KOCH MEMBRANE SYSTEMS

THE CURRENT USE OF HOLLOW FIBRE ULTRAFILTRATION AS PRE-TREATMENT FOR REVERSE OSMOSIS

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Membrane Processes

- Lower Pressure Membrane Processes
  - ◊ Microfiltration (UF)
  - ◊ Ultrafiltration (MF)
- Higher Pressure Membrane Processes
  - ◊ Nanofiltration (NF)
  - ◊ Reverse Osmosis (RO)

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Membrane Configurations

- Open Feed Channel Configuration
  - ◊ Tubular
  - ◊ Hollow- Fibre
- Narrow Feed Channel Configuration
  - ◊ Spiral (Flat Sheet)

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Tubular Membranes

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Tubular Membrane System

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Spiral Membrane Elements

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Spiral Membrane System

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Hollow Fibre Membrane Cartridge

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Hollow Fibre Membrane Cartridge

Year 1990

5 inch (diameter) x 43 inch (length)
Membrane Area = 82 ft2 (7.6 M2)
Nominal Capacity = 4.8 gpm (1.1 M3/h)

Year 2000

8 inch (diameter) x 72 inch (length)
Membrane Area = 544 ft2 (50.5 M2)
Nominal Capacity = 32.1 gpm (7.3 M3/h)

Year 2003

10 inch (diameter) x 72 inch (length)
Membrane Area = 871ft2 (80.9 M2)
Nominal Capacity = 51.4 gpm (11.7 M3/h)

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Hollow Fibre Membrane Stage

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Hollow Fibre Membrane System

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Hollow Fibre Packaged System

