INDUSTRIAL WATER MANAGEMENT

WASTE MEASUREMENT AND MINIMISATION

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UNESCO-IHE
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Consulting Engineers & Scientists

Water Audit

- Mass Balance principles
- The manufacturing process
- Evaporation and blowdown losses
- Results
- Reducing water use
- Reducing contamination of water
- Re-using water
- Recycling water

Mass Balance Principles

"When you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot measure it, your knowledge is of a meagre and unsatisfactory kind."

William Kelvin, 1894

Mass Balance Principles

- *Mass and heat balances based on*
  - *conservation of matter*
  - *conservation of energy*
- *What goes in comes out unless it stays there*
- *For a system:* Σ *mass in =* Σ *mass out*

Mass Balance Principles

- *Water Audit*
  - *Mass balance on water*
  - *May also need to consider concentrations of specific contaminants*
  - *May identify leakage losses*

The Manufacturing Process

- identify the unit operations used in the manufacturing process
- prepare a process flow diagram showing operating temperatures and pressures
- identify the water quality required for each unit operation

The Manufacturing Process

- *characterise water and wastewater streams for each unit operation (quality and quantity)*
- *generate a mass balance for each part of the process showing raw materials in and products out including water*
- *prepare a plot plan and identify drains*

The Manufacturing Process

- remember that water is exported in the product:
  - Soft drinks and beverages >99%
  - Pharmaceutical liquid products >95%
  - Wet products - eg cosmetics >50%
  - “Dry” products (paper, salt) ~10%

