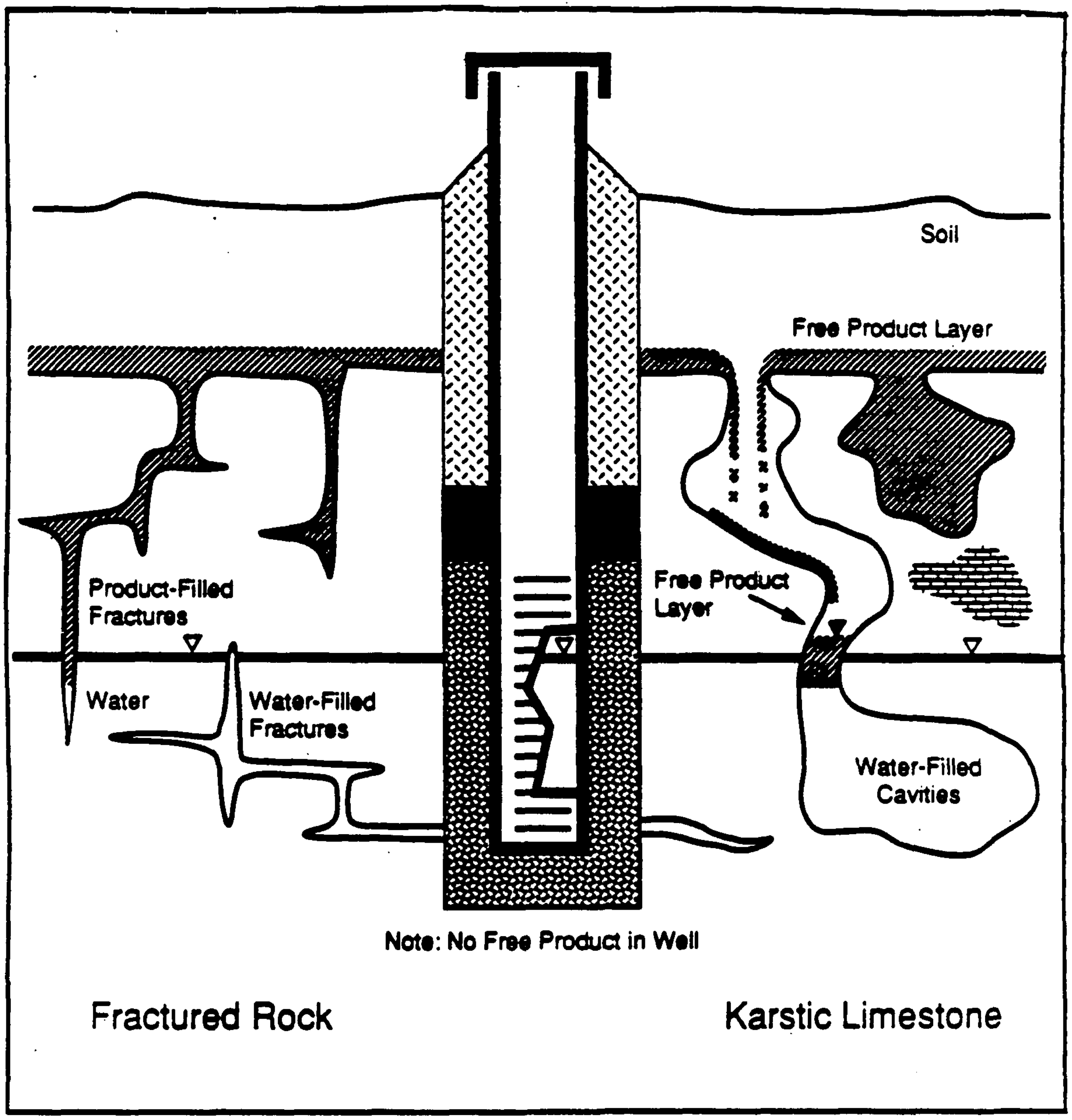
WHEN GROUND-WATER MONITORING IS APPROPRIATE

Geologic conditions

- Level of ground-water table must be less than 20 feet from the surface
- Fluctuations in water table level may restrict use
- Gradient of ground-water flow must be known for effective placement of monitoring wells
- Well placement must account for fractures and cavities in the soil

SLIDE IV-60

POORLY PLACED GROUND-WATER MONITORING WELL



SLIDE IV-61

CONSIDERATIONS

- Site assessment is necessary
- Operation of detection devices is simple
- Avoid damage to tanks and pipes during installation

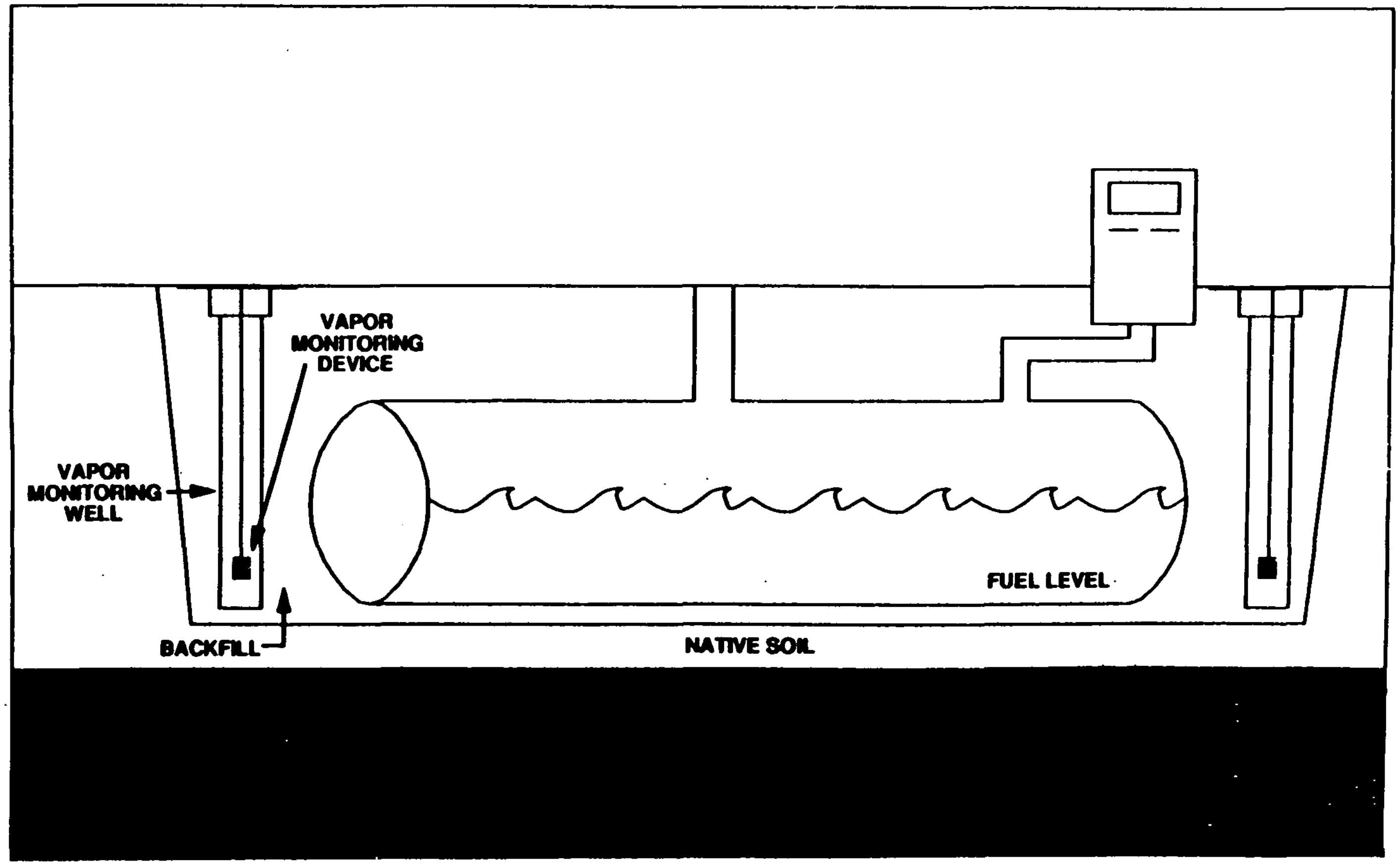
SLIDE IV-62

HOW VAPOR MONITORING SYSTEMS WORK

- Check for presence of product fumes near UST system
- Automatic systems incorporate network of sensors
- Manual systems use air samples collected from a network of wells