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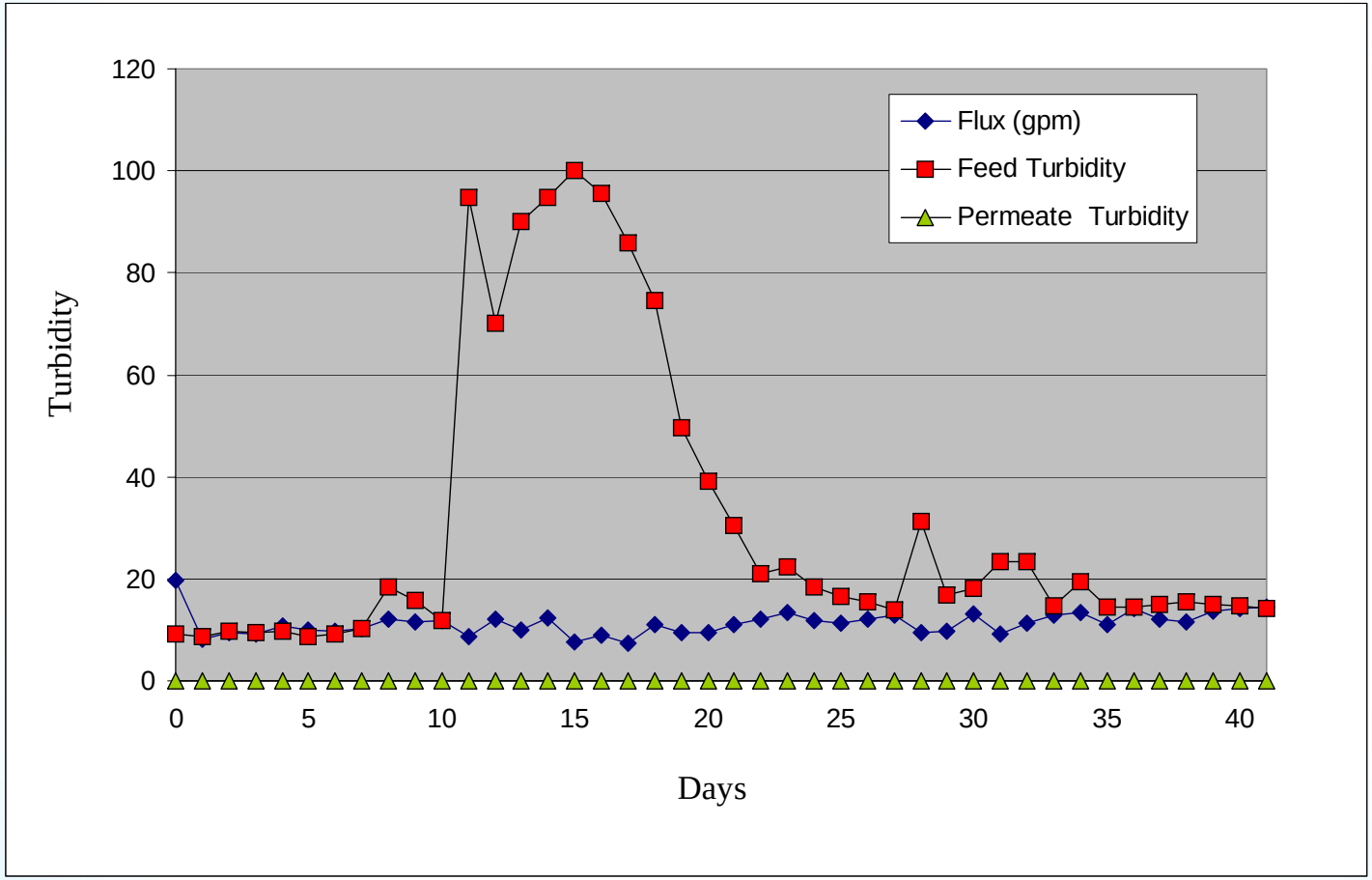
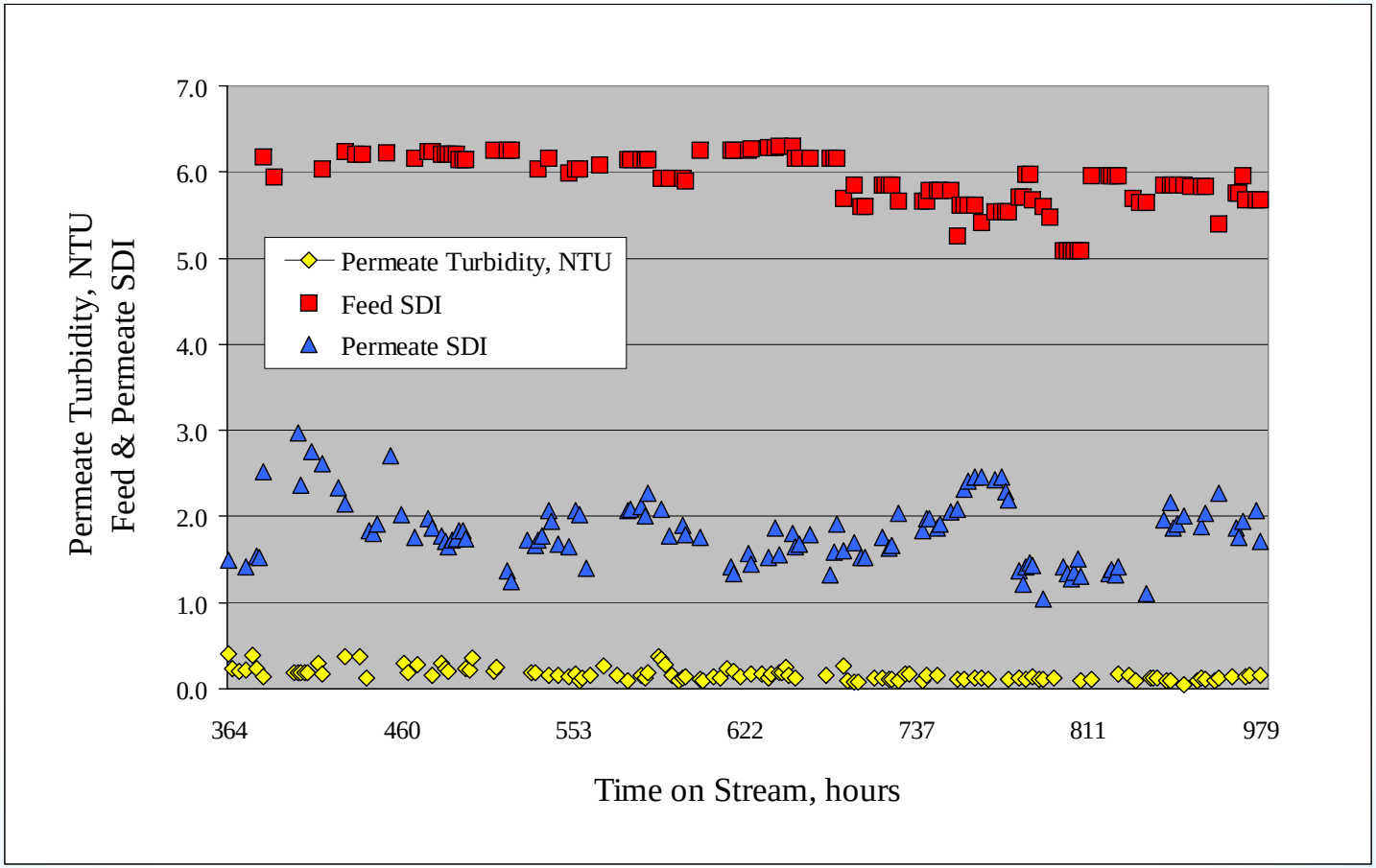
Membrane Processes Compared to Conventional Treatment

