Understanding Water Quality and Optimizing Water Usage

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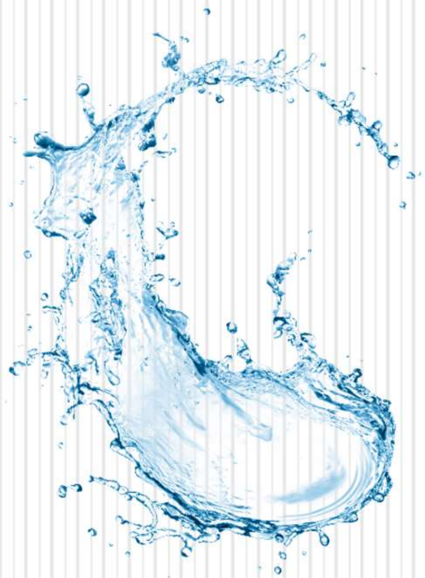
Water Quality = Finishing Quality



- Water is a significant variable in the pretreatment process comprising >95% of the pretreatment process chemistry.
- Thought must be given to water's contribution and it's ultimate cost in the pretreatment operation.
- Water's primary role is to remove chemical, soil residue and contaminants from the metal substrate.
- This creates a contaminant free surface which promotes optimum coating adhesion and performance.
- Water quality has a critical importance in achieving your specified coating performance standards.

Water Quality = Finishing Quality

- Water quality is directly related to the impurities or contaminants that it contains.
- A major issue for a superior quality pretreatment process is the level of total dissolved solids (TDS) accumulating in the rinse water.
- Excessive TDS in the water deposits on the metal substrate during rinsing. As it evaporates the impurities remain on the metal substrate.
- Poor water quality results in salt spray failure, rust, warranty claims, excessive water treatment costs, maintenance costs, labor costs and environment compliance issues.
- High quality water does come at a cost.

Water Quality = Finishing Quality

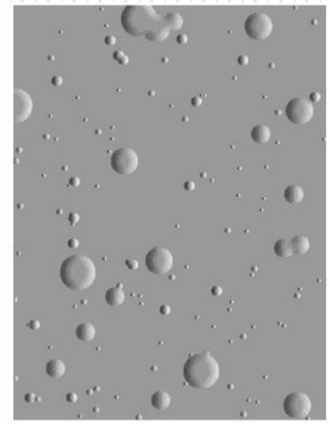
- Achieving high water quality requires costs in the form of water purification equipment.
- Which costs would we prefer;
  - Unexpected, unpredictable, possibly devastating cost of poor water quality.
  - Predictable, budgeted, proactive cost of good water.
- Thought must be given to the role water plays in the pretreatment process with an understanding that good water quality is key to preventing paint problems.
- Optimizing, monitoring and controlling the quality of water in the pretreatment process is also essential.
- The choice depends on your specified performance standards and whether or not you have the tolerance to handle field failures and dissatisfied customers.

Water Quality: Effects on Paint Performance

- Paint coatings are semi-permeable membranes allowing moisture to migrate through the polymer film as a result of osmotic pressure.
- When adhesion of the coating to the substrate is impaired, moisture permeates the coating which causes it to swell, creating a corrosion site and lifting the coating away from the substrate.
- Powder coatings with high levels of inert extenders or low crosslink density are more permeable and more susceptible to corrosion.

Water Quality: Effects on Paint Performance

- As the coating respires, **salts left on the substrate from poor water quality**, will absorb transmitted moisture until the salts re-solubilize.
- This breaks the bonds that may have existed with the deposited salts and the coating substrate interface.
- The end result is coating delamination and substrate degradation.
- Coating performance related to poor rinsing may deteriorate over days or weeks after coating application.
- Coated parts can pass adhesion testing one day and fail the next.



