

The Theoretical Floor Rises When You Ask for More

— From an osmotic pressure of **29.7458** bar, the minimum work is **0.9508** kWh/m³ at **25** per cent recovery and **1.5273** at **75** — against a plant at **3.0** the ratio is **2.6190**, and the floor is a moving target — [Paper 446]

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— *From thinking to syncing.* —

Abstract

A theoretical floor is taken to be a fixed target. This paper shows that how much one asks for moves the floor itself—so “how many times the floor” is undetermined without stating the condition. No new theorem or law is claimed. First, the osmotic pressure of seawater is **29.7458** bar, inside the known range of **25** to **30** (Section 2). Second, the minimum work at **50** per cent recovery is **1.1455** kWh/m³ (Section 2). Third, this is the core of the paper. Raising the recovery from **25** to **75** per cent takes the floor from **0.9508** to **1.5273** kWh/m³, a factor of **1.61** (Section 3). Fourth, against a plant at **3.0** kWh/m³, the ratio at **50** per cent recovery is **2.6190** (Section 2). Fifth, as the recovery approaches zero, the floor approaches the osmotic pressure itself (Section 3). Sixth, the separator is whether the floor is fixed or moves with the demand (Section 4). **Keywords:** seawater desalination, reverse osmosis, osmotic pressure, minimum work of separation, recovery ratio.

Scope of this paper (scope note): No new theorem or law is claimed—osmotic pressure, the minimum work of reversible separation and the thermodynamic floor for reverse osmosis are all standard. No plant is designed—choice of membrane, number of stages and energy recovery are not the subject. No plant figure is asserted—3.0 kWh/m³ is representative and moves with scale, site and pretreatment. Pre- and post-treatment are excluded—intake, clarification, disinfection and distribution are not the subject; only the separation itself. The composition is simplified—seawater is treated as an ideal 0.6 mol/L sodium chloride solution, with no activity coefficients and no other ions. No process is preferred—comparing thermal and membrane methods is not the subject. Relation to earlier papers: Paper 445 showed that the waiting is for diffusion, not reaction—there too, which of two limits decided what to do. Paper 300 showed that common root and distinct root can be decided—“a fixed floor” and “a floor that moves with demand” are distinct roots by that criterion. Paper 417 showed that the ceiling on chain length moves with the requirement—there too, moving the demand moved the limit. This is a second instance of the same shape. Paper 423 showed that a right table still loses—there too, a quantity stated without its condition misled. What is added is giving the osmotic pressure as 29.7458 bar and checking it against the known range, tabulating the minimum work at three recoveries, showing the floor moving by a factor of 1.61, giving the ratio to a plant as 2.6190, placing the zero-recovery limit as the boundary, and placing the separator at “fixed or moving with demand”.

1. Notation and the Question

Setting: The osmotic pressure of a solution of concentration c and dissociation number i is

$$\Pi = i c R T$$

Recovering fresh water from seawater at a recovery r , the reversible minimum work per cubic metre of product is

$$W_{\min}(r) = \Pi \frac{\ln(1/(1-r))}{r}$$

Below, $i = 2$, $c = 0.6$ mol/L and $T = 298.15$ K.

Observation 1.1

A theoretical floor is taken to be a fixed target. A number set by thermodynamics—something one approaches.

Observation 1.2

But r appears in the expression. Until one fixes how much to extract, $W_{\min}$ is undetermined—the floor itself is a function of the demand.

Question: Change the demand, and how far does the floor move.

2. The Osmotic Pressure Is 29.7458 Bar

Computation 2.1: Take the osmotic pressure of seawater.

$\Pi = 2.9746 \times 10^6$ Pa, that is **29.7458** bar.

Observation 2.2

It falls inside the known 25 to 30 bar. An independent check—even the simplified composition matches in order and value.

Computation 2.3: Take the minimum work at 50 per cent recovery.

It is **1.1455** kWh/m³.

Observation 2.4

Against a plant at 3.0 kWh/m³, the ratio is **2.6190**. Under three times the floor—far closer than the common picture of “there is still a tenfold waste”.

Observation 2.5

So there is only a factor of 2.6 of room left. However clever the engineering, no more is available—this number says the ceiling is near.

3. The Floor Moves by a Factor of 1.61

Computation 3.1: Vary the recovery and take the minimum work.

Recovery	Minimum work [kWh/m ³]
0.25	0.9508
0.50	1.1455
0.75	1.5273

Observation 3.2

Raise the recovery and the floor rises. From 0.9508 to 1.5273, a factor of **1.61**—the more one tries to take, the more work each cubic metre costs at minimum.

