

**2014「產業用水效率提升輔導說明會」**

主辦單位：經濟部工業局

執行單位：財團法人環境與發展基金會

金屬製品製造業節水技術分享

梁德明

工業技術研究院材料與化工研究所  
水科技組

中華民國103年5月2日

# 回收水用途及其處理方式

---

| 回收水用途             | 處理方式                     |
|-------------------|--------------------------|
| 景觀用水              | 二級處理+過濾+消毒               |
| 非製程洗滌水            | 二級處理+過濾+消毒               |
| 冷卻水塔補充水<br>(低電導度) | 二級處理+高級處理+過濾+離子交換樹脂+消毒   |
| 冷卻水塔補充水<br>(高電導度) | 二級處理+高級處理+過濾+電透析(ED)+消毒  |
| 製程冷卻及洗滌水          | 二級處理+高級處理+過濾+消毒          |
| 製程用水              | 二級處理+高級處理+過濾+活性炭+薄膜過濾+消毒 |
| 其他(消防用水)          | 過濾(雨水)                   |

# 水回收污染物處理技術篩選

| 污染物          | 處理方法                              |                                   |
|--------------|-----------------------------------|-----------------------------------|
|              | 物理化學                              | 生物                                |
| 有機物（如COD）    | 混凝沈澱/浮除、砂濾、活性碳、氧化（化學或電解）、薄膜       | 活性污泥、接觸氧化、生物網膜（BioNET）、生物活性碳（BAC） |
| 無機鹽類（如鈣、鎂硬度） | 混凝沈澱/浮除、砂濾、結晶（FBC）、離子交換樹脂、薄膜      |                                   |
| 重金屬（如鐵、銅、鉻）  | 混凝沈澱/浮除、砂濾、結晶（FBC）、離子交換樹脂、薄膜、電解回收 |                                   |
| 懸浮物質（如SS）    | 混凝沈澱/浮除、砂濾、薄膜                     |                                   |
| 色度           | 混凝沈澱/浮除、砂濾、活性碳、氧化（化學或電解）、薄膜       | 生物網膜（BioNET）、生物活性碳（BAC）、厭氣處理      |
| 電導度          | 薄膜、離子交換、電透析                       |                                   |

## 鍋爐與冷卻水水質

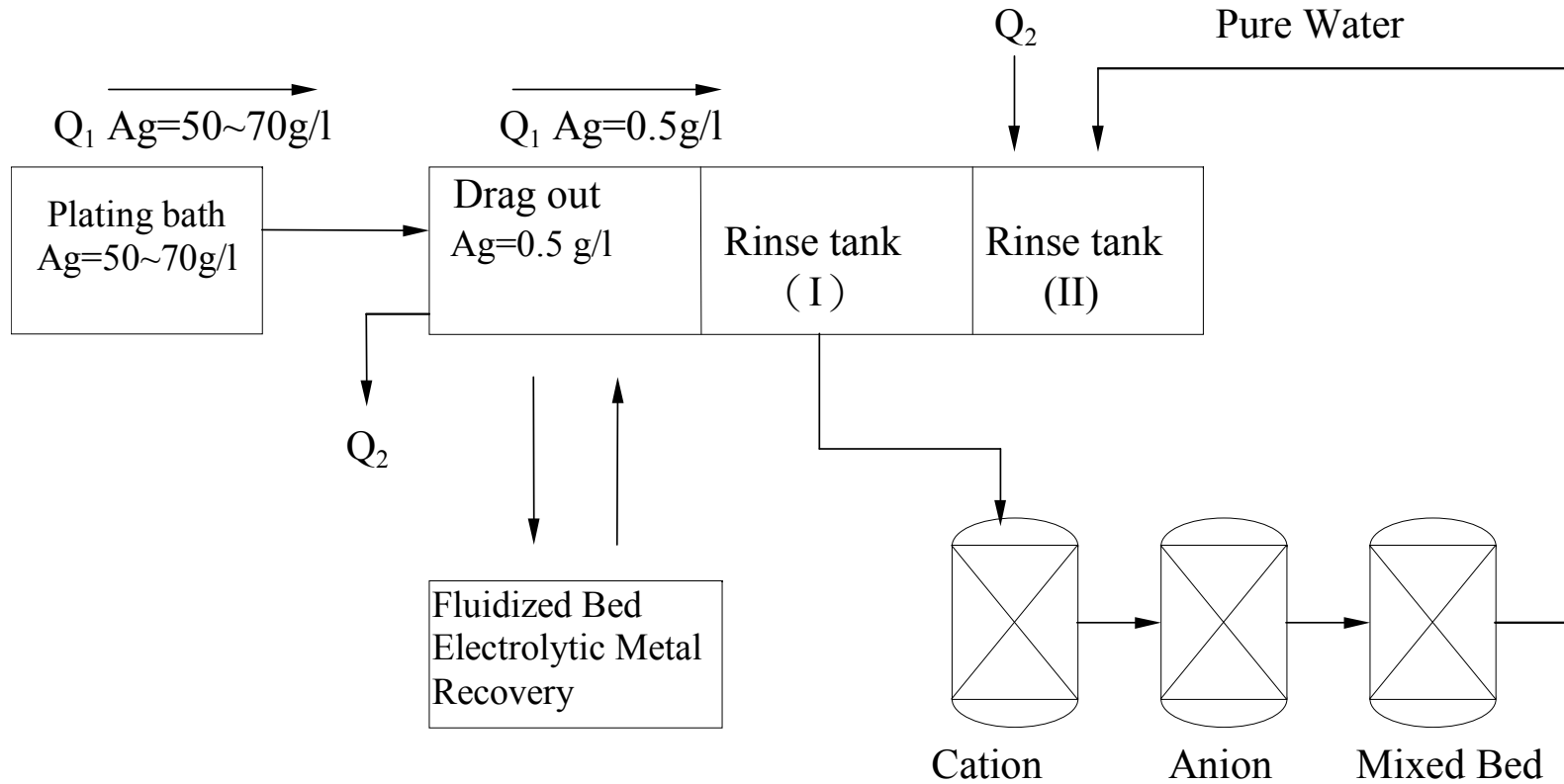
| Characteristics                 | Boiler Feedwater (psig) |         |          |           | Cooling Water |          |                          |          |
|---------------------------------|-------------------------|---------|----------|-----------|---------------|----------|--------------------------|----------|
|                                 |                         |         |          |           | Once-Through  |          | Makeup for Recirculation |          |
|                                 | 0-150                   | 150-700 | 700-1500 | 1500-5000 | Fresh         | Brackish | Fresh                    | Brackish |
| Silica (SiO <sub>2</sub> )      | 30                      | 10      | 1.0      | 0.01      | 50            | 25       | 50                       | 25       |
| Aluminum (Al)                   | 5                       | 0.1     | 0.01     | 0.01      | —             | —        | 0.1                      | —        |
| Iron (Fe)                       | 1                       | 0.3     | 0.05     | 0.01      | —             | —        | 0.5                      | —        |
| Manganese (Mn)                  | 0.3                     | 0.01    | 0.01     | —         | —             | —        | 0.5                      | —        |
| Copper (Cu)                     | 0.5                     | 0.05    | 0.05     | 0.01      | —             | —        | —                        | —        |
| Calcium (Ca)                    | —                       | 0       | 0        | "         | 200           | 420      | 50                       | 420      |
| Magnesium (Mg)                  | —                       | 0       | 0        | "         | —             | —        | —                        | —        |
| Sodium and potassium            | —                       | —       | —        | —         | —             | —        | —                        | —        |
| Ammonia (NH <sub>3</sub> )      | 0.1                     | 0.1     | 0.1      | 0.7       | —             | —        | —                        | —        |
| Bicarbonate (HCO <sub>3</sub> ) | 170                     | 120     | 50       | "         | 600           | —        | 25                       | —        |
| Sulfate (SO <sub>4</sub> )      | —                       | —       | —        | —         | 680           | 2,700    | 200                      | 2,700    |
| Chloride (Cl)                   | —                       | —       | —        | —         | 600           | —        | 500                      | —        |
| Fluoride (F)                    | —                       | —       | —        | —         | 600           | 19,000   | 500                      | 19,000   |
| Nitrate (NO <sub>3</sub> )      | —                       | —       | —        | —         | —             | —        | —                        | —        |

## 鍋爐與冷卻水水質

### 鍋爐與冷卻水水質

| Characteristics                | Boiler Feedwater (psig) |          |          |           | Cooling Water |          |                          |          |
|--------------------------------|-------------------------|----------|----------|-----------|---------------|----------|--------------------------|----------|
|                                |                         |          |          |           | Once-Through  |          | Makeup for Recirculation |          |
|                                | 0-150                   | 150-700  | 700-1500 | 1500-5000 | Fresh         | Brackish | Fresh                    | Brackish |
| Phosphate ( $\text{PO}_4$ )    | —                       | —        | —        | —         | —             | —        | —                        | —        |
| Dissolved solids               | 700                     | 500      | 200      | 0.5       | 1,000         | 35,000   | 500                      | 35,000   |
| Suspended solids               | 10                      | 5        | 0        | 0         | 5,000         | 2,500    | 100                      | 100      |
| Hardness ( $\text{CaCO}_3$ )   | 20                      | 1.0      | 0.1      | 0.07      | 850           | 6,250    | 130                      | 6,250    |
| Alkalinity ( $\text{CaCO}_3$ ) | 140                     | 100      | 40       | 0         | 500           | 115      | 20                       | 115      |
| Acidity ( $\text{CaCO}_3$ )    | —                       | —        | —        | —         | —             | —        | —                        | —        |
| pH (units)                     | 8.0-10.0                | 8.0-10.0 | 8.2-9.2  | 8.8-9.2   | 5.0-8.3       | —        | —                        | —        |
| Color (units)                  | —                       | —        | —        | —         | —             | —        | —                        | —        |
| Organics                       | —                       | —        | —        | —         | —             | —        | —                        | —        |
| MBAS                           | —                       | —        | —        | —         | —             | —        | 1                        | —        |
| $\text{CCl}_4$                 | —                       | —        | —        | —         | —             | —        | 1                        | —        |
| COD                            | 5                       | 5        | 0.5      | 0         | 75            | 75       | 75                       | 75       |
| Dissolved oxygen               | <0.03                   | <0.03    | <0.03    | <0.005    | —             | —        | —                        | —        |
| Temperature, °F                | 120                     | 120      | 120      | 120       | 100           | 120      | 100                      | 120      |
| Turbidity (JTU)                | 10                      | 5        | 0.5      | 0.05      | 5,000         | 100      | —                        | —        |

