# DOWEX Ion Exchange Resins

## DOWEX Resins as Organic Solvent Desiccants

DOWEX* ion exchange resins can be used as desiccants for organic solvents, after having been dried to a low moisture level, in a manner similar to the use of silica gels and molecular sieves. DOWEX resins have the advantage of being very easily regenerated (dried) at low temperatures relative to other desiccants. The resins are particularly useful for the removal of trace amounts of water from non-polar solvents, such as the chlorinated hydrocarbons used in dry cleaning, vapor degreasing, etc. Most non-polar materials are not imbibed into the resin structure, and therefore, many of the inhibitor systems used in these solvent systems are not taken from the solvent upon drying.

Solvents which are relatively non-ionic in character can be dried to moisture levels of less than 10 ppm. Capacities of 20 lbs. of water adsorbed per 100 lbs. of dried resin desiccant are obtainable. Reversibility can be accomplished using temperatures as low as 300°F, a decided improvement over the 365 - 650°F required by molecular sieves. Water content in the organic liquid fed to the desiccant affects the capacity obtained, with higher water content yielding higher capacity (Figure 1). Similarly, flow rate through the desiccant affects the capacity, with lower flow rates yielding higher capacity (Figure 2).

Figure 1. Effect of water content in feed on desiccant capacity

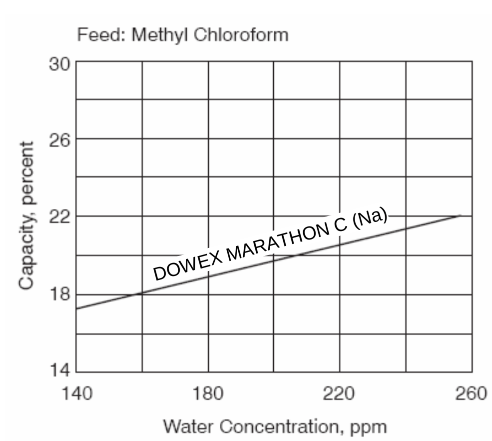
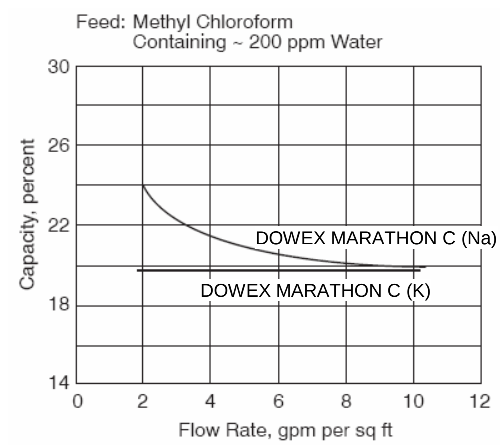



Figure 2. Effect of flow rate on desiccant capacity




## The Product

DOWEX ion exchange resins used for desiccant applications are strong acid cation exchange resins based on polymers of styrene crosslinked with divinylbenzene and functionalized by sulfonation. This yields a resin containing a sulfonate group to which an exchangeable $H^+$ ion is attached. This resin type is the most stable synthetic organic ion exchange resin polymer system available. For use as a desiccant, the $H^+$ ion is generally exchanged for a sodium ion and dried. The wet resin is available commercially in the sodium form and the drying step is usually carried out in the user's desiccant drying equipment. The commercially available form shrinks approximately 50% when dried to the desiccant resin level.



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## The Product (cont.)

It is sometimes advantageous to use the resin in the potassium form to improve the kinetics of drying a specific solvent system. When this is required, the $H^+$ form of the resin can be purchased and converted to the potassium form by neutralization in a batch reactor, using a 5% KOH solution at 0.16 pounds KOH per pound of resin. Column flow through contact may also be used if equipment is available. Care needs to be taken to rinse the resin free of excess reagents with good quality water prior to drying the resin for desiccant use.

DOWEX MARATHON* C (Na) cation exchange resin in the sodium form is the product recommended for desiccant applications.

Table 1. Typical properties† of DOWEX MARATHON C (Na) resin converted for desiccant use

| | |
|---|---|
| Physical form | Plastic spheres |
| Size | 585 µm |
| Bulk density (dried) | 57 lbs/cu ft |
| Particle density (dried) | 1.5 g/cc |
| Swelling characteristics | About 1% of dry volume / 1 wt% moisture uptake |
| 100% saturation capacity | 90 - 95% by weight |

Theoretical pressure drop through dry desiccant

Pressure drop = 1.084 $\mu qL$

Pressure drop = pressure drop in psi
$\mu$ = fluid viscosity, centipoises
q = superficial flow rate, gpm/sq ft
L = bed depth, feet

† Typical properties not to be considered specification items.

