**Dow**
**Liquid Separations**

**DOWEX**
**Ion Exchange Resin**

# DOWEX MARATHON WBA-2 Engineering Information

**July 2003**

# DOWEX MARATHON WBA-2 Weak Base Anion Exchange Resin

**General Information**

DOWEX* MARATHON* WBA-2 resin is a high capacity, macroporous, weak base anion exchange resin of uniform bead size distribution. It is based on a styrene-divinylbenzene copolymer matrix with dimethylamine functional groups. DOWEX MARATHON WBA-2 is specifically designed to give high throughput and economical operation in both water and non-water applications. It is particularly effective when used at flow rates of 25 bed volumes/hour (3 gpm/ft$^3$) or less, providing high capacity of up to 1.25 eq/l (30 kgr/ft$^3$) or more. In addition, its high physical strength and small bead size make it more resistant to bead breakage.

Weak base anion resins are used in demineralizer systems for two reasons:

1. They have a higher total exchange capacity and regenerate more efficiently than strong base anion resins. This makes weak base resins more economical to operate on waters containing significant levels of chloride and sulfate.
2. They have better elution of naturally occurring organic species relative to strong base resins. The high reversibility to organics, aided by the absence of large beads, leads to a good resistance to fouling with adequate caustic (> 80 g/l or 5 lbs/ft$^3$) and gives protection to the strong base anion resin typically used downstream.

DOWEX MARATHON WBA-2 may be used in a simple two stage plant giving good quality water but without removal of silica or carbon dioxide. For full demineralization, the resin may be used in combination with a strong base anion resin such as DOWEX MARATHON A in a separate vessel, or combined with DOWEX MARATHON A LB in a single vessel as a layered bed. The tailored bead sizes of DOWEX MARATHON WBA-2 and DOWEX MARATHON A LB result in an excellent separation of the two resins. With such a combination of weak and strong base anion resins, a very high level of regenerant chemical efficiency can be achieved. Further information is given in the *Operating Characteristics* section of this leaflet.

The swelling of DOWEX MARATHON WBA-2 in the operational cycle is important and must be considered in the engineering design. The maximum operational swelling of DOWEX MARATHON WBA-2 is 23% when converted from the free amine form to the fully exhausted state. Operational swelling is around 20%.

The physical and chemical stability allows DOWEX MARATHON WBA-2 to be used to treat organic solvents or highly concentrated solutions.

| **Guaranteed Sales Specifications** | | **FB (free base) form** |
|---|---|---|
| Total exchange capacity, min. | eq/l | 1.7 |
| Water content | % | 40 – 51 |
| Uniformity coefficient, max. | | 1.1 |

| **Typical Physical and Chemical Properties** | | **FB (free base) form** |
|---|---|---|
| Mean particle size† | µm | 550 ± 50 |
| Whole beads | % | 95 – 100 |
| Total swelling (FB → HCl) | % | 23 |
| Particle density | g/ml | 1.04 |
| Shipping weight | g/l | 640 |
| | lbs/ft$^3$ | 40 |

† For additional particle size information, please refer to the Particle Size Distribution Cross Reference Chart (Form No. 177-01775).

| **Recommended Operating Conditions** | |
|---|---|
| Maximum operating temperature | 100ºC (212ºF) |
| pH range | 0 – 7 |
| Bed depth, min. | 800 mm (2.6 ft) |
| Flow rates: | |
| Service/fast rinse | 5 – 30 m/h (2 – 12 gpm/ft$^2$) |
| Backwash | See figure 1 |
| Co-current regeneration/displacement rinse | 1 – 10 m/h (0.4 – 4 gpm/ft$^2$) |
| Counter-current regeneration/displacement rinse | 5 – 20 m/h (2 – 8 gpm/ft$^2$) |
| Total rinse requirement | 2 – 4 bed volumes |
| Regenerant | 2 – 5% NaOH |