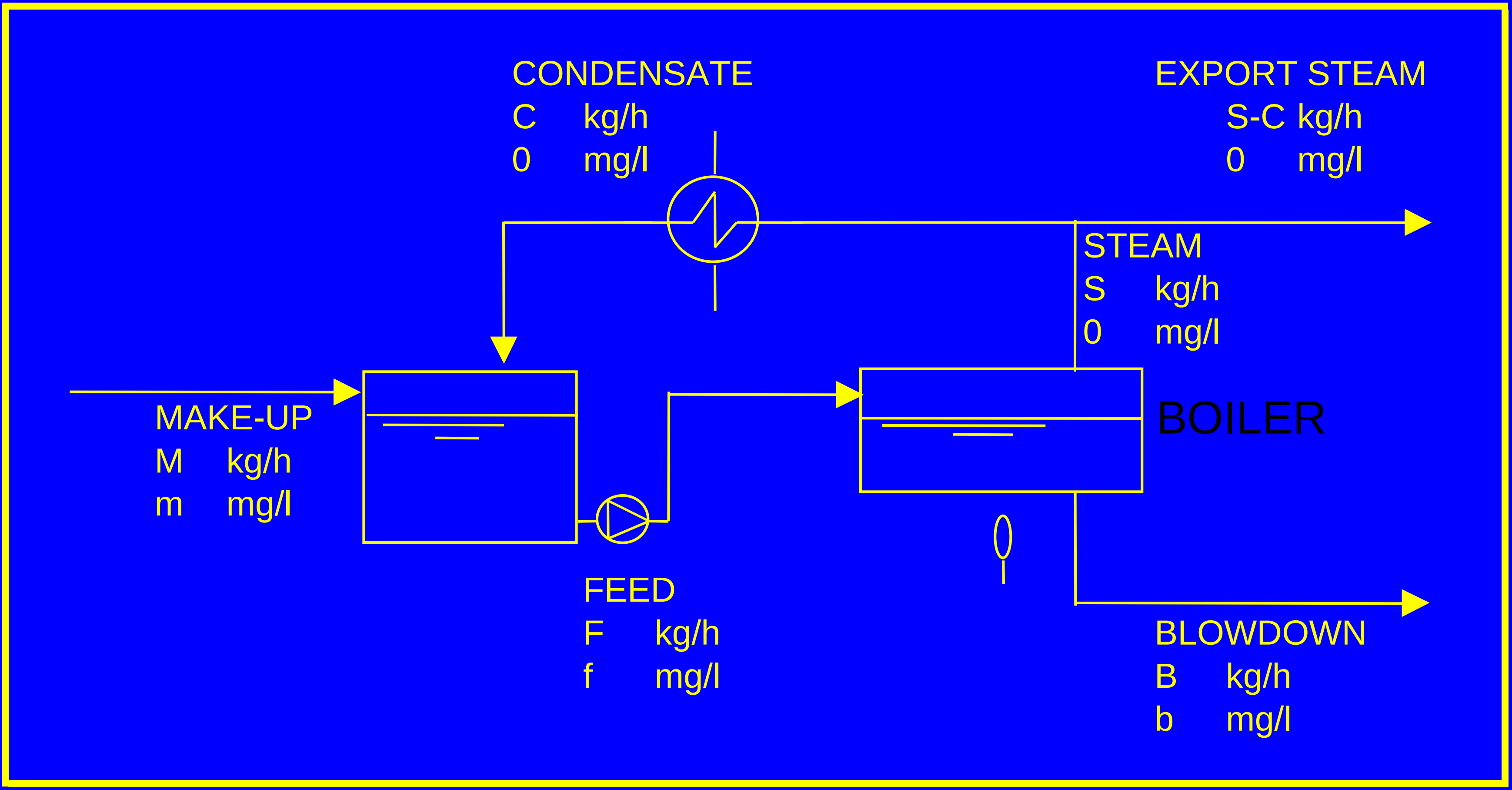
The Manufacturing Process

- *review the chemical inventory*
- *review historical data*
  - *what quantities of chamicals have been purchased in previous years?*
  - *how much water has been purchased?*
  - *how much wastewater discharge has been assessed by the receiving authority?*
- *identify the discharge criteria*

Evaporation & Blowdown

- *Steam from boiler*
- *Fate of condensate*
- *Boiler blowdown*
- *Cooling tower evaporation*
- *Cooling tower blowdown*
- *Cooling tower windage*

