

# INDUSTRIAL WASTE INSPECTION STUDY MANUAL

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Compiled by  
Bill Garrett  
Chris Smith

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CALIFORNIA  
WATER POLLUTION CONTROL  
ASSOCIATION

## CHAPTER III GENERAL SAFETY

### GENERAL STUDY INFORMATION

This and the following sections deal with each of the subject matter areas covered by the examination. The material presented here is basic and should only serve as a starting point for further research. Remember that this is not a book on the subject of Industrial Waste Inspection but rather is a study guide.

**ACCIDENTS DON'T JUST HAPPEN — THEY ARE CAUSED.** There are two main parts to each and every accident. The first part is the unsafe condition. The unsafe condition might be a damaged hand tool or a defective vehicle or a broken ventilator. When the unsafe condition meets an unsafe act then an accident will result. The unsafe act might be driving too fast, not examining tools before usage or not following established safety procedures. Accidents are preventable.

It is the employer's responsibility to maintain a safe work environment, to provide proper tools and safety equipment, provide safety training, and other safeguards for employee protection on the job. The employer must also establish and enforce safety rules. Employers must also ask "Is it safe?" before requiring anyone to do a specific task.

The employee is responsible to know and observe safety rules, to correctly use the proper safety equipment, and to work in a manner that not only safeguards themselves but also protects their fellow employees. All accidents, even seemingly slight ones, should be reported to a supervisor as soon as possible after appropriate first aid. It is vital that the employee be alert and well rested free from the influence of alcohol and drugs.

The employee must also report any potentially dangerous conditions to a supervisor and other employees. The employee must take time to think "Is it safe?" before and during each job.

Many of the safety items are just plain common sense such as washing your hands before eating or smoking. Face a ladder when climbing up or down.

In the final analysis, safety is a personal commitment. The following information touches many aspects of safety that may directly impact the IWI.

### SUMMARY OF TITLE 8 CALIFORNIA ADMINISTRATIVE CODE (General Industrial Safety Orders)

Required Safety Regulations For  
Situations Frequently Encountered  
In Industrial Waste Monitoring and Inspection Activities  
(Specific Sections of Code Cited are Identified by §)  
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- I. Accident Prevention Program. Every employer shall inaugurate and maintain an accident prevention program which shall include, but not be limited to the following:
- A. A training program designed to instruct employees in general safe work practices and specific instructions with respect to hazards unique to the employee's job assignment. [§ 3203(a)(1)]

- B. Scheduled periodic inspections to identify and correct unsafe conditions and work practices which may be found. [§ 3203(a)(2)]
- II. Working Near or Over Vats and Tanks. Every open vat, pan, tank, and similar container or vessel which contains hazardous substances, into which employees can fall and the top of which is less than 36 inches above the floor or working level, shall be guarded on all sides by: [§ 3480(a)]
- A. A substantial railing of height not less than 36 inches above the floor or working level, or
- B. The top height increased to 36 inches, or
- C. A complete cover.
- When employees are required to work directly above such open vats, pans, tanks, or similar containers and vessels, one of the following conditions shall be complied with: [§ (c)]
- A. The employee shall be provided with and shall wear an approved safety belt and life line. The life line shall be so adjusted that the employee cannot fall into the vat, pan, tank or similar container or vessel. Such safety belts and life lines shall be resistant to any deteriorating effects of the dusts, fumes, mists, vapors, or gases arising from the contents of the tank.
- B. The vat, pan, tank or similar container or vessel top shall be covered with a grating or grill which has no opening whose least dimension exceeds two inches. This grating or grill shall be of sufficient strength to withstand any load that is customarily imposed upon it. Provisions shall be taken to protect the employee against exposure to temperature harmful to the human body.
- C. The vat, pan, tank or similar container or vessel shall be provided with a platform or walkway above the vessel. This platform or walkway shall be equipped with standard 36 inch railing and 4 inch toeboard.

III. Protective Clothing and Devices. Employees working in confined spaces which have last contained substances corrosive to the skin or substances which can be absorbed through the skin shall be provided with, and shall be required to wear, appropriate personal protective clothing or devices as outlined below: [§ (a)(9)]

- A. General. The employer shall assure that the employee is instructed and uses protective equipment in accordance with the manufacturer's instructions. [§ 3380(c)]
- The employer shall assure that employee owned personal protective equipment complies with applicable standards and regulations. The employer shall assure this equipment is maintained in a safe, sanitary condition [§ (d)].
- Protectors shall be of such design, fit and durability as to provide adequate protection against the hazards for which they are designed. They shall be reasonably comfortable and shall not unduly encumber the employ-

ee's movements necessary to perform his work. [§ 3380(e)]

- B. Sanitation of Protective Clothing and Devices. Protectors shall be capable of being cleaned easily and disinfected. These protectors shall be kept clean and in good repair. Safety devices, including protective clothing worn by the employee, shall not be interchanged among the employees until properly cleaned, except that safety devices worn over shoes or outer clothing such as metal footguards and safety harnesses, which do not contact the skin of the wearer need not be cleaned prior to interchange among employees. [§ 3387]
- C. Jewelry. Wrist watches, rings, or other jewelry should not be worn while working with or around machinery with moving parts in which such objects may be caught or around electrically energized equipment. [§ 3386(a)]
- D. Eye Protection. Employees working in locations where eye hazards due to flying particles, hazardous substances, or injurious light rays are inherent in the work shall be provided by his employer with suitable eye protection and the employee shall use the eye protection equipment. [§ 3382(a)]

Where eye protection is required and the employee requires vision correction, such eye protection shall be provided as follows: [§ 3382(c)]

- 1) Safety spectacles with suitable corrected lenses, or
- 2) Safety goggles designed to fit over spectacles, or
- 3) Protective goggles with correctives lenses mounted behind the protective lenses.

Note: The wearing of contact lens is prohibited in working environments having harmful exposure to materials or light flashes, except when special precautionary procedures, which are medically approved, have been established for the protection of the exposed employee. [§ 3382(c)]

Eye protection equipment must meet appropriate standards for unit strength, as well as impact, penetration, heat and flammability resistance, optical quality and eye zone coverage. [§ 3382(d)]

- E. Body Protection. Clothing appropriate for the work being done shall be worn. Loose sleeves, tails, ties, lapels, cuffs, or other loose clothing which can be entangled in moving machinery shall not be worn. [§ 3383(b)]
- Clothing saturated or impregnated with flammable liquids, corrosive substances, irritants, or oxidizing agents shall be removed and shall not be worn until properly cleaned. [§ 3383(c)]
- F. Hand Protection. Hand protection shall be required for employees whose work involves unusual and excessive exposure of hands to cuts, burns, harmful physical or chemical agents or of radioactive materials which are encountered and capable of causing injury or impairments. However, hand protection shall not be required where there is a danger of the hand protection becoming caught in moving machinery or materials. [§ 3384]
- G. Foot Protection. Appropriate foot protection shall be required for employees who are exposed to foot injuries from hot, corrosive, poisonous substances, falling objects, crushing or penetrating actions which may cause injuries or who are required to work in abnormally wet locations. [§ 3385(a)]

Footwear which is defective or inappropriate to the

extent that its ordinary use creates the possibility of foot injuries shall not be worn. [§ 3385(b)]

Safety-toe footwear for employees shall meet appropriate standards. [§ 3385(c)]

- H. Head Protection. Employees exposed to flying or falling objects shall be safeguarded by means of approved head protection meeting appropriate standards, i.e., a hard hat. [§ 3381(a)]

Where there is a risk of injury from hair entanglements in moving parts of machinery, combustibles, or toxic contaminants, employees shall confine their hair to eliminate the hazard. [§ 3381(e)]

- IV. Medical Services and First Aid. In the absence of an infirmary, clinic, or hospital, in the near proximity to the workplace, a person shall be adequately trained to render first aid. Training shall be equal to that of the American Red Cross. [§ 3400(b)]

There shall be adequate first-aid materials, approved by the consulting physician, readily available for workmen on every job. Such materials shall be kept in a sanitary and usable condition. A frequent inspection shall be made of all first-aid materials, which shall be replenished as necessary. [§ 3400(c)]

At isolated locations, provisions must be made in advance for prompt medical attention in case of serious injuries. This may be accomplished by proper equipment for prompt transportation of the injured person to a physician or a telephone communication system for contacting a doctor. [§ 3400(f)]

Note: When working at a remote location, know the location of the nearest working telephone before starting the job.

- V. Use of Hand Tools. The employer shall be responsible for the safe condition of tools when furnished by him and user shall inspect tools to assure safe condition. All tools shall be restricted to the use for which they are intended, and should be used only by those employees who are required and qualified to use such tools. [§ 3556(a)]

Hand tools shall be kept in good condition, and safely stored. Unsafe hand tools shall not be used. [§ 3556(b)]

All hand-held powered drills, reciprocating saws, saber, scroll, and jig saws shall be equipped with a constant pressure switch or control, and may have a lock-on control provided that turnoff can be accomplished by a single motion of the same finger or fingers that turn it on. [§ 3557(b)]

Note: While not required by either the General Industrial Safety Orders or the National Electrical Code, it is recommended that all portable electrical tools be used with an approved Ground Fault Circuit Interrupter. This is especially so when working around liquid containers such as interceptors or flumes.

- VI. Use of compressed Gas Cylinders. Compressed gas cylinders shall be stored or transported in a manner to prevent them from creating a hazard by tipping, falling, or rolling. [§ 4650(e)]

Valve protection caps, where cylinder is designed to accept a cap, shall always be in place, hand-tight, except where cylinders are in use or connected for use. [§ 4650(f)]

Unless cylinders are secured on a special truck or rack, regulators shall be removed and valve-protection caps, when provided for, shall be put in place before cylinders are moved. [§ 4650(g)]

Compressed gas cylinders in portable service shall be

conveyed by suitable trucks to which they are securely fastened, and all gas cylinders in service shall be securely held in substantial racks or secured to other rigid structures so that they will not fall or be knocked over. [§ 4650(h)]

Cylinder valves shall be closed before moving cylinders. [§ 4650(k)]

Cylinder valves shall be closed when work is finished. [§ 4650(l)]

Valves of empty cylinders shall be closed. [§ 4650(m)]

Leaking regulators, cylinder valves, hose, piping system, apparatus, and fittings shall not be used. [§ 4650(p)]

- VII. Use of Ropes to Lift Equipment. Any rope used to lift equipment shall not be loaded above its safe working load limit. The following are safe working load limits for several commonly used sizes of three strand Manila rope. [§ 3474(k)]

Manila Rope Diameter (inches)	Maximum Safe Working Load (lbs.)
1/4	120
3/8	270
1/2	530
5/8	880
3/4	1080
1	1800

- VIII. Exposure to Airborne Contaminants. The following are maximum allowable exposure limits to gases commonly encountered in industrial waste field activities. [§ 5155(b)(1)]

- A. 8-Hour Time-Weighted Average Concentrations Not to be Exceeded:

1. Ammonia - 25 ppm
2. Chlorine - 1 ppm
3. Hydrogen Sulfide - 10 ppm

- B. Concentrations Above which Exposure Time Must be Carefully Monitored (Excursion Exposures)

1. Ammonia - not applicable
2. Chlorine - 2 ppm
3. Hydrogen Sulfide - 20 ppm

- C. Maximum Exposure Time Above Excursion Exposure

1. Chlorine - 5 minutes every 8 hours
2. Hydrogen Sulfide - 10 minutes every 8 hours

- D. Maximum Concentration Not to be Exceeded For Any Length of Time Under Any Circumstances

1. Chlorine - 3 ppm
2. Hydrogen Sulfide - 50 ppm

- IX. Working In Confined Spaces.

- A. Definition. A confined space is any space such as silos, tanks, vats, vessels, boilers, compartments, ducts, sewers, pipelines, vaults, bins, tubs, and pits where both of the following can occur:

1. The existing ventilation is insufficient to remove dangerous air contamination and/or oxygen deficiency which may exist or develop. [§ 5156(b)(1)(A)]
2. Ready access or egress for the removal of a suddenly disabled employee is difficult due to the location and/or size of the opening(s). [§ 5156(b)(1)(B)]

- B. Dangerous Air Contamination. An atmosphere present-

ing a threat of causing death, injury, acute illness, or disablement due to:

1. Flammable gases or vapors at a concentration greater than 20% of their lower explosive (lower flammable) limit. [§ 5156(b)(2)(A)]
2. Combustible particles at a concentration greater than 20% of the minimum explosive concentration of the particulate. [§ 5156(b)(2)]
3. Any toxic substance at an atmospheric concentration immediately hazardous to life or health. [§ 5156(b)(2)]

- C. Oxygen Deficiency. Any atmosphere containing oxygen at a concentration less than 19.5% by volume is considered oxygen deficient. [§ 5156(b)(3)]

Note: Normal atmospheric oxygen content is 20.9% by volume.

- D. Operating Procedures and Employee Training. Prior to any employee being permitted to enter a confined space, the employer shall:

1. Develop written, understandable operating and rescue procedures and shall provide these to affected employees. [§ 5157(a)(1)]
2. Provide operating procedures in the field that include provision for the surveillance of the surrounding area to avoid hazards such as drifting vapors from tanks, piping, and sewers. [§ 5157(a)(2)]
3. Train employees, including standby persons, in the operating and rescue procedures including instructions as to the hazards they may encounter. [§ 5157(a)(3)]

- E. Pre-Entry Requirements

1. Lines which may convey flammable, injurious or incapacitating substances into the space shall be disconnected, blinded off, or blocked off by other positive means to prevent the development of dangerous air contamination and/or oxygen deficiency within the space. However, this requirement does not require blocking of all laterals to sewers or storm drains, except where experience or knowledge of industrial use indicates materials resulting in dangerous air contamination may be dumped into an occupied sewer, then all such laterals shall be blocked. [§ 5158(a)]
2. The space shall be emptied, flushed, or otherwise purged of flammable, injurious, or incapacitating substances to the extent feasible. [§ 5158(b)]
3. The air shall be tested with an appropriate device or method to determine whether dangerous air contamination and/or an oxygen deficiency exists and a written record of such testing results shall be made and kept at the work site for the duration of the work. Affected employees and/or their representative shall be afforded an opportunity to review and record the testing results. [§ 5158(c)]
4. No source of ignition shall be introduced until the implementation of appropriate provisions of this section have ensured that dangerous air contamination due to flammable and/or explosive substances does not exist. [§ 5158(h)]
5. To the extent feasible, provision shall be made to permit ready entry and exit. [§ 5158(j)]
6. After initial purging of the confined space has removed dangerous air contamination and/or oxygen

deficiency as demonstrated by additional testing conducted (and recorded), entry and work within the space may proceed subject to the following provision: [§ 5158(g)]

Testing shall be conducted with sufficient frequency to ensure that the development of dangerous air contamination and/or oxygen deficiency does not occur during the performance of any operation. [§ 5158(e)(1)]

7. Appropriate, approved, respiratory protective equipment including an independent source of breathing air, shall be provided for in the event of the need to enter the space to effect a rescue. [§ 4149(a)(2)]

8. At least one person trained in first aid and cardiopulmonary resuscitation (CPR) shall be immediately available in the event of an emergency. [§ 5159(b)(1)]

- F. Working Within Confined Spaces

1. Tanks, vessels, or other combined spaces with side and top openings shall be entered from side openings when practicable. [§ 5159(a)(1)]
2. An approved safety belt with an attached line shall be used. If entry is made through a top opening the safety belt shall be of the harness type that suspends a person in an upright position. [§ 5159(a)(3) and [§ 5159(a)(5)]

3. The free end of the attached line shall be secured outside the entry opening. [§ 5159(a)(3)]

4. The line shall be at least 1/2 inch diameter and 2,000 pounds breaking strength. [§ 5159(a)(3)]

Note: 1/2 inch manila rope has a rated breaking strength of 2,380 lbs., 1/2 inch polypropylene rope has a rated breaking strength of 3,780 lbs.

5. At least one employee shall stand by on the outside of the confined space ready to give assistance in case of emergency. At least one additional employee who may have other duties shall be within sight or call of the standby employee(s). [§ 5159(a)(4)]

6. If entry has been made through a top opening a hoisting device or other effective means shall be provided for lifting employees out of the space. [§ 5159(a)(5)]

7. Only approved lighting and electrical equipment, in accordance with the Low-Voltage Electrical Safety Orders, shall be used. [§ 5159(a)(8)]

8. An effective means of communication between employees inside a confined space and a standby employee shall be provided and used whenever employees inside a confined space are out of sight of standby employee(s). All affected employees shall be trained in the use of such communication systems and the system shall be tested before each use to confirm its effective operation. [§ 5159(b)(2)]

9. In the event of an emergency, a standby employee may enter the confined space, but only after alerting at least one additional employee outside the confined space of the existence of an emergency and of the standby employee's intent to enter the confined space. [§ 5159(a)(4)]

## PROTECT PERSONNEL FROM HYDROGEN SULFIDE

This section deals with occupational exposures to hydrogen sulfide in all places of employment. The purpose of this article is to provide information for the protection of workers from actual or potential exposures to hydrogen sulfide gas. This article is also intended to provide warning that hydrogen sulfide is an insidious hazard because short exposures to high concentrations may dull the sense of smell. Therefore, absence of odor should not be considered as indicative of a nonhazardous concentration.

### Properties of Hydrogen Sulfide

Hydrogen sulfide is a colorless gas with a characteristic rotten egg odor at low concentrations. At higher concentrations, it has a sweetish odor; at still higher concentrations, no odor may be detected. Hydrogen sulfide is produced when organic matter containing sulfur decomposes; hydrogen sulfide may therefore be found in wastewater or organic waste treatment plants. A common sewer gas, it may find its way into utility manholes, vaults, or other underground spaces. It is particularly dangerous when encountered in tanks, vessels, and other enclosed spaces.

Hydrogen sulfide is an extremely toxic and irritating gas. Free hydrogen sulfide in the blood reduces its oxygen-carrying capacity, thereby depressing the nervous system. Sufficiently high concentrations cause blocking of the phrenic nerve, resulting in immediate collapse and death as a result of respiratory failure and asphyxiation. Because hydrogen sulfide is oxidized quite rapidly to sulfates in the body, no permanent after effects occur. In cases of recovery from acute exposures, there is always the possibility that pulmonary edema may develop. Symptoms such as nervousness, dry nonproductive cough, nausea, headache, and insomnia, lasting up to about 3 days, have occurred after acute exposures to hydrogen sulfide. At low concentrations, the predominant effect of hydrogen sulfide is on the eyes and respiratory tract. Eye irritation, conjunctivitis, pain, lacrimation, keratitis, and photophobia may persist for several days. Respiratory tract symptoms include coughing, painful breathing, and pain in the nose and throat.

There is no evidence that repeated exposures to hydrogen sulfide result in accumulative or systemic poisoning. Effects such as eye irritation, respiratory tract irritation, slow pulse rate, lassitude, digestive disturbances, and cold sweats may occur, but these symptoms disappear in a relatively short time after removal from the exposure. Repeated exposures to hydrogen sulfide do not seem to cause any increase or decrease in susceptibility to this gas.

The paralytic effect of hydrogen sulfide on the olfactory nerve is probably its most significant property. This paralysis may create a false sense of security. A worker can be overcome after the typical rotten egg odor has disappeared. Some victims of sudden acute overexposure have reported a brief, sickeningly sweet odor just before they lapse into unconsciousness.

Subjective olfactory responses to various concentrations of hydrogen sulfide have been summarized as follows:

- 0.02 ppm: No odor
- 0.13 ppm: Minimal perceptible odor
- 0.77 ppm: Faint but readily perceptible odor
- 4.60 ppm: Easily detectable, moderate odor
- 27.0 ppm: Strong, unpleasant, but not intolerable odor

Physiological responses to various concentrations of hydrogen sulfide have been reported as follows:

10 ppm:	Beginning eye irritation
50 - 100 ppm:	Slight conjunctivitis and respiratory tract irritation after one hour exposure
100 ppm:	Coughing, eye irritation, loss of sense of smell after 2 to 15 minutes. Altered respiration, pain in the eyes, and drowsiness after 15 to 30 minutes, followed by throat irritation after 1 hour. Several hours exposure results in gradual increase in severity of these symptoms, and death may occur within the next 48 hours.
200 - 300 ppm:	Marked conjunctivitis and respiratory tract irritation after 1 hour of exposure
500 - 700 ppm:	Loss of consciousness; death possible in 30 minutes to 1 hour
700 - 1000 ppm:	Rapid unconsciousness; cessation of respiration, and death
1000 - 2000 ppm:	Unconsciousness at once, early cessation of respiration, and death in a few minutes. Death may occur even if individual is removed to fresh air at once.

#### Permissible Exposure Limits

The American Conference of Governmental Industrial Hygienists has established the threshold limit value of 10 ppm as a time-weighted average concentration for a 7 or 8 hour workday and a 40 hour workweek. Fluctuations above this concentration should not exceed 20 ppm in order that workers may not develop conjunctivitis.

#### POISONOUS GASES

##### Five (5) gases encountered on the job:

1. Carbon Dioxide (CO<sub>2</sub>)
2. Methane (CH<sub>4</sub>)
3. Hydrogen Sulfide (H<sub>2</sub>S)
4. Ammonia (NH<sub>3</sub>)
5. Chlorine (Cl<sub>2</sub>)

1-4 are gases found in sewers  
5 is present at treatment plants

#### Characteristics:

1. CO<sub>2</sub> is colorless and odorless  
Heavier than air  
No flammability or explosiveness  
Toxic limit is 10% for a few minutes
2. CH<sub>4</sub> is colorless and odorless  
Lighter than air  
Explosive at 6%  
9% causes nausea
3. H<sub>2</sub>S is colorless with rotten egg odor  
Heavier than air  
Explosive at 4%  
Toxic limit 0.07% for 2 minutes
4. NH<sub>3</sub> is colorless with sharp urine-like odor  
Lighter than air  
Explosive at 15%  
Toxic limit 0.01%
5. Cl<sub>2</sub> is greenish/yellow gas with penetrating odor  
Heavier than air  
Explosive  
Extremely toxic - Very small % causes severe coughing

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#### PHYSIOLOGICAL RESPONSES TO HYDROGEN CYANIDE

Concentration		Response
p.p.m. by volume	mg/m* (approx.)	
18-36	20-40	Some symptoms after several hours
45-54	50-60	Tolerated for 0.5-1 h without immediate or delayed effects
110-135	120-150	Fatal after 0.5-1 h or later, or dangerous to life
135	150	Fatal after 0.5 h
181	200	Fatal after 10 minutes
270	300	Immediately fatal

\*The equivalent concentrations in mg/m<sup>3</sup> are strictly valid only at 25°C and 1 atm.

## CHAPTER IV GENERAL WASTEWATER TREATMENT

### WASTEWATER ORIGINS

Much of all wastewater generated comes from residential use — bathrooms, kitchens and washing machines — which we call domestic waste. This type of waste may account for a significant percentage of the total flow coming into the treatment facility, although that percentage may seasonally fluctuate as with a canner season.

Another major source of wastewater as a user class is the commercial community, which includes everything from shoe stores to large restaurants and office buildings. The waste from these sources varies widely in type and strength when compared with domestic waste which is fairly consistent in strength.

A third major source of wastewater is from the industrial segment. The wastewater from this user class is extremely variable in strength and volume. The wastewater influent into a treatment facility from IU's has the potential for facility upsets since the volumes and strengths may be of sufficient quality to kill microorganisms necessary for wastewater treatment.

All of the wastewater from the various sources mentioned begins its journey to the treatment facility from the property owner's lateral to the main line in the street. From there the wastewater may be pumped by a sanitary pump station which lifts the wastewater to a higher elevation, or to a main trunk line and on to the treatment plant.

#### I. Treatment Processes

##### A. Primary Treatment

Raw sewage contains various types of solids. The character of these solids is both inorganic and organic. The following are methods used commonly to remove these pollutants.

##### 1. Screening

Bar screens are used to remove the larger pieces of debris such as pieces of wood, rags, cans and bottles. These bars are typically spaced about two inches apart and are set vertically.

##### 2. Grit Removal

After the bar screens will be some sort of units designed to settle out mainly inorganic solids such as sand. The units may be in the form of a channel where a minute of detention time is allowed for settling. The solids which settle here are removed and then hauled away and disposed of.

##### 3. Primary Sedimentation

After passing through grit removal the sewage passes into sedimentation tanks of some sort. The main objective here is to remove most of the suspended solids by settling. The solids that settle are called raw sludge. This sludge is moved along the bottom of the tank by paddles to one end of the tank. The sludge is then pumped from the primary sedimentation tank to the digester tanks for further treatment. Some primary sedimentation tanks are circular in construction instead of rectangular, in which case the

sludge is scraped toward the center of the tank for removal to the digesters. The partly clarified liquid flows from the sedimentation tank into another stage of treatment which is called "secondary."

#### 4. Solids Treatment

The sewage solids are pumped into heated digesting tanks for a detention period from two to three weeks. Digestion is mainly the action of methane producing bacteria, reducing volatile acids to carbon dioxide and methane gas, thus reducing volatile solids to non-volatile.

The methane gas is often used to power electrical generators at the treatment facilities and may be used to power cars and trucks. Once the digestion of sludge is completed it will usually be pumped to containment areas for dewatering and eventual disposal.

#### B. Secondary Treatment

This type of treatment is accomplished under aerobic conditions; i.e., with a constant supply of oxygen. Treatment is rapid and complete by utilizing aerobic bacteria. In secondary treatment about 70% of the influent BOD is removed. There is some variety in secondary treatment processes, but there are two main treatment types. They are trickling filter and activated sludge.

##### 1. Trickling Filter

A trickling filter will be circular with concrete walls usually varying in height from 5 feet to 25 feet. Distribution arms spray the sewage pumped from the primary sedimentation tanks as they rotate around the inside of the filter walls. The trickling filters are loosely filled with a type of filter media. The media provides a surface area for the aerated wastewater to flow over.

Gelatinous masses of algae growth act as the matrix for the oxidizing bacteria as it enfolds the filter media. Dissolved solids such as sugars and starches are absorbed into this matrix upon contact with the media and undergo bacterial digestion. Fine particles of suspended solids (colloids) are also coagulated so they may become settleable solids upon leaving the trickling filter. These solids are then settled out in secondary sedimentation tanks which are considered as units of the trickling filters. Sludge from the secondary sedimentation tanks are also pumped to the digesters.

##### 2. Activated Sludge

Many treatment facilities use activated sludge for secondary treatment instead of trickling filters. The activated sludge process is a biological treatment process which speeds up the decomposition of wastes in the wastewater. In this process activated sludge is added to wastewater and the mixture (mixed liquor) is aerated and agitated. The term "activated" refers to the fact that the raw sludge particles produced in raw or settled wastewater (primary effluent) are teeming with bacteria, fungi, and protozoa.

Activated sludge is different from primary sludge in that the sludge particles contain many living things which feed on the incoming wastewater.

After some time in the aeration tank, the activated sludge is settled out by sedimentation and is either disposed of (wasted) or returned to the aeration tank. The activated sludge process also has secondary clarifiers to settle out the solids.

### 3. Oxidation Ponds

The use of oxidation ponds is desirable as a polishing step for the secondary treatment process, but only a few agencies have them. The main limitation for their use is space and land prices. The biological process taking place in the pond is similar to that of the trickling filter. In the oxidation pond, oxygen is supplied to the aerobic bacteria by the photosynthetic process of the algal cell. The algal cells utilize the carbon dioxide being produced through the metabolism of the aerobic bacteria, and in combination with sunlight and chlorophyll, produces dissolved oxygen and cellular material. The oxidation ponds thus convert the remaining BOD into algal and bacterial cells.

### C. Tertiary Treatment

This is the final polishing treatment, the process which removes most of the remaining pollutants and cellular growth. Many treatment facilities have some sort of tertiary treatment. By the end of the tertiary treatment process the wastewater may have upwards of 95% of influent pollutants removed.

The tertiary treatment process will often use a dissolved air flotation tank which is designed to remove algae, greases, and other suspended and settleable solids. Wastewater entering the tanks is subjected to thousands of air bubbles while chemicals (alum or polymers) are being added to the flow. The chemicals combine with the particulate matter in the water to form a "floc" which is carried to the surface by the thousands of air bubbles or as a sludge which settles to the bottom of the tanks. The floc and the sludge are mechanically removed from the tanks.

A type of filter is usually then employed to remove the remaining tiny particles of algae, bacterial growth and slime from the treated water. A combination of sand and activated carbon or coal may be used to achieve final treatment of the wastewater.

A necessary last step will be the addition of chlorine or other disinfectant for a sufficient period of time to achieve disinfection of the wastewater. Usually a series of chlorine diffusers is used to disperse the chlorine for maximum contact. To prevent excess chlorine from being discharged by the treatment plant a dechlorination step may be necessary. Dechlorination is accomplished by the addition of liquid sulfur dioxide (SO<sub>2</sub>) through diffusers. At the final discharge point a high volume of air may be diffused into the water to help raise the dissolved oxygen (DO) content.

## II. Industrial Waste Problems at the POTW

A discharge of industrial wastes may affect a treatment plant to the extent that it fails to meet the discharge requirements set by the NPDES permit, the regulating agency, or other authority. One cause for the failure may be a process upset occurring due to toxic materials that destroy or affect the metabolism of microorganisms that are part of the treatment process. Another cause may be toxic materials that pass through the treatment process and are present in the plant

effluent. Hydraulic overloads can upset treatment processes by "washing out" the microorganisms in the treatment process. Solids carry-over to the effluent will result from a process upset, as will odors resulting from upset biological treatment processes.

Industrial discharges may cause problems in both the collection system and treatment plant including excessive solids that may cause stoppages, corrosive substances that may damage the pipes, and flammable materials that may cause fires or explosions. Dangerous gases may result from some discharges. In some cases, the gases will cause an oxygen deficiency. In others, toxic gases such as hydrogen sulfide or cyanide may be present. Additionally, some gases may create flammable or explosive conditions.