# 線上回收與再生

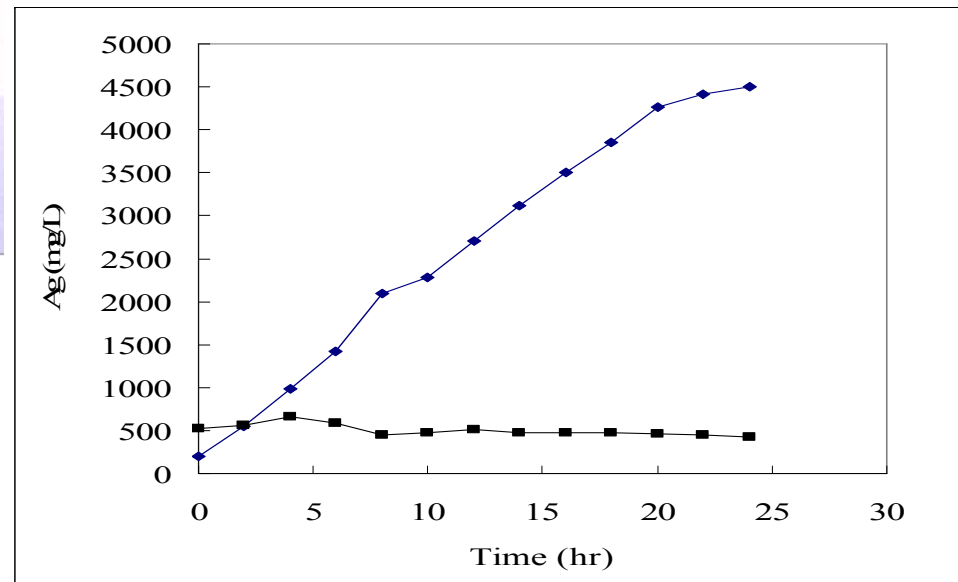


On Line Recycling Rinsewater for Silver Cyanide Plating Shop

# Ag



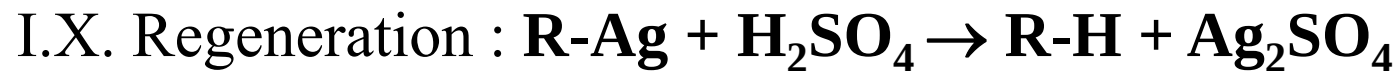
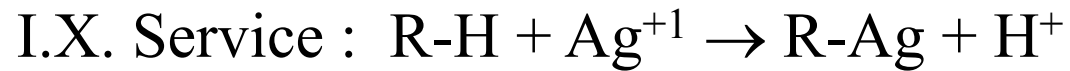
流體化床線上電解回收設備(銀回收量10公斤/天)



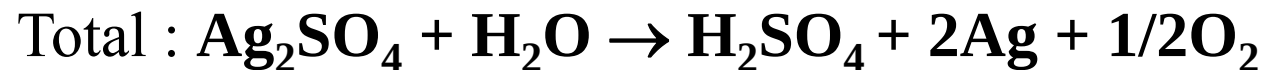
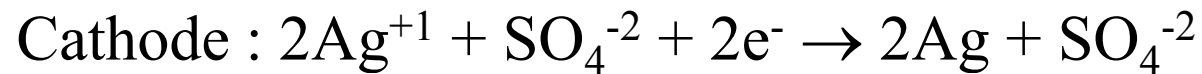
Silver concentration in the drag out rinse tank with and without metal recovery

# Ag

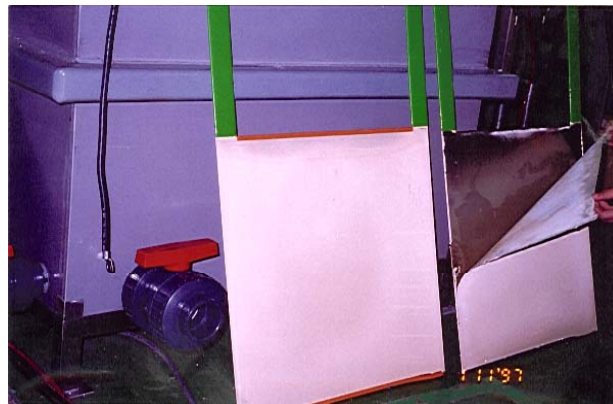
## Chemistry change in the I.X. and E.R. Process



## Metal Recovery

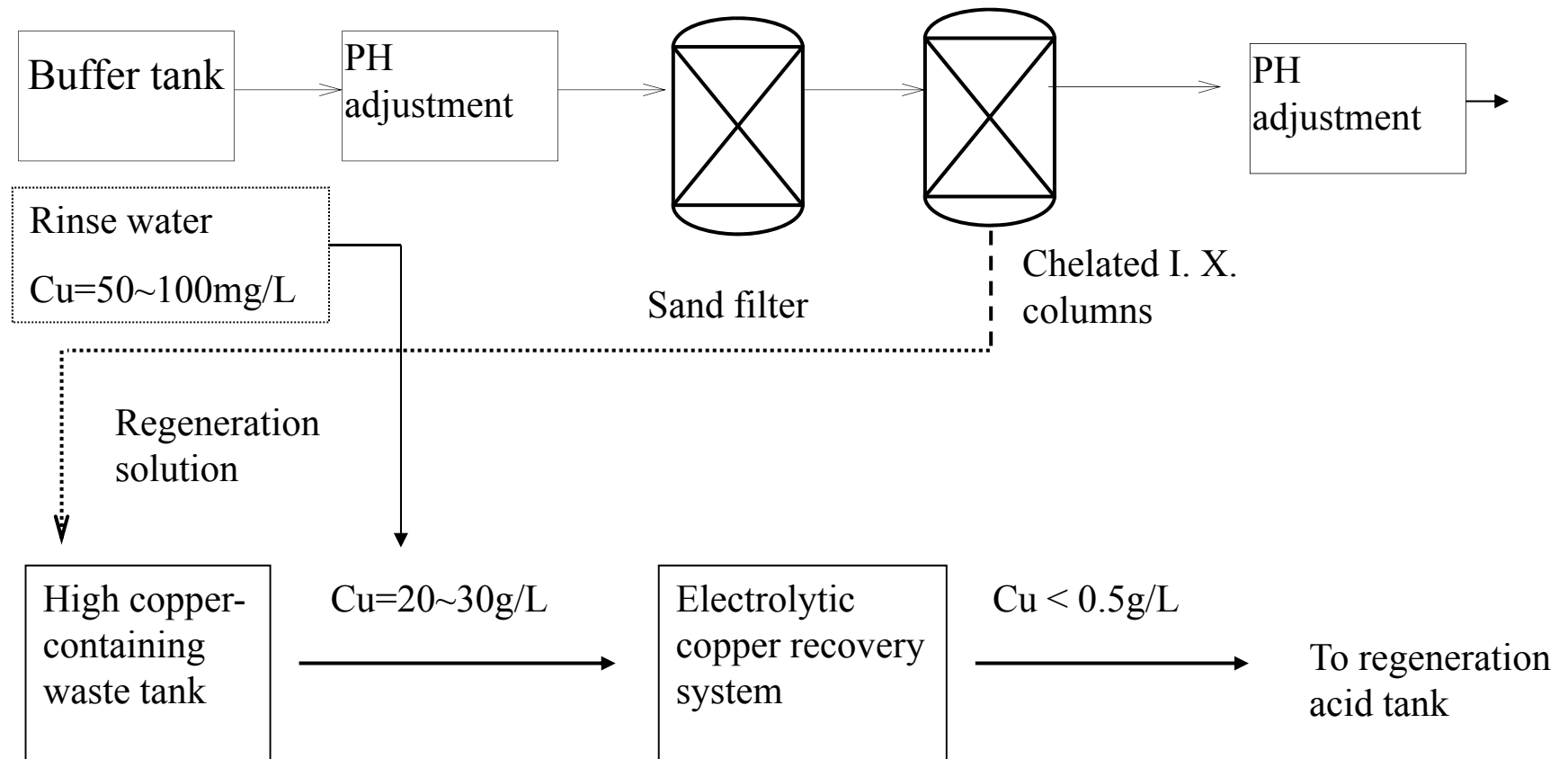


電解回收之金屬  
銀



The full scale ion exchange system  
for Ag removal, Capacity=40M<sup>3</sup>/Hr

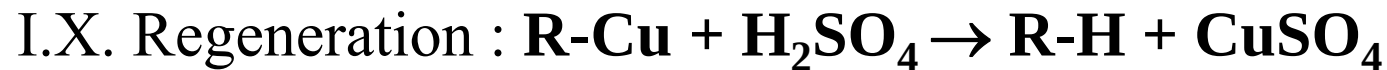
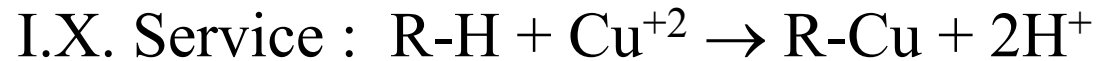
# 回收規劃流程



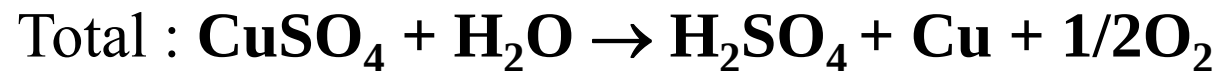
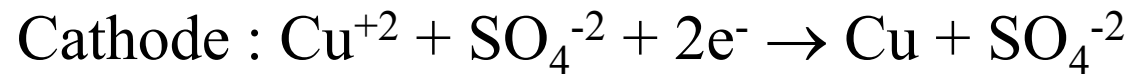
Copper recovery from rinse water by i. x. and E.R. systems