Evaporation & Blowdown



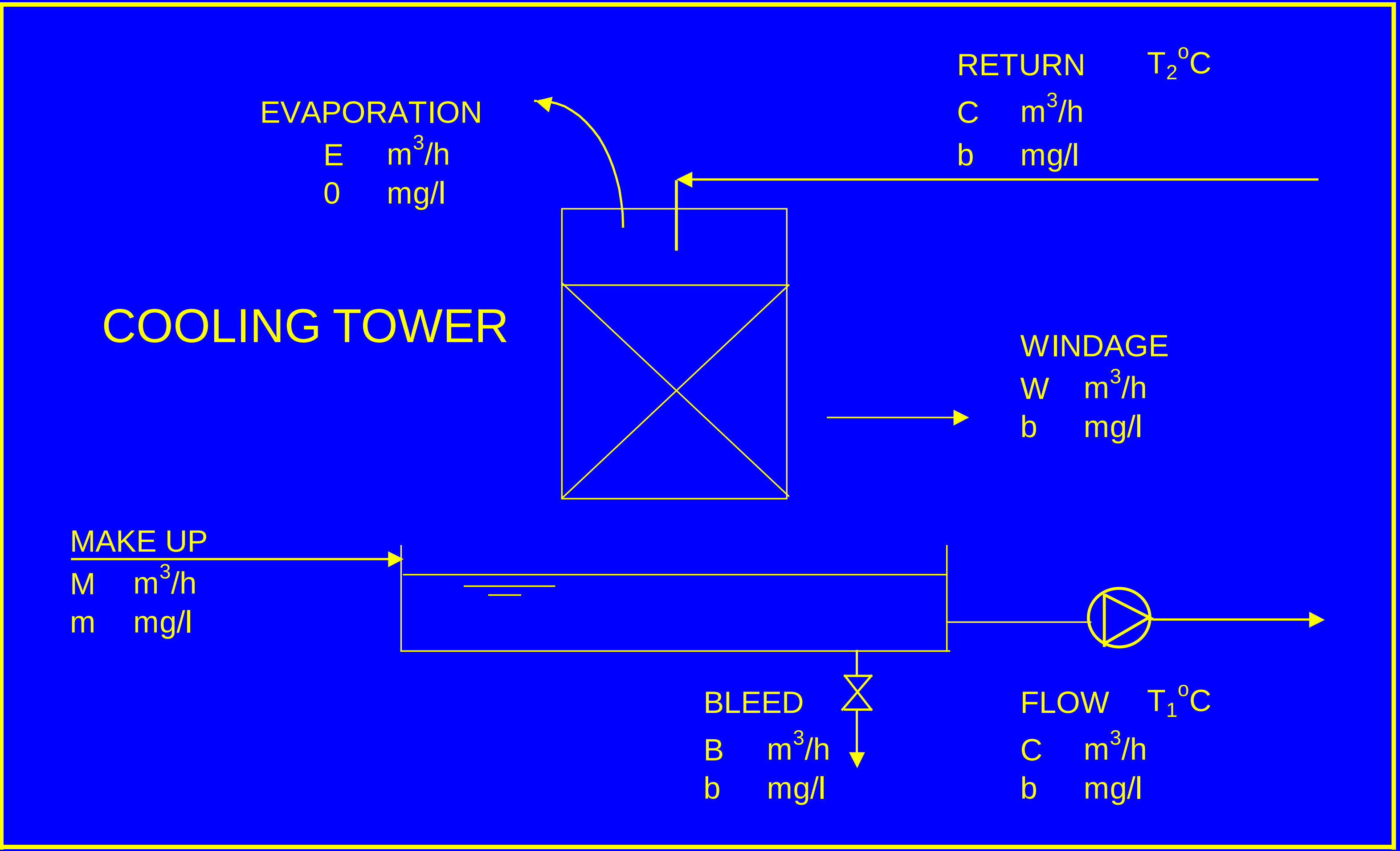
Evaporation & Blowdown

Boiler blowdown calculation by mass balance

$$\frac{B}{S} = (1 - r) \times \frac{m}{(b - m)}$$

B = blowdown
S = steam rate
b = boiler water concentration
m = make-up water concentration
r = fractional condensate return

Evaporation & Blowdown



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Evaporation & Blowdown

Cooling Tower Losses

MASS BALANCE

$$M = E + B + W$$
$$Mm = Bb + Wb$$
$$\therefore M = (B + W)CF$$
$$\therefore E = (B + W)(CF - 1)$$
$$\therefore B + W = E/(CF - 1)$$
$$\therefore M = E.CF/(CF - 1)$$

HEAT BALANCE

$$C \times 4.2 \times T_1 = C \times 4.2 \times T_2 + E \times 2450$$
$$\therefore C \times 4.2 \times \Delta C = E \times 2450$$
$$\therefore E/\Delta C = C \times 0.0017$$

Results

- *Identify any unaccounted water losses*
- *Identify potential water reduction measures*
- *Identify potential opportunities for re-use and recycling*

Results

- *Assess water consumption per unit of product and compare with industry benchmarks*
- *Assess whether water consumption can be reduced*

Results

A water audit on a cellophane factory identified 500m^3/day of mains water (8% of the factory's water intake) which could not be accounted for. A subsequent leak survey found a major pipe leak. The leak was costing the company about £100,000 per annum.

Reducing Water Use

- *Unnecessary use including*
  - *pipe leaks*
  - *uncontrolled steam losses*
  - *leaking or open valves*
- *Necessary but excessive use*
  - *over-rinsing*
  - *over-bleeding systems to control TDS*

Reducing Water Use

A laboratory stored bottled samples prior to analysis at below ambient temperature. This was achieved by standing the bottles in a bath through which mains water continuously ran to sewer. The total volume was about 0.5m^3/h. Since the water was never turned off it ran for 24 hours per day, 365 days per year at a cost of £4000 per annum for water and discharge.

A laboratory sample cooler was installed at a cost of £2000 with a payback of six months.

Reducing Water Use

A 6000kW cooling tower has an evaporation loss of about 10m^3/h when operating at full load. A factory set a manual valve to give a blowdown flow of 3m^3/h that is equivalent to a concentration factor of 4.

During winter the tower load was lower and evaporation reduced to 6m^3/h corresponding to a blowdown of 2m^3/h.

