Purolite® Product Bulletin

Nuclear Grade Ion Exchange Resins for Power Generation

Nuclear Grade Ion Exchange Resins

Just ask Purolite.

PUROLITE®
ION EXCHANGE RESINS

1. Introduction

The need for polishing impurities from coolant in reactor circuits became apparent with the introduction of nuclear power in the 1950's. Since then, ion exchange resins have played an important part in nuclear power generation and the application of special resins has continued to grow.

Nuclear power stations in the Americas, Europe and Asia now operate with a number of Purolite resins. Changes in nuclear reactor design by power utilities around the world and in operations such as power up-rates and reactor life extensions have fueled the need for new resins with greater selectivity, higher purity and improved filtration. The **Purolite NRW** product range meets the latest published requirements for the new generation of nuclear power stations.

Purolite continue 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 three production plants located in the USA, Europe and Asia. Each manufacturing plant is fully accredited to international standards for quality control at all stages of production.

2. Nuclear Power Applications

The **Purolite® NRW** product range includes a diverse collection of chemically and mechanically stable cation, anion and mixed bed resins allowing designers and end users to choose the optimum product for their requirements. Most engineers think of ion exchange only in terms of demineralization. Purolite's view is more dynamic and we have developed and introduced a nuclear grade colloid removal resin which provides enhanced filtration which is needed to achieve increasing quality requirements and meet new and existing discharge specifications.

Purolite® NRW products allow power plants to properly address needs in all areas of operations 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**

Nuclear grade resins required in nuclear power systems must be free of trace contaminants that may support chemical corrosion of system metals and deposition within the plant which will impact system life. Hence strict control of trace impurities is essential. 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 with both good resistance to osmotic shock and high breaking weight is essential to minimize attrition and pressure drop issues. Modern nuclear power designs also expect resins to be produced with an optimum particle size range. Such resins are expected to result in minimum pressure drop and minimum flow restriction helping to optimize performance and achieving full utilization of the resin bed. These characteristics allow power stations to achieve the highest quality and operating efficiency from their plants while minimizing the generation of solid radioactive waste.

Purolite offers products for all nuclear demineralizer applications, including both regenerable and non-regenerable, separate bed and mixed beds products. Equipment designers and end users should consult the nearest Purolite Sales Office for assistance on product selection.

3. Nuclear Grade Strong Acid Cation Resins

The Purolite range of nuclear grade strong acid cation (SAC) resins comprises four products, three 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 product **Purolite NRW1100** and, finally, **Purolite NRW1160**, the highest cross linked gel resin available. **Purolite NRW1160** tolerates aggressive oxidizing environments commonly found in spent fuel pools, and also performs well as a very highly selective polishing resin for high purity waters. **Purolite NRW1160** is not recommended for regenerable applications.

Table 1 – Strong Acid Cation (SAC) Products for Nuclear Power Generation

Product Name	Matrix	Total Capacity eq/l (H^+)	Moisture Retention (H^+)	Mean Diameter	Uniformity Coefficient	Application
Purolite NRW1000*	**Gel**	**1.8**	**51 - 55%**	**570 ± 50 µm**	**≤ 1.2**	*Separate bed demineralization cation and radwaste*
Purolite NRW1100*	**Gel**	**2.0**	**46 - 50%**	**650 ± 50 µm**	**≤ 1.2**	*All nuclear plant applications where cation resins are used*
Purolite NRW1160	**Gel**	**2.5**	**36 - 41%**	**625 ± 75 µm**	**≤ 1.2**	*Polishing cation for high purity water in secondary circuits and layering on polishing mixed beds*
Purolite NRW1600*	**Macro**	**2.1**	**43 - 48%**	**570 ± 50 µm**	**≤ 1.2**	*Cation resin vessels or layering for added cation capacity*

**Nuclear Grade Cation resins also available in lithiated form*
All the above Purolite NRW cation resins are shipped in the H^+ form. Unless specified.

Purolite also offers a very special macroporous cation resin, **Purolite NRW1600**, which is unique in the industry. This macroporous, highly specialized resin has a high loading capacity with good kinetics, yet has high selectivity and is known for greater loading of cesium, cobalt, nickel, and other metal ions. This product is ideal for use during plant outage for maintenance when special cleanup is required as well as in some full power operations.

Purolite NRW1600 is also highly selective for sodium in the presence of amines, therefore, making it a highly 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).

4. Nuclear Grade Strong Base Anion Resins

Purolite nuclear grade strong base anion (SBA) resins complement the selection of nuclear grade cation resins, beginning with the Type I porous gel, **Purolite NRW4000**, which provides an economic polishing solution and is recommended for use in regenerable systems (usually following a cation column with **Purolite NRW1000**). **Purolite NRW6000** and **Purolite NRW8000**, two Type I non-porous clear gel anion resins, offer increasingly higher capacity than **Purolite NRW4000**, with **Purolite NRW8000** providing the highest capacity at 1.3 eq/l in the OH^- form. These latter two resins offer greater ionic loading, greater selectivity and potentially longer operating life in non-regenerable applications. These higher capacity anion resins offer durability and solid performance in difficult rigorous environmental conditions where selectivity and good kinetics are essential. **Purolite NRW6000** 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 or boron from the circuit.