Water Quality: Effects on Pretreatment Process

- Hardness in water is caused by the presence of mineral salts, mostly calcium, magnesium, iron, and manganese.
- Mineral salts react with the cleaner to form soap film or scum, which does not rinse away easily.
- Mineral salts in hard water reacts with cleaners to form insoluble precipitates that clog spray nozzles.

Water Quality: Effects on Pretreatment Process

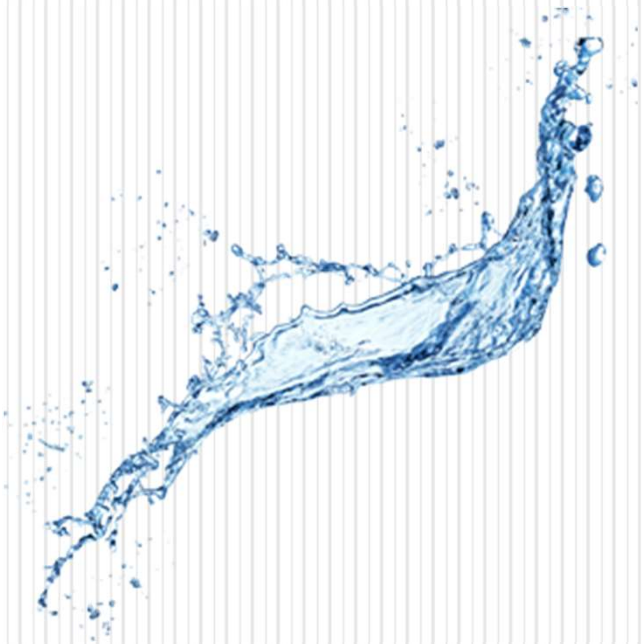
- Chelating agents are very effective in counteracting water hardness.
- Chelating agents are able to "tie up" the hard minerals that are found in water and free up the cleaning agents to work on the actual soils.
- Chelating agents can interfere with the ability of other chemicals to removed emulsified oils and dissolved metals from solution which can lead to waste disposal problems.
- Proper cleaner selection is based on the substrate to be cleaned and consideration should be given to in-coming water quality.

Water Quality: Effects on Pretreatment Process

- Pretreatment performance is impeded when high levels of dissolved solids are transmitted to the parts via rinse water.
- Other elements found in water that contribute to poor pretreatment performance are chlorides and sulfates.
- Chlorides and sulfates in high concentrations will lead to the formation of corrosion points on the surface of the substrate.
- Incoming water with high chloride and sulfate levels may require a RO/ DI system for optimum pretreatment quality.

Water Quality: Water Sources

- Four various water sources can be used to supply a pretreatment system.
- Two common measurements are used in metal finishing to measure water quality.
- Pretreatment design, process equipment and the performance requirements of the finished goods, determine which water sources may be appropriate for the application.
- The following sections present a brief description of each water source.



Water Quality: Ground Water

- Ground water combines with carbon dioxide forming weak carbonic acid.
- Ground water moves through soil and rock dissolving very small amounts of minerals and holds them in solution.
- Calcium and magnesium dissolved in water are the two most common minerals that make water "hard."
- Water hardness is the amount of dissolved calcium and magnesium in the water.

