



## DOWEX™ UPCORE™ Ion Exchange Resins Retrofit of Demineralizer with UPCORE System Cuts Chemical Costs by 50%

### Site Information

#### Location

Indiana, USA

#### Purpose

- Improve short service-cycle run lengths
- Improve the quality of unreliable product water

#### Comparative Performance

- Station realizing 50% reduction in operating costs and 61% cutback in regeneration time.
- Storage vessels full of high-quality water



*The Wabash River Coal Gasification Repowering Project repowered a 1950s vintage pulverized coal-fired plant.*

*After five years of problems with their make-up water demineralizer system, the CInergy Wabash River coal gasification plant installed an UPCORE™ system using DOWEX™ UPCORE ion exchange resins. The result was a 50% reduction in regeneration chemical costs that gives a 16-month return on the investment of nearly \$0.5 million for the new installation. Other benefits include: 17% capacity increase of high-quality water, 61% cutback in regeneration time, and reduced dependence on mobile water demineralization trailers.*

### Introduction

The make-up water demineralizer vessels at the Wabash River coal gasification plant were originally designed in a counter-current flow configuration with service water flowing downward and regeneration chemicals flowing upward. Each of the two trains consists of primary vessels for strong acid cation and strong base anion resins. Downstream of these primary vessels is a small cation resin bed to polish the sodium leakage from the primary cation resin bed. The design flow rate is 500 gpm (114 m<sup>3</sup>/h) per train.

The plant experienced operational problems immediately after the 1995 start-up of the original system (1). The decision to retrofit the two-train ion exchange system using UPCORE™ technology came after nearly five years of struggling with short service-cycle run lengths and unreliable product water quality. During this time, regeneration chemical consumption was about two to three times the projected design rates. This added about \$3.40 to the cost of every 1000 gal (3.8 m<sup>3</sup>) of water produced.

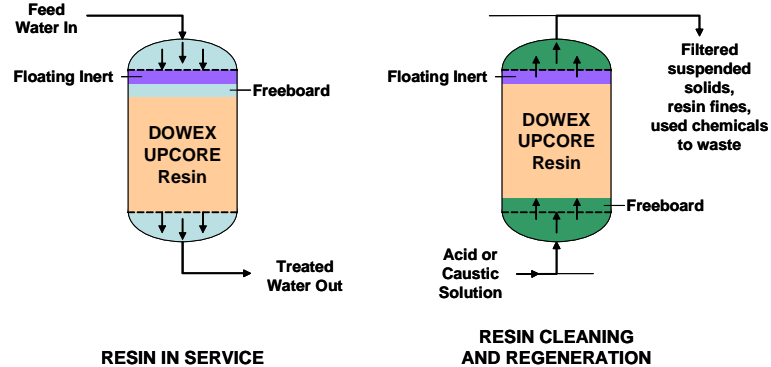
## UPCORE™ System

The UPCORE™ system is based on the following principles:

- Counter-current ion exchange technology
- Packed bed design
- Upflow regeneration/downflow service
- Uniform particle size (UPS) resin technology

In the service cycle, a wide operational flow flexibility is possible. In this cycle, the feed water enters the vessel from the top (Figure 1). Before regeneration, compaction water flows at high velocity from the bottom to the top and compacts the resin bed against the inert resin and upper nozzle plate. Without flow interruption, the regenerant and subsequently the rinse water passes through the resin bed in an upflow direction. There is no need for a separate backwash tank because the suspended solids are automatically removed from the surface of the resin bed during the compaction step of each regeneration cycle.

Figure 1. Diagram of the UPCORE system



The advantages to the UPCORE system include

- Excellent water quality
- High chemical efficiency
- Short regeneration time
- Simple construction and control
- Self cleaning
- Insensitivity to production flow variations and stops
- No risk of carry-over of resin fines
- Anion resin layered beds without the need for a middle plate

The UPCORE system uses DOWEX™ UPCORE Mono ion exchange resins, which provide high operating capacity and chemical efficiency, reduced waste production, low total organic carbon (TOC) extractables, and outstanding mechanical integrity. These resins have high resistance to attrition, preventing generation of fines as the resins age in service.