### Objectionable Characteristics of Industrial Wastes:

Some undesirable properties and effects of various industrial waste discharges are presented in this section.

### Possible Collection System Problems:

1. Acid - cause corrosion of pipes and liberation of hydrogen sulfide gas.
2. Alkali Wastes - cause sealing of sewers
3. Thermal Wastes - raise the temperature of wastewater, speeding up decomposition and thus causing septic conditions. Septic conditions can produce odor and corrosion problems as well as toxic, flammable, explosive and oxygen-deficient atmospheres.
4. Solids - excessive solids may settle and cause stoppages and septic conditions
5. Oils and Greases - build up on pipe walls, reducing capacity and causing stoppages and septic conditions.
6. Odors - the discharge itself may be odorous, or the odors may result from the conditions caused by the discharge.
7. Toxic Substances - may include infectious wastes, poisons (such as pesticides) or gases (such as cyanide or hydrogen sulfide).
8. Flammable and Explosive Materials - includes fuels, paint thinners, and hydrogen sulfide.

Note: Hydrogen sulfide will cause odors, corrosion, and can be explosive and toxic to your respiratory system.

### Possible Treatment Plant Problems:

1. Organic Overloads - more suspended and dissolved solids than the plant can handle.
2. Toxic Substances - (see previous section on collection systems).
3. Oils and Greases - may pass through plant and form surface scums on receiving waters (see previous section on collection systems).
4. Acids and Alkalies - cause corrosion or scaling of pipes and can be toxic to organisms in treatment processes.
5. Hydraulic Overloads - reduce detention or treatment times and cause incomplete treatment of wastes.
6. Refractory Materials - materials that are not removed by plant processes, such as nutrients, color, taste and odor producing substances, and some toxic materials.
7. Hazardous Wastes - solvents, fuels, corrosives, poisonous substances, infectious wastes, radioactive wastes, gases (explosive, toxic or oxygen displacement).

Thus, it is possible for a seemingly harmless food processing plant waste, for example, to discharge excessive solids and organic materials and cause intolerable conditions in the collection system and wastewater treatment plant.

## WASTE TREATMENT—CONVENTIONAL POLLUTANTS Industrial Waste Impact on Bacteria

Industrial wastes—industries discharging into the sewer system may have wastes containing any one of the waste types listed in the following table. Their normal discharges probably will not

seriously affect operation because the biomass is acclimated to it. Problems usually will occur whenever the concentration of any of these exceeds the normal amount. The following table is presented to help the operator identify the industrial inclusions and the type of filamentous growths which can occur.

Type of Waste	Typical Major Sources	Types of Typical Microorganisms
1. Proteinous	Meat Packing Plants	Fungi (F)
2. Carbohydrates	Containing Sugars and Starches as from Food Processing Plants	Lactic Acid Bacteria (F)
3. Lactic acids	From Milk Producing Plants	Toxothrix (F)
4. Hydrogen sulfides	From Sewage which has turned Septic in Sewers or Food Plants or Oil Companies	Vitreoscilla (F)
5. High or Low pH	From Various types of Industries	
6. Toxic Wastes	Chemical mfg	
7. Metallic Salts i.e., Chromium	Electroplating	

(F) = Filamentous

Operator's Pocket Guide to Activated Sludge  
by Stevens, Thompson and Runyan, Inc.

## CHAPTER V THE PRETREATMENT PROGRAM

This chapter deals with some of the various aspects of the Pretreatment Source Control Program (PSCP), but should only be used as an introduction to this complex program.

### A. Objectives of the Pretreatment Program

There are five main objectives of the PSCP, and they are:

1. Prevent interference of normal POTW operations
2. Prevent pass-through of pollutants to the receiving waters
3. Protect the safety of POTW personnel
4. Prevent sludge contamination
5. Prevent POTW NPDES permit violations

### B. Categorical Pretreatment Standards

The EPA has promulgated a number of categorical pretreatment standards for various industries. The following information deals with these standards.

Local administration of National Categorical Pretreatment Standards has become a major focus for municipalities in the development and implementation of their pretreatment programs. This section provides a short history of categorical pretreatment standards, and a brief discussion of the relationship between the standards for direct dischargers and those for indirect dischargers (industries that discharge to POTWs are indirect dischargers).

#### Background of Categorical Standard Categories

The initial list of 27 categorical industries was established by Congress under Section 306 of the Clean Water Act (CWA) of 1972. Several changes have occurred in the list since 1972 as a result of court decrees, settlement agreements resulting from litigation, and from EPA's internal work plan development process. The most significant change grew out of the 1976 Settlement Agreement between EPA and the Natural Resources Defense Council (NRDC). This Agreement identified 21 industrial categories by Standard Industrial Classification (SIC) code and required EPA to establish toxic pollutant regulations for these categories. In 1979, as a result of the court ordered modification to the 1976 NRDC Settlement Agreement, the categorization scheme was changed to include 34 categories.

In 1982, a court ordered further modification of the NRDC Settlement Agreement resulting in a total of 38 priority categories, 7 of which had previously been deferred. At present, EPA's list of regulated categories number 26, 12 having been exempted under the paragraph 8 provision of the NRDC Consent Agreement. Paragraph 8 allows EPA to reconsider and exempt any industry category that does not warrant regulation after detailed evaluation. The number often cited is 29, this total is derived when the three categories having phases I and II are counted separately rather than as one category.

Pollutant discharge standards applicable to specific categories of industries were promulgated as early as the mid-1970s and included industries such as: processors of dairy products, fruits and vegetables, seafood, and sugar as well as manufacturers of chemicals, plastics, fertilizer, soap, paint and other products. Although the regulations were primarily concerned with setting standards for industries that discharge directly into rivers, lakes,

and other natural water bodies, many of them also contained pretreatment standards for industries that discharge to POTWs. Generally they are superseded by more recent regulations.

Most of the pretreatment standards in the early regulations limited only conventional pollutants such as pH, oil and grease, BOD, and suspended solids. In some industry categories, the pretreatment standards section simply referred to 40 CFR Part 128, which has been deleted and substantively replaced by 40 CFR Part 403. The Prohibited Discharge Standards contained in 40 CFR 403.5 are as stringent or more stringent than the pretreatment standards expressed in many of the early regulations.

#### Development of Categorical Pretreatment Standards

As a result of the suit brought by the Natural Resources Defense Council (NRDC) against EPA in 1976, EPA was forced to shift its focus from the control of conventional pollutants to the control of toxic pollutants. As part of the settlement of this suit, EPA agreed to develop technology-based standards to control 65 toxic substances and classes of toxic substances produced in the original 21 categories of industries. EPA later refined its effort to include a more detailed list of 129 (now 126) pollutants representative of the broader list of 65 toxic pollutants. In developing the pretreatment standards for these pollutants and these industries, EPA needed to know what level of each pollutant would cause interference with wastewater treatment processes and what amount of each pollutant is removed by typical treatment processes and, therefore, does not pass through into the receiving waters. Various studies were then conducted to provide the technical data needed to establish specific pretreatment standards. As a result of these efforts, categorical pretreatment standards have been promulgated and continue to be promulgated for pollutants discharged from industries identified as being the primary sources of toxic pollutants.

Categorical standards are technology-based and limit the discharge of specific pollutants. They are based upon available treatment technologies, and as such, they constitute minimum standards and may be superseded by more stringent sludge disposal limitations or water quality-based standards developed to protect specific lakes, streams, and other natural waters. Economic impacts on affected industries are taken into consideration in the development of categorical standards which assume industry-wide usage of the best available technology (BAT) for pollution control.

The Industrial Technologies Division (formerly the Effluent Guidelines Division) of EPA first developed categorical standards for industries that discharge directly into natural waters. Pretreatment standards for indirect dischargers (industries that discharge to POTWs) are based on the standards for direct dischargers. If POTW treatment plant processes remove any of an industry's pollutants as discharged from that industry are generally not promulgated. However, if a specific pollutant passes through the POTW to a greater extent than it would if the industrial user were a direct discharger using the "best available technology", then the indirect dischargers are required to meet the same pollutant standards as those applied to direct dischargers of that category.

EPA policy is to establish categorical standards that are production-based whenever possible. A production-based standard is a particularly equitable form of standard. Industries that conserve process waters are not penalized by a production-based standard as they would be with a simple concentration-based standard. Moreover, production-based standards discourage the substitution of dilution for treatment. However, application of these standards requires a POTW to have reliable data concerning industrial production rates.

A number of industries in the list identified as primary sources of toxic pollutants have been excluded from regulation for various reasons allowed in the NRDC vs. EPA Settlement Decree.

### C. Reporting Requirements

The PSCP requires each entity involved to report certain information within specified time frames. The details of these reporting requirements are outlined below:

#### 1. POTW Reporting Requirements

- a. Annual report - this report is a detailed report to the Regional Board (RB) of all aspects of the years program including compliers and non-compliers (consult with EPA or RB for latest format).
- b. Quarterly report - this report will list the major IU's that are noncompliant for the quarter, including a description of the violations and what actions by the POTW are being taken
- c. Program Modification Report - any substantial proposed program modifications must be reported to the SWRCB. A substantial modification may include:

- Change in the POTW's legal authorities
- Revision of local limits
- IU monitoring and reporting requirements

#### 2. Industrial User Reporting Requirements

- a. Baseline Monitoring Report (BMR) - This report describes the production processes and quantifies production rates and discharge volumes. The discharger must state his compliance status and give a timetable for corrective action.
- b. Compliance Schedule Progress Reports - here a non-complier reports each step toward meeting their compliance deadline.
- c. Final Compliance Report - within 90 days of compliance deadline the IU must file a report which includes the sampling results for regulated pollutants, average a max daily flows of regulated discharges and a statement of compliance. New IU's must file a compliance report upon commencement of discharge.
- d. Periodic Compliance Reports - after their compliance report an IU must file at least semi-annually self-monitoring results.
- e. Accidental Spill and Upset Reports - verbal report within 24 hours and a written report within 5 days

Note: All records must be kept for at least three years, and all reports must be signed by a principal executive officer of at least the level of vice president. Also the POTW may require much more frequent reports from an IU.

#### 3. Total Toxic Organics (TTO) - six of the EPA's industrial categories have a TTO pretreatment standard. They are:

- Electroplating
- Metal Finishing

- Electrical and Electronic Components (Phases I and II)
- Copper Forming
- Aluminum Forming
- Coil Coating (Can making Subcategory only)

An excellent source of information about this subject is the EPA's own publication entitled, "Guidance Manual for Implementing Total Toxic Organics (TTO) Pretreatment Standards". This publication has a complete listing of all the organic compounds regulated under each category as well as useful sampling, sample preservation, and holding times information. A TTO requirement was promulgated for those industries listed above because industry studies indicated significant potential for TTO discharge.

### D. Production Based Standards (PBS)

In promulgating standards the EPA came up with two types of regulations. They are: concentration based limits, and production based limits.

A concentration based limitation is one where a number expressed in milligrams per liter (mg/l) is assigned to a categorical industry as an effluent discharge standard. A laboratory analysis of the wastewater from such an industry is compared to the limitation and the compliance status readily ascertained. The production based limit is calculated from the actual production of an industry and requires accurate production numbers as well as measurement of effluent flow and contamination levels. These limits could be expressed as weight of pollutant per weight of product or weight of pollutant per surface area of product or in the case of fume scrubber waster, weight of pollutant per volume of air scrubbed.

The EPA identifies 10 industries with high product rinse flow rates, and established production based standards for these. In these industries where flow reduction is a major part of the treatment technology defined as the basis for pretreatment standards, EPA issued production-based standards since concentration-based limitations would not ensure an equal reduction in the mass of pollutants discharged.

Some industries may reduce pollutants somewhat by flow reduction but not significantly. For these industries both types of standards were issued. A POTW may choose either if it feels that dilution is an expected problem.

A third group has only concentration-based standards because it was not possible to establish a correlation between production and achievable pollutant discharge in order to develop a PBS.

It is administratively more difficult to accurately measure compliance with PBS. With a concentration based limitation you need only take a sample, analyze, and compare results to the standard. With PBS, however, you must measure the flow of the regulated wastestream and determine the corresponding production rate. The most difficult step in this process is confirming the production rate.

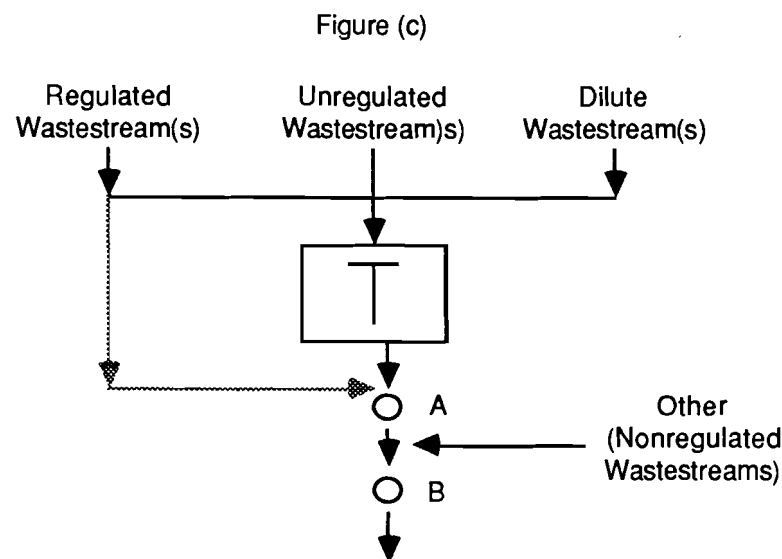
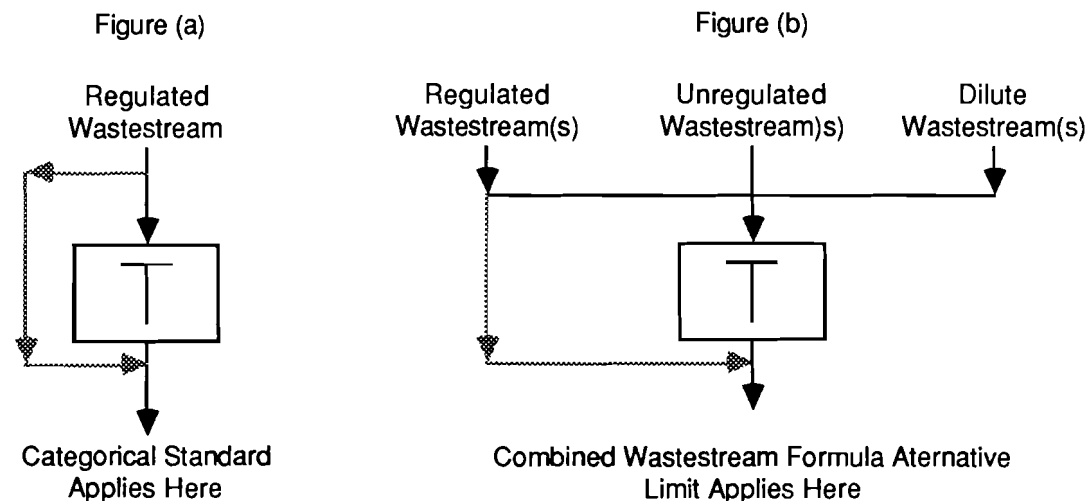
#### 1. Use of Equivalent Mass Limits

The Control Authority (CA) may use an average daily production value based on a reasonable measure of the actual production rate to determine compliance. The equation is:

$$\text{standard} \times \frac{\text{average production rate}}{\text{conversion factor}} = \text{equivalent mass limit}$$

#### 2. Use of Equivalent Concentration Limits

The CA may elect to establish a concentration limit for reasons of cost, technical and managerial considerations. Here the average daily flow is used. The advantage of this equivalent concentration limit is that it eliminates the need



Point A: Combined Wastream Formula Alternative Limit Applies

Point B: Control Authority May Apply the CWF, But If It Is Not Applied ... Calculate Adjusted Limit as Follows:

1) Adjusted Mass Limit =

$$\text{(CWF Mass Limit for Point A)} + \frac{\text{(Actual Mass of Pollutant in Nonregulated Wastreams Added After Treatment)}}{\text{(Flow at Point A)}}$$

2) Adjusted Concentration Limit =

$$\frac{\text{(CWF Concentration Limit for Point A)} \times \text{(Flow at Point A)} + \text{(Actual Mass of Pollutant in Nonregulated Wastreams Added After Treatment)}}{\text{(Flow at Point B)}}$$

Note: T = Treatment Facility

to directly measure production each time you monitor. The equation is:

$$\frac{\text{standard} \times \text{average production rate}}{\text{average flow rate} \times \text{conversion factor}} = \text{equiv. conc. limit}$$

### 3. Use of PBS with a Permit System

The EPA strongly recommends that equivalent limits be applied using a permit, contract, order, or other official document that is transmitted to the IU. The document should clearly spell out 1) the equivalent limit 2) the flow and/or production rates upon which the limit is based, and 3) the requirement to notify the CA of changes in flow and/or production rates requiring limit revision.

### E. Combined Wastream Formula (CWF)

The CWF is a method for calculating alternative pollutant limits for IU's where regulated process effluent is mixed with other wastewaters (either regulated or unregulated) prior to treatment. The EPA recognizes that separate treatment of wastes at an integrated plant can be costly, wasteful of energy, inefficient, and environmentally counterproductive.

To understand the CWF the following definitions will need to be learned:

*Regulated Wastream* — a wastestream from an industrial process that is regulated by a categorical standard for pollutant X.

*Unregulated Wastream* — a wastestream not regulated but also not a dilute wastestream as defined below.

*Dilute Wastream* — a wastestream that includes:

- Sanitary Wastewater
- Noncontact cooling water and boiler blowdown
- Wastreams listed in 40 CFR Part 403

Note that if a CA is concerned that an unregulated stream is actually acting as dilution, the CA can establish a limit more stringent than otherwise derived.

### F. Miscellaneous Pretreatment Topics

#### 1. Removal Credits

The EPA has provided a mechanism whereby a POTW could allow higher categorical limitations upon receiving such authority from the EPA and State. The approval is contingent upon demonstrating a consistent removal percentage for specific pollutants by a POTW. In effect the POTW passes along to the IU's a portion of its removal efficiency back to the IU's in the form of higher concentration limits.

Although this will result in fewer violations of limitations by the IU's because of the higher pollutant limits granted, the increased pollutants will mostly end up in the POTW's sludge. Increased concentrations of pollutants in the sludge may adversely effect the POTW's sludge disposal options.

#### 2. Fundamentally Different Factors (FDF)

The EPA has a provision in the regulations that allows an IU or any interested party to request a variance for the establishment of limits either less stringent or more stringent than required by a Categorical Pretreatment Standard. The primary criterion for approval of an FDF variance is that the factors relating to the discharge from the IU controlled by the Categorical Pretreatment Stan-

standard are fundamentally different from the factors considered by the EPA in establishing the standards.

### G. The Roles of the EPA, State and Local Agencies

Once the PSCP is delegated to the State, then the EPA's role changes to overview of the program. The EPA will overview in the following ways:

- a) concurrence role in removal credits applications
- b) program grants - such as contract assistance for State audits of POTW's and unregulated IU's
- c) audits of State board

Regional Boards will be running the PSCP. The EPA will substantially retain FDF decisions.

The State Board will be responsible for the overall consistency and high quality of PSCP implementation. The SB will check enforcement efforts for timeliness and appropriateness. The SB will function as a resource for the RB's. The SB will be sensitive to the quality of work, number of audits, and number of inspections by the RB's. The SB may look directly at certain IU's.

There will be at least 30 audits per year. The audits are currently using private contractors to train RB personnel in conducting an audit.

Once California has authority delegated to it then all of the above will occur. Also the POTW's will submit their annual and other reports to the RB's. RB's will enforce if the POTW is unable to.

### AFFECTED POTWS

Any POTW (or combination of POTWS operated by the same authority) with a total design flow greater than 5 million gallons per day and which receives from industrial users pollutants which pass through untreated or interfere with the operation of the POTW or are subject to pretreatment standards developed pursuant to Section 307(b) or 307(c) of the Clean Water Act.

### PRETREATMENT STANDARDS — PROHIBITED DISCHARGES

1. Pollutants which create a fire or explosion hazard in the POTW.
2. Pollutants which will cause corrosive structural damage to the POTW, but in no case discharges with pH lower than 5.0, unless the works is specifically designed to accommodate such discharges.
3. Solid or viscous pollutants in amounts which will cause obstruction to the flow in sewers, or other interference with the operation of the POTW.
4. Any pollutant, including oxygen demanding pollutants (BOD, etc.), released in a discharge of such volume or strength as to cause interference in the POTW.
5. Heat in amounts which will inhibit biological activity in the POTW resulting in interference, but in no case heat in such quantities that the temperature at the treatment works influent exceeds 40 C (104 F) unless the works is designed to accommodate such heat.

**PRETREATMENT STANDARDS —  
CATEGORICAL STANDARDS**

1. All categorical pretreatment standards for existing and new industrial users shall be enforced by the POTW.
2. The POTW may, with approval of EPA, revise the pollutant discharge limits in each of the categorical pretreatment standards to reflect the consistent POTW removal seen for each pollutant.
3. Categorical pretreatment standards for 34 separate categories of industries (which will regulate discharge of 65 toxic, incompatible pollutants through the required installation of best available technology (BAT) pretreatment facilities) will be issued by EPA by July 1981, and industry is to comply with these categorical standards within 3 years of promulgation or July 1984, whichever is earliest. Pursuant to a court settlement of a lawsuit brought against EPA by the National Resources Defense Council (NRDC), interim categorical pretreatment standards for 8 categories of industries have been published which call for the installation of best practicable technology (BPT) facilities to control discharges of toxic constituents of greatest environmental concern. These 8 interim standards will be replaced by BAT standards by July 1981.

Affected POTWs must have an EPA approved pretreatment program by no later than July 1, 1983. The pretreatment program must contain, as a minimum, the following mandatory requirements:

**Mandatory Requirements of a POTW Pretreatment Program**

**Legal Authority:**

The POTW must have the legal authority to:

1. Deny or place conditions upon new or increased amounts of pollutants from industrial users.
2. Require industrial users to comply with all pretreatment standards.
3. Issue permits or enter into contracts with industrial users to control the contribution to the POTW by each industrial user.
4. Require industrial users to install necessary technology to meet pretreatment standards and to insure submission of all notices and self monitoring reports.
5. Carry out all necessary inspection, surveillance, and monitoring procedures to determine if industrial users are in compliance with applicable pretreatment requirements.
6. Obtain remedies for noncompliance by industrial users which shall include civil and criminal penalties and/or liquidated damages, and the authority to immediately halt and eliminate industrial discharges which present an imminent or substantial endangerment to the health or well-

fare of persons, the environment or causes interference with the operation of the POTW.

**Procedures:**

The POTW must have the procedures to:

1. Identify and locate all possible industrial users which might be subject to the POTW Pretreatment Program.
2. Identify the character and volume of pollutants from industrial users.
3. Notify industrial users of applicable pretreatment standards.
4. Receive and analyze self-monitoring reports and notices from industrial users.
5. Randomly sample and analyze the effluent from industrial users and conduct surveillance and inspection activities to verify compliance with pretreatment standards.
6. Investigate instances of noncompliance with pretreatment standards with sample collection and analysis and collection of other information performed in a matter consistent with rules for court admissibility of evidence.
7. Comply with public participation requirements of 40 CFR Part 25 and publish annually, in the largest daily newspaper published in the municipality in which the POTW is located, a list of all industrial users which in the past 12 months were not in compliance with applicable pretreatment standards. The corrective actions taken shall also be published.

**Funding:**

The POTW must have adequate resources and qualified personnel and a source of funding to develop and carry out the above requirements.

**Categories of Industries Subject to BAT Categorical Pretreatment Standards**

- |                                 |                                      |
|---------------------------------|--------------------------------------|
| 1. Adhesives                    | 19. Textile Mills*                   |
| 2. Leather Tanning & Finishing* | 20. Timber Products*                 |
| 3. Soaps & Detergents           | 21. Coal Mining                      |
| 4. Aluminum Forming             | 22. Ore Mining                       |
| 5. Battery Manufacturing        | 23. Petroleum Refining*              |
| 6. Coil Coating                 | 24. Steam Electric Power Plants*     |
| 7. Copper Forming               | 25. Organic Chemicals                |
| 8. Electroplating*              | 26. Pesticides                       |
| 9. Foundries                    | 27. Pharmaceuticals                  |
| 10. Iron & Steel                | 28. Plastic & Synthetic Materials    |
| 11. Nonferrous Metals*          | 29. Rubber                           |
| 12. Photographic Supplies       | 30. Auto & Other Laundries           |
| 13. Plastics Processing         | 31. Mechanical Products              |
| 14. Porcelain Enamel            | 32. Electric & Electronic Components |
| 15. Gum & Wood Chemicals        | 33. Explosives Manufacturing         |
| 16. Paint & Ink                 | 34. Inorganic Chemicals*             |
| 17. Printing & Publishing       |                                      |
| 18. Pulp & Paper                |                                      |

\*Indicates categories for which interim BPT categorical standards have been issued.

**CHAPTER VI  
MONITORING**

**A. The Monitoring Program**

**Objectives:**

The Monitoring program has the following objectives:

1. To sample the discharges of non-domestic users;
2. To analyze the samples for pollutants of interest;
3. To evaluate the results for compliance;
4. To conduct surveillance and inspections to identify non-compliance. The Monitoring program should identify sampling frequencies, locations and procedures.

**MONITORING METHODOLOGIES**

For the program to be successful and comprehensive, it should incorporate four different monitoring methodologies:

1. **SCHEDULED MONITORING.** Scheduled monitoring involves the systematic sampling and inspection of non-domestic users according to a pre-determined schedule. A monitoring schedule should be developed in such a manner that dischargers are able to anticipate and plan for the monitoring visit well in advance of its occurrence. Notification may need to be made well in advance of the visit to arrange for proper access to sampling points. The schedule should provide for at least annual sampling of each significant contributor.

Scheduled monitoring should serve a number of needs, including: 1) checking for compliance with the ordinance, 2) user charge determinations, and 3) verification of self-monitoring. Scheduled monitoring should be aimed at obtaining all the information necessary to determine adherence to the local ordinance. On site inspections of the pretreatment facilities and plant operations should be conducted.

2. **UNSCHEDULED SURVEILLANCE.** Unscheduled surveillance provides for the random survey of sampling or inspection of any non-domestic user pollutant discharge within the sewer service area, and should be conducted regularly to spot check the discharge. This type of monitoring should be focused on maintaining a degree of surveillance, and would not generally be announced or formally planned for by means of appointments, etc. Users should be observed under normal operating conditions to obtain information on the true nature of wastewater. In addition to serving as a random check on scheduled monitoring, random sampling is a good followup activity to verify or refute suspicions of non-compliance.
3. **DEMAND MONITORING.** Demand monitoring is conducted in response to an upset or potential disruption of POTW operation that may have been caused by a user's discharge. Discharges containing excessive quantities of toxic, hazardous, or prohibited materials could create the need for identification of the source, type, and concentration of discharge. Sampling may take place at non-domestic

user sites or in the collection system. Investigation of the discharge source may enable the POTW to contain the material, curtail subsequent occurrences, minimize danger to the public health or safety, or assess fines or penalties. Demand monitoring may not always enable the identification of the source of pollutant; nevertheless, it should be initiated rapidly and in a conspicuous manner. Consistent efforts to track down violations are designed not only to catch the offender, but also to eliminate future discharges of prohibited materials by projecting an image of quick response to violations or emergency conditions.

Specific occurrences which might call for demand monitoring:

- Explosive, corrosive, toxic, or hazardous materials in the sewer system
- Violation of POTW permit requirements
- Violations of pretreatment regulations
- Catastrophe at an industrial site
- Operational difficulties with manufacturing processes or pretreatment equipment at an industrial site
- Reported spills.

4. **SELF MONITORING.** Self-monitoring requires that non-domestic user perform its own sampling and analysis in order to complete and maintain self-monitoring reports. Such self-monitoring makes it possible for the user to notify the POTW of any discharge in excess of established limits. By making the user more aware of its discharge volume and characteristics, self-monitoring may lead to operational changes resulting in reduced discharges and less frequent violations.

Self-monitoring can supplement the POTW program, which may not be able to adequately perform monitoring on all users depending on available resources and staff. Although self-monitoring data alone should not be relied upon for enforcement activities, these periodic reports can be useful in documenting the longer term patterns of problems and compliance when checked by the POTW's monitoring activities.

**MONITORING SCHEDULES**

Monitoring schedules should be determined on the basis of the size and significance of a user's discharge. Major contributors should be sampled regularly and more frequently than, for example, a non-toxic discharger with low volume of flow. Seasonal variations in operations of a facility may have to be taken into account. Most facilities should be scheduled for a minimum of once per year for inspection and sampling. An example monitoring schedule chart is illustrated.

**ACCESS**

Access to facilities and records must be authorized by the ordinance. The POTW may place special requirements on users for providing access, installing proper sampling points, flow measurements, and access to plant operating records.



