CHEMICAL FEEDERS
&
FEEDER CALIBRATION

Course Purpose

Identify the types of liquid, powder, and gas chemical feeders used in water treatment, and review how they are calibrated.

Course objectives

At the conclusion of this presentation, you should be able to:

1. Identify the feeders used to add liquid, powdered, and gas chemicals in water treatment.
2. *Distinguish types of positive displacement pumps.*
3. Describe volumetric and gravimetric feeders
4. *Present the reasons and methods for calibrating chemical feeders.*

Course itinerary

1. Overview
2. Review pumps
3. Liquid feeders
4. Dry feeders
5. Gas feeders
6. Extended video
7. Calibration
8. Handy Conversions

Thanks

Pennsylvania Department of Environmental Protection

American Water College

AWWA “Operator Certification Study Guide”

Dutypoint

C&B Equipment, Inc

City of Radford, VA

Pulaski County Public Service Authority

NRV Regional Water Authority

Town of Wise, VA

Course itinerary

1. **Overview**
2. Review pumps
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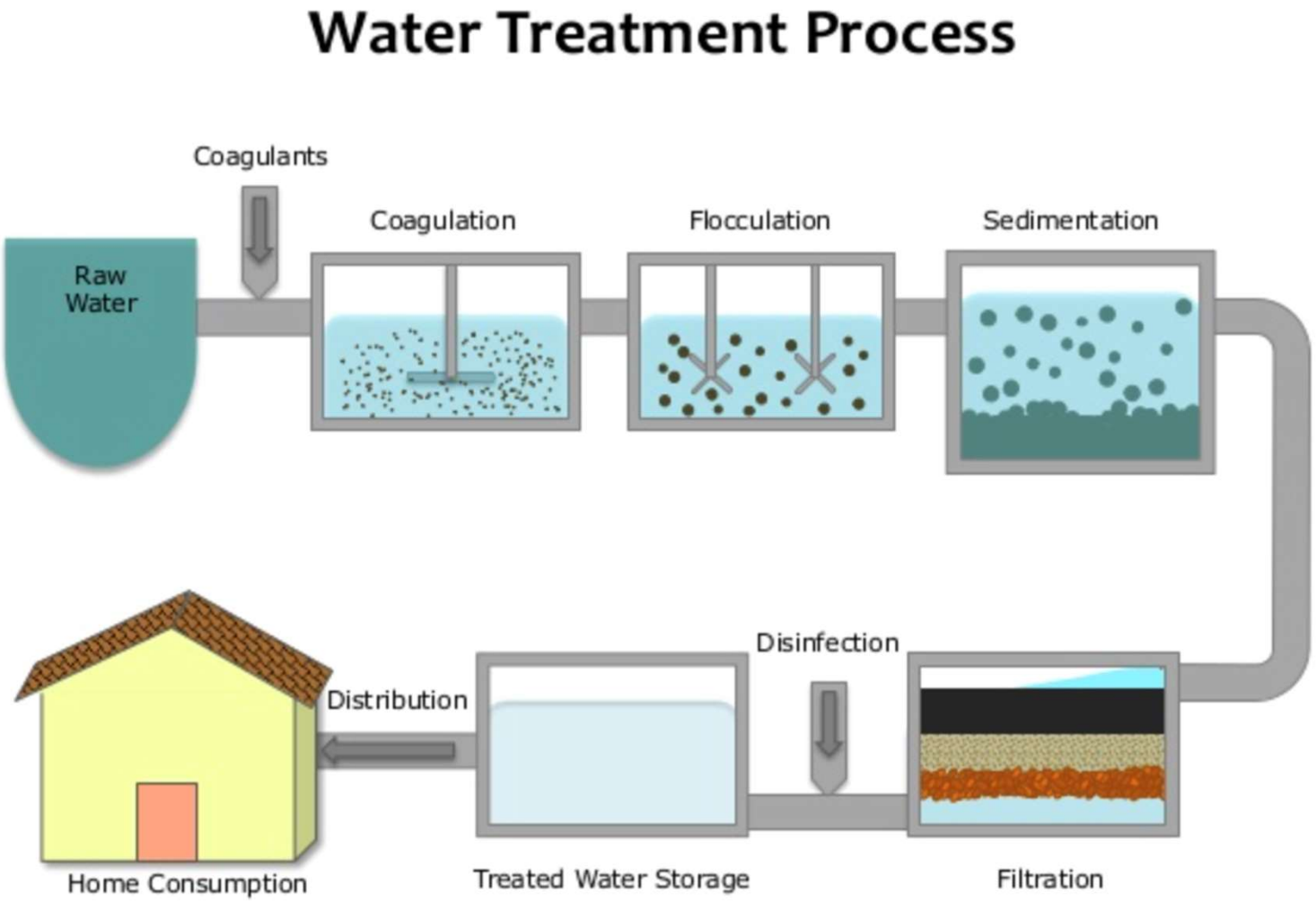
Water Treatment Plant

VDH VIRGINIA DEPARTMENT OF HEALTH

WTP schematic



Examples of chemicals added

- Chlorine
- Permanganate
- Coagulant
- Alum
- Polymer
- Fluoride
- Caustic
- Lime
- Corrosion inhibitors
- Powdered activated carbon

3 forms of water treatment chemicals

Liquid

Dry (powdered)

Gas

Why Are Chemical Feeders Used?

Chemicals in liquid, dry, or gaseous form are used to achieve treatment goals

Effectiveness depends on accurate dosing

Chemical feeders provide more consistent and accurate dosing than manual application

Feeders require monitoring and adjustments made by operators to maintain treatment effectiveness

Types of chemical feeders

LIQUID	**chemical enters and leaves feeder in a liquid state**
DRY	**chemical enters and leaves feeder in a dry state**
GASEOUS	**gas enters indicator and is introduced to flow stream**

Types of liquid feeders

Positive displacement metering pumps

- **reciprocating**
  - **piston, plunger**
  - **diaphragm**
- **rotary**
- **peristaltic**

Gravity feed rotometer (*drip feeder*)

Types of dry feeders

Volumetric

Gravimetric

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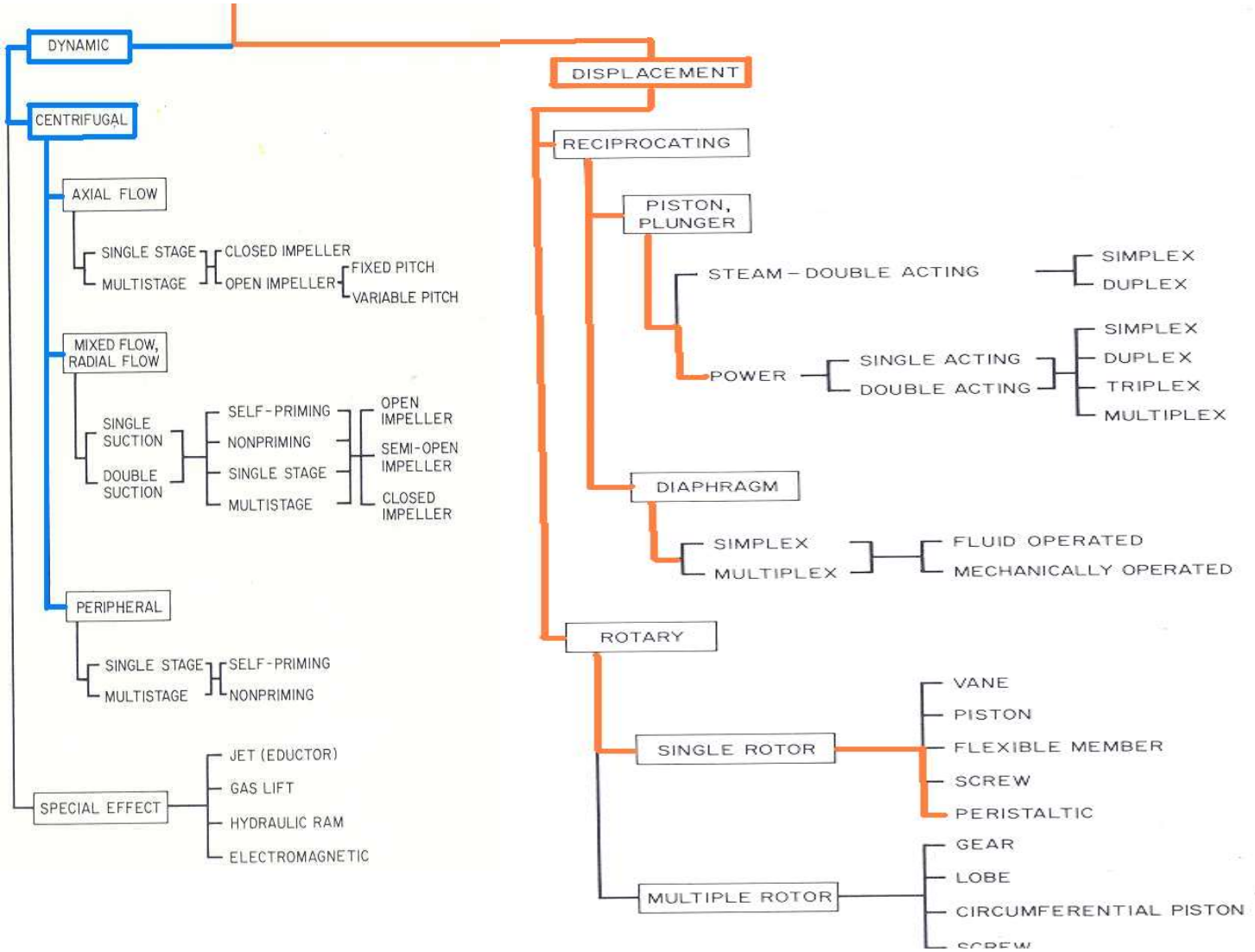
PUMPS



1-minute intro to pump curves

https://www.youtube.com/watch?v=ERBc_sym42g

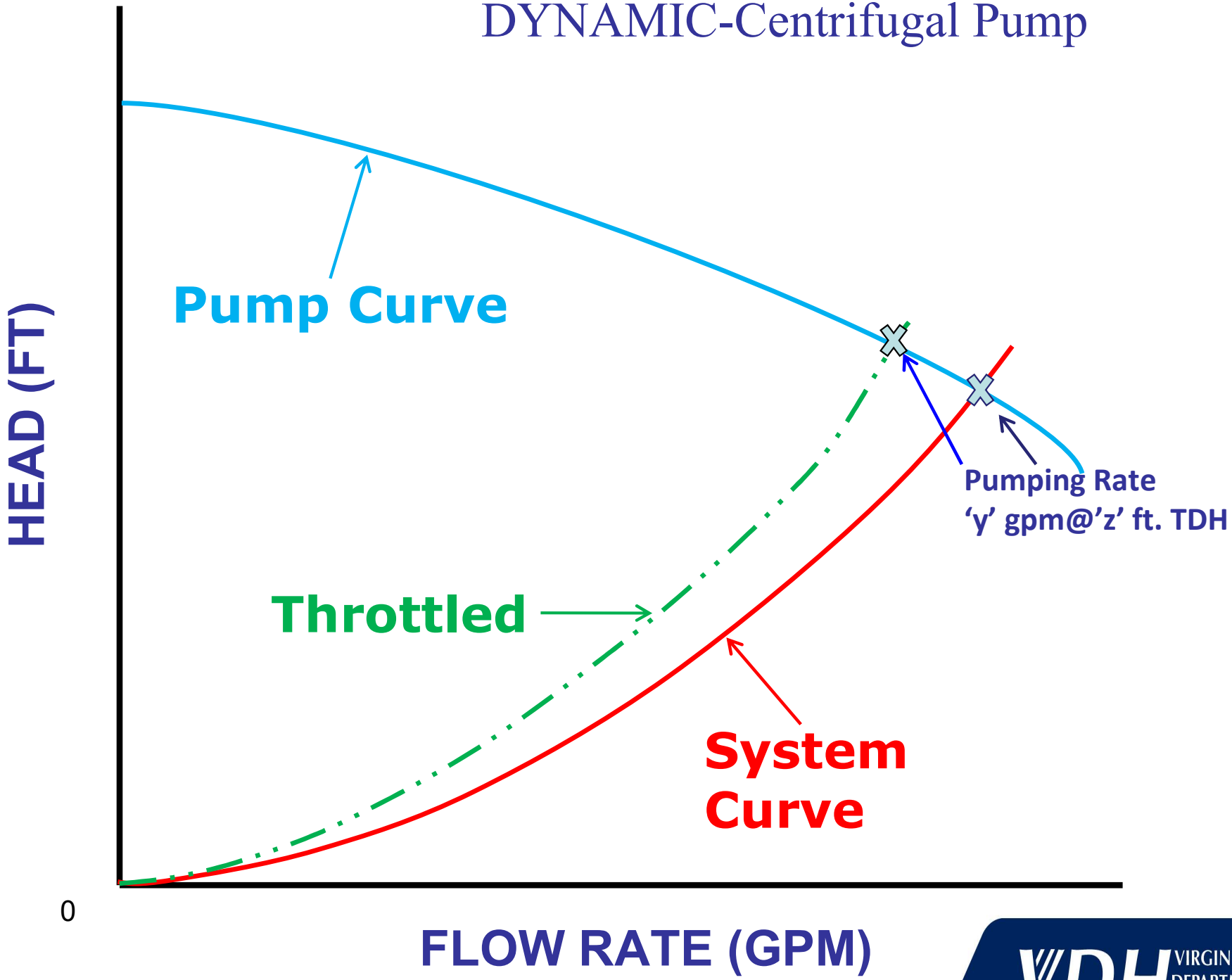
Very Interesting

What about centrifugal pumps and positive displacement pumps?