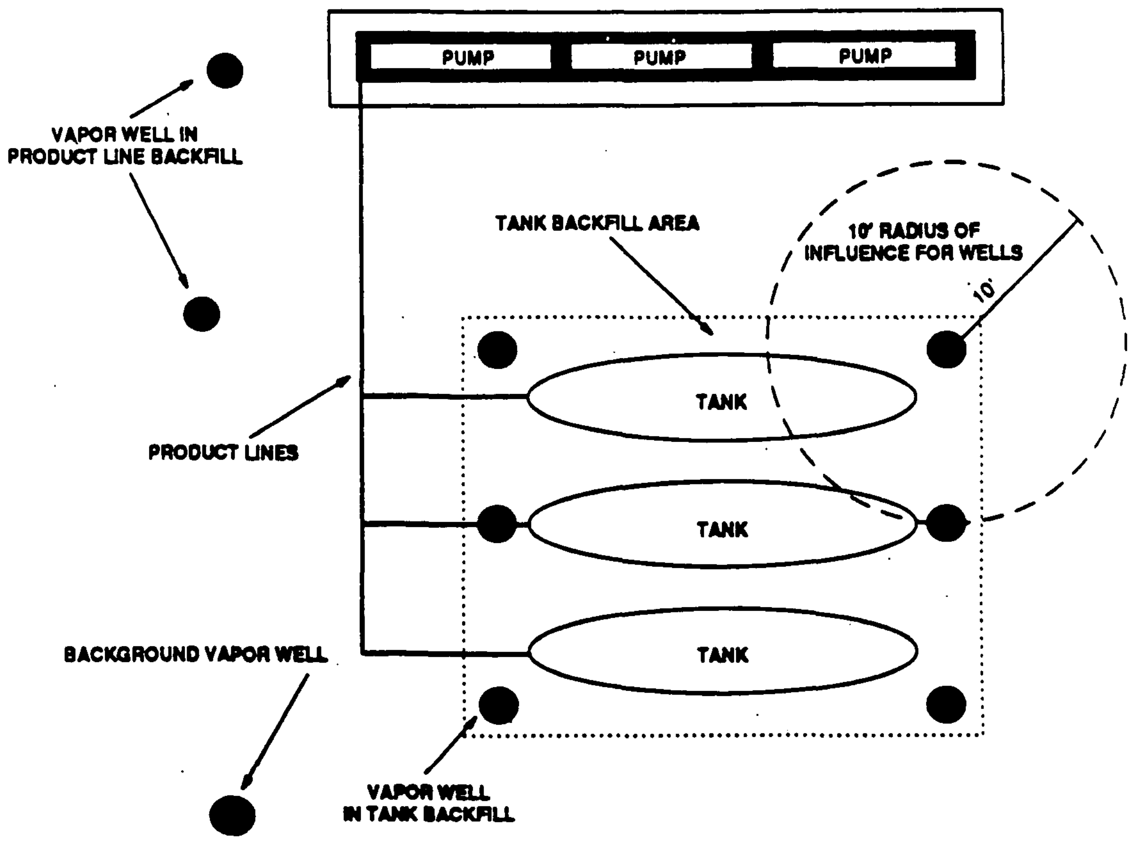
SLIDE IV-64

UNDERGROUND STORAGE TANK SYSTEM WITH VAPOR MONITORING WELLS



SLIDE IV-65

MAP VIEW OF TYPICAL UST SITE WITH VAPOR MONITORING



SLIDE IV-66

WHEN VAPOR MONITORING IS APPROPRIATE

UST system characteristics

- Can be used for both tanks and piping
- Can be installed with new or existing tanks and piping

SLIDE IV-67

WHEN VAPOR MONITORING IS APPROPRIATE

Product characteristics

- Must be used with products that vaporize readily (e.g., gasoline)

SLIDE IV-68

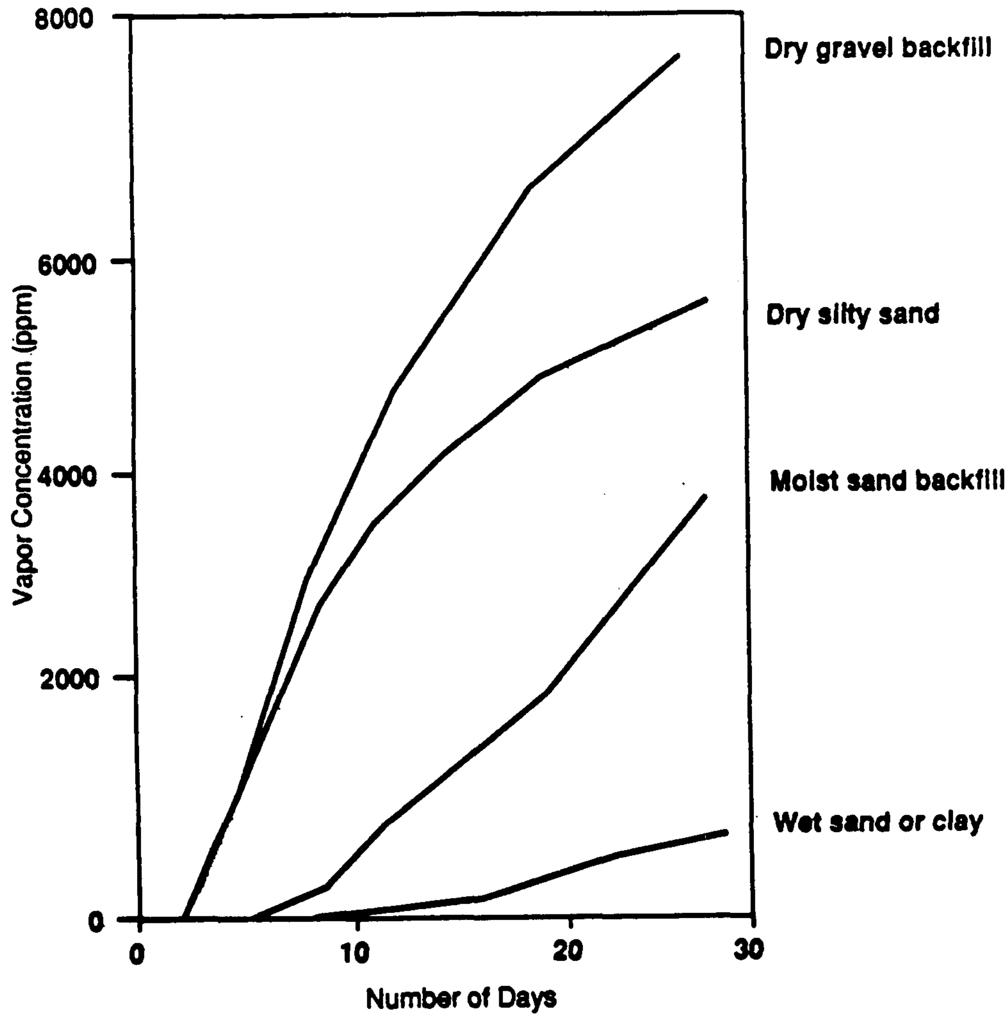
WHEN VAPOR MONITORING IS APPROPRIATE

Soil conditions

- Backfill around tank must allow the passage of vapors
- Soil should be clean and should not contain substances that will produce vapors

SLIDE IV-69

THE EFFECT OF SOIL ON VAPOR CONCENTRATIONS AT A WELL



SLIDE IV-70

WHEN VAPOR MONITORING IS APPROPRIATE

Climatic factors

- Temperature affects the volatility of released product
- This method should not be used in areas with heavy annual rainfall or extremely moist climates
- Water fills spaces between soil particles
- Vapors may dissolve in the moisture
- Heavy rains may fill wells with water and drown sensors if not properly capped and sealed

SLIDE IV-71

WHEN VAPOR MONITORING IS APPROPRIATE

Geologic conditions

- This method should not be used in areas with high groundwater, which interferes with vapor detection

SLIDE IV-72

CONSIDERATIONS

- Manual monitoring systems require monthly time investments
  - Large sites require considerable time each month
  - Samples are often sent off-site for analysis
- Spill/overfill protection needed

SLIDE IV-73A

HOW SIR WORKS

- Daily measurements of product level in tank combined with complete records of all withdrawals from the UST and deliveries to the UST
- SIR vendor uses sophisticated statistical software to conduct computerized analysis of data
- SIR vendor provides monthly reports that can identify if UST is leaking

SLIDE IV-73B

HOW SIR WORKS

- SIR must be done monthly and meet the PD/PFA and minimum detectable leak rate (0.2 gallons per hour)
- Monthly SIR results must be available at the UST facility
- SIR can qualify as a tank tightness test if it meets Federal requirements for PD/PFA and minimum detectable leak rate (0.1 gallons per hour)