## The Drying Process

The advantages of using DOWEX ion exchange resins as desiccants are best realized when using column operations. That is, the fluid to be dried is passed through the dry resin bed under controlled conditions of temperature and flow. Under these conditions, equilibrium loading of the resin is reached at the inlet end of the column while the moisture level in the effluent stream is in equilibrium with dry resin. This allows optimum use of the resin's capacity and, at the same time, allows the product solvent moisture level to be controlled by the extent to which the desiccant has previously been dried. Moisture content of the treated organic solvent should be monitored to detect the end of the loading run.

Resin bed depths used are typically between 3 and 6 feet, with column depths sufficiently greater to contain the volume change which the DOWEX ion exchange resin undergoes when water is imbibed during the drying process. The resin swells about 1% (dry volume basis) for each 1% water imbibed (weight basis). NOTE: This expansion requires that column configuration be such that the volume change can occur vertically. Tall, narrow columns might restrain this expansion and cause strong lateral pressures to develop in the column, resulting in resin being crushed, or in a column being ruptured. Figure 3 depicts typical desiccation equipment.

Flow rates, commonly used with non-polar solvent drying systems, are in the range of 5 - 10 gpm/sq ft based on the empty column cross-section. With polar liquids, the flow rates are typically lower (about 1 gpm/sq ft) since the kinetics of drying decrease as the polarity of the liquid increases. Figure 4 depicts a typical capacity for a desiccation run.



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## The Drying Process (cont.)

Figure 3. Typical desiccation equipment

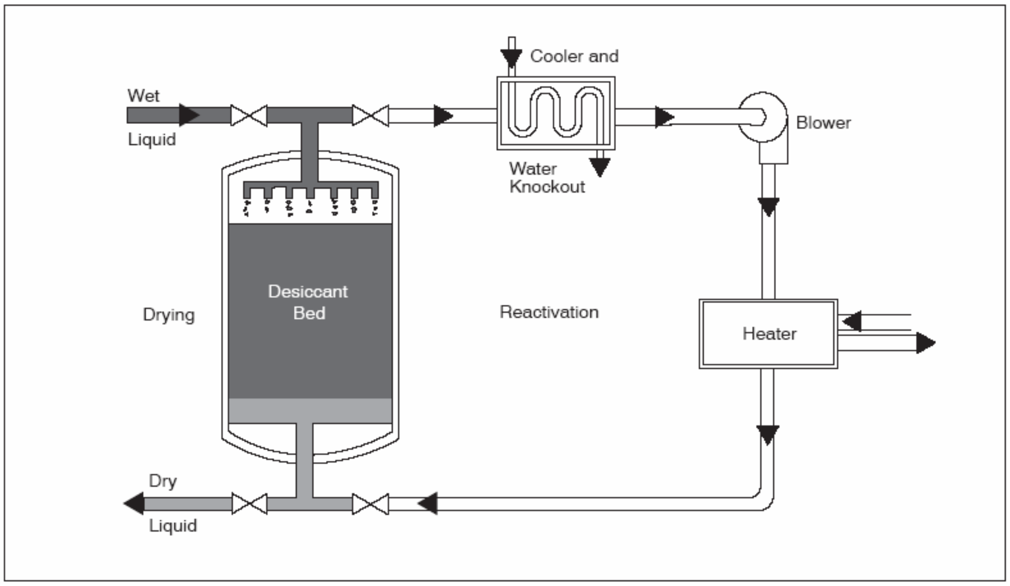
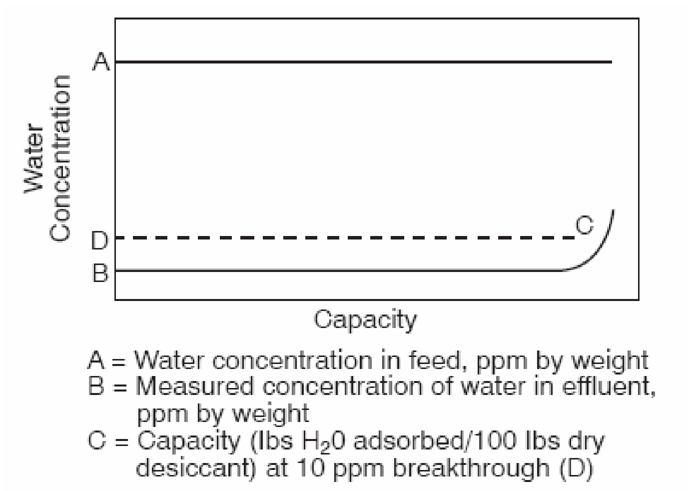