## Using CADIX for a Retrofit Evaluation

The retrofit evaluation of the make-up water demineralizer system at the Wabash River facility began with a software application program called CADIX (Computer Aided Design for Ion eXchange). The CADIX program is a comprehensive ion exchange engineering tool for system design and evaluation of existing plant performance. Moreover, CADIX provides an evaluation of the economic feasibility of a retrofit using UPCORE™.

The performance advantages projected with the retrofit of the Wabash River facility using the UPCORE system are:

- High-quality product water reliability
- Service cycle run length of 260,000 gal (984 m<sup>3</sup>)
- Sulfuric acid use for regeneration cycle reduced from 220 to 97 gal (0.8 to 0.4 m<sup>3</sup>)
- Sodium hydroxide use for regeneration cycle reduced from 500 to 176 gal (1.9 to 0.7 m<sup>3</sup>)
- Cost for regeneration chemicals reduced from \$3.39 to \$1.50 per 1000 gal (3.8 m<sup>3</sup>) of product water
- Total time for regeneration reduced from 4 hours to 2 hours
- Elimination of need to periodically transfer the resin to a separate tank for backwashing
- Increased supply of available product water

## Plant Characteristics

The feed water conditions and plant design characteristics are listed in Tables 1 and 2.

Table 1. Feed water conditions at Wabash River plant

Parameter	Value
Total dissolved cations, ppm as ion	
Calcium	32.1
Magnesium	15
Sodium	41.2
Potassium	3.4
Total dissolved anions, ppm as ion	
Chloride	62.1
Nitrate	1.9
Sulfate	94
Bicarbonate	60
Total silica, ppm as silica	1.8
Feed water pH	7.5
Feed water temp., °F (°C)	80 (27)
Feed water flow, gpm (m <sup>3</sup> /h)	500 (114)

Table 2. Plant design characteristics at Wabash River plant

Parameter	Cation Resin	Anion Resin
Regeneration chemicals	H <sub>2</sub> SO <sub>4</sub> stepwise	Hot NaOH (100°F, 38°C)
Bulk chemical concentration, wt %	93	50
Water quality for resin compaction	Demineralized	Demineralized
Resin type	DOWEX UPCORE Mono C-600	DOWEX UPCORE Mono A-500
Vessel diameter, ft (m)	8 (2.4)	8 (2.4)
Vessel straight-side height, ft (m)	6.5 (2)	6.5 (2)

## Plant Performance

Table 3 shows the projected results of the UPCORE™ system compared to the actual performance at the Wabash River Station (2). The service cycle run length is terminated when the throughput reaches 240,000 gal (908 m<sup>3</sup>). This ensures consistent operation of the two-train demineralizer. In addition, not allowing the silica to break is good practice since this system does not have a mixed bed polisher downstream. In fact, silica leakage remains steady at 9 to 10 ppb when regenerating with a 2.0 wt % NaOH solution that is heated to approximately 100°F (38°C) (Table 4).

Table 3. Performance characteristics of the retrofit using the UPCORE™ system

Parameter	Actual	CADIX Projection
Service cycle run length, gal (m <sup>3</sup> )	240,000 (908)	224,350 (849)
Effluent water conductivity, micromhos/cm	0.07 to 0.08	0.25
Effluent silica, ppb	10	< 20
Total time for regeneration, h	1.5	2.0

Table 4. Actual regeneration conditions for the UPCORE system at the Wabash River plant