Centrifugal pumps vs positive displacement

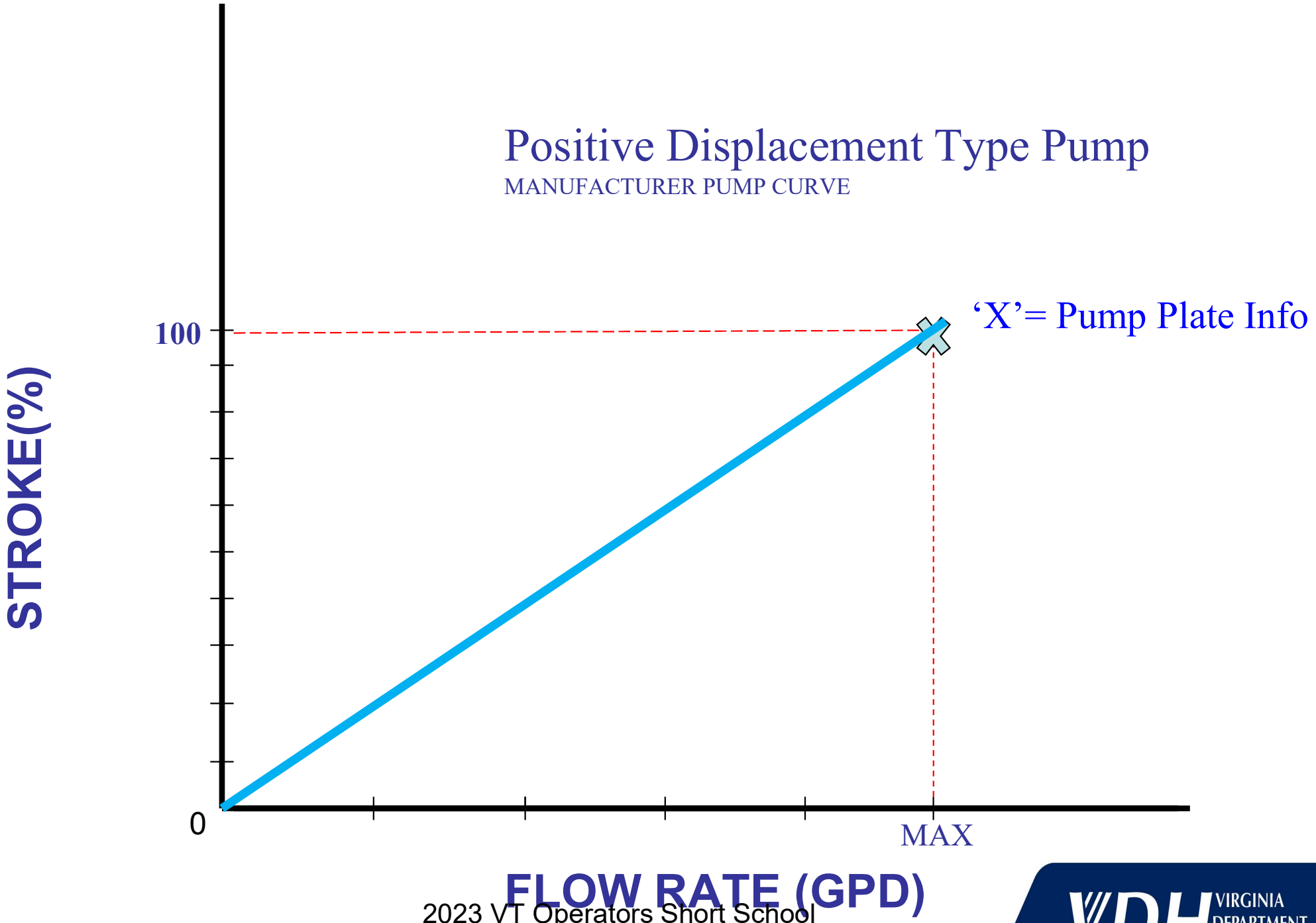
https://www.youtube.com/watch?v=o0Bh7Xwwa9M

DYNAMIC-Centrifugal Pump

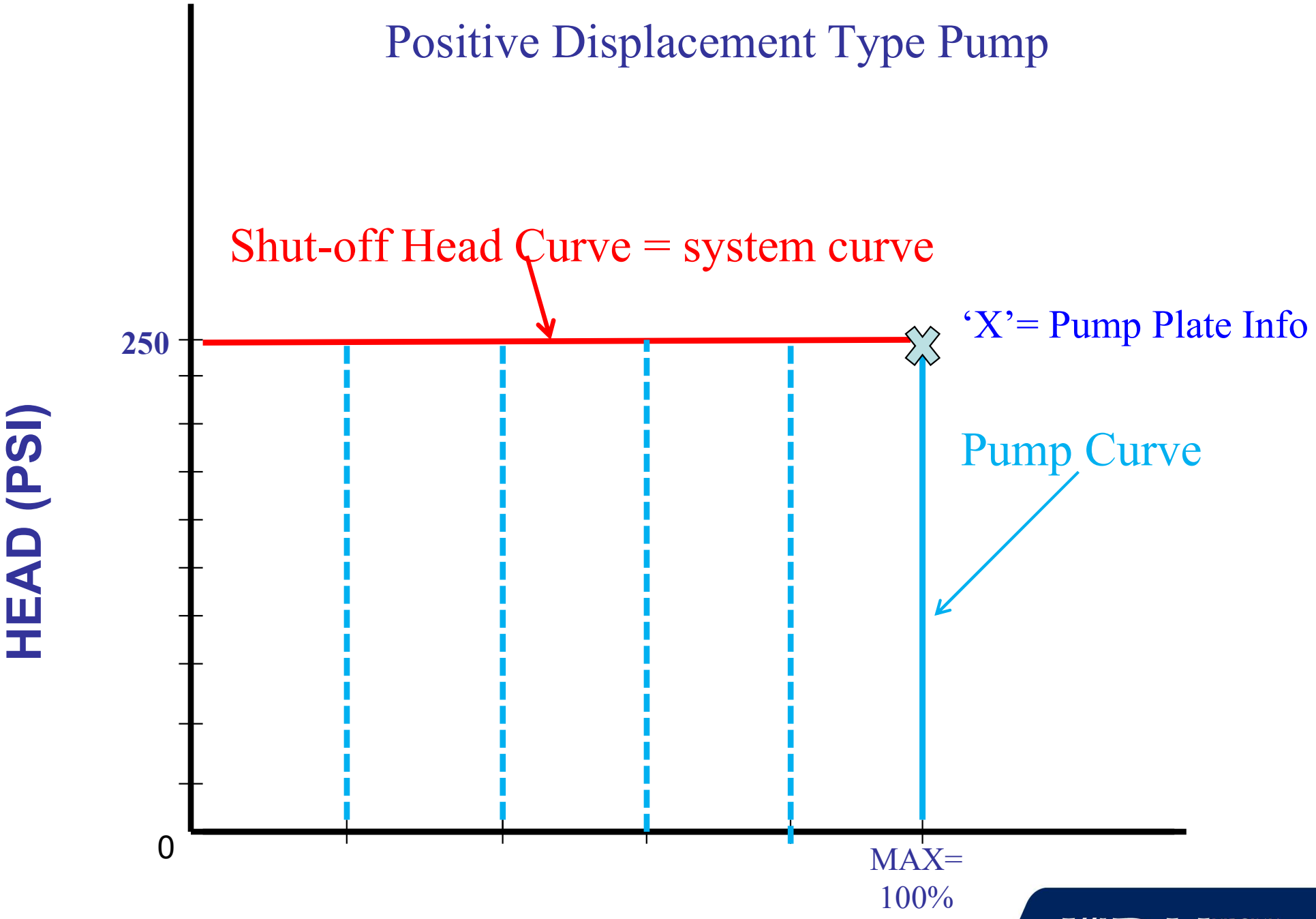


Positive Displacement Type Pump

MANUFACTURER PUMP CURVE



Positive Displacement Type Pump



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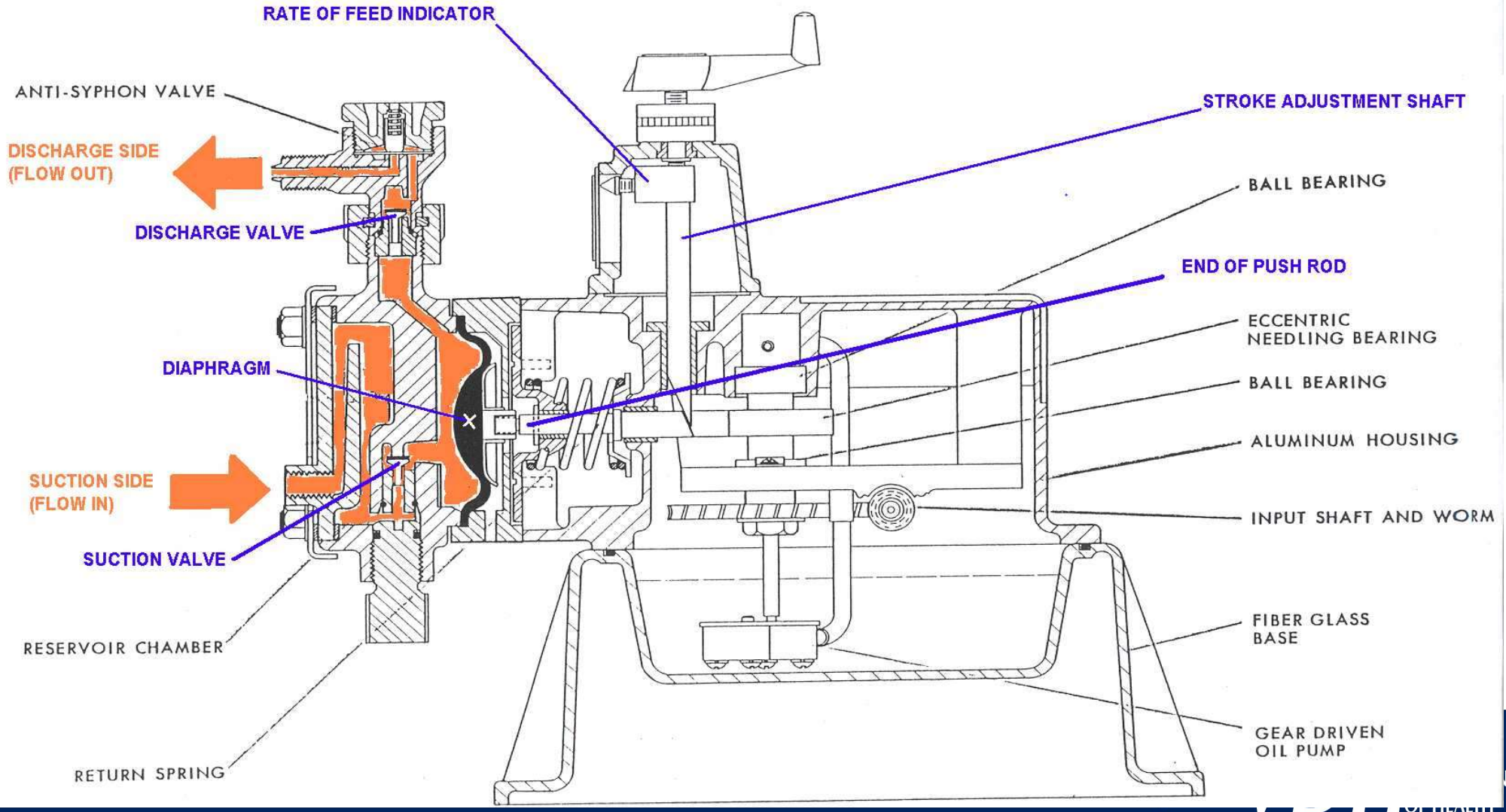
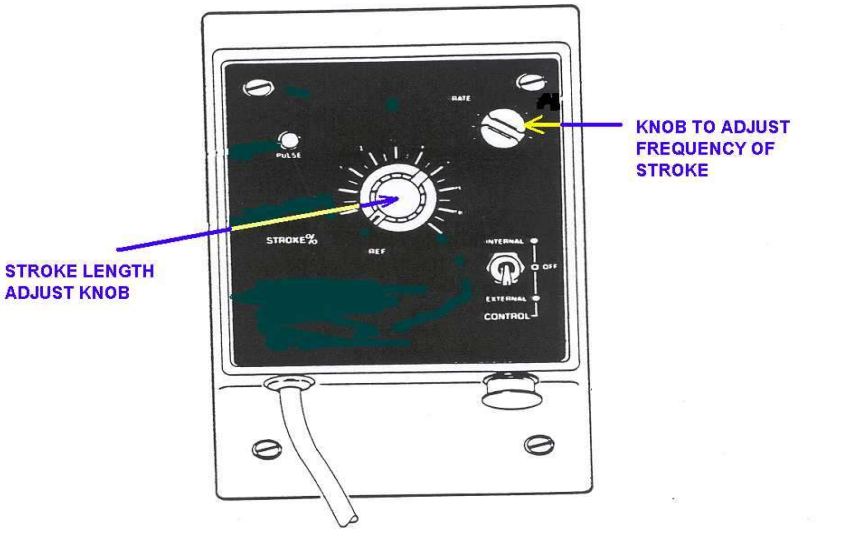
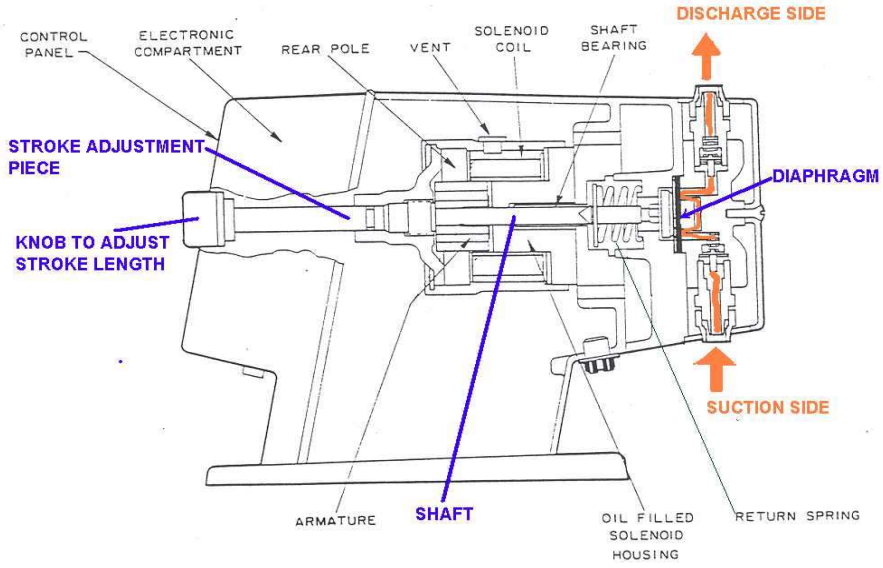
Mechanical diaphragm metering pump