# Cu

## Chemistry change in the I.X. and E.R. Process



### Metal Recovery

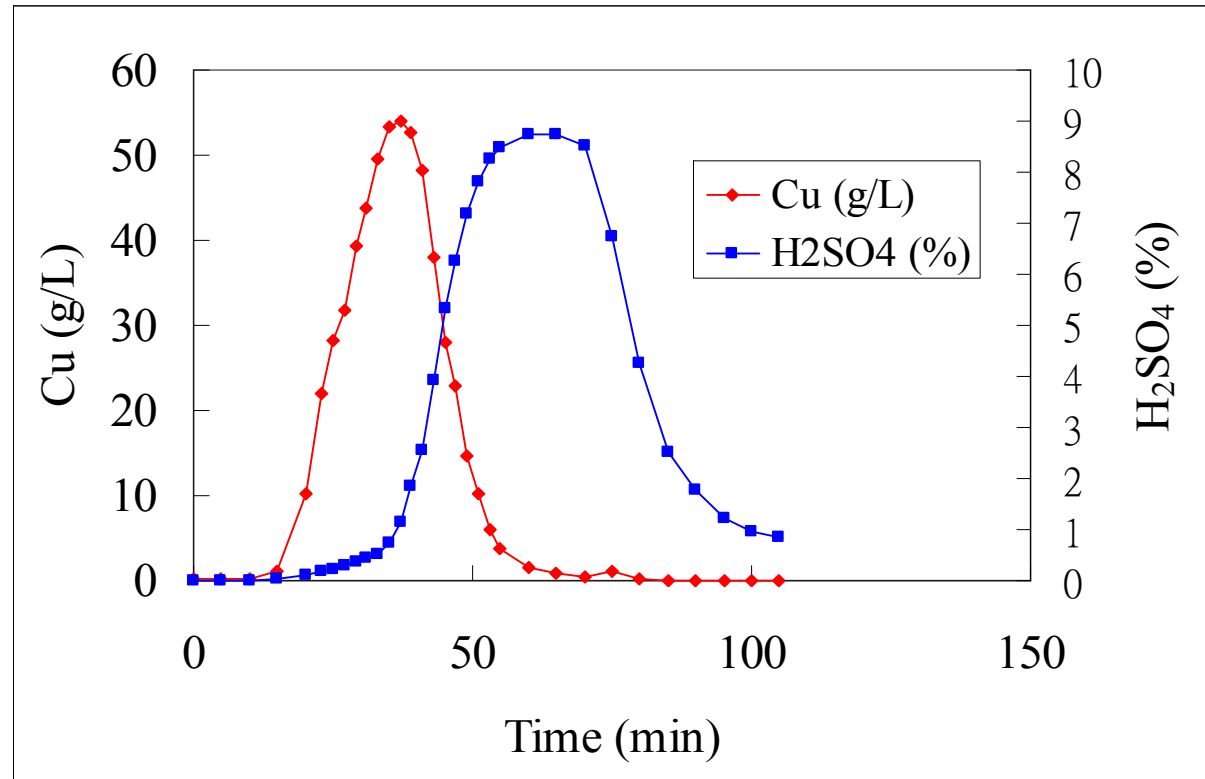


Ion exchange  
system for  
copper removal.  
Capacity=30M<sup>3</sup>/  
Hr



ER system for  
copper removal.

# Cu



Regeneration curves for copper and acid concentrations from the full scale i.x. system

---

## 化學銅電解氧化處理銅離子與COD濃度變化

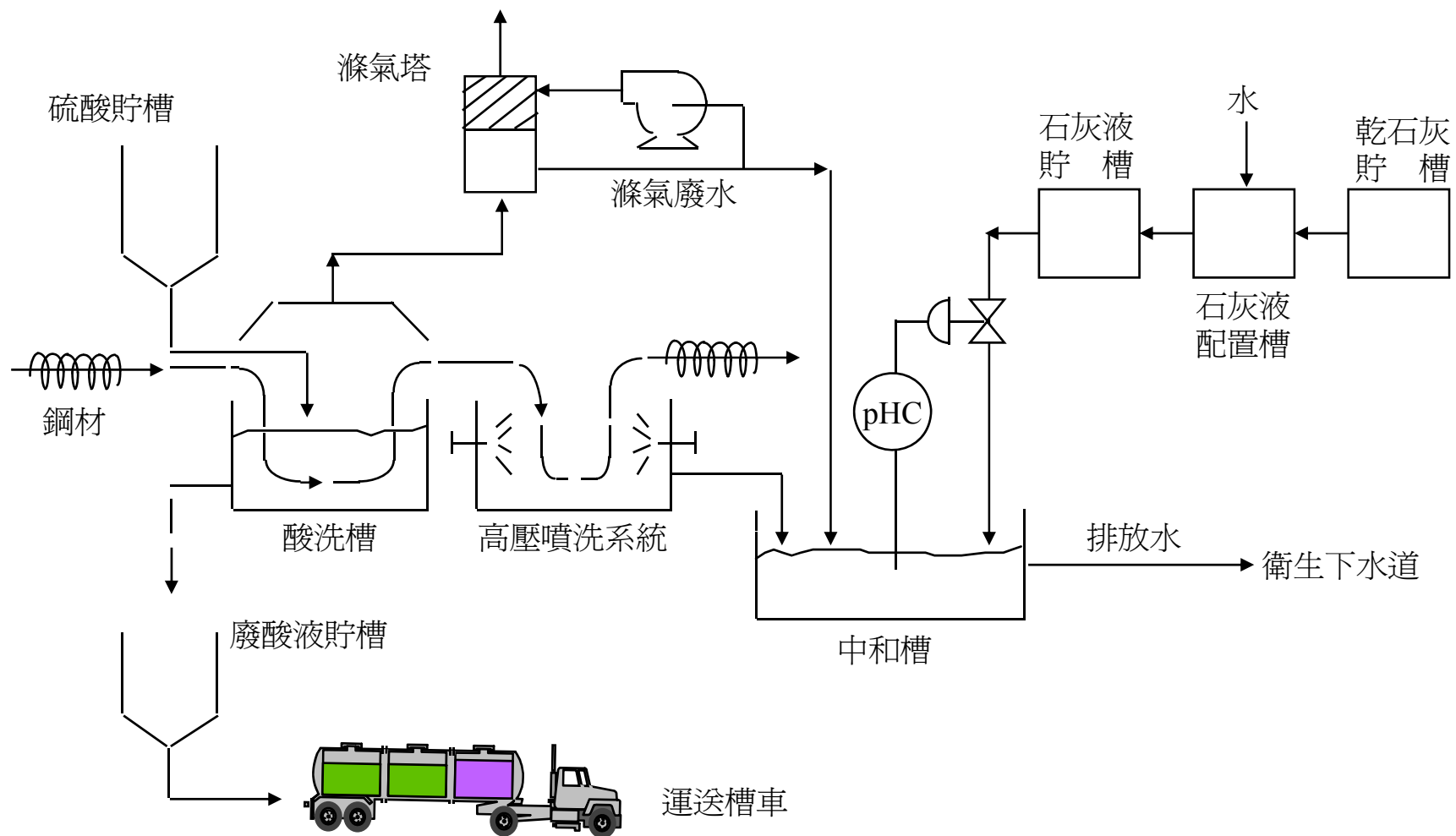
| 時間 (hr) | 電流<br>(A) | 電壓 (V) | Cu (mg/L) | COD (mg/L) |
|---------|-----------|--------|-----------|------------|
| 0       | 5.0       | 3.65   | 1,104     | 24,765     |
| 2       | 5.0       | 3.65   | 130       | 16,665     |
| 4       | 5.0       | 3.54   | 10        | 12,080     |
| 6       | 5.0       | 3.48   | 6         | 6,239      |
| 8       | 5.0       | 4.34   | 1.5       | 4,061      |

---

## 化學鎳流體化床電解結果

| 時間<br>(hr) | 電流<br>(A) | 電壓<br>(V) | 鎳<br>(mg/L) | COD (mg/L) |
|------------|-----------|-----------|-------------|------------|
| 0          | 17        | 4.0       | 1,941       | 6,550      |
| 2.6        | 17        | 4.0       | 1,153       | 5,350      |
| 5.7        | 17        | 3.8       | 515         | 4,115      |
| 8.7        | 17        | 3.8       | 247         | 2,687      |
| 12         | 17        | 3.8       | 152         | 1,770      |
| 22         | 17        | 3.8       | 71          | 1,131      |