SLIDE IV-73C

WHEN SIR IS APPROPRIATE

- UST system characteristics
  - Primarily used for tanks with capacity less than 18,000 gallons
- Product characteristics
  - Generally not restricted by product type
- Soil conditions
  - No restrictions exist

SLIDE IV-73D

WHEN SIR IS APPROPRIATE

- Climatic factors
  - -- Temperature changes affect data, so SIR vendors must take climatic factors into consideration
- Geologic conditions
  - -- Ground water covering all or part of a tank may mask a leak or distort the data

SLIDE IV-73E

CONSIDERATIONS

- SIR can be used for tank and piping
- SIR is a very sophisticated statistical analysis that must meet Federal requirements
- SIR requires the use of good inventory measurement practices

SLIDE IV-73F

CONSIDERATIONS

- Data can be sent to SIR vendor on paper or using computer modems or diskettes
- SIR can identify leaking systems, miscalibrated meters, tilted tanks, and loss resulting from theft
- SIR requires minimal investment of staff time and equipment costs; overall costs compare favorably to other methods
- State and local governments can place restrictions on SIR use

SLIDE IV-74

COMBINATION METHOD

- Inventory control must be combined with tank tightness testing
- This combined method can be used only for ten years following new tank installation or existing tank upgrade

SLIDE IV-75

INVENTORY CONTROL

How inventory control works

- Daily accounting system is used
- Tank volume, deliveries, and sales are recorded daily
- Accounts of deliveries and product sold from tank are compared with daily volume measurements
- Overage/shortage determined monthly

SLIDE IV-76

HOW INVENTORY CONTROL WORKS

Daily tank gauging and reconciling

- Measure product level with a gauge stick marked to one-eighth of an inch
- Translate level of product from gauge to volume of product in tank, using manufacturer calibration chart
- Record product volume and day's withdrawals and receipts on ledger form

SLIDE IV-77

HOW INVENTORY CONTROL WORKS

- Gauge stick must be inserted through fill pipe until it touches bottom of tank

SLIDE IV-78

SAMPLE CALIBRATION CHART CONVERTING PRODUCT DEPTH TO GALLONS*

Tank Size / Depth in Inches	550 Gal. 49½" x 5'5"	1000 Gal. 49½" x 10'	1000 Gal. 64" x 6'	1500 Gal. 64" x 9'	2000 Gal. 64" x 12'	2500 Gal. 64" x 15'	3000 Gal. 64" x 18'	4000 Gal. 64" x 24'
1	2	4	3	4	6	8	9	13
2	7	13	9	13	18	23	27	37
3	13	24	17	25	34	42	51	68
4	20	38	26	39	52	65	78	104
5	29	52	36	54	75	90	108	145
6	37	68	47	71	94	118	142	189
7	47	86	59	89	119	148	178	238
8	57	104	72	108	144	180	217	289
9	68	124	85	128	171	214	257	343
10	79	144	100	150	200	250	300	400
11	90	165	114	172	229	287	344	459
12	102	187	130	195	260	325	390	520
13	115	209	145	218	291	364	437	583
14	127	232	162	243	324	495	486	648
15	140	255	178	268	357	447	536	715

* Note that product depth in left column converts to gallons in the other columns.

SLIDE IV-79

PART OF A MONTHLY RECONCILIATION FORM

LINE	DAY	REGULAR	UNLEADED
	1		
	2		
	3		
	4		
	5		
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		
	16		
	17		
	18		
	19		
	20		
	21		
	22		
	23		
	24		
	25		
	26		
	27		
	28		
	29		
	30		
	31		
1	Cum. Over Total		
2	% Thru.		
3	Cum. Short. Total		
4	% Thru.		

Attention: The cumulative sum of monthly overages or shortages should not exceed 1.0% of the monthly throughput plus 130 gallons.

SLIDE IV-80

MONTHLY RECONCILIATION (INVENTORY CONTROL)

Monthly reconciliation

- At least monthly, daily product volume data are reconciled with delivery and withdrawal amounts
- If overage/shortage is greater than or equal to 1.0 percent of tank's flow-through volume plus 130 gallons of product, UST may be leaking
  - -- If this occurs over two consecutive months, owner/operator must report results to local implementing agency as possible leak

SLIDE IV-81

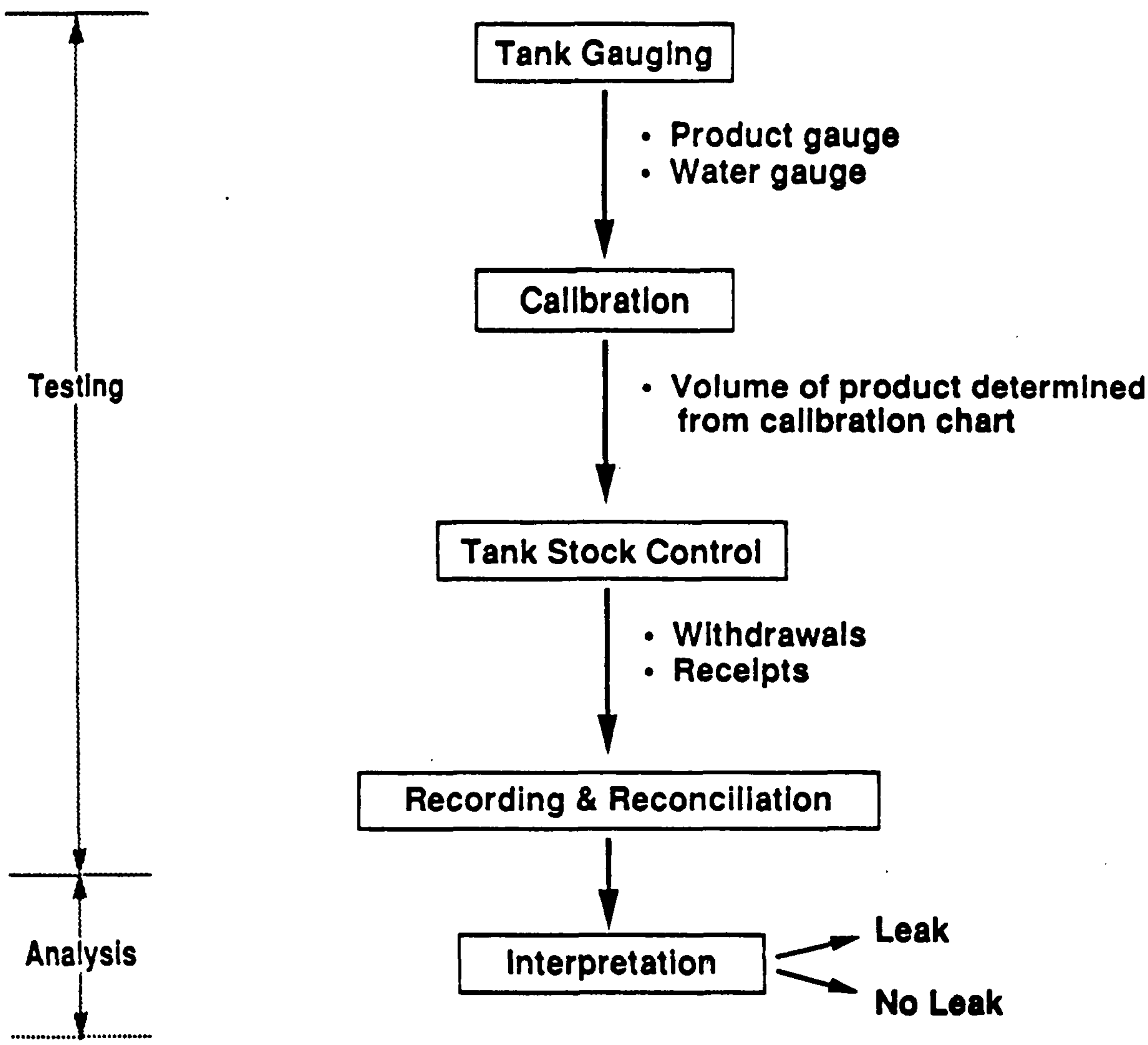
HOW INVENTORY CONTROL WORKS

Tank stock control

- Dispensing meters must be correctly calibrated
- Product delivery volumes must be verified
- Unaccounted for additions and withdrawals must be included in reconciliation

SLIDE IV-82

GENERAL PROCEDURE FOR INVENTORY CONTROL



SLIDE IV-83

WHEN INVENTORY CONTROL IS APPROPRIATE

UST system characteristics

- Applicable for any size UST as long as performance standard of 1.0 percent flow-through plus 130 gallons is met

SLIDE IV-84

WHEN INVENTORY CONTROL IS APPROPRIATE

Product characteristics

- Effective for diesel and gasoline fuels and products with similar viscosities and thermal properties
- For other products, make sure this method can be used satisfactorily with those substances

