ABC

Exam Review

This study review guide is not a replacement for study materials gained through course work, classes and job experience. This publication is provided as an aide to prepare for the ABC Wastewater Certification exam.

*Study guide courtesy of Morrisville State College

Lecture

And

Content

Outline

Section I: Basic Wastewater Treatment Concepts

Lecture Outline

1. What is pure water?

2. Wastewater characteristics:

   Bacteriological

   Physical

   Chemical

3. Types of waste discharges

   Domestic

   Industrial

4. Measuring wastewater characteristics:

   BOD

   Settleable solids

Suspended solids

Dissolved solids

Total solids

Volatile solids

Other tests

5. Example composition of solids in medium strength raw sewage

Organic

Suspended solids

Dissolved solids

Inorganic

Suspended solids

Dissolved solids

Total solids

6. Objectives of wastewater treatment:

   Remove organic material

   Eliminate disease producing agents

7. The NPDES Permit

   (National Pollutant Discharge Elimination System)

8. Calculation of treatment plant Flows:

   gallons per minute (gpm)

   Million Gallons per Day (MGD)

   cubic feet per second (cfs or ft^3/sec)

   conversions:

   1 cubic foot = 7.48 gallons

   days, hours, minutes, seconds

Examples:

Other conversions:

$1\ ft^3/sec = 0.646\ MGD = 448.8\ gpm$

$1\ MGD = 1.547\ ft^3/sec = 694.4\ gpm$

$1\ gpm = 0.002228\ ft^3/sec = 0.00144\ MGD$

Examples:

9. The Flow Formula: **Q=VA**

Q (Flow) = ft^3/sec V (Velocity) = ft/sec A (Area) = ft^2

To solve for Velocity or Area using the Flow Formula

Velocity: $V = \frac{Q}{A}$

Area: $A = \frac{Q}{V}$

Examples:

10. Calculations using the Pounds Formula

MG X mg/L X 8.34 lbs/gal = lbs

<u>Examples</u>:

11. Dimensional Analysis

Work only with the dimensions or units

To work with dimensional analysis you must know

- how to express a horizontal fraction as a vertical fraction
- how to divide by a fraction
- how to divide out and cancel terms in the numerator and denominator

<u>Examples</u>:

PLATE POSITION

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Section II: Pretreatment of Wastewater

Lecture Outline

1. What is the major objective of pretreatment in a wastewater treatment plant?

   Protection of equipment

   Protection of the biological process

   Industrial waste pretreatment

2. Pretreatment Methods:

   Screening

   Grinding

   Grit removal

   Pre-aeration

   Chemical addition

3. Screening:

Bar screens and racks

Fine mesh screens

4. Grinding:

Comminutors

Barminutors

Muffin monsters

5. Grit removal:

Grit channels

Velocity of 0.7 to 1.2 ft/sec

Average grit particle settling velocity of 0.075 ft/sec

Example 1: The grit channel at the front of the wastewater treatment plant is 2 ft wide and 1 ft deep. If the flow meter registers a flow of 1 MGD, how far down the channel would an average sized particle travel before it reaches the bottom and is removed?

Aerated grit chambers

Cyclone grit separators

Grit washing or classification

6. Disposal of screenings and grit

7. Pre-aeration

8. Chemical addition

Chlorine

Hydrogen peroxide

Odor masking agents

9. Removal efficiency

$$\textbf{Percent Efficiency} = \frac{\textbf{IN - OUT}}{\textbf{IN}} \textbf{ X 100}$$

Example 2: 210 mg/L SS reach the plant in the raw wastewater flow. After the flow passes through the grit channel the SS are reduced to 195 mg/L. What is the efficiency of removal of SS in the grit channel?

Example 3: The BOD in the raw influent is measured as 160 mg/L. If after treatment the final BOD is measured as 24 mg/L, what is the efficiency of BOD removal at this plant?

Example 4: 225 mg/L SS come into the plant in the influent. The SS level is reduced through the process to an effluent SS level of 15 mg/L. Calculate the efficiency of SS removal.

