Reverse Osmosis (7)

Lecture 10

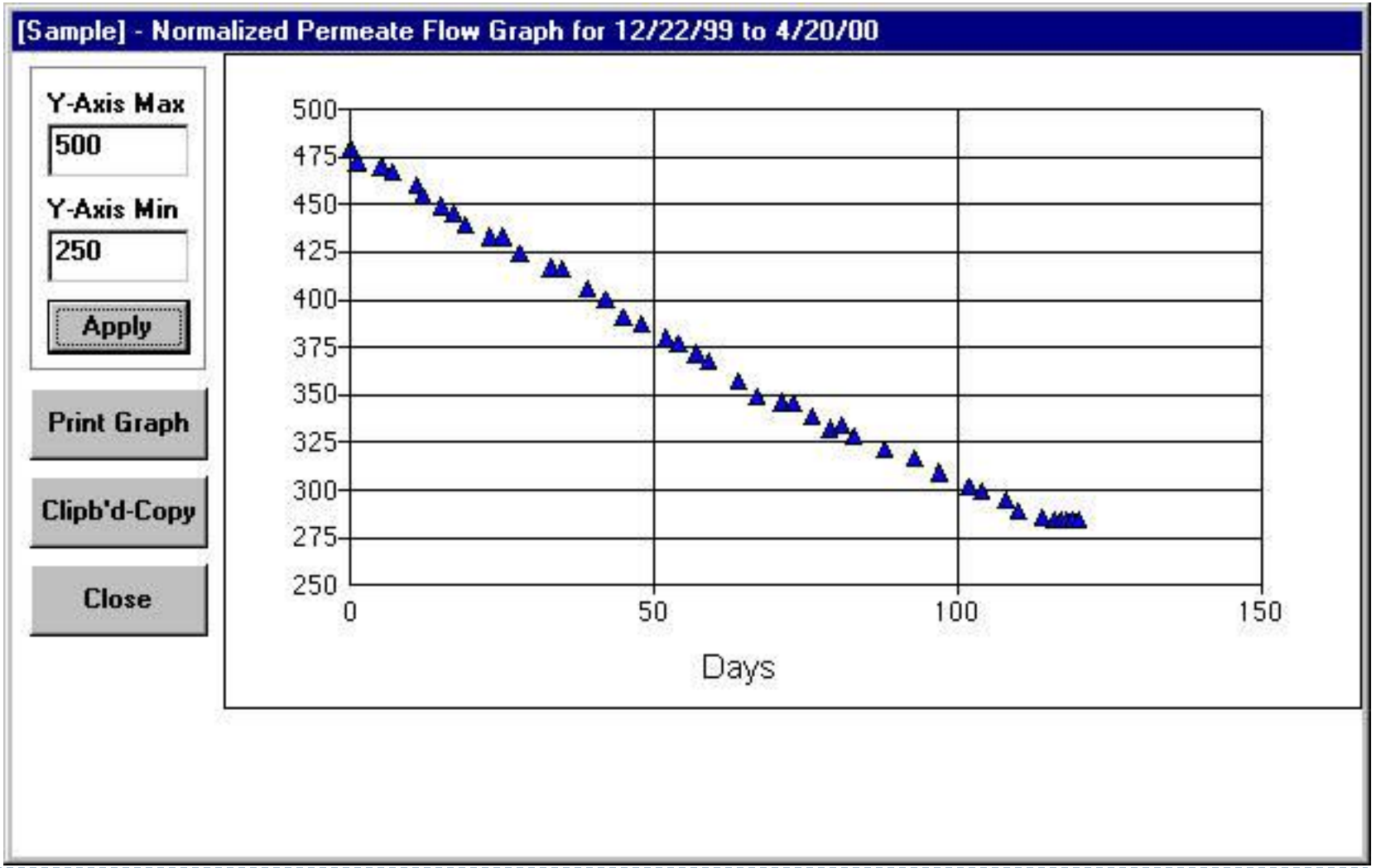
9. RO Data Trending and Normalization

- The RO membranes are the heart of the RO system and **certain data points need to be collected** to determine the health of the RO membranes.
- These data points include the **system pressures, flows, quality and temperature.**
- Water **temperature** is **directly proportional** to **pressure.**
- As the **water temperature decreases** it becomes more **viscous** and the RO **permeate flow will drop** as it requires more pressure to push the water through the membrane.
- Likewise, when the **water temperature increases** the RO **permeate flow will increase**.
- As a result, performance data for an RO system must be normalized.