# 酸洗流程及相關污染防治流程

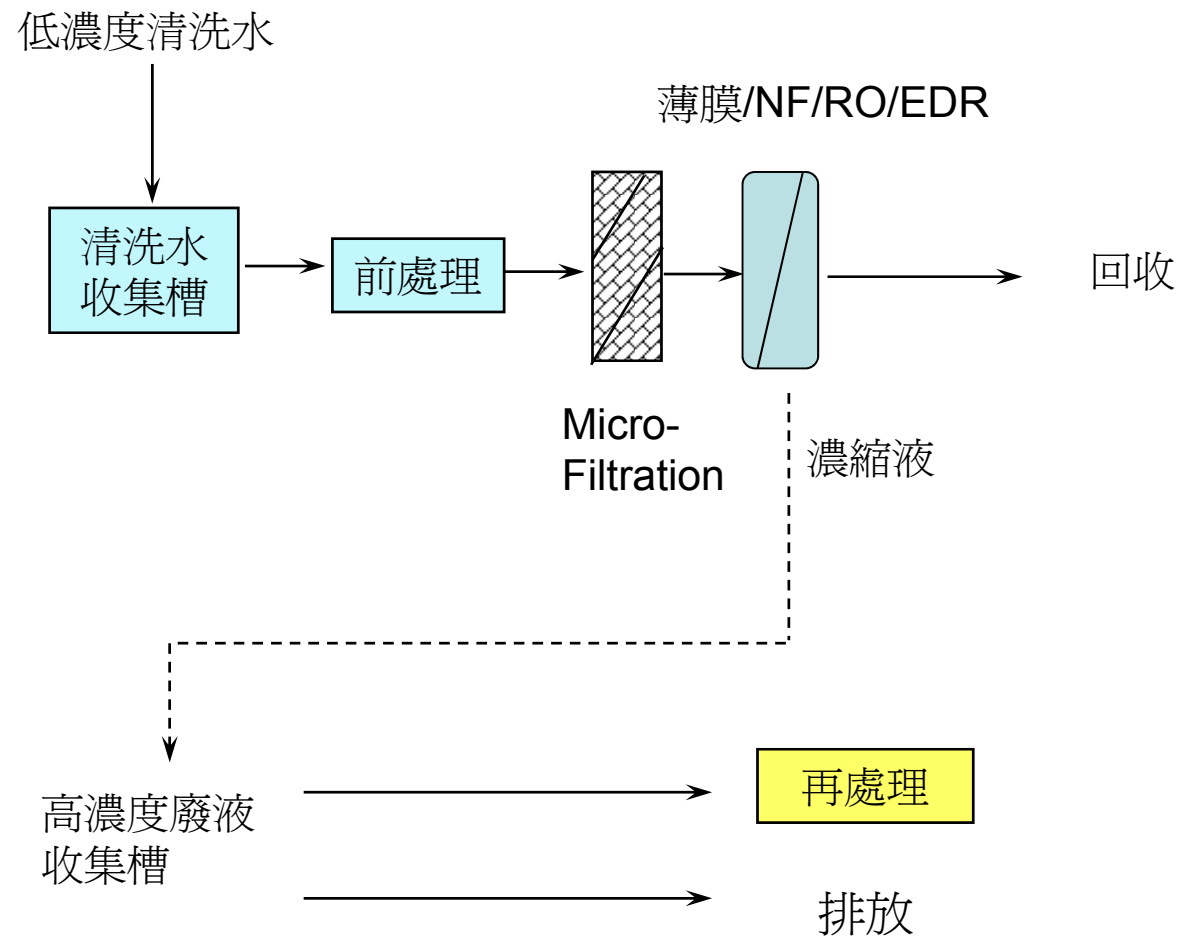


## 各單位用水量、排水量統計表

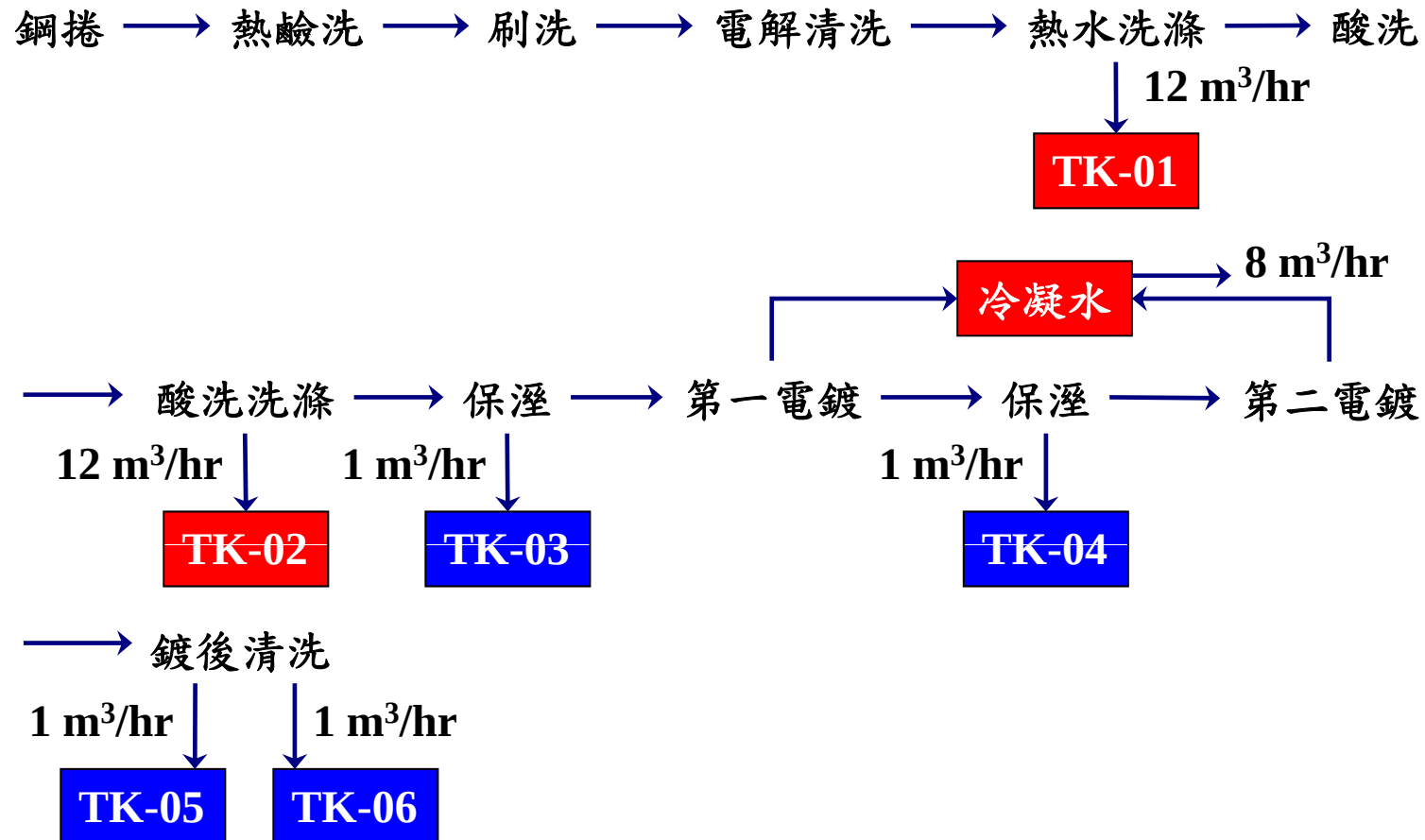
---

| 使用單元  | 使用量(升/天) | 排出量(升/天) |
|-------|----------|----------|
| 酸洗    | 5,670    | 0        |
| 蒸氣    | 5,300    | 0        |
| 噴洗    | 81,000   | 81,000   |
| 滌氣塔   | 3,000    | 2,700    |
| 廢水前處理 | 8,660    | 8,660    |
| 其它    | 8,990    | 8,990    |