- Membrane processes produce consistent and high quality filtrate regardless of feed water quality
- Membrane processes have smaller footprint
- Membrane processes are fully automated to allow remote operation and minimum operator support.
- Membrane processes have comparable costs to conventional pretreatment depending on the feed water quality and site specific conditions

Surface Water
Feed Vs Filtrate NTU – UF Pilot Plant



Open Inlet Seawater
Feed Vs Filtrate SDI – UF Pilot Plant



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Hollow Fibre Membrane Compared to Spiral Membrane

- Hollow fibres have open feed channels
- Spiral membranes have narrow feed channels
- Hollow fibres can be backflushed
- Spiral membranes can not be backflushed

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Case Studies

Wastewater Reclamation and Reuse

- Tangshan Steel Works
  - ◊ Abandoned Coal Mine Wastewater
- Chennai Petroleum Corporation Limited (CPCL)
  - ◊ Municipal Wastewater
- CAPCO
  - ◊ CPI Wastewater/Cooling Tower Blowdown
- Caoyang Steel Company
  - ◊ Cooling Tower Blowdown

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Project Incentives

5 Year Program - Industry Water Saving

- Water Law - 2002
- Industries regulated to conserve and reuse water
- City water and ground water sources used for the operation of the existing steel production plant
- Existing water sources not available for expansion of the steel production plant
- Wastewater from abandoned mine was available for expansion of the steel production plant

Project Background

Description of Wastewater

- Water collected in abandoned coal mine
- Rainwater, groundwater and mine leachate
- High in suspended and dissolved solids

Use of Reclaimed Water

- Steel Manufacturing Operations
- Boiler Makeup Water

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Wastewater Treatment

Integrated Conventional and Membrane

- Conventional
  - ◊ Coagulation, Flocculation, Sedimentation
- Membrane
  - ◊ Ultrafiltration (UF)/Reverse Osmosis (RO)
  - ◊ Ultrafiltration System Production Capacity
    - 680 m^3/h (4.3 MGD)
  - ◊ Reverse Osmosis System Production Capacity
    - 500 m^3/h (3.2 MGD)
- Ion Exchange Polishing

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Ultrafiltration System

Description

- Purpose
  - ◊ Reduce suspended solids and turbidity
- Process Arrangement
  - ◊ Three parallel cartridge racks
  - ◊ Single pass/Circulation (SS > 30 mg/liter)
- UF Cartridges
  - ◊ 8 inch x 72 inch pressure cartridges
  - ◊ Inside to outside permeate flow direction
  - ◊ 3 trains x 46 cartridges = 138 cartridges (total)
  - ◊ 50.5 m2 (544 ft^2) membrane area per cartridge

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Reverse Osmosis System

Description

- Purpose
  - ◊ Reduce hardness and dissolved solids
- Process Arrangement
  - ◊ Three parallel trains
- RO Elements
  - ◊ TFC Membrane
  - ◊ 8 inch x 60 inch (long) elements
  - ◊ 108 elements per train (18/9 array)
  - ◊ 324 total element
  - ◊ 54 m2 (575 ft^2) per membrane element