Section III: Primary Treatment

Lecture Outline

1. Major functions of primary treatment

2. Primary treatment removal efficiencies

   Settleable solids ____________________

   Suspended solids ____________________

   Total solids ____________________

   BOD ____________________

   Bacteria ____________________

3. Types of clarifiers

   Circular:

   Rim feed

   Center feed

Rectangular:

Plug flow

4. Clarifier components

   Influent channel or pipe

   Target baffle or Deflector plate

   Effluent weir

   Effluent trough or launder

   Scum skimmer or water sprays

   Scum baffle

   Scum trough

   Scum pit

   Sludge scraper or collector

   Sludge collection sump

   Sludge removal pump

5. Clarifier Detention time

$$\text{Detention Time (hrs)} = \frac{\text{Tank Vol ft}^3 \times 7.48 \text{ gal/ft}^3 \times 24 \text{ hrs/day}}{\text{Flow gal/day}}$$

$$\text{Detention time} = \frac{\text{Volume}}{\text{Flow}}$$

Example 1:

A rectangular primary clarifier is 60 ft long, has a width of 30 ft and an average depth of 10 ft. Calculate the detention time if the flow to the tank is 3.0 MGD.

Example 2:

A circular clarifier is 100 ft in diameter and has an average depth of 12 ft. Calculate the detention time if the flow to the tank is 6.8 MGD.

6. Surface Settling Rate (SSR) or Surface Loading Rate

$$\text{SSR (gpd/ft}^2) = \frac{\text{Flow Rate gpd}}{\text{Surface Area ft}^2}$$

Example 3:

The plant flow rate is 3.12 MGD. If the primary clarifier is circular with a diameter of 85 ft what would be the Surface Settling Rate in gpd/ft^2?

7. Weir Overflow Rate (WOR)

$$\text{WOR (gpd/ft)} = \frac{\text{Flow Rate in gpd}}{\text{Length of Weir in ft}}$$

Example 4:

Calculate the Weir Overflow Rate for the same conditions in Example #3; Q = 3.12 MGD and Dia = 85 ft.

Example 5:

A rectangular clarifier has 4 effluent troughs each 40 ft long. If the flow to this tank is 4.2 MGD what would be the WOR? (Hint: each trough has weirs on each side.)

8. Primary Sludge Removal

Average concentrations

Measuring daily sludge accumulation

Imhoff cone

Suspended solids removal

Removal time

Sludge pumping

9. Primary Sludge Pumping Rates

Ground rules:

1% concentration = 10,000 mg/L

LBS Formula: MGD X mg/L X 8.34 lbs/gal = lbs

or: gal/day X percent as decimal X 8.34 = lbs

Algebraic changes in the pounds formula:

$$\text{MGD} = \frac{\text{lbs}}{\text{mg/L} \times 8.34} \quad \text{or} \quad \text{mg/L} = \frac{\text{lbs}}{\text{MGD} \times 8.34}$$

Example 6:

If 54,000 gallons of 4% sludge are pumped to the digester, how many dry pounds of solids (TS) are pumped?

Example 7:

The suspended solids in the raw influent are measured to be 235 mg/L. A sample is taken of primary effluent and the suspended solids concentration is found to be 125 mg/L. Find the following:

a) Percent efficiency of SS removal.

b) Pounds of SS removed in the clarifier each day if the flow averages 5.64 MGD. If the volatility of the sludge collected is 74%, how pounds of volatile solids (VS) are removed each day?

c) If the sludge is removed from the clarifier at 3% solids, how many gpm would need to pumped to remove the sludge collected in b?

d) If the sludge concentration is increased to 5% solids before it is removed, how many gpm should be pumped?

e) If the primary sludge pump is rated at 30 gpm how would you set the timer to remove the 5% sludge of part d?

f) How much volume is saved in the digester by increasing the primary sludge concentration from 3% to 5% ?

10. Clarifier operational problems

Short circuiting

Floating sludge

Overpumping

Section IV: Secondary Biological Treatment

Lecture Outline

Part One: Theory and Operation

1. Purpose of Secondary Biological Treatment

2. Biological wastewater treatment is a "conversion" process

3. Five major groups of organisms found in biological treatment systems

   ____

   ____

   ____

   ____

   ____

4. Bacterial growth

Organic material + O_2 + Bacteria -> Energy + New Cells + CO_2 + H_2O

Adsorption

Absorption

5. Environmental growth "Factors" or "Pressures"

Food and the Idea Growth Curve

Flow or Hydraulic Loading

Oxygen (aerobic or anaerobic)

Temperature

pH

Toxic or Poisonous materials

6. Secondary Treatment Processes consist of:

Biological growth

Suspended

Attached

Clarification

7. Activated Sludge

Aeration Tank

Mechanical

Diffused

Secondary clarification

Circular

Rectangular

Three main controls

Air supply

Return Sludge (RAS)

Waste Sludge (WAS)