EXAMPLES OF INDUSTRIAL WASTEWATER DISCHARGE MONITORING FREQUENCY				
AVERAGE DAILY FLOW, GPD	SELF-MONITORING FREQUENCY, TIMES/YEAR	POTW MONITORING FREQUENCY, TIMES/YEAR	SAMPLE TYPE	FLOW MONITORING REQUIRED
<b>Industries which require pretreatment:</b>				
>100,000	12	4	24 hr. composite	yes
50,000 - 100,000	6	2	24 hr. composite	yes
25,000 - 50,000	4	2	24 hr. composite	yes
10,000 - 25,000	4	1	24 hr. composite	yes
<10,000	2	1	24 hr. composite	
<b>Industries which have some toxic discharges but do not require pretreatment:</b>				
>100,000	6	2	24 hr. composite	yes
50,000 - 100,000	4	2	24 hr. composite	yes
25,000 - 50,000	4	1	24 hr. composite	yes
10,000 - 25,000	2	1	grab	
5,000 - 10,000	2	1	grab	
<5,000	none	1	grab	
<b>Industries which have non-toxic discharges:</b>				
>100,000	6	2	24 hr. composite	yes
50,000 - 100,000	4	1	24 hr. composite	yes
25,000 - 50,000	4	1	24 hr. composite	
10,000 - 25,000	2	1	grab	
<10,000	none	1	grab	

### MONITORING PROCEDURES

Monitoring should be effective and objective. To assure this, well defined procedures should guide on-site inspections and sampling activities. Sampling crews should have specific information about the industry. Facility reports should include:

1. A sketch of the location of all wastewater effluent lines, floor drains, sewer cleanouts, and outfalls to the public sewers.
2. A description of product lines and processes used in the plant.
3. A detailed description and appropriate sketches of existing pretreatment facilities at the industrial site, including operating data and past effectiveness in preventing pollutant discharges.
4. A list of the pollutants at the industrial facility. Stored chemicals and raw materials that have pollutant potential should be included.
5. Identification of any specific safety concerns.

#### B. Industrial Investigation

Industrial investigations are an integral part of the industrial waste program. It is by means of the investigations performed in the field that much of the information essential to the functioning of the program and the issuing of an adequate industrial user permit is obtained. Therefore, the investigator must become as knowledgeable as possible about each type of industry to be investigated, including types of wastes generated that are potentially most detrimental to the operation of the sewer system and the POTW.

There are many types of industrial wastes which are discharged to the sewerage system. Some of these wastes pass through the

system or contaminate sludges, thus causing harm to the environment and others affect the transport system and treatment works. The investigator needs to be aware of these wastes and their possible sources. A listing of the kinds of pertinent questions that an inspector might ask during the interviews at a particular industry are given in another handout.

The primary objectives of industrial investigations are:

1. To verify information obtained through the industrial waste discharge permit application.
2. To gain complete information of the industry's operations including a determination of processes, products, raw material, and wastewater discharges.
3. To insure that the master list of industries from the survey is up to date through visually locating and confirming any missing facilities.
4. To talk to industrial officials, inform them of the pretreatment program, answer their questions, and generally establish a framework for mutual cooperation to meet the program objectives.
5. To locate or begin the process of locating an appropriate sampling point for both industry self-monitoring and POTW monitoring activities.

Industrial investigations may be divided into two types, 1) initial investigations of new industries and 2) follow-up investigations of existing industries. Each type has its own procedures as described in the following sections.

#### Initial Investigations

Introduction:

Appointments might be appropriate for some major industries so that industry has an opportunity to prepare for the inspection.

Upon entering an industry the investigators should identify themselves and present business cards or other identification. They should explain the purpose of their visit and the necessity for compliance with the POTW regulations and ordinance requirements. Ask for their assistance and cooperation up front.

An interview should then be requested with the plant manager, production manager, or equivalent person in authority. If necessary, the manager can then contact additional personnel who have a more thorough knowledge of the workings of the plant to answer specific questions of the investigators. Maintain a businesslike and professional approach at all times. The investigator is dealing with important matters affecting the manager's company and therefore, the investigator should value his own time as well as the manager's.

#### Interview

After giving a brief explanation of the industrial waste control program the investigators should obtain a verbal description of the plant facilities and processes to gather as much information as possible pertaining to industrial waste or waste potential. Questions should be asked based on data required to complete the permit application, including: number of employees, operating hours, raw materials, and products. A business card obtained from the contact will aid in obtaining the industry's correct name, address and phone number. Establish who will be the official industry contact person.

Other useful questions concern:

1. Water usage. If available, water usage figures should be discussed with the industry. The investigator should explain that the approach to determining the waste discharge flows will be to account for all the water used or consumed. It is also useful to get the name and address of the landlord, particularly if the landlord provides water and sewer services. Pump hours may be required if wells provide all of the IU's water.
2. Chemicals stored on hand which are not part of the plant waste stream, but which might cause harm to the sewer system if discharged, should be listed. Examples are solvents, paints, acids, fuels, oils and biocides. In connection with the waste sources the location and type of floor drains in the facility should be noted.
3. The type of pretreatment system, if any: Included in pretreatment systems are precautionary devices, settling pits, and conventional chemical treatment of wastes, as well as oil and grease traps.
4. Cooling water: Whenever possible it should be determined both in the initial interview and in the plant tour whether these sources are contaminated, volumes, and whether discharge is to sanitary sewers or to other drainage systems.
5. Boiler and cooling tower maintenance: Included should be questions about treatment additives, particularly with reference to algicides (which may contain chromates). The frequency of blowdown should be determined, as well as the nature of any substances which may contaminate this blowdown. It should also be determined whether or not boiler and cooling tower blowdown is discharged to the sanitary sewer.
6. The name, type and location of any waste disposal service (scavenger) employed: Included are those which handle waste oil, solvents, sludges, or spoiled batches of products. In the event that an unlicensed hauler or disposal site is used for a hazardous waste, the investigator may

wish to point out that the firm has liability for the improper disposal of that waste.

If there are two inspectors, the report form should be completed by one of the investigators while the other takes freehand notes. These will be compared later for consistency and completeness.

Occasionally difficulties will arise with industries where process information is proprietary. In these cases it is important to reassure the contact that the interest of the City is in waste flows and in possible hazardous materials stored on hand. Details of process machinery or of proportions of product constituents used are not normally essential. Only experience can dictate how much of such process information is important to the investigation.

In the event of an uncooperative industry where investigators are refused admittance the inspecting team should attempt to set-up an appointment at a later date. If the investigators are still refused entrance they should point out to the plant manager the proper code section of the City's rules and regulations, which allows the City or its representatives to enter. If this action fails, the next course of action will be determined by the Supervisor of the Investigation and Sampling group, based on the investigative report which should indicate the plant manager's degree of cooperation (or lack thereof) and the reasons given for his failure to admit inspectors. During the course of the interview tact and mutual consideration are of the utmost importance. By these means good public relations are enhanced and often the complexities of later legal actions may be avoided.

Plant Tour: After the initial interview a tour of the plant facilities should be taken to offer an opportunity for visual examination of the facility. A tour should always be taken. No interview, no matter how complete it may seem, is a substitute for an actual visualization of the waste generating processes involved. It may be discovered that waste sources have been overlooked simply because plant personnel consider them extremely minor. Some waste sources may simply not be recalled by plant personnel until they are seen when touring the operation. The tour gives an opportunity both to flush out details and to reaffirm answers given earlier to significant questions asked in the interview.

There are several kinds of information to be gathered. Whenever possible, particularly for a large industry with high waste flows, investigators should come prepared to know something of what wastes might be generated. There are various sources of literature which may be used and the experiences of other investigators with similar industries should not be overlooked.

Some of the types of information to be gathered during plant tours are described below:

1. Wastewater Flows: All visible wastewater flows should be estimated, preferably by plant personnel familiar with these flows. When flows are from pipes, plant personnel should be asked for the duration of flow and to estimate how much wastewater is discharged. Pipe diameter should be noted as well as how full the pipe is. If the waste stream is uncontaminated water from air conditioners, reactor vessels, or air compressors, the size of the unit cooled should be noted. As emphasized in the initial interview the discharge of these flows, whether to storm drains, sanitary sewer, or dry wells should be determined. All recirculating systems should be described. Occasionally the industry will have a metered waste flow. Readings for a representative period of time should be recorded as well as any monitored waste parameters such as pH.

An attempt should be made to account for all water

uses and losses such as evaporation, loss to product, and washwater for the plant.

2. Containers and Vessels: The size and shape of all vessels containing liquids should be noted. The proximity of floor drains and type of liquid stored should also be noted. If the vessels or containers are cleaned, the amount of discharge at the time of cleaning, the frequency of cleaning, and the methods of cleaning are all important. If vessels are not cleaned, this fact should be noted as well as reasons why cleaning is not necessary.
3. Batch Discharges: Reactors, plating tanks, and many types of process tanks often contain chemicals which may be periodically discharged. Metal cleaning solutions are a prime example. The amounts, chemical nature, brand name and frequency of discharge are all of major importance. If pretreatment of these solutions is practiced (neutralization, etc.) this fact should be noted as well as the method used to determine that the waste has been pretreated to acceptable levels. How these solutions are fed into the waste stream, whether gradually or all at once, is significant. If the plant's products are of liquid nature, spoiled batches may be either discharged or sent out: note disposal service employed. General plant wash-down, its frequency and quantity, is also of concern; in many plants the washdown is the largest and/or most significant discharge.
4. Air Pollution Control Equipment: Equipment installed in the plant for air pollution control may use water. In some plants, the effluent from air scrubbing may be the principal waste source and may contain a wide variety of process chemicals which are not encountered in any other waste stream. Booths for spray painting sometimes use a "water curtain" for fume control. Any such devices encountered should be described as well as any substances which are likely to be found in the water discharged from them.
5. Sludges: Many plant processes such as cleaning, degreasing, grinding, or chemical pretreatment, produce sludges which must be disposed. How this occurs, how often, and the quantities involved are all important. As in the case with batch discharges, any waste disposal service used should be recorded. Sludges which are put in the dumpster should be described.
6. Vapor Degreasers: Vapor degreasers are used for cleaning metal in a wide variety of industrial applications. They almost always produce sludges and solvent waste, and are often water cooled, producing a steady stream of uncontaminated cooling water. The presence of these devices should always be noted as well as appropriate answers to questions concerning the wastes associated with them.
7. Pretreatment Systems: If the plant employs pretreatment of any kind the process should be described in detail as well as the final disposal of any removed constituents and sludges. When oil and grease traps are present their frequency of cleanout and the name and location of the firm employed to clean them should be recorded. If stone chip neutralizing units are used, the maintenance frequency should be noted. Any details pertaining to chemical pretreatment systems such as analytical data, discharge pH, and methods of sludge disposal should be carefully gathered.
8. Storage Areas: All liquid storage areas should be examined. Hazardous chemicals encountered should be listed. Any floor drains should be noted. If chemicals stored are

unknown, the brand name, use, and chemical supplier should be noted. The supplier's address should be noted in case it becomes necessary to seek data from that source.

9. Industries which are not connected: Concerns of the investigator when inspecting an industry which is not connected to the sewer system include: 1) The possibility of connecting in the future and 2) the name of the firm that maintains that septic system. Along these same lines, if the industry requires the cleaning of a gas/oil separator or a sludge pit e.g. laundry settling pits, the name and location of the firm performing this task should be noted.
  10. Sampling Points: For industries with nondomestic waste flows, the investigators should determine sampling points during the plant tour including the location of the industry's control manhole(s) required by the City's rules and regulations. Ideally these points would be at the end of process streams and before any dilution with uncontaminated water or domestic waste occurs. The sampling point(s) should then be noted for the future use of sampling personnel. If the industry itself has taken samples of wastewater for analysis, the location of the points where samples were taken should be recorded as well as relevant data concerning flows which might contribute to dilution. If analysis of plant wastewater have been performed by the industry, results of such analysis should be obtained wherever possible.
  11. Investigators must become very familiar with the City's rules and regulations in order to be able to recognize violations. When direct violations of City regulations are encountered, the investigators should point out that such violations MAY exist. Reference should be made to the appropriate authority and the industry advised of sources of further information. Common violations encountered which can be readily detected include caustic and acid discharges, excessive oil and greases being dumped, high coloration and dumping of viscous substance or solids into the sewers.
- Closing Interview: After the plant tour the contact should be given a copy of City rules and regulations and a permit application with instruction sheet. It should be pointed out that all copies of the permit application are to be sent to the City. Point out that Instructions for the completion of each page of the permit are on the backs of each part. The appropriate telephone number for further information should also be given.
- If deemed necessary, a list of licensed waste disposal services may also be left. This list shows firms which are licensed to transport and dispose of various hazardous wastes. Since the industry generating these wastes retains liability for their disposal, this list is often useful.
- At times it is helpful to go over parts of the form with the person or persons who will be filling it out in order to simplify the work of the contact and to clear any confusion which might exist. This is done as a courtesy and often avoids difficulties which can arise from a misunderstanding of the information required. After the industry has been investigated but prior to visiting another industry, the investigators should compare notes to insure that no pertinent facts have been omitted.

Detailed reports on new industries are to be written by investigators upon return to the office in accordance with established POTW procedures.

## FOLLOW-UP INVESTIGATIONS

In addition to new industries, specific industries are often targeted in advance for reinvestigation. When possible, follow-ups are made on a community by community basis along with new investigations; however, there will be times when these investigations must be performed throughout the metropolitan sewer system as a direct result of a pressing need or a particular problem relating to a particular industry. For the most part these inspections serve to (1) update files, (2) determine the level of compliance with permit conditions, and rules and regulations, (3) to effect changes in permit conditions and as status reports at the time of permit renewal, (4) to carry out studies prior to sampling to determine the best location for samples and the types of samples to be taken, and (5) to alleviate specific problems such as illegal discharges to the sewer system. Information concerning these industries will be present in the City's file system as an ongoing part of the Industrial Waste Program.

Data Collection: It is advisable that investigators familiarize themselves with all materials in the files concerning the industry to be inspected on a follow-up investigation. Investigators should study these materials and if necessary discuss the situation with others who were previously involved with the industry. A thorough familiarity will save much time and confusion in the field and in the office later.

The introduction, interview, and tour for a follow-up inspection will be similar to those procedures used with a new industry only of a more limited scope as dictated by the particular information sought. Cooperation between the industry, the municipality, and the City should be stressed at all times before, during, and after the inspection.

Reports for follow-up investigations are written in a manner similar to those for initial investigations. On the whole they are simply more specific in light of information which may already exist in City files.

## FIELD LOG OF INDUSTRIES INVESTIGATED

During the course of industrial investigations it is recommended that a log be kept which summarizes: new industries investigated, follow-up investigations of existing industries including the nature of the investigation, and a notation of any possible violations of City rules and regulations.

## INDUSTRIAL INVESTIGATION REPORTS

Purpose: After the investigator(s) return to the office, the field notes will be used as the basis for writing an investigative report. This is one of the most crucial points of the whole investigative procedure, and is often the greatest source of problems. The necessity of writing a clear and concise report in order to provide pertinent information as a basis for future decisions cannot be stressed enough. Information should be in a neat, organized manner. Scattered thoughts, fragmented sentences, bad grammar, and spelling mistakes erode the credibility of the report. Keep in mind that the investigative report will be a permanent record on

the industry and may be reviewed several times for purposes of determining compliance requirements, permit conditions, monitoring and sampling requirements, and even litigation if necessary. The report should therefore be factual and contain a minimum of subjective opinion concerning the industry's representatives, employees, processes, or facilities.

Instructions for Filling Out Reports: All blanks on the report form are to be completed for each facility investigated. If the required information cannot be obtained, an explanation should be provided in the blank or in the comment section. The data recorded must be as accurate as possible as it provides most of the basic information known about the industry including the correct address and contacts for future correspondence.

The actual filling out of a report will depend on the form used by each POTW. Each POTW will need to develop its own form to best incorporate those questions most appropriate to their unique situation.

A space should be provided for reviewer's comments: This space is for comments by reviewers of the report. Investigator's comments should be in the body of the report.

On any additional report sheets all data gathered during the plant tour should be organized and clearly presented. Included should be the following:

- (a) What are the company's basic operations;
- (b) A brief process description of all chemicals used and which of these are or could be discharged as well as all water used and what contaminants are in the wastewater discharged; in addition, the investigator should indicate volumes and frequency of batch discharges, flow and duration of continuous discharges, and type of sewer the wastes are discharged to;
- (c) Any diagrams important in clarifying processes, pretreatment systems or plant layout should be included in the investigative report. These diagrams should be drawn and labeled on a report sheet designed for this purpose;
- (d) A summary of the wastes which are discharged to the sewerage system and a list of the possible prohibited pollutants requiring analysis. Any other actions which may be required should also be described. If violations of City rules and regulations are encountered these should be listed. If it is felt that a letter to the industry is required the possible contents of this letter should be given;
- (e) The signature of the author of the report and the date the report was written.

Finally, the investigator should proof-read the report for correct grammar, spelling, organization and most of all content as if he were the reviewer and had to decide what action is to be taken. Keeping this in mind while proof-reading will save the reviewer of the report unnecessary speculation and aggravation.

The proof-read reports should then be reviewed by the other investigator(s) present during the inspection. Any additions or corrections should be made at the end of the report along with the reviewer's initials and date review.

## CHAPTER VII SAMPLING

### Sampling Techniques

Accurate flow measurement and sampling techniques are of prime importance in obtaining valid monitoring information. Techniques must be utilized which are appropriate to the type of limit established and pollutant parameters being monitored. Different types of samples yield differing levels of information. Certain pollutant parameters demand a specific sample type to accurately monitor their presence (e.g. pH, volatile organics and oil/grease require grab samples). Some parameters require that averages of samples be taken (e.g. electroplater regulations call for four-day averages). Each sampling program will utilize those techniques which are appropriate to the pollutant parameters of concern and the definition of a violation of discharge limits as established in the local ordinance. Three types of samples may be utilized:

A GRAB SAMPLE is a single volume of wastewater obtained from a single source at one point in time. It is sufficient to confirm or deny the presence and concentration of pollutants in the wastewater characteristics when the flow or concentration varies with time. Grab samples collected at specific intervals are useful for observing wastewater variability over time.

A TIME COMPOSITE SAMPLE is a sequential collection of equal volume grab samples obtained from a single source at specified time intervals and combined in a single reservoir. This type of sample can give an evaluation of the average wastewater composition over the collection time. It does not provide any measure of the total pounds of pollutant discharged, since pollutant loading is a flow related value.

A FLOW-PROPORTIONAL COMPOSITE SAMPLE is one made up of samples collected in increments with individual sample volumes determined in proportion to the measured flow at the time each sample is taken, or samples taken at given cumulative flow increments. This type of sample, when analyzed and compared to total flow, provides the most accurate measure of wastewater quality and pollutant loading.

### SAMPLE PRESERVATION OF WATER AND WASTEWATER SAMPLES

Parameter	Preservative	Holding Period
Alkalinity	Refrigeration at 4°C	24 hours
BOD	Refrigeration at 4°C	6 hours
Calcium	None required	7 days
COD	2 ml H <sub>2</sub> SO <sub>4</sub> per liter	7 days
Chloride	None required	7 days
Color	Refrigeration at 4°C	24 hours
Cyanide	NaOH to pH 10	24 hours
Dissolved Oxygen	Determine on site	No holding
Fluoride	None required	7 days
Hardness	None required	7 days
Metals, Total	5 ml HNO <sub>3</sub> per liter	6 months
Metals, Dissolved	3 ml 1:1 HNO <sub>3</sub> /1 filtrate	6 months
Ammonia	H <sub>2</sub> SO <sub>4</sub> to pH 2; @ 4°C	7 days
Organic Nitrogen	H <sub>2</sub> SO <sub>4</sub> to pH 2; @ 4°C	Unstable
NO <sub>3</sub> , NO <sub>2</sub>	H <sub>2</sub> SO <sub>4</sub> to pH 2; @ 4°C	7 days

Hexane Extractable Materials	2 ml H <sub>2</sub> SO <sub>4</sub> /l @ 4°C	24 hours
pH	Determine on site	No holding
Phenolics	1.0 g CuSO <sub>4</sub> /l + H <sub>2</sub> PO <sub>4</sub> to pH 4.0 - 4°C	24 hours
Phosphorus	H <sub>2</sub> SO <sub>4</sub> to pH 2; @ 4°C	7 days
Solids	None available	7 days
Specific Conductance	None required	6 days
Sulfate	Refrigeration at 4°C	7 days
Sulfide	2 ml Zn acetate per liter	7 days
Turbidity	None available	7 days

### Instructions for Use of Proper Sample Containers

Sample containers are chosen to minimize changes in the sample after it is taken. The container must resist attack by the sample. It must not absorb constituents of interest nor allow them to escape, and it must not add contamination which will appear in later analyses. Containers must therefore be properly prepared to avoid such contamination. A rigid washing and cleaning procedure is followed to ensure that sample containers are free of contaminants. Suitable containers for sample collection are glass or polyethylene bottles and jars, some of which are rinsed with dilute acid before use.

### Preservation and Storage of Samples

Complete preservation of samples, either domestic sewage, industrial wastes or natural waters, is virtually impossible. Regardless of the nature of the sample, complete stability for every constituent can never be achieved. At best, preservation techniques can only retard the chemical and biological changes that inevitably continue after the sample is removed from the source.

The changes that take place in a sample are either chemical or biological. In the former case, certain changes occur in the chemical structure of the constituents that are a function of physical conditions. Metal cations may precipitate as hydroxides or form complexes with other constituents; cations or anions may change valence states under certain reducing or oxidizing conditions; other constituents may dissolve or volatilize with the passage of time. Metal cations (e.g. iron and lead), may also absorb onto surfaces such as glass, plastic, quartz, etc. Biological changes taking place in a sample may change the state of an element or ion to a different state. Soluble constituents may be converted to organically bound material in cell structures, or cell lysis may result in release of cellular materials into solution. The well known nitrogen and phosphorus cycles are examples of biological influence on sample composition.

Methods of preservation are relatively limited and are intended generally to (1) retard biological action, (2) retard hydrolysis of chemical compounds and complexes, and (3) reduce volatility of constituents.

Preservation methods are generally limited to pH control, chemical addition, and refrigeration. The attached table shows the various collection procedures and preservatives that may be used to retard changes in samples.

### Documentation of Chain of Custody

Chain of custody is necessary for any sample collected and submitted to the laboratory. For routine samples, it is useful to show

routine control of sample flow. Chain of custody is especially important for samples where analytical data will be used for litigation purposes. Samples for litigation purposes are personally delivered to the laboratory by the sample collector, submitted with a chain of custody form, and logged in through a computer by assigning a laboratory identification number. They are then stored by sample evidence technicians in separate locked refrigerators. All samples submitted are properly labeled with the sample number; name of the collector; date, time, and place of collection. All samples are examined by the evidence technician for leakage or any irregularities which should be noted on the form.

### Sample Analysis

A method for accurate, rapid analysis of samples must be provided. Certain parameters, such as pH, require immediate analysis upon sampling, which others have longer holding times. It is essential that analytical results be accurate and reproducible to ensure that monitoring activities will provide the quality of information necessary for a successful pretreatment program, not only from the standpoint of providing a fair assessment of industrial contributors, but also to provide defensible data that may be required for enforcement activities.

Precise and well recognized techniques have been established for the analysis of wastewater. EPA's Guidelines Establishing Test Procedures for Analysis of Pollutants - Proposed Regulations (Dec., 1979) stipulate specific analytic methods that are recommended by EPA. Three analytical handbooks are the basis of these guidelines and each provides a short synopsis of the analytical method for each parameter, information on interfering substances, and step-by-step instructions on how to carry out the analysis:

Manual of Methods for Chemical Analysis of Water & Wastes (EPA)

Standard Methods for the Examination of Water and Wastewater (American Public Health Association)

Annual Book of Standards, Part 32, Water, Atmospheric Analysis, 1975 (American Society for Testing and Materials)

These three publications supply the basic information that a trained lab technician would need to carry out analysis of traditional parameters in connection with monitoring programs.

Priority pollutant analysis, in contrast to the well-established procedures for analysis of traditional pollutant parameters, is a currently developing science. These may require complex analytical procedures involving sophisticated equipment and a high level of expertise. It is likely that only a few priority pollutants will be of importance in a particular category of industrial discharge to a sewer system, for which surrogate parameters may be used instead of difficult and expensive analyses.

For those POTW's with sufficient analytical capabilities for analysis of priority pollutants, reference should be made to the various protocols for analysis:

Sampling and Analysis Procedures for Screening of Industrial Effluents for Priority Pollutants

Analytical Methods for the Verification Phase of the BAT Review

### Quality Assurance

The potential errors encountered during analysis of wastewater samples can have a great impact on the acceptability of monitoring information. Without the aid of independent checks and general

quality control, the lab technician can report erroneous results without being aware that a problem exists.

A quality assurance program must be established to ensure reproducibility of data and its subsequent integrity in enforcement proceedings. EPA's Handbook for Analytical Quality Control in Water and Wastewater Laboratories provides guidance toward sound and reliable techniques and procedures. The EPA Manual of Methods for Chemical Analysis of Water and Wastes also includes information pertinent to laboratory quality control.

Essential parts of any laboratory quality control methodology include:

Periodic calibration of equipment

Periodic checks on shelf life of chemicals used in analysis

Periodic analysis of known samples to test the accuracy of analytical techniques

Replicate analysis by splitting samples with industrial contributors or with independent labs to confirm analytic findings.

### Statistical Approach to Sampling

For every sampling program four factors must be established:

1. Number of samples
2. Sampling frequency
3. Parameters to be measured
4. Location(s) of sampling

These variables are usually established by the discharge permit requirements which may or may not be scientifically sound. When a new program is being initiated or the permit requirements need review, statistical methods and scientific judgement should be used to establish the best procedures.

This chapter explains various statistical terms and techniques and their applications to sampling. Each new concept is introduced with an example to illustrate its use. After the basic terms are defined and illustrated, statistical methods are introduced for analyzing data and determining the above four factors. These methods are also illustrated with examples.

### Basic Statistics and Statistical Relationships

Data representing a physical phenomenon are broadly classified as Continuous, such as temperatures measured constantly and recorded as a continuous curve; Discrete, such as recorded hourly; and as Deterministic, those capable of description by an explicit mathematical relationship or formula; or Non-deterministic, which are random. Due to water quality changes and the complexity of the processes affecting the water or wastewater characteristics, one cannot predict an exact value for a datum at a future instant in time. Such future data are random in character and are conveniently described in terms of probability statements and statistical averages rather than by explicit equations. However, long term changes in water quality tend to have a functional character with random fluctuation components. Statistical evaluation techniques provide a tool with which to detect and qualify both the deterministic and random components of a water or wastewater quality record.

### Statistical Sample Parameters — Definitions and Examples (1)

A wastewater stream is sampled once a week for a period of one year and the concentration of a certain parameter recorded.

**TABLE 4.1  
WASTEWATER PARAMETER DATA**

Week	Concentration (mg/L)	Week	Concentration (mg/L)
1	35.8	27	31.1
2	33.0	28	33.6
3	33.6	29	28.9
4	35.0	30	35.6
5	33.5	31	32.9
6	34.7	32	31.8
7	33.6	33	37.4
8	36.9	34	32.0
9	38.8	35	34.8
10	35.5	36	31.7
11	32.2	37	32.7
12	32.2	38	36.0
13	33.3	39	34.2
14	33.5	40	30.3
15	33.0	41	39.6
16	33.1	42	34.6
17	33.5	43	31.7
18	31.9	44	30.3
19	31.7	45	34.4
20	32.4	46	32.4
21	34.8	47	31.1
22	33.5	48	36.5
23	33.9	49	33.2
24	32.0	50	34.3
25	34.2	51	35.8
26	33.4	52	32.4

**TABLE 4.2  
WASTEWATER PARAMETER DATA IN DECREASING NUMERICAL ORDER**

Observation Number	Concentration (mg/L)	Observation Number	Concentration (mg/L)
1	39.6	27	33.5
2	38.8	28	33.4
3	37.4	29	33.3
4	36.9	30	33.2
5	36.5	31	33.1
6	36.0	32	33.0
7	35.8	33	33.0
8	35.8	34	32.9
9	35.6	35	32.7
10	35.5	36	32.4
11	35.0	37	32.4
12	34.8	38	32.4
13	34.8	39	32.2
14	34.7	40	32.2
15	34.6	41	32.0
16	34.4	42	32.0
17	34.3	43	31.9
18	34.2	44	31.8
19	34.2	45	31.7
20	33.9	46	31.7
21	33.6	47	31.7
22	33.6	48	31.1
23	33.6	49	31.1
24	33.5	50	30.3
25	33.5	51	30.3
26	33.5	52	28.9

These data do not give much information as presented, so certain calculations are performed to give more meaning. Two things providing useful information about a set of data are: measures of central tendency, such as arithmetic mean and median; and measures of deviation, such as range, variance and standard deviation.

**4.1.1.1. The Arithmetic Mean**

The arithmetic mean or simply the mean is used to locate the "center" of a data set. It is defined to be the sum of all the observations divided by the number of observations (N):

$$\bar{X} = \frac{\sum_{i=1}^N X}{N}$$

where:  $X_i$  are the observations, with  $i$  ranging from 1 to  $N$

$N$  is the number of observations

$$\sum_{i=1}^N$$

is the operator "sum" of all values of the variable following it (in this case  $X_i$ ) as  $i$  covers the integers from 1 to  $N$ .

$$\sum_{i=1}^N X_i = X_1 + X_2 + X_3 + \dots + X_N$$

In the above example (from Table 4.1),  $X_1 = 35.8$ ,  $X_2 = 33.0$ , ...,  $X_N = X_{52} = 32.4$ ;

$$\sum_{i=1}^N X_i = 35.8 + 33.0 + 33.6 + \dots + 35.8 + 32.4 = 1748.3;$$

and so the mean which is denoted  $\bar{X}$  (read "X-bar"), is:

$$\bar{X} = \frac{\sum_{i=1}^N X_i}{N} = \frac{1748.3}{52} = 33.6 \text{ mg/L}$$

The mean can be greatly affected by extreme values. If in Table 4.2 the first observation is replaced by 396.0 the mean becomes:

$$\bar{X} = \frac{396.0 + 38.8 + 37.4 + \dots + 28.9}{52} = \frac{2104.7}{52} = 40.5 \text{ mg/L}$$

which is considerably greater than former value of 33.6.