Water Quality: Ground Water

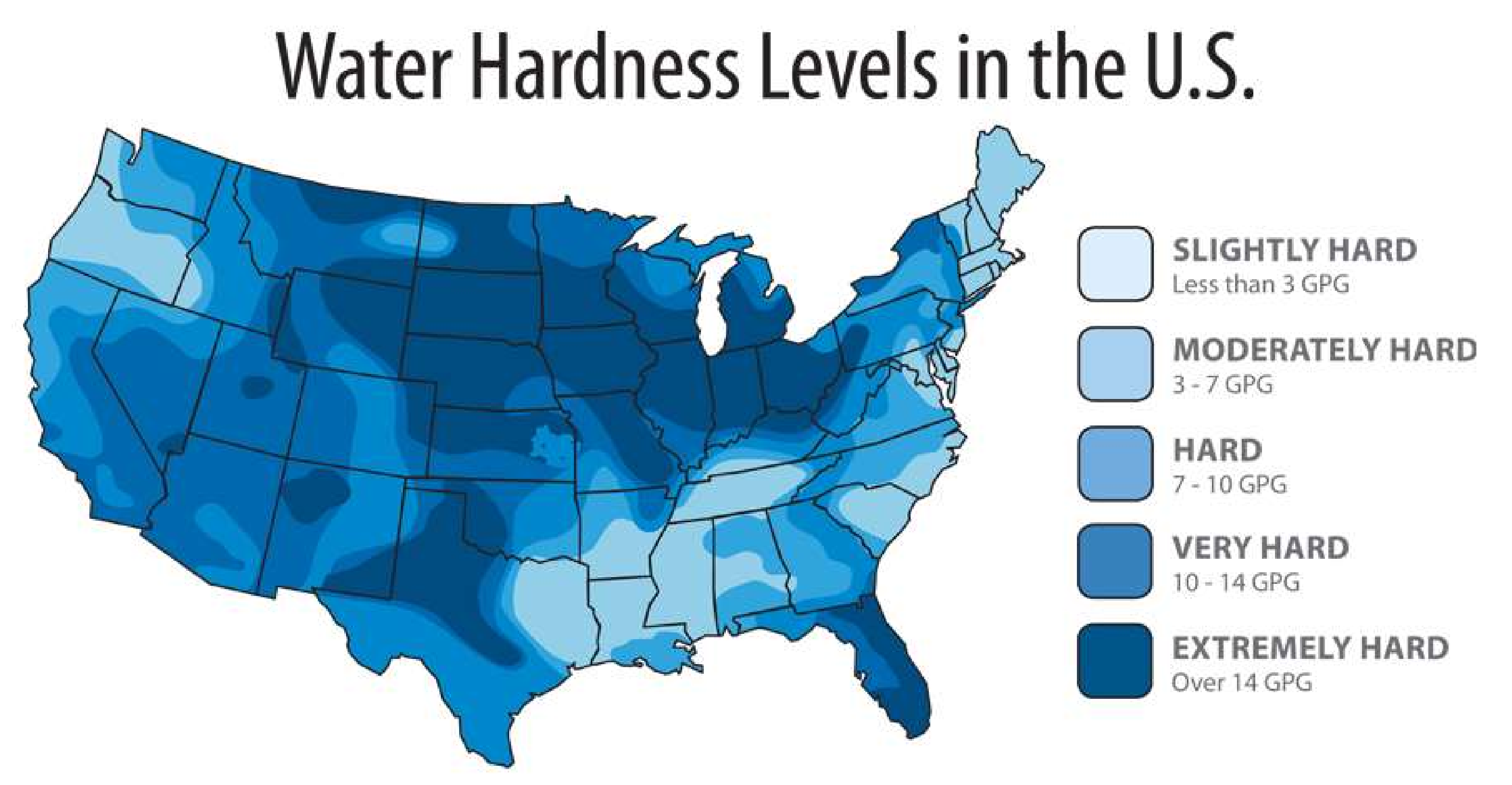
- Five most common metals and ions present in ground water in descending order.
  - **$CaCO_3$**
    - **Calcium carbonate** (limestone) forms water scale in process equipment.
  - **Sodium**
    - Sodium remaining on the metal surface can serve as an initiator for the corrosion process.
  - **Sulfate**
    - Sulfate ions accelerate corrosion.
  - **Magnesium**
    - Magnesium combined with $CaCO_3$ create hardness and water scale.
  - **Chloride**
    - Chloride ions accelerate corrosion.