8. Activated Sludge treatment variations and modes of operation

Variations:

High Rate

Conventional

Contact Stabilization

Extended Aeration

Modes of Operation:

Complete mix

Plug Flow

Step Aeration

Tapered Aeration

Batch Process

Kraus Process

Pure Oxygen Aeration

Oxidation Ditch

ABF process

9. The Concept of Sludge Quality

Visual Observations

Aeration Tank

Clarifier

Floc formation and the settleometer

10. Trickling Filter Biological Treatment Systems

Components

Wastewater flow

Filter media

Underdrain and air flow

Recirculation

The Biological process

Zoogleal Film

Sloughing

11. Trickling Filter Classification

Standard Rate

High Rate

Roughing Filters

Filter Staging

12. Trickling Filter-Solids Contact (TF/SC)

Aeration channel

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13. Rotating Biological Contactors (RBC's)

Components

Plastic media

Rotating Drums

Stages and Trains

Series and Parallel flow

Biological Growth

Zoogleal slime layer

Sloughing

Visual Observations

14. Wastewater Stabilization Ponds

Microbiology

Facultative systems

Normal operation

Part Two: Process Control Calculations

15. Hydraulic Loadings

Effects of influent flow -> treatment time

Activated Sludge: Detention Time

$$DT = \frac{\text{Aeration Tank Volume}}{\text{Flow to the Aeation Tank}}$$

Trickling Filters: gpd/ft^2

$$HL = \frac{\text{Flow to the Filter in gpd}}{\text{Surface Area of Filter in ft}^2}$$

Example 1: A single filter system has a trickling filter that is 90 ft in diameter. If the total flow to the filter is 0.5 MGD calculate the hydraulic loading for the filter.

Filter comparison by hydraulic loading:

Roughing Filter	100 - 1,000 gpd/ft^2
High Rate Filter	100 - 1,000 gpd/ft^2
Standard Rate	25 - 100 gpd/ft^2

RBC's: gpd/ft^2

$$HL = \frac{\text{Flow to RBC's in gpd}}{\text{Surface Area of Plastic discs in ft}^2}$$

Example 2: The flow to an RBC treatment system averages 2.5 MGD. The surface area of plastic media is given by the manufacturer as 800,000 ft^2. Calculate the hydraulic loading.

RBC comparison by hydraulic loading:

BOD removal	1.5 - 6 gpd/ft^2
Nitrogen removal	1.5 - 1.8 gpd/ft^2

Stabilization Lagoons: inches/day

$$HL = \frac{\text{Depth of Pond in inches}}{\text{Detention Time in days}}$$

other information: 1 acre = 43,560 ft^2

1 MGD = 36.8 ac-in/day

Example 3: A wastewater stabilization pond has an average width of 400 ft and an average length of 700 ft. At an influent flow rate of 0.3 MGD the pond depth is operated at a depth of 3.5 ft. Calculate the hydraulic loading for this pond. (Hint: first calculate the detention time.)

Normal ranges for lagoon hydraulic loadings

Detention time may vary between 30 days to 120 days

Hydraulic loading may vary between 0.5 inches to several inches per day

16. Organic loadings

Effects of influent organic strength -> rate of biological growth

Activated Sludge: use Food to Microorganism Ratio (F/M)

(sometimes given as lbs/1,000 gal volume)

$$F/M = \frac{\text{Pounds of BOD in Influent}}{\text{Pounds of MLSS or MLVSS in Aeration Tank}}$$

Example 4: A rectangular aeration tank has the dimensions of 80 ft long, 30 ft wide, and 12 ft deep. The average MLSS in the tank is 1,500 mg/L. Flow to the tank is 0.85 MGD with a primary effluent BOD concentration of 95 mg/L. Calculate the F/M ratio.

Activated Sludge comparisons for F/M ratio:

Conventional range	0.2 - 0.5
High rate	1.0
Extended aeration	0.01 - 0.1

Trickling Filters: lbs BOD/day/1,000 ft^3

$$\text{Organic Loading} = \frac{\text{BOD Applied lbs BOD/day}}{\text{Volume of Media in 1000 ft}^3\text{ units}}$$

Example 5: A primary effluent flow of 1.17 MGD with a BOD of 105 mg/L is sent to two trickling filters operated in parallel flow. Each filter is 85 ft in diameter and has a media depth of 6 ft. Calculate the organic loading in this system.