Soil conditions

- Are not a factor

SLIDE IV-85

WHEN INVENTORY CONTROL IS APPROPRIATE

Climatic factors

- Ambient air and ground temperatures can affect measured product volume

- Temperature difference between newly-delivered product and product in tank limits accuracy

SLIDE IV-86

WHEN INVENTORY CONTROL IS APPROPRIATE

Geologic conditions

- High ground water may interfere with testing
  - -- This method may be inappropriate for areas with permanent high ground water
- Monthly measurement using a gauge covered with water-finding paste must be taken to identify any water in tank, and accounted for in reconciliation

SLIDE IV-87

CONSIDERATIONS

- Must be combined with periodic tank tightness tests
- Regular calibrations and calculations
- Staff time
- Small leaks can go undetected for a long period
- Used only with metered storage tanks
- Deliveries made through drop tube extending to within one foot of tank's bottom

SLIDE IV-89

FACTORS AFFECTING INVENTORY CONTROL RESULTS

- Temperature variation
- Meter calibration accuracy
- Tank volume/calibration chart discrepancy
- Delivery overage or shortage
- Theft
- Tank tilt

SLIDE IV-91

HOW TANK TIGHTNESS TESTING WORKS

- Identifies leaks in closed tank systems
  - -- Volumetric tests
  - -- Non-volumetric tests

SLIDE IV-92

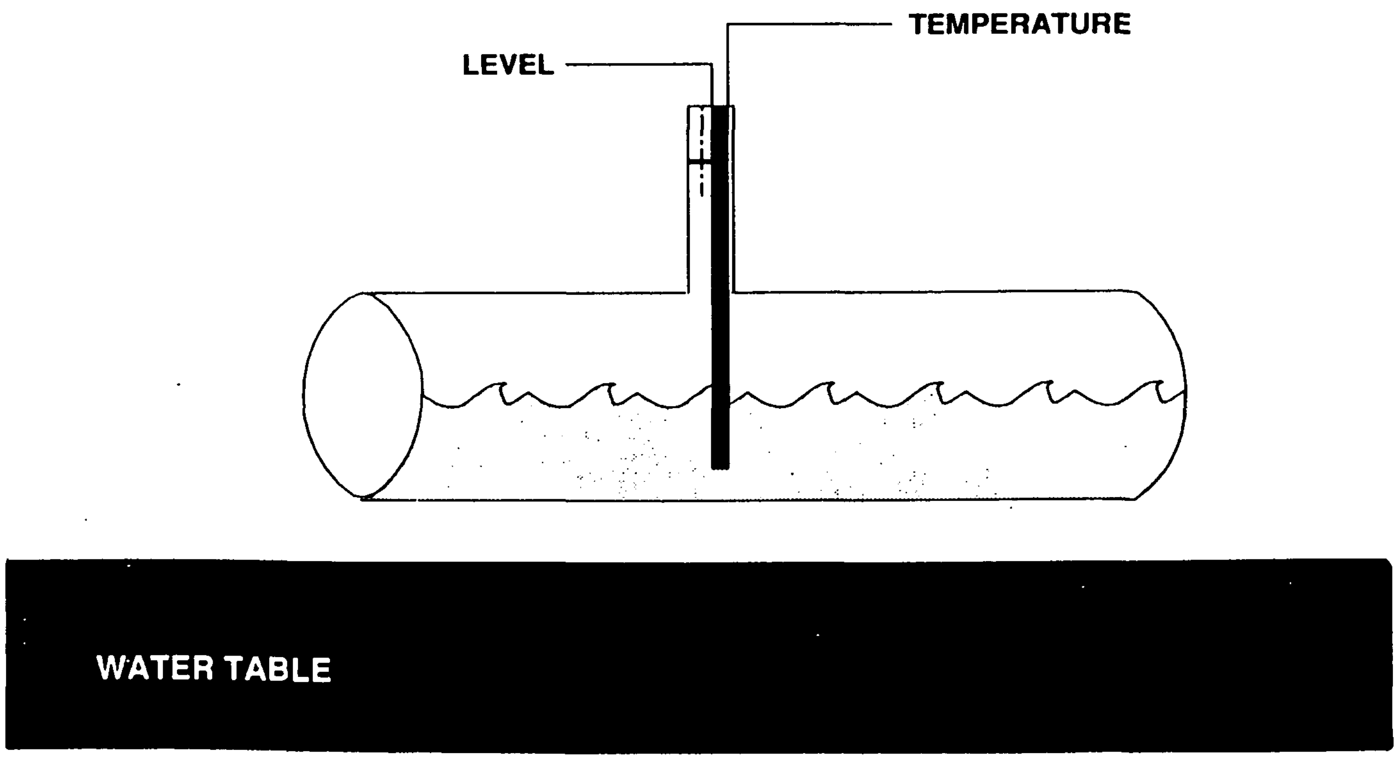
HOW TANK TIGHTNESS TESTING WORKS

Volumetric Testing

- Changes in product level or volume in tank are measured precisely (in milliliters or thousandths of an inch) over several hours
- Changes in product temperature must also be measured to account for temperature-induced changes in product level
- Net decrease in product volume during test indicates leak

SLIDE IV-93

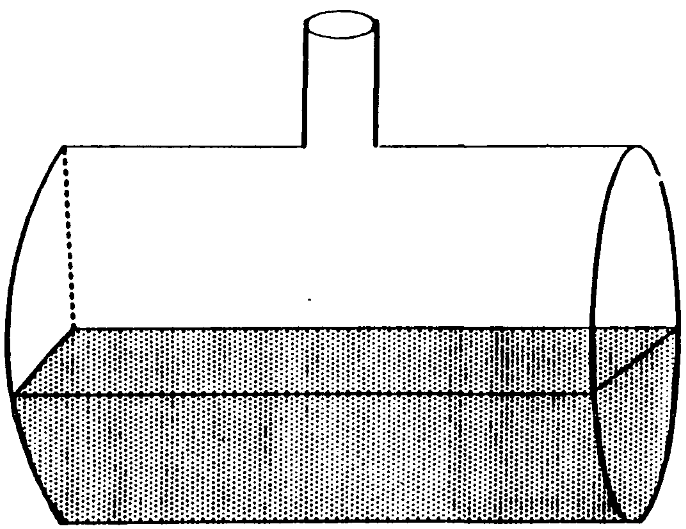
TEMPERATURE AND LEVEL GAUGES



SLIDE IV-95

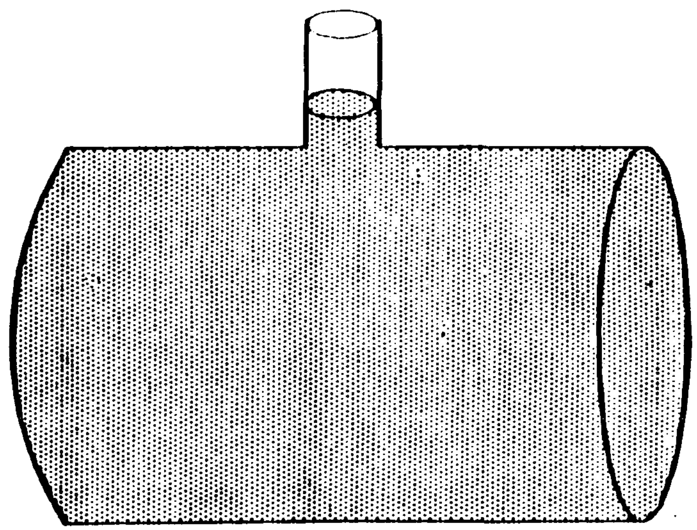
COMPARISON OF PARTIALLY-FILLED AND OVERFILLED TANKS