Diaphragm metering pump



CONTROL PANEL



Collection of working pumps

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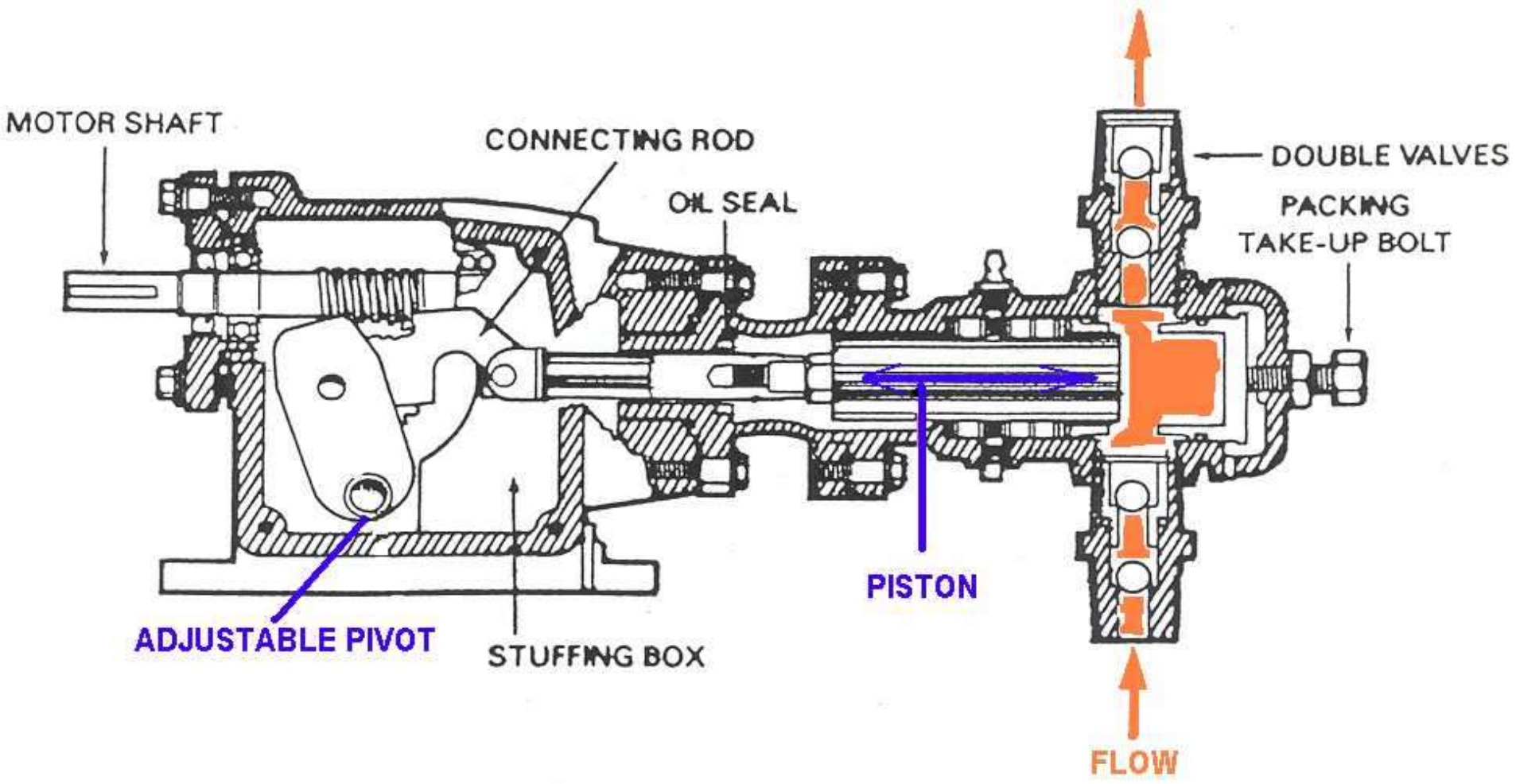
Piston pump


MOTOR SHAFT
CONNECTING ROD
OIL SEAL
DOUBLE VALVES
PACKING
TAKE-UP BOLT
PISTON
ADJUSTABLE PIVOT
STUFFING BOX
FLOW

Positive Displacement Pump Settings

Pumping Rate Setting

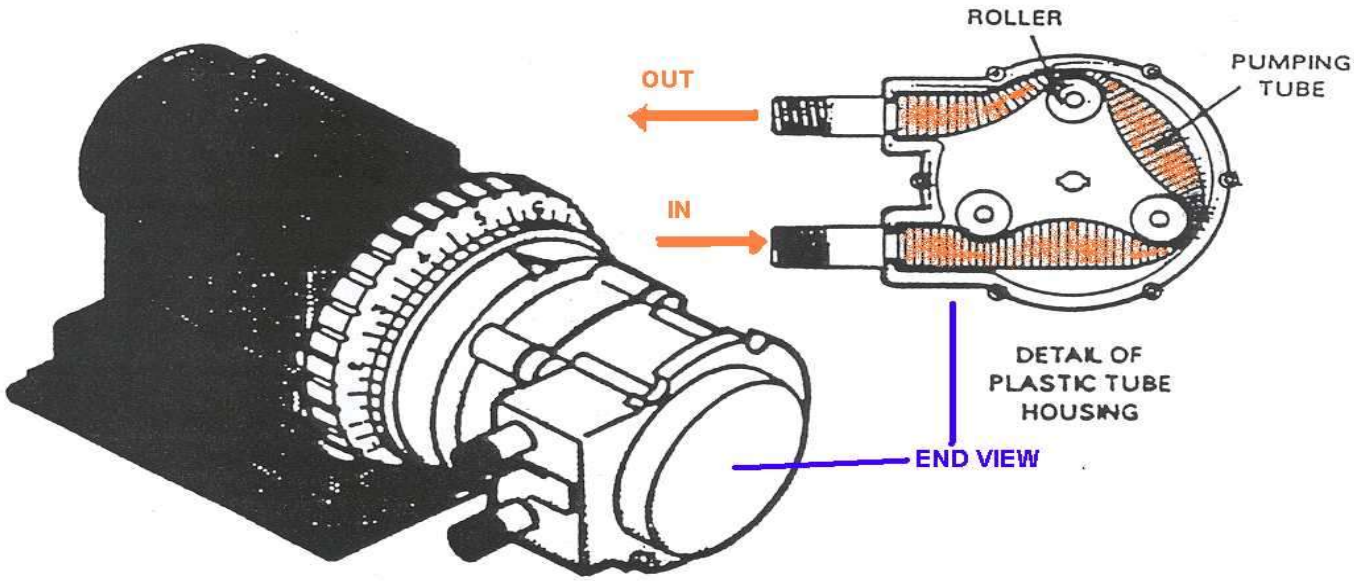
- Two controlling factors
  - Stroke length
  - Motor speed(stroke frequency)

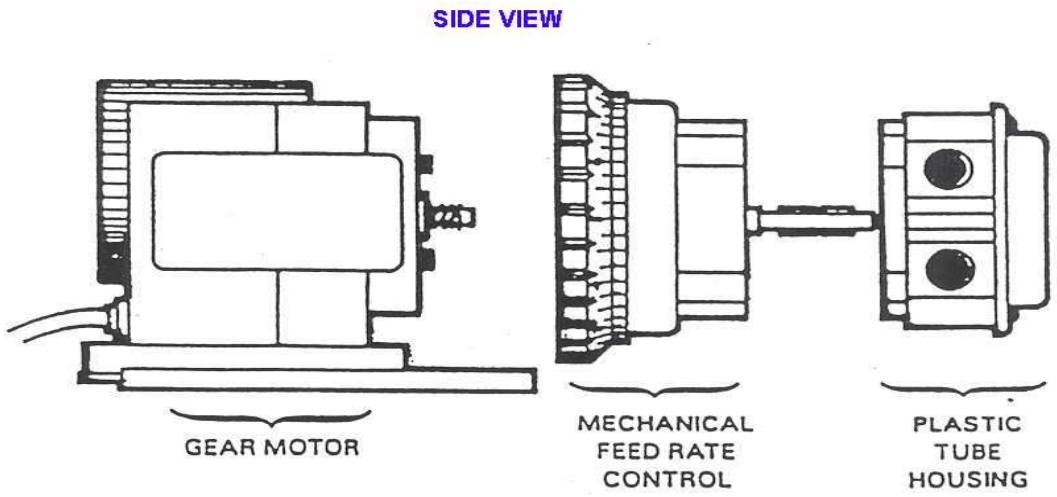
Optimal Setting Selections

- Single motor speed pump – use stroke length
- Variable motor speed pump – set stroke length to 50% and vary motor speed.

Transitioning to peristaltic pump

Peristaltic pump





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Peristaltic pump

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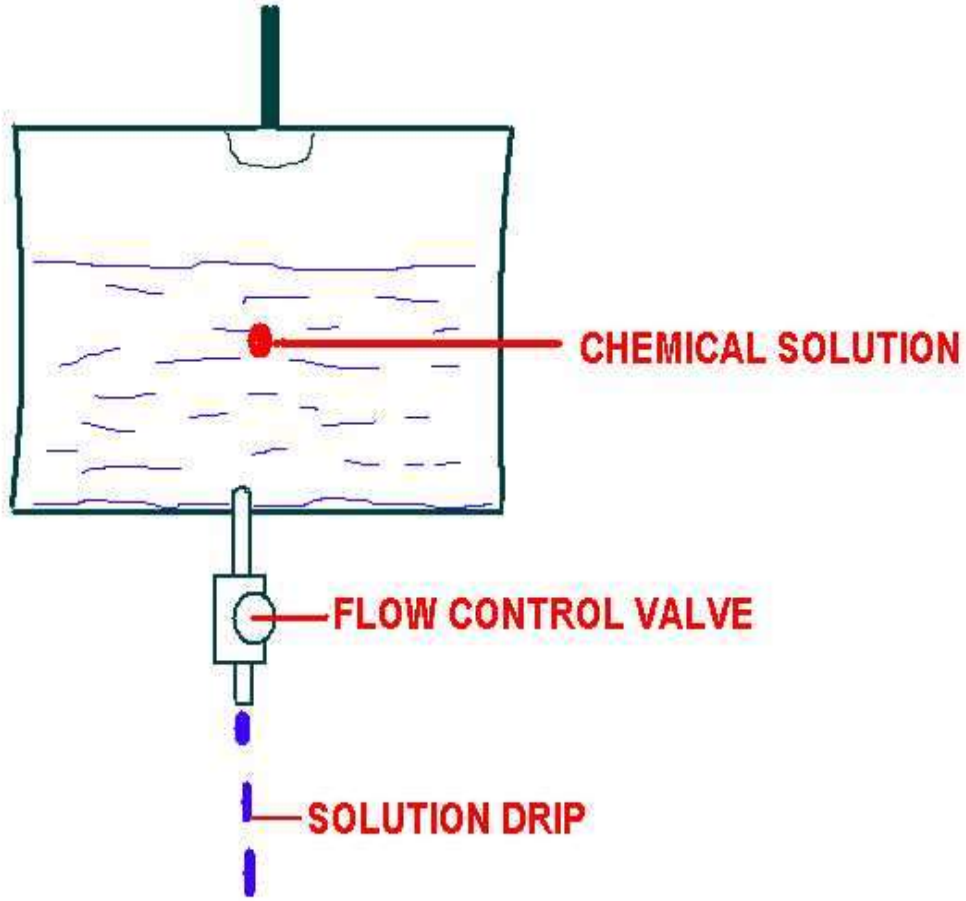
What is a peristaltic pump?