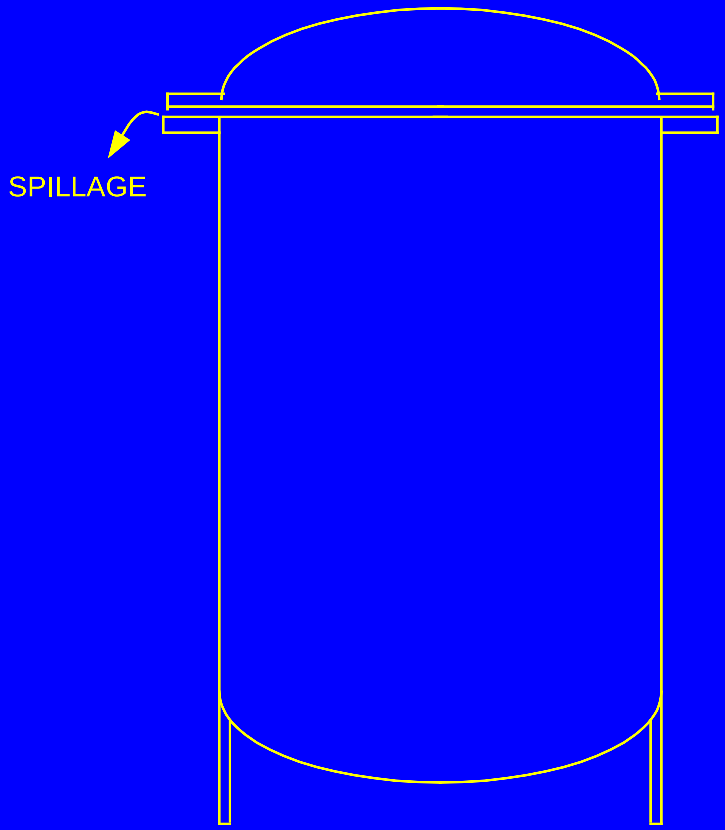
Installing a £2000 automatic conductivity controlled blowdown valve saved 4000m^{3}pa of water and reduced costs by £2,400pa giving a payback of less than 1 year.

Reducing Contamination of Water

- *Preventing a contaminant from entering the wastewater means*
  - *it will not be present in the final discharge*
  - *it does not have to be removed*
- *Often preventing contamination is very simple and cheap*

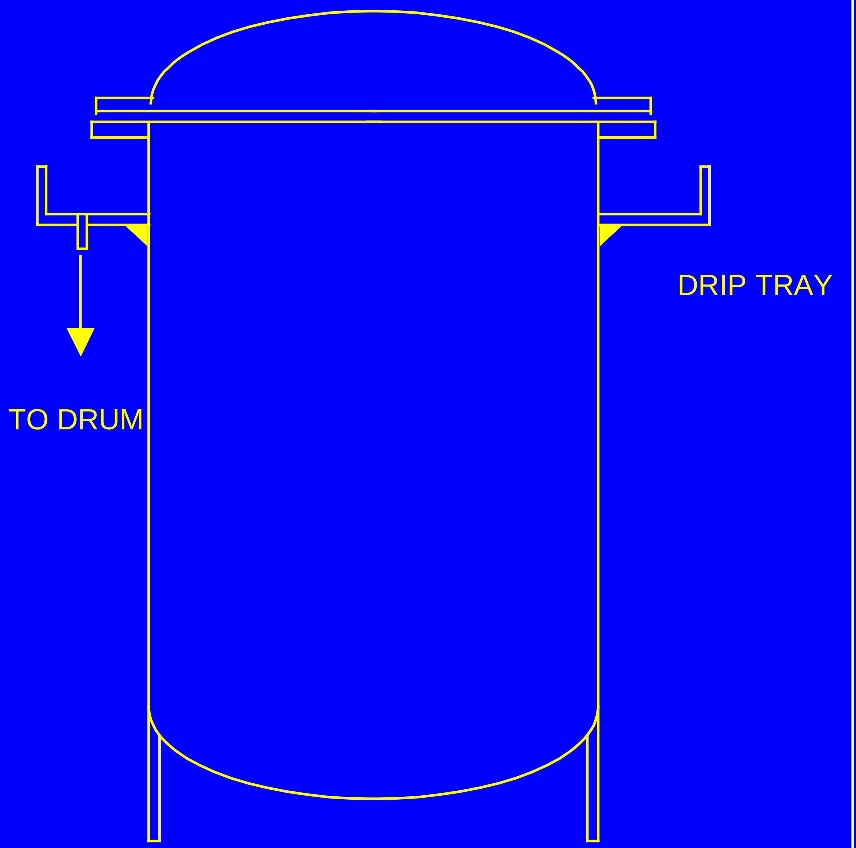
Reducing Contamination of Water

A resin factory uses product filters. When a filter was opened at the end of a batch for cleaning there was a spillage of solvent onto the floor and this was washed to the drain where it contributed most of the 2000mg/l of COD in the discharge to sewer.