## *Hydraulic Characteristics*

**Backwash Expansion**

Backwash expansion of the resin to accomplish reclassification of the bed and removal of accumulated fine particles should be done at flowrates sufficient to expand the bed between 50 and 100% of its original height in the free base form. Figure 1 details percent bed expansion for DOWEX MARATHON WBA-2 resin when backwashed at various flowrates. It includes data for two different bases:

1. Regenerated - The percent expansion is determined relative to the bed depth in the regenerated (free base) form. This is the data to use for backwashing new or completely regenerated resin.
2. Exhausted - Resin in the exhausted form swells by up to 20% of it's original volume. This is the data to use for backwashing completely exhausted resin relative to the bed depth in the free base form.

**Example**

Resin depth is 1.5 m (5 ft) in the free amine form. The goal is to expand the bed to 3.0 m (9.9 ft) during backwash. Bed depth in the exhausted form is 20% more at 1.8 m (5.9 ft). Temperature of the backwash water is 15°C (60°F).

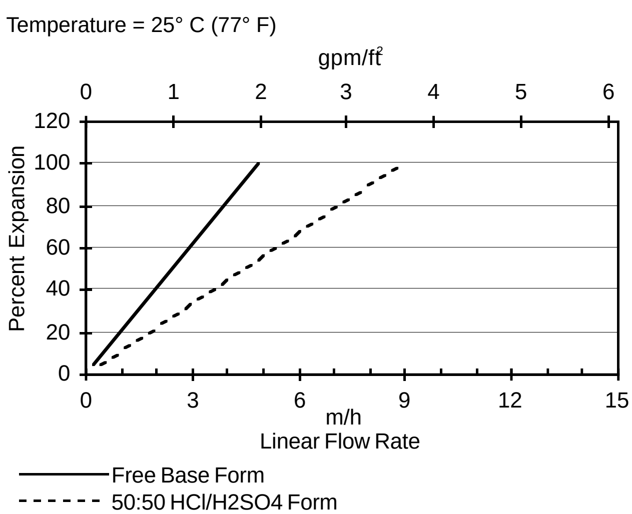
The target expansion of the exhausted resin is:

[(3.0m - 1.5m)/1.5m] x 100 = 100% relative to the free base form bed depth.

From Figure 1, the flowrate required for 100% expansion in the regenerated form is shown to be 9.0 m/h (3.7 gpm/$ft^2$ ) at 25°C (77°F). The temperature correction factor is then applied to determine the required flowrate at 15°C (60°F):

9.0 m/h [1 + 0.008 {(1.8 x 15) - 45}] = 7.7 m/h (3.1 gpm/$ft^2$)

**Figure 1. Backwash expansion vs. flow rate**




### For other temperatures use:

$F_T = F_{77°F}$ [1+ 0.008 ($T_{°F}$ -77)], where F ≡ gpm/$ft^2$

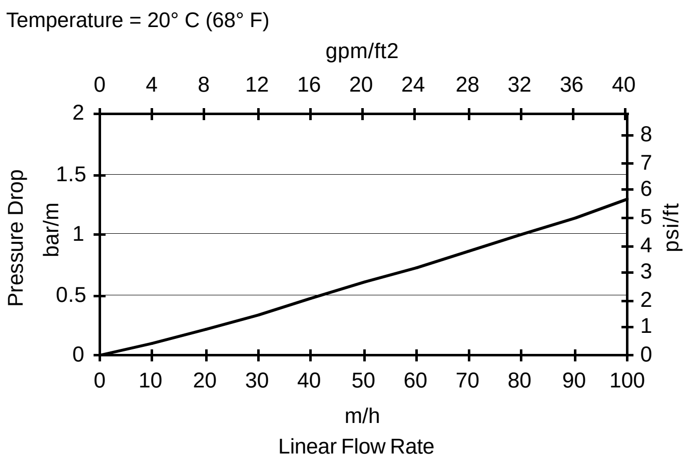
$F_T = F_{25°C}$ [1+ 0.008 (1.8$T_{°C}$ - 45)], where F ≡ m/h