Trickling Filter organic loading comparisons:

Roughing rate	$>$ 300 lbs BOD/day/1,000 ft^3
High rate	25 - 300 lbs BOD/day/1,000 ft^3
Standard rate	5 - 25 lbs BOD/day/1,000 ft^3

<u>RBC's</u>: lbs BOD/day/1,000 ft^2

$$\text{Organic Loading} = \frac{\text{BOD Applied lbs BOD/day}}{\text{Area of Media in 1000 ft}^2\text{ units}}$$

<u>Example 6</u>: The primary effluent flow has a BOD concentration of 95 mg/L. The volume of flow reaching the RBC's is 5.7 MGD. If the total surface area of the media is 1,500,000 ft^2, what would be the organic loading?

Comparisons for RBC organic loading:

Range for BOD removal: 3 - 5 lbs BOD/day/1,000 ft^2

<u>Stabilization Lagoons</u>: lbs BOD/day/acre

$$\text{Organic loading} = \frac{\text{Influent BOD lbs/day}}{\text{Pond Area in acres}}$$

Example 7: A wastewater stabilization lagoon with a width of 400 ft, length of 700 ft, and a depth of 3.5 ft receives a daily flow of 0.3 MGD. If the influent flow contains 200 mg/L of BOD calculate the organic loading of this treatment system: (Hint: 1 acre of area = 43,560 ft^2)

Typical organic loadings for stabilization ponds:

Facultative lagoons	20 - 50 lbs BOD/day/acre
Aerated lagoons	60 - 200 lbs BOD/day/acre

Other process calculations for Activated Sludge control:

17. Sludge Volume Index (SVI)

$$SVI = \frac{\text{Settled Sludge Volume @ 30 min X 1000}}{\text{MLSS}}$$

Example 8: A sample from the end of the aeration tank is used to run a settleometer test. After 30 min of settling the volume read from the settleometer is 250. If the MLSS in the aeration tank is 2,000 mg/L what would be the SVI?

Comparisons for SVI values:

Conventional range	80 - 130
Slow settling	> 200
Fast settling	< 80

note: make sure you know the settling volume used.

18. Mean Cell Residence Time (MCRT) or Sludge Age

$$MCRT = \frac{\text{Aeration lbs + Clarifier lbs}}{\text{Wasted lbs + Clarifier Effluent lbs}}$$

Alternate calculation with minimum sludge storage in the clarifier:

$$MCRT = \frac{\text{Aeration lbs}}{\text{Wasted lbs + Clarifier Effluent lbs}}$$

Example 9: Calculate the MCRT for the following conditions:

Influent plant flow	5.5 MGD
Aeration volume	1.22 MG
Aeration concentration (MLSS)	2,100 mg/L
2 clarifiers	
Diameter each clarifier	70 ft
Average depth of clarifier	12 ft
Average Depth of Blanket	10 ft
Waste sludge flow (total)	20 gpm
Waste sludge concentration	9,015 mg/L
Effluent suspended solids	17 mg/L

Comparisons for MCRT values:

Conventional range	5 to 15 days
Old sludge	> 15 days
Young sludge	< 5 days

19. Using a target MCRT value to calculate waste sludge flow:

$$\text{sludge to waste, lbs/day} = \frac{\text{total lbs in the system}}{\text{desired MCRT}} - \text{lbs eff SS}$$

$$\text{WSF, gpd} = \frac{\text{waste lbs/day X 1000000 gal/MG}}{\text{sludge conc mg/L X 8.34 lbs/gal}}$$

Example 10: Use the same plant operational data given in example #9 to calculate the required waste sludge flow (WSF) for a target MCRT or Sludge Age of 12 days.

20. The Sludge Unit (SU) approach for solids inventory:

Volumes or flows in MG units (sometimes 10,000 gal units)

Concentrations by centrifuge spin

SU = Volume (MG) X Concentration (%spin)

1 SU = 1 MG X 1% spin

See Appendix A for calculation summary.