Reducing Contamination of Water

Drip trays were fitted to the filters at a cost of £100 per filter. Catching the solvent in the drip tray and disposing of it off site reduced the effluent COD to 500mg/l and reduced the discharge cost by £3000 per annum.

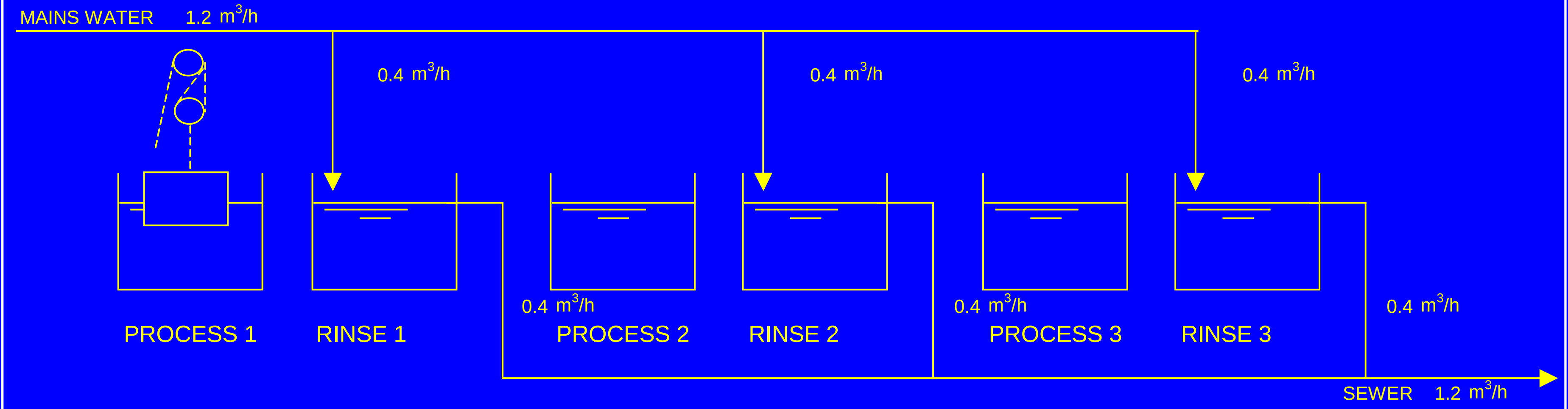


Re-using Water

- *Often the wastewater from one unit operation is of good enough quality to use as feed to another*
- *Lower grade uses can usually be found -eg concentrate from reverse osmosis systems can be re-used for WC flushing or floor washdown*

Re-using Water

A plating factory operated a process in which workpieces were dipped into a series of baths. Each of three rinse baths was continuously fed with mains water at 0.4m^3/h giving a total usage of 1.2m^3/h or 2400m^3 per annum.



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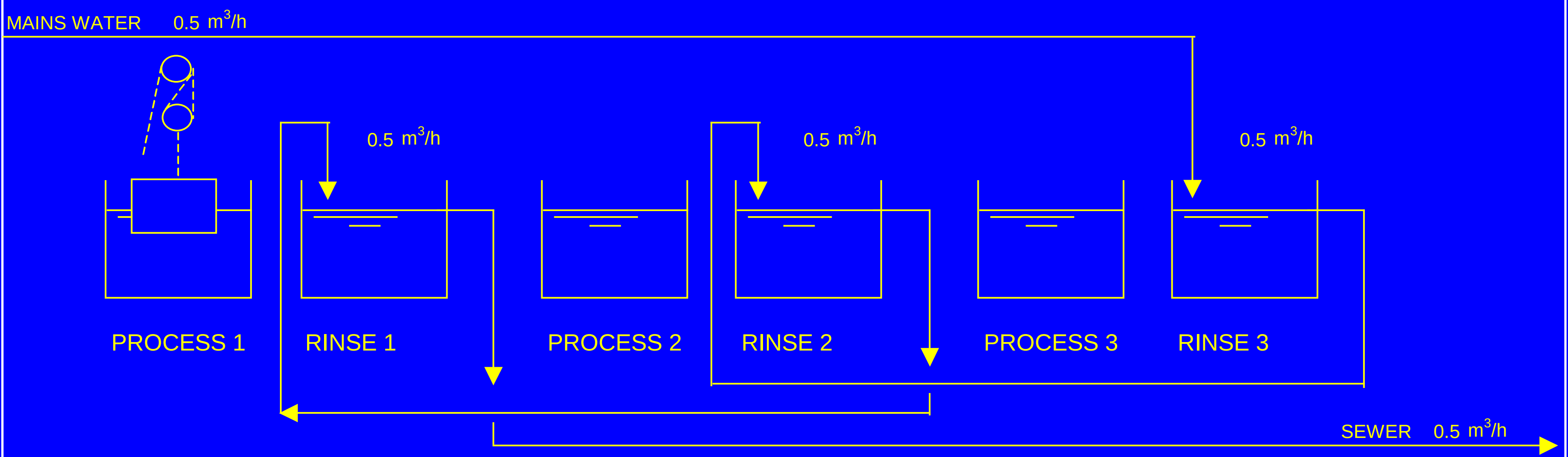
Re-using Water