Partially-Filled Tank



Large volume changes produce only very small level changes

Overfilled Tank



A small volume change can produce a drastic level change

SLIDE IV-96

HOW TANK TIGHTNESS TESTING WORKS

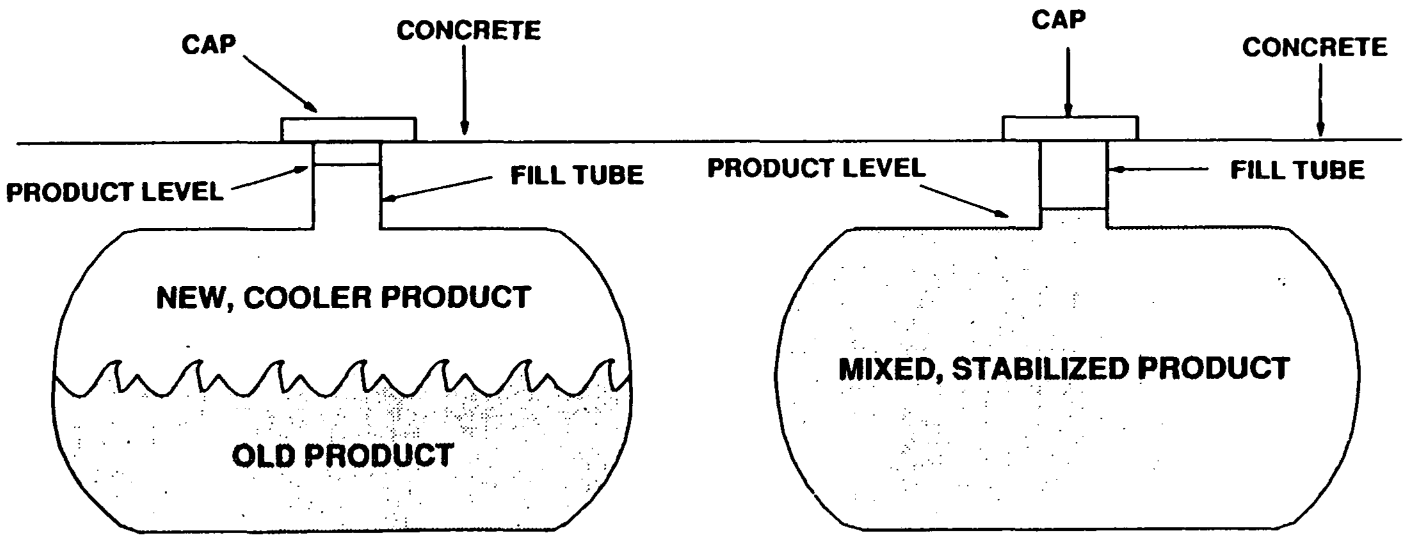
Non-volumetric testing

- Negative pressure (vacuum) is placed in tank. Equipment "listens" for small air bubbles

- Tracers that will escape from a leak and be detected in the backfill can be added to the product

SLIDE IV-97

HOW TEMPERATURE CHANGES CAN BE MISTAKEN FOR A LEAK

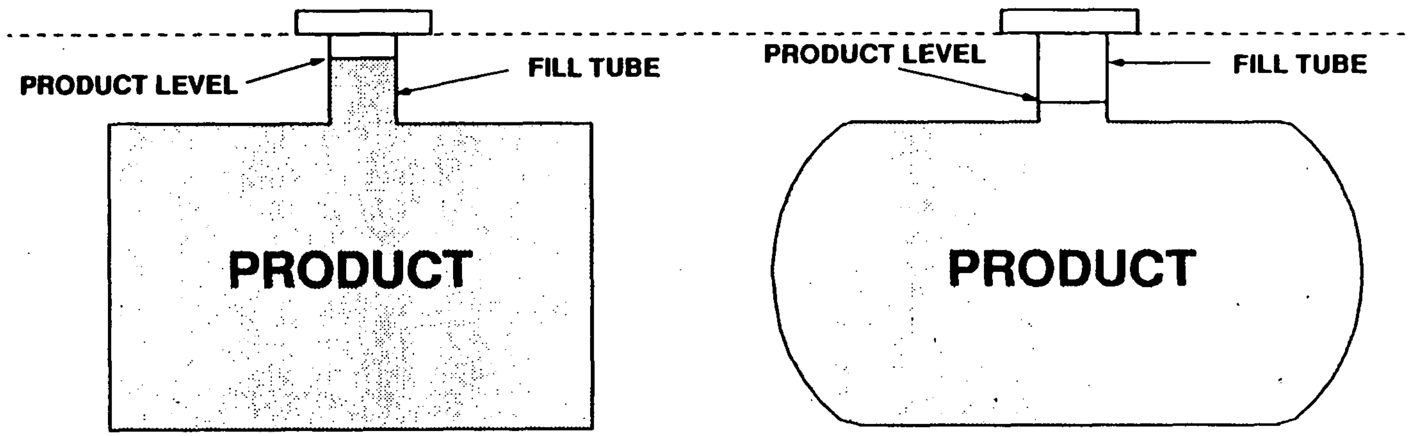


(A) **A tank has just had additional product added.**

(B) **After several hours, product mixture has stabilized temperature, resulting in lower product level.**

SLIDE IV-98

HOW STRUCTURAL DEFORMATION OF THE TANK CAN BE MISTAKEN FOR A LEAK



(A) An empty underground tank has just been filled with product

(B) In response to the pressure and/or temperature of the product, the ends of the tank begin to deflect (structural deformation), and the level of the product goes down.

SLIDE IV-99

WHEN TANK TIGHTNESS TESTING IS APPROPRIATE

- UST system characteristics
  - -- Test tanks smaller than 15,000 gallons
  - -- If system is automated, up to four tanks may be tested at one time
  - -- Piping may be tested similarly
- Product characteristics
  - -- Primarily used in tanks containing gasoline, diesel, and light heating oils

SLIDE IV-100

WHEN TANK TIGHTNESS TESTING IS APPROPRIATE

- Soil conditions
  - -- Uncompacted backfill causes tank end deflection
- Climatic factors
  - -- Volumetric testing requires stable product temperature
- Geologic conditions
  - -- Ground water level must be determined
  - -- Presence of ground water may mask an actual leak

SLIDE IV-101

CONSIDERATIONS

- Must be used with inventory control
- Tank must be taken out of service during test
- Permanent installation of equipment unnecessary
- Many different commercial methods are available
- Tester must follow proper testing methods

SLIDE IV-102

HOW DO I SELECT THE RIGHT LEAK DETECTION METHOD FOR A SPECIFIC UST?

- Deadlines for compliance

- Monthly leak detection

  - Automatic tank gauging
  - Manual tank gauging
  - Secondary containment with interstitial monitoring
  - Ground-water monitoring
  - Vapor monitoring
  - Statistical inventory reconciliation

- Inventory control and tank tightness testing

CHAPTER V-1

LEAK DETECTION METHODS FOR UST PIPING

SLIDE V-2

WHAT DO I NEED TO KNOW ABOUT UST PIPING MONITORING AND LEAK DETECTION?

- UST piping
- Leak detection requirements for UST piping
- Leak detection methods

SLIDE V-3

PRESSURIZED PIPING SYSTEMS

- Product is pushed through a pump in bottom of tank
- Very large releases can occur quickly at a break
- Systems are usually chosen for high volume sites