Step Description	Cation Resin		Anion Resin	
	Time (min)	Flow Rate	Time (min)	Flow Rate
Compaction water	3.0	502 gpm (114 m <sup>3</sup> /h)	3.0	412 gpm (94 m <sup>3</sup> /h)
1.8% H <sub>2</sub> SO <sub>4</sub> step	13.7	—	—	—
3.6% H <sub>2</sub> SO <sub>4</sub> step	13.5	—	—	—
Bed preheat - 100°F	—	—	8.5	—
2.0 wt % NaOH injection	—	—	28.5	—
Slow rinse	20.6	—	25.3	—
Settle	10.0	—	10.0	—
Fast rinse	4.3	480 gpm (109 m <sup>3</sup> /h)	13.1	480 gpm (109 m <sup>3</sup> /h)
<b>Total</b>	<b>65.1</b>	<b>15,534 gal (59 m<sup>3</sup>)</b>	<b>88.4</b>	<b>23,369 gal (89 m<sup>3</sup>)</b>

## Operational Advantages with UPCORE™

The performance improved dramatically immediately following the conversion of this two-train demineralizer to an UPCORE™ system, particularly with regards to ease of operation and reduced regeneration time.

Prior to the conversion, the standard practice was to sluice the resin bed to a resin maintenance vessel for high-flow-rate backwashing. This operation required as much as 10 hours of downtime for each demineralizer train. This task was usually performed during outages but should have been done every 4 to 6 months just based on differential pressure indications. With the self-cleaning properties of the UPCORE system, the need to remove the resin for backwashing is eliminated. And although this facility relies on a surface water source, which has the potential for large accumulation of suspended solids, the UPCORE system continues to demonstrate effective removal of particulates and unwanted material with a simple 3-min compaction step (Table 4).

The total time to complete a regeneration with the UPCORE™ system is 92 min. Reducing the time for regeneration means more time in service and, consequently, less dependence on portable demineralizer trailers. Renting mobile demineralizers for extra capacity of make-up water enables the facility to deal with sudden water losses in the heat recovery steam generator (HRSG). These water losses result from HRSG tube leaks and can amount to as much as 200 gpm (45 m<sup>3</sup>/h).

Finally, compared to the original design, the UPCORE system is producing 10 to 12 gpm (2.3 to 2.7 m<sup>3</sup>/h) more water, while yielding less pressure drop (approx. 3 psig).

## Economic Benefits with UPCORE™

The system performance of a demineralizer is typically characterized by three parameters: water quality, throughput capacity, and chemical consumption (efficiency). The goal of the system designer is to minimize regenerant levels and capital cost while maximizing throughput and water quality. As mentioned earlier, the product water quality at the Wabash River facility with the UPCORE system consistently exceeds the design of the original system. The dollar savings due to reduced regeneration chemicals usage and increased throughput capacity are as follows:

### 112 gal (0.4 m<sup>3</sup>) reduction for bulk H<sub>2</sub>SO<sub>4</sub> and 305 gal (1.2 m<sup>3</sup>) reduction for bulk NaOH

- Annual savings of \$324,182

### 17% increase in capacity

- 4,172,000 extra gal (15,791 m<sup>3</sup>) of water each month
- As much as \$40,000 per month savings on leasing portable demineralization trailers

## Conclusions

The Wabash River station is realizing 50% reduction in operating costs and 61% cutback in regeneration time with the UPCORE system. The facility now maintains storage vessels full of high-quality water regardless of their operational mode: simple cycle, combined cycle natural gas, or combined cycle syngas. The total cost for the retrofit project was \$490,000. The project is expected to see a return on investment in 16 months of operation.

## References

1. Conversion of a CCR Demineralizer to the Dow UPCORE System, Osborn, T., CInergy Power Generation Services, 22<sup>nd</sup> Annual Electric Utility Chemistry Workshop, Champaign, IL (May 2002).
2. Osborn, T., CInergy Power Generation Services, personal communication (July 2002).

### DOWEX™ Ion Exchange Resins For more information about DOWEX resins, call the Dow Liquid Separations business:

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Notice: Oxidizing agents such as nitric acid attack organic ion exchange resins under certain conditions. This could lead to anything from slight resin degradation to a violent exothermic reaction (explosion). Before using strong oxidizing agents, consult sources knowledgeable in handling such materials.

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