A simple modification costing £500 allowed a counter current rinse system to be adopted with mains water flowing only into Rinse 3 and discharge only from Rinse 1. Water consumption reduced by 1400m^{3}pa with cost reduced by £1500pa.



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Recycling Water

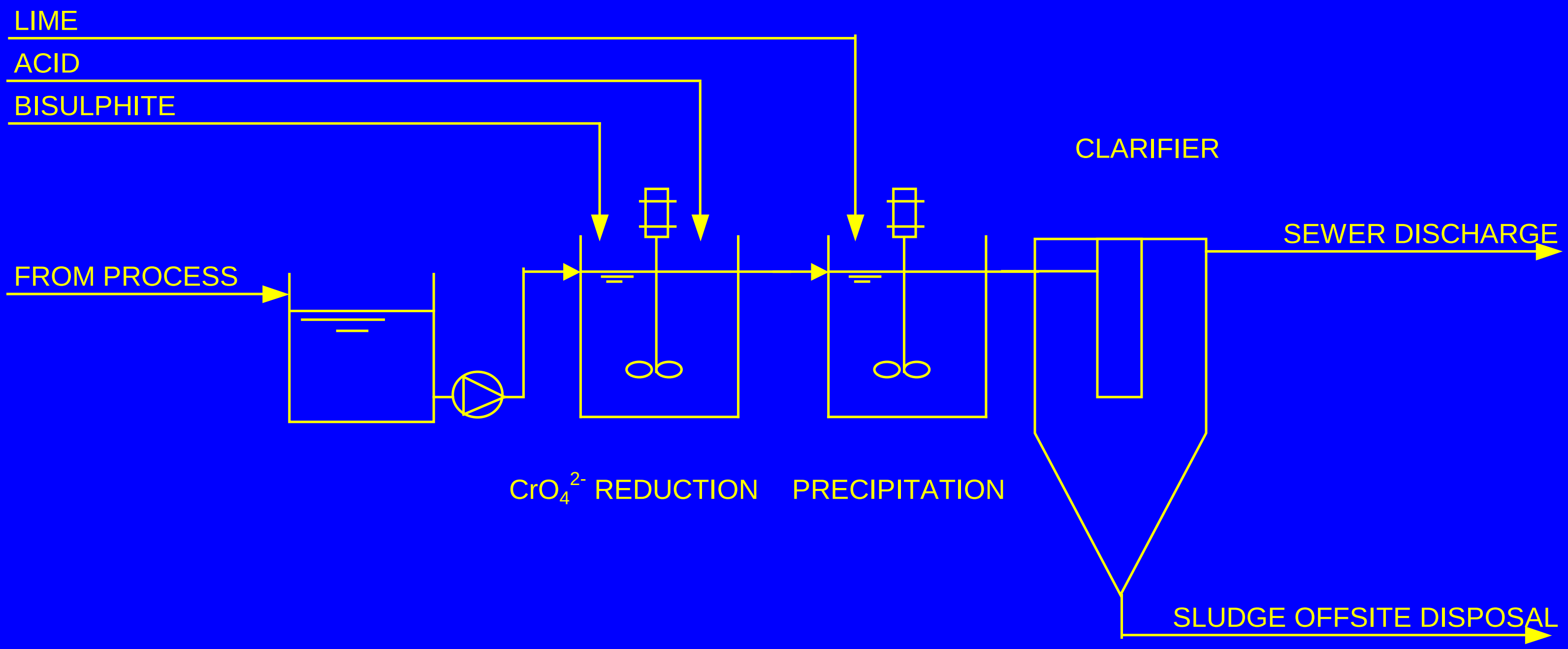
- *Where wastewater has to be treated for discharge it is often economically attractive to treat to a higher standard suitable for use either in the same process or in a different one*