Table 2 – Strong Base Anion (SBA) Products for Nuclear Power Generation

Product Name	Matrix	Total Capacity eq/l (OH^-)	Moisture Retention (Cl^-)	Mean Diameter	Uniformity Coefficient	Application
Purolite NRW4000	**Gel**	**1.0**	**48 - 54%**	**570 ± 50 µm**	**≤ 1.2**	*Separate bed demineralizer anion and radwaste*
Purolite NRW6000	**Gel**	**1.1**	**43 - 48%**	**570 ± 50 µm**	**≤ 1.2**	*All nuclear plant anion applications. Anion resin vessels or underlay*
Purolite NRW8000	**Gel**	**1.3**	**40 - 45%**	**570 ± 50 µm**	**≤ 1.2**	*Extreme polishing applications and underlay for sulfate control*
Purolite NRW5010	**Macro**	**0.4**	**70 - 75%**	**775 ± 125 µm**	**≤ 1.8**	*Ultra polishing overlay for fine colloidal particulate from primary coolant and radwaste*
Purolite NRW5050	**Macro**	**0.9**	**53 - 58%**	**570 ± 50 µm**	**≤ 1.2**	*Anion for high organics water and boron removal*

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^- form. Unless specified.

5. Nuclear Grade Strong Base Anion Colloid Removal Resin

The macroporous nuclear grade anion resin **Purolite NRW5010** is a signature product that functions, primarily, as a special polishing filter media and, secondarily, as an ion exchange media. This highly specialized macroporous resin removes colloidal material, and has been successfully used in removing radioactive isotopes (0.10 µm and smaller) from primary coolant water. These colloidal corrosion products, which do not settle and cannot be filtered successfully by conventional media or filter, will pass or plug conventional cartridges filters. This will contribute significantly to resolve source term and treatment difficulties. **Purolite NRW5010** can be installed in its own unique unit or can be layered on other cleanup beds during refueling outages in conjunction with **Purolite NRW1600,** the

macroporous cesium and cobalt selective SAC resin, to enhance performance. The layered approach can also be used with final polishing mixed bed resins such as **Purolite NRW3560** and **Purolite NRW3460**. **Purolite NRW5010** can also be used on CVCS beds during full power, on reactor water and spent fuel cleanup beds.

6. Nuclear Grade Mixed Bed Resins

Purolite nuclear grade mixed bed resins incorporate the same diversity demonstrated in our range of nuclear grade cation and anion resins. This allows users to economically achieve conventional 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 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 clear gel anion resins. These products are well established in the industry and are used in all demineralizers within the primary and secondary systems especially CVCS, cleanup beds, SFP, RWC, 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.

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 and is designed for use in SGBD and special polishing of radwaste streams

7. Purolite Services and Support

The Purolite field sales and support team is the largest in the ion exchange industry. With extensive worldwide coverage, via a network of fully supported local sales offices, the technical support offered to our clients is enhanced by production flexibility and product availability. This has allowed Purolite to become a leading resin producer for the worldwide nuclear industry.

Purolite field sales and technical support teams are available to assist with resin selection, product application, plant problems troubleshooting, optimizing efficiency and developing cost effective solutions. Manufacturing and processing facilities are globally 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 are backed by the latest ISO 9001 certified operations and are regularly audited by nuclear support organizations. Continual assessment and updating of testing facilities and methodology is addressed across all manufacturing and processing areas. Worldwide research laboratories support quality control and state of the art manufacturing.

Table 3 – Mixed Bed (MB) Products 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 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^+/OH^- form. Unless specified

Glossary

Acronyms:

BWR	***Boiling Water Reactor***
CP	***Condensate Polishing***
CVCS	***Chemical Volume Control System***
MB	***Mixed Bed***
MU	***Makeup***
NRW	***Nuclear Grade Resin***
PWR	***Pressurized Water Reactor***
RWC	***Reactor Water Cleanup***
SAC	***Strong Acid Cation***
SBA	***Strong Base Anion***
SFP	***Spent Fuel Pool or Pond***
SGBD	***Steam Generator Blow Down***

Purolite was founded in 1981 and is a leading manufacturer of ion exchange, catalyst, adsorbent and specialty resins. Headquartered in Bala Cynwyd, PA, the company has ISO-9001 certified manufacturing facilities in the USA, China, and Romania and operates dedicated R&D centers in the USA, China, Romania, Russia, and the UK. Purolite, the only company focused exclusively on the ion exchange market, has 40 sales offices in more than 30 countries.

Please call one of the main regional offices on the following page to obtain full contact details for the nearest Purolite office responsible for your area.

Americas

The Purolite Company
150 Monument Road
Bala Cynwyd, PA 19004 USA
Tel +1 610 668 9090
Tel +1 800 343 1500
Fax +1 610 668 8139

Europe

Purolite International Ltd
Llantrisant Business Park
Llantrisant, Wales
CF72 8LF
UK
Tel +44 1443 229334
Fax +44 1443 227073

Asia Pacific

Purolite (China) Co ltd
Building D-705
No. 122 Shuguang Road
Hangzhou, Zhejiang
China, 310007
Tel +86 571 87631382
Fax +86 571 87631385

For further information on Purolite products & services visit www.purolite.com

Just ask Purolite.

PUROLITE®
ION EXCHANGE RESINS