



Introduction to the NOMAD Excel Water Desalination Technology

Section 1. Highlights of the NOMAD Excel Water Desalination Technology

The NOMAD Excel water treatment system converts wastewater into irrigation or surface discharge quality fresh water by reliably removing salts, organics, metals, radionuclides, and other contaminants.

The original NOMAD technology, now NOMAD Excel after several design improvements (see below) remains the only cost-effective and proven technology to treat oilfield by-product water. For 20 years NOMAD has worked in every major US shale basin including Marcellus, Barnett, Eagle Ford and Permian. NOMAD technology has generated over 30 million barrels of fresh water in Texas alone. NOMAD is the only proven technology for the treatment of by-product water that is available at commercial scale.

Each NOMAD Excel unit is capable of generating 2000 barrels per day (BPD) of distilled quality fresh water. Living up to its name, NOMAD Excel technology remains rugged, modular and skid-mounted for easy deployment. Its low height design makes it suitable for transport on highways.

NOMAD Excel units are ideal for by-product water treatment because individual units can be added or removed to meet changes in treatment volumes so that the units can run at peak efficiency. NOMAD's 2000 BPD capacity has proven to be the ideal sizing for modular deployment.

NOMAD Excel is classified as a Mechanical Vapor Recompression (MVR) Thermal Evaporator. NOMAD employs an Alfa Laval three stage heat recovery system. It's the most energy efficient evaporator/exchanger system available; period. Efficient heat recovery in a thermal technology directly translates into low operating cost. The heat exchangers are easily serviced, minimizing downtime and maintenance cost, giving NOMAD Excel yet another advantage over other evaporator designs.

NOMAD Excel's low scaling, owing to the heat exchangers and a versatile pre-treatment system, allows salts in the waste water to be concentrated to just below saturation. This translates into high and repeatable fresh water yields.

Several design improvements have been identified for NOMAD Excel including replacing the gas fired vapor recompression driver with a direct coupled VFD electric drive motor and simplifying the automation control system. Both are expected to reduce operating expense (OPEX), provide operational flexibility and further improve reliability. In addition, more efficient use of skid space is expected for NOMAD Excel, perhaps completely eliminating one of the three skids thereby reducing mobilization OPEX.

Section 2. Background of MVR Thermal Evaporators in the Oilfield and What Separates NOMAD Excel from the Others.

MVR thermal evaporators have been extensively used by the food, chemical, and pharmaceutical industries because of their ability to reliably and cost effectively deliver high quality water from a variety of poor-quality feed streams.

Because of its ability to purify a wide range of oilfield wastewaters into a distilled quality product, MVR evaporators got a lot of attention beginning in the late 90s from oil and gas producers needing to reduce their demand on freshwater sources to satisfy their hydraulic fracturing programs. The NOMAD (now NOMAD Excel) technology was the only commercially available MVR to emerge from this period because it was, and remains, the only technology that is cost effective, and adequately designed to operate in the oilfield. Over 30 million clean barrels were generated by NOMAD in Texas alone before oil and gas companies learned that hydraulic fracturing treatments could be effectively designed using clean brines rather than fresh water. The industry's need for MVR desalination of wastewater essentially "dried up" thereby idling the NOMAD by the late 2010s.

Encore Green Environmental was able to purchase the NOMAD technology from then owner, XRI, in early 2021 and the purchased units are currently being refurbished into NOMAD Excel. Important design improvements to further improve reliability and versatility have been described above. No other MVR thermal desalination technology has emerged at commercial scale since NOMAD. Some are in research and development stages but are not commercialized. The original NOMAD can truly be regarded as being ahead of its time.

Section 3. Description of NOMAD Excel Process Flow

Mechanical vapor recompression is a highly efficient distillation process wherein a mechanically-driven blower or compressor is used to maintain system heat balance so that once running, the water purification process can be sustained without an external heat source. The major advantage of mechanical recompression over conventional distillation is the ability to transfer the heat of the water vapor to dirty water feed stream in a closed system thus saving a significant amount of energy over conventional "one pass" distillation systems.

Here is how it works. See figure 1 below.