The mean is the most often used measure of the "center" of a data set.

**4.1.1.2 The Median**

The median of a set of data is the observation in the middle, that is, the number that is located such that half of the observations are less than it and half are greater. To find the median of set of observations, arrange the data in numerical order as in Table 4.2.

If  $N$  is the number of observations in the ordered data set (in this case,  $N$ , is 52), then the median is defined to be the mean of the  $\frac{N}{2}$ <sup>th</sup> and  $\frac{N}{2} + 1$ <sup>st</sup> observations if  $N$  is even (between the 26th and 27th here, which would be 33.5) or the  $N + 1 \div 2$ <sup>th</sup> observation if  $N$  is odd (that is with 15 ordered observations, the median is the 8th value).

The median is a good measure of the location of the center of a set of data because it is unaffected by extreme values, since if the largest observation were 396.0 instead of 39.6, the median would still be 33.5. Unfortunately, it does not make use of all the information contained in the data, but rather uses only the relative sizes of the observations.

**4.1.1.3 The Range**

In addition to knowing where the "center" of a data set is, it is useful to know how spread out the data set is. One indicator of the spread of a data set is the range, which is defined as the difference between the largest and the smallest values in the set. For example, in Table 4.2, the largest is 39.6 (#1) and the smallest is 28.9 (#52) and so the range is  $R = 39.6 - 28.9 = 10.7$ .

Like the median, the range is simple to compute, once the data are arranged in decreasing or increasing order, but does not use all the information in the data.

**4.1.1.4 The Variance**

The variance, which is the average of the squares of the deviations of the data from the mean, is another indicator of how spread out the observations are. To find the variance, subtract the mean from each observation, square each of these differences, sum the squared terms, then divide the sum by one less than the number of observations, or in symbols:

$$S_X^2 = \frac{\sum_{i=1}^N (X_i - \bar{X})^2}{N - 1}$$

Table 4.3 shows how this is done:  $i$  is the week and  $X_i$  is the corresponding concentration.

$$\begin{aligned} \sum_{i=1}^{52} (X_i - \bar{X})^2 &= \sum_{i=1}^{52} (X_i - 33.6)^2 \\ &= 218.11 \text{ (mg/L)}^2 \\ \text{Variance} = S_X^2 &= \frac{\sum_{i=1}^N (X_i - \bar{X})^2}{N - 1} = \frac{\sum_{i=1}^{52} (X_i - 33.6)^2}{51} \\ &= \frac{218.11}{51} = 4.28 \text{ (mg/L)}^2 \end{aligned}$$

There is another formula for computing  $S_X^2$  which will be given here without an example:

$$S_X^2 = \frac{\sum_{i=1}^N (X_i^2) - N(\bar{X}^2)}{N - 1}$$

This formula says to square each observation and sum the squares. Then multiply the square of the mean (found earlier) by the number of observations ( $N$ ), subtract this from the sum of squares just computed, then divide by  $N-1$ . This formula involves fewer steps since there is only one subtraction, as opposed to  $N$  subtractions using the other method, and less time since there is just one pass through the data.

**4.1.1.5 The Standard Deviation**

The units of the variance are the square of the units of the mean and of the original data. That is, if the data are expressed in mg/L, the variance is in  $\text{mg}^2/\text{L}^2$ . Because of this, the standard deviation, which is the square root of the variance, is more commonly used as a measure of dispersion. In our example, the variance,  $S_X^2$ , is 4.28, and so the standard deviation is:

$$S_X = \sqrt{S_X^2} = \sqrt{4.28} = 2.07 \text{ mg/L}$$

since the data are expressed as mg/L, the standard deviation is also in mg/L. The mean ( $\bar{X}$ ) and standard deviation ( $S_X$ ) are actually only estimates of parameters known as the population mean ( $\mu_X$ ) and population standard deviation ( $\sigma_X$ ).

An interesting and useful fact about these two numbers is that in a normally distributed population (which is discussed later and is a phenomenon which occurs quite frequently), 68.3% of the observations will fall within  $\mu_X \pm \sigma_X$ , 95.5% will be found within  $\mu_X \pm 2\sigma_X$ , and 99.7% within  $\mu_X \pm 3\sigma_X$ .

Since  $\bar{X}$  approximates  $\mu_X$  and  $S_X$  approximates  $\sigma_X$ , these percentages will hold approximately for  $\bar{X} \pm S_X$ ,  $\bar{X} \pm 2S_X$  and  $\bar{X} \pm 3S_X$ .

## CHAPTER VIII FLOW MEASUREMENT

Flow measurements taken during the course of sampling serve to relate the concentrations of waste constituents to the total output of the industry. The application of some regulatory requirements for some EPA categorical dischargers is based on total flow. In addition, by coupling concentrations with flow measurements it is possible to calculate how many pounds or kilograms of a constituent are contributed to the sewerage system by an industry.

Flow measurements are also necessary when discrete samples are composited proportional to flow. As previously discussed, two variations of composite sampling based on flow are commonly used. Discrete sample portions of equal volume are collected at time intervals proportional to flow rate; or if the collection intervals are equal, then the sample volumes vary proportionally with flow.

Flow measurements are the basis of many user charge systems. They are also a basic consideration in the design of treatment facilities.

### TYPES OF FLOW

There are two basic types of flow: flow in open channels or partially filled pipes, and flow in closed conduits. The most frequently encountered flow in wastewater measurement is flow in open channels. There are cases, however, when the flow within the piping of a plant must be measured; for example, with the monitoring of individual processes or pieces of equipment.

Flow in open channels may be either constant (steady flow) or variable (unsteady flow). Flow is said to be uniform if the velocity and depth are constant along the conduit and non-uniform if velocity or depth, or both, vary along the conduit. Flow measuring devices should always be installed at locations where the flow is uniform.

### FLOW MEASUREMENT SYSTEMS

All systems used to measure constant flows consist of three parts: (1) a primary flow device, (2) a flow sensing apparatus, and (3) a recording mechanism.

A primary flow device is a mechanism or a structure which induces the flow to eliminate certain terms of the energy equation so that the flow rate can be calculated from easily attainable parameters. Usually the device is based on some proportional relationship between the flow and elevation head (depth), pressure head, or an induced electric current. Of the primary devices discussed in this manual, weirs and flumes relate depth to flow. Venturi meters and orifice meters relate pressure to flow and electromagnetic flowmeters relate an induced voltage to flow.

The flow sensing apparatus provides a means for measuring the responses of the primary device to the flow. Sensing devices essentially measure depth, pressure, or electric current changes which result from the primary flow device and transmit them to a recording mechanism.

The recording mechanism may be as simple as a counter or as complex as an automatic graphing system. The responses of the primary flow device are recorded in such a manner that they may be effectively interpreted by monitoring personnel. Recording devices may either record individual flow events or may be arranged so that they keep running totals of the flow over a period of time.

### FLOW MEASUREMENT IN OPEN CHANNELS

Flows in open channels are measured primarily by using weirs and flumes which relate depth to total flow. If the channel is large or uniform, flow may be measured by the velocity-area method. This involves using a current meter and calculating the channel cross sectional areas at various points. Still another method involves the use of dyes or tracing chemicals. This method, however, requires considerable skill and exact measurement techniques and it is not commonly used for wastewater.

#### Weirs

A weir is an obstruction built across an open channel or pipe and over which water is allowed to flow. The crest of the weir is the upper edge of the weir to which water must rise before passing over the structure. The depth from the weir crest to the water surface is called the head on the weir; this head is measured at a given distance behind the weir, and is proportional to the flow. Water may flow over the horizontal crest of the weir or it may flow through an opening or a notch. Refer to reference materials for complete profiles of the weirs described here.

Weirs may be broad crested or sharp crested. Broad crested weirs are normally permanent overflow structures and are usually not used for flow measurement. Sharp crested weirs derive their name from the thin or beveled crest employed. In crossing a sharp crested weir the water does not contact any part of the downstream edge but rather springs past it. This stream of water passing over the crest is known as the nappe. The depth,  $H$ , in the weir profile following, represents the head which must be measured in order to determine flow rate. The minimum head should always be about 0.2 foot to prevent water from clinging to the crest or to the face of the weir.

#### Types of Weirs

There are three common types of sharp crested weirs: rectangular weirs, Cipolletti weirs, and V-notch weirs.

**Rectangular Weirs** — Rectangular weirs may have end contractions or they may be without end contractions and extend completely across the channel. A notched weir is said to have "end contractions" which result from the path of flow. This is due to a slide contraction from the nappe flowing over the weir crest. A rectangular weir without end contractions is called a suppressed weir.

**Cipolletti Weirs** — Cipolletti weirs are trapezoidal, with end slopes of one horizontal to four vertical. The shape of the Cipolletti weir eliminates the need for corrections for end contractions when mathematical formulas are used to calculate flows.

Both rectangular weirs and Cipolletti weirs are used primarily to measure larger flows. This is due to the requirement that the head on the weir be at least 0.2 foot. With the fairly long crests of these weirs, small flows simply cannot be measured accurately. For small flows the V-notch or triangular weir is a better choice.

**V-notch Weirs** — V-notch weirs are essentially plates that contain a V-shaped notch. The notch angle may be 22 1/2, 45, 60 or 90

degrees, with 60 and 90 degree angles being the most common. The flows measured are usually less than 1 cubic foot per second (450 gpm) and should never exceed 2 cubic feet per second. Because of their ability to handle small flows, V-notch weirs are the most common type of weir used in wastewater measurement.

**Other weirs** — There are a number of other weirs available which give good results. One is a special type known as a combination weir. It consists of a small 90 degree V-notch below a rectangular weir with end contractions. The idea behind this design is that for low flows the V-notch can most accurately measure the flow, whereas for larger flow rates the rectangular section, because of its greater capacity, can more accurately gauge the flow. These weirs work quite well in wastewater measurement except when the flow rate is such that it crests the weir at the transition zone between the V-notch and the rectangular section. A number of flowmeter manufacturers market electronic components for their meters which are compatible with the combination weir.

#### Flow Calculations

There are a number of formulas based on weir geometry, which are used to calculate the flow over a weir. A great deal of research has been done, however, concerning sharp crested weirs and tables are available which relate weir head measurements to flow. These weir tables are given in Appendix 8 and should be used in calculating flows in the field. It will be noted that there are separate tables for weirs with "end contractions" and for weirs without "end contractions".

#### Advantages and Disadvantages of Weirs

Weirs are the simplest and cheapest device for measuring flow. There are, however, restrictions on their use. For weirs to be used effectively, the minimum distance from the weir crest to the bottom of the downstream channel must be 0.5 foot. This insures that the flow discharges freely through the weir. As previously mentioned, the minimum head on the weir should be 0.2 foot. For Cipolletti and rectangular weirs, the maximum head should be about one-half the crest length because of poorly defined head-to-flow relationships. Obviously, for a V-notch weir the maximum head should not be higher than the top of the notch. These flow restrictions all define situations where weirs may or may not be used.

Weirs frequently cause problems with settling. Wastewater high in suspended solids tend to deposit solids behind the weir. This means that the area near the weir must be periodically cleaned to obtain accurate measurements. In addition, the loss of solids may affect the collection of a representative sample. Hence samples should be taken as far upstream from the weir as practical or in the turbulent zone immediately downstream of the weir. Sharp weir crests are also subject to damage from corrosion and wear.

#### Weir Design Requirements

The following factors must be considered in design and installation of a weir for measuring wastewater flows:

- The weir should consist either of thin plate about 1/8 to 1/4 inch thick, with a straight edge, or a thicker plate with a knife edge. The height of the weir from the bottom of the channel to the crest should be at least two times the expected head of water above the crest. The upstream velocity of flow should be greater than 0.3 ft/sec before installation.
- Weirs sometimes must be ventilated to prevent a vacuum on the underside of the falling water. This is usually done with plastic tubing or, if the weir is enclosed in a box, by installing vents just below the crest.

- When using temporary weirs, the connection of the weir to the channel should be waterproof. Hydraulic or water stop cement has been found to work extremely well. Not only does it seal the weir in the channel but also it adds considerable strength to the installation. A good method for sealing leaks is to apply a plastic mass of Bentonite clay. Because of its microstructure, Bentonite swells excessively on contact with water, thus sealing any leaks. Grease should not be used if oil and grease concentrations will be tested in samples taken near the weir.
- The weir should be exactly level to insure uniform depth of flow.
- The weir crest must be kept clean. When a weir is used in a wastewater that is high in solids, the channel must be kept clear.
- The weir should be located at the end of a straight stretch (at least 20 times the maximum head on the weir) of the sewer with little or no slope.
- The device used to measure the head should be placed upstream at a distance of at least 4 times the maximum head on the weir and should be located in a quiet section of the sewer, away from all disturbances. This avoids the drawdown area created by the nappe.
- If the sewer is flowing full, other methods should be used to calculate flow.

#### Weir Installation Procedures

Under the right circumstances a weir that fits into the exit pipe of the manhole should be used. This allows for a good quality sample because less water is pooled behind the weir and the head loss is low. There are a few restrictions that preclude this type of weir installation. If the channel or pipe is flowing about 3/4 full, the restriction caused by the placement of the weir will quite likely cause water to flow over the top of the weir, that is, exceed the measuring capacity of the weir. In this event either a larger weir (usually a 90 degree V-notch) that spans the manhole or flume must be used. Another limiting factor for in-pipe weir installation is the wastewater velocity as it approaches the weir. The purpose of a weir is to reduce the velocity head of the energy equation to the point where it plays no significant part in the calculation. If after installation of a weir location in the manhole exit pipe, the velocity is high enough to cause turbulent flow, then the degree of error in the measurement will be too high and an alternate method for measurement must be employed. Sometimes, however, the ripples and eddies of turbulent flow can be smoothed out by inducing head loss upstream with baffles.

In small diameter pipes, especially 6 inch and smaller, weirs may clog with paper towels and other stringy matter. This must be avoided since it causes an erroneous head reading by the flowmeter.

In the event that a large weir must be inserted in the manhole, plywood can be used initially and then later used as a template for a more durable weir cut from sheet aluminum. Plywood has the disadvantage that it is difficult to fabricate a beveled edge or "sharp crest" in the field. One method that produces adequate results is to tack strips of sheet metal to the inside face of the roughed-out weir.

Installation of larger weirs which span the manhole can take as long as four hours, and is much more time-consuming than those that fit inside of the outlet pipe. The length of the weir should be determined so that the weir becomes a chord of the downstream half of the circular manhole. When installed in this manner, the hydrostatic force resulting from the pooling of water helps to stabilize the weir. Hydraulic or water stop cement should be grouted around the seam of the weir/manhole interface. By using water stop cement, the weir needn't be a perfect fit as the cement will seal even large gaps. The weir should be grouted into place with-

out disturbing the flow in the invert so that the cement has adequate time to set up before the weir is made operable. After the cement has attained its initial strength, the invert can be closed off by wedging a sandbag into the invert beneath the weir. The sandbag must be positioned so that it seals all leaks. It is essential that the sandbag be tethered to a rung in the manhole so that it cannot be dislodged. The tether also facilitates removal of the bag at the end of the measuring period.

### FLUMES

A flume is an artificial channel or chute constructed across the flow so that the water passes through it. The flow is proportional to the depth of water in the flume and, as in the case with the weir, is calculated by measuring the depth (head). Two common types of flumes are used in wastewater measurement: (1) Parshall flume and (2) the Palmer-Bowlus flume.

**Parshall Flumes** — Find a diagram of a Parshall flume in one of the references. You will see that there are three main parts: a converging section, a throat section, and a diverging section. The elevation of the water should always be measured at  $\frac{2}{3}$  of the length of the converging section. The head is best measured in a stilling well to avoid the effect of sudden changes in flow.

Two conditions of flow can occur through a Parshall flume, free flow and submerged flow. Submerged flow occurs when the water elevations downstream are high enough to reduce flow velocity. This condition is indicated when a ripple or a wave is formed just downstream from the throat.

The flume is usually a permanent installation built of wood, fiberglass, concrete, plastic, or metal and can be installed in any convenient location, such as a manhole, if there is enough room.

**Palmer-Bowlus Flume** — A Palmer-Bowlus flume may be nothing more complex than a level throat section of floor, with trapezoidal sides, placed into a sewer. The simplicity of the Palmer-Bowlus Flume is its principal advantage over the Parshall Flume. The length of the floor should be approximately equal to the conditions (critical flow) downstream from the flume. Depth measurements are taken upstream from the region of this unstable flow.

### Advantages and Disadvantages of Flumes

Flumes are generally more expensive and more difficult to install than weirs, but usually have sufficient velocity to be self-cleaning. Varying upstream approach velocities also affect flumes much less than weirs. Flumes are also less accurate but properly installed will give results within  $\pm 5$  to 10%. To achieve optimum accuracy, depth of flow thru the flume should be maintained between 0.2 and 0.7 times the flume depth. In the case of Parshall flumes, accurate measurements may be obtained even if the flume is submerged. Flumes are particularly useful when measuring large flow rates.

### Flume Installation

- The channel upstream from the flume must be straight so that the approaching flow is evenly distributed across the channel.
- Flow should be free of turbulence so that an accurate depth can be determined by the flowmeter.
- Slope of the approaching channel should not be greater than 5 per cent. Both Palmer-Bowlus and Parshall flumes require subcritical flow prior to entrance to the throat section of the flume. Subcritical flow can be attained only with small slopes.

### Velocity-Area Method of Flow Measurement

The velocity-area method of flow calculation is based on the fundamental hydraulic principle that flow (Q) in a channel is equal to

average velocity (V) multiplied by the area of the cross section of the flow (A).

$$Q = V \times A$$

Flow measurements are taken with current meters as described above. The principal difficulty in using the method is the calculation of the cross sectional areas of the flow.

When the cross section of the channel is irregular, as in the case of a stream, various complex measurements must be made along the length and width of the flow. These are not discussed in this manual since channels of this type are not commonly found in wastewater flow measurement. When the channel is a circular or an elliptical pipe which is not flowing full, the cross sectional area calculations are also complicated.

Wherever the velocity-area method is used, both the flow and the cross section should be measured at several points along the channel to obtain the most representative picture of the flow.

The velocity-area method is primarily used in stream flow. Because calculations are complex and results are approximate, the use of the velocity-area method is limited to situations where simple geometry prevails (rectangles and trapezoids) or where no other method is applicable, as in the case of very large channels.

### FLOW IN PARTIALLY FILLED PIPES

The most common in-plant situation in industrial waste monitoring involves flow by gravity in full or partially filled pipes. For the most part, these flows are measured in the same manner as flows in open channels. Weirs, flumes and similar devices are used for the flow beyond the end of the pipe. There are, however, methods which are especially applicable to flows of this nature.

### Open Flow Nozzles

Open channel flow nozzles are combinations of a flume and a sharp crested weir. These devices are attached to the end of a conduit flowing partially full and must have a free-fall discharge. Open flow nozzles are designed for a predetermined relationship between head and flow. Two common types are the Kennison nozzle and the parabolic nozzle.

### Estimated Flow Methods

There are several methods for estimating flows in partially filled pipes. These methods are not intended to replace the more accurate open channel flow methods described above, but rather to provide measurements whenever they are needed. Initial flow measurements required for the design of primary flow devices, such as weirs and flumes, may be made by using estimation methods as well as routine measurements which do not require the degree of accuracy necessary for enforcement purposes.

### Manning Equation: Calculating velocity in open channels

$$V = \frac{1.486}{n} \times R^{2/3} \times S^{1/2}$$

V = velocity in feet per second

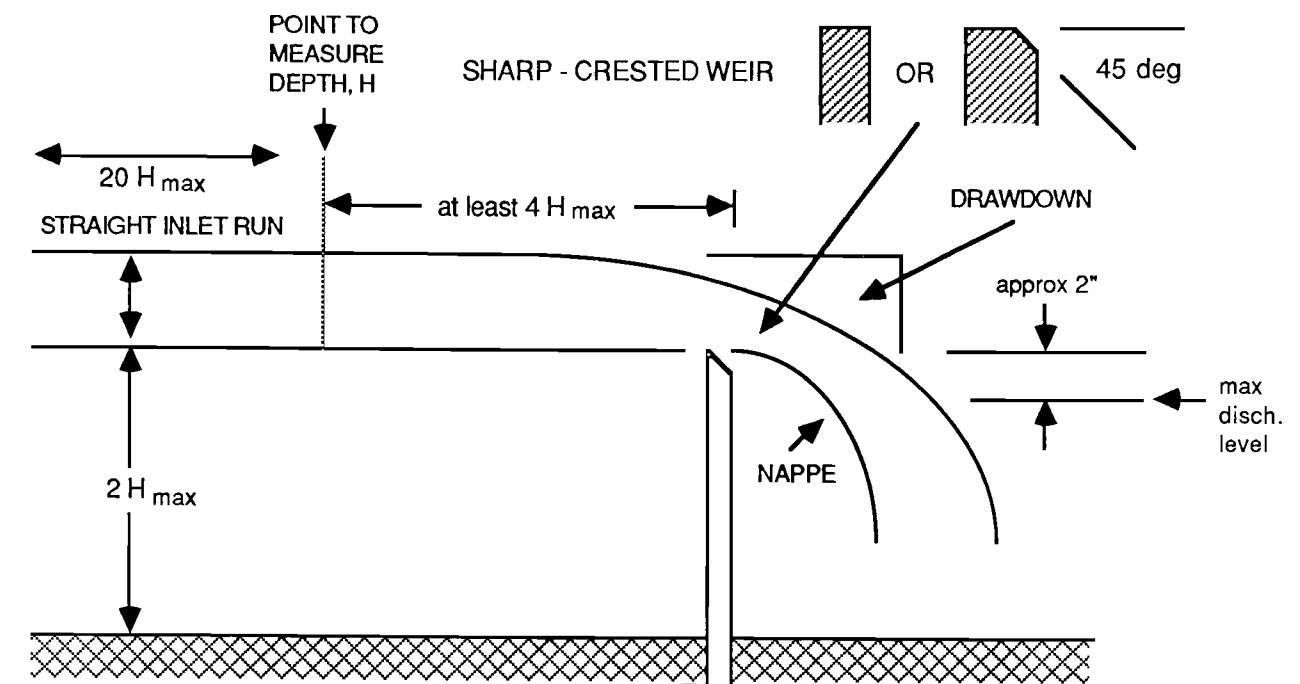
n = coefficient of roughness

R = hydraulic radius (cross sectional area of the liquid/wetted perimeter)

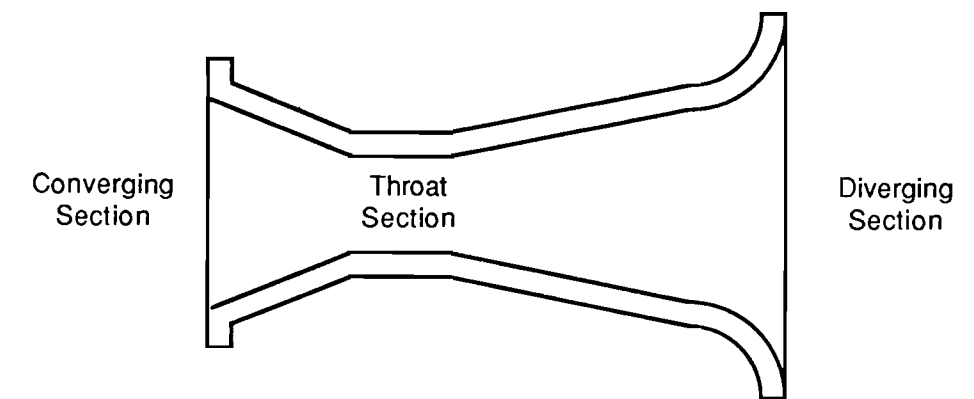
S = slope of energy grade line (feet/feet)

reference: "Wastewater Engineering: Collection and Pumping of Wastewater" Metcalf & Eddy.

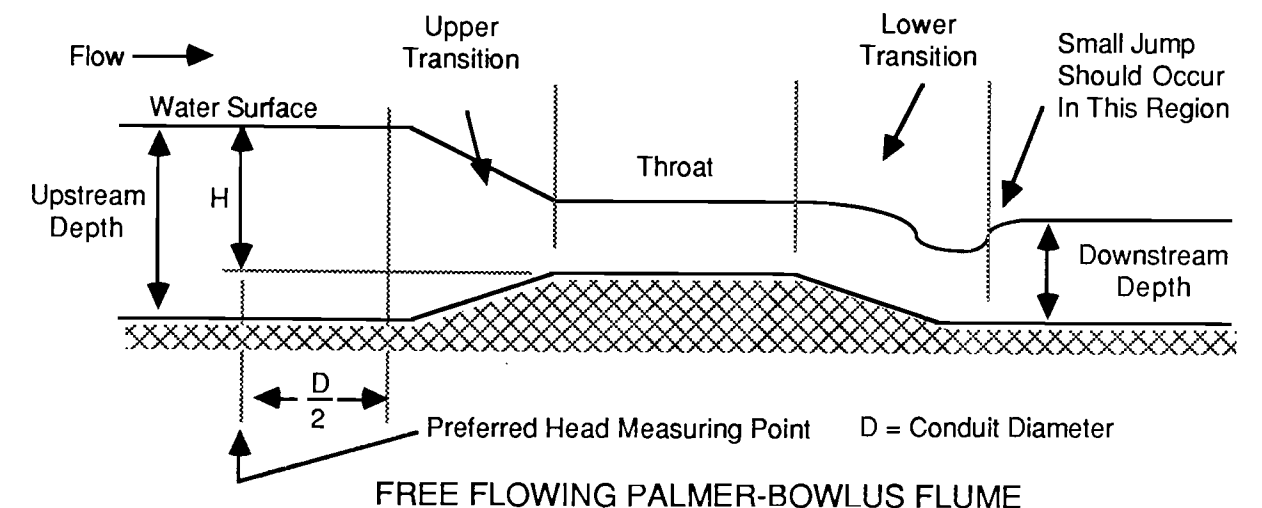
The Manning Equation. If the slope of the channel is known and if the roughness of its surface can be determined, the flow may be calculated by this formula. The method used involves Manning's equation.



PROFILE OF SHARP-CRESTED WEIR



GENERAL FLUME CONFIGURATION



FREE FLOWING PALMER-BOWLUS FLUME

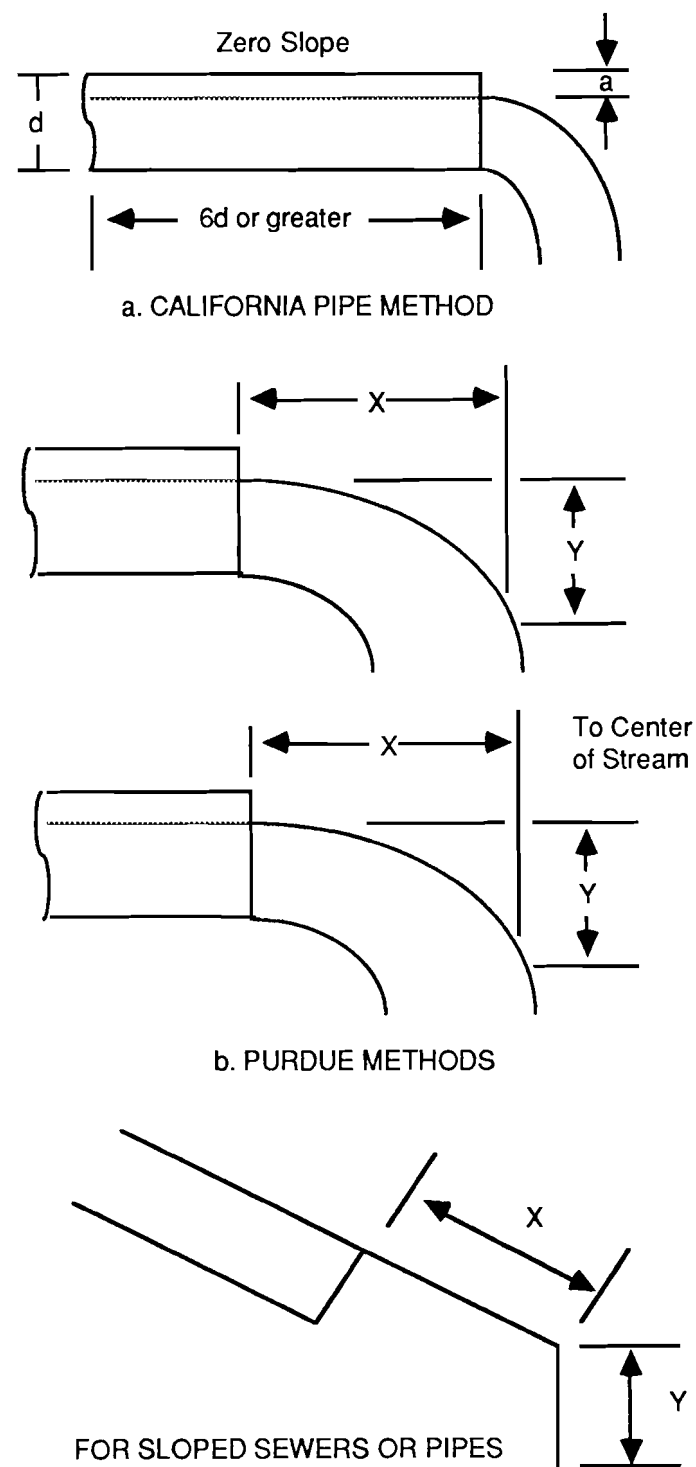


FIGURE 4-8  
TRAJECTORY METHODS

The Manning's formula method may be used with flows in filled or partially filled sewer pipes or in channels. It is an approximation primarily because it is difficult to measure roughness directly, leading to the selection of the roughness factor from an empirical table.