https://www.youtube.com/watch?v=_9IjMMoAFdA

Drip Feeder



Drip Feeder

Water Treatment feed pumps and mixing

https://www.youtube.com/watch?v=YJnN9sJP62U

Course itinerary

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Types of dry feeders

Volumetric –

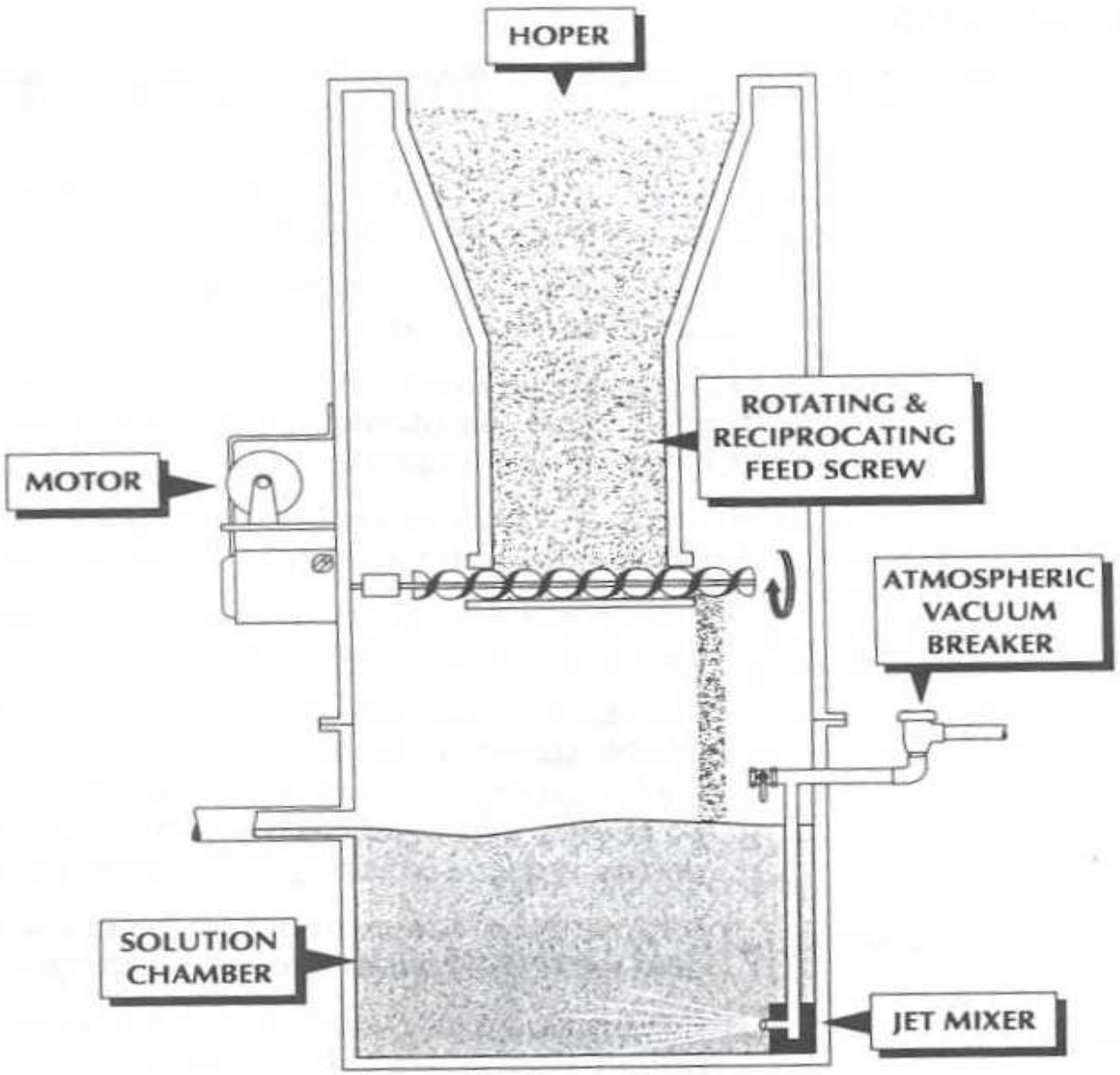
- **chemical fed based on volume**

Gravimetric-

- **chemical fed based on weight**

Dry Feeder

Volumetric feeder



Volumetric Notes

Volumetric Feeders. Volumetric feeders accurately dispense powdered material. The material may be applied directly or used to produce a slurry that is applied to the process. Volumetric feeders are used for lime feed and lime slaking, dry polymer and clay feed, and the feed of fire-side additives to boiler furnaces.

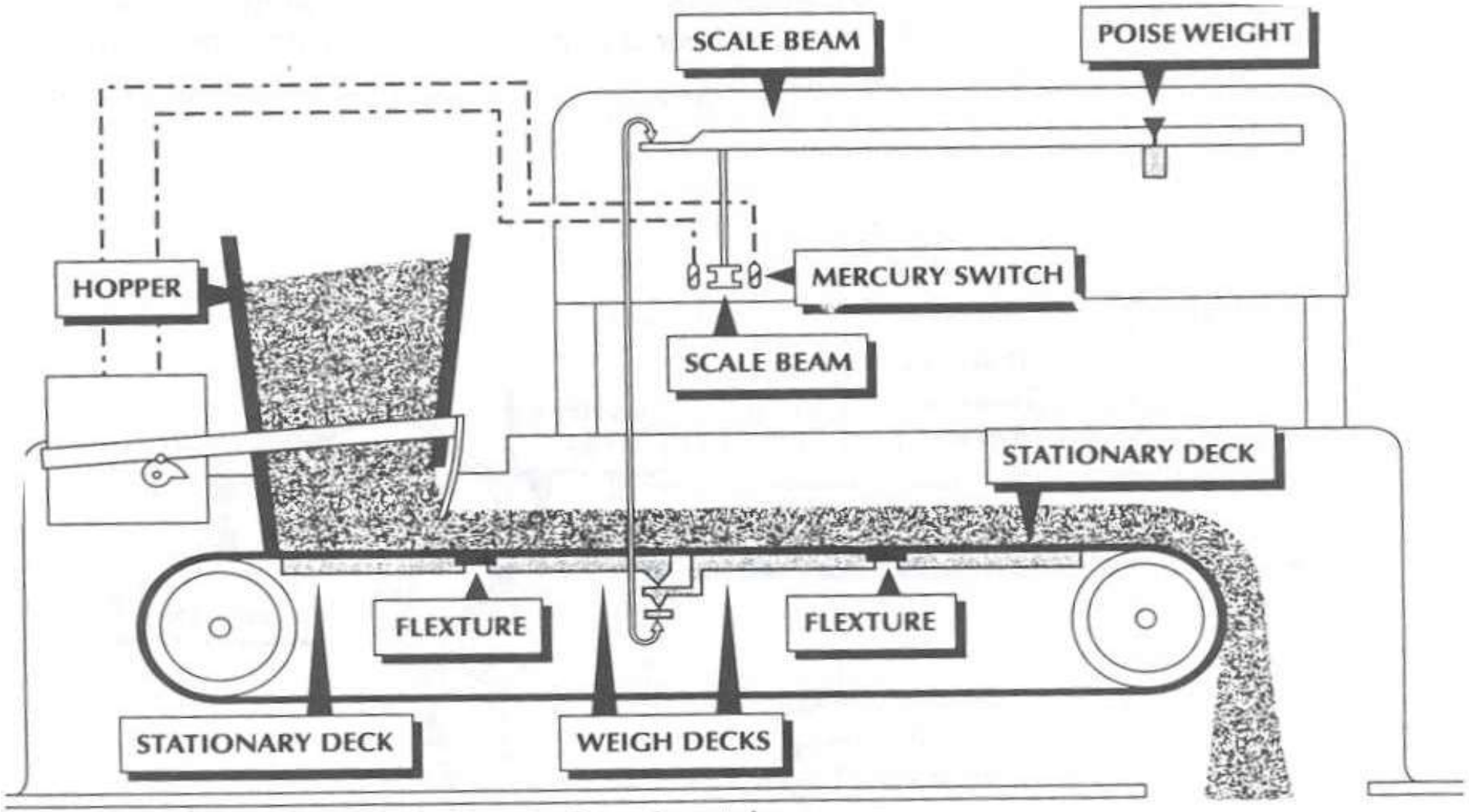
The performance and accuracy of volumetric dry feeders depend largely on the characteristics of the powder being metered. Key characteristics that affect powder feed are particle size distribution, loose and packed bulk densities, moisture content, and abrasiveness.

Volumetric Notes

A typical volumetric feed system includes a bulk storage bin or silo, a feed hopper, and a metering device. The most common metering device is a helical screw or auger. The rotational speed of the screw determines the feed rate.

Some powders tend to bridge, or "rathole," causing uneven feed. To ensure even flow of powder to the helix area, auxiliary devices may be required. Among the more common are flexing hopper walls, bin vibrators, and oversized auxiliary augers positioned above the feed helix.

Gravimetric Feeder



Gravimetric

Gravimetric Notes

Gravimetric Feeders. Gravimetric feeders proportion chemicals by weight rather than by volume and are accurate to within 1-2%. A gravimetric feeder is a scale, balanced to ensure delivery of a desired weight of chemical to the system. The chemical discharged by a gravimetric feeder is usually put into solution or suspension.

Because gravimetric feeders are considerably more expensive than volumetric feeders, they are used only with large systems needing accurate feed or for chemicals whose flow properties prohibit the use of volumetric feeders.

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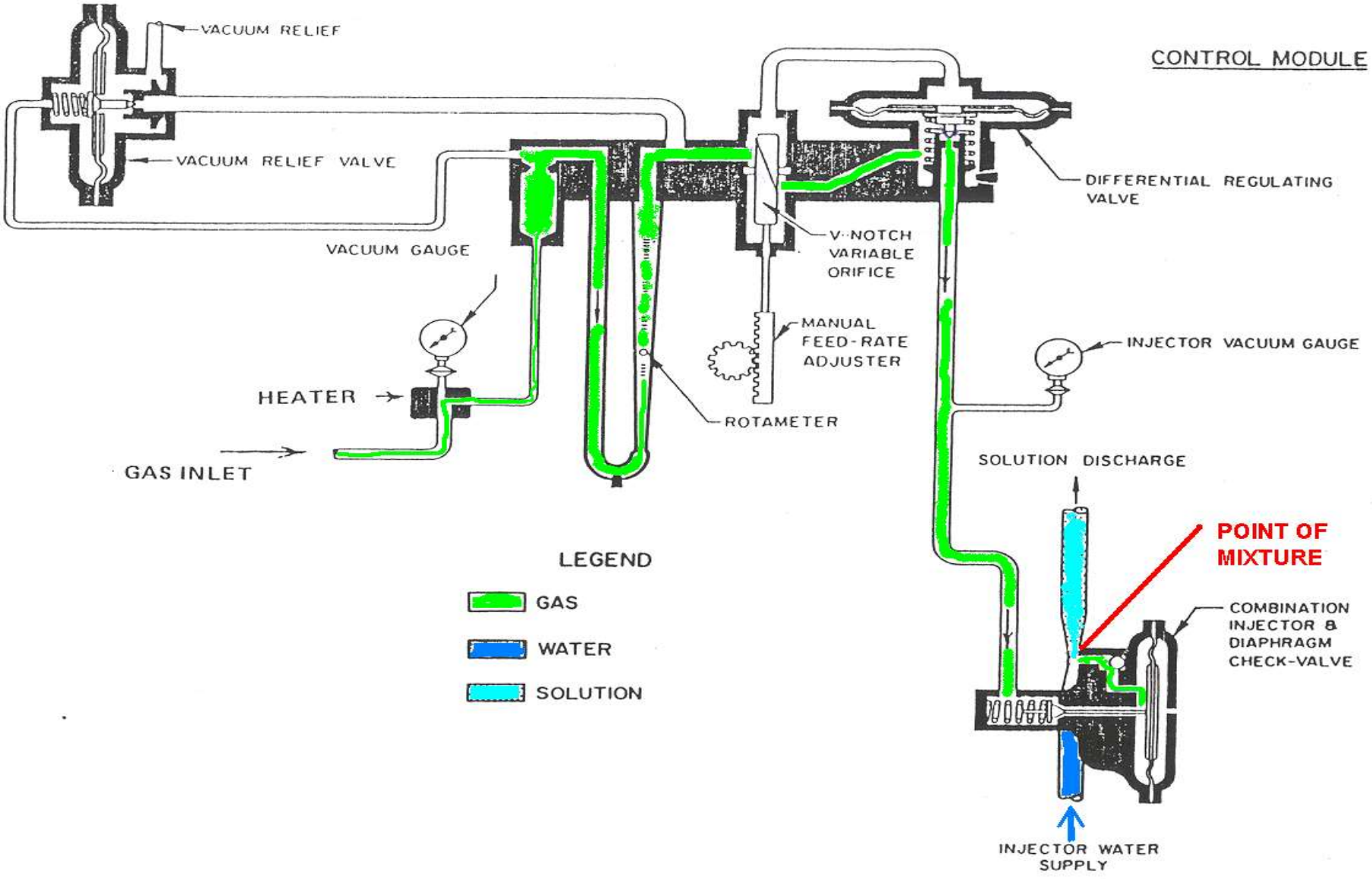
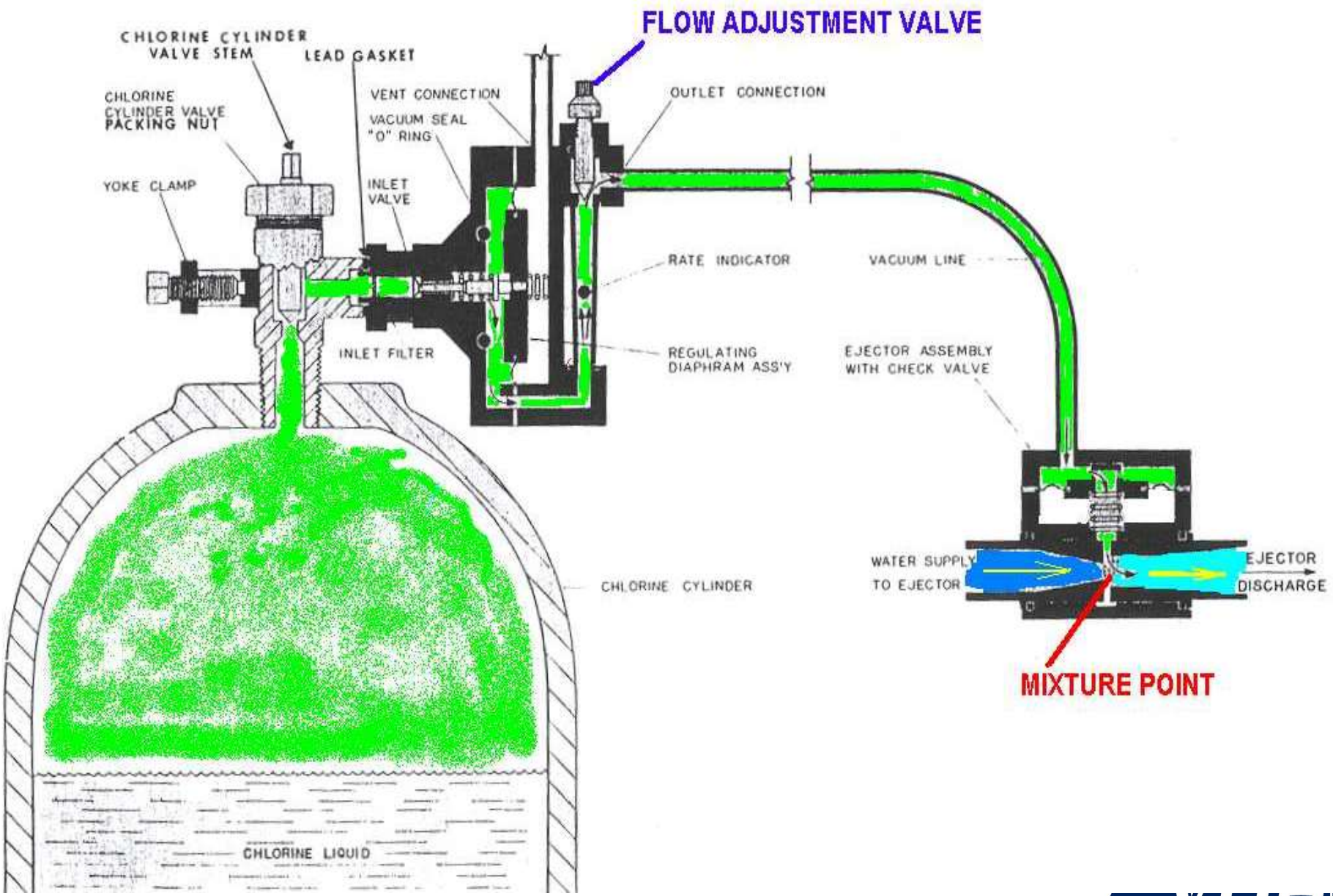
Example of vacuum type