SLIDE V-4

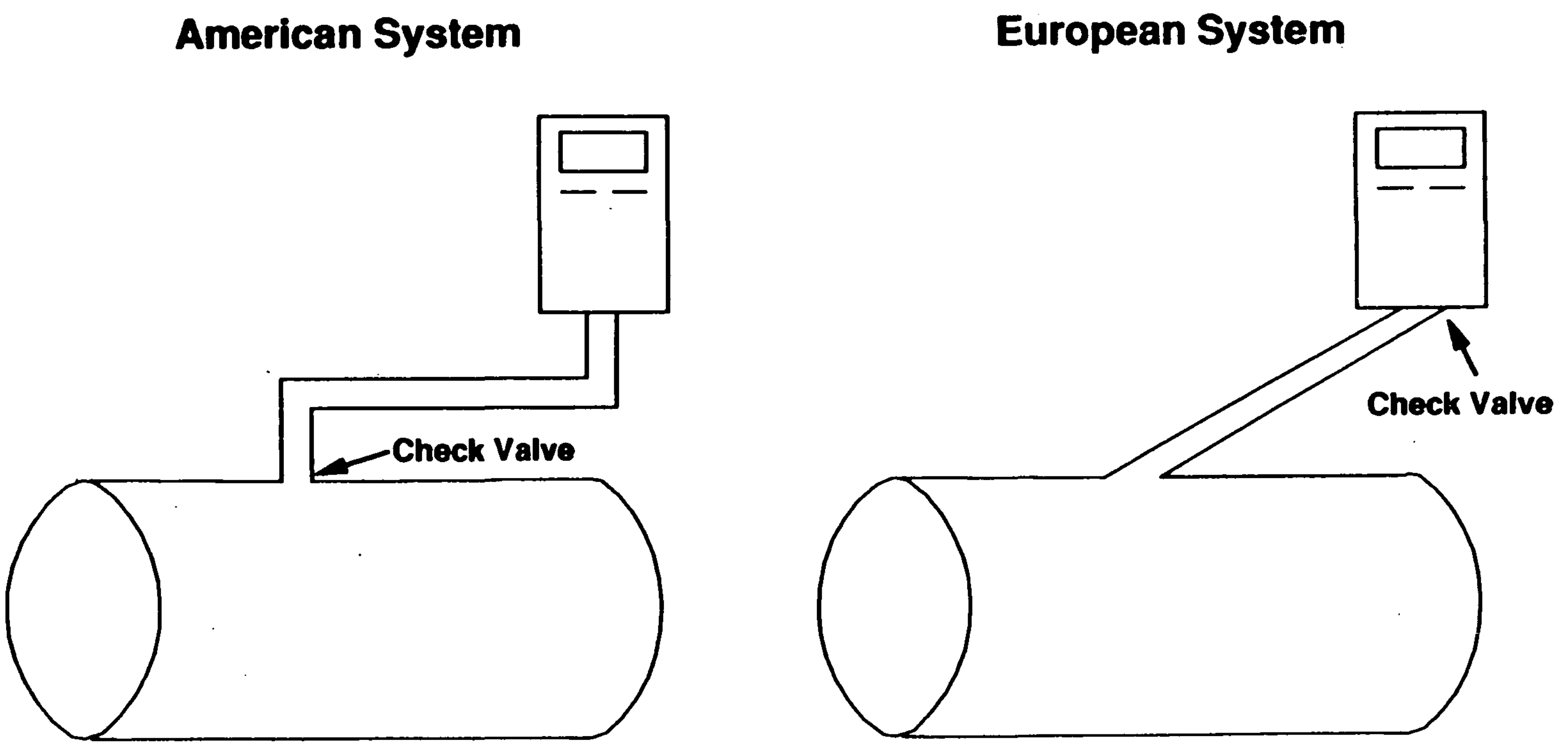
SUCTION PIPING SYSTEMS

- A positive displacement pump creates a vacuum which draws product from the tank to the pump

- If a leak in the lines occurs, suction is interrupted, and product flows back through the piping toward the tank

SLIDE V-5

AMERICAN AND EUROPEAN PIPING SYSTEMS WITH CHECK VALVES



SLIDE V-6

LEAK DETECTION FOR UST PIPING

- Deadlines
- Requirements
- Methods

SLIDE V-7

PRESSURIZED PIPING DEADLINES

- New pressurized piping: must comply with UST leak detection requirements when installed
- Existing pressurized piping: must comply with UST leak detection requirements by December 1990

SLIDE V-8

SUCTION PIPING DEADLINES

- No leak detection is required for new or existing "European" style piping

  -- Adequate slope
  -- One check valve

- New "American" style suction piping must comply with UST leak detection requirements when installed

- Existing "American" style suction piping must comply with UST leak detection requirements according to the following timetable

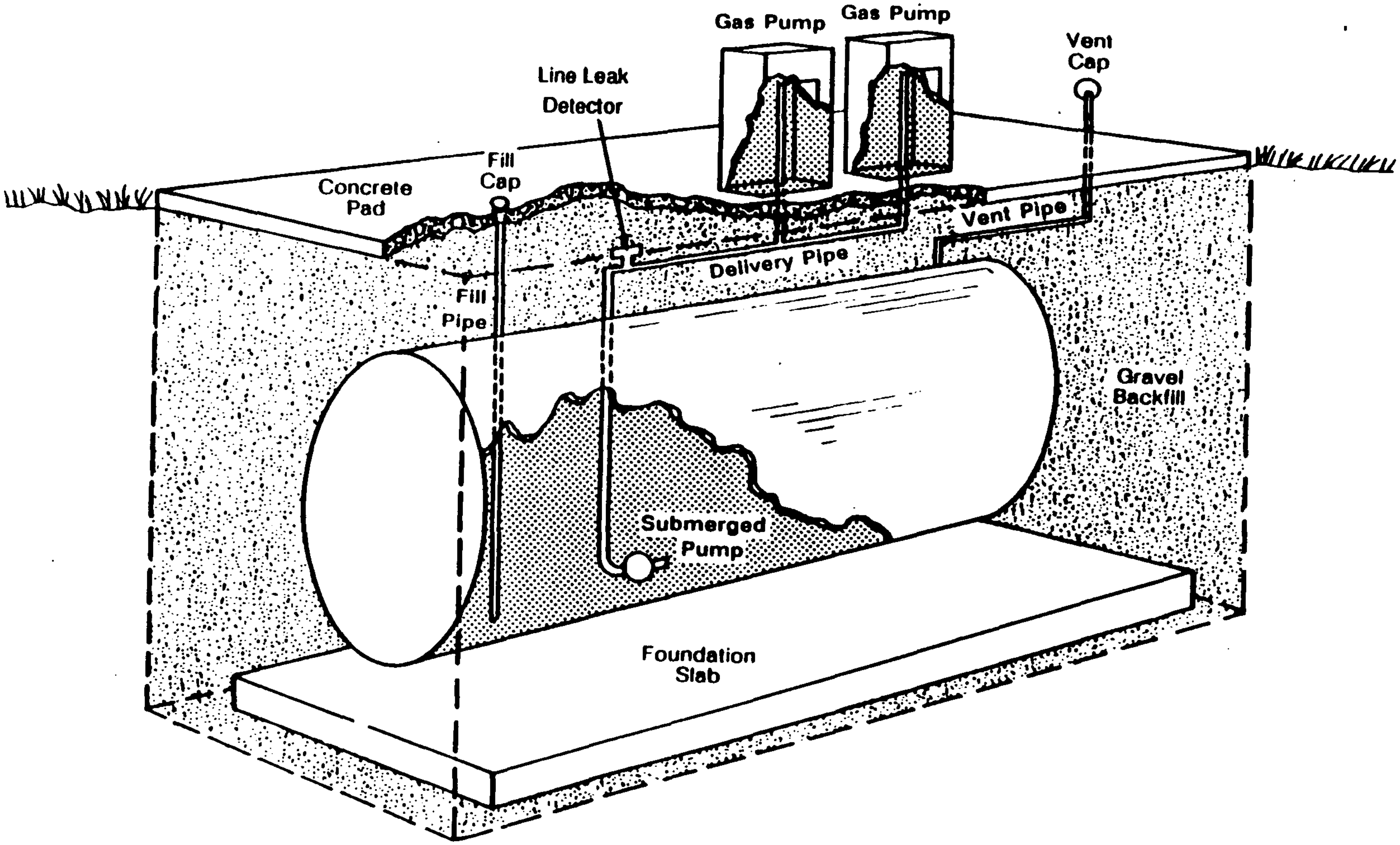
SLIDE V-9

Installation Date	Must Comply By
Before 1965*	December 1989
1965 - 1969	December 1990
1970 - 1974	December 1991
1975 - 1979	December 1992
1980 - 1988	December 1993

* Or if installation date is unknown

SLIDE V-10

PRESSURIZED PIPING SYSTEM



SLIDE V-11

REQUIREMENTS FOR PRESSURIZED PIPING

Pressurized piping (new and existing)

- Each pressurized piping run must have an automatic line leak detector (LLD)

- Pressurized piping must also have one of the following:

  -- Monthly ground-water monitoring

  -- Monthly vapor monitoring

  -- Monthly interstitial monitoring

  -- Annual tightness test

SLIDE V-12

SUCTION PIPING REQUIREMENTS

If new and existing suction piping requires leak detection, then one of the following four methods must be used

- **Line tightness testing (every three years)**
- **Ground-water monitoring**
- **Vapor monitoring**
- **Secondary containment with interstitial monitoring**

SLIDE V-13

AUTOMATIC LINE LEAK DETECTORS

- Automatic flow restrictor
- Automatic shutoff device

SLIDE V-14

LEAK DETECTION METHODS

- Automatic line leak detectors
- Line tightness testing methods
- Monthly monitoring methods

SLIDE V-15

REQUIREMENTS FOR PD/PFA

- Line tightness testing must meet the requirements for the probability of detection and false alarm (PD/PFA) by December 1990
- Automatic line leak detectors must meet the PD/PFA requirements by September 1991

SLIDE V-16

HOW AUTOMATIC FLOW RESTRICTORS WORK

- Mechanical devices installed directly in the piping or pump housing
- When pressure in the pump delivery system drops below a certain threshold, a test is automatically performed
- Devices trigger an alarm when a leak is detected

SLIDE V-17

HOW AUTOMATIC FLOW RESTRICTORS WORK

- Restrictors reduce flow of product when there is a leak
- Restrictors limit product flow to 3 gallons per hour

SLIDE V-18

WHEN AUTOMATIC FLOW RESTRICTORS ARE APPROPRIATE

- Use only for pressurized piping
- Most gas station USTs already have automatic flow restrictors

SLIDE V-19

CONSIDERATIONS

- Causes slight lag in product delivery when properly operating
- On-site staff may tamper with system to avoid delays in product delivery
- Requires little owner/operator involvement