Water Quality: Measurements

- **Total Dissolved Solids** (TDS) refers to a measurement of all inorganic solids dissolved in the water.
- TDS will measure all ions that contribute to water hardness, like calcium, but also those that do not, like sodium.
- TDS measurement is a better reflection of the total mineral content of the water rather than a water hardness measurement.
- Water hardness is typically reported in grains per gallon, milligrams per liter (mg/l) or parts per million (ppm). One grain of hardness equals approximately 17.1 ppm (mg/L) in TDS.
- *Note that since TDS includes inorganic solids, 17 ppm does not necessarily equal 1 grain of hardness.*

Degree of Hardness	TDS (ppm)	Conductivity (µs/cm)	Grains per Gallon (gpg)
Very Soft	0-70	0-140	<1
Soft	70-150	140-300	<1
Slightly Hard	150-250	300-500	1.0-3.5
Moderately Hard	250-320	500-640	3.5-7.0
Hard	320-420	640-840	7.0-10.5
Very Hard	Above 420	Above 840	10.5>

Water Quality: Measurements



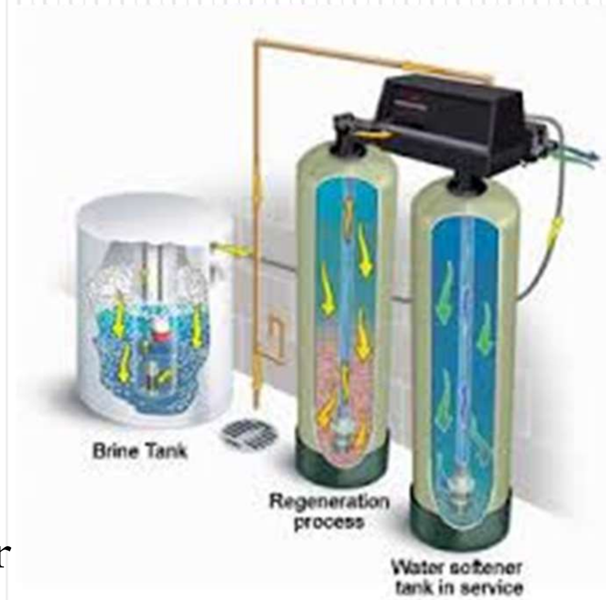
- Water in Mexico has relatively high TDS (500+TDS), and particularly a high silica concentration. High silica concentration limits the recovery that an RO system can deliver.

Water Quality: Measurements

- Conductivity measures the ability of a substance to conduct electric current.
- Measurement is made with an electronic sensor or meter in micro (µS) or milli (mS) siemens per centimeter.
- How many µS in 1 mS? The answer is 1000.
- Conductivity increases with increasing ion content providing a good approximation of the TDS measurement (conversion factor of 1 ppm = 1.56 µS/cm).
- The measurement combines all ions in the sample including those that do not contribute to the water's hardness.

Water Quality: Reducing Water Scale with Softened Water

- **Softened water is not the answer**; softening process replaces the calcium and magnesium ions with sodium ions (salt).
- Water softeners do not remove TDS. Water softeners work through a process of ion exchange. Therefore, the TDS level will remain virtually constant (there may be minor differences).
- Soft water lowers tendency of water to form scale.
- Softened water is more prone to foaming.
- Sodium remaining on the substrate serves as an initiator for the corrosion process creating poor salt spray performance.
- Recommend softened water for **cleaning stage only**.



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Water Quality: Improving Water Quality with Reverse Osmosis (RO) Water

- Water is pretreated via water softener/carbon filter or by chemical injection to remove hardness and chloride ions.
- Ions are removed by forcing source water through semi-permeable membranes producing higher water purity than ground water or softened water.
- More corrosive than ground water requiring stainless steel tanks and pumps in the pretreatment system.
- Reduce pretreatment chemical usage when used as make-up water for chemical baths.
- Improve pretreatment performance.
- Feedwater temperature affects output.