**Trajectory Methods** — Trajectory methods may be used to estimate flow from pipes which are freely discharging into the air. They are based on two measurements of the stream, a horizontal and a vertical, after it has left the pipe.

The California Pipe method is based on the measurements shown on Figure 2. There must be a horizontal section of pipe equal in length to at least six times the diameter of the pipe just before the discharge point. If such a section is not available, one must be added. Only two measurements are required: (1) the diameter and (2) the distance from the top of the sewer to the water surface. The flow may be calculated by using an equation and tables.

The main restriction on the California Pipe method is the required section of horizontal pipe. Such sections are relatively uncommon in sewer outfalls.

The Purdue method, which is shown on Figure 2, does not require a horizontal pipe section. The horizontal measurement is simply taken at the slope of the pipe. The vertical measurement, however, is not at a right angle to this measurement; it is a "true" vertical which is perpendicular to the horizon.

#### FLOW SENSING DEVICES

For the methods of measuring flow which have been discussed in this manual, measuring the output of the primary flow devices is a question of measuring depth. This is true for weirs, flumes, and estimation methods, as well as for velocity-area calculations.

There are five principal methods of measuring depth: staff gauges, floats, bubbler tubes, pressure sensors, and ultrasonic meters.

#### Staff Gauge

The simplest and cheapest method for determining depth is to measure it directly with a staff gauge. Staff gauges are usually porcelain enameled iron scales graduated in hundredths of feet. Zero on the gauge is usually set at the crest of the weir or the floor of the flume. The difficulty in using staff gauges lies in the fact that someone must physically read them. They provide no means of recording variations in depth with time. They are, however, handy reference devices and it is useful to have them installed in order to verify that other equipment is operating properly.

#### Floats

The simplest device which is capable of recording fluctuations in water level is the float. The float may be attached to a recording device so that changes in water level are mechanically translated into graphs. A disadvantage is that floats have a tendency to collect debris which weights the float down, resulting in an erroneous reading.

#### Bubbler Tubes

The bubbler tube is a fairly maintenance-free means of measuring liquid level operating on the principle that a small, constantly regulated air supply, bubbling into a liquid at a slightly higher pressure than the head, will produce a back-pressure directly proportional to the static head. The back-pressure in the bubbler tube actuates a pressure gauge which indicates the water level directly. Because air is constantly bubbling out of the bubbler tube, the system is self-purging. Bubbler tubes may be set at any

depth. It is common, however, to set the tube depth at the height of the crest for weirs to minimize the effects of sediment.

It cannot be overstressed that proper placement of the bubbler tube is extremely important for accurate measurement of the waste flow. Bubbler tubes, because they must protrude into the flow, have a tendency to catch towels and stringy debris. This however, will not affect their accuracy, provided that the tube is adequately anchored. This can be done most effectively by drilling two vertically in-line holes in a lightweight concrete block and attaching clips by expansion anchors. These clips can hold a stainless steel bubbler line without damage.

When installing a large weir that spans the entire manhole, the bubbler line can be installed most accurately with the use of a level, prior to blocking the flow with a sandbag. In this instance the bubbler tube must also be "zeroed" on the flowmeter before it is submerged.

During weir installation, when no flow is present, water can be dumped behind the weir from a bucket. What does not discharge over the crest will form a surface to which the bubbler line can be positioned and the flowmeter adjusted to read zero for this level.

The bubbler tube need not be at the crest of the weir. If flow is steady, a staff gauge can be used to measure the correct head. This number can be dialed into the flowmeter, thus electronically adjusting the "level" of the bubbler tube. Usually it is difficult to get an accurate measurement with a staff gauge due to the variable slope of the channel. It is therefore necessary to use levels so that an accurate measurement can be obtained.

All measurements must be made from a reference plane. For best results, never use the floor of the manhole for the reference plane since it almost always has a slope. A better practice is to choose a horizontal datum plane above the weir and make all measurements down from it.

#### Pressure Sensors

Pressure sensors operate on the principle that changes in water depth will produce changes in pressure on a diaphragm, or sensor, proportional to the depth of flow. Like bubbler tubes, pressure sensors may be set at any convenient depth. The greater the depth, however, the narrower will be the pressure range to which the system is sensitive. In weirs, sediment may also interfere with the accuracy of the measurements. For these reasons, pressure sensors are set near the crest when used with weirs.

#### Ultrasonic Sensing

Pulsed ultrasound sensing is a relatively recent development in flow measuring. Ultrasound waves travel in a straight line until they are either reflected or absorbed by a surface. These ultrasound waves are above the human hearing frequency range. Ultrasound is unaffected by gravity.

A sending unit sends pulsed ultrasound down to the water surface which reflects the waves back to the unit. The longer it takes for the waves to return to the sending unit the lower the flow is.

Ultrasound sensing has the advantage of not actually being in the waste flow itself and therefore is not plagued with solids and plugging problems. Ultrasonic flow measuring has its share of limitations too, however. Floating debris or foam on the wastewater will give false readings, and these systems are affected by high winds.

#### FLOW RECORDING DEVICES

There are essentially two types of flow recording systems: analog systems and digital systems. Analog systems record the variations sensed in a direct visual form. Digital recorders provide the same information in electronic bits, or impulses, and the bits are

then translated into a visual form. Moving graphs, counters, and dials may all be used in both systems to provide readings which may be interpreted by the observer.

#### FLOW MEASUREMENT IN CLOSED CONDUITS

As previously mentioned, flow in open channels or partially filled pipes is the most common type of flow encountered in wastewater measurement. Flow in closed conduits is usually restricted to in-plant piping. Many industries, however, have devices installed on their effluent lines for measuring their own flows. Sampling personnel should thus be familiar with the most common types of closed conduit measuring devices and should know something about their operation. The main disadvantage to such devices is their inaccessibility which makes inspection and maintenance difficult.

#### Venturi Meters

Venturi meters are a common flow measurement device used in closed conduits. The venturi meter consists of a pipe segment which has a converging section, a throat section, and diverging section. By constricting the flow, the meter causes the fluid velocity to increase. The increased velocity in turn causes a drop in pressure. This drop in pressure is proportional to the flow, and thus the flow rate can be calculated by using a formula.

Venturi meters must be installed downstream from a straight, uniform section of pipe at a distance of several pipe diameters. When waste streams are high in solids, provisions should be made to prevent clogging of the pressure measuring taps.

#### Orifice Meters

An orifice meter employs a thin plate with a hole, or orifice, which is used to obstruct flow. The principle is the same as that of the venturi meter. The orifice increases velocity and thus reduces pressure in proportion to the flow.

Orifice meters are among the oldest flow measuring devices. They are cheap, reliable, and relatively easy to install. The disadvantages of orifice meters include settling of solids which may occur behind the plate and the large head losses involved. It is not uncommon to need a section of straight pipe equal to 40 to 60 pipe diameters upstream of the installation to achieve good results. Orifice meters are quite sensitive to upstream disturbances.

#### Flow Nozzles

Flow nozzles are intermediate between venturi meters and orifice meters both in design and in terms of head loss. The principles and the equations used to calculate flows are basically the same as for venturi meters. The major advantage to flow nozzles is that they can be installed between pipe flanges. Like orifice meters, flow nozzles are sensitive to upstream disturbances. They require a length of straight pipe equal to 20 or more times the pipe diameter upstream for efficient operation.

#### Magnetic flowmeters

A magnetic flowmeter operation is based on the fact that a conductor which moves through a magnetic field produces a voltage proportional to the speed at which the conductor moves. In the case of magnetic flowmeters, the conductor is a stream of water or wastewater and the magnetic field is produced by electromagnets surrounding the pipe. The induced voltage is drawn off by a pair of electrodes which are in contact with the stream.

Magnet flowmeters are very accurate. They have a wide flow range, have not moving parts, and introduce little head loss. Unfortunately, they are very expensive. Electrodes must be cleaned regularly and should not be exposed to corrosion.

#### Acoustic Flowmeters

Acoustic flowmeters operate on the principle that sound waves travel at different rates depending on whether they move with or against the flow. The time lag is proportional to the velocity and hence the flow rate. These devices, like magnetic flowmeters, give excellent results but are expensive.

#### Pitot Tubes and Rotameters

Both pitot tubes and rotameters, which are shown of Figure 4-16, produce flow measurements based on the relationship between flow, velocity and pressure. Liquid levels measured in small diameter tubes are empirically related to flow by using various hydraulic equations. Both devices are relatively impractical for wastewater flow measurement. Rotameters must be kept extremely clean. Pitot tubes are subject to clogging and are of variable accuracy. Both devices, however, are useful on clean water lines.

#### VOLUMETRIC METHODS OF FLOW MEASUREMENT

When measuring flows in tanks, wastewater sumps with pumps, or from individual pieces of process equipment which are emptied into the waste stream, two simple techniques can be used which will give a fairly accurate idea of the flow involved.

#### Tanks and Containers

The easiest way to measure average flow from a container is to calculate its volume and measure the time required to empty it or fill it.

#### Stopwatch and Bucket

The simplest method of measuring flow from the end of a small pipe is by using a stopwatch and bucket. The time required to fill a container of a given volume is measured and the resulting figure is a direct measurement of flow. The minimum filling time in using this method should be 10 seconds and the maximum size of the container should be 5 gallons. This limits the flow range which may be measured to 30 gallons per minute. Three consecutive measurements should be made to improve accuracy.

## CHAPTER IX HAZARDOUS WASTE REGULATIONS

### I. Federal

#### Regulatory Background

Congress enacted the Resource Conservation and Recovery Act (RCRA) in 1976, and amended it in 1978, 1980, and 1984. The primary goals of RCRA are:

- To protect public health and the environment from hazardous and other solid wastes.
- To protect and preserve natural resources through programs of resource recovery, including production of energy from waste.

RCRA's principal regulatory focus is on the control of hazardous waste. The Act is based on the "cradle-to-grave" control of hazardous wastes and creates a comprehensive system to establish criteria for the identification of hazardous wastes, to trace their movement from point of generation through transport and to control the ultimate means of treatment storage or disposal. Federal and State permit programs regulate treatment, storage, and disposal facilities.

Extensive hazardous waste regulations have been promulgated under RCRA's authority.

The balance of this chapter provides a brief overview of RCRA regulations most applicable to control authorities and their industrial users and is intended to provide guidance in understanding the implications of RCRA for the State and POTW pretreatment programs.

Each of the parts below briefly describes a key element of the RCRA regulations. It is not the intent of the chapter to act as a substitute for the regulations, but rather to highlight those portions which are applicable to POTWs and IUs they service.

#### HAZARDOUS WASTE IDENTIFICATION AND LISTING

##### Definition of "Solid Waste"

Any facility that generates a material which must be discarded or disposed of must determine if that material is a solid waste. "Solid Waste" is currently defined as any material that is abandoned or being disposed of, burned, or incinerated, or stored, treated or accumulated before or in lieu of these activities. In addition, most recycled materials are not considered solid wastes by EPA, depending on the recycling activity and the nature of the recycled material. Four types of recycling activities which are potentially subject to RCRA regulations are: ultimate disposal (e.g. land application); burning wastes for energy recovery or to produce fuel; regeneration of wastes; and speculation accumulation. Five categories of recycled materials currently defined as solid wastes are: spent materials, sludges, by-products, commercial chemical products, and scrap metal.

##### Exclusions from Definition of Solid Waste

Some materials are not considered solid wastes under RCRA, including domestic sewage or any mixture of domestic sewage and other wastes that pass through a sewer system to a POTW. Also excluded are wastes regulated under other Federal laws, such as industrial wastewater discharged directly to public waters and many nuclear or radioactive materials.

#### Identification of Hazardous Waste

There are two ways to know if a waste is regulated as a hazardous waste under Federal law:

- If it exhibits one or more of the following four characteristics — ignitability, corrosivity, reactivity, and toxicity (based on EPA extraction procedures) — it is considered a characteristic waste under RCRA.
- If it (or any part of it) is listed in 40 CFR Part 261.31-261.33, it is commonly called a listed waste in RCRA regulations.

For most of the characteristics (ignitability, corrosivity, reactivity, and toxicity), EPA has developed or approved methods for determining whether a waste is hazardous. Certain characteristics, however, are based on a narrative standard. A solid waste generator must determine whether its waste exhibits any of these four characteristics if its waste is not a listed waste (as described below).

EPA developed lists of hazardous wastes based on what was known about specific chemicals and wastestreams. Whether or not a waste is hazardous according to the criteria for characteristic wastes, if a facility's waste appears on any of the lists, it is regulated hazardous waste. Thus, that facility must comply with the notification requirements of RCRA. Most listed wastes are considered toxic; however, some wastes appear on a list solely because they exhibit one or more of the characteristics of hazardous waste (described above).

#### RCRA Requirements for Facilities that Generate, Store, Transport or Dispose of Hazardous Waste

EPA has the authority to regulate generators of hazardous waste in order to protect human health and the environment. These regulations specify hazardous waste management procedures for generators, including recordkeeping, personnel training, labeling, use of appropriate containers, information reporting, and use of shipping manifests. Basic requirements for generators of hazardous waste are itemized below.

- Any business that generates, transports, treats, stores, or disposes of hazardous wastes must notify EPA or an authorized State representative and obtain an identification number unless the business is exempt (see subsection Exceptions and Exemptions to RCRA Regulations for Generators). IUs covered by the Domestic Sewage Exemption are required to notify EPA of any hazardous wastewaters discharged to POTWs.
- Businesses (POTWs or IUs) which generate, store, transport, or dispose of any hazardous wastes must comply with applicable local, State, and Federal hazardous waste management requirements, both while the waste remains on the premises and when transported offsite. Specifically generators are required to obtain EPA identification numbers, prepare manifests, and submit biennial reports.

EPA and the Department of Transportation have jointly set standards for hazardous waste transportation, which include notification, recordkeeping, labelling, and manifest requirements, as well as the requirement to transport hazardous wastes only to



permitted facilities for treatment, as designated on hazardous waste shipping manifests. Hazardous waste transporters hauling wastes to POTW collection systems or treatment plants must ensure that these wastes meet all local, State and Federal pretreatment standards, in addition to RCRA requirements.

#### Exceptions and Exemptions to RCRA Regulations for Generators

Wastes normally subject to hazardous waste regulations are exempt under three specific circumstances. First, domestic sewage (untreated sanitary wastes that pass through a sewer system) or any mixture of domestic sewage and other wastes that pass through a sewer system to a POTW for treatment are excluded from regulation under 40 CFR Part 261.4(a). Second, the regulations contain a broad exemption for the onsite treatment and storage of wastewaters and wastewater treatment sludges (including wastewater treatment units, totally enclosed treatment facilities, and elementary neutralization units).

Lastly, EPA does not regulate generators of less than 100 kg/month of hazardous waste as stringently as it regulates generators of larger quantities. Several States (such as California) have requirements which are more stringent than EPA's. The last section deals with California's RCRA program in some detail.

#### OVERLAP OF RCRA REGULATIONS AND PRETREATMENT PROGRAM REQUIREMENTS

While RCRA regulates specific waste types and imposes controls to ensure that designated wastes are subject to rigorous tracking and management practices, the National Pretreatment Program requires POTWs to impose Federal and locally-derived limits on industries engaged in the discharge of toxic pollutants. It may be helpful to understand the ways in which hazardous waste management under RCRA and the regulation of direct discharge of toxic pollutants under the pretreatment program interface. Three such instances are briefly described below:

- IUs regulated under pretreatment may often also be hazardous waste generators under RCRA. Many IUs may generate hazardous wastes in the course of pretreating wastewaters (e.g. some electroplating wastewater treatment sludges are listed hazardous wastes). The General Pretreatment Regulations, under 40 CFR Part 403.8(f)(2)(iii), require POTWs to assist IUs in complying with RCRA by notifying them of applicable Subtitle C and D requirements.
- Under the Domestic Sewage Exemption [40 CFR Part 261.4(a)(1)(ii)] of RCRA, any waste generator or industry may discharge what would otherwise be considered hazardous waste into the sanitary sewer if such discharges are mixed with domestic sewage. RCRA defers to the Clean Water Act and pretreatment program regulations to make sure that wastes released to POTWs under this exemption are properly managed.
- POTWs themselves may be regulated parties subject to RCRA requirements. POTWs that generate a sludge which fails the extraction procedure toxicity test are deemed hazardous waste generators and must comply with RCRA regulations. POTWs which receive hazardous waste by truck, rail, or dedicated pipe are considered treatment, storage, and disposal facilities under RCRA and are subject to regulation.

POTWs that are classified as treatment, storage, and disposal facilities can be regulated through the NPDES permit (permit-by-rule) or with a RCRA permit. If the POTW is to be regulated by a RCRA permit, the owner/operator must apply for Parts A and B of a RCRA Transportation, Storage, or Disposal Facility permit and comply with all conditions, including corrective action

requirements. Several conditions must also be met if the POTW is to be regulated by a Permit-by-Rule:

- The POTW owner/operator must have a NPDES permit and must comply with the conditions included in the permit, also possibly corrective action requirements.
- Hazardous wastes received by the POTW must meet all Federal, State and local pretreatment requirements.
- The POTW must apply and obtain an EPA Hazardous Waste Facility identification number.
- The POTW must use the hazardous waste manifest system and keep a written operating record at the facility.
- The POTW owner/operator must report biannually to State or EPA Region Waste Management Division.

#### II. State

### CALIFORNIA'S RCRA PROGRAM

#### Regulatory Background

California enacted the Hazardous Waste Control Law in 1972 and has amended it many times since then (Health and Safety Code, Division 20, Chapter 6.5). The primary goals of the Hazardous Waste Control Law are:

- to protect public health and the environment from hazardous wastes, and
- to promote the use of alternative technology for handling hazardous wastes.

This law is similar to the Federal Resource Conservation and Recovery Act (RCRA) in that it creates a "cradle to grave" control system for:

- hazardous wastes and creates a comprehensive system for identification of hazardous wastes generator compliance standards,
- transporter standards,
- treatment, storage and disposal facility permit standards, and
- a tracking system to trace the hazardous waste from the point of generation to its ultimate disposal or treatment.

Extensive hazardous waste regulations have been promulgated under the authority of the Health and Safety Code. These regulations are codified in the California Administrative Code, Title 22, Division 4, Chapter 30.

The balance of this chapter provides a brief overview of California hazardous waste regulations most applicable to control authorities and their industrial users and is intended to provide guidance in understanding the implications of California's hazardous waste law for the wastewater treatment plant operated by your municipality, for your local pretreatment program, and for local industries served by the treatment plant.

Each of the sections below briefly describes a key element of the California hazardous waste regulations. It is not the intent of this chapter to act as a substitute for the regulations, but rather to highlight those portions which are applicable to POTWs and the IUs they serve. Details on the elements described below can be found in the statutes or regulations described above.

#### Definition of Waste

A waste is any material for which no use or reuse is intended and which is to be discarded or any recyclable material. Recyclable materials are exempt from regulation if not regulated under RCRA and if:

- recycled and used at the site where generated,
- used as an ingredient to make a product, provided it is not treated before such use,

- used as a substitute for a commercial product; or, returned to the original process from which it was generated without first being treated.

None of the exemptions above are applicable if:

- the material is used in a manner constituting disposal or is used to produce a product which is applied to land,
- the material is burned for energy recovery, used to produce a fuel, or is contained in fuel, or
- the material is accumulated speculatively.

#### Exclusions from the Definition of Waste

Most of the exemptions provided by RCRA are not found in the California law. The only wastes exempted by California law are:

- radioactive wastes,
- wastes from drilled for geothermal resources, and
- effluent from a biological process on the property of a generator treating oil or its products, and
- water discharged to navigable waters in compliance with the Federal Clean Water Act.

#### Identification of a Waste as Hazardous

A generator of a waste must determine whether or not the waste is hazardous. The determination must be made in accordance with the criteria in Article 11 of Title 22, Division 4, Chapter 30, CAC. These criteria, while similar to federal criteria, are more stringent in several areas, including the toxicity criteria and the waste extraction test.

#### Requirements for Hazardous Waste Generators

The Department of Health Services and local Health Officers have authority to regulate generators of hazardous wastes. California regulations specify hazardous waste management procedures for generators, including: operator training, reporting, labeling, container handling standards, tank standards, use of shipping manifests, contingency planning and emergency procedures. Basic requirements for generators are listed below.

- Generators must obtain an identification number from the EPA.
- Generators may accumulate hazardous waste on site for less than 90 days if the generator complies with Article 24 as it

applies to interim status facilities, Article 25 as it applies to interim status facilities, Article 19 and 20 and Section 67105.

#### Exceptions and Exemptions to Regulations for Generators

There are no exemptions under California law relating to:

- domestic sewage or mixtures of domestic sewage and other wastes that pass through a sewer system to a POTW,
- onsite treatment and storage of wastewaters and wastewater treatment sludges, if they are hazardous, or
- small quantity generators.

#### Requirements for Transporters of Hazardous Waste

All EPA and Federal Department of Transportation standards regarding notification, reporting, recordkeeping, labeling, placarding and manifest requirements are enforced by the State of California. In addition, a transporter of hazardous waste must register with the Department of Health Services and have each vehicle and container certified by the California Highway Patrol on an annual basis. The registration process includes the payment of a fee, proof of liability (sudden environmental impairment) insurance at specified levels, and documentation of driver training.

#### Relationship of State Hazardous Waste Regulations and Pretreatment Program Requirements

State hazardous waste regulations do not include the federal exemptions. Some instances to note are described below:

- A pretreatment unit is required to have a permit as a hazardous waste treatment facility if the waste it is receiving is hazardous. This is true regardless of whether the unit is totally enclosed, elementary, neutralization, or wastewater treatment units discharging to a POTW or under an NPDES permit.
- The hazardous waste law allows the granting of a variance from permit requirements if the hazardous waste treated is:
- Insignificant as a potential hazard to human health and safety because of its small quantity, low concentration or physical or chemical characteristics; or, handled pursuant to regulations of another governmental agency in a manner which is consistent with the hazardous waste law.
- POTWs which accept hazardous waste for treatment are deemed to have a permit if the conditions listed in the permit by rule regulations are met (California Administrative Code, Title 22, Section 66392).

## CHAPTER X CONVENTIONAL WASTEWATER TREATMENT METHODS FOR THE ELECTROPLATING AND METAL FINISHING INDUSTRIES

### Introduction

The majority of metals and cyanide discharged by industry into the Nation's waterways comes from metal finishing facilities, primarily from electroplating processes. Most of the constituents in metal finishing wastes (e.g. metals, cyanides and organics) are toxic and potentially threaten aquatic life and human health. The degree of risk posed by these discharges is hard to determine because it depends on site-specific factors. However, small amounts or the types of chemicals discharged by metal finishers are toxic enough to cause the EPA to set stringent, safe threshold levels for these chemicals in surface waters. Typical concentrations of these metals in untreated metal finishing discharges are several times greater than water quality criteria for the same metals. Even when diluted by the volume of the receiving water, metal finishing discharges can severely degrade water quality.

As a result of the toxicity of pollutants in metal finishing wastes and of the volume of these discharges, this industry is subject to categorical standards (40 CFR Parts 413 and 433) as established by the U.S. EPA. The goal of these regulations is to reduce the contaminants in metal finishing discharges to levels that are environmentally acceptable while remaining technically feasible and affordable for the industry. The EPA developed categorical standards for facilities that discharge to a surface water (direct discharger) and to those facilities that discharge to publicly owned treatment works (indirect dischargers). The main thrust of this Chapter is for indirect dischargers covered by categorical pretreatment standards.

This chapter provides an overview of the electroplating and metal finishing manufacturing processes, the sources of water pollution, and a description of conventional wastewater treatment for this industrial effluent.

### The Electroplating and Metal Finishing Manufacturing Processes

Electroplating is a process for applying a thin metal coating such as zinc, copper, nickel, chromium, etc., to the surface of metal parts, which are usually made of iron, steel, brass or aluminum. The coatings serve to protect the metal from corrosion, to build up the surface thickness, or to decorate the piece. Many commonly used items are electroplated. For example, automobile bumpers and door handles are often chrome plated, printed circuit boards are copper plated, and watch bands and necklaces can be plated with precious metals such as gold or silver.

There are six processes regulated by 40 CFR Part 413, including electroplating, electroless plating, anodizing, coating, chemical etching and milling, and printed circuit board manufacturing. The following discussion describes the general process steps for electroplating.

### Electroplating Process Steps

Most electroplating processes can be divided into three principal work steps as shown in Figure 1:

#### 1. Surface Preparation

Surface preparation involves steps to clean the part before it is plated. Cleaning is usually accomplished by placing the work piece in a tank containing a solvent or alkaline solution, and then in an acid dip to remove corrosion. Both the alkaline and the acid dip are followed by rinsing in running water.

#### 2. Plating Application

In the second work step, a metal coating is applied from a solution containing the plating metal in dissolved form and other chemicals. The part to be plated is placed in the solution and charged with electricity to attract the dissolved metal to its surface much like a magnet attracts iron filings. Plating is followed by rinsing with water to flush the process solution from the work area.

#### 3. Post Treatment

Some plating steps are followed by post treatment of the work piece to color it or to add corrosion resistance. Chromate, for example, is a common post treatment for zinc and cadmium plating. Post treatment steps are also followed by rinsing in running water. Some electroplating processes are complete after the plating step and do not require post treatment.

Sometimes the configuration of an electroplating process line will appear to be complicated. Because of space constraints, work flow requirements, ancillary components of a work step, or poor tank layout, the three plating steps can be difficult to recognize. See Figure 1-1. Next Page)

### Sources of Water Pollution

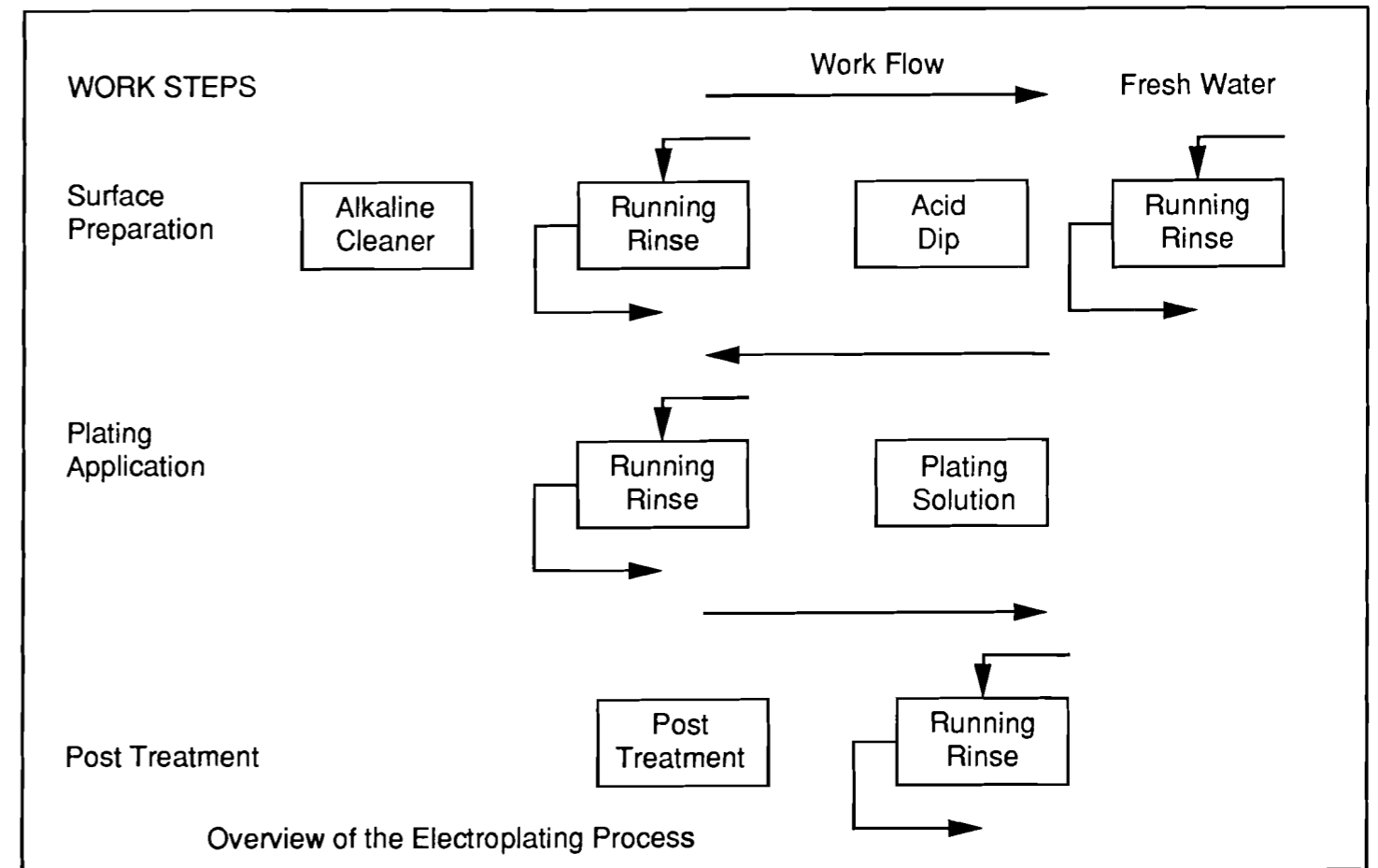
Contaminants in the effluent from electroplating shops originate in several ways. The most obvious source of pollution is from "drag-out", which is plating solution that clings to the work piece and contaminates the rinse water. The amount of pollutants contributed by drag-out is a function of many factors including the design of the racks or barrels carrying the parts to be plated and the shape of the parts themselves. Plating procedures and several interrelated parameters of the process solution, such as concentration of toxic chemicals, temperature, viscosity, and surface tension also affect drag-out rates.