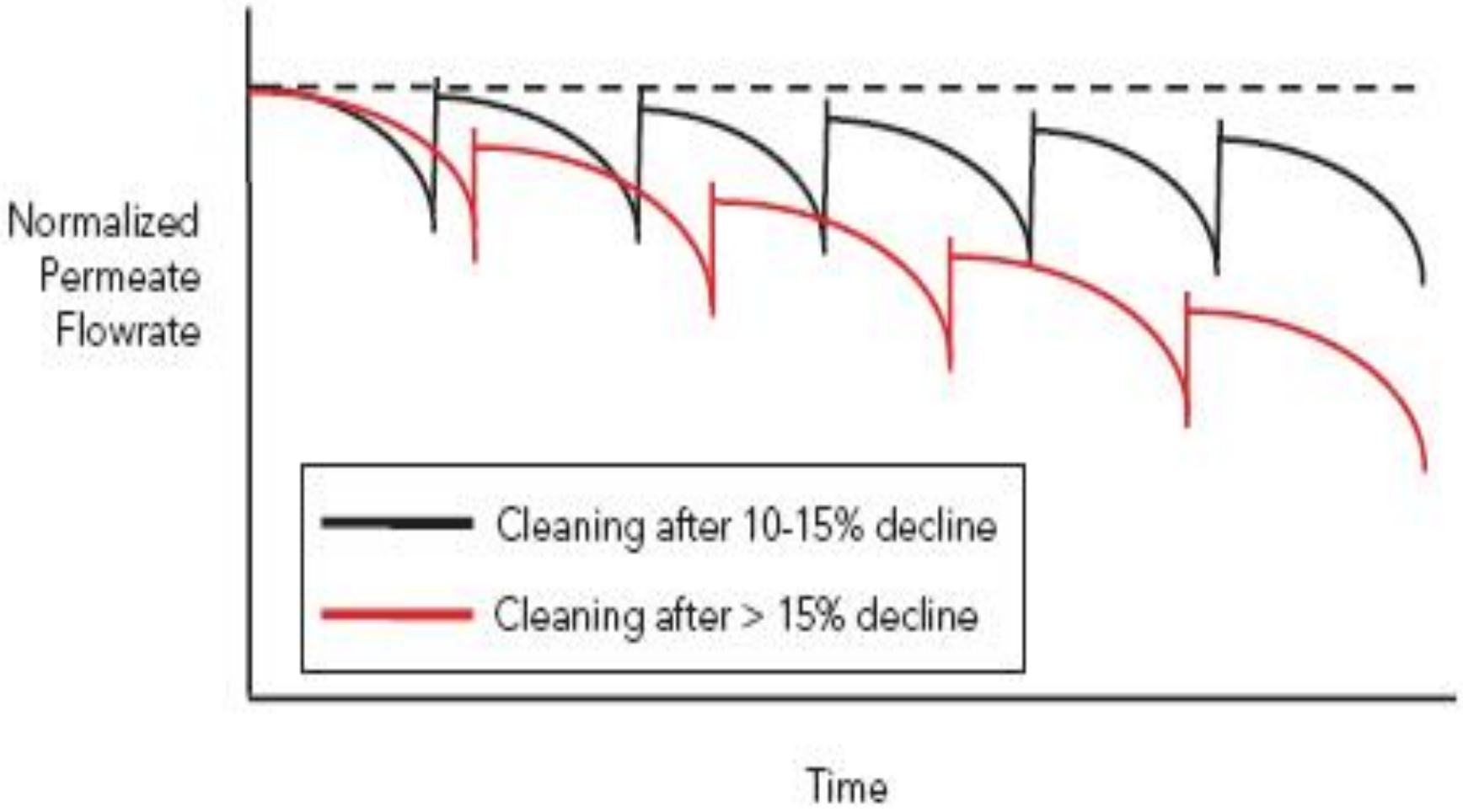
9.RO Data Trending and Normalization

- The normalized flows, pressures and salt rejection should be calculated, graphed and compared to the baseline data to help troubleshoot any problems and also determine when to clean or inspect the membranes for damage.
- Data normalization helps display the true performance of the RO membranes.
- **As a general rule, when the normalized change is ±15% from the baseline data then you need to take action.**
- If you don't follow this rule then RO membrane cleanings may not be very effective at bringing the membranes back to near new performance.

9.RO Data Trending and Normalization



9.RO Data Trending and Normalization



9.1. Data Normalization

- The performance of an RO system is influenced by changes in the feed water TDS, feed pressure, temperature and recovery ratio.

- **Data normalization** is a process to convert the **real performance** of the RO system into a form which can be compared to a given **reference performance** which may be the designed performance or the measured initial performance.

9.1. Data Normalization

- A **difference** between the normalized data and the initial or designed performance may indicate that there are some **problems** in the system as shown below:

1. Membrane **fouling** and/or scaling.
2. Membrane **chemical damage** - poor salt rejection due to a chemical change in the membrane structure by excessive exposure to chlorine or extreme pH.
3. **Mechanical failure**.
4. **Hydraulic plugging** - the presence of foulants (large size colloids) or scale stuck to the flow channel spacing between the membrane leaves of spiral - wound elements

9.1. Data Normalization

- The **problems** could be **identified early** when the **normalized** data are **recorded daily**.
- Thus, the effects of the above four problems can be directly monitored by the three variables as shown below.
- Salt rejection
- Normalized differential pressure
- Normalized permeate flow rate

9.2. Membrane Cleaning

- Membrane cleaning is dictated by **increase in pressure drop**, **decrease in permeate recovery**, and **decrease in salt rejection**.
- In addition, identification of foulants as well as analysis of feed and outlet water are important factors in determining the proper cleaning solution.
- The following is a summary of cleaning methods of various fouling and scaling compounds.