Water Quality: Improving Water Quality with Deionized (DI) Water

- Two reactions produce DI water.
  - Ions are removed and replaced with hydrogen ions by a cation exchange resin, which is regenerated by an acid.
  - Acid is removed through an anion exchange that is regenerated with an alkaline solution.
- DI water has an extremely low TDS level (0–15 ppm).
- DI water system is the best way to remove salts and chlorides.
- Higher operating cost than a RO water system.
- DI water is corrosive. Stainless steel construction and corrosion resistant components are required when using DI water.
- Typical conductivity of <23 μS/cm.

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Water Quality: Proper Rinse Limits

- **Suggested Rinse Water Parameters after Cleaning Stage.**
  - 300 ppm TDS (470 µS/cm conductivity) above the incoming water source.
  - <1,500 ppm TDS (2.3 mS/cm conductivity).
  - First rinse after cleaner may operate at 1,500 ppm TDS (2.3 mS/cm) if followed by a second rinse.
    - Second cleaner rinse <600 ppm TDS (940 µS/cm conductivity).
    - Consider using a fresh water halo after first rinse when operating at higher conductivity/TDS ranges.
  - Chemical titration <10% b/v of the previous chemical stage.
    - Previous stage concentration divided by product factor (supplier specified) = A
    - Rinse bath sample size divided by previous bath sample size = B
    - "A" x 0.10 x "B" = maximum rinse bath chemical titration
    - Example: (2% cleaner/0.69=2.9) x 0.10 x (100 mL/10 mL = 10) = 2.9 mL limit

Water Quality: Proper Rinse Limits

- **Suggested Rinse Water Parameters after Iron / Zinc Pretreatment.**
  - 300 ppm TDS (470 µS/cm conductivity) above the incoming water source.
  - First rinse <1,000 ppm TDS (1.6 mS/cm conductivity) followed by second rinse.
  - Second rinse operate <160 ppm TDS (250 µS/cm).
  - Consider using a fresh water halo after first rinse when operating at higher conductivity/TDS ranges.
  - Chemical titration <5% b/v of the previous chemical stage.
    - Previous stage concentration divided by product factor (supplier specified) = A
    - Rinse bath sample size divided by previous bath sample size = B
    - "A" x 0.05 x "B" = maximum rinse bath chemical titration
    - Example: (2.5% pretreatment/0.65=3.8) x 0.05 x (100 mL/10 mL = 10) = 1.9 mL limit

Water Quality: Proper Rinse Limits

- **Suggested Rinse Water Parameters before/after Zirconium Pretreatment.**
- Rinse with DI / RO water prior to the application of the zirconium pretreatment for optimum pretreatment performance.
  - <150 ppm TDS (234 µS/cm conductivity) rinse prior.
  - Consider a DI or RO water halo (fresh) before the parts enter the zirconium pretreatment stage.
  - <32 ppm TDS (50 µS/cm conductivity) for fresh water halo.
- Rinse with DI / RO water after zirconium pretreatment for optimum pretreatment performance.
  - <65 ppm TDS (100 µS/cm conductivity) for the rinses after zirconium pretreatment.
  - Consider using a fresh DI / RO water halo at the end of the final rinse.
  - <32 ppm TDS (50 µS/cm conductivity) for the final fresh water halo.

Water Quality: Proper Rinse Limits

- **Suggested Final Rinse Water Parameters**
- Final rinse with DI / RO water for optimum pretreatment performance.
  - <65 ppm TDS (100 µS/cm conductivity) final rinse.
  - <25 ppm TDS (39 µS/cm conductivity) final rinse prior to e-coat.
  - Consider a DI or RO water halo (fresh) at end of final rinse stage.
  - <32 ppm TDS (50 µS/cm conductivity) for fresh water halo.
  - Total chloride and sulfate <70 ppm.
    - Total chloride <50 ppm.
    - Total sulfate <50 ppm.
  - If using a final chemical seal rinse, parameters would be adjusted.