Recycling Water

- *Think of wastewater as a resource*
- *Treatment for recycling may be cheaper than treating raw water*
- *Rain water has a low cost (storage) and usually requires very little treatment*

Recycling Water

A cadmium plater used mains water "once through" to rinse product and treated by precipitation to meet 0.2mg/l Cd. New legislation required zero discharge of cadmium.



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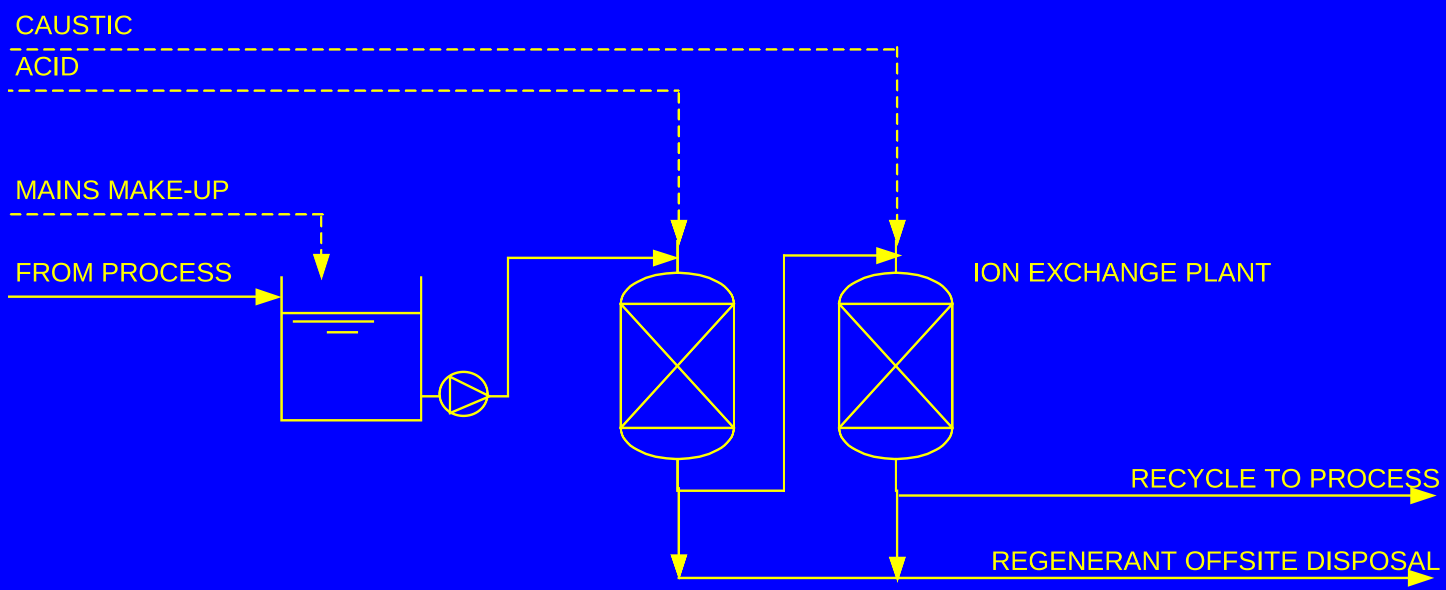
Recycling Water

A deionisation plant which removed the cadmium, and other ions, from the rinse water producing a high purity water which was recycled. The cadmium was concentrated into a small volume of waste regenerant which was taken off site.



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Recycling Water

Capital cost of the ion exchange plant: £100,000
Reduction in mains water: £15,000pa
Reduction in sewer discharge costs: £33,500pa
Reduction in chemicals costs: £4,000pa
Increase in off-site disposal costs: £3,500
Net savings: £49,000pa
Payback: <2 years

The cadmium discharge problem was solved and the product was improved by the use of deionised rinse water.

Water Audit

WATER LOSSES

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COST MONEY !!!