SLIDE V-20

AUTOMATIC FLOW SHUTOFF

- Two different types of automatic flow shutoff devices
    - Pressure increase monitor
    - Pressure decrease monitor

SLIDE V-21

HOW AUTOMATIC FLOW SHUTOFF DEVICES WORK

Pressure Increase Monitor

- Normal rate of pressurization in pipes is calculated
- The rate of increase in line pressure is measured when pump is activated
- If there is a leak, it will take longer for the piping to become fully pressurized
- The system shuts down automatically

SLIDE V-22

HOW AUTOMATIC FLOW SHUTOFF DEVICES WORK

Pressure Decrease Monitor

- System monitors line pressure over several minutes when dispenser is not in use
- A leak is indicated if:
  - -- Constant pressure can not be maintained
  - -- Pressure decreases more quickly than its normal rate

SLIDE V-23

WHEN SHUTOFF DEVICES ARE APPROPRIATE

- Used for pressurized piping only

SLIDE V-24

CONSIDERATIONS

- Devices are subject to tampering if they are not locked or tamper-proofed in some way
- Test cannot be run while dispensers are in use
- Devices provide nearly continuous leak detection and require little time from staff

SLIDE V-25

LINE TIGHTNESS TESTING

- Direct volumetric line tightness test
- Indirect line tightness test

SLIDE V-26

HOW THE DIRECT VOLUMETRIC LINE TIGHTNESS TEST WORKS

- Tests the ability of UST piping to maintain a specified pressure
- A hand pump or the dispenser and the submerged pump is used to pressurize the piping leading back to the tank
- The amount of volume lost is determined
- If a certain volume of product is lost, a leak is indicated

SLIDE V-27

WHEN THE DIRECT VOLUMETRIC LINE TIGHTNESS TEST IS APPROPRIATE

- It is practical when performed in conjunction with tank testing
- Line tightness testing may be performed on both pressurized and suction systems

SLIDE V-28

CONSIDERATIONS

- Line must be shut down for several hours for the test
- Test requires no permanent equipment
- Test can conveniently be performed along with tank tightness testing
- Test needs to be performed only once every three years for suction piping
- Problems are due to poor fittings and gaskets, vapor pockets, bad check valves, etc.

SLIDE V-29

HOW THE INDIRECT LINE TIGHTNESS TEST WORKS

- Piping is tested as a part of a full tank system test
- Procedures are the same as for tank tightness with the following additions:
  - -- Overfill methods must be used
  - -- If test finds no leaks, both tank and lines are assumed to be intact
  - -- If tank is leaking, separate test of piping must be conducted

SLIDE V-30

WHEN THE INDIRECT LINE TIGHTNESS TEST IS APPROPRIATE

- Indirect line tightness tests must be done in conjunction with tank testing; tanks and piping may be on different test schedules
- Line tightness testing may be performed on both pressurized and suction systems

SLIDE V-31

CONSIDERATIONS

- Lines must be shut down for at least several hours
- Test must be performed only once every three years for suction piping (annually for pressurized piping)
- After filling the line, tester should wait for three hours before beginning data collection
- Vapor pockets can inhibit effective testing

SLIDE V-32

SECONDARY CONTAINMENT WITH INTERSTITIAL MONITORING

- Methods, considerations, and applications of interstitial monitoring with secondary containment for piping systems are similar to those for tanks
- Use trench liners or double-walled piping

SLIDE V-33

HOW SECONDARY CONTAINMENT WITH INTERSTITIAL MONITORING WORKS

For trench liners

- Backfill and piping are placed in a lined trench
- Trench should be sloped away from the tank excavation to differentiate between tank leaks and piping leaks
- An interstitial monitor is placed between piping and the trench liner

SLIDE V-34

HOW SECONDARY CONTAINMENT WITH INTERSTITIAL MONITORING WORKS

For double-walled piping

- Piping that carries the product is contained within a larger outer pipe
- Monitor is placed in sump or between inner and outer pipes

SLIDE V-35

WHEN SECONDARY CONTAINMENT WITH INTERSTITIAL MONITORING IS APPROPRIATE

UST system characteristics

- Can be used for both tanks and piping
- Secondary containment is not practical for existing piping

SLIDE V-36

WHEN SECONDARY CONTAINMENT WITH INTERSTITIAL MONITORING IS APPROPRIATE

Product characteristics

- Methods may be used for all fuel types, including hazardous substances

Soil conditions

- No restrictions exist

SLIDE V-37

WHEN SECONDARY CONTAINMENT WITH INTERSTITIAL MONITORING IS APPROPRIATE

Climatic factors

- No restrictions. However, in areas with heavy rainfall a fully enclosed containment system should be used

Geologic conditions

- In areas of high ground water, a fully enclosed containment system should be used

SLIDE V-38

CONSIDERATIONS

- Correct installation is essential
- Monitoring can often be integrated with the tank monitoring system
- Prevents environmental contamination and reduces potential for cleanup costs

SLIDE V-39

GROUND-WATER MONITORING

How does ground-water monitoring work?

- **Use of this method for piping is generally the same as its use for tanks**
- **Additional wells are needed every 10 to 20 feet of piping run**

SLIDE V-40

WHEN GROUND-WATER MONITORING IS APPROPRIATE

UST system characteristics

- Ground-water monitoring can be used to detect leaks from both tanks and piping
- Ground-water monitoring may be used on any size piping run. For larger systems, more wells are added
- May be retrofitted on existing tanks and piping

SLIDE V-41

WHEN GROUND-WATER MONITORING IS APPROPRIATE

Product characteristics

- Density must be lower than that of water
- Product should not mix easily with water
- Two examples are gasoline and diesel fuel

SLIDE V-42

WHEN GROUND-WATER MONITORING IS APPROPRIATE

Soil conditions

- Backfill between well and UST must be permeable
- Soil or backfill must be porous enough to allow released product to travel to wells
- Hydraulic conductivity should be more than 0.01 cm/sec

SLIDE V-43

WHEN GROUND-WATER MONITORING IS APPROPRIATE

Climatic factors

- Very low temperatures may interfere. Ice can freeze monitors and interfere with product-soluble devices

SLIDE V-44

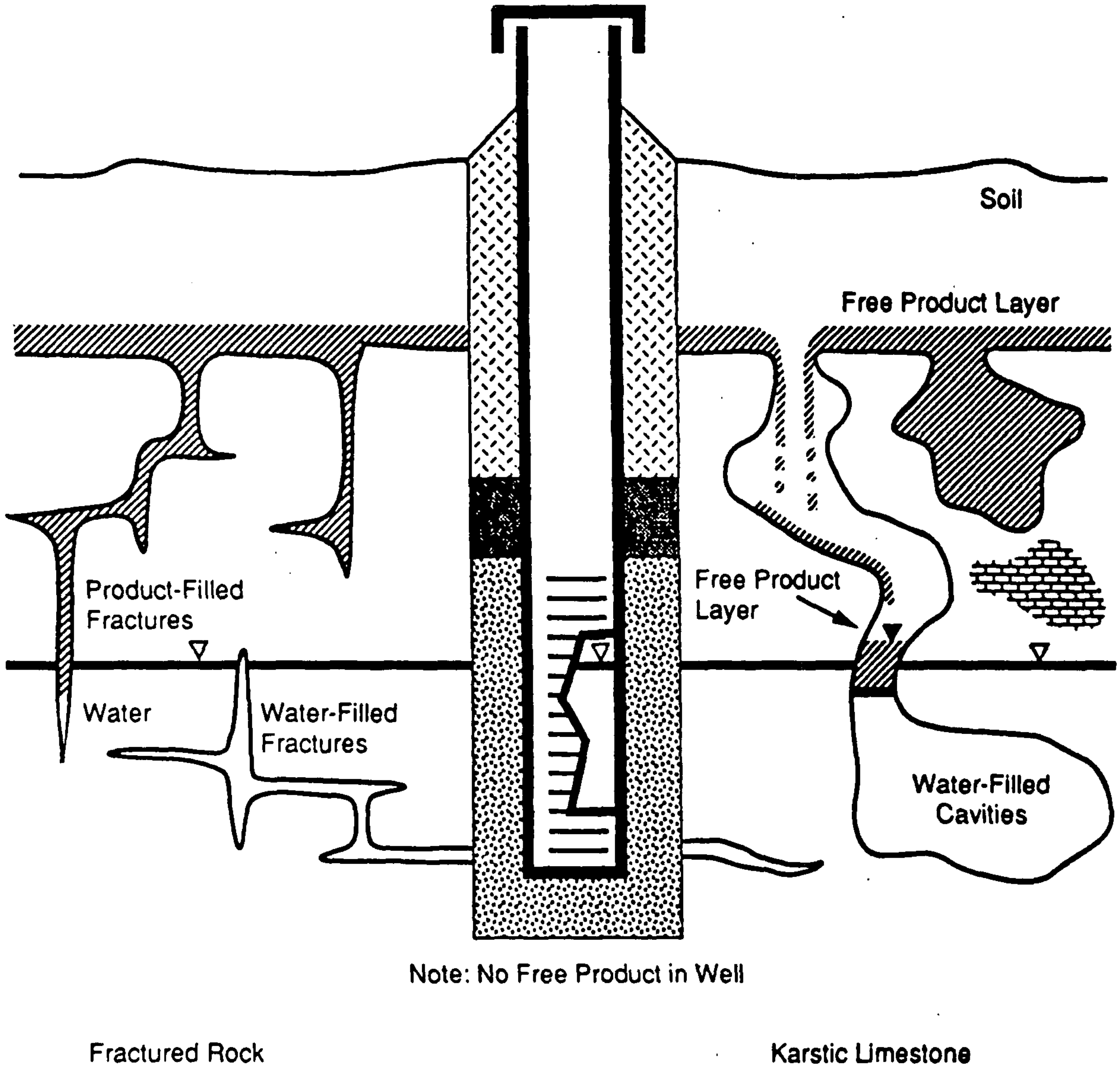
WHEN GROUND-WATER MONITORING IS APPROPRIATE