Large volumes of rinse water are usually needed to clean the drag-out from the work with conventional rinsing techniques. Rinsing actually serves two purposes:

1. It cleans the part, which prevents staining and other quality control problems.
2. It protects subsequent process baths from "drag-in" contamination.

Because of high flow rates used in conventional rinsing techniques, rinse waters are contaminated with relatively dilute concentrations of process solutions. Typically, rinse waters that follow plating solutions contain between 15 and 100 milligrams per liter (mg/l) of the metal being plated.

Most job shops operate several plating lines such as zinc, copper, nickel, cadmium, and chromium. The rinse waters discharged



from each line are usually combined in a common pipe or floor trench, and the concentrations of the individual metals from each process are diluted in the entire volume of the shop's wastewater, usually to less than 50 mg/L each.

Another source of contamination from electroplating shops is used or spent process solutions. Platers discard spent cleaners, acids, and bright dips. Although these solutions are not usually made up of metals, it is not uncommon to find cyanide and heavy metals in concentrations of several thousand milligrams per liter in these solutions. This contamination is caused by drag-in from previous process cycles and from metals leached from the work by the process chemicals. Plating solutions and other process chemicals containing high metal concentrations are rarely discarded. Instead, they are decontaminated or rejuvenated in place so they are usually not a hazardous waste problem.

Accidental spills, leaks and drips of process solutions also can contribute to effluent contamination. Additional pollution sources include sludges from the bottoms of plating baths generated during chemical purification, backwash from plating tank filter systems, and stripping solutions.

### Application of Pretreatment Program Categorical Standards

Facilities regulated by 40 CFR Part 413 are classified into two categories:

- Facilities discharging <10,000 gallons (38,000 liters) per day
- Facilities discharging >10,000 gallons (38,000 liters) per day

The pollutants regulated for each type of facility vary; more pollutants are regulated for the larger facilities as shown in Table 1.

**TABLE 1  
Comparison of Regulated Pollutants**

Pollutant	<10,000 gpd of regulated process flow	>10,000 gpd of regulated process flow
Cadmium (T)	X	X
Chromium (T)		X
Copper (T)		X
Lead (T)	X	X
Nickel (T)		X
Silver (T) #		X
Zinc (T)		X
Cyanide (T)		X
Cyanide (A)	X	
Total Metals [sum concentration of (T) chromium, (T) copper, (T) lead, (T) nickel]		X
Total Toxic Organics	X	X
# Applies to precious metal electroplating		

The EPA has further divided the industry into two groups on the basis of wastewater complexity:

### Integrated Facility

- Electroplating is only one of several operations necessary for manufacture of a product at a single physical location
- Significant quantities of process wastewater are generated from non-electroplating operations

- One or more electroplating process water lines is combined with one or more plant sewers carrying process wastewater from non-electroplating manufacturing operations prior to or at the point of treatment (or proposed treatment)

#### Nonintegrated

- Any facility which is not integrated; includes job shops and captive shops within a larger facility.

#### Metal Finishing Pretreatment Standards (40 CFR Part 433)

The standards for finishing regulate 46 process operations. These include the six previously identified as being regulated by the Electroplating regulations and 40 additional processes. The Metal Finishing Standards for the 40 different processes apply only if one of the six electroplating processes are also present at the facility.

The 46 processes are as follows; the first six are those also regulated by the Electroplating Standards for:

- |  |                                  |
|--|----------------------------------|
| 1. Electroplating                      | 24. Electric Discharge Machining |
| 2. Electroless Plating                 | 25. Electrochemical Machining    |
| 3. Anodizing                           | 26. Electron Beam Machining      |
| 4. Conversion Coating                  | 27. Laser Beam Machining         |
| 5. Etching (Chemical Milling)          | 28. Plasma Arc Machining         |
| 6. Printed circuit Board Manufacturing | 29. Ultrasonic Machining         |
| 7. Cleaning                            | 30. Sintering                    |
| 8. Machining                           | 31. Laminating                   |
| 9. Grinding                            | 32. Hop Dip Coating              |
| 10. Polishing                          | 33. Sputtering                   |
| 11. Barrel Finishing (Tumbling)        | 34. Vapor Plating                |
| 12. Burnishing                         | 35. Thermal Infusion             |
| 13. Impact Deformation                 | 36. Salt Bath Descaling          |
| 14. Pressure Deformation               | 37. Solvent Degreasing           |
| 15. Shearing                           | 38. Paint Stripping              |
| 16. Heat Treating                      | 39. Painting                     |
| 17. Thermal Cutting                    | 40. Electrostatic Painting       |
| 18. Welding                            | 41. Electropainting              |
| 19. Brazing                            | 42. Vacuum Metalizing            |
| 20. Soldering                          | 43. Assembly                     |
| 21. Flame Spraying                     | 44. Calibration                  |
| 22. Sand Blasting                      | 45. Testing                      |
| 23. Other Abrasive Jet Machining       | 46. Mechanical Plating           |

#### Conventional Treatment Technologies

##### A. Chemical Treatment

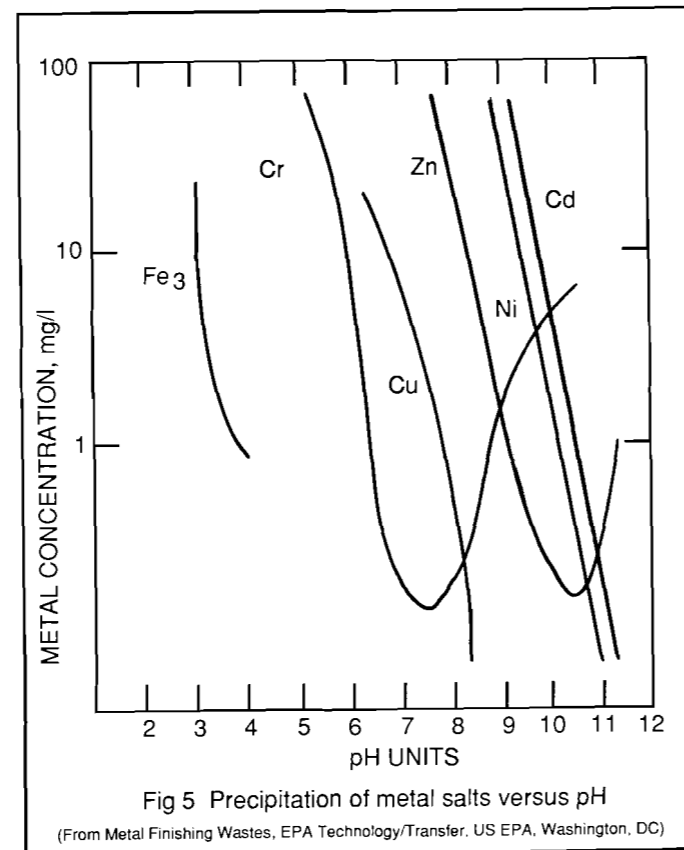
##### 1. Oxidation/reduction

Destruction of cyanides by chlorination under alkaline conditions and chromates by reducing sulfur dioxide or sulfites under acid conditions. Afterwards, effluents are neutralized preferably to pH 8.5 so undesirable metallic radicals in solution (Cd, Cr, Cu, Fe, Ni, Zn) will precipitate and can be removed by settling or filtration. Due to cyanide treatment in alkaline conditions and chromate treatment in acid conditions, it is essential to separate these wastestreams prior to treatment.

##### 2. Precipitation

Treatment of metal finishing wastes by neutralization followed by gravity settling for separation of suspended solids - with additional treatment steps for hexavalent chromium and cyanide - has become so widely used in the metal finishing industry that it is usually referred to as "conventional" treatment. Figure 1 is a

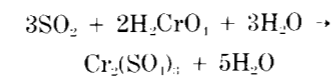
schematic of a conventional treatment facility for electroplating wastes containing chromium and cyanides in addition to other heavy metals, acids, and alkalis.



#### Electroplating Industry Conventional Wastewater Treatment

##### a. Chromium Reduction Units

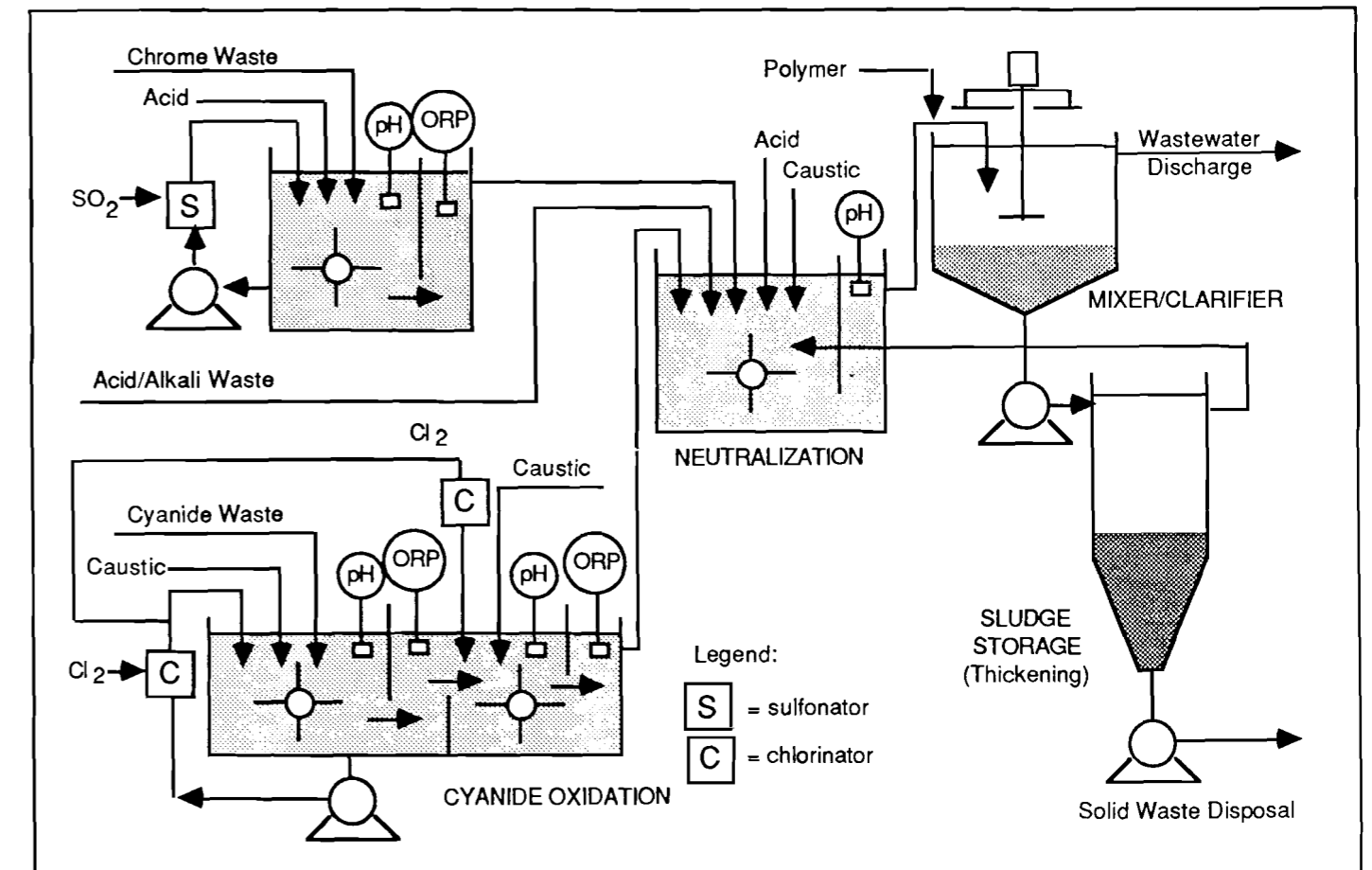
Chromium complexes are usually present in electroplating wastewater as trivalent chromium (Cr+3) or as hexavalent chromium (Cr+6). Although most heavy metals are precipitated readily as insoluble hydroxides by pH adjustment in the neutralizer, hexavalent chromium first must be reduced to trivalent chromium. Reduction usually is done by reaction with gaseous sulfur dioxide (SO<sub>2</sub>) or a solution of sodium bisulfite (NaHSO<sub>3</sub>). The net reaction using sulfur dioxide is:



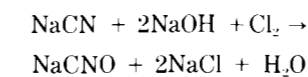
Because the reaction proceeds rapidly at low pH, an acid is added to control the chromic acid wastewater pH between 2 and 3. Gaseous sulfur dioxide is metered continuously into the reaction tank to satisfy the reduction demand based on the concentration of hexavalent chromium.

##### b. Cyanide Oxidation Units

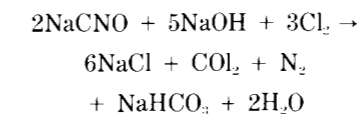
Dilute cyanide rinse streams resulting from plating operations and cyanide dips also must be treated separately to oxidize the highly toxic cyanide, first to less toxic cyanate, then to harmless bicarbonates and nitrogen. The oxidation reagent is usually chlor-



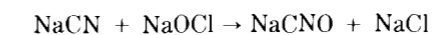
ine, which can be introduced into the system by adding chlorine gas (Cl<sub>2</sub>) or sodium hypochlorite (NaOCl). Using chlorine the typical reaction in the first stage is:



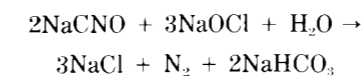
and in the second stage,



When sodium hypochlorite is used, the typical reaction in the first stage is:



and in the second stage,



Continuous systems (Figure 1) use two series - connected reaction tanks. In the first stage, the pH is adjusted between 9 and 11 using an alkali such as caustic or lime. The pH in the second reaction chamber is controlled at approximately 8.5. Chlorine is added continuously to both stages. Because the demand for chlorine in the second stage is proportional to demand in the first stage, the chlorine is fed to both stages from the same feeder at

a set ratio based on demand in the first stage. Demand in the first stage is determined by measuring ORP. The reaction time needed is approximately 25 to 30 minutes in each stage.

##### c. Neutralization/Precipitation Techniques

The mixed acid/alkali waste streams from the various metal cleaning and plating operations are combined in the neutralizer with the effluent from the chromium reduction and cyanide oxidation steps. Because the heavy metals are soluble at low pH (acidic) conditions in the wastewater, the pH is adjusted to a range of 7.5 to 9.5. In this pH range, the minimum solubility of a mixture of metals is reached and the metals precipitate as hydroxides. As demonstrated in figure 5 each metal has a different optimum pH for precipitation. In some cases, wastes might be separately precipitated at different pH's or the mixed waste might be bench tested to determine the overall optimum pH for precipitation within a single reaction tank.

Many types of neutralization systems can be designed with various degrees of automation and controls, depending on the volumetric flow rates and the variability of the flow rates or pH entering the neutralizer. Because a change of 1 pH unit represents a tenfold change in hydrogen ion concentration (Table 3), it will be difficult to maintain the pH in the narrow range where maximum removal of pollutants is realized if the neutralizer feed is subject to wide variations.

Single-stage, continuous neutralizers-where all the alkali such as lime, Ca(OH)<sub>2</sub>, or caustic soda, NaOH, is fed into a single reaction vessel - are usually suitable for electroplating applica-

tions. If, however, the wastewater is subject to rapid changes in flow rates or pH, a multistage neutralizer is required. In the multistage units, most of the alkali is added in the first vessel to increase the pH to 6. Final pH adjustments of the wastewater are made in the remaining reaction vessels to promote precipitation and to enhance the settling characteristics of the metal hydroxides. To maintain adequate pH control, the retention time for typical neutralization systems is 10 to 30 minutes. A system using lime usually requires more retention time, as the time required for completely dissolving the lime retards the response of the system to the reagent addition.

d. Clarification

Metal hydroxides and other insoluble pollutants are removed from the wastewater by gravity settling. The solids removal efficiency depends on the settling rate of suspended solids in the wastewater feed. Typically, some of these solids settle very slowly because of their small size and their slight density difference compared with the water. Because economical design of the clarifier limits the retention time in the settling chamber, some level of suspended solids will appear in the overflow.

To enhance the settling characteristics of the suspended solids, flocculating agents - such as polymers, alum, or ferrous sulfate — are added in a mixing chamber before the flocculator. In the flocculator, the wastewater is agitated gently to allow the solids to coagulate. The wastewater then enters the clarifier, where the solids settle out. The solids in the underflow can be discharged to a holding tank for thickening, or they can be discharged directly to sludge disposal. The optimum dosages of flocculating agents, the size and costs for flocculation and clarification hardware, and the associated solids removal efficiencies can be estimated only by laboratory testing.

e. Sludge Handling

The solids from clarifiers are typically discharged to sludge holding tanks at solids concentrations of 0.5 to 3 percent; overflow from the tank is recycled to the clarifier. Usually metal hydroxide solids will concentrate to approximately 3 to 5 percent solids in these tanks if given adequate retention time. The tanks also provide adequate storage time and volume for the sludge before shipment to a disposal site.

Further concentration of the thickened sludge requires the use of mechanical dewatering equipment. Centrifuges, rotary vacuum filters, belt filters, and filter presses have been used to dewater metal hydroxide sludge. The applicability of a particular dewatering device for a specific sludge, and the degree of cake dryness the device will achieve, can only be determined by bench-scale testing with the intended feed material.

B. Ion Exchange

Ion exchangers create a chemical reaction between a solid and a fluid to interchange ions from one substance to another. The solid is known as an exchange resin and is usually made from organic compounds. Generally, in electroplating processes, ion exchange units are used to extract pollution chemicals from the drag-out tank as the solution is cycled through the unit. A cationic section of the deionizer removes metals, hydrogen, and ammonium, and an anionic section removes nonmetals, such as sulfates, carbonates, and chlorides. This technology can be cost prohibitive, especially for small shops. After the "active sites" on the exchange resin have been occupied the resin is "recharged" and then, put back into service. The accumulated ions are stripped from the exchange resins with acids (for the cationic bed) and bases (for the anionic bed). The contaminants in the regeneration wastes must then be treated either through precipitation or off site disposal.

C. Reverse Osmosis

In reverse osmosis, pressure is applied to the surface of a solution (wastewater) to force pure water through a semipermeable membrane too dense to permit the passage of the contaminant. Reverse osmosis can be used on drag-out tanks in order to recirculate purified water to the drag-out tank, and, at the same time, concentrate the process solution and return it to the process tank. This type of unit is also very expensive.

D. Electrolysis

Electrolysis uses electricity and semipermeable, chemically treated, plastic membranes to separate soluble minerals from water. By applying an electrical current, cations are drawn to a cathode, and anions are drawn to an anode, leaving purified water in a center cell. Electrolysis is expensive and difficult to maintain.

Inspecting the Electroplater or Metal Finisher

Initially, an evaluation of an operation should be made to identify certain key processes and collect operational data that will be needed throughout POTW permitting:

- Identify all inputs and discharges
- Identify all sources of contamination

Quantify pollution concentration and flows of all regulated process wastestreams, and all other wastestreams or dilution streams that are mixed with the regulated wastestreams.

Determine if water flow varies and why: production rate, work shift, batch discharge.

Identify existing sample locations, and determine new locations if existing ones are inadequate (sample points should provide adequate data for use of the combined wastestream formula to adjust categorical standards, or to compare categorical standards with local discharge limits).

In-House Pollution Control Methods

The IWI may be able to help reduce pollution by suggesting the following techniques:

Methods to Reduce Water Consumption

- Restricted pipe orifice sprays or mists to reduce flow
- Manual operation of water supply
- Intermittent rinsing of work
- Static rinse tanks
- Countercurrent rinse tanks
- Series rinse tanks
- Air agitation in rinse tanks to improve rinsing efficiency
- Chemical addition to improve rinsing efficiency
- Automatic discharge controls on rinse tanks
- Clean water addition through automatic measurement of conductivity
- Drag out system; recycles rinse water into plating baths, generally only for baths that have a high evaporation rate and need supplemental water
- Proper drainage of rinsed material back into rinse tank
- Use of demineralized water to minimize scale build up in rinse tank

Methods to Reduce Discharge of Contaminants at the Source

- Pretreatment at the production source
- Modifying discharge frequency of strong spent solutions
- Treatment of process solutions to extend usefulness
- Alteration of production process such as noncyanide cleaners
- Use of spray rinses or "air knife" system on material from plating tanks

- Use of minimum chemical concentrations that will obtain quality products
- Use of spent baths as treatment reagents

Tables 2 and 3 are a summary of recovery techniques and conventional chemical treatment methods respectively. Each table expands on the information presented in this chapter.

TABLE 2. Ion Concentration vs. pH for Water Solutions

pH	Free hydrogen ion (acid) concentration (gram-ions/liter)	Free hydroxyl ion (base) concentration (gram-ions/liter)
1	0.1	0.000000000001
2	0.01	0.00000000001
3	0.001	0.0000000001
4	0.0001	0.000000001
5	0.00001	0.00000001
6	0.000001	0.0000001
7 (neutral)	0.0000001	0.0000001
8	0.00000001	0.000001
9	0.000000001	0.00001
10	0.0000000001	0.0001
11	0.00000000001	0.001
12	0.000000000001	0.01
13	0.0000000000001	0.1

TABLE 3. METAL FINISHING AND TOXIC WASTES Summary of Recovery Techniques

Technique	Common Applications	Comments
1. Ion Exchange	Gold, silver, chromium, nickel plating, phosphoric acid, anodizing solutions, aluminum etchants	Suited for metal complexed solution, low concentration removal, and selective process bath stabilization
2. Electrolytic	Gold, silver, tin, copper, chromium plating solutions, cadmium	Suited for metal recovery from concentrated waste stream
3. Electrolysis	Gold, silver, copper, chromic acid, nickel, zinc, cobalt plating	Ion exchange membrane allows minimal objectionable inorganic return
4. Evaporation	Chromic acids, chrome, lead-tin, nickel, copper, cadmium, brass, bronze, gold, zinc plating	Efficient for low volume, high concentration recovery of plating or process solutions
5. Reverse osmosis	Nickel plating	Recovers brighteners and other organics. Suited for plating or process solution and rinse water recovery

## CHAPTER XI

### CHEMISTRY DEFINITIONS AND MISCELLANEOUS TOPICS

There are a number of topics in chemistry that the IWI must be able to work with. It is assumed that each IWI has had at least a basic chemistry background. A number of the questions on each test will have a chemistry origin. A knowledge of basic mathematics is also assumed. Below find some of the more important topics in chemistry for the IWI. If you are unfamiliar with any of the topics shown then find a reference that completely explains it.

**Atomic Weight** — The weight of an element relative to carbon. This is the weight given in the periodic table. You should be able to use gram atomic weights in various stoichiometry problems.

**Mole** — A mole is  $6.023 \times 10^{23}$  items. The mole is significant in chemistry because one mole of atoms of any element will weigh one gram atomic weight. For example, one mole of carbon atoms will weigh 12 grams; one mole of hydrogen atoms will weigh 1 gram; and one mole of chlorine atoms will weigh 35.5 grams.

**Normality** — Normality is the number of equivalent weights per liter. Normality is extremely useful to the analytical chemist because it allows calculations involving solutions to be solved as proportions.

$$N_1 * V_1 = N_2 * V_2$$

With this equation we can calculate the strength of an unknown solution if we know its volume and titrate it with a solution of known strength. This concept is valid for both acid-base and oxidation-reduction reactions.

**Equivalent Weight** — For acid-base reactions this is the weight of acid or base that would transfer or gain one mole of protons. For oxidation-reduction this would be the weight of oxidant or reductant that gains or loses a mole of electrons. Some examples: nitric acid will donate one proton hence its equivalent weight is its gram atomic weight divided by one; sulfuric acid will donate two protons hence its equivalent weight is its atomic weight divided by two; dichromate will accept six electrons in certain reactions hence its equivalent weight is its atomic weight divided by six.

**Oxidation-Reduction** — Reactions involving the transfer of electrons, with oxidation being loss of electrons and reduction being the gain in electrons. You should be able to balance redox equations and perform simple calculations based on the equation.

**Acid-Base** — Reactions involving the transfer of a proton, with acids losing protons and bases accepting them.

**Density** — The density is the mass of a substance per unit volume. A related quantity is the specific gravity which is the density relative to water, which weighs 1.0 grams/ml. A solution with a specific gravity of 1.5 would weigh 1.5 grams/ml.

#### Chemical Definitions

**Biochemical Oxygen Demand (BOD)** — means the quantity of oxygen utilized in the biochemical oxidation of organic matter under standard laboratory procedure: five days at twenty degrees centigrade expressed in terms of weight and concentration (milligrams per liter (mg/l)). This test is used extensively in water

pollution control to measure the amount of oxygen-demanding organic material in a sample. BOD test results are used for calculating wastewater loadings, treatment plant efficiencies, to monitor the impact to the environment, and very often used in calculating sewer service charges to industrial users.

Testing should occur as soon as possible after sampling. If composite samples are used compositing time should be held to 24 hours and samples should be held at 4°C with compositing. If grab samples are used they should be cooled to 4°C unless testing begins within 2 hours. In no case should samples be held longer than 48 hours.

**Chemical Oxygen Demand (COD)** — This is another test used to measure the amount of organic material present in a sample. The main advantage of using the COD test rather than the BOD test is speed — the COD test being complete in 3 to 4 days generally gives higher results than the BOD test. Often the IWI can establish a rough correlation for the individual industrial user between COD and BOD test results. For example, a plater might average 2½ times higher COD numbers than BOD numbers. Thus a COD number could serve as a rough indicator of a violation where speed is important.

The COD test involves adding excess oxidant to the sample, using acid and heat as catalysts and measuring the remaining oxidant. By knowing the amount of oxidant consumed an estimate of oxygen demanding content of the sample can be made. The oxidant most commonly used is potassium dichromate.

**Dissolved Oxygen (DO)** — The amount of dissolved oxygen in water is a measure of how much life can be supported in that water. An unpolluted aquatic system will have a relatively high DO level which supports the natural biota. Pollution of a natural water way results in a depression of DO as organic matter oxidizes a portion of the available DO. The consequences to an aquatic system of a lowered DO may result in the complete destruction of the natural ecosystem.

There are two common methods used for measuring DO levels in waste, the membrane electrode method and the iodometric or Winkler method. For field use the membrane electrode method is definitely the preferred method since it is fast and reliable.

**Suspended Solids (SS)** — means the total suspended matter that floats on the surface of, or is suspended in, water, wastewater or other liquids, and which is removable by laboratory filtering. Suspended solids are also known as nonfilterable residue determinations and are used for waste strength characterizations, process control, measuring process efficiency, measuring environmental impact, and like BOD is a very common billing parameter.

Basically a weighed filter has a measured amount of sample run through it which retains the solids. The filter is then dried and reweighed, and the nonfilterable residue can then be calculated. Note: For all of the above definitions a more complete description of laboratory techniques can be found in Standard Methods and other reference materials.

**pH** — pH is defined as the negative logarithm of the hydrogen in moles per liter. The pH scale goes from zero to fourteen with a value of seven units being considered neutral. Values below seven are considered as acid; values above seven are basic. It is important to note that a one unit change in pH represents a ten-fold

change in the concentration of the hydrogen ion. As an example, if the pH is changed from six to five, a ten fold increase in hydrogen concentration has occurred.

pH has a great impact on almost all biological and chemical processes used for water and wastewater treatment, and proper measurement of this value is critical. pH is measured using a pH meter consisting of a potentiometer, glass pH electrode, reference electrode and temperature compensating device. When calibrating the instrument, use two buffers which bracket the expected pH value for greatest accuracy. Both the reference and pH electrode must be properly cleaned and maintained.

pH is of particular interest to the IWI for any of several reasons. Most agencies have an ordinance with specific pH limitations such as 5.0 to 10.0. For categorical pretreatment industries covered under Federal standards the pH is usually 6.0 to 9.0. Violations of pH may also result in severe collection system problems. Acidic wastewater is corrosive to most types of pipes and may contribute to the formation of hydrogen sulfide gas. If the pH violation is severe enough it may very adversely affect the treatment plant itself.

#### Conductivity

The conductivity of pure water is nearly zero hence the conductivity of a natural water can be related to the concentration of dissolved species. Commercial instruments are available that will give a direct readout of conductivity in micromhos/centimeter. Conductivity readings should be reported at 25 C.

### ENFORCEMENT

#### Philosophy

An unfortunate by-product of municipal, State or Federal regulations is noncompliance with those regulations. Noncompliance can be dealt with in many ways but does need to be dealt with in some way. Most people are uncomfortable with the enforcement power over others that they have. Many are reluctant to use it.

But in the "real" world of wastewater regulations we find "good" people and "bad" people. Also, management and politics can run rampant — even amuck. Still there must be punishment for the wicked and nonpunishment for the righteous. In the competitive business world this often needs to translate into dollars lost by noncompliers to take away their unfair competitive advantage over compliers.

#### The Strategy

There are two basic enforcement types. The first is administrative and the second is legal. The first is usually less formal and is compliance oriented. The legal remedies are more formal with possible criminal penalties. An effective pretreatment program will use at some time all enforcement remedies available. Each noncompliance should be dealt with on a case-by-case basis. There are numerous enforcement factors involved including the demonstration of good-faith by the noncompliers.

Each municipality should have code sections listing the remedies and steps of administrative enforcement. A typical noncompliant discharger will yield to a cooperative approach by the municipality. As more progressive enforcement steps are brought into play the incidents of noncompliance diminish dramatically. Few companies use the bad guy/bad faith strategy in dealing with a municipality. Most companies are smart enough to use a cooperative approach rather than creating an adversarial climate. However, occasionally the emergency case of the blatant polluter will require swift and hard action using legal remedies.