Section V: Sludge Digestion

Lecture Outline

1. Sludge sources

   Raw or Primary sludge

   Secondary biological sludge

   Chemical

   Other

2. Objectives of sludge digestion

   Stabilization

   Reduce mass and volume

   Destroy pathogenic organisms

   Condition sludge for further handling

   Useful by-products

3. Digestion processes

Aerobic

Anaerobic

4. Aerobic Digestion

Biological process

VS + aerobic bacteria + O_2 -> CO_2 + H_2O + NH_3 + energy

VS + aerobic bacteria + O_2 -> CO_2 + H_2O + NO_3 + energy (nitrification)

Relationship to Activated Sludge process

Process equipment

Cycle of operation

5. Aerobic Digestion operational performance factors

Sludge type

Digestion time

Digestion temperature

Volatile solids loading

Air supply and D.O residual

Percent volatile solids reduction

6. Anaerobic Digestion

Biological process

Volatile acid formers

$VS + \text{acid bacteria} \rightarrow CH_3COOH + CO_2 + H_2 + H_2O + \text{energy}$

Methane formers

$CH_3COOH + \text{methane bacteria} \rightarrow CH_4 + CO_2 + \text{energy}$

Process equipment

Tanks and stages

Mixing

Heating

Gas system

7. Anaerobic Digestion operational performance factors

Sludge type

Digestion time

Digestion temperature

Volatile solids loading

VA/Alk ratio and pH

Gas production

Percent volatile solids reduction

8. Anaerobic digester control: VA/Alk calculation

$$\text{VA/Alk ratio} = \frac{\text{Volatile Acids mg/L}}{\text{Alkalinity mg/L}}$$

Example 1: A sample of digesting sludge is taken from an anaerobic digester to determine both the volatile acid level and the alkalinity level. If the volatile acids concentration is 220 mg/L and the alkalinity is 2,800 mg/L calculate the VA/Alk ratio.

Criteria: range 0.1 to 0.35, not greater than 0.35.

9. Digester control: volatile solids loading

$$\text{VS loading} = \frac{\text{Lbs of VSS sent to the digester}}{\text{Volume of digester ft}^3}$$

Example 2: An anaerobic digester is 50 ft in diameter and has a side wall depth of 25 ft. If 8,000 lbs of raw sludge (with a volatile content of 74%) are fed to the tank each day what is the volatile solids loading?

Criteria:

Aerobic digestion -	0.07 to 0.20 lbs VS/day/ft^3
Anaerobic digestion -	0.15 to 0.35 lbs VS/day/ft^3

10. Measuring stabilization

Volatile solids content

Pathogen indicator organism reduction

Specific oxygen uptake rate

11. Calculating percent volatile solids reduction

$$\%VS\ Reduction = \frac{VS\ in - VS\ out}{VS\ in - (VS\ in \times VS\ out)} \times 100$$

Example 3: Raw sludge being fed to an anaerobic digester has a volatile solids content of 68%. If after digestion the digested sludge volatile solids content is 54% what is the overall volatile solids reduction?

Criteria: 50% VS reduction

Anaerobic digestion - 40% to 60% reduction

Aerobic digestion - 25% to 35% reduction

12. Sludge Conditioning

Purpose

Chemical addition

Heat treatment

Elutriation

13. Sludge Thickening Processes

Applications

Gravity thickening

Flotation thickening

14. Sludge Dewatering Processes

Sludge drying beds

Centrifugation

Vacuum filtration

Belt filter press

15. Final Sludge Disposal

Incineration

Land application

Landfill

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Section VI: Effluent Chlorination and Disinfection

Lecture Outline

1. Objectives of Disinfection in Wastewater Treatment

   Reduction of pathogenic organisms

2. Treatment Process Removals

   Pre-treatment

   Primary treatment

   Trickling Filters

   Activated Sludge

3. Types of Disinfection Processes

   Chlorination

   Ozone

   Ultraviolet Light (UV)

4. Sources of Chlorine for Disinfection

Chlorine gas

Chlorine Dioxide gas

Hypochlorites

5. Reactions of Chlorine in Wastewater

Free Chlorine: $Cl_2 + H_2O \rightarrow HOCl + HCl^-$

Chlorine Dioxide: $2ClO_2 + H_2O \rightarrow ClO_3^- + ClO_2^- + 2H^+$

Hypochlorite: $NaOCl + H_2O \rightarrow NaOH + HOCl + OCl^- + H^+$

6. Reactions With Impurities

Inorganic reducing materials: H_2S

Ammonia: NH_3

Breakpoint chlorination

7. Factors Influencing Disinfection

pH

Temperature

Time

Mixing

Interfering material

Tank design and injection point

8. Chlorine Requirements:

Chlorine Demand = Chlorine Dosage - Chlorine Residual

Chlorine Demand

Chlorine Dosage

Chlorine Residual

Example 1: A gas chlorinator is set at a feed rate of 50 lbs per day (24 hrs). After a contact time of 30 minutes a chlorine residual of 0.5 mg/L can be measured. If the flow through the plant is 0.85 MGD, find the chlorine dosage and chlorine demand.