### Pressure Drop

The pressure drop across a resin bed can vary depending on a number of factors. These include resin type, bead size, interstitial space (bed voidage), flow rate, temperature and degree of bed contamination. The presence of smaller beads in conventional resins results in filling of the interstitial spaces between the larger beads, thereby increasing the pressure drop. Compared to conventional resins, uniform beads have a higher bed voidage which compensates for the smaller mean bead diameter, resulting in similar pressure drop characteristics to the conventional resins.

The data in Figure 2 shows the pressure drop per unit bed depth as a function of both flow velocity and water temperature for the resin. These figures refer to a new resin bed at the beginning of the operational cycle with the resin in the free amine form (i.e., regenerated) in a backwashed, settled condition and should be considered indicative. The total pressure drop of a unit in operation will also depend on the design, in addition to other factors such as level of fines and suspended solids. Vessel geometry is also an important consideration, as in very small diameter units, particularly with deep beds, bed compaction may occur which could substantially increase the pressure drop.

**Figure 2. Pressure drop**




**For other temperatures use:**

$P_T = P_{20°C} / (0.026\ T_{°C} + 0.48)$, where P ≡ bar/m
$P_T = P_{68°F} / (0.014\ T_{°F} + 0.05)$, where P ≡ psi/ft

## *Operating Characteristics*

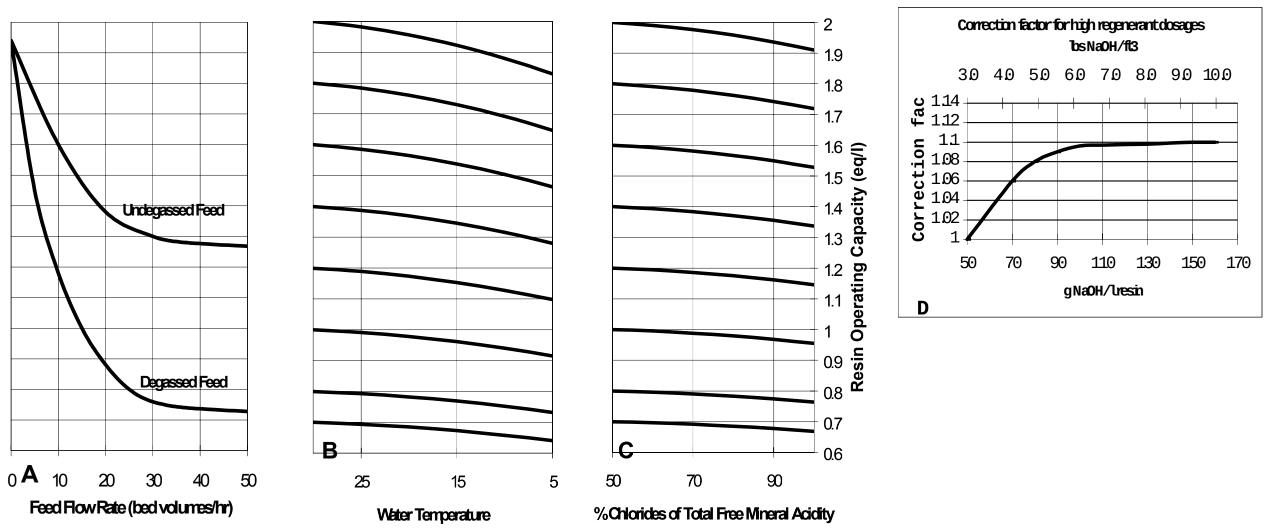
### General

As a weak base anion resin, DOWEX MARATHON WBA-2 removes free mineral acidity (FMA) from the cation effluent and, apart from a short period at the beginning of the operational cycle, will not remove carbon dioxide or silica. It therefore provides a highly efficient partial demineralization. The capacity of the resin is higher if carbon dioxide is present in the water, thus the logical location of a degassing tower would be after the weak base anion resin. The chemical efficiency remains the same however, so the position of the degasser can be selected according to the overall chemical engineering.