#### Enforcement Procedures

Progressive enforcement will typically proceed as follows:

1. Notification (Verbal or Written)
2. Show Cause Meeting (Often Public)
3. Cease and Desist Order (with compliance date and possible fines)
4. Termination of Service
5. Judicial
  - a. consent decree
  - b. civil penalties
  - c. criminal penalties

Phases 1 and 2 are the most typical ones that you will use. There should be a significant decrease in enforcement incidents after step 2. Only the most serious violators will get to Phases 4 or 5 as they have resisted all reasonable attempts by the POTW to correct the violations.

#### Let's discuss each of the enforcement procedures

##### 1. Notification

A written policy for notification should be established by the POTW. Not only will notification be consistent with all industries and amongst all inspectors it will formalize and record the notification. A written record of all notification, especially verbal, is often neglected. It is necessary to properly document all discussions with the discharger. Document everything even when they are fully compliant. If you have notified the discharger of a violation with no results then go to the next phase.

##### 2. Show Cause Meeting

There may be two levels of action here. A less formal meeting could be between the discharger and POTW personnel including the Director only. Here the discharger gets the opportunity to tell his side of the issue. The POTW can evaluate the discharger's case and hopefully achieve a compliance schedule. Larger municipalities with more serious violations may have a meeting open to the public with appropriate officials of not only the POTW but of the municipality also. At this meeting the municipality may issue a Cease and Desist Order with a compliance deadline. Noncompliance with the Cease and Desist Order will be cause for termination of service or court action. A show cause meeting is a most useful tool of the POTW to maximize understanding between the discharger and the POTW. Resolution of most problems should be achieved without going to a higher level of enforcement.

##### 3. Cease and Desist Order

This is a formal declaration issued by the POTW stating the problem, the solution, a deadline for implementation of the solution and often includes monetary penalties. Most municipal codes have an appeal process available to the discharger. Know the appeal process.

Non compliance with the conditions of Cease and Desist orders are the same for moving to steps 4 or 5.

##### 4. Termination of Service

This is a very serious step with severe implications for all concerned. A business may be rendered inoperative; jobs may be lost. Careful consideration to all the consequences of this action need to be weighed. Termination may be of an emergency and temporary nature which is absolutely warranted to protect the treatment facility. Politics and management will almost certainly get involved with any termination of service. Have your case well developed and documented.

Often this step will be skipped to go to court action.

5. Judicial Remedies

- a. Here the most common court action is the Consent Decree. The object here is to get a negotiated settlement with the discharger. The POTW's case is presented to a judge. Once the judge signs the Consent Decree, continued noncompliance is in defiance of the court. A deadline will be part of the Consent Decree and will have to pass before further court action is attempted. However, if you can prove to the judge that the discharger cannot possibly achieve compliance in the remaining time, then further court action becomes possible. Contempt of Court charges may be one consequence of continued noncompliance by the violator.
- b. Civil penalties may spring from the Consent Decree process or may be the initial consequence of a municipal lawsuit. Note that the City Attorney will typically get involved with steps (a) and (b) only. The first two steps are typically still compliance oriented and the jurisdictional responsibility of the City Attorney.

- c. This step is reserved for only the most serious, blatant and persistent polluters. There are almost always overlapping jurisdictional responsibilities between the City Attorney's office and the County District Attorney's office. This allows the D.A. to handle criminal prosecutions within the municipality for environmental pollution cases. The D.A. is less compliance oriented and more criminal penalty oriented. The D.A. knows that pollution cases have high public visibility and will generally be receptive to handling the properly prepared case. The next handout deals with preparing a case for a D.A..
- Now let's recap the enforcement topic. Any enforcement action must consider not only the significance of the violations, but also the history of the violator. A measured response is always called for with an emphasis toward cooperative resolution of a problem whenever possible. Minor infractions do not warrant formal proceedings. Major violations may require a quick effective response that almost completely skips the usual first steps. Whatever steps are appropriate, they must be applied uniformly and consistently to assure equitable enforcement of requirements.

**ENFORCEMENT RESPONSE GUIDE**  
 From EPA Pretreatment Compliance Monitoring  
 and Enforcement Guidance  
 (Dated July, 1986)

**SAMPLING, MONITORING, AND REPORTING**

NONCOMPLIANCE	CIRCUMSTANCES	RANGE OF RESPONSE
Failure to sample, monitor, or report (routine reports, BMR's).	Isolated or infrequent.	Phone call or written letter of violation (LOV) requiring a report within 10 days. If no response is received, issue an Administrative Order (AO).
Failure to sample, monitor, report, or notify.	IU does not respond to letters, does not follow through on verbal or written agreement, or frequent violation—SNC.**	AO or judicial action, including penalties if no response is received. Request criminal investigation.
Failure to notify of effluent limit violation or slug discharge.*	Isolated or infrequent. No known effects.	Phone call or LOV. If no response within 10 days, issue an AO.***
Failure to notify of effluent limit violation or slug discharge.*	Frequent or continued violation—SNC.	Show cause meeting, AO or judicial actions, including penalties.
Failure to notify of effluent violation or slug discharge.*	Known environmental or POTW damage results—SNC.	Judicial action and penalties. Sewer ban.
Minor sampling, monitoring, or reporting deficiencies (computational or typographical errors).	Isolated or infrequent.	Phone call or LOV. Corrections to be made on the next submittal. AO if continued.
Major or gross sampling, monitoring, or reporting, deficiencies (missing information, late reports).	Isolated or infrequent.	LOV or AO. Corrections to be made on the next submittal.
Major or gross reporting deficiencies.	Continued. Remains uncorrected 30 days or more—SNC.	AO or judicial action.

\* Proposed revisions on June 12, 1986, (51 FR 21454) to the General Pretreatment Regulations include a requirement to repeat effluent analysis after each violation and provide the information to the Control Authority within 21 days.  
 \*\* SNC. This denotes that the circumstances of a particular violation are severe enough to meet the criteria specified on pages 3-52 and 3-53 for Significant Noncompliance (SNC).  
 \*\*\* Whenever a letter of violation is issued that requires a response and the industrial user fails to respond, the Control Authority should issue an administrative order to require the industrial user to respond and return to compliance immediately.  
 LOV: Letter of Violation  
 AO: Administrative Order

**COMPLIANCE SCHEDULES (Construction phases or planning)**

NONCOMPLIANCE	CIRCUMSTANCES	RANGE OF RESPONSE
Reporting false information.	Any instance—SNC.	Request for criminal investigation. Judicial action, penalties, sewer ban.
Missed interim date.	Will not cause late final date or other interim dates.	LOV.
Missed interim date.	Will result in other missed interim dates. Violation for good or valid cause.	LOV or AO.
Missed interim date.	Will result in other missed interim dates. No good or valid cause—SNC.	LOV, AO, or judicial action, including penalty.
Missed final date.	Violation due to force majeure (strike, act of God, etc.).	Contact permittee and require documentation of good or valid cause; show cause.
Missed final date.	90 days or more outstanding. Failure or refusal to comply without good or valid cause.	AO or judicial action, including penalty.
Failure to install monitoring equipment.	Continued—SNC.	AO to begin monitoring (using outside contracts, if necessary) and install equipment within minimal time. Temporary sewer ban.

**EFFLUENT LIMITS**

NONCOMPLIANCE	CIRCUMSTANCES	RANGE OF RESPONSE
Exceeding final limits (categorical local or prohibited).	Infrequent or isolated minor violations.	LOV.
Exceeding final limits.	Infrequent or isolated major violations exceed the limits by TRC of a single effluent limit.	LOV, AO (judicial action if environmental harm resulted, including penalty).
Exceeding final limits.	Violation(s) that are SNC.	AO or judicial action, including penalty.
Exceeding interim limits (categorical or local).	Without known damages.	LOV or AO.
Exceeding interim limits.	Results in known environmental or POTW damage—SNC.	AO or judicial action, including penalty.
Reported slug load.	Isolated without known damage.	Show cause or AO.
Reported slug load.	Isolated with known interference, pass-through, or damage—SNC.	AO or judicial action, including penalty.
Reported slug load.	Recurring—SNC.	Judicial action, including penalty. Sewer ban.
Discharge without a permit or approval.	One time without known environmental or POTW damage.	AO.
Discharge without a permit or approval.	One time that results in environmental damage or continuing violation—SNC.	AO or judicial action for penalty. Request for criminal investigation.
Discharge without a permit or approval.	Continuing violation with known environmental or POTW damage—SNC.	Judicial action and penalty. Request for criminal investigation. Disconnect from sewer.

LOV: Letter of Violation  
 AO: Administrative Order

**NONCOMPLIANCE DETECTED THROUGH INSPECTIONS OR FIELD INVESTIGATIONS**

NONCOMPLIANCE	CIRCUMSTANCES	RANGE OF RESPONSE
Minor violation of analytical procedures.	Any instance.	LOV.
Major violation of analytical procedures.	No evidence of intent.	LOV or AO.
Major violation of analytical procedures.	Evidence of negligence or intent—SNC.	AO or judicial action and penalty (possible criminal action).
Minor violation of permit condition.	No evidence of negligence or intent.	LOV. Immediate correction required.
Minor violation of permit condition.	Evidence of negligence or intent—SNC.	AO or judicial action and penalty (possible criminal action).
Major violation of permit condition.	Evidence of negligence or intent—SNC.	AO or judicial action and penalty (possible criminal action). Sewer ban.

**CALIFORNIA GOVERNMENT CODE**

Cities, Counties, and Other Agencies 54739

54737. Affirmative vote required to approve contract

The affirmative vote of four-fifths of the legislative body is required to approve the contracts.  
Added Stats 1970 ch 1249 2.4  
Prior Law: Based on:

- (a) Former 54812, as added by Stats 1949 ch 81 1.
- (b) Stats 1947 ch 1470 5.

54738. Contracts with industrial establishment for sewage facilities to abate water pollution: Payment by industrial establishment.

When determined by its legislative body to be in the public interest or necessary for the protection of the public health, the local agency may enter into and perform contracts, not to exceed a term of 40 years, with any industrial establishment for the provision and operation by the local agency of sewerage facilities to abate or reduce the pollution of water caused by discharges of industrial waste by the industrial establishment and the payment periodically or otherwise by the industrial establishment to the local agency of amounts at least sufficient, in the determination of such legislative body, to compensate the local agency for the cost of providing, including any payment of principal and interest charges, and of operating and maintaining the sewerage facilities serving such industrial establishment, or such portion of such cost as the legislative body determines is fair and equitable. Such contracts may be made irrespective of whether bonds are issued in connection therewith.

Added Stats 1970 ch 1249 2.4.  
Prior Law: Based on Former 54813, as added by Stats 1949 ch 1555 2.

54739. Requiring pretreatment and prevention measures respecting industrial waste.

- (1) Any city, county, municipal utility district, public utility district, sanitary district, county sanitation district, or any municipal or public district authorized to acquire, construct, own, or operate a sanitation system, a sewer system, or both, may require:

LOV: Letter of Violation  
AO: Administrative Order

- (a) Pretreatment of any industrial waste which would otherwise be detrimental to the treatment works or its proper and efficient operation and maintenance; or
- (b) The prevention of the entry of such waste into the collection system and treatment works; or
- (c) The payment of excess costs to the system for supplementary treatment plants, facilities, or operations needed as a result of allowing the entry into the collection system and treatment works of such industrial waste.

54739 LOCAL AGENCIES

- (2) The provisions of this section shall be in addition to other requirements provided for in the respective enabling acts of those special districts listed in subdivision (1).

Added Stats 1971 ch 924 1.  
Cross References:

Civil liability for violations: 5474054740. Civil liability for violation: Agency's petition to court, and proceedings thereon

- (a) Any person who intentionally or negligently violates any requirement adopted or ordered by a local agency pursuant to paragraph (a) or (b) of subdivision (1) of Section 54739 may be civilly liable in a sum of not to exceed six thousand dollars (\$6,000) for each day in which such violation occurs.
- (b) The local agency may petition the superior court to impose, assess and recover such sums. In determining such amount, the court shall take into consideration all relevant circumstances, including, but not limited to, the extent of harm caused by the violation, the nature and persistence of the violation, the length of time over which the violation occurs, and corrective action, if any.

Added Stats 1972 ch 813 6.  
Prior Law: Based on former H & S C 4766.5, 6523.01, as added by Stats 1971 ch 924 2 3.  
Collateral References:

Law Review Articles:  
Review of Selected 1972 Code Legislation. 4 Pacific IJ 502 54750-54771. Added by Stats 1963 ch 1810 1 and repealed by Stats 1965 ch 587 9.

**Summary of Enforcement Actions**

As part of the background information for the issuance of Federal administrative orders, a general review of the legal authorities agencies may use to prosecute industrial dischargers are provided. The EPA exercises control over indirect industrial dischargers to the treatment works according to Section 309 of the Clean

Water Act. The EPA may initiate either criminal or civil actions against the offending discharger (according to the nature of the violation). The County District Attorney acts as the public prosecutor for criminal offenses and is capable of exercising fairly broad discretion as to which actions are to be pursued; this legal authority is provided by Section 26500 of the Government Code. In some local cities, the City Attorney's office will prosecute industrial wastewater discharge violations which are misdemeanors. Civil actions against industrial dischargers which are authorized by the Government Code (in particular Section 54740) and the Health and Safety Code are to be handled by the POTW's counsel.

**Discussion**

The Clean Water Act, as contained in Public Law 95-217, provides for the Administrator of the EPA to initiate either criminal or civil actions against industrial dischargers which violate Federal pretreatment standards. This Federal action is defined in Section 309 of Public Law 95-217. Administrative Orders can be issued under Section 309 (a)(3) which provides in part that the Administrator "shall issue an order requiring such person (i.e., the violating industrial discharger) to comply with such section or requirement, or he shall bring a civil action in accordance with subsection (b) of this section." Failure to comply with an Administrative Order could subject the industrial discharger to civil penalties not to exceed \$10,000 per day of such violation. These EPA enforcement remedies may be escalated to criminal actions if the discharger willfully or negligently violated pretreatment standards. If it can be shown that the discharge violation resulted from a conscious action, which was not accidental or involuntary on the part of the discharger, according to Section 309 (c)(1), the responsible parties "shall be punished by a fine of not less than \$2,500 nor more than \$25,000 per day of violation, or by imprisonment for not more than one year, or by both."

In addition to the above, the Administrator of the EPA is also authorized (according to Section 309(b)) to commence civil action, which may involve "appropriate relief, including a permanent or temporary injunction." The U.S. Attorney's office may initiate civil prosecution; the appropriate relief in these instances would be for the offending discharger to pay damages in the amount of the savings incurred from the delay in compliance.

The public prosecutor (usually the District Attorney) is responsible for pursuing criminal actions within the POTW's service area. Criminal complaints filed in a municipal court must be "approved, authorized or concurred in by the district attorney before they are effective" according to Section 26500 of the Government Code. The district attorney is given a relatively broad discretion as to which actions are to be pursued. The district attorney will not act as a collection agency for the POTW and will not pursue civil cases.

Most POTW referrals to the County District Attorney involve violations of the "Wastewater Ordinance" which are misdemeanors. Section 4766 of the Health and Safety Code, as amended in 1976, specifies "A violation of a regulation or ordinance of a district is a misdemeanor, punishable by a fine not to exceed one thousand dollars (\$1,000), imprisonment not to exceed 30 days or both." Each day of violation is considered a separate offense. In some instances involving the discharge of hazardous material as defined by Section 25189.5 of the Health and Safety Code, the criminal complaint may be filed as a felony.

Most criminal actions are referred to the District Attorney for prosecution; however, if a violation of the "Wastewater Ordinance"

occurred in a city which has assumed responsibility for taking misdemeanor cases, the violation would be handled by the city attorney.

For those cases determined to be civil actions covered by the Health and Safety Code and the Government Code, the POTW's counsel would pursue appropriate actions. This situation would apply not only to strict monetary disputes, but also to actions covered by Section 54740 of the Government Code. Section 54740 states that "(a) Any person who intentionally or negligently violates any requirement adopted or ordered by a local agency pursuant to paragraph (a) or (b) of subdivision (1) of Section 54739 may be civilly liable in a sum not to exceed six thousand (\$6,000) for each day in which such violation occurs."

In those instances involving concurrent prosecutions of violations of the Federal pretreatment standards (i.e., prosecutions by both the U.S. Attorney and District Attorney), it is assumed that the prosecution under the Clean Water Act would take precedence due to the larger fines authorized. However, if a discharge of pollutants involved violations of both the local limits and the Federal pretreatment standards, it is believed that both the U.S. Attorney and District Attorney could pursue concurrent actions.

**Basic Public Relations**

There are many people in this country that are now financially well off, even rich, from seminars dealing with dealing with people. Most of those seminars seem to boil down to a few common sense tenets. The IWI has an added factor in dealing with the "general public", and that is the wide range of people that the job requires you to interact with. One interaction might be with a corporate vice president resisting a pretreatment system and the next may be from a retired schoolteacher complaining about the latest sewer service rate increase.

Common sense and the golden rule apply to both public contacts above. In all dealings with the public one must be a good listener and try to put yourself in their place and understand their concerns and viewpoints. Many times the public is incompletely informed of the facts in which case tact and persuasion are invaluable personal attributes. Time constraints may prevent you for spending as much time as desirable with each public contact, so concise articulation is another fine quality to possess.

Many adversarial public contacts can be avoided by endeavoring to be fair, reasonable and consistent in ones day to day duties. As a balancing viewpoint the IWI needs to consider not merely the concerns of those who are noncompliant but also the viewpoint of those who are. The IWI must not bestow an unfair competitive advantage to the noncomplier. In interacting with the "squeaky wheels" consider how best to deal with them to make them nonsqueakers.

The IWI's individual outlook and personality will have a great deal to do with how successful he/she is in dealing with the public. It is helpful if one considers each public contact as a customer needing assistance.

In dealing with industrial representatives your personal contact with that person or persons is crucial. You are viewed by the industry as representing your agency. What you say and do may affect your agencies relations with with a particular industry for years to come. The tone of your relationship should be a cooperative and friendly one if at all possible. Adversarial relationships are counterproductive and should be avoided where possible. Good communications with your customers will assure their cooperation if you can show a need for an action that you require. Most people will give their full cooperation once you have established that a real need exists.

**COMPARISON: SIGNIFICANT VIOLATION TO  
SIGNIFICANT NONCOMPLIANCE**

*From EPA Pretreatment Compliance Monitoring  
and Enforcement Guidance  
(Dated July, 1986)*

Significant Violation	Significant Noncompliance
<ul style="list-style-type: none"> <li>• A violation that remains uncorrected 45 days after notification of noncompliance.</li> <li>• That is part of a pattern of noncompliance over a 12 month period.</li> </ul>	<p>Chronic Violations. Sixty-six percent or more of the measurements exceed the same daily maximum limit or the same average limit in a 6-month period.</p> <p>Technical Review Criteria (TRC) Violations. Thirty-three percent or more of the measurements exceed the same daily maximum limit or the same average limit by more than the TRC in a 6-month period.</p>
<ul style="list-style-type: none"> <li>• That involves a failure to accurately report noncompliance.</li> </ul>	<p>Failure to provide reports for compliance schedules, self-monitoring data, permit applications data, or categorical standards (baseline monitoring reports, 90-day compliance reports, and periodic reports) within 30 days from the due date.</p>
<ul style="list-style-type: none"> <li>• That resulted in the POTW exercising its emergency authority under Section 403.8(f)(1)(vi)(B).</li> </ul>	<p>Any discharge of a pollutant that has caused imminent endangerment to human health/welfare or to the environment and has resulted in the POTW's exercise of its emergency authority to halt or prevent such a discharge.</p> <p>Any other violation(s) of an effluent limit (average or daily maximum) that the Control Authority believes has caused, alone or in combination with other discharges, interference (e.g., sludge loads) or pass-through, or endangered the health of the sewage treatment personnel or the public.</p> <p>Violations of compliance schedule milestones, contained in a local control mechanism or enforcement order, for starting construction, completing construction, and attaining final compliance by 90 days or more after the schedule date.</p> <p>Any other violation or group of violations that the POTW considers to be significant.</p>

As guidance, EPA recommends that any violation(s) during the previous 12 months that resulted in an industrial user being in Significant Noncompliance, should be considered a Significant Violation.

**THE GRADE IV EXAMINATION**

There is a major change in the material covered by the Grade IV exam, as technical questions are less emphasized in favor of supervisory and management type questions. A person approaching Grade IV certification is assumed to be at or near supervisory level and also assumed to have a good deal of self-motivation. Therefore, supervisory and management material is not presented here. A second reason is the wealth of material, some of it conflicting, that would have to be presented to fairly cover the range of subjects.

The theories on supervising and managing personnel are not only many but also changes with the times. Some of the ideas are rather more universally accepted on the subject and you should be familiar with them.

Other subject areas for the Grade IV candidate include basic budgeting and accounting procedures and definitions. The technical questions for the Grade IV will be a bit more difficult than

the Grade III test and the math questions will be more complex as well.

**PREPARING FOR THE ORAL EXAMINATION**

The oral exam is to be taken by all Grade IV candidates after they pass the written portion of the exam. Each individual passing the written exam will be given two opportunities to pass the oral exam. As passing scores must be obtained on both the written and oral exams before the Grade IV certificate is issued. More details on administration of the Grade IV oral exam are found in Chapter I of this manual.

The oral board will generally consist of three people as follows: one from the IWI vocation, one from the VCP Committee and one of supervisory to management level. The board will not record your responses, but may take notes in the event they are needed for an appeal. The board will have questions as well as baseline answers against which they can judge your response. This will help insure that all candidates are judged against the same criteria.

On the day of the test you will be presented with the questions in written form and allowed twenty minutes to prepare your answers. You will not be allowed to use notes or references of any kind. You will then be given an additional twenty minutes to present your answers to the oral board. The board can be expected to ask additional questions to further investigate your knowledge of the four original subjects.

You will be asked one question in each of the following four areas:

**1. Emergency Preparedness/Safety**

May include earthquake preparedness and response, managing safety programs, contamination of water supply or any other natural or man caused disaster.

**2. Situation Problem Solving in Personal Relations/Supervision**

May include grievances, problem employees, hiring/firing procedures, disciplining employees, motivating employees, managing the boss, etc.

**3. Technical Questions**

May include any of the topics mentioned, Grade I through IV.

**4. Situation Problem Solving in Wastewater Management**

May include budgeting, relationships between disciplines, dealing with regulatory agencies, etc.

It may be very useful to prepare for yourself several questions in each of these areas and present the answers to a panel of your coworkers sometime before the actual exam.

It is essential to realize that you will be judged not only on the technical merit of your answers, but also on the way you present yourself. It is assumed that persons taking the Grade IV oral may represent their agencies and therefore will be judged on their ability to communicate orally and to present themselves professionally. Your dress and manner should be that of a professional when you appear for your Grade IV oral exam.



## CHAPTER XII SAMPLE PROBLEMS

### EQUIVALENTS AND FORMULAS

- 12 inches = 1 foot  
 36 inches = 3 feet = 1 yard  
 5,280 feet = 1 mile  
 1,440 minutes = 24 hours = 1 day  
 144 square inches = 1 square foot  
 9 square feet = 1 square yard  
 43,650 square feet = 1 acre  
 1,728 cubic inches = 1 cubic foot  
 27 cubic feet = 1 cubic yard  
 1 cubic foot of water contains 7.48 gallons and weighs 62.4 pounds  
 1 gallon of water weighs 8.34 pounds  
 1 million gallons per day (MGD) = 694 gallons per minute (GPM)  
 = 1.55 cubic feet per second (CFS)  
 1 milligram per liter (mg/L) approximately equals 1 pound per million pounds  
 3.785 liters = 1 gallon  
 453.6 grams = 1 pound  
 1 gram = 1000 milligrams  
 1000 grams = 1 kilogram  
 1 kilogram = 2.2 pounds  
 28.35 grams = 1 ounce  
 16 ounces = 1 pound
- Flow :  $Q = AV$   
 Area : Rectangle —  $A = LW$   
 Circle —  $A = \pi r^2$
- Circumference of a Circle:  $C = \pi d$
- Volume: Rectangular Solid —  $Vol = LWD$   
 Right Circular Cylinder —  $Vol = \frac{\pi d^2}{4}$
- Q = FLOW  
 A = AREA  
 V = VELOCITY  
 L = LENGTH  
 D = DIAMETER  
 $\pi = 3.14$
- C = CIRCUMFERENCE  
 VOL = VOLUME  
 D = DEPTH  
 R = RADIUS  
 W = WIDTH

### SAMPLE QUESTIONS

(Answers on page 56)

1. Which of the following applies to each of the following sewer gases:  
 Carbon Dioxide, Methane, Hydrogen Sulfide, Ammonia: \_\_\_\_\_  
 a) Odorless    b) Colorless    c) Flammable    d) Toxic

2. Flammable or explosive data in an MSDS (Material Safety Data Sheet) contain information on the range of \_\_\_\_\_ over which a flammable vapor will flash or explode.
1. Boiling points
  2. Concentrations
  3. Solubility Products
  4. Temperatures
  5. Vapor Pressures
3. Which of the following is the minimum diameter of manila rope that CAL OSHA regulations require to be used as a lifeline when entry into a confined space is made?  
 a)  $\frac{3}{8}$  inch    b)  $\frac{1}{2}$  inch    c)  $\frac{5}{8}$  inch    d)  $\frac{3}{4}$  inch    e) 1 inch
4. An orifice or flow nozzle meter can be used for a fully flowing, freely discharging pipe, discharging from a full pipe to the atmosphere.
- True    False
5. Since the Palmer-Bowlus flume has a smaller head loss than a Parshall flume, smaller changes in flow rate are easier and more accurately detected with Palmer-Bowlus flume.
- True    False
6. Head measurements on weirs should be taken at a distance upstream of the weir of twice the maximum expected head to be measured.
- True    False
7. What is the detention time, in minutes, for a 40,000 gpd flow going through a 1500 gallon interceptor?
8. A company is required to take a 24 hour composite sample for its monthly report. The sample volume must be 2 liters, and a sample taken every 30 minutes. If the company's flow is constant over a 24 hour period, how many milliliters of wastewater should be taken every 30 minutes to achieve the final volume of 2 liters?
9. A company has five (5) separate in-house wastewater streams each discharging to the sewer through separate outlets. The flows of the five streams are:

Stream A	20 gpm
B	150 gpm
C	75 gpm
D	50 gpm
E	360 gpm

Assuming the flow rate is steady from each connection, and each stream is to be sampled twelve (12) times and a 5 liter flow composite obtained, what volume per grab sample must be obtained from each waste stream?

10. A company has a wastewater flow of 100,000 gpd in its eight (8) hour day. If the company wants to sample every 20 minutes and have a 3 liter composite sample volume, how many milliliters should be taken every 20 minutes?

11. A pickle packaging plant discharges a sodium chloride brine waste amounting to 10,000 pounds of salt per seven (7) day week. If the POTW's 30 MGD flow has 100 mg/l of Na, what percent of this is from the pickle company?

$$\text{MW: NaCl} = 58.44 \quad \text{Na} = 22.99$$

12. A shampoo manufacturer has a flow rate of 20,000 gallons per day. The B.O.D. of the wastewater is 2,000 mg/l. If the POTW downstream has an influent B.O.D. of 250 mg/l, and an influent flow of 2.6 MGD, what percent of the influent B.O.D. comes from the shampoo manufacturer?

$$\text{POTW flow rate} = 30 \text{ mgd}$$

13. A plating company has a total chromium level of 25 mg/l in their discharge of 40,000 gallons per day. If the downstream POTW has a flow of 45 MGD and a chromium removal rate of 45%, what would be the expected concentration of chromium in mg/l, in the POTW's effluent?

14. A company has a cylindrical tank eight (8) feet in diameter and seven (7) feet tall. The company uses this tank as a detention tank for chromium treatment. The company's flow is 15,000 gallons per 8 hour day. What is the detention time, in minutes, for this tank?

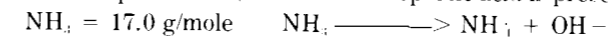
15. A company has a clarifier measuring 10.5 feet  $\times$  6.25 feet  $\times$  4.75 feet. If the company's flow is 30,000 gallons per 8 hour day, what is the detention time for the clarifier?

16. If a company needs a 30 minute detention time for their 100,000 gpd (24 hour day) flow, what size clarifier, in cubic feet, would they need?

17. A company discharges 35,000 gallons per day. The average pH = 2.0. How many gallons of a 25% NaOH (wt/vol) solution would be necessary to maintain a discharge pH of 8.5?

$$\text{M.W. NaOH} = 40.0$$

18. A plating company has a discharge pH of 5.0. Their discharge pH requirement is 6.5. If their daily flow is 30,000 gallons, how many pounds of anhydrous ammonia would be necessary to achieve a pH of 6.5? (Assume a monoprotic acid is present).



19. A battery company uses lime to neutralize their sulfuric acid wastes. If the company has a 50,000 gpd flow, uses 85% slurry of lime for neutralization, and the initial pH is 1.5, how many gallons of 85% lime slurry will the company use?

$$\text{M.W. CaO} = 56.08$$

20. Three industrial plants producing wastes with a high suspended solids content are:

- a) Breweries
- b) Textile dyehouses
- c) Oil fields
- d) Packing houses
- e) Canneries
- f) Laundries

21. For vegetable processing plants, the pounds of BOD produced and discharged in wastewaters per ton of vegetable processed is within which of the following ranges:

- a) 0.1 to 1.0
- b) 1.0 to 10.0
- c) 10.0 to 100.0
- d) 100.0 to 1000.0

22. High strength organic waste from a petroleum or a chemical process industry are usually deficient in some nutrients need-

ed for successful pretreatment by biological oxidation prior to discharge to a POTW. The nutrients usually added to correct this deficiency are:

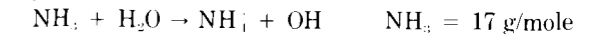
- a) Nitrogen
- b) Phosphorus
- c) Bicarbonate
- d) All of the above
- e) a and b above
- f) b and c above

23. A. What is the COD of a 70% isopropyl alcohol solution (wt./vol. %)?

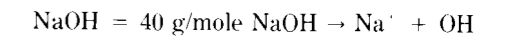
(isopropyl alcohol,  $\text{C}_3\text{H}_8\text{O}$ , MW = 60.1, density = 0.785)

- B. If 300 gallons are dumped into a sewer with a 5 mgd flow, what would be the expected increase in COD in the sewer?