Gas chlorinator

Gas Chlorinator



Gas Chlorinator



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7. Calibration
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ChemFeed pumps and calibration
PA Dept Environmental Protection

2:05 Considerations

2:44 minimize parts inventory

6:51Two types of flow pace signals

7:07 Check valves

8:05 Pump loses prime

9:05 Estimate the pump output

9:47 Pump calibration

10:55 Calibration steps

11:30 Use actual chemical, not water

13:25 Graphing calibration data

14:45 When to calibrate?

ChemFeed pumps and calibration
PA Dept Environmental Protection

https://www.youtube.com/watch?v=htadz2eC0EY

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Chemical feeder calibration purpose

- Effective control of treatment process
- Economy of operation - optimum chemical use
- Knowledge of individual feeder capabilities at specific settings

Frequency of calibration

Minimum - one time per year

Any time change(s) in:

- **chemical strength**
- **chemical purity**
- **mechanical adjustment to feeder**
- **treated water flow changes**

Any time equipment maintenance or repair performed

Chemical feeder calibration

- **Draw a chart which will indicate a dosage (solution feeder) or feed rate (dry feeder) for a specific feeder setting**

Calibration chart needed for:

Liquid chemical feeders

Dry chemical feeders

Gas feeders have indicators that provide pounds of chemical being fed – calibration not needed

Factors affecting calibration chart

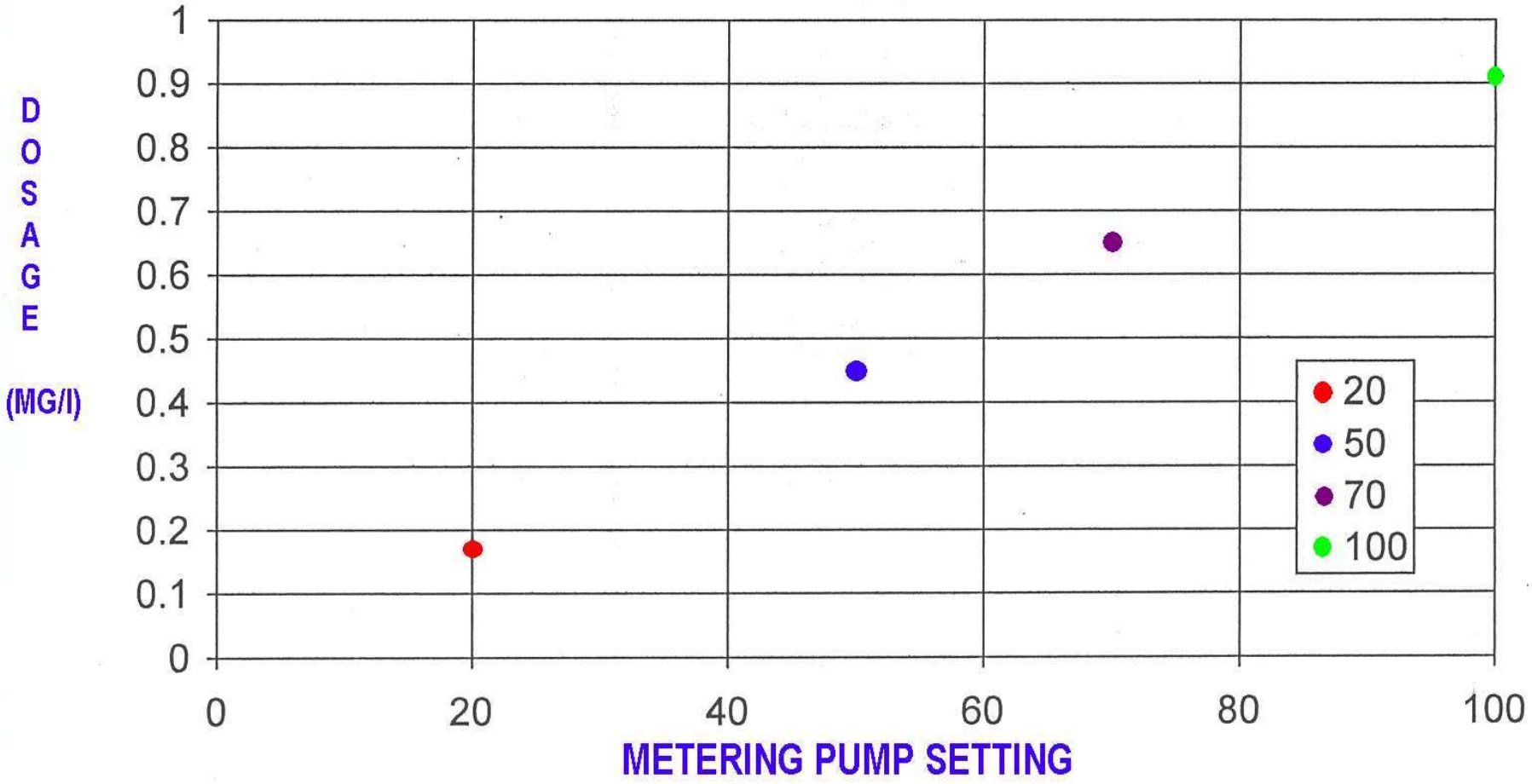
SOLUTION FEEDER

- solution strength changes
- mechanical change in feeder(pump)
  - stroke length
- treated water flow rate change

DRY FEEDER

- chemical purity
- mechanical change
- belt change/motor speed
- treated water flow rate change

Solution Feeder Calibration Chart - step 1 - plot points



Prepare new calibration charts

Chemical strength changes

Chemical purity changes

Feeder has been adjusted

Water flow changes

Equipment repair

Equipment maintenance

If any change occurs:

DRAW A NEW CALIBRATION CHART IMMEDIATELY!

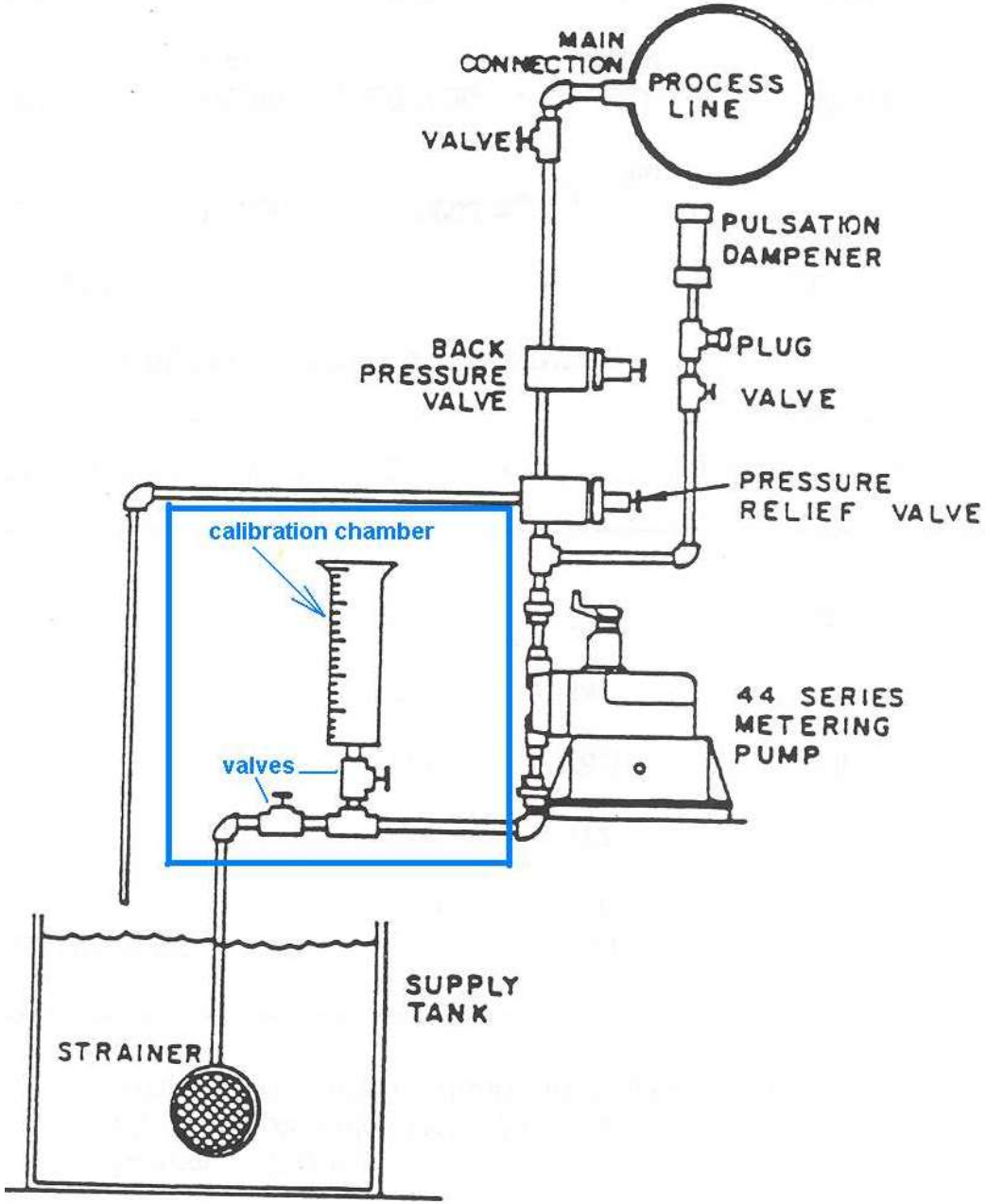
CALIBRATION METHODS

Positive displacement pump calibration

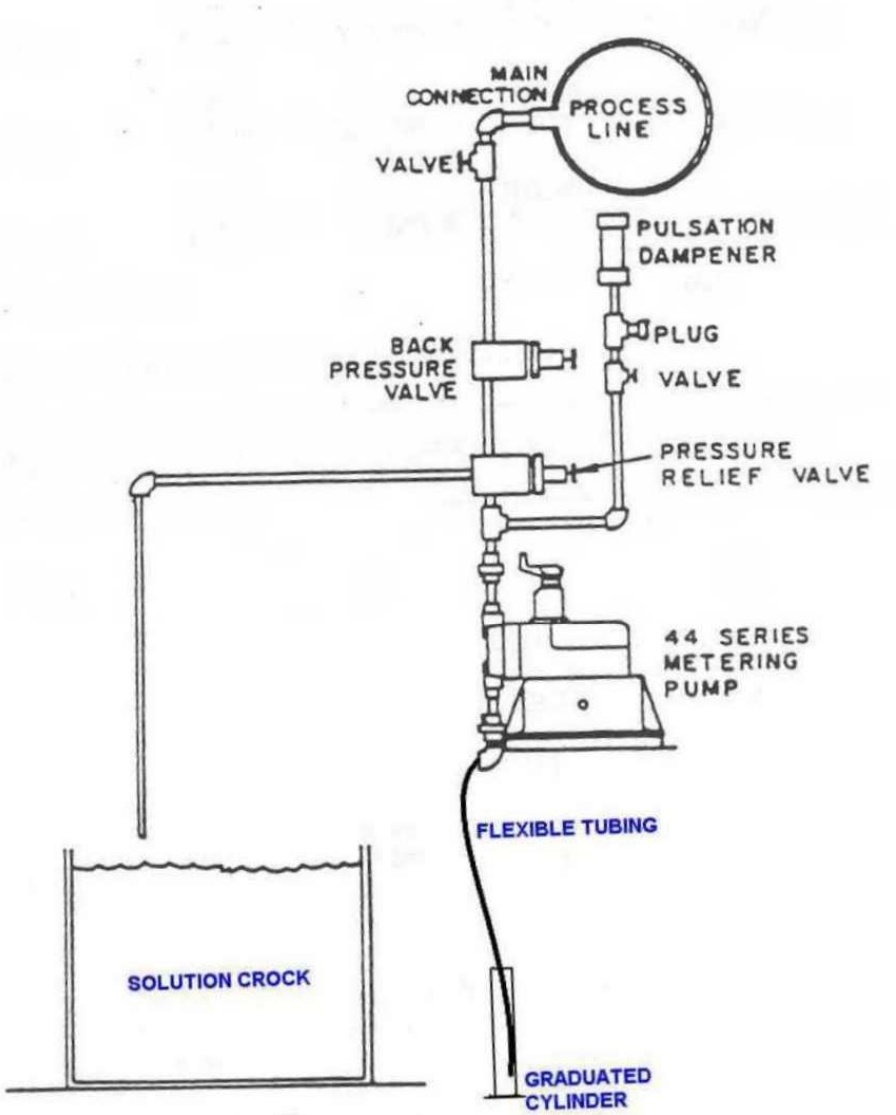
EQUIPMENT

- graduated cylinder
- stopwatch
- calculator
- graph paper
- plain paper
- straight edge(ruler)