### Chemical Efficiency

DOWEX MARATHON WBA-2 regenerates extremely efficiently, leading to lower operating costs and reduced waste disposal. Figure 3 shows the amount of caustic soda normally required based on a consumption of 135% of the stoichiometric chemical equivalent. This is a typical figure, but if the water is free from organic matter, 5-10% less chemical may be used. A water with a high organic content may need 10% more. If caustic soda is very expensive, it may be economical to use less caustic soda and heat to 40°C (104°F).

**Figure 3. Operational Capacity Data**




To calculate operational capacity and regeneration requirements:

1. Locate a point on graph A from the plant feed flow rate (bed volumes per hour) and the feed carbon dioxide composition (degassed or undegassed).
2. Transfer the point from graph A horizontally to graph B and follow the guideline curves on graph B to locate a new point on the x-axis according to the feed water temperature.
3. Transfer the point from graph B horizontally to graph C and follow the guideline curves on graph C to locate a new point on the x-axis according to the percentage chlorides of FMA.
4. From the new point obtained on graph C, read off the resin operational capacity on the right hand side of the diagram.
5. Make a final correction to this operating capacity if higher caustic dosages are used by multiplying by the correction factor shown in graph D.

### Regeneration Chemicals

The usual regenerant is caustic soda and Figure 3 relates to the use of this chemical. The resin may also be regenerated with sodium carbonate or ammonium hydroxide. If the amount of these chemicals is the equivalent of the recommended sodium hydroxide, there will be a 10% drop in operational capacity.

The elution of organic matter from DOWEX MARATHON WBA-2 will remain very good with any regenerant, providing the correct regeneration level is used.

### Combination of Weak Base and Strong Base Anion Resins

For complete demineralization, particularly for waters containing a high proportion of FMA, it is advantageous to combine a weak base anion resin with a strong base anion resin, as the loading and regeneration of FMA on the weak base is chemically very efficient. Using thoroughfare regeneration, it is possible to extend this efficiency to the whole anion resin system by designing the process in such a way that the excess caustic from the strong base anion resin regeneration is used to regenerate the weak base anion resin. In addition, the overall operating capacity is increased and the strong base anion resin is protected from organics by the weak base resin.

### Overrun

When a weak base anion is placed before a strong base anion, it is possible to run DOWEX MARATHON WBA-2 to an FMA endpoint only, thereby using the strong base to adsorb silica and carbon dioxide. It is common practice, however, to operate the weak base resin over the FMA breakpoint in order to gain additional operating capacity by allowing the strong base resin to absorb the leakage and maintain product water quality. This is called the overrun condition.

### Layout

The two anion resins can be placed either in separate vessels, in one vessel with two compartments separated by an intermediate nozzle plate, or in a single vessel without a plate as a layered bed. In the separate vessel configuration, the weak base resin can also be regenerated in co-flow. In the case of two separate vessels, a degasser is normally placed downstream of the weak base resin to maximize its capacity.

### Silica Precipitation

When defining the plant operation and regeneration conditions, it is important to consider the overall service run length and silica level in the feed, due to the tendency of silica to polymerize onto the strong base anion resin and become difficult to remove during regeneration. Silica solubility is lowest at neutral pH and increases with pH and temperature. During thoroughfare regeneration, care should be taken that the silica eluted from the strong base resin does not precipitate in the lower pH conditions prevailing within the weak base resin. To minimize this risk, it is important to dilute the silica peak coming off the strong base anion by limiting caustic temperature and concentration and ensuring adequate chemical injection velocity.

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† Toll-free telephone number for the following countries: Austria, Belgium, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom

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.





Form No. 177-02013-703