9. Monitoring Chlorine Residual (Combined)

Iodometric Method

DPD Titrimetric Method

Amperometric Titration

10. Monitoring Coliform Bacteria

MPN Method

Membrane Filter Method

11. Other Applications for Chlorination

Collection Systems

In plant treatment

Activated Sludge

Digester

Normal Disinfection Levels

- Raw wastewater
- Primary clarifier effluent
- Trickling filter effluent
- Activated sludge effluent
- AWT effluent

12. Dechlorination: needs

Protection of receiving streams

13. Reactions with Sulfur Dioxide

Chemical properties

Reaction with chlorine

$SO_2 + H_2O \rightarrow H_2SO_3 + HOCl \rightarrow H_2SO_4 + HCl$

Reaction with combined residual

$NH_2Cl + H_2SO_3 + H_2O \rightarrow NH_4HSO_4 + HCl$

Chemical reaction with chlorine is one to one

Section VII: Pumps and Maintenance

Lecture Outline

1. Centrifugal Pump Theory of Operation

   A. The basic components of the centrifugal pump

   Impeller

   Volute case

   Shaft

   Packing

   Suction

   Discharge

   B. Energy Transfer in the centrifugal pump

   Power = Energy

   Elevation head

   Pressure head

   Velocity head

   Atmospheric pressure

Head versus Pressure

Depends on height or depth and weight of the fluid

P = height X weight

1 psi = 2.31 ft of head

1 ft of head = 0.433 psi

Example 1: A pressure gage on the discharge side of a centrifugal pump reads 65 psi. If the pump is not running, how high up is the water level in the discharge line?

Example 2: The water level in a water storage tank rises 109 ft above ground level. If a pressure gage is installed at ground level to monitor the changing water level in the tank, what would the gage read in psig?

2. Calculation of Pumping Rates

A. Rate of flow produced by the pump

$$\text{Rate of flow} = \frac{\text{volume of water}}{\text{period of time}} = \frac{\text{gallons}}{\text{minutes}}$$

Example 3: During a 15 minute pumping test, 15,820 gallons of water are pumped into an empty rectangular storage tank. Calculate the pumping rate in gpm.

Example 4: A tank that is 40 ft in diameter is filled with water to a depth of 3 ft. To conduct a pumping test, the outlet valve is closed and the pump is allowed to discharge into the tank. After 1 hour and 15 minutes the water level in the tank is measured to be 5.25 ft. What is the pumping rate in gpm?

3. Static, Dynamic, Suction, and Discharge Head

A. Static Head

Static suction head

Static suction lift

Static discharge head

Total static head

Example 5: A pressure gage on the suction side of the pump reads 9 psi when the pump is off. A second pressure gage on the discharge side of the pump reads 85 psi. Calculate the total static head of this system.

B. Dynamic Head

Dynamic suction head

Dynamic suction lift

Dynamic discharge head

Total dynamic head

Example 6: During the operation of a pump system the pressures are recorded to calculate Total Dynamic Head. The inlet pressure reads 98 psi and the discharge pressure reads 261 psi. Calculate the TDH.

Example 7: The inlet pressure gage reads -6 psi and the discharge pressure gage reads 48 psi while the pump is *running*. Calculate the TDH. (**Extra:** If the inlet gage reads in inches of mercury vacuum how would the -6 psi be represented?)

4. Horsepower and Efficiency

A. Horsepower

Water horsepower

Brake horsepower

Motor horsepower

$$WHP = \frac{\text{Flow rate gpm} \times \text{TDH ft} \times 8.34}{33000}$$

Example 8: A pump is producing 2,000 gpm against a head of 20 ft. What horsepower (water horsepower) will be required to do the work?

Example 9: What is the maximum pumping rate (gpm) of a pump that is producing 15 whp against a head of 65 ft?

B. Efficiency

Motor efficiency

Pump efficiency

Wire-to-water efficiency

Example 10: A pump is to delivering 460 gpm of water against a head of 95 ft with a rated pump efficiency of 75 percent. What horsepower must be delivered to the pump to provide this flow?

Example 11: You have already calculated the required water horsepower for a pumping application to be 6 whp. If the pump to be used is 80% efficient and the motor is 92% efficient, what motor horsepower will be required? What is the wire-to-water efficiency?