Optimizing Water Usage – RO Cost of Operations

- System Design
  - Operating Hours: 8 hours per day
  - Operating Days: 320 days per year
  - Finished Water: **3,072,000 gallons per year**
  - Plant Recovery: 75 %
  - RO Feed Flow: 27 gpm
  - Total Concentrate Flow: 7 gpm
  - Total Permeate Flow: 20 gpm
- Cost of Operations Totals

Electricity:	3.53 kWh / 1000 gallons	$0.25 / 1000 gallons
Chemicals:	0.633 lbs / 1000 gallons	$0.17 / 1000 gallons
RO Membrane Replace:	$1,470.00 per change	$0.05 / 1000 gallons
Membrane Cleaning:	$112.00 per cleaning	$0.04 / 1000 gallons
Labor:		$3.61 / 1000 gallons
Feed Water:		$2.00 / 1000 gallons
Sewer Treatment:		$0.69 / 1000 gallons

- TOTAL: **$6.80 / 1000** gallons of finished water produced
- TOTAL without Water/Sewer: $4.12 / 1000 gallons of finished water produced
- ANNUAL COSTS: **$20,900.99**

Optimizing Water Usage – Cost Benefit of Using RO

- One 3000 gallon final RO water rinse tank overflowing at 3 gpm for 8 hours = 1,440 gallons x 320 days = 460,800 gallons per year
- 3000 gallon RO water rinse tank dumped once per week (40 times per year) = 120,000 gallons per year
- Total 580,800 gallons per year of water (RO) consumed for one rinse tank = $3,950.00 per year (RO water cost)
- Leaving 2,491,200 gallons of RO water capacity for other rinses and chemical stages.
- RO make up water in cleaning stage will have a significant impact on maintenance and labor costs.
- RO water will optimize pretreatment performance when used as final rinse and in the pretreatment stage.

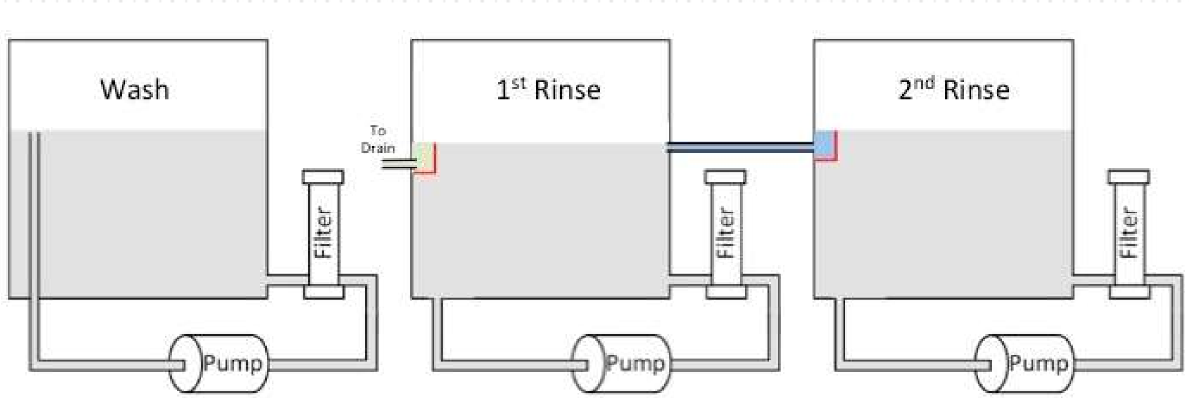
Optimizing Water Usage – Conductivity Control

- Some pretreatment systems rely on a variable flowmeter to regulate rinse water overflow.
- Rinse overflow adjusted by educated guess with or without aid of chemical titration.

- Conductivity Controllers (conductivity probes) measure the total dissolved solids of water in a rinse tank.
- Overflowing rinse based on a conductivity set point which energizes a fresh water solenoid valve.
- Constant monitoring and control of rinse overflow.

