Automatic KH Titration

Reading time: ~15 minutes · Execution time: ~30 minutes setup + 1-2h calibration and tuning · Audience: anyone who already has a dosing pump configured (see guide 11) and wants to automate KH measurement

🔵 **Advanced Guide** — not part of the 01-08 onboarding path. Requires a dosing pump with at least 3 free channels + a dedicated pH probe.

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1. What you are about to do

KH (carbonate hardness, measured in **dKH** or "German degrees of carbonate hardness") is one of the most important parameters in a reef tank: it measures the water's ability to "buffer" pH and is the primary indicator of your corals' consumption.

KH is traditionally measured with a **drop test kit**: you take a water sample, add acid reagent drop by drop until an indicator changes color, and count the drops. A simple procedure, but:

- It must be done **at least once a week** (ideally more often for those fine-tuning parameters)
- It requires manual precision (drops are never exactly the same)
- Color change perception is **subjective**
- It doesn't leave a spontaneous historical record

The **automatic KH titrator** performs exactly the same process but with a machine precise to the hundredth of an ml, activatable **on-demand or scheduled every night**, with a permanent history in the portal.

In this guide, you will configure:

- The **assignment of 3 dosing pump channels** to the roles Sample / Reagent / Drain
- The **dedicated pH probe** for the titration chamber
- (Optional) A **smart plug for a stirrer** to mix the sample + reagent
- **Measurement parameters** (sample volume, reagent steps, target endpoint pH, safety features)
- **Factor calibration** (= "how many dKH equal 1 ml of reagent?")
- (Optional) **Scheduled daily execution** (e.g., every night at 03:00)

⚠️ **Non-trivial initial cost**: titrator = dosing pump (at least 3 free channels) + dedicated pH probe + chamber + HCl reagent. If you already have the dosing pump from guide 11, this is a natural extension. If you don't have it yet, configure it first.

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2. What you need

Hardware

- ✅ A **JoyReef dosing pump** configured and online (guide 11) **with at least 3 free channels** (not already used for Balling/trace elements)
- ✅ A **pH probe** dedicated to the titration chamber, **NOT the reactor probe** nor the tank probe: it's a third probe. Connected to a dedicated **pH device** (see guide 18) and **calibrated**
- ✅ A **titration chamber**: small container (50-100 ml) where the reaction occurs, with:
- Inlet for the sample (tank water)
- Inlet for the reagent (HCl)
- Outlet for the drain
- Hole for the pH probe
- (Optional) a small magnetic stirrer or a recirculation pump
- ✅ **Diluted HCl reagent** in known concentration (typically 0.1 M, purchasable online or at specialized reef stores)
- ✅ Three dedicated peristaltic tubes for the 3 pumps (sample/reagent/drain)

Smart plug (optional)

- ✅ A **smart plug** for the chamber **stirrer** (if you have one). If the stirrer is included in the chamber and works mechanically with a constant-on recirculation pump, it's not needed.

Software / Preliminary Configuration

- ✅ A **primary tank** already set up (guide 04)
- ✅ A **reliable KH drop test kit** (Salifert, Red Sea, Hanna, etc.) for initial factor calibration — **essential**

> ⚠️ **HCl reagent is corrosive**. Keep the bottle away from children/animals, wear gloves when handling it, and do not drop it on metals. When the reagent runs out, the system will continue to "run empty" until the max_reagent_ml safety triggers → keep an eye on the bottle level.

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3. How automatic titration works

The Chemical Principle (in 30 seconds)

KH measures how much **acid** is needed to bring the water to a "neutral acid" pH (pH ~4.5). Higher KH = more buffering power = more reagent required to drop to that pH.

Procedure:

1. **Take a fixed volume** of tank water (e.g., 50 ml) — called the "sample"

2. **Add HCl acid in small steps** (e.g., 0.1 ml at a time)
3. **Measure the pH** after each step, waiting for it to stabilize
4. **Continue until the pH drops below the target** (e.g., 4.5)
5. **The total ml of acid used** is proportional to the KH

Formula:

```
dKH = total_reagent_ml_used × factor (dKH/ml)
```

The **factor** depends on your specific reagent concentration and sample volume. It is derived once (calibration) and remains valid as long as you don't change reagent or sample volume.