C. Horsepower and kilowatts

1 horsepower = 746 watts

1 horsepower = 0.746 kilowatts

Example 12: If 11 kilowatts (kW) of power are supplied to a motor that produces 13 brake horsepower, what is the efficiency of the motor?

5. Reading Pump Performance Curves

A. Description

Head (TDH)

Capacity (gpm)

Pump speed (rpm)

Impeller diameter (inches)

B. Performance information

Horsepower

Efficiency

NPSH required

<u>Example 13</u>: A centrifugal pump described in curve A is operating with a impeller diameter of 15 inches and is able to produce 2,500 gpm. Using curve A find the following:

TDH: ____________________

Efficiency: ____________________

HP: ____________________

NPSH: ____________________

Example 14: A centrifugal pump described in curve B is operating with a impeller diameter of 13 inches and is pumping against a head (TDH) of 140 ft. Using curve B find the following:

Capacity: ____________________

Efficiency: ____________________

HP: ____________________

NPSH: ____________________

6. Normal Maintenance Procedures

   A. Routine inspections

      Observations and records

      Unusual noises

      Odors

      Heat

      Preventative maintenance

   B. Lubrication

      Frequency

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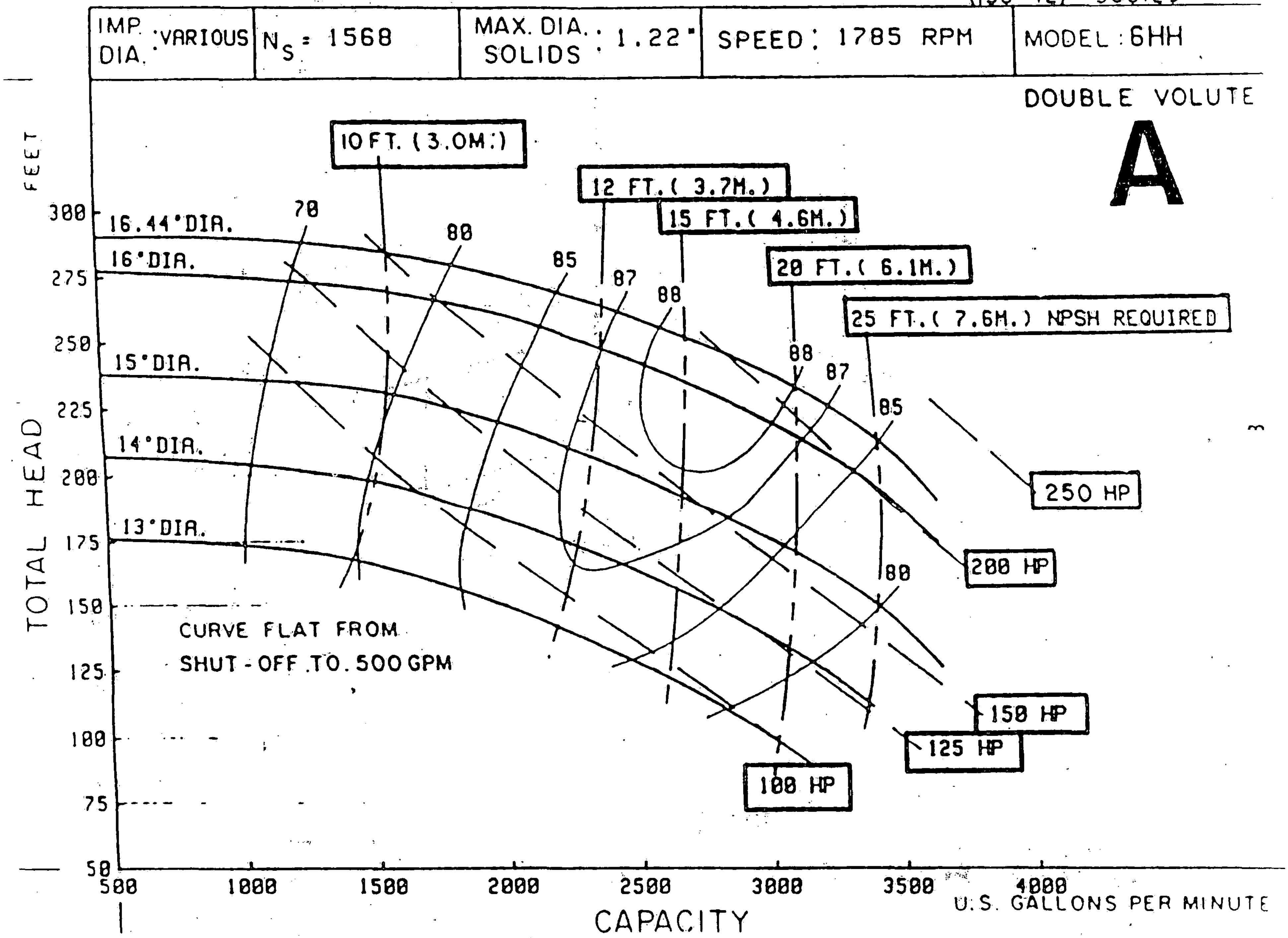