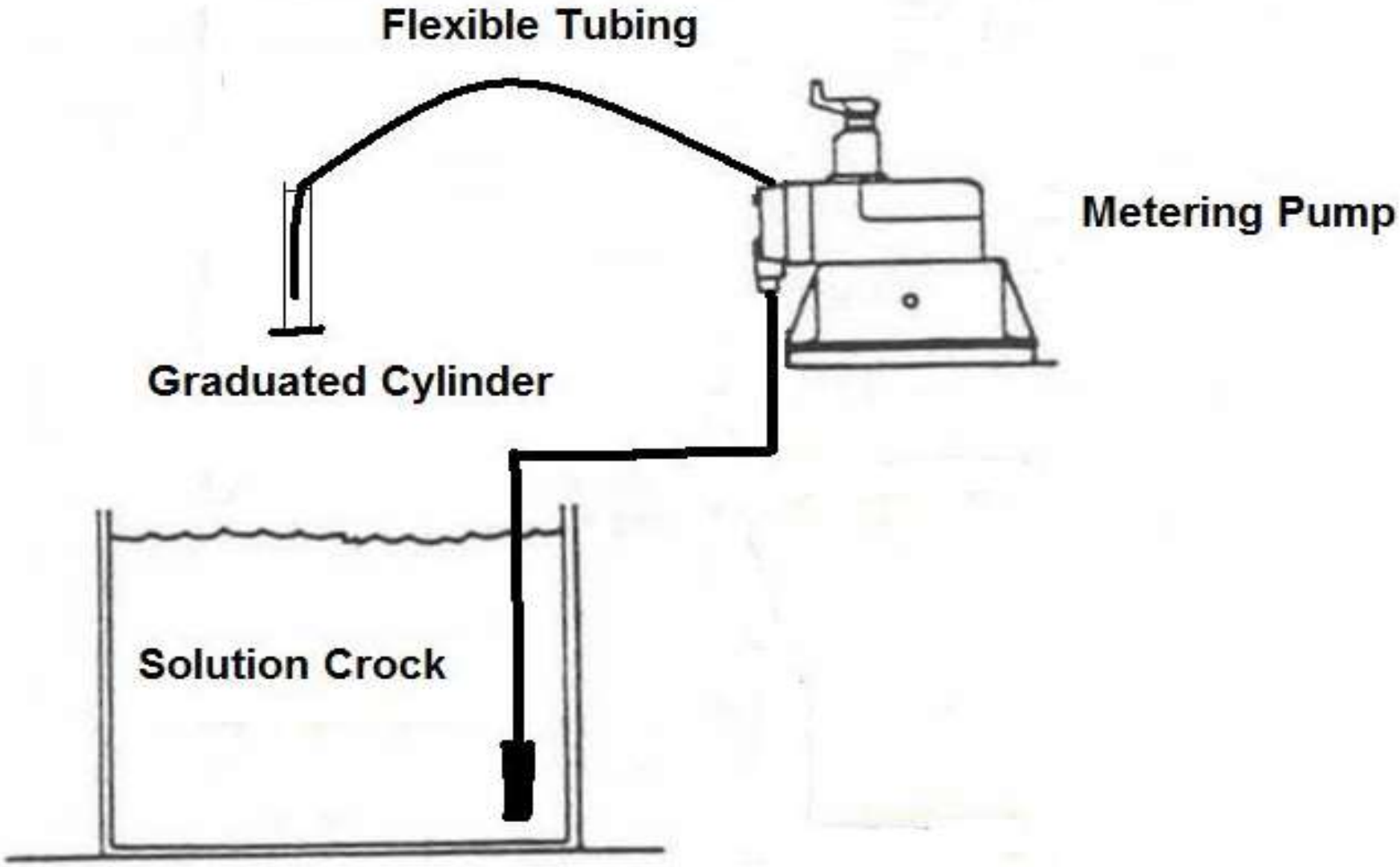
EQUIPMENT SET UP 'A'



EQUIPMENT SET UP ‘B’



EQUIPMENT SET UP ‘C’



Calibration Tubes

Positive Displacement Pump Settings

Pumping Rate Setting

- Two controlling factors
  - Stroke length
  - Motor speed (stroke frequency)

Optimal Setting Selections

- Single motor speed pump – use stroke length
- Variable motor speed pump – set stroke length to 50% and vary motor speed.

Positive Displacement Pump Calibration
PROCEDURE (1 of 2)

Organize table to record *pumping rate* data

Gather data

- **Record the stroke setting**
- **Fill graduated cylinder with solution**
- **close and open valves (setup A) or insert pump suction line into cylinder (setup B)**
- **run pump 5 minutes at highest (100%) setting**
- **record the ml of liquid withdrawn during 5 minutes in data table**
- **repeat above steps for 100% setting**
  - **continued next slide**

Positive Displacement Pump Calibration
PROCEDURE (2 of 2)

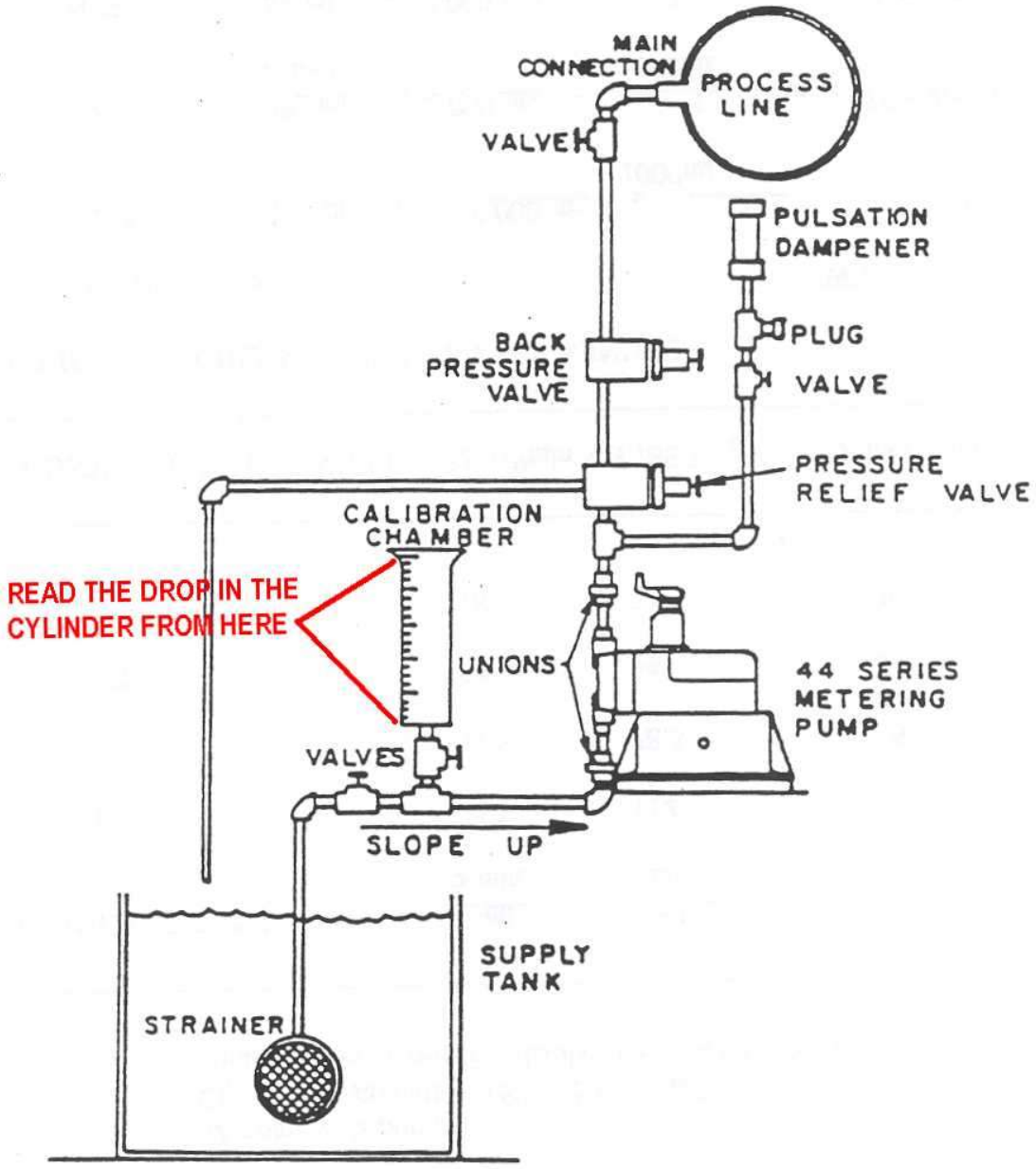
- Repeat previous steps for the 20%, 50% and 70% settings; twice

calculate average pumping rate

calculate average weight of chemical pumped for each setting

calculate average dosage for each setting

graph average dosage verses setting



Variable or multiple speed pump

- Previous procedure was for a single speed pump
- Variable speed pump requires running pump at the 4 stroke settings for ***each speed***
- A calibration chart must be drawn for ***each speed***

EXAMPLE
Positive displacement pump calibration

SITUATION-need calibration curve for single speed positive displacement pump used as a chlorinator

GIVEN:

32 GPM Well submersible pump

Chlorine solution- 0.5% (5,000 mg/L)

Positive Displacement Pump capacity-5 gph @ 150 psi

EXAMPLE
Positive displacement pump calibration

GENERAL INFORMATION

TWO UNIT CONVERSIONS ARE NECESSARY

Well flow: (32 gal/min) X (3.785 L/gal)=121 L/min

100% chemical concentration = 1,000,000 mg/L
0.5% numerically is 0.005
0.5% chem. conc. =0.005 X 1,000,000 mg/L
= 5,000 mg/L

EXAMPLE Positive displacement pump calibration STEP 1

VOLUME OF LIQUID PUMPED IN 5 MINUTES

PUMP SETTING	V_1(ml)	V_2(ml)	V_{avg}(ml)
100%	110	112	111
70%	77.5	78.5	78
50%	54	54	54
20%	18	22	20

$$V_{avg} = [V_1 + V_2] \div 2$$

EXAMPLE Positive displacement pump calibration STEP 2

VOLUME OF LIQUID PUMPED IN 1 MINUTE = PUMPING RATE, R

PUMP SETTING	V_{avg}(ml)	R(ml/min)
100%	111ml ÷ 5 min = 22.2	
70%	78 ml ÷ 5 min = 15.6	
50%	54 ml ÷ 5 min = 10.8	
20%	20 ml ÷ 5 min = 4	