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Operating Data

Ultrafiltration System

- Flux = 85 lmh (50 gfd)
- Feed Pressure = 0.5 – 2.0 bar
- Backwash Frequency = 30 minutes
- CIP frequency = 4 to 8 weeks
- Feed Water Turbidity = 14 NTU (average)
- Product Water Turbidity = < 0.5 NTU
- Product Water SDI < 2.0

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Operating Data

Reverse Osmosis System

- Flux = 30 lmh
- Feed Pressure = 9.5 bar (1st array)
- Feed Pressure = 8.4 bar (2nd array)
- CIP frequency > 6 months
- Product Water Conductivity = 4.5 - 10.0 µS/cm

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Summary

Integrated UF/RO membrane treatment of coal mine wastewater has been successfully used to provide a high quality, reliable and secure water source where no other practical water source was available for the expansion of the Tangshan Steel Works.

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Operating Data

Process Stream Description

	Process Stream	Item			
		Turbidity (NTU)	**SS** (ppm)	**Conductivity** (µS/cm)	**SDI_{15}**
1	Raw Water	50 - 500	250	450-800	
2	UF Feed	7 - 50 Average 14	10-50	450-800	
3	RO Feed	ND	ND	450-800	< 2
4	RO Product	ND	ND	4.5-10.0	

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Wastewater Treatment

Integrated Conventional and Membrane

- Site: CPCL, Chennai, Tamil Nadu, India
- Start-Up: December 2004
- Feed Water: Secondary Clarified Municipal Wastewater
- Product Water: Process and Cooling Tower Makeup Water
- UF Pretreatment: Coagulation, Media Filter and Cartridge Filter

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Wastewater Treatment

CPCL

- **Ultrafiltration System**
  - ◊ Capacity: 430 m^3/hr (2.7 MGD)
  - ◊ Cartridges: 10 inch x 72 inch (80.9 m^2/cartridge)
  - ◊ Configuration: 6 x 18 (108 cartridges)
- **Reverse Osmosis**
  - ◊ Capacity: 320 m^3/h (2.0 MGD)
  - ◊ Elements: 8 inch x 40 inch TFC
  - ◊ Configuration: 4 trains (14/7) = 504 elements total

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Wastewater Treatment

Integrated Conventional and Membrane

- Site: Caoyang Power, Liao Ning Province, China
- Start-Up Date: December 2004
- Feed Water: Cooling Tower Blowdown Water
- Product Water: Boiler Makeup Water
- Pretreatment: Fibre Filter

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Wastewater Treatment

Caoyang Power Company

- Ultrafiltration System
  - ◊ Capacity: 160 m^3/hr (1.0 MGD)
  - ◊ Cartridges: 10 inch x 72 inch (80.9 m^2/cartridge)
  - ◊ Configuration: 2 x 16 (32 cartridges)
- Reverse Osmosis System
  - ◊ Capacity: 120 m^3/hr (0.75 MGD)
  - ◊ Elements: 8 inch x 40 inch TFC
  - ◊ Configuration: 2 trains (9/5) = 168 elements total

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Wastewater Treatment

Integrated Conventional and Membrane

- Site: CAPCO, Kaoshing, Taiwan
- Start-Up Date: June 2001
- Feed Water: Biologically Treated CIP Organic Wastewater

  Cooling Tower Blowdown Water
- Product Water: Process and Cooling Tower Makeup Water
- Pretreatment: Coagulation, Carbon, Media Filter, Cartridge Filter

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Wastewater Treatment

CAPCO

- Ultrafiltration System
  - ◊ Capacity: 375 m^3/hr (2.4 MGD)
  - ◊ Cartridges: 6 inch x 48 inch (11.2 m^2/cartridge)
  - ◊ Configuration: 5 x 110 (550 cartridges)
- Reverse Osmosis System
  - ◊ Capacity: 275 m^3/hr (1.7 MGD)
  - ◊ Elements: 8 inch x 40 inch TFC
  - ◊ Configuration: 6 trains (6/3) = 324 elements total

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Conclusions

- Integrated conventional and membrane processing for reclamation and re-use is used on a variety of wastewaters
- Hollow Fibre UF provides a consistent and high quality filtrate for spiral RO
- Feed water quality and consistency, and site conditions will determine the project economics