Figure 4. Typical capacity curve




## Reactivation – A Critical Step

One of the major advantages of the use of DOWEX ion exchange resins as desiccants is the ease with which they can be reactivated. Tabulated in Table 2 are the important reactivation parameters.

Table 2. Reactivation information

| | |
|---|---|
| Bed temperature | 275 - 300 degrees F |
| Specific heat | 0.28 BTU / lb / degree F |
| Heat requirements | 1,800 BTU / lb water |
| Purge gas flow rate | 10 - 30 ft / min |
| Purge gas | Air, nitrogen, natural gas, etc. |
| Heat supply | Electricity or low pressure steam |

## Reactivation – A Critical Step (cont.)

Reactivation is preferentially carried out with the dry purge gas flowing in a direction countercurrent to the flow direction of the fluid being dried. This results in the most dry part of the desiccant bed being contacted last during the subsequent solvent drying cycle and therefore results in the driest product. The reactivation portion of the operating cycle requires enough time for the transfer of the 1,800 BTU by the purge gas to the desiccant for each pound of water imbibed on the desiccant. It is therefore advantageous to operate two columns as a pair, one in the operating mode and one in the reactivation mode. Following reactivation, it is necessary to cool the desiccant column prior to refilling with fluid. Then, the fluid being used should be a portion of the low water product and should be introduced in an upflow direction to insure the complete removal of air or other gas from the column (to prevent flow channelling). The column will then be ready for use.

## Summary

The best ionic form of DOWEX ion exchange resin to use as the desiccant depends on several factors: the nature of the liquid to be dried, the water content in that liquid, the desired level of water in the product liquid, and the flow rate. DOWEX MARATHON C resin in the sodium form has a high capacity for most organic liquids. However, DOWEX MARATHON C resin in the potassium form should be considered for very polar liquids.

DOWEX ion exchange resin desiccants exceed other solid desiccants in the drying of non-polar organic liquids, and completely dry resins (good reactivation) will reduce the water content in such materials to below 1 ppm. It should be reemphasized that resins swell as they imbibe water and space must be provided in the operating column to contain the increased volume. DOWEX ion exchange resins are very resistant to bead damage during the slow expansion and contraction which the desiccant undergoes during the complete drying cycle.

DOWEX ion exchange resins have the important advantage of low reactivation temperature requirements (275 - 300°F) when compared with the recommended temperatures for synthetic gel zeolites (400 - 600°F). Data summarizing the operating capacities obtainable using DOWEX ion exchange resins as desiccants are tabulated in the Appendix.

### Appendix

**Operating Data Summary**

| Liquid | Desiccant DOWEX Resin Ionic form | Flow Rate gpm/sq ft | Flow Rate gpm/cu ft | Water Concentration In feed ppm (wt) | Water Concentration In product ppm (wt) or % | Capacity lb water/100 lb dry desiccant |
|---|---|---|---|---|---|---|
| Methylene Chloride | K | 5.0 | 1.7 | 98 | 2.0 | 5.3 |
| | K | 5.0 | 1.7 | 358 | 2.0 | 6.5 |
| | K | 5.0 | 1.7 | 621 | 2.0 | 8.3 |
| | K | 5.0 | 1.7 | 855 | 2.0 | 10.4 |
| | K | 5.0 | 1.7 | 1,096 | 2.0 | 11.8 |
| | K | 5.0 | 1.7 | 1,420 | 3.0 | 15.9 |
| | MS | 10.0 | 3.3 | 890 | 4.0 | 7.2 |
| Carbon Tetrachloride | K | 10.0 | 6.7 | 69 | 1.0 | 21.5 |
| | Na | 10.0 | 6.7 | 60 | 1.0 | 27.0 |
| 1, 1, 1, - Trichloroethane | Na | 3.0 | 1.2 | 200 | 1.0 | 24.4 |
| | K | 3.0 | 1.2 | 200 | 1.0 | 19.7 |
| | K | 5.0 | 2.0 | 200 | 1.0 | 21.2 |
| | Na | 5.0 | 2.0 | 200 | 1.0 | 23.6 |
| | K | 10.0 | 4.0 | 200 | 1.0 | 22.4 |
| | MS | 10.0 | 4.0 | 200 | 1.0 | 18.0 |