- a. The process starts by heating a portion of clean water from the distillate collection tank with an auxiliary start-up boiler. When sufficient steam is generated to operate the steam blower, the auxiliary boiler is extinguished.
- b. The steam blower functions to boost the heat of the water vapor prior to its entry into the evaporator exchanger. The evaporator exchanger or (liquid to vapor heat exchanger) is the central component of the process. It is a highly efficient titanium plate exchanger divided up into several independent cartridges, thus optimizing the heat exchange capacity of the system.
- c. In the evaporator exchanger, saturated, high temperature steam from the steam blower loses heat across the exchanger plate to the colder feed brine and the steam begins to condense. The resultant heat of condensation is transferred to the feed brine. The heat transfer doesn't stop there. Because of the surface area and channel design of the evaporator exchanger and the

velocity of fluids entering and exiting, the now condensed steam is also able to transfer its sensible heat to the feed stream. This more complete energy transfer is one reason than NOMAD Excel is able to generate the high volume of clean water with such a small footprint.

- d. The result of the heat transfer from the blower heated steam to the feed brine is that a portion of the feed brine flashes into steam. A segment of this steam is directed to the steam blower to be compressed and the process repeats. The remaining steam is condensed into the distillate vessel as clean water. The unflashed brine water containing the salts and contaminants is recirculated back to the feed side of the exchanger so that more water vapor can be extracted with more passes through the evaporator exchanger. Eventually the brine stream approaches salt saturation and is routed out of the process so that it can be disposed.
- e. Further heat recovery efficiency is afforded by the heat exchangers piped into the fluid streams leaving the unit; the distillate stream and brine waste stream. These exchangers transfer sensible heat from the exiting streams and preheat the feed brine entering the unit.
- f. This process is maintained with an automation system that maintains heat balance of the steam system by speeding up or slowing down the motor that drives the steam blower, regulates fluid velocities in the evaporator exchanger, maintains waste brine salinity near salt saturation, warns of abnormal distillate quality, and protects equipment in the event of a system upset.

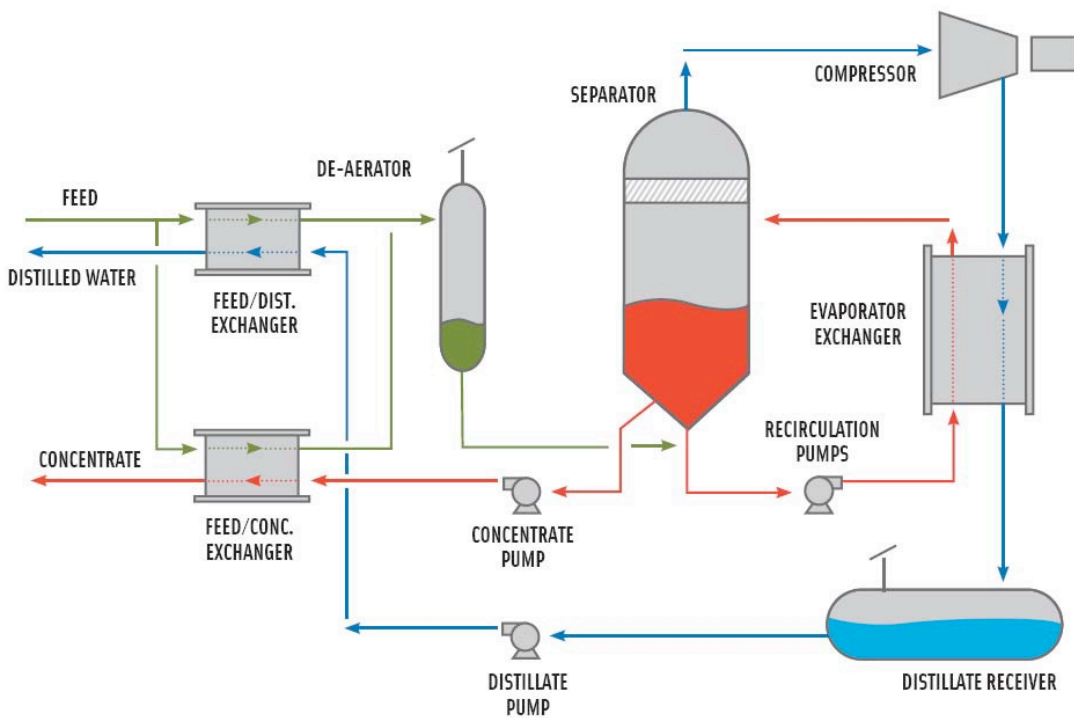


Figure 1: Proces flow diagram of an MVR thermal evaporator.