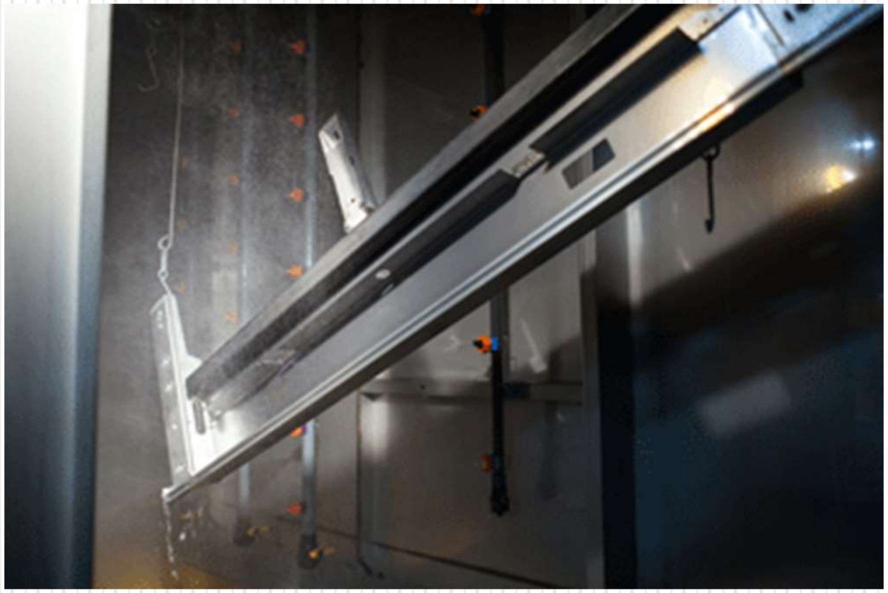
Optimizing Water Usage – Counter Flow Rinsing

- **Counter Flow Rinsing** is a method of reusing water from one rinsing operation to another, less critical rinsing operation before being discharged to treatment.
- The rinse water both removes and neutralizes drag-out from the work piece.



Optimizing Water Usage – Reduce Drag-out

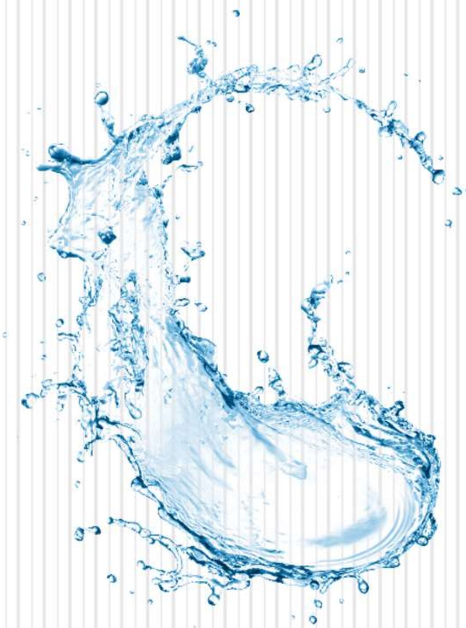
- Process lines can be modified to reduce drag-out of bath chemicals.
- Extended floor drain pans to help contain drag-out.
- Reorient parts to maximize drainage.
- Make small design changes to maximize drainage.



Optimizing Water Usage – Spray Nozzles

- Plugged spray nozzles can cause areas of the parts to be poorly pretreated.
- Common response to quality failures is to increase the flow and frequency of bath changes when merely cleaning the nozzles could ensure that the solution cleans and coats the parts.
- Properly position nozzles for an ideal spray pattern to ensure the solution cleans the parts and doesn't flow into other stages.

Water Quality = Finishing Quality



- In Summary;
  - Good water quality is fundamental to any aqueous pretreatment system.
  - Poor water quality will limit the effectiveness of the chemical stages, leading to greater chemical usage.
  - Water quality will impact pretreatment process performance.
    - Salt Spray Testing.
    - Humidity Testing.
  - Inadequate or inefficient water quality can be costly.

Thank You

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