

# Management of liquid radioactive waste

## Innovation

Nuclear facilities generate large amounts of liquid radioactive waste during operation and decommissioning. Binding the radioactivity of the waste and reducing the volume is essential for safe and cost efficient storage of the generated waste. In order to achieve these targets the waste is concentrated as far as possible and later processed to form disposable waste packages. NUKEM Technologies provides proven as well as innovative technologies in all areas of liquid waste management.

Our solutions for ...



Active Laundry

## Liquid Waste

Concentrates

Process Effluents

### > ... Concentration



### > ... Solidification



### > ... Filtration



Our solutions for ...

... Concentration



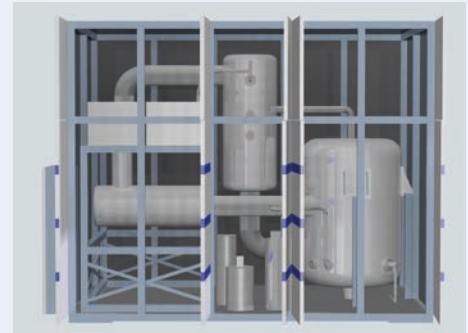
## Vapor Compression Evaporator

The vapor compression evaporator is designed as a skid mounted and fully operational facility, for concentrating inorganic liquid radioactive waste. As basic principle of the evaporation, the heat pump system was chosen, i.e. the liquid radioactive waste is evaporated by the condensation heat of the compressed vapour. The liquid inside the evaporator tubes is transported with a natural circulation due to the density difference between the evaporator head and evaporator bottom.

The treatment capacity of liquid radioactive waste can be chosen from 40 l/h up to 3500 l/h.

Properties:

- Only electrical energy for the vapor compression is necessary, therefore, no steam or cooling water is required
- Compact, skid mounted design
- Very high efficiency of the heat exchanger and low maintenance expense – surface of the vertical heat exchanger will be permanently flushed with turbulent waste water because of evaporation on tube side. After every operation period, the tube surface will be purged with compressed air which is used for discharging concentrate. Deposit on the surface is therefore almost impossible
- High quality of condensate because of the multistage vapour purification system integrated in the vapour separator
- Low energy demand because of high efficiency of the heat exchange and exploitation of remaining heat content in the distillate



*Vapor Compression Evaporator*



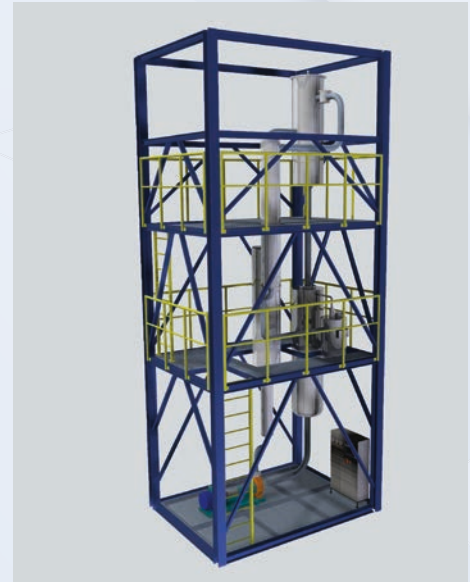
*Vapor Compression Evaporator  
(detailed view)*

## Natural Circulation Evaporator

The natural circulation evaporator refers to the type of heat-transfer. Heat-transfer takes place by passing of the media to be evaporated along a heated surface driven by difference in density. Boiling takes place on the heating surface. The evaporator is not equipped with mechanical moving parts and it is possible to use a 'valve-less' design. This allows the employment of the natural circulation evaporator favorable in hot cells for treatment of media with high radioactivity concentration in reprocessing plants.

Properties:

- No mechanical moving parts.
- Valve-less design possible.
- Favorable design for hot cells in particular for Canyon type of cells and Large Cells



*Natural Circulation Evaporator*

## Double Pipe Evaporator (UGU)

The double pipe concentrator UGU (Ustanovka Glubokogo Uparivaniya which means facility for enhanced concentration) is a high performance evaporator system for concentration of liquid waste. It comprises normally four modular, parallel operating, steam-heated heat exchanger including preheater. Downstream a separator for concentrate separation and a condenser are installed.

Properties:

- Throughput up to 500 l/h
- Variable Product concentration up to 800 g/l
- Super concentration up to salt melt is possible
- Full automatic mode
- Control via steam pressure and steam temperature
- Simple and robust construction
- Cost effective
- Modular expansion



*UGU, Bohunice NPP (Slovakia)*

Our solutions for ...