What the machine does in practice (sequence)

```
AT START of measurement:
  1. SAMPLE pump:  pumps SAMPLE_ML ml of tank water into the chamber
  2. MIXER ON:     turns on the stirrer (if configured)
  3. settle SETTLE_SECONDS sec

TITRATION LOOP:
  4. REAGENT pump: pumps STEP_ML ml of HCl
  5. settle SETTLE_SECONDS sec
  6. READS pH from the probe
  7. if pH > target_ph - 0.5:    continues with normal steps (loop step 4)
     if pH > target_ph:          switches to fine steps (FINE_STEP_ML, more precise)
     if pH ≤ target_ph:          measurement complete, exit
  8. safety check:
     - if total reagent > MAX_REAGENT_ML → FAULT
     - if total duration > MAX_DURATION_SECONDS → FAULT

AT END of measurement:
  9. CALCULATE: dKH = total_reagent_ml × factor
  10. MIXER OFF
  11. DRAIN pump: empties the chamber
  12. RINSE LOOP × RINSE_CYCLES:
      a. SAMPLE pump: RINSE_ML ml of tank water (to clean reagent residues)
      b. DRAIN pump: empties
  13. SAVE result + send to portal
```

Normal and Fine Steps

The `step_ml` (e.g., 0.1 ml) is the volume added in each "normal" iteration — fast but risks "overshooting" the target.

The `fine_step_ml` (e.g., 0.02 ml) activates when approaching the target (pH < target+0.5): slower but more precise.

Result: measurement precise to **±0.05 dKH** in 5-15 minutes.

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4. Step 1 — Calibrate the dedicated pH probe

First of all. Uncalibrated pH probe = incorrect KH measurement.

Same procedure as sec. 6 of guide 18: open the titration chamber's **pH device** in **Devices**, go to the **Calibration** section (`portal.joy-reef.com/ph/{id}`) and calibrate with pH 7.0 and pH 4.0 buffers.

> 💡 The probe used for titration is a **separate pH device** from the one for the calcium reactor and the one for the tank: give it a clear name (e.g., "KH titration pH") to avoid confusion during calibration and recalibration.
>
> 💡 **Recalibrate every 2-3 months**: this probe is particularly important as it determines KH precision. It gets dirty/fouled easily due to reagent residues: clean with RO water during every maintenance session.