Operating Data Summary continued on next page



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| Operating Data Summary (continued) | | | | | | |
|---|---|---|---|---|---|---|
| Liquid | Desiccant DOWEX Resin Ionic form | Flow Rate gpm/sq ft | Flow Rate gpm/cu ft | Water Concentration In feed ppm (wt) | Water Concentration In product ppm (wt) or % | Capacity lb water/100 lb dry desiccant |
| Trichloroethylene | K | 10.0 | 4.0 | 229 | 3.0 | 17.3 |
| | Na | 10.0 | 4.0 | 208 | 4.0 | 17.9 |
| | Na | 5.0 | 10.4 | 183 | 2.0 | 16.5 |
| Perchloroethylene | K | 10.0 | 4.0 | 68 | 3.0 | 27.1 |
| | K | 20.0 | 8.0 | 79 | 3.0 | 24.5 |
| Propylene Dichloride | K | 10.0 | 4.0 | 580 | 7.0 | 8.6 |
| | K | 10.0 | 4.0 | 746 | 6.0 | 8.9 |
| Orthodichlorobenzene | K | 30.0 | 10.0 | 233 | 1.0 | 18.7 |
| | Na | 30.0 | 10.0 | 274 | 1.0 | 24.0 |
| Monochlorobenzene | Na | 13.0 | 15.7 | 180 | 2.5 | 4.5 |
| Benzene | K | 5.0 | 2.0 | 665 | 5.0 | 23.0 |
| | AA | 7.5 | 6.0 | 430 | 2.5 | 5.0 |
| | SG | 7.5 | 6.0 | 430 | 2.5 | 10.2 |
| | MS | 7.5 | 6.0 | 430 | 2.5 | 16.4 |
| Toluene | Na | 3.0 | 2.0 | 111 | 1.0 | 11.5 |
| Hexane | K | 10.0 | 4.0 | 70 | 6.0 | 25.8 |
| Octane | Na | 10.0 | 4.0 | 88 | 7.0 | 21+ |
| | K | 10.0 | 4.0 | 98 | 5.0 | 23.1 |
| Butylene Oxide | Na | 0.92 | 0.2 | 3,450 | – | 4.3 |
| DOWTHERM* A heat transfer agent | K | 10.0 | 5.0 | 680 | 1.0 | 24.0 |
| The above capacities are calculated for a 10 ppm breakthrough point. | | | | | | |
| The following capacities are calculated for a 0.2% water breakthrough point. | | | | | | |
| Ethanol | K | 0.5 | 0.1 | 2.5% | 250+ | 5.4 |
| | MS | 0.5 | 0.1 | 2.5% | 250+ | 12.0 |
| Acetone | K | 0.75 | 0.15 | 1.4% | 200+ | 7.5 |
| Isopropanol | Na | 0.5 | 0.65 | 11.19% | 70 | 18.5 |
| Triethylene Glycol | K | 0.5 | 0.06 | 1.98% | 0.01% | 4.6 |
| | MS | 0.5 | 0.06 | 2.01% | 0.01% | 13.9 |
| The following liquids have not been run to breakthrough. The capacities listed were those at the end of the run. + designates the capacity as a minimum value. | | | | | | |
| Monochloro-trifluroromethane | K | 20.0 | 9.2 | 21 ppm | 1 | 3.5+ |
| Nitromethane | K | 0.48 | 0.16 | 0.5% | 1 | 5.37+ |
| Acrylonitrile | K | 0.8 | 0.28 | 0.56% | 42 | 7.63+ |
| Aniline | K | 0.49 | 0.14 | 0.48% | 177 | 3.42+ |
| Diisobutyl Ketone | K | 0.25 | 0.08 | 0.5% | 155 | 1.6+ |
| o-Chlorophenol | K | 0.25 | 0.08 | 0.55% | 52 | 2.14+ |
| Ethyl Acetate | K | 0.42 | 0.14 | 0.56% | 0.11% | 5.12+ |

Note: MS = Molecular sieve; Na = Sodium form; K = Potassium form; SG = Silica gel; AA = Activated alumina

**DOWEX Ion Exchange Resins**
For more information about DOWEX resins, call the Dow Liquid Separations business:
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Warning: 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. 177-01722-1005