

# APPLICATION GUIDE

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## Nuclear Grade Ion Exchange Resins for Power Generation

This guide looks at the range of applications for Purolite NRW nuclear grade resins—all of which meet the latest published requirements for nuclear power stations.

## NUCLEAR GRADE ION EXCHANGE RESINS

This Application Guide looks at high-capacity, specialty ion exchange resins for nuclear power applications. For more detailed information on any product, or to find a product for an application not mentioned, visit [www.purolite.com](http://www.purolite.com) or contact the closest Purolite regional office listed on the back cover.

### INTRODUCTION

Founded in 1981, Purolite is a leading manufacturer of ion exchange, catalyst, adsorbent and specialty resins. With global headquarters in the United States, Purolite is the only company that focuses 100% of its resources on the development and production of resin technology.

Responding to our customers' needs, Purolite has the widest variety of products and the industry's largest technical sales force. Globally, we have five strategically located research and development centers and eight application laboratories. Our ISO 9001 certified manufacturing facilities in the United States of America, United Kingdom, Romania and China combined with more than 40 sales offices in 30 countries ensure complete worldwide coverage.



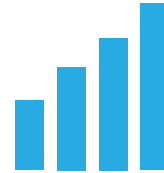
#### PREMIER PRODUCTS

The quality and consistency of our products is fundamental to our performance. Throughout all Purolite plants, production is carefully controlled to ensure that our products meet the most stringent criteria, regardless of where they are produced.



#### RELIABLE SERVICE

We are technical experts and problem solvers. Reliable and well trained, we understand the urgency required to keep businesses operating smoothly. Purolite employs the largest technical sales organization in the industry.



#### INNOVATIVE SOLUTIONS

Our continued investment in research & development means we are always perfecting and discovering innovative uses for ion exchange resins and adsorbents. We strive to make the impossible possible.

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### NUCLEAR GRADE ION EXCHANGE RESINS FOR POWER GENERATION

Ion exchange has played an increasingly important role in nuclear power since its commercialization, and application of specialty resins in managing radioactive waste continues to grow.

Changes in nuclear reactor design by power utilities around the world and in operations such as power uprates and reactor life extensions have fueled the need for new resins with greater selectivity, higher purity and improved filtration.

Purolite continues to develop and upgrade the “NRW” nuclear-grade resins to meet or exceed the standards set within the nuclear industry with regard to purity, integrity and performance.

Purolite NRW products are manufactured at our production plants located in the U.S.A., Europe and Asia. Each manufacturing plant is fully accredited to international standards for quality control at all stages of production and the entire Purolite® NRW product range meets the latest published requirements for the new generation of nuclear power stations.

### Nuclear power applications

The Purolite NRW product range includes a group of chemically and mechanically stable cation, anion and mixed bed resins that are specialized for nuclear applications and allow system designers and end users to choose the optimum product for their requirements. While many think of ion exchange only in terms of demineralization, Purolite’s view is more dynamic.

Purolite NRW products allow power plants to properly address needs in all areas of operation, including:

- Polishing requirements for makeup water (MU)
- Deep bed condensate polishing (CP)
- Chemical volume control (CVCS) during full power
- Reactor water cleanup (RWC)
- Radioactive waste cleanup
- Outage cleanup with high ionic loads and fine colloids
- Steam generator blow down (SGBD) recovery
- Spent fuel pool (SFP) cleanup



Strict control of trace impurities is essential. Nuclear-grade resins used in nuclear power systems must be free of trace contaminants that can support metal corrosion, eventually impacting fuel efficiency and service life of the unit.

Purolite has developed a nuclear-grade colloid removal resin to provide the enhanced filtration needed to achieve increasing quality requirements and meet new and existing discharge specifications.

Additionally, resins must be manufactured with high capacity and the highest achievable degree of conversion to the desired ionic form in order to ensure maximum ionic loading and minimum equilibrium and kinetic leakage.

Bead integrity and high breaking weight promotes good resistance to osmotic shock and the minimization of attrition and pressure drop issues. Modern nuclear power designs also demand that resins are produced with an optimum particle size distribution to further promote good distribution and further minimize pressure drop. These characteristics allow power stations to reach the highest operating efficiency while minimizing the generation of solid radioactive waste.

Purolite offers the highest quality products for all nuclear demineralizer applications, including both regenerable and non-regenerable, separate bed and mixed beds products.

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**Table 1 – Strong acid cation (SAC) resins for nuclear power generation**

PRODUCT NAME	MATRIX	TOTAL CAPACITY eq/l (H <sup>+</sup> )	MOISTURE RETENTION (H <sup>+</sup> )	MEAN DIAMETER (µm)	UNIFORMITY COEFFICIENT	APPLICATION
Purolite NRW1000*	Gel	1.8	51 – 55%	570 ± 50	≤ 1.2	Separate bed demineralization cation and radwaste
Purolite NRW1100*	Gel	2.0	46 – 50%	650 ± 50	≤ 1.2	All nuclear plant applications where cation resins are used
Purolite NRW1160	Gel	2.5	36 – 41%	625 ± 75	≤ 1.2	Polishing cation for high-purity water in secondary circuits and layering on polishing mixed beds
Purolite NRW1180	Gel	2.6	30 – 35%	425 – 1200 range	≤ 1.6	Polishing cation in aggressive environments
Purolite NRW160*	Macro	2.1	43 – 48%	425 – 1200 range	≤ 1.6	Cation resin vessels or layering for added cation capacity

\*Nuclear-grade cation resins are also available in lithiated form.  
 All the above Purolite NRW cation resins are shipped in the H<sup>+</sup> form, unless specified.

**Nuclear-grade strong acid cation resins**

The Purolite range of nuclear-grade strong acid cation (SAC) resins comprises five products (Table 1)—four gel and one macroporous resin. Gel resins are designed to meet a variety of applications and include the cost-effective and easily regenerable Purolite NRW1000, the higher capacity, kinetically efficient and more selective Purolite NRW1100, and the highest cross-linked gel resins available, Purolite NRW1160 and Purolite NRW1180. Purolite NRW1160 is ideal for non-regenerable condensate and SFP. It also performs well as a very highly selective polishing resin for high-purity water. Purolite NRW1180 tolerates aggressive oxidizing environments commonly found in spent fuel pools. Purolite NRW1160 and Purolite NRW1180 are not recommended for regenerable applications.

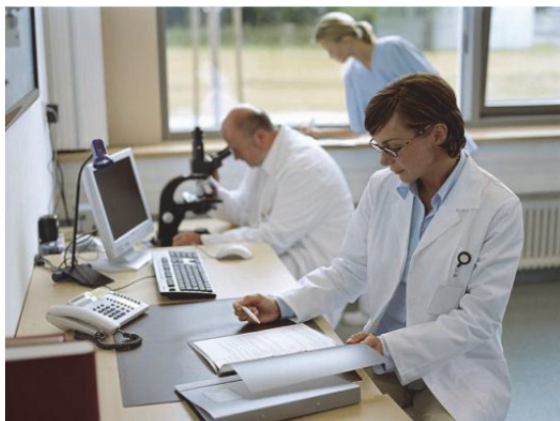
Purolite also offers a unique macroporous cation resin, Purolite NRW160. This highly specialized resin has a high loading capacity with good

kinetics and high selectivity. It is known for greater loading of cesium, cobalt, nickel and other metal ions and is ideal for use during plant maintenance outages when special cleanup is required as well as in some full power operations.

Additionally, Purolite NRW160 is highly selective for sodium in the presence of amines, making it a very effective resin for use in steam generator blow down, allowing for longer service runs, minimal sodium leakage and fewer resin changes during the life of the power station.

Several nuclear-grade cation resins are available in natural lithium-6 or high-purity lithium-7 form for primary coolant water pH control in (CVCS) demineralizers (i.e. in PWR Power Stations).

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**Nuclear-grade strong base anion resins**

Purolite nuclear-grade strong base anion (SBA) resins (Table 2) complement the selection of nuclear-grade cation resins. The Type I porous gel, Purolite NRW4000, provides an economic polishing solution and is recommended for use in regenerable systems (usually following a cation

column with Purolite NRW1100). Three Type I non-porous clear gel anion resins—Purolite NRW6000, Purolite NRW7000 and Purolite NRW8000—offer even higher capacity than Purolite NRW4000. (Purolite NRW8000 provides the highest capacity at 1.3 eq/l in the OH<sup>-</sup> form). These three resins offer greater ionic loading, greater selectivity and potentially longer operating life in non-regenerable applications. These higher capacity anion resins are durable and offer solid performance in difficult rigorous environmental conditions where selectivity and good kinetics are essential. Purolite NRW7000 and Purolite NRW8000 are not recommended for regenerable systems.

A high-capacity macroporous anion resin, Purolite NRW5050, is also available for use where specialty amines surface fouling may contribute to premature loss of kinetic performance. For example, prior to an outage, Purolite NRW5050 can be used to remove fouling precursors from the condensate stream.

**Table 2 – Strong base anion (SBA) resins for nuclear power generation**

PRODUCT NAME	MATRIX	TOTAL CAPACITY eq/l (OH <sup>-</sup> )	MOISTURE RETENTION (Cl <sup>-</sup> )	MEAN DIAMETER (µm)	UNIFORMITY COEFFICIENT	APPLICATION
<b>Purolite NRW4000</b>	Gel	1.0	48 – 54%	570 ± 50	≤ 1.2	Separate bed demineralizer anion and radwaste
<b>Purolite NRW6000*</b>	Gel	1.1	43 – 48%	570 ± 50	≤ 1.2	All nuclear plant anion applications. Anion resin vessels or underlay
<b>Purolite NRW7000</b>	Gel	1.15	54 – 60% (OH <sup>-</sup> form)	625 ± 75	≤ 1.2	All nuclear plant anion applications. Anion resin vessels or underlay
<b>Purolite NRW8000</b>	Gel	1.3	40 – 45%	570 ± 50	≤ 1.2	Extreme polishing applications and underlay for sulfate control
<b>Purolite NRW5010</b>	Macro	0.4	70 – 75%	425 – 1200 range	≤ 1.8	Ultra polishing overlay for fine colloidal particulate from primary coolant and radwaste
<b>Purolite NRW5050*</b>	Macro	0.9	53 – 58%	570 ± 50	≤ 1.2	Anion for high organics water and boron removal
<b>Purolite NRW5070</b>	Macro	1.0	50 – 55%	425 – 1200 range	≤ 1.7	Ultra polishing overlay for fine colloidal particulate from primary coolant and radwaste

\* Nuclear-grade anion resins Purolite NRW6000 and Purolite NRW5050 are also available in boronated form. All the above Purolite NRW Anion resins are shipped in the OH<sup>-</sup> form, unless specified.

### Nuclear-grade strong base anion colloid removal resin

The macroporous nuclear-grade anion resins Purolite NRW5010 and Purolite NRW5070 are signature products that function primarily as special polishing filter media and, secondarily, as ion exchange media. These highly specialized macroporous resins remove colloidal material and successfully remove radioactive isotopes (0.10 µm and smaller) from primary coolant water. Colloidal corrosion products, which do not settle and cannot be filtered successfully by conventional media or filter, will pass or plug conventional cartridge filters. Their removal contributes significantly to resolve source term and treatment difficulties. Purolite NRW5010 and Purolite NRW5070 can be installed in their own unit or can be layered on

other cleanup beds in conjunction with Purolite NRW160, the macroporous cesium and cobalt selective SAC resin, to enhance performance during refueling outages. The layered approach can also be used with final polishing mixed bed resins such as Purolite NRW3560 and Purolite NRW3460. Purolite NRW5010 and Purolite NRW5070 can also be used on CVCS beds during full power, on reactor water and spent fuel cleanup beds. Purolite NRW5070 is preferentially used for long-term service due to its greater crush strength.

### Nuclear-grade mixed bed resins

Purolite nuclear-grade mixed bed resins (Table 3) incorporate the same quality characteristics and broad selection demonstrated in our range of nuclear-grade cation and anion resins. This allows users to economically achieve conventional

Table 3 – Mixed bed (MB) resins for nuclear power generation					
PRODUCT NAME	CATION CAPACITY (eq/l)	ANION CAPACITY (eq/l)	EQUIVALENT RATIO	MATRIX	APPLICATION
Purolite NRW3240*	1.8	1.0	1:1	Gel/gel	Makeup demineralization and radwaste
Purolite NRW3260*	1.8	1.1	1:1	Gel/gel	Primary polishing and radwaste
Purolite NRW3460*	2.0	1.1	1:1	Gel/gel	Primary polishing and cleanup systems
Purolite NRW3540*	2.1	1.0	1:1	Macro/gel	Primary polishing and cleanup systems, steam generator blow down demineralization
Purolite NRW3550*	2.1	0.9	1:1	Macro/macro	Primary polishing and cleanup systems, steam generator blow down demineralization. For high organics water and boron removal
Purolite NRW3560*	2.1	1.1	1:1	Macro/gel	Primary polishing and layered cleanup systems, steam generator blow down and spent fuel pool demineralization
Purolite NRW3561*	2.1	1.1	1:1 (Volume ratio)	Macro/gel	Primary polishing and layered cleanup systems, steam generator blow down and spent fuel pool demineralization
Purolite NRW3562	2.1	1.1	2:1 (Volume ratio)	Macro/gel	Steam generator blow down, radwaste cleanup
Purolite NRW3670*	2.5	1.15	1:1	Gel/gel	High-purity condensate polishing, reactor water cleanup

\* Nuclear-grade mixed beds also available with the cation component in the lithiated form.  
 All the above Purolite NRW mixed bed resins are shipped in the H<sup>+</sup>/OH<sup>-</sup> form, unless specified.

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polishing objectives or to address the more rigorous applications found in steam generator blow down, condensate polishing and spent fuel pool demineralization.

The mixed bed products include the economical Purolite NRW3240, a combination of gel SAC and porous gel SBA, and Purolite NRW3260, a combination of gel SAC and non-porous, clear SBA. These products are recommended for use in makeup and radwaste final polishing and are used in systems where regeneration may be required. Purolite NRW3460 is recommended for polishing applications where higher capacity and good kinetics are required to control low-level impurities such as in RWC and the CVCS. Purolite NRW3670 is a combination of a very high-capacity gel SAC and a Type I non-porous clear gel anion for use in high-purity polishing systems such as BWR condensate polishing and RWC.

Purolite NRW3540 and Purolite NRW3560 are signature products of Purolite, incorporating a combination of the macroporous SAC with either porous or non-porous gel anion resins. These products are well established in the industry and are used in all demineralizers within primary and secondary systems—especially CVCS, cleanup beds, SFP, RWC, and SGBD. Purolite NRW3550 consists of macroporous SAC and macroporous SBA resins and is used where anion resins require good kinetics and resistance to potential organic fouling such as in condensate polishing and radwaste treatment.

Purolite nuclear-grade polishing mixed bed components are combined in chemical equivalent ratios (unless otherwise specified) for maximum operating capacity. Other cation-to-anion ratios are available on request for condensate polishing and other specialty applications where bed life can be extended and spent resin volume reduced.

Purolite NRW3561 is a 1:1 ratio by volume (approx. 2:1 equivalence) and Purolite NRW3562 is a 2:1 ratio by volume (approx. 4:1 equivalent) mixed bed resin composed of the macroporous SAC and the non-porous clear gel anion. It is designed for use in SGBD and special polishing of radwaste streams.

#### Purolite service and support

Responding to the needs of our customers, Purolite has built the largest technical sales force in the industry, the widest variety of products and

five strategically located Research and Development centers. Our ISO9001 certified manufacturing facilities in the U.S.A., Romania and China—combined with a network of over 40 sales offices in more than 30 countries—ensure complete worldwide coverage and allows Purolite to be a leading resin producer and supplier for the global nuclear industry.

Purolite field sales and technical support teams are available to assist with resin selection, product application, plant problems and troubleshooting in order to optimize efficiency and develop cost-effective solutions.

Our manufacturing and processing facilities are positioned to assure security of supply for safe and efficient nuclear plant operation. Global sourcing contracts are in place to secure raw materials along with confirmed secondary source of supply.

Quality control and assurance is backed by the latest ISO 9001 certified operations that are regularly audited by nuclear support organizations. Continual assessment and updating of testing facilities and methodology are addressed across all manufacturing and processing areas. Worldwide research laboratories support quality control and state-of-the-art manufacturing.

## Glossary

### Acronyms:

<b>BWR</b>	Boiling Water Reactor
<b>CP</b>	Condensate Polishing
<b>CVCS</b>	Chemical Volume Control System
<b>RCV (Asia)</b>	Chemical Volume Control System
<b>TEP (Asia)</b>	Deborating and final process
<b>MB</b>	Mixed Bed
<b>MU</b>	Makeup
<b>NRW</b>	Nuclear-Grade Resin
<b>PWR</b>	Pressurized Water Reactor
<b>RW</b>	Radwaste
<b>TEU (Asia)</b>	Radwaste
<b>RWC</b>	Reactor Water Cleanup
<b>SAC</b>	Strong Acid Cation
<b>SBA</b>	Strong Base Anion
<b>SFP</b>	Spent Fuel Pool or Pond
<b>PTR (Asia)</b>	Spent Fuel Pool or Pond
<b>SGBD</b>	Steam Generator Blow Down
<b>APG (Asia)</b>	Steam Generator Blow Down

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