... Filtration



## Reverse Osmosis

Reverse osmosis is a physical process used to concentrate substances dissolved in liquids. Reverse osmosis is the reverse of natural osmotic process. In reverse osmosis, semipermeable membranes that are only permeable to water molecules are used. The separation of pure water (permeate) and concentrate is achieved by applying counter pressure on the raw water side, which works against the osmotic pressure.

Properties:

- Reduction of radioactive waste by means of concentration
- Well suited as an after-treatment stage, e.g. after a biological treatment
- Low operational cost and small facility size
- Purified water can be re-used as process water



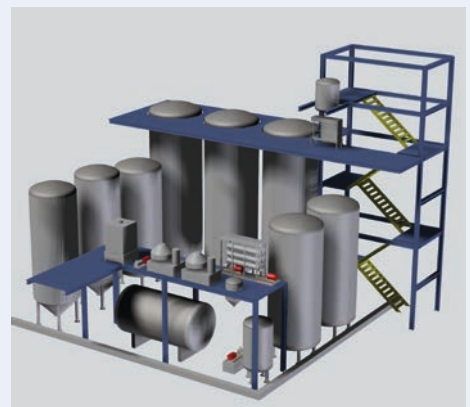
*Reverse Osmosis*

## Biological Treatment

Biological processes use microorganisms for purification of organically polluted liquid wastes. Organic substances are metabolized by micro-organisms and converted into  $\text{CO}_2$ . The radio-nuclides are incorporated into the biomass.

Properties:

- Very well suited for waste water from the active laundry
- Low investment and operational costs
- Radioactive waste minimization
- Chemicals required only in special cases
- Treated water can be re-used (after-treatment by means of reverse osmosis may be needed)



*Biological Treatment*

Our solutions for ...

... Solidification



### NUKEM Conical Mixer

The NUKEM Conical Mixer (NCM) is the latest system for container cementation. Active or inactive grout can be prepared fully automatically in the external NCM. The grout can be filled in any container by an adapted filling station. The NCM is subsequently automatically cleaned with an attached Recycling System. The NCM is suitable to process all solid and liquid radioactive waste, with a maximum particle size of 30 mm.

Properties:

- Suitable for all cementation purposes
- Suitable for all types and sizes of containers and drums
- Active cementation and grouting is possible
- Available mixer size up to 4 m<sup>3</sup> batch capacity
- Effective mixing even at filling grades of down to 20% of the mixer volume.
- High throughput due to less than 5 minutes mixing time
- >95% use of container capacity
- Integrated Safety System
- No secondary waste due to integrated recycling system
- Cost effective



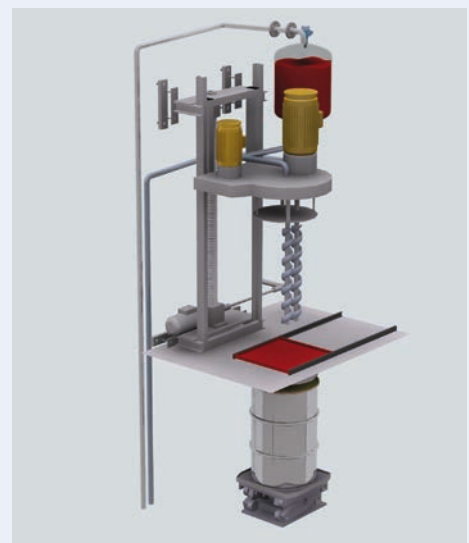
*NCM, Leningrad NPP (Russia)*

### In-drum Cementation

In-drum cementation is the standard solution for cementation of liquid radioactive waste inside a 200 l drum. The In-Drum Mixer is a combination of a planetary mixer with counter-rotating, double helical mixer elements. It is a well proven technology, and the preferred solution for simple in-drum cementation processes which require only a small throughput.

Properties:

- Suitable for 200 l drums
- Cost effective
- Optional with lost stirrer
- Compact footprint
- Automatic mode or manual mode by master slave manipulators are available
- Easy to clean and to decontaminate



*In-drum Cementation, Qinshan NPP (China)*

## Grouting

The Grouting of conditioned or loose radioactive waste is carried out with a special grout. The grout has a very low viscosity similar to water and can flow into every void. Therefore, a vibration table is not necessary. This property of the grout is achieved by using the high shear mixer which produces a colloidal suspension.

Properties:

- Small water/cement ratio by using the high shear mixer
- High strength and a low porosity of the grout
- Minimum void fraction
- Reducing of the hydration heat by using blast furnace slag
- Variable plant size from 100 l/h to 2m<sup>3</sup>/h

## Advantages

- Effective segregation of materials into free release and radioactive waste
- High percentage of free release material
- Minimisation of radioactive waste
- Less radioactive waste treatment and disposal cost
- Flexible solutions to cover the needs of the different clients



*Grouting, Chernobyl NPP (Ukraine)*