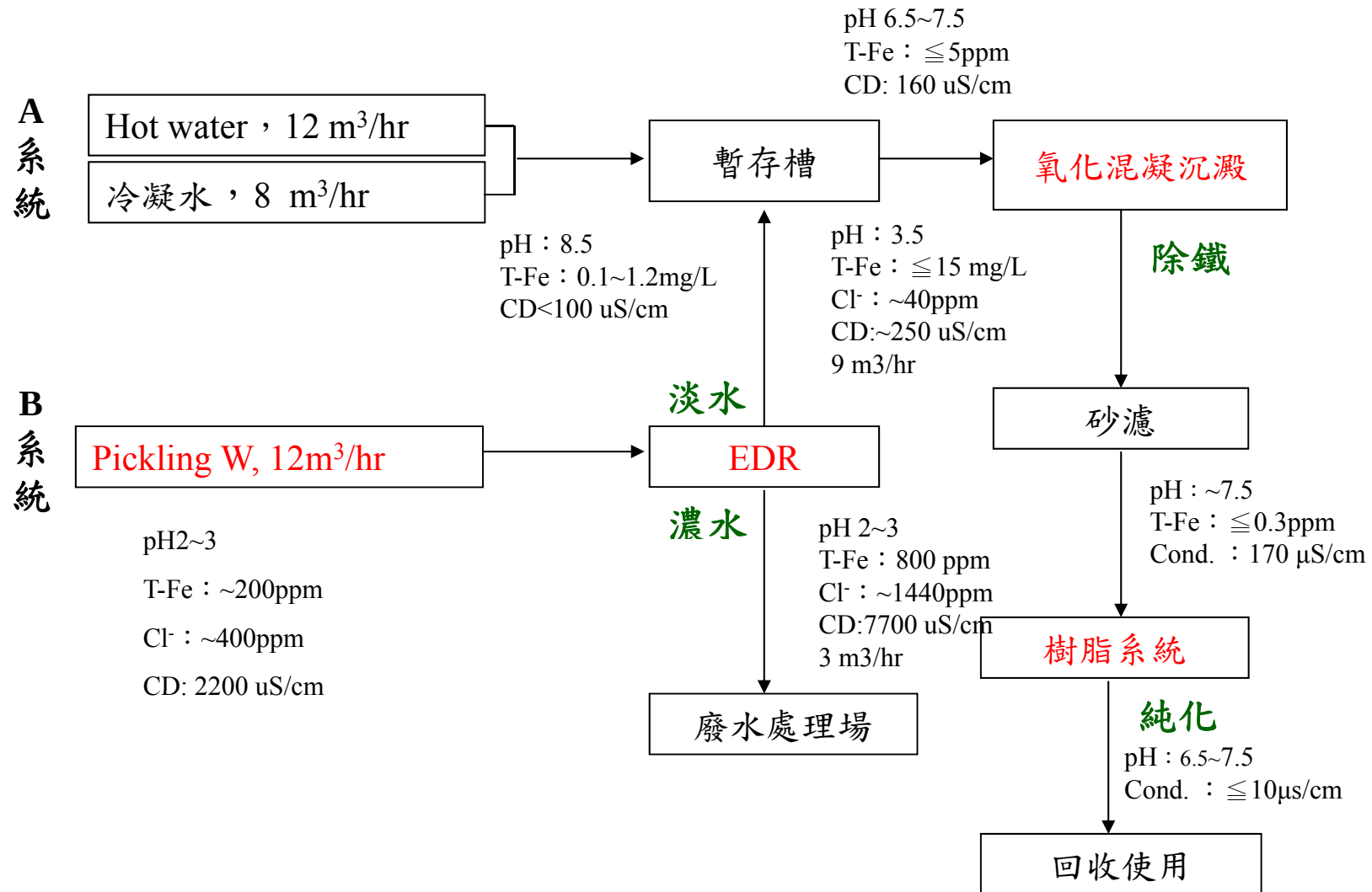
# 酸洗回收流程



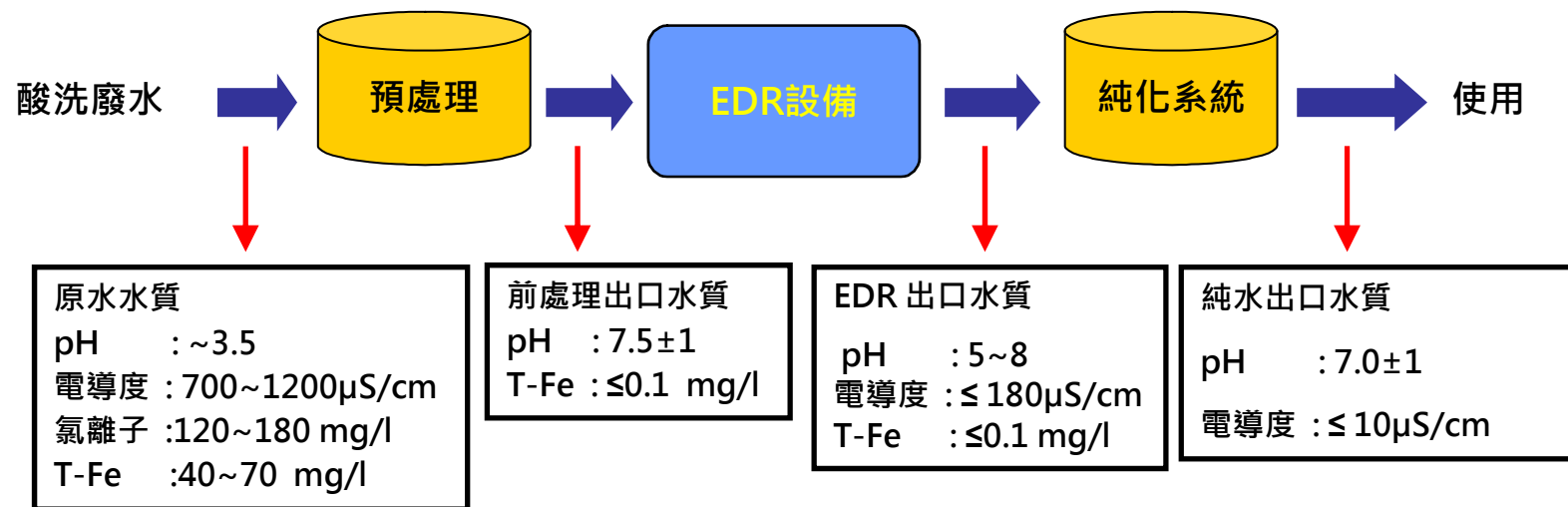
# 電鍍流程



# 處理流程規劃



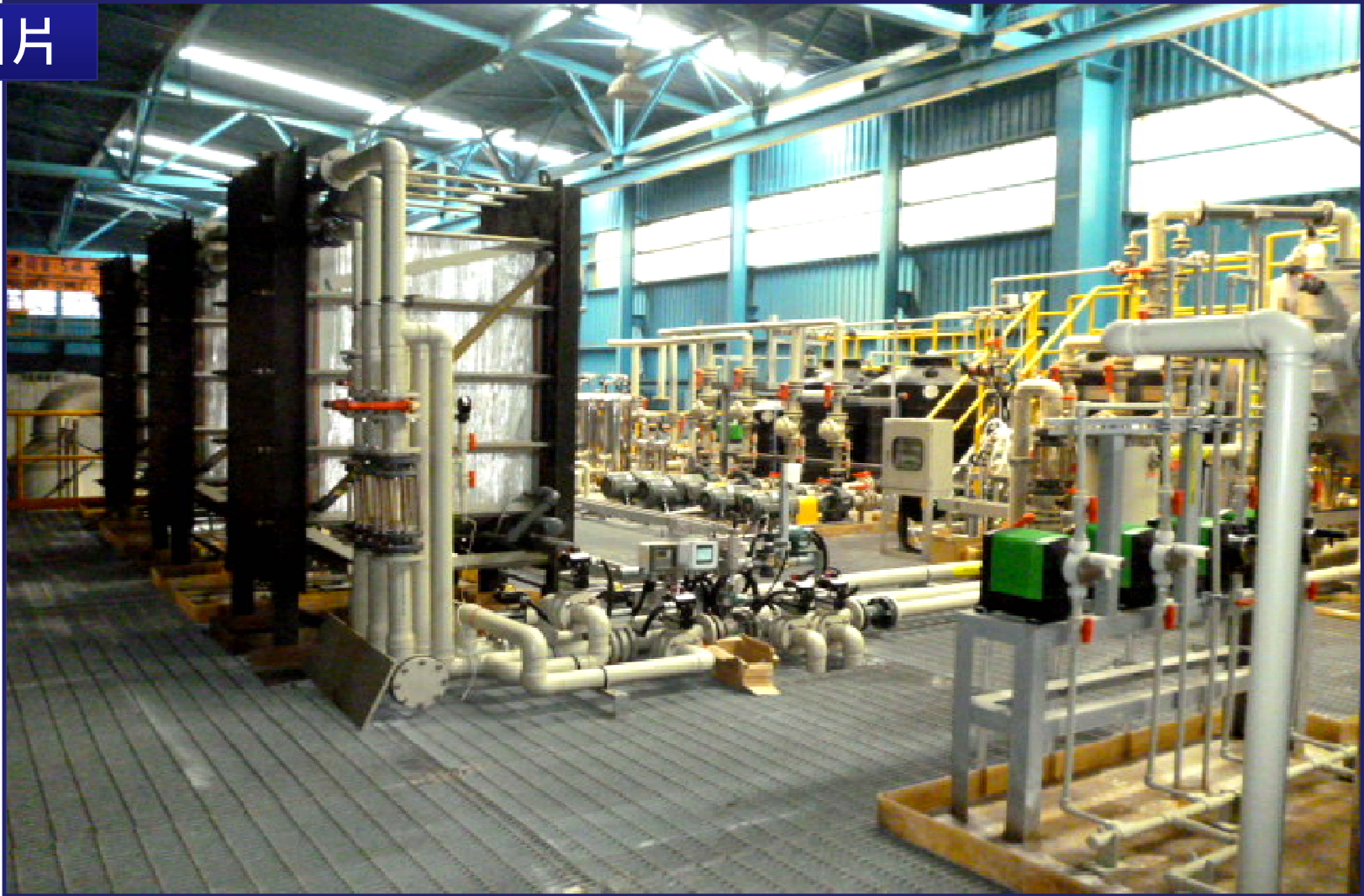
# 鋼板鍍鋅清洗水脫鹽回收



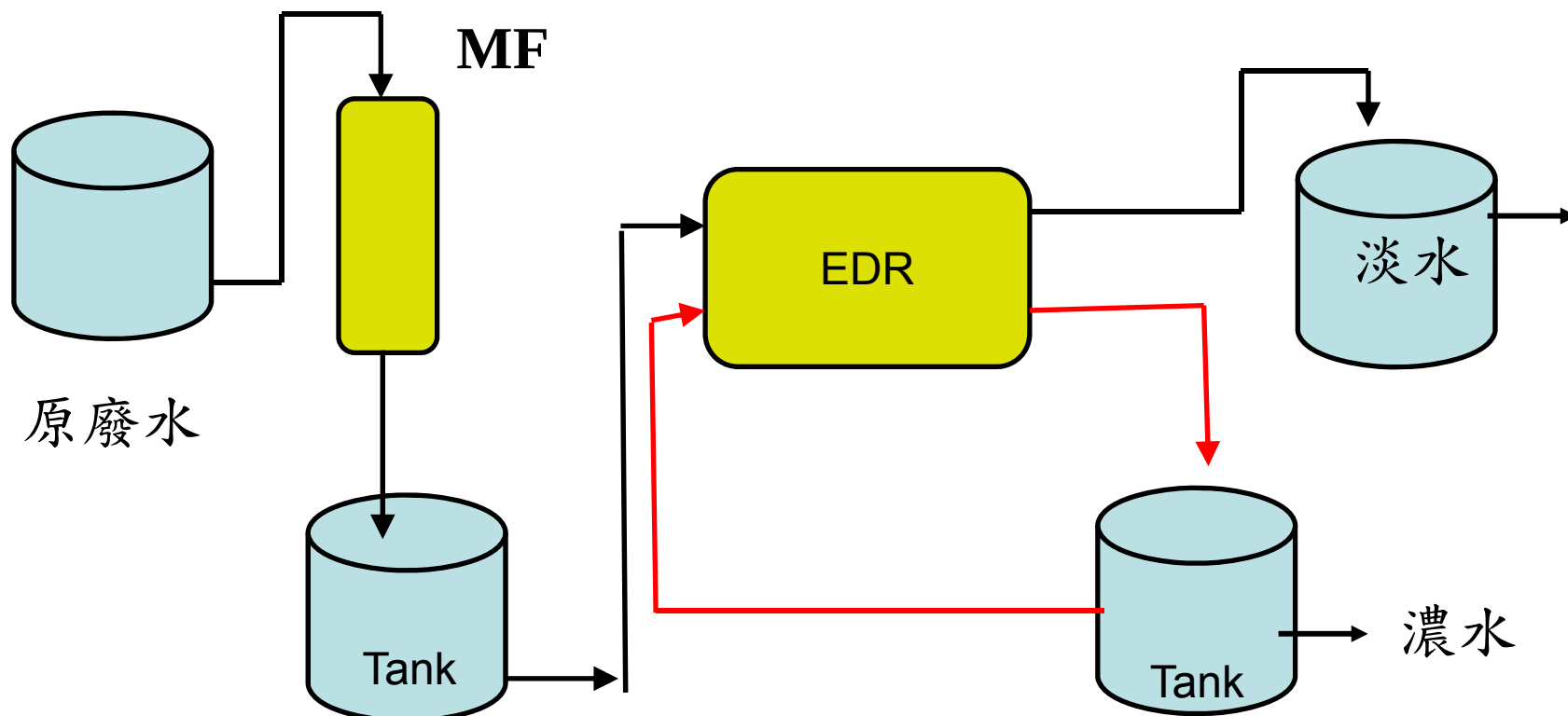
| 產水量<br>(m <sup>3</sup> /day) | 脫鹽率<br>(%) | EDR運轉成本(NT/m <sup>3</sup> )<br>(含電費、藥品費) |
|------------------------------|------------|------------------------------------------|
| 558                          | 85 ↑       | 3.36                                     |