9.2. Membrane Cleaning

- **Calcium Carbonate and Metal Oxides Scale:** Clean with low pH water. The water pH is adjusted to 3-4 and sulfuric, hydrochloric, or citric acids are used.
- **Calcium Sulfate Scale:** Clean with a solution that include sodium tripolyphosphate or sodium salt of ethylenediamine tetra acetic acid.
- **Silica:** Detergents and hydraulic cleaning.
- **Organics and bio-fouling:** similar solution to calcium sulfate cleaning. In addition, use of detergents and biocides are recommended.

9.3. Membrane Cleaning Procedure

- Generally, **low pH solutions** are used to clean **metallic scales** while **alkaline solutions** are used to clean **biological and organic fouling**.
- **System cleaning follows the following basic steps:**

1. **Preparation** of the cleaning solution and adjustment of temperature and pH.
2. **Displacement** of the solution in RO modules by pumping the cleaning solution.

9.3. Membrane Cleaning Procedure

3. **Recycling and soaking** of the element. Soaking time may vary from few hours to overnight depending on the fouling level.
4. **Flushing** the unit with RO permeate water. The flushing procedure continues until the pH and conductivity of the effluent solution approach those of the feed water.

9.4. Cleaning System Specifications

- The RO cleaning system is formed of a tank, 5 µm cartridge filter, pumping unit, and instrumentation.
- Cleaning solution is pumped from the tank through the cartridge filter to the RO array.
- Solution is then recycled back to the tank.
- Instrumentation includes pH, temperature, flow rate, pressure, and level controllers.

9.4. Cleaning System Specifications

- RO membranes will inevitably require **periodic cleaning,** anywhere from **1 to 4 times a year** depending on the feed water quality.
- As a general rule, if the normalized pressure drop or the normalized salt passage has increased by 15%, then it is time to clean the RO membranes.
- If the normalized permeate flow has decreased by 15% then it is also time to clean the RO membranes.
- You can either clean the RO membranes in place or have them removed from the RO system and cleaned off site by a service company that specializes in this service.
- It has been proven that **off site** membrane cleaning is more effective at providing a better cleaning than onsite cleaning .

9.5. Membrane Sterilization

- Membrane sterilization is necessary if the system is shut down for period of more than 2 days.

Sterilization compounds include the following:

- Hydrogen peroxide .
- Sodium bisulfite/glycerin.
- Formaldehyde .
- Copper sulfate.

9.5. Membrane Sterilization

- Procedure for membrane sterilization includes:

1. Preparation of the sterilizing solution,
2. Initial flushing with RO permeate water,
3. Circulation of the sterilizing solution,
4. Drainage, and
5. Tight closure during the storage period.

10. Membrane Storage

- Various forms of membrane storage include the following:
- **Short-term storage** of membrane elements in place inside the pressure tubes (5 to 30 days).
- **Long-term storage** of membrane elements in place inside the pressure tubes (>30 days).

10. Membrane Storage

- For both modes of storage, the membrane elements remain in place inside the pressure tubes.
- Both storage modes have similar sequence and are summarized below:

1. Cleaning of the membrane elements.
2. Flushing the membrane element with acidified water to prevent precipitation of scaling material.

10. Membrane Storage

3. A suitable biocide is added to the flushing water to prevent microorganism growth.
4. The pressure tubes are filled with the above solution.
5. The cleaning, flushing, and filling sequence is repeated on frequent basis subject to the effectiveness of the biocide.

10. Membrane Storage

- Before, returning the system to service, the membrane elements are flushed with feed water.
- During the flushing process, the brine and product streams are rejected.
- Also, water samples are collected from both streams to check for presence of biocides.
- Dry storage of membrane elements as spares or before start-up of the plant.

10. Membrane Storage

- Storage of membrane elements during transportation or prior to installation should provide protection from direct sunlight.

- The elements should be stored in a cool, dry place, and at a temperature range of 20°C to 35°C.

Questions

- Answer with Yes or No:

1. In RO system water temperature is directly proportional to pressure.
2. A difference between the normalized data and the initial or designed performance may indicate that there are not any problems in the system.
3. As a general rule, when the normalized change is ±25% from the baseline data then you need to take action.
4. Membrane cleaning is dictated by increase in pressure drop, increase in permeate recovery, and decrease in salt rejection.

Questions

Answer the following questions:

1. Discuss briefly the basic steps of the RO system cleaning.
2. Mention the various forms of membrane storage.

Complete the following statements with the proper word(s):

1. Storage of membrane elements during transportation or prior to installation should provide protection from----------.
2. The elements should be stored in a cool, dry place, and at a temperature range of ------ to -------.