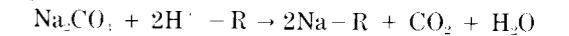
24. How many pounds of anhydrous ammonia are required to neutralize an industrial waste flow of 50,000 gallons per day having a pH of 2.5?



25. How many pounds of NaOH are needed to neutralize an industrial wastewater flow of 35,000 gpd with a pH of 1.0? (Assume a monoprotic acid is present).  
 water



26. How many pounds of soda ash ( $\text{Na}_2\text{CO}_3$ , F.W. = 105.99) would be needed to neutralize an industrial waste flow of 45,000 gpd with a pH of 3.0?



27. A company has a 35,000 gpd discharge in a sixteen hour day. A composite sample of 2 liters is needed. The sampler is set to take 125 ml. each time the pump is activated.

- a. For a flow proportional sample, at what gallon interval should the sampler activate to take a sample?
- b. If the flow rate is constant, how many minutes will there be between samples?

28. A company has five (5) sewer connections with the following discharges:

A	350 gpd
B	75 gpd
C	725 gpd
D	1200 gpd
E	200 gpd

A flow weighted composite sample of 5 liters is desired. How many milliliters should be composited from each connection?

29. If a company's flow is 45,000 gpd at a constant rate in an eight hour day, and a sampler takes 125 ml. of sample for every 1500 gallons of flow, what is the time between pulses and what is the final composite volume?

30. A meat packing plant discharges a B.O.D. strength of 3500 mg/l, suspended solids of 1300 mg/l, and a flow of 45,000 gpd. If the local sewer agency assesses the following charges, what would be the company's yearly sewer service fee (assume company works 260 days per year)?

$$\text{B.O.D.} = \$68.00/\text{lb.}$$

$$\text{S.S.} = \$59.00/\text{lb.}$$

$$\text{Flow} = \$218.00/\text{million gallons}$$

31. A metal finisher has mg/l discharge limitations of: Cu = 3.0, Pb = 2.5, Cr = 5.6, and Ni = 3.3. The company had the following mg/l values in a recent sample taken for sewer use fees: Cu = 15.0, Pb = 3.2, Cr = 18.3, Ni = 6.3. The company's flow is 30,000 gallons per day. The sewer use penalties

per pound discharged over the limitations are:

Cu: \$225.00  
Pb: \$325.00  
Cr: \$250.00  
Ni: \$375.00

What would be the company's monetary penalty per day for exceeding the discharge limitations?

32. A company uses 20,000 gallons per day of water. The company claims the following water loss percentage:

Landscaping 13%  
Evaporative 10%  
Other 5%

The company's B.O.D. and suspended solids concentration are 650 mg/l and 800 mg/l. The following sewer use fees are applied toward this company:

B.O.D. = \$65.00/lb. discharged  
S.S. = \$72.00/lb. discharged  
Flow = \$225.00/MG

What would be the company's annual sewer use fee? Assume the company works 312 days per year.

33. A company is suspected of having an illegal connection to the sewer to dispose of high B.O.D. strength wastes. The company claims a flow of 100,000 gpd with a B.O.D. of 500 mg/l. Monitoring equipment is installed upstream and downstream of the company. The upstream readings were: Flow = 300,000; B.O.D. = 350 mg/l. The downstream sample results were: Flow = 400,000 gallons; B.O.D. = 450 mg/l. Does the company have an illegal connection?

34. A plating company has an underground hard chrome waste recirculation tank closely located to an underground sewer. The company's flow is 25,000 gallons per day with a chromium content of 10.5 mg/l. During routine sewer monitoring upstream and downstream of this company, the following data was obtained:

Flow	Upstream 150,000 gpd	Downstream 175,000 gpd
Chromium Concentration	0.85 mg/l	3.2 mg/l

Could an inspector suspect a leak in the underground chromium tank migrating into the sewer system?

35. A POTW has the capacity to treat 150,000 lbs. of B.O.D. per day. A food processing industry would like to locate within the service district. The company's anticipated industrial waste strength would be: B.O.D. = 3500 mg/l with a flow of 48,000 gpd. If the average B.O.D. into this 30 MGD plant is 450 mg/l, could this new industry come on line without causing overloading problems?

36. List two advantages and two disadvantages that lime has over caustic soda as a precipitating agent for heavy metals treatment.

37. The National EPA pretreatment standards are the most stringent pretreatment requirements that a POTW can impose on an industrial waste discharger.

True False

38. How much sulfur dioxide is required to treat 1,100 gallons of chromic acid containing 1,400 mg/L of hexavalent chromium? Assume that one pound of hexavalent chromium is reduced to

the trivalent state by the addition of three pounds of sulfur dioxide.

39. A company that reclaims lead has an industrial waste discharge of 65,000 gpd, containing an average of 7,500 mg/l of sulfite (measured as sulfite sulfur). The company works 250 days per year. The local sewage agency has an industrial waste revenue program that charges \$23.50 per thousand pounds of COD. How much surcharge does this company pay each year from the sulfite discharge? (MW of sulfur = 32.)

40. For a multiple tank counterflow rinse system the following relationship exists:

$$\frac{C_p}{C_n} = R^n$$

Where  $C_p$  = plating bath concentration  
 $C_n$  = concentration in the nth rinse tank  
 $R$  = rinse ratio; (ratio of rinse water volumetric flowrate to the drag out volumetric flow rate)  
 $n$  = Number of rinse tanks

Given a)  $C_p$  = 20 oz./gal  
b)  $C_n$  = .005 oz./gal  
c) drag out flow rate = 2 gal/hr

Find 1) What GPM rinse rate must be used to allow "b" to be true using one (1) rinse tank?  
2) How many rinse tanks must be used to keep rinse-sewer flowrate < 5 GPM?

41. A radiator shop has a 500 gal. muriatic acid cleaning tank with a pH of 2.5. The company wants to drain the tank to the sewerage system. The company also has a 200 gal. caustic tank, NaOH, pH = 11.9, that needs to be drained. If the caustic tank is set for one gallon per minute, what must be the flow from the acid tank to maintain a pH of 7.0? How long will the draining take?

42. A zinc plater has a 24 hrs. daily flow of 30,000 gpd. with a discharge pH of 4.0. If the company has a 4,000 gal. anhydrous ammonia tank for neutralization, how many days will the tank last if the pH of the discharge must remain at 7.0, and how many pounds per hour of ammonia would be used?

$\text{NH}_3$ , M.W. = 17 Density  $\text{NH}_3$  = 0.7710 g/ml

43. An anodizing shop is required to maintain a discharge pH of 6.5 for their flow of 45,000 gpd. The company uses sulfuric acid as their neutralizing agent. If the company has a 1,000 gal. acid storage tank, what minimum molar concentration of  $\text{H}_2\text{SO}_4$  would be needed to insure that 1000 gal. of acid would be sufficient to neutralize the entire days caustic tainted flow of pH 11.5?

$\text{H}_2\text{SO}_4$ , M.W. = 98 NaOH = 40 g.

44. A company is required to construct an outdoors spill containment system. The containment area must minimally be able to hold 1) double the volume of the following tanks:

A. Cylindrical 8 ft. high, 8 ft. in diameter  
B. Square tank 6' x 6' x 6'  
C. Rectangular tank 20' x 4' x 3'

Also 2) a 12" rainfall in a 24 hours period

If the owner has a 200' x 200' pad/area and if the owner of the company wants a 15" wall maximum height, will the containment area be sufficient?

## ANSWERS

1. a) Odorless
- 2) Concentrations
- b) 1/2 inch
4. False
5. False (i.e., smaller changes in flow rate are easier and more accurately detected with the Palmer-Bowlus flume than the Parshall flume)
6. False
7. Solution:  $V = Q \times t$

$$t = V/Q = \frac{1,500 \text{ gallons}}{40,000 \text{ gpd}} \times 1440 \text{ minutes/day}$$

$$t = 54 \text{ minutes}$$

8. Since company's flow is constant, calculate total number of discrete samples for composite.

$$24 \text{ hours} \times \frac{60 \text{ minutes}}{\text{hour}} \times \frac{1 \text{ sample}}{30 \text{ minutes}} = 48 \text{ samples}$$

If 48 samples are needed and you need 2,000 ml's final volume, then:

$$\frac{2,000 \text{ ml}}{48 \text{ samples}} = 41.67 = 41.7 \text{ ml/sample}$$

9. First (1), Total up Volume

	(1)	(2)	(4)	(6)
A	20	20/655 = 0.0305	152.5	12.7 ml
B	150	150/655 = 0.2290	1145.0	95.4 ml
C	75	75/655 = 0.1145	572.5	47.7 ml
D	50	50/655 = 0.0763	381.5	31.8 ml
E	360	360/655 = 0.5496	2748.0	229.0 ml
	655 gpm	(3) 0.9999	(5) 4999.5	(7) 4999.2 ml

Second (2), calculate what percentage of the total each connection is.

Third (3), quickly add (2). The total should be very close to one.

Fourth (4), the final volume must be 5 liters or 5,000 milliliters. Multiply each value in (2) by 5,000 ml to obtain total ml's needed from each connection.

Fifth (5), quickly add (4) — answer should be very close to 5,000 milliliters.

Sixth (6), divide each total in (4) by 12 to obtain grab volume for each waste stream.

Seventh (7), as a final check add all numbers in (6). The answer should be close to 5,000 ml.

10. Total number of samples needed

$$8 \text{ hours} \times \frac{60 \text{ minutes}}{\text{hour}} \times \frac{1 \text{ sample}}{20 \text{ minutes}} = 24 \text{ samples}$$

Number of milliliters per sample

$$\frac{3,000 \text{ ml}}{24 \text{ samples}} = 125 \text{ ml}$$

11. Amount of NaCl discharged in one day

$$\frac{10,000 \text{ lb.}}{7 \text{ day}} = 1428.6 \text{ lbs/day of NaCl}$$

Note: Question asks for Na; NOT NaCl or Cl

$$\frac{22.9 \text{ g/mole Na}}{58.44 \text{ g/mole NaCl}} = 0.3934 \text{ ratio of Na to NaCl by weight}$$

$$1428.6 \text{ lbs. NaCl} \times 0.3934 = 562.01 \text{ lbs. Na}$$

Na contribution by Industry to POTW:

$$\frac{562.01 \text{ lbs. Na} \times \frac{453,600 \text{ mg}}{\text{lb.}}}{30,000,000 \text{ gal.} \times 3.785 \text{ l/gal}} = 2.25 \text{ mg/l Na}$$

% Contribution:

$$\frac{2.25 \text{ mg/l Na}}{100 \text{ mg/l}} \times 100 = 2.25\%$$

12. Flow = 20,000 gal/day

B.O.D. = 2,000 mg/l

lbs B.O.D.: To convert flow and concentration to pounds, you take the flow in million gallon units and the concentration in mg/l and multiply by 8.34.

$$0.020 \text{ mgd.} \times 2,000 \text{ mg/l} \times 8.34 = 333.6 \text{ lbs B.O.D./day}$$

To explain the 8.34:

$$0.020 \text{ MG/d} \times \frac{1,000,000 \text{ gal}}{\text{MG}} \times \frac{3.785 \text{ liter}}{\text{gal}} \times \frac{2000 \text{ mg}}{\text{liter}} \times \frac{1 \text{ lb.}}{453,600 \text{ mg}}$$

Three fractions are constants; therefore, multiplying them out and cancelling units you get:

$$(\text{flow}) \text{ MG/d} \times \frac{1,000,000 \text{ gal}}{\text{MG}} \times \frac{3.785 \text{ l}}{\text{gal}} \times (\text{conc}) \text{ mg/l} \times \frac{1 \text{ lb.}}{453,600 \text{ mg}} = 8.343562 \times (\text{flow}) \times (\text{conc}) = \text{lb/day}$$

or 8.34

On with the problem → Influent % B.O.D.  $\frac{333.6}{5421.0} \times 100 = 6.15\%$

13. Total amount of chromium discharged:

Co. flow = 40,000 GPD = 0.040 MGD

[Cr] = 25 mg/l

$$0.040 \text{ MGD} \times 25 \text{ mg/l} \times 8.34 = 8.34 \text{ lbs./day}$$

POTW has a 45% removal rate for CR

$$8.34 \text{ lbs./day} \times 0.45 = 3.753 \text{ lbs. removed}$$

8.34 - 3.753 = 4.587 lbs. remaining in POTW's discharge

Cr contribution in POTW's discharge from I.W. =

$$\frac{4.587 \text{ lbs.} \times 453,600 \text{ mg/lb}}{45,000,000 \text{ gal.} \times 3.785 \text{ l/gal.}} = 0.012 \text{ mg/l}$$



28.

	% of flow			Volume per connection
A	350	350/2550	= 0.1373	× 5,000 ml = 686.5 ml
B	75	75/2550	= 0.0294	× 5,000 ml = 147.0 ml
C	725	725/2550	= 0.2843	× 5,000 ml = 1421.5 ml
D	1200	1200/2550	= 0.4706	× 5,000 ml = 2353.0 ml
E	200	200/2550	= 0.0784	× 5,000 ml = 392.0 ml
Total: 2550 gallon/day				5000.0

answer checks

29. 45,000 gallons of flow in 8 hrs

$$\frac{45,000 \text{ gal}}{1,500 \text{ gal}} = 30 \text{ pulses}$$

8 hrs × 60 min/hr = 480 minutes in working day

$$\frac{480 \text{ min}}{30 \text{ pulses}} = 16 \text{ minutes/pulse OR}$$

16 minutes between pulses

$$\frac{125 \text{ ml}}{\text{pulse}} \times 30 \text{ pulses} = 3750 \text{ ml or } 3.75 \text{ liter total composite sample volume}$$

30. B.O.D. pounds per year:  
 3500 mg/l × 0.045 MGD × 8.34 × 260 day/year = 341,523 lbs/year  
 S.S. pounds per year:  
 1300 mg/l × 0.045 MGD × 8.34 × 260 day/year = 126,851.4 lbs/year  
 Flow in MG per year:

$$\frac{45,000 \text{ gallons}}{\text{day}} \times \frac{260 \text{ days}}{\text{year}} \times \frac{1 \text{ MG}}{1,000,000 \text{ gal}} = 11.7 \text{ MGY flow}$$

Total yearly sewer charges:

B.O.D.	\$68.00/lb	×	341,523	=	23,223,564.00
S.S.	\$59.00/lb	×	126,851.4	=	7,484,232.60
Flow	\$218/MG	×	11.7	=	2,550.60
					\$30,710,347.20

31. To calculate pounds multiply flow in MGD, times concentration in mg/l times 8.34. Example: Cu 0.030 MGD × 3.0 mg/l × 8.34 = 0.75 lbs/day.

Constituent	conc. limit	lbs/day allowed	conc. observed	lbs/day observed	lbs/day over compliance
Cu	3.0	0.75	15.0	3.75	3.00
Pb	2.5	0.63	3.2	0.80	0.17
Cr	5.6	1.40	18.3	4.58	3.18
Ni	3.3	0.83	6.3	1.58	0.75

Element	dollars/lbs over	lbs over	Total
Cu	225.00	3.00	\$675.00
Pb	325.00	0.17	55.25
Cr	250.00	3.18	795.00
Ni	375.00	0.75	281.25
			\$1806.50/day

32. Total yearly flow:  
 20,000 gal/day × 312 day/year = 6,240,000 gallons per year  
 Total water losses:  
 10% + 13% + 5% = 28%

Net water to sewer = (6,240,000)(1 - 0.28) = 4,492,800 gal/year  
 B.O.D. charges:  
 650 mg/l × 4.4928 MGY × 8.34 × \$65.00/lb = \$1,583,105.40/year  
 S.S. charges:  
 800 mg/l × 4.4928 MGY × 8.34 × \$72.00/lb = \$2,158,269.20/year  
 Flow charges:  
 4.4928 × \$225.00/MG = \$1010.88  
 Total Yearly Charge = \$3,742,385.48

33. Monitoring upstream:  
 flow = 300,000 gpd  
 B.O.D. = 350 mg/l  
 Therefore 0.30 MG × 350 mg/l × 8.34 = 875.7 lbs B.O.D./day  
 downstream:  
 flow = 400,000 gpd  
 B.O.D. = 450 mg/l  
 Therefore 0.40 MG × 450 mg/l × 8.34 = 1501.2 lbs B.O.D./day  
 The theoretical flow and B.O.D. discharge from the company would be:  
 flow 400,000 - 300,000 = 100,000 gpd  
 B.O.D. 1501.2 - 875.7 = 625.5 lbs/day  
 The company claims their flow = 100,000 gpd with a B.O.D. of 500 mg/l. Therefore, B.O.D. lbs/day = 0.10 × 500 × 8.34 = 417 lbs/day  
 The flow reported from this company is correct, however, the difference in lbs of B.O.D. discharged is 625.5 - 417 = 208.5 lbs/day B.O.D. The company therefore has a small flow, very high strength illegal connection.

34. monitoring upstream:  
 flow = 150,000 gpd  
 [Cr] = 0.85 mg/l  
 Total pounds of Cr = 0.15 MG × 0.85 × 8.34 = 1.06 lbs/day  
 downstream:  
 flow = 175,000 gpd  
 [Cr] = 3.2 mg/l  
 Total pounds of Cr = 0.175 MG × 3.2 mg/l × 8.34 = 4.67 lbs/day  
 company's Cr discharge:  
 25,000 gpd  
 [Cr] = 10.5 mg/l  
 Total known pounds/day discharged from company = 0.025 MG × 10.5 mg/l × 8.34 = 2.19 lbs/day  
 Net pounds of chromium in sewer downstream of company:  
 4.67 lbs - 1.06 lbs = 3.61 lbs  
 company discharges 2.19 lbs/day Therefore,  
 3.61 - 2.19 = 1.42 lbs/day of chromium unaccounted for.  
 An industrial waste inspector could suspect Cr intrusion into the sewer from this tank.

35. Total existing B.O.D. loading of the P.O.T.W.:  
 Flow = 30 MGD  
 B.O.D. = 450 mg/l  
 30 MG × 450 × 8.34 = 112,590 lbs B.O.D./day  
 Proposed I.W. discharge:  
 Flow = 48,000 gpd  
 B.O.D. = 3,500 mg/l

Total proposed lbs discharged = 0.048 × 3,500 mg/l × 8.34 = 1401.1 lbs/day  
 The POTW's maximum treatment capability is 150,000 lbs/day of B.O.D. Adding the existing B.O.D. loading with the proposed:  
 112,590 + 1401.1 = 113,991.1 lbs/day  
 Based on this information the treatment plant could accept the additional B.O.D.

36. Advantages:  
 1) Less expensive  
 2) Less dangerous to handle  
 Disadvantages:  
 1) More difficult to handle, must be slaked  
 2) Larger amounts of sludge are formed

37. False

38. Known: Waste, gal = 1,100 gal  
 Conc, mg/L = 1,400 mg Cr<sup>6+</sup>/L  
 Treat, lbs/lb = 3 lbs SO<sub>2</sub>/lb Cr<sup>6+</sup>  
 Unknown: Dosage, lbs SO<sub>2</sub>  
 1. Calculate the pounds of Cr<sup>6+</sup> to be treated:  
 Cr<sup>6+</sup> Treated, lbs = (Waste, MG)(Cr<sup>6+</sup>, mg/L)(8.34 lbs/gal) = (0.0011 MG)(1,400 mg/L)(8.34 lbs/gal) = 12.8 lbs Cr<sup>6+</sup>  
 2. Calculate the dosage of sulfur dioxide:  
 Dosage, lbs SO<sub>2</sub> = (Cr<sup>6+</sup> Treated, lbs)(3 lbs SO<sub>2</sub>/lb Cr<sup>6+</sup>) = (12.8 lbs Cr<sup>6+</sup>)(3 lbs SO<sub>2</sub>/lb Cr<sup>6+</sup>) = 38.4 lbs SO<sub>2</sub>

39. Oxidation of sulfite to sulfate: SO<sub>3</sub><sup>2-</sup> → SO<sub>4</sub><sup>2-</sup>  
 balancing oxygen by adding H<sub>2</sub>O:  
 H<sub>2</sub>O + SO<sub>3</sub><sup>2-</sup> → SO<sub>4</sub><sup>2-</sup>  
 balancing hydrogen by adding H<sup>+</sup>:  
 H<sub>2</sub>O + SO<sub>3</sub><sup>2-</sup> → SO<sub>4</sub><sup>2-</sup> + 2H<sup>+</sup>  
 balancing charge by adding e-:  
 H<sub>2</sub>O + SO<sub>3</sub><sup>2-</sup> → SO<sub>4</sub><sup>2-</sup> + 2H<sup>+</sup> + 2e-  
 There are 2 equivalents per mole of SO<sub>3</sub><sup>2-</sup>; also, there are 8,000 mg of COD per equivalent  

$$\frac{7500 \text{ mg}}{\text{liter}} \times \frac{\text{mole}}{32,000 \text{ mg}} \times \frac{2 \text{ equivalents}}{\text{mole}} \times \frac{8,000 \text{ mg COD}}{\text{equivalent}} \times \frac{3.785 \text{ l}}{\text{gallon}} \times \frac{65,000 \text{ gal}}{\text{day}} \times \frac{250 \text{ days}}{\text{year}} \times \frac{1 \text{ g}}{1,000 \text{ mg}} \times \frac{\text{lb}}{\text{thou. pounds}} \times \frac{\text{thou. pounds}}{\$23.50} = 453.6 \text{ gm}$$
  
 \*\* company pays \$11,949.38 per year for the COD contributed by the sulfite

40. 1) 
$$\frac{C_p}{C_n} = \left( \frac{\text{rinse rate}}{\text{drag-out rate}} \right)^n$$
  

$$\frac{20 \text{ oz/gal}}{.005 \text{ oz/gal}} = \left( \frac{x \text{ gal/hour}}{2 \text{ gal/hour}} \right)^1$$
  

$$\text{rinse rate} = x = \frac{(20)(2)}{.005} = 8,000 \text{ gal/hour} \times \frac{1 \text{ hour}}{60 \text{ minutes}} = 133 \text{ GPM}$$

2) 
$$\frac{C_p}{C_n} = \left( \frac{\text{rinse rate}}{\text{drag-out rate}} \right)^n$$
  

$$\frac{20 \text{ oz/gal}}{.005 \text{ oz/gal}} = \left( \frac{5 \text{ gal/min}}{2 \text{ gal/hr (1 hr/60 min)}} \right)^n$$
  
 4000 = 150<sup>n</sup>  
 log 4000 = n log 150  

$$\frac{\log 4000}{\log 150} = n$$
  

$$\frac{3.602}{2.176} = n = 1.66 \text{ tanks} \rightarrow \text{round to } 2 \text{ tanks}$$

41. Acid tank: 500 gal, pH 2.5  
 pH = -log [H<sup>+</sup>]  
 2.5 = -log [H<sup>+</sup>]  
 10<sup>-2.5</sup> = [H<sup>+</sup>] = 3.162 × 10<sup>-3</sup> M [H<sup>+</sup>]  
 Total moles: 3.162 × 10<sup>-3</sup> M × 500 gal × 3.785 l/gal = 5.984 moles [H<sup>+</sup>]  
 Caustic tank = 200 gal pH 11.9  
 pOH = -log [OH<sup>-</sup>]      pOH = 14 - pH  
 (14 - 11.9) = -log [OH<sup>-</sup>]  
 2.1 = -log [OH<sup>-</sup>]  
 10<sup>-2.1</sup> = [OH<sup>-</sup>] = 7.943 × 10<sup>-3</sup> M = [OH<sup>-</sup>]  
 Total moles OH<sup>-</sup> = 7.943 × 10<sup>-3</sup> × 200 gal × 3.785 l/gal = 6.01 moles OH<sup>-</sup>  
 The total moles of H<sup>+</sup> approximately equals the total moles of OH<sup>-</sup>, therefore, the time necessary to drain both tanks must be equal.

$$\frac{500 \text{ gal H}^+}{200 \text{ gal OH}^-} = 2.5 \quad \text{The acid tank must be drained } 2.5 \text{ times faster than the caustic tank.}$$

If the caustic tank is set for 1 gpm, the acid tank must be set for 1 × 2.5 = 2.5 gpm.  
 To check: H<sup>+</sup> = 2.5 gpm × 3.785 l/gal 3.162 × 10<sup>-3</sup> M  
 = 0.0299 moles/minute H<sup>+</sup>  
 OH<sup>-</sup> = 1 gpm × 3.785 l/gal × 7.943 × 10<sup>-3</sup> M  
 = 0.0301 moles/minute OH<sup>-</sup>

42. 30,000 gal of pH 4.0  
 pH = -log [H<sup>+</sup>]  
 4.0 = -log [H<sup>+</sup>]  
 10<sup>-4</sup> = [H<sup>+</sup>]  
 Total moles H<sup>+</sup> = 10<sup>-4</sup> moles/l × 30,000 gal × 3.785 l/gal = 11.355 moles H<sup>+</sup>

$$\frac{30,000 \text{ gal}}{24 \text{ hrs} \times 60 \text{ min/hr}} = 20.833 \text{ gpm}$$

$$\text{moles H}^+/\text{min} = \frac{11.355}{24 \times 60} = 7.885 \times 10^{-3} \text{ moles H}^+/\text{minute}$$

NH<sub>3</sub> → aq. → NH<sub>4</sub><sup>+</sup> + OH<sup>-</sup>      Density = 0.7710 g/mal

$$4,000 \text{ gal} \times \frac{3785 \text{ ml}}{\text{gal}} \times \frac{0.7710 \text{ g}}{\text{ml}} \times \frac{1 \text{ lb}}{453.6 \text{ g}}$$

$$\text{NH}_3 = 25734 \text{ lbs} \Rightarrow 25734 \times 453.6 \text{ g/lb} = 11,672,940 \text{ g}$$

$$\text{moles NH}_3 = \frac{11,672,940 \text{ g}}{17 \text{ g/mole}} = 686643.52 \text{ moles}$$

One mole of H<sup>+</sup> will react with one mole NH<sub>3</sub>:

$$\frac{686643.52 \text{ moles NH}_3}{7.885 \times 10^{-3} \text{ moles H}^+ \text{ minute}} = \frac{87,082,247}{60} = \text{hours NH}_3 \text{ tank can last}$$

$$= 1451370.7 \text{ hours}$$

$$\frac{25,734 \text{ lbs}}{1451370.7 \text{ hrs}} = 0.0177 \text{ lbs/hr}$$

$$\text{Total minutes NH}_3 \text{ tank can last: } \frac{87082247 \text{ minutes}}{60 \text{ min/hr} \times 24 \text{ hr/day}}$$

$$\frac{60473.8 \text{ days}}{365} = 165.68 \text{ years}$$

43. 45,000 gpd at pH 11.5

$$\begin{aligned} \text{pOH} &= 14 - \text{pH} \\ &= 14 - 11.5 \\ &= 2.5 \end{aligned}$$

$$\begin{aligned} \text{pOH} &= 14 - \text{pH} \\ &= 14 - 6.5 \\ &= 7.5 \end{aligned}$$

$$\begin{aligned} 2.5 &= -\log [\text{OH}^-] \\ 10^{-2.5} &= [\text{OH}^-] \end{aligned}$$

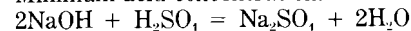
$$\begin{aligned} 7.5 &= -\log [\text{OH}^-] \\ 10^{-7.5} &= [\text{OH}^-] \end{aligned}$$

$$10^{-2.5} - 10^{-7.5} = \text{net amount of OH}^- \text{ to be neutralized}$$

$$= 3.162 \times 10^{-3} \text{ M concentration of OH}^-$$

$$** 45,000 \text{ gal} \times 3.785 \text{ l/gal} \times 3.162 \times 10^{-3} \text{ M} = 538.57 \text{ moles OH}^- \text{ to be neutralized}$$

Minimum acid concentration:



1 mole of H<sub>2</sub>SO<sub>4</sub> will react with 2 moles of NaOH. If there is 538.57 moles OH<sup>-</sup> to be neutralized you need 538.57/2 = 269.285 moles H<sub>2</sub>SO<sub>4</sub> needed

$$\frac{269.285 \text{ moles}}{1,000 \text{ gal} \times 3.785 \text{ l/gal}} = 0.071 \text{ M H}_2\text{SO}_4 \text{ minimally}$$

44. Area of cylinder =  $\pi r^2 \times h$

$$\text{A. } v = \pi r^2 h \times 7.48 \text{ gal/ft}^3 \times 2 = (3.14)(16)(8)(7.48)(2) = 6015.8 \text{ gal}$$

$$\text{B. } (6 \times 6 \times 6) \times 7.48 \times 2 = 3231.4 \text{ gal}$$

$$\text{C. } (20 \times 4 \times 3) \times 7.48 \times 2 = 3590.4$$

$$12'' \text{ rainfall in } 200 \times 200 \text{ area} = 200 \times 200 \times 1 \times 7.48 = 299,200 \text{ gal}$$

containment area must hold:

$$\begin{aligned} 6015.8 & \text{ volume of area with } 15'' \text{ wall} = (200 \times 200 \times \\ 3231.4 & \quad 15/12) \times 7.48 = 374,000 \text{ gal} \\ 3590.4 & \\ 299,200.0 & \\ 312,037.6 & \text{ gal} \end{aligned}$$

Spill containment area will be sufficient.

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