Geologic conditions

- Level of ground-water table must be no more than 20 feet below the surface
- Fluctuations in water table level must be taken into account
- Gradient of ground-water flow must be taken into account

SLIDE V-45

CREVICES AND FRACTURES



SLIDE V-46

CONSIDERATIONS

- Site hydrogeological assessment is needed
- Operation of detection devices is simple
- Can be integrated with tank ground-water monitoring system
- Avoid damage to pipes during installation

SLIDE V-47

VAPOR MONITORING

- **Use of this method for piping is generally the same as its use for tanks**

- **Wells used for piping monitoring can be shallower than those used for tank monitoring**

SLIDE V-48

WHEN VAPOR MONITORING IS APPROPRIATE

UST system characteristics

- Can be used for both tanks and piping
- Can be installed with new or existing tanks and piping

SLIDE V-49

WHEN VAPOR MONITORING IS APPROPRIATE

Product characteristics

- Vapor monitoring must be used with products that vaporize readily (e.g., gasoline)

SLIDE V-50

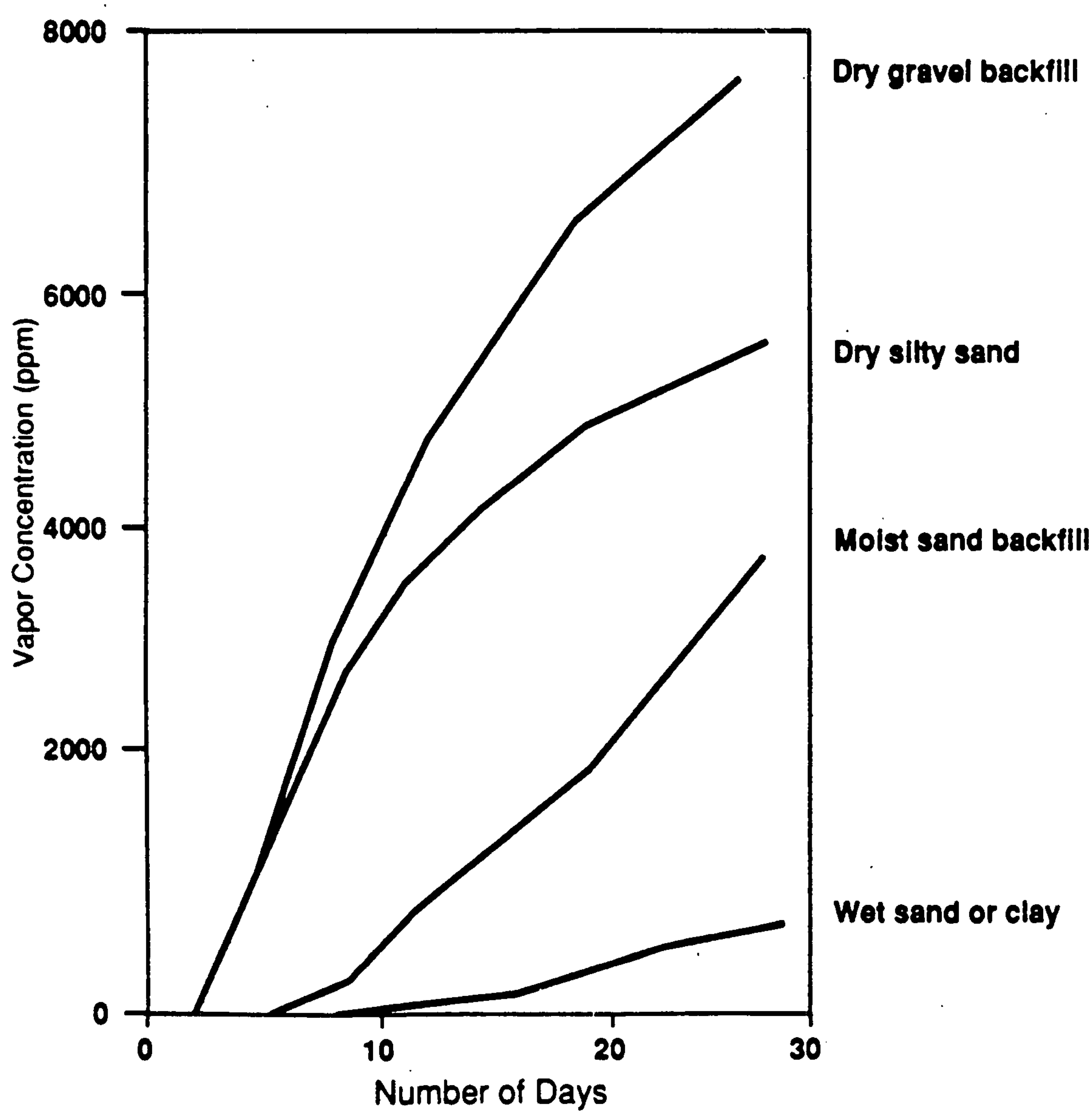
WHEN VAPOR MONITORING IS APPROPRIATE

Soil conditions

- Backfill around tank must allow the passage of vapors
- Soil must be clean and should not contain substances that will produce vapors

SLIDE V-51

THE EFFECT OF SOIL CONDITIONS ON VAPOR CONCENTRATIONS AT A WELL



SLIDE V-52

WHEN VAPOR MONITORING IS APPROPRIATE

Climatic factors

- **Temperature affects the volatility of released product**

SLIDE V-53

WHEN VAPOR MONITORING IS APPROPRIATE

Geologic conditions

- This method cannot be used in areas with high ground water, which interferes with vapor detection
- Water fills spaces between soil particles

SLIDE V-54

CONSIDERATIONS

- Can easily be integrated with tank vapor monitoring system

SLIDE V-55

HOW SIR WORKS

- Daily measurements of product level in tank combined with complete records of all withdrawals from the UST and deliveries to the UST

- SIR vendor uses sophisticated statistical software to conduct computerized analysis of data

- SIR vendor provides monthly reports that can identify if UST is leaking

- SIR must be done monthly and meet the PD/PFA and minimum detectable leak rate (0.2 gallons per hour)

- Monthly SIR results must be available at the UST facility

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WHEN SIR IS APPROPRIATE

- UST system characteristics
  - -- Requires daily measurements
- Product characteristics
  - -- Generally not restricted by product type
- Soil conditions
  - -- No restrictions
- Climatic factors
  - -- Temperature changes affect data, so SIR vendors must take climatic factors into consideration
- Geologic conditions
  - -- SIR for piping is not affected by geologic conditions

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CONSIDERATIONS

- SIR can be used for tank and piping
- SIR is a very sophisticated statistical analysis that must meet Federal requirements
- SIR requires the use of good inventory measurement practices

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CONSIDERATIONS

- Data can be sent to SIR vendor on paper or using computer modems or diskettes
- SIR can identify leaking systems, miscalibrated meters, tilted tanks, and loss resulting from theft
- SIR requires minimal investment of staff time and equipment costs; overall costs compare favorably to other methods
- State and local governments can place restrictions on SIR use

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WHAT DO I NEED TO KNOW ABOUT UST PIPING MONITORING AND LEAK DETECTION?

- UST Piping
- Leak Detection for UST Piping
- Leak Detection Methods