## 鋼板鍍鋅清洗水脫鹽回收

實場圖片

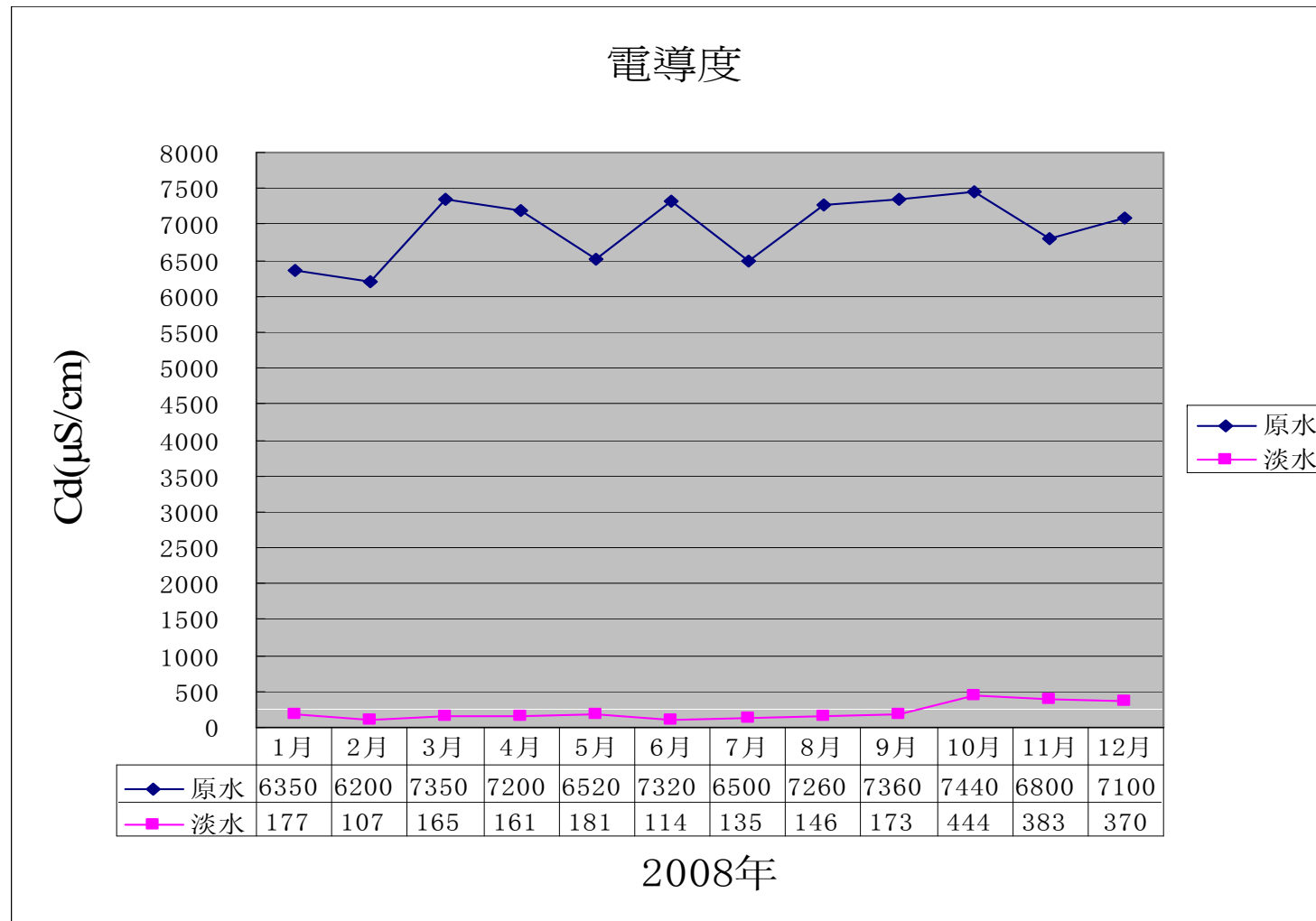


# 螺絲電鍍廢水脫鹽回收

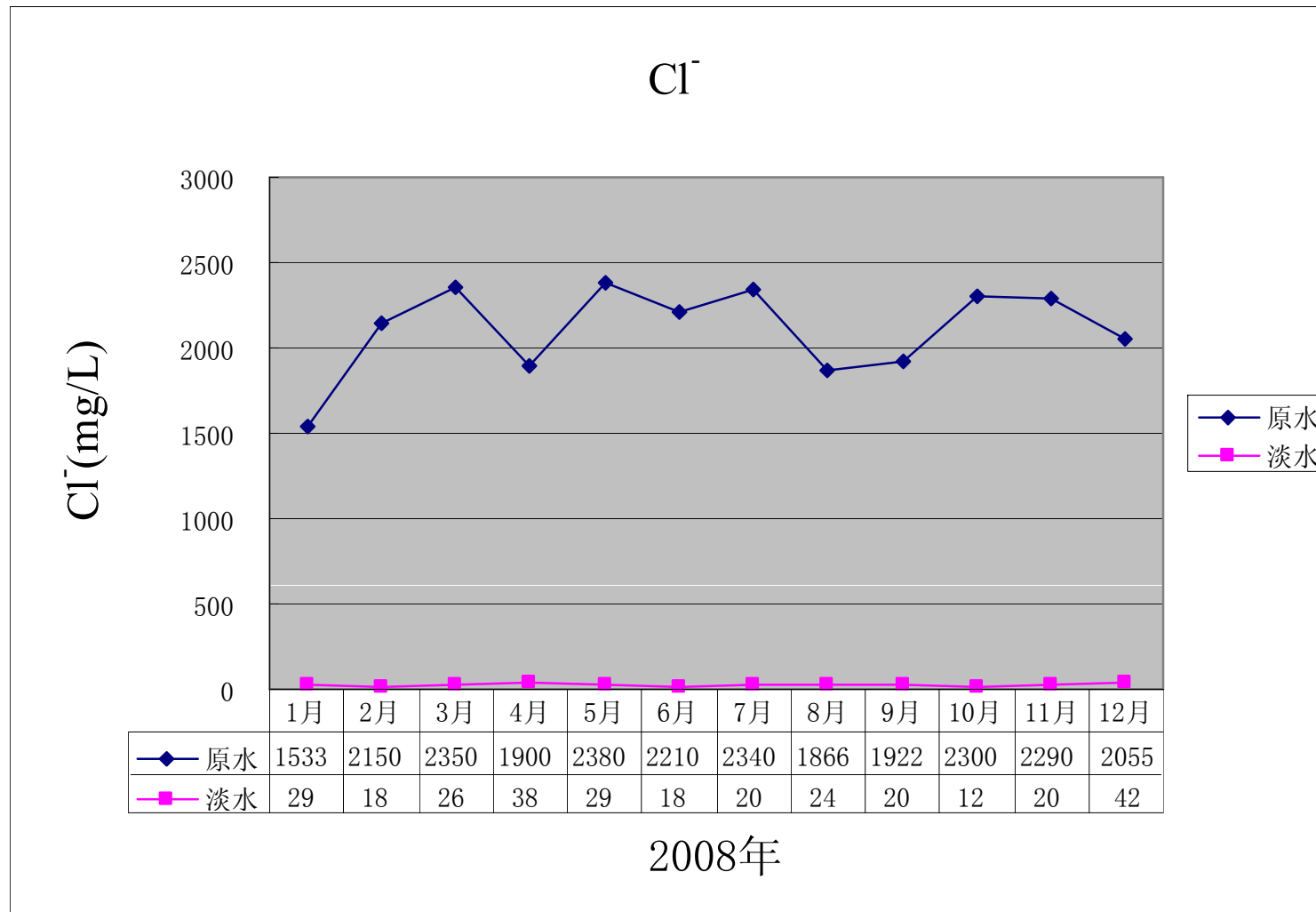


|     | 電費<br>(元/m <sup>3</sup> ) | 藥品費<br>(元/m <sup>3</sup> ) | 維修費用<br>(元/m <sup>3</sup> ) | 設備攤提<br>(元/m <sup>3</sup> ) | 合計<br>(元/m <sup>3</sup> ) |
|-----|---------------------------|----------------------------|-----------------------------|-----------------------------|---------------------------|
| EDR | 2.13                      | 0.77                       | 4.25                        | 5                           | 12.15                     |