R_{100} = PUMPING RATE AT 100% SETTING

R_{70} = PUMPING RATE AT 70% SETTING

R_{50} = PUMPING RATE AT 50% SETTING

R_{20} = PUMPING RATE AT 20% SETTING

EXAMPLE Positive displacement pump calibration
STEP 3

CALCULATE WEIGHT OF CHEMICAL PUMPED IN ONE MINUTE BY CHEMICAL FEEDER

Feeder Setting ****

100% wt.= 22.2 ml/min X 5000 mg/L X 1 L/1000 ml

= 111 mg/min

70% wt.= 15.6 ml/min X 5000 mg/L X 1 L/1000 ml

= 78 mg/min

50% wt.= 10.8 ml/min X 5000 mg/L X 1 L/1000 ml

= 54 mg/min

20% wt.= 4 ml/min X 5000 mg/L X 1 L/1000 ml

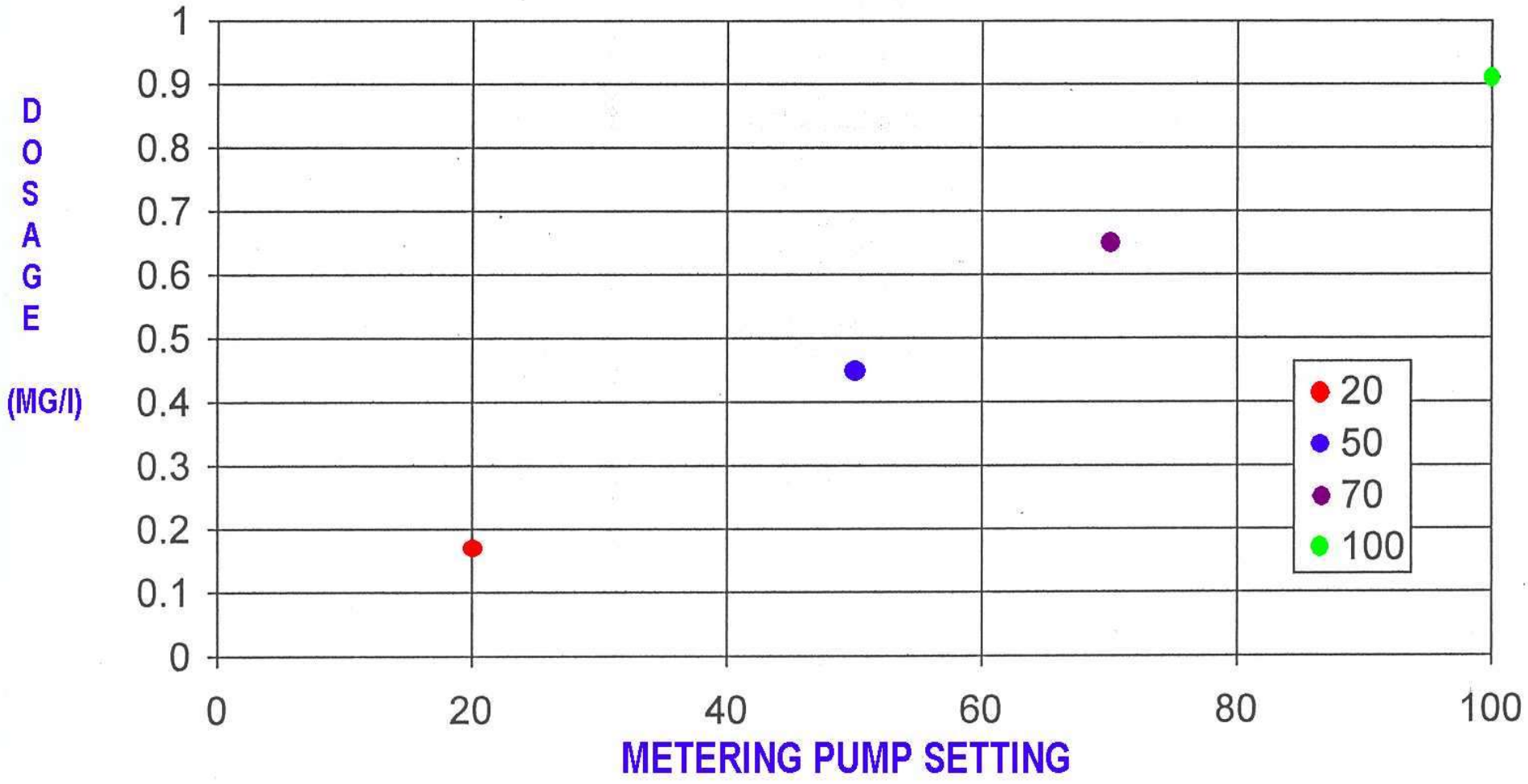
= 20 mg/min

DETERMINE PLOTTING POINTS

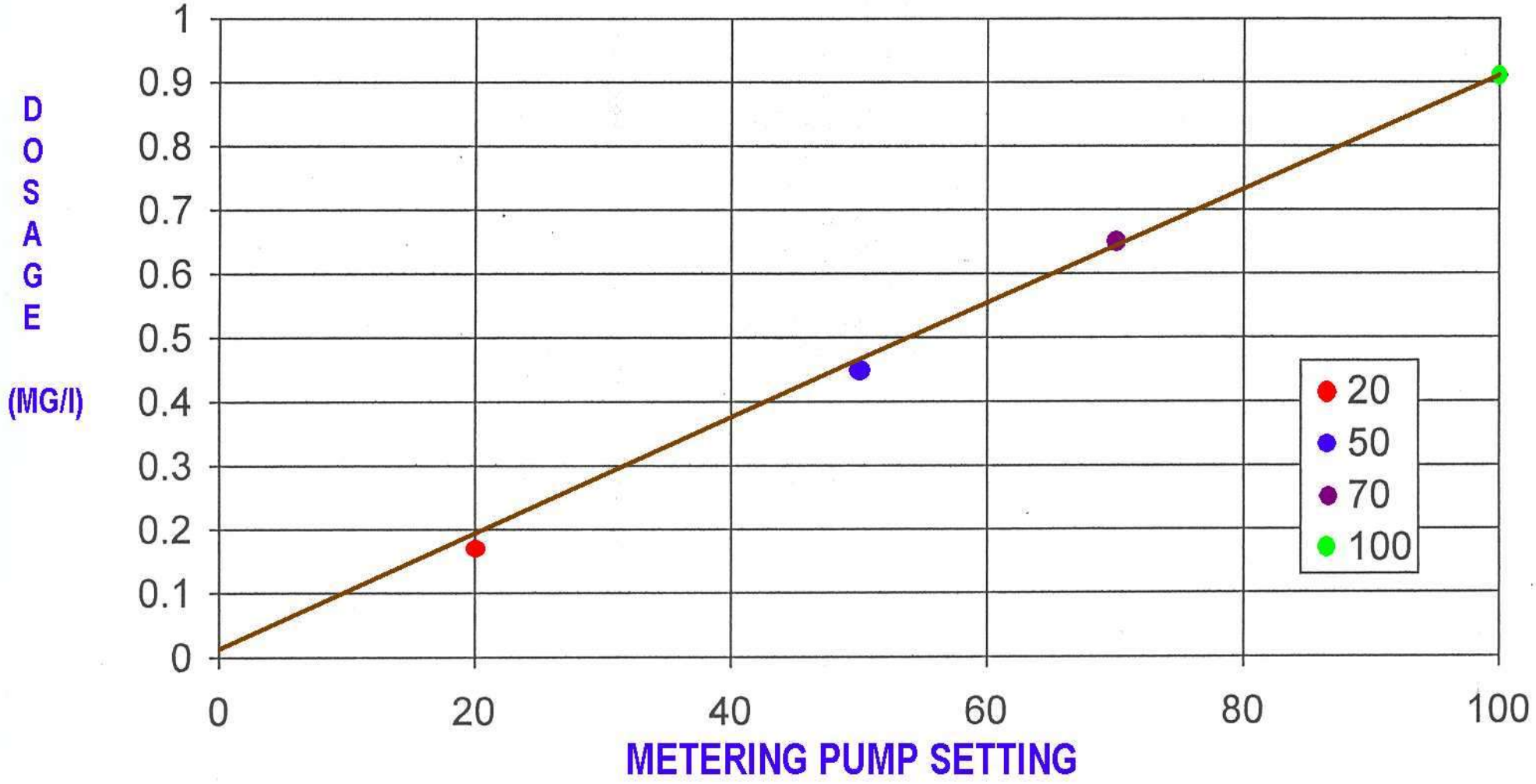
CALCULATE DOSAGE FOR SETTING

SETTING(x axis)		DOSAGE(y axis)
100%	111 mg/min ÷ 121 L/min=	0.91 mg/L
70%	78 mg/min ÷ 121 L/min=	0.65 mg/L
50%	54 mg/min ÷ 121 L/min=	0.45 mg/L
20%	20 mg/min ÷ 121 L/min=	0.17 mg/L

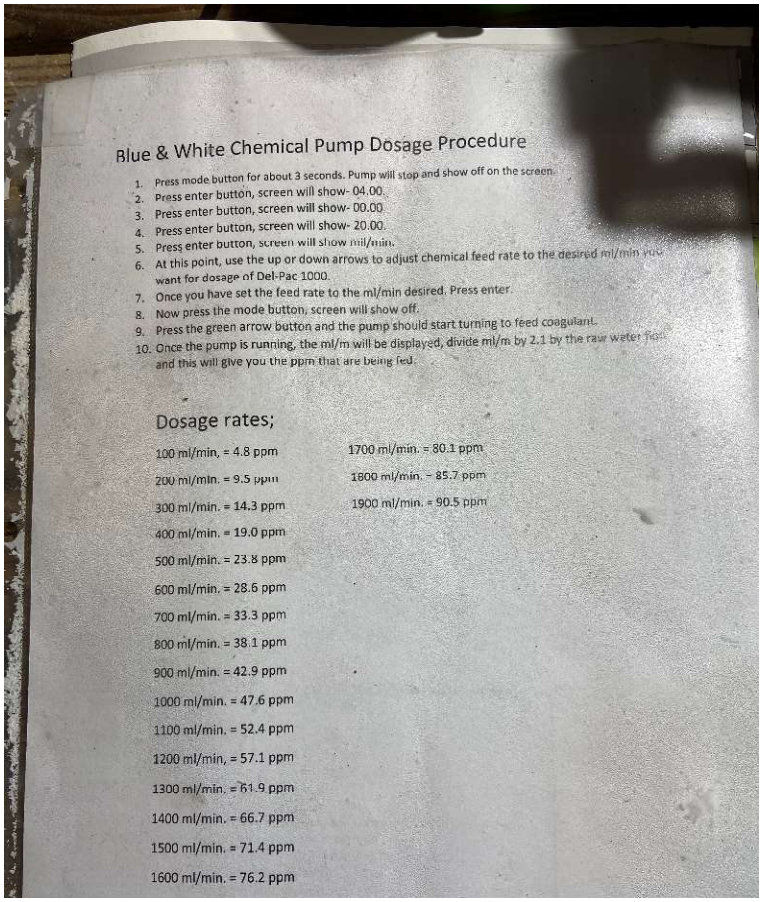
Solution Feeder Calibration Chart - step 1 - plot points



Solution Feeder Calibration Chart - step 2- draw line



Dosage rate chart



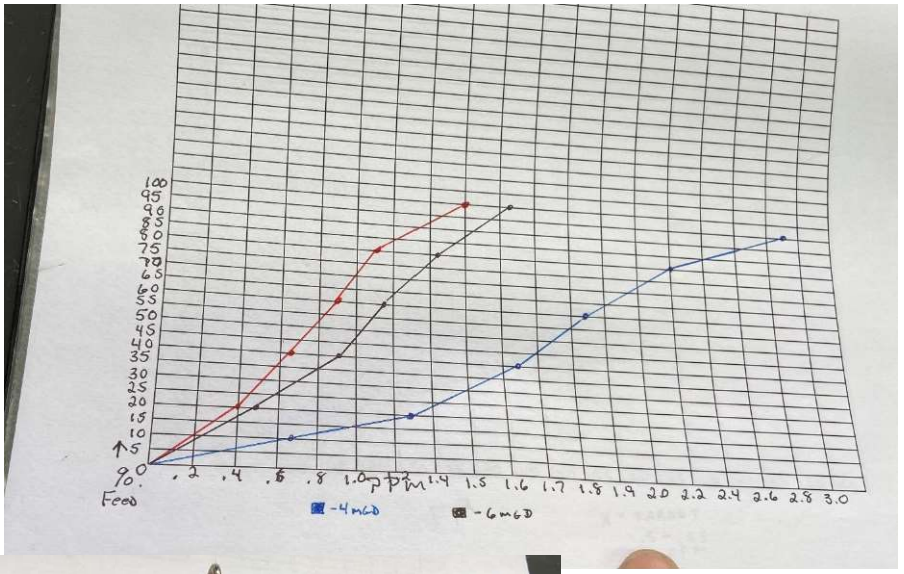
Blue & White Chemical Pump Dosage Procedure

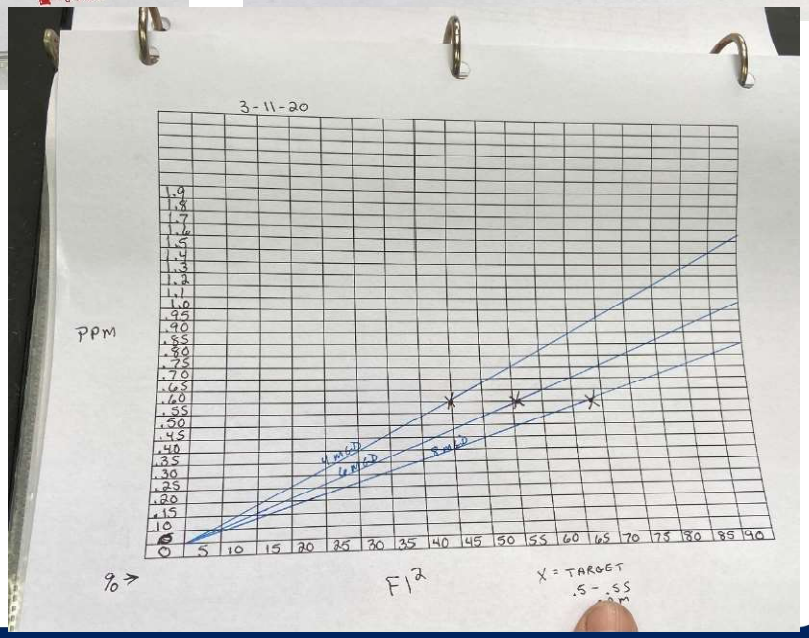
1. Press mode button for about 3 seconds. Pump will stop and show off on the screen.
2. Press enter button, screen will show- 04.00.
3. Press enter button, screen will show- 00.00.
4. Press enter button, screen will show- 20.00.
5. Press enter button, screen will show ml/min.
6. At this point, use the up or down arrows to adjust chemical feed rate to the desired ml/min you want for dosage of Del-Pac 1000.
7. Once you have set the feed rate to the ml/min desired. Press enter.
8. Now press the mode button, screen will show off.
9. Press the green arrow button and the pump should start turning to feed coagulant.
10. Once the pump is running, the ml/m will be displayed, divide ml/m by 2.1 by the raw water flow and this will give you the ppm that are being fed.