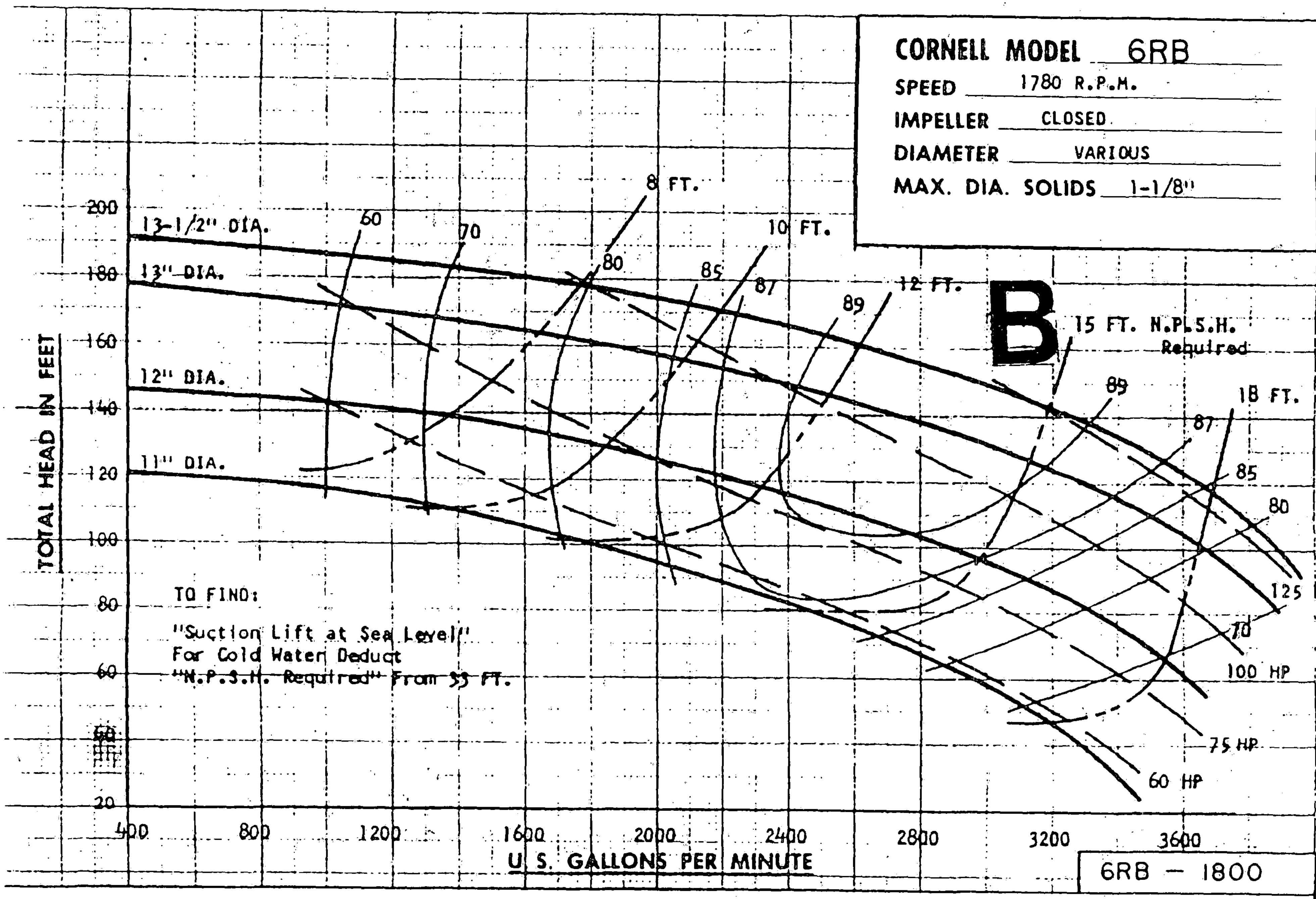

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