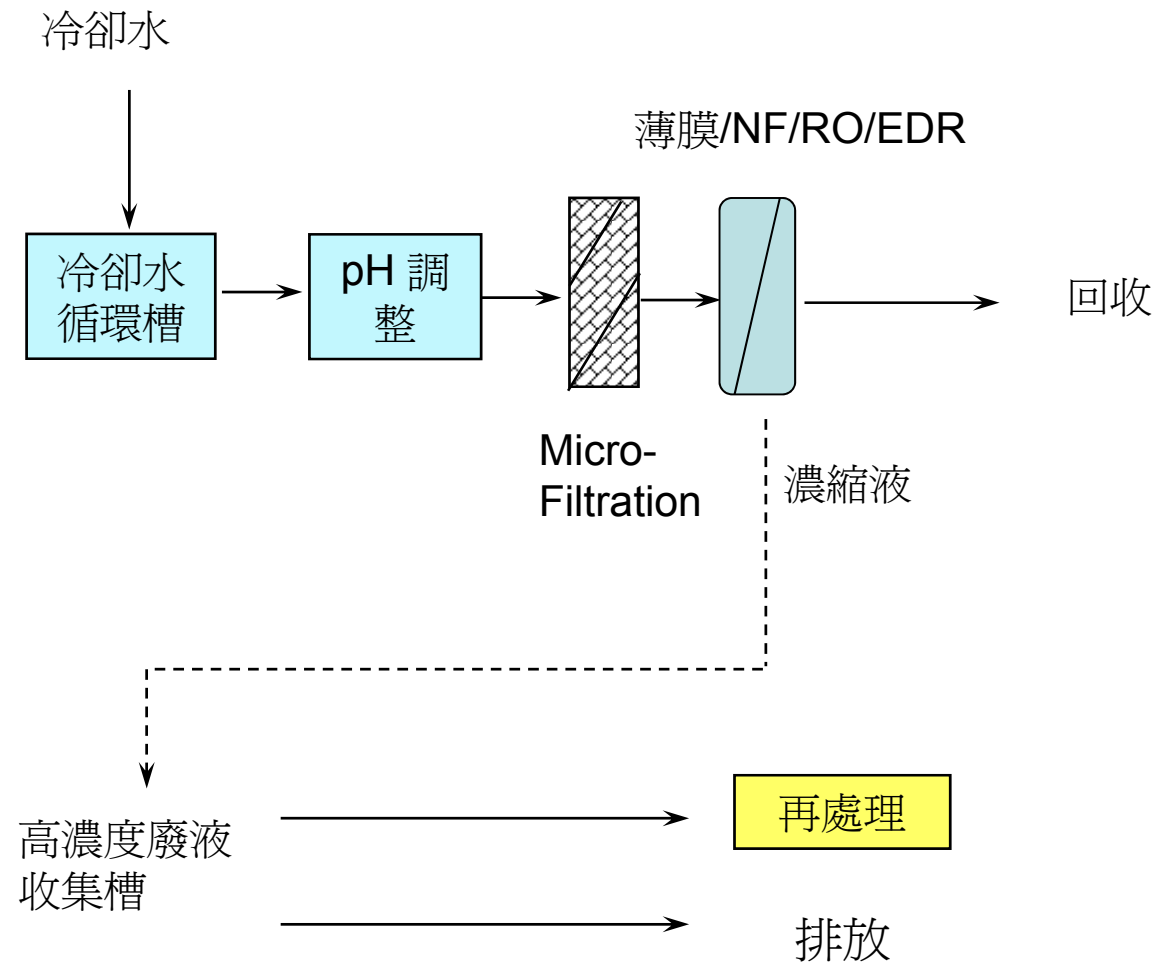
# 螺絲電鍍廢水脫鹽回收



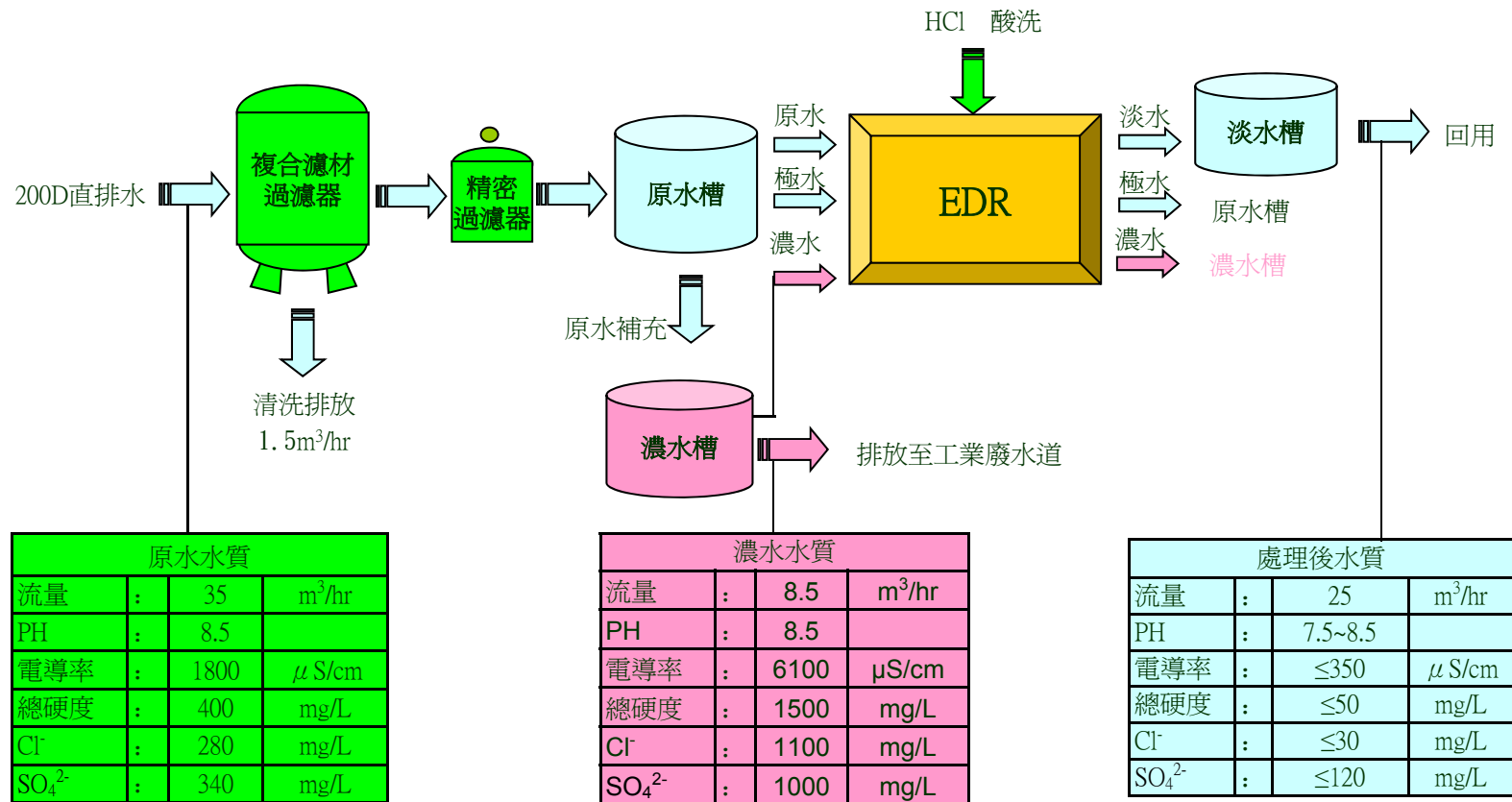
# 螺絲電鍍廢水脫鹽回收



# 冷卻循環水回收

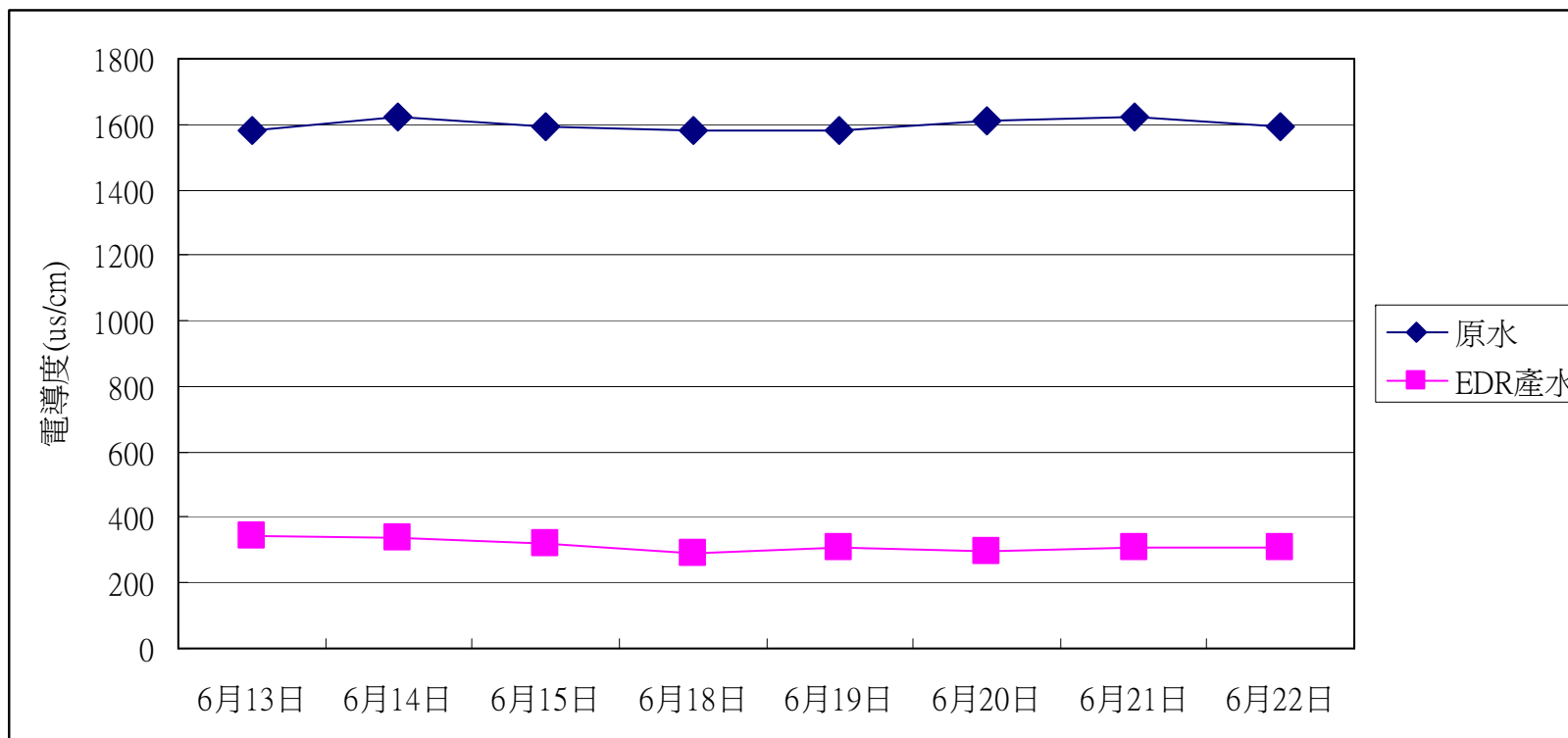


# 鋼材直接冷卻循環水脫鹽回收



## 鋼材直接冷卻循環水脫鹽回收

| 樣品名稱 | pH  | COD<br>(mg/L) | SS<br>(mg/L) | SO <sub>4</sub> <sup>2-</sup><br>(mg/L) | Cl <sup>-</sup><br>(mg/L) | Ca <sup>2+</sup><br>(mg/L) | Mg <sup>2+</sup><br>(mg/L) | Na <sup>+</sup><br>(mg/L) |
|------|-----|---------------|--------------|-----------------------------------------|---------------------------|----------------------------|----------------------------|---------------------------|
| 原水   | 8.5 | 24            | 4            | 316                                     | 298                       | 124                        | 12                         | 188                       |
| 淡水   | 6.2 | 11            | --           | 112                                     | 21                        | 11                         | 0.5                        | 42                        |



## 鋼材直接冷卻循環水脫鹽回收



| Cost               | 電廢  | 藥品 | 折舊<br>(10yr) | 膜更換<br>(3 yr) | 合計   |
|--------------------|-----|----|--------------|---------------|------|
| NT /m <sup>3</sup> | 3.5 | 2  | 4.5          | 4             | 13.5 |

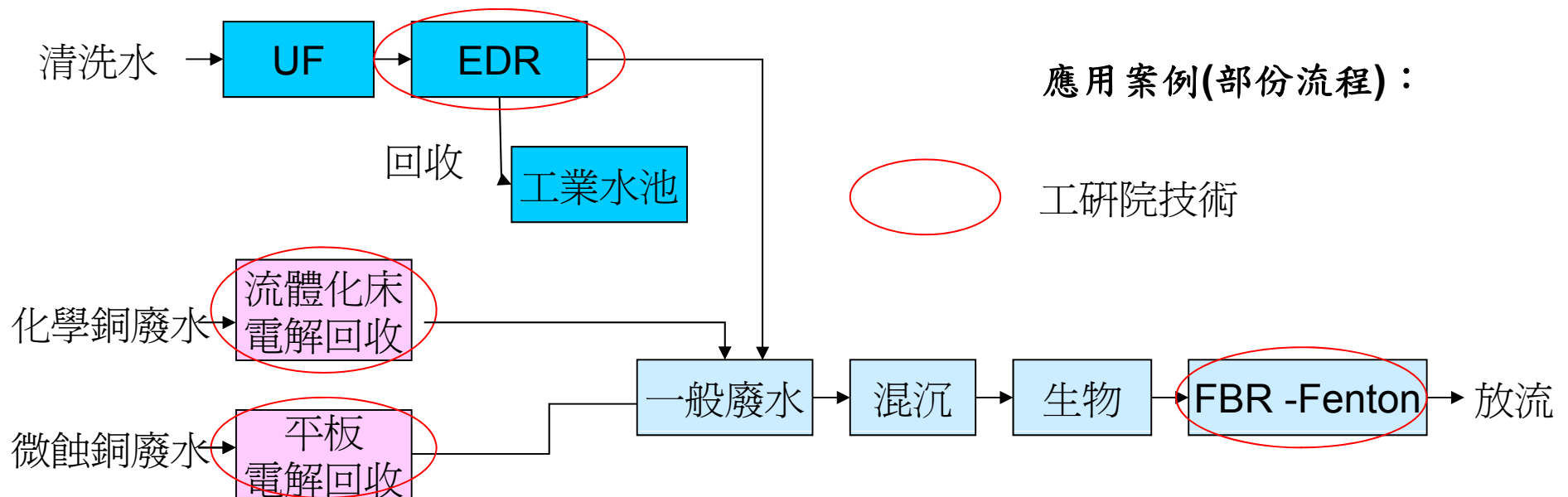
# PCB 製程廢水處理回收技術

## 關鍵議題：

- 重金屬回收
- 螯合重金屬廢水處理-破壞螯合物/回收金屬
- 有機物去除
- 清洗水回收

## 關鍵技術(具低污泥與高效率等特點)

- 平板電解回收技術
- 流體化床電解回收技術
- 離子交換樹脂
- 生物處理(如BioNET, MBR)
- 流體化床Fenton
- 倒極式電透析(EDR)