Observation 3.3

Because what remains gets saltier. The more is drawn off, the higher the osmotic pressure of what is left—the last drop is the dearest.

Observation 3.4

As the recovery approaches zero, the floor approaches the osmotic pressure itself. Nothing gets concentrated—the boundary, and the true minimum.

Observation 3.5

So “how many times the floor” is undetermined without the recovery. The same plant reads **3.16** times at 0.25 and 1.96 at 0.75—the number takes on a life of its own.

4. The Separator

The separator: is the floor fixed, or does it move with the demand.

Observation 4.1

With a fixed floor, the ratio measures the plant alone. Two plants can be compared directly—which is how the quantity is used.

Observation 4.2

With a moving floor, the ratio mixes two things. The performance of the plant and how much was asked of it—lower the recovery and the ratio improves without touching the plant.

Observation 4.3

These are distinct roots by the criterion of Paper 300. Both are called “efficiency”—one a property of the plant, one of the plant paired with a demand.

Observation 4.4

The same shape as Paper 417. There, raising the requirement from 1 to 10 alone dropped the ceiling from 6 steps to 5—here raising the recovery raises the floor. In both, the limit was a function of the demand.

Observation 4.5

So print the recovery whenever the ratio is reported. “2.6 times the floor” alone has no fixed meaning—the same shape as Paper 423, where a probability needed its starting point and stopping rule.

Observation 4.6

To be honest—seawater has been treated as an ideal sodium chloride solution. No activity coefficients, no other ions—the values shift a little, but the floor remains an increasing function of the recovery.

Observation 4.7

One last thing—the plant figure of 3.0 excludes pretreatment and distribution. Only the separation is being compared—compare total electricity and the ratio grows.

5. Roll Call and Closing

1. The osmotic pressure is **29.7458 bar** (Computation 2.1): **inside the known range.**
2. **1.1455 kWh/m³** at **50 % recovery** (Computation 2.3): **the minimum work.**
3. The ratio to a plant is **2.6190** (Observation 2.4): **the ceiling is near.**
4. **0.9508** at **0.25** (Computation 3.1): **a lower floor.**
5. **1.5273** at **0.75** (Computation 3.1): **a higher floor.**
6. A factor of **1.61** (Observation 3.2): **the core.**
7. Because what remains gets saltier (Observation 3.3): **the last drop is dearest.**
8. Zero recovery approaches the osmotic pressure (Observation 3.4): **the boundary.**
9. The same plant reads **3.16** or **1.96** (Observation 3.5): **the number drifts.**
10. The separator is fixed or moving (Observation 4.3): **distinct roots by Paper 300.**

Closing: A theoretical floor is taken to be a fixed target—a number set by thermodynamics, something one approaches—but the recovery τ appears in the expression, and until one fixes how much to extract the minimum work is undetermined. The floor itself is a function of the demand. The value of the floor is trustworthy enough—the osmotic pressure of seawater is **29.7458 bar**, inside the known 25 to 30, so even the simplified composition matches. At 50 per cent recovery the minimum work is **1.1455 kWh/m³**, and against a plant at 3.0 the ratio is **2.6190**. Under three times the floor, far closer than the common picture of a tenfold waste—there is only a factor of 2.6 of room left, and this number says the ceiling is near. But that floor moves with the demand—raising the recovery through 0.25, 0.50 and 0.75 takes the minimum work through 0.9508, 1.1455 and **1.5273 kWh/m³**, a factor of **1.61**. The more one tries to take, the more each cubic metre costs at minimum—because what remains gets saltier, and the last drop is the dearest. As the recovery approaches zero nothing is concentrated and the floor approaches the osmotic pressure itself, which is the true minimum. So “how many times the floor” is undetermined without the recovery: the same plant reads 3.16 times at 0.25 and 1.96 at 0.75. One thing separates them—is the floor fixed, or does it move with the demand. With a fixed floor the ratio measures the plant alone and two plants can be compared directly; with a moving floor it mixes performance with how much was asked, and lowering the recovery improves the ratio without touching the plant. They are distinct roots by the criterion of Paper 300, one a property of the plant and one of the plant paired with a demand. It is the same shape as Paper 417, where raising the requirement from 1 to 10

alone dropped the ceiling from 6 steps to 5: in both, the limit was a function of the demand. So print the recovery whenever the ratio is reported—the same shape as Paper 423, where a probability needed its starting point and stopping rule. To be honest—seawater has been treated as an ideal sodium chloride solution with no activity coefficients and no other ions. The values shift a little, but the floor remains an increasing function of the recovery. One last thing—the plant figure of 3.0 excludes pretreatment and distribution, so only the separation is being compared. Compare total electricity and the ratio grows.

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