Dosage rates;

100 ml/min. = 4.8 ppm
200 ml/min. = 9.5 ppm
300 ml/min. = 14.3 ppm
400 ml/min. = 19.0 ppm
500 ml/min. = 23.8 ppm
600 ml/min. = 28.6 ppm
700 ml/min. = 33.3 ppm
800 ml/min. = 38.1 ppm
900 ml/min. = 42.9 ppm
1000 ml/min. = 47.6 ppm
1100 ml/min. = 52.4 ppm
1200 ml/min. = 57.1 ppm
1300 ml/min. = 61.9 ppm
1400 ml/min. = 66.7 ppm
1500 ml/min. = 71.4 ppm
1600 ml/min. = 76.2 ppm
1700 ml/min. = 80.1 ppm
1800 ml/min. = 85.7 ppm
1900 ml/min. = 90.5 ppm

Pump Curves in action!





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Dry feeder calibration

EQUIPMENT

- weighing pan
- weighing scales
- stopwatch
- plain paper
- graph paper
- straight edge(ruler)
- calculator

Dry Feeder Calibration PROCEDURE

Weigh pan and record

Gather data to determine *average* feed rates

- **set feeder at 100% setting**
- **collect sample for 5 minutes**
- **weigh sample, subtract pan weight and record in a table of data**
- **repeat previous two steps twice**
- **repeat three times for settings of 25%, 50% and 75%**

Calculate one minute feed rate for each weighing and record

▫ **continue next slide**

Dry Feeder Calibration
PROCEDURE

- Calculate average feed rate per minute for each setting and record
- Calculate daily feed rate (weight fed per 24 hours) for each setting
- Plot '*weight fed per 24 hours*' verses '*setting*' on graph paper

DRY FEEDER CALIBRATION EXAMPLE

DRY FEEDER CALIBRATION EXAMPLE (STEP 1)

WEIGHING RECORD

(WEIGHT OF GRAB SAMPLE OVER 5 MINUTE COLLECTION TIME)

SETTING	$W_{1(grams)}$	$W_{2(grams)}$	$W_{3(grams)}$
100%	443	405	430
75%	272	310	315
50%	203	210	199
25%	160	115	100

W_1 – first weighing for the setting
W_2 – second weighing for the setting
W_3 – third weighing for the setting

DRY FEEDER CALIBRATION EXAMPLE (STEP 2)

FEED RATE RECORD

(CALCULATE FEED RATE FOR 1 MINUTE FEED TIME BY DIVIDING WEIGHING DATA BY 5)

SETTING	$F_{1(grams/min)}$	$F_{2(grams/min)}$	$F_{3(grams/min)}$
100%	443÷5=89	405÷5=81	430÷5=86
75%	272÷5=54	310÷5=62	315÷5=63
50%	203÷5=41	210÷5=42	199÷5=40
25%	160÷5=32	115÷5=23	100÷5=20

F_1 – one minute feed rate from first weighing record for the setting
F_2 – one minute feed rate from second weighing record for the setting
F_3 – one minute feed rate from third weighing record for the setting

DRY FEEDER CALIBRATION EXAMPLE (STEP 3)

FEEDER SETTING – CALCULATE *AVERAGE* FEED RATE in gram/min

SETTING AVERAGE FEED RATE(R) = $[(F_1 + F_2 + F_3) \div 3]$

SETTING

100% $R_{100} = (89 + 81 + 86) \div 3 = 85$ gram/min

75% $R_{75} = (54 + 62 + 63) \div 3 = 60$ gram/min

50% $R_{50} = (41 + 42 + 40) \div 3 = 41$ gram/min

25% $R_{25} = (32 + 23 + 20) \div 3 = 25$ gram/min

R_{100} –average feed rate for 100% setting
R_{75} – average feed rate for 75% setting
R_{50} – average feed rate for 50% setting
R_{25} -- average feed rate for 25% setting

DRY FEEDER CALIBRATION EXAMPLE (STEP 4)

DRY FEEDERS ARE RATED IN lb/day

CONVERSION CALCULATIONS

Convert units from gram/min to lb/day for each feeder setting

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453.9 grams = 1.0 lb **1440 min = 1 day**

R_{100}= 85 gram/min x(1 lb/453.9 gm)x(1440 min/day)=269.7 lb/day

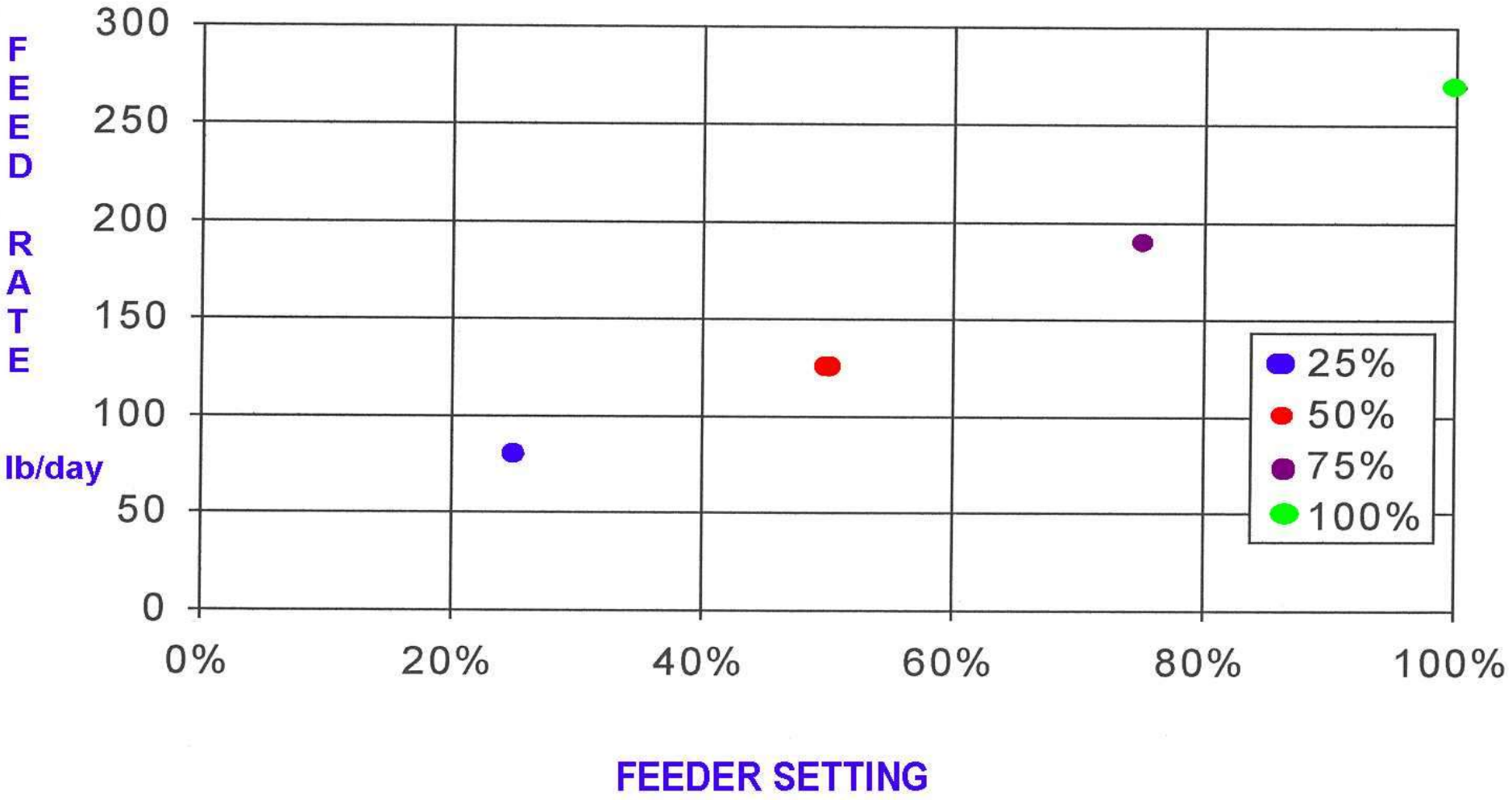
R_{75} = 60 gram/min x(1 lb/453.9 gm)x(1440 min/day)=190.4 lb/day

R_{50} = 41 gram/min x(1 lb/453.9 gm)x(1440 min/day)=130.0 lb/day

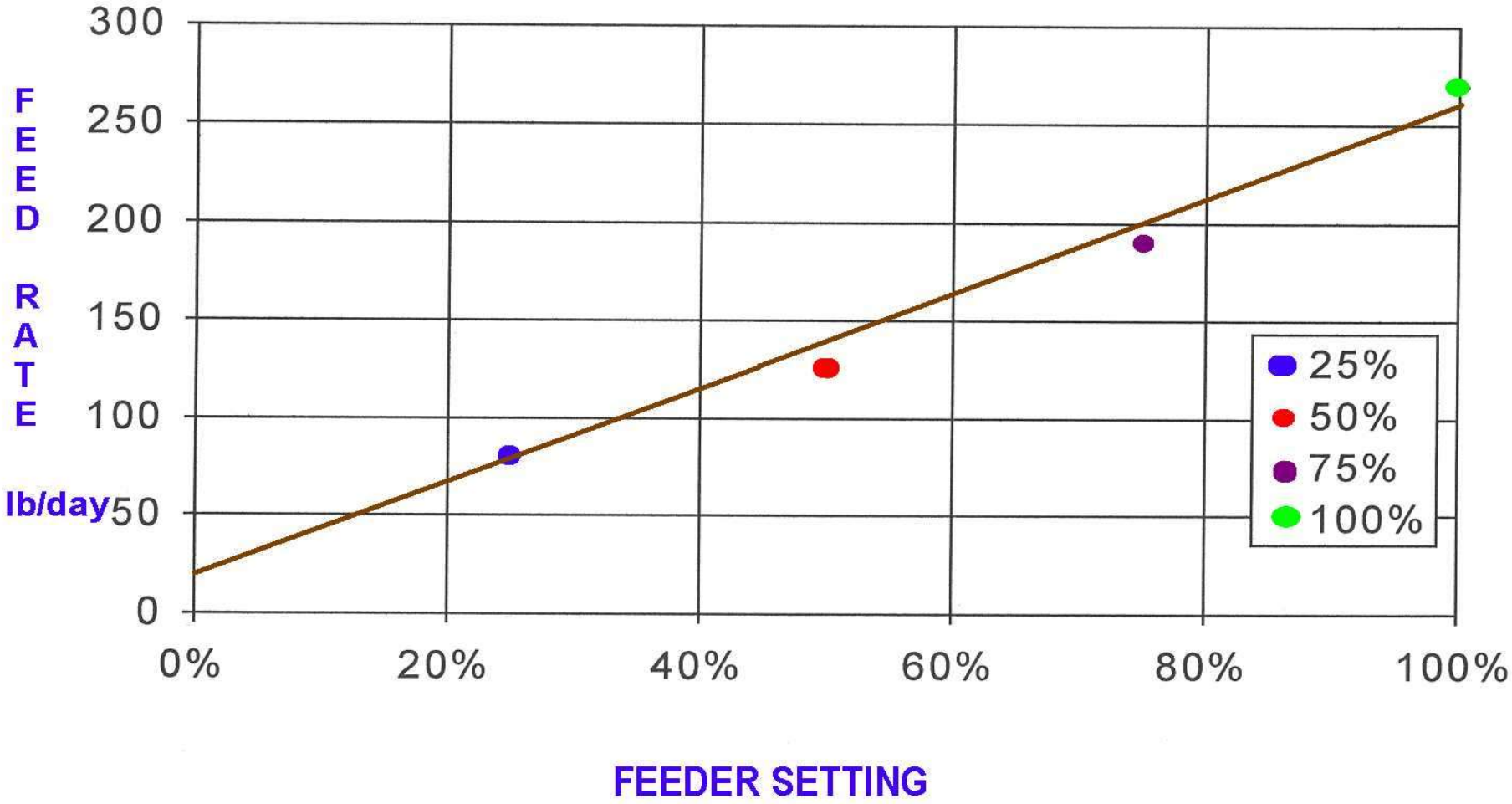
R_{25} = 25 gram/min x(1 lb/453.9 gm)x(1440 min/day)=79.3 lb/day

R_{100} –average feed rate for 100% setting
R_{75} – average feed rate for 75% setting
R_{50} – average feed rate for 50% setting
R_{25} -- average feed rate for 25% setting

DRY FEEDER CALIBRATION CHART- STEP 1- PLOT POINTS



DRY FEEDER CALIBRATION
CHART- STEP 2 - draw best fit line



Course itinerary

1. Overview
2. Review pumps
3. Liquid feeders
4. Dry feeders
5. Gas feeders
6. Extended video
7. Calibration
8. **Handy Conversions**

Handy conversion factors

1 mg/L = 8.34 pounds/million gallons

1 cubic ft of water weighs 62.4 pounds

1 cubic ft = 7.48 gallons

1 gallon = 3.785 Liters

Water weighs 8.34 pounds/gallon

1 pound = 454 grams

Course itinerary

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Course objectives

At the conclusion of this presentation, you should be able to:

1. Identify the feeders used to add liquid, powdered, and gas chemicals in water treatment.
2. *Distinguish types of positive displacement pumps.*
3. Describe volumetric and gravimetric feeders
4. *Present the reasons and methods for calibrating chemical feeders.*

Contact information

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