## 結垢物對熱傳的影響

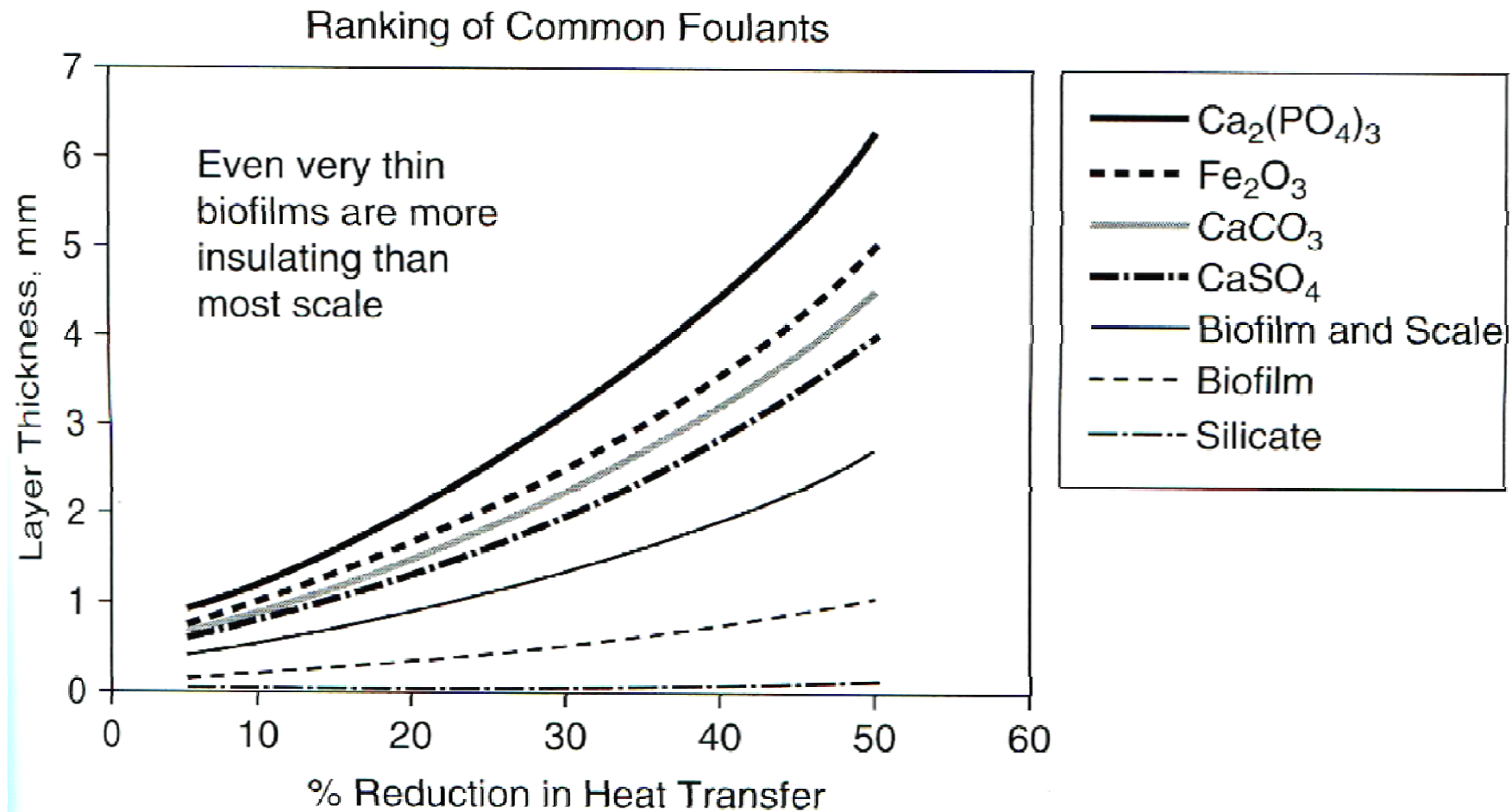


FIGURE 14.5 Insulating power of common foulants in heat exchangers.

# 進水水質要求

---

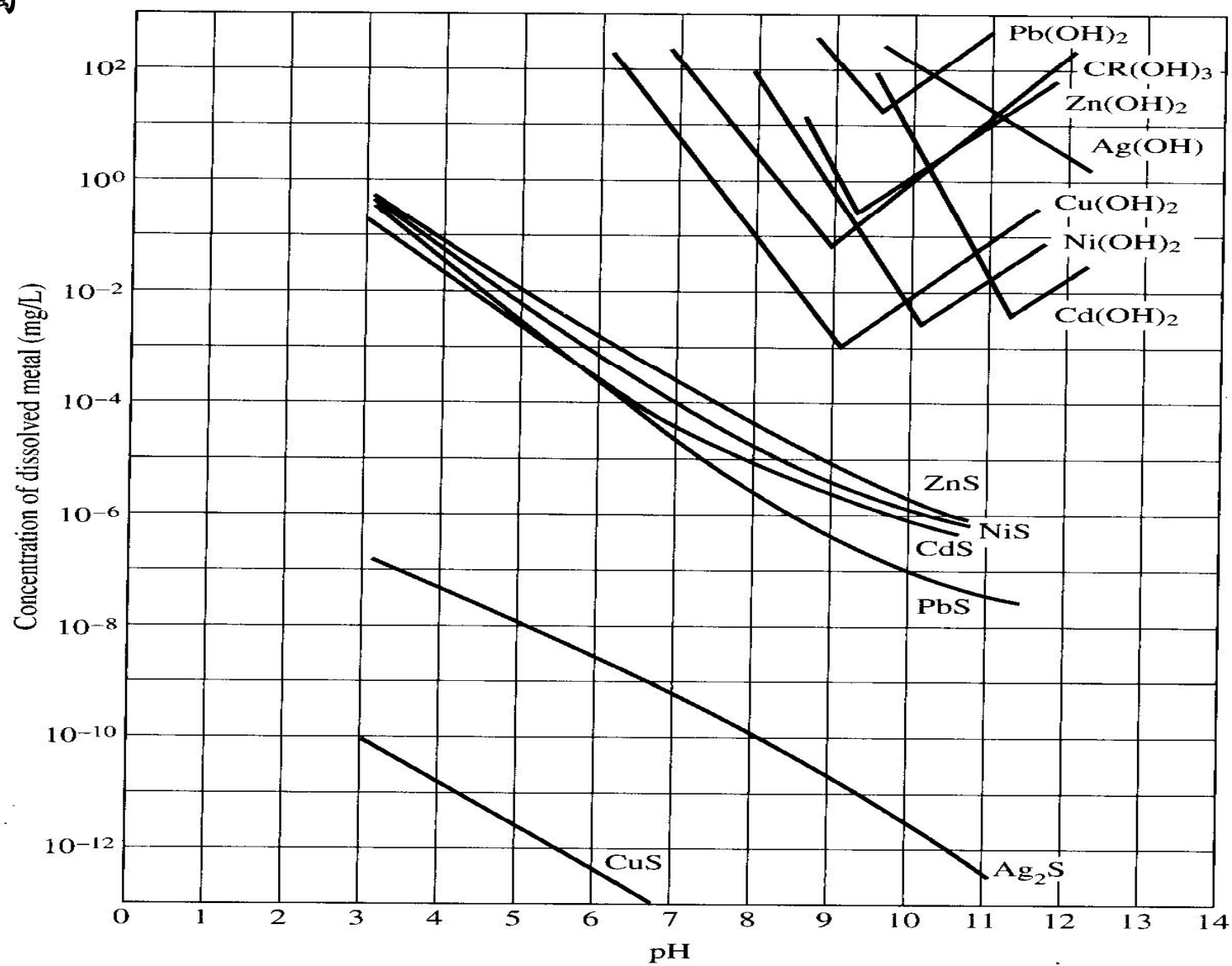
**Table 2.7 Feed water requirements to minimise fouling**

| Parameter         | Value       |
|-------------------|-------------|
| SDI <sub>15</sub> | ≤4          |
| Turbidity         | < 1*        |
| Iron**            | < 0.05 mg/l |
| Manganese         | < 0.5 mg/l  |
| Hydrogen sulphide | < 0.1 mg/l  |
| Organics (TOC)    | < 10 mg/l   |

\* Some membrane manufacturers recommend that turbidity be < 0.2 NTU

\*\* At pH > 7.0 and 5–10 mg/l dissolved oxygen; at lower pH and lower oxygen levels, slightly higher iron levels can be tolerated

# 重金屬



**FIGURE 4.8** Heavy metals precipitation as the hydroxide and the sulfide.

# UF/MF 清洗

**Table 2.14 Cleaning techniques for UF and MF membranes**

| Foulant                                            | Cleaning reagent                               | Process condition         | Reagent action                               |
|----------------------------------------------------|------------------------------------------------|---------------------------|----------------------------------------------|
| Fats and oils, proteins, polysaccharides, bacteria | 0.5N NaOH + 200 ppm chlorine                   | 30–60 min at 25–55°C      | Hydrolysis and oxidation                     |
| DNA, mineral salts                                 | 0.1M–0.5M acid (acetic, citric, nitric)        | 30–60 min at 25–55°C      | Solubilisation                               |
| Fats, oils, proteins, biopolymers                  | 0.1% sodium dodecyl sulphate, 0.1% TritonX-100 | 30 min overnight, 25–55°C | Wetting, emulsifying, suspending, dispersing |
| Cell fragments, fats, oils, proteins               | Enzyme detergents                              | 30 min overnight, 30–40°C | Catalytic breakdown (proteolysis)            |
| DNA                                                | 0.5% DNAase                                    | 30 min overnight, 30–40°C | Enzyme hydrolysis                            |
| Fats, oils, and grease                             | 2–50% ethanol                                  | 30–60 min at 25–55°C      | Solubilisation                               |

# RO/NF 清洗

Table 2.13 Cleaning methods for RO and NF membrane systems

| Foulant                                                       | Example                                                                                 | Chemical cleaner                                                                                                                                           |
|---------------------------------------------------------------|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Scale (pH adjustment and/or scale inhibitor)                  | $\text{CaCO}_3$ , $\text{CaSO}_4$ , $\text{BaSO}_4$ , $\text{SrSO}_4$ , $\text{SiO}_2$  | Citric acid, 0.2% (wt.) HCl, 0.5% (wt.) phosphoric acid, or EDTA-based solution;<br>Clean silicate-based foulants with ammonium bifluoride-based solutions |
| Colloidal clays/silt (filtration and/or charge stabilisation) | $\text{SiO}_2$ , $\text{Fe}(\text{OH})_3$ , $\text{Al}(\text{OH})_3$ , $\text{FeSiO}_3$ | EDTA- or BIZ-type detergents at high pH;<br>Clean silicate-based foulants with ammonium-bifluoride-based solutions                                         |
| Biological (sodium bisulphite addition or chlorination)       | Iron-reducing bacteria, sulphur-reducing bacteria, mycobacteria, pseudomonas            | EDTA- or BIZ-type detergents at high pH;<br>Shock disinfection with hydrogen peroxide, peracetic acid                                                      |
| Organic (filtration)                                          | Polyelectrolytes, oil, grease                                                           | Detergents/surfactants, isopropanol                                                                                                                        |

Source: Amjad, Reverse Osmosis, 1993

敬請指正  
謝謝