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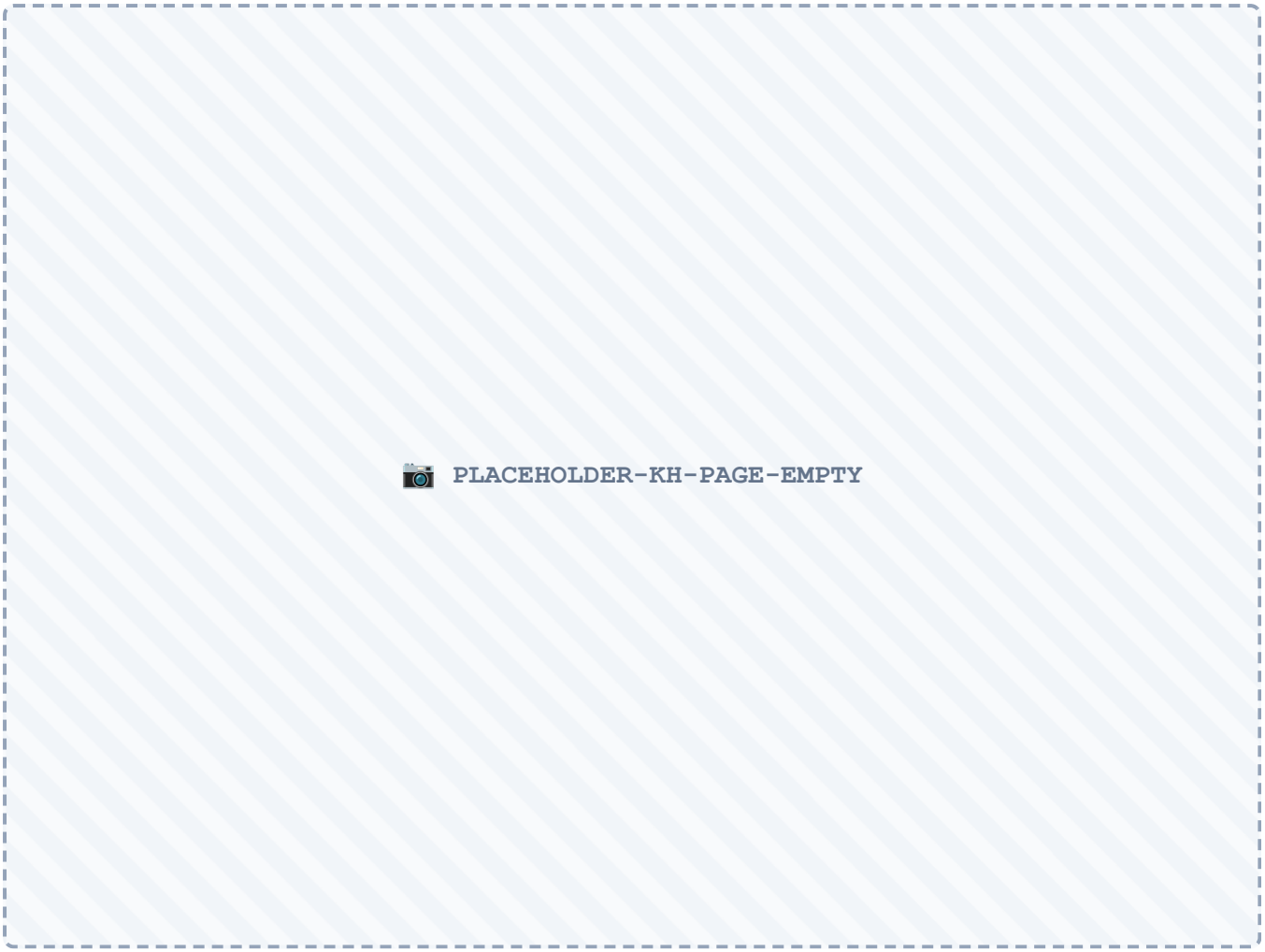
5. Step 2 — Open the KH Titration page

From the JoyReef portal:

1. Open **portal.joy-reef.com** and log in
2. In the left menu, click on **"KH Titration"** (it may be in *Config → KH Titration*)
3. Or go directly to `portal.joy-reef.com/kh-titration`

The **"KH Titration"** page opens with a header showing status (Active/Off) + "Last execution: --" and a "Save Settings" button.

You will see an **orange banner "Incomplete Configuration"** until you have selected a dosing pump + 3 pumps + pH probe. This is normal on first access.



🖼️ **Image to insert here (Empty KH page):** screenshot of the page at first access, with the "Activate" toggle off and the "Incomplete Configuration" banner visible.

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6. Step 3 — Configure devices

In the **"Devices"** section, you find 6 menus in 2 groups.

Main Group

- **Dosing Pump**: select the dosing pump you will use for titration (must already be configured, guide 11)
- **pH Probe**: select the titration chamber's **pH device** (see guide 18)
- **Stirrer Plug (opt.)**: if you have a stirrer on a smart plug, select it. Otherwise leave "None".

Pump Assignment

Once the dosing pump is selected, 3 menus appear to assign roles:

- **Sample**: select the **pump channel** that pumps water from the tank to the chamber (e.g., "Pump 4")

- **Reagent**: the channel that pumps HCl reagent from the bottle to the chamber (e.g., "Pump 5")
- **Drain**: the channel that empties the chamber into the drain (e.g., "Pump 6")

⚠️ **Important**: the 3 channels assigned to titration **cannot be used for other doses** (Balling, trace elements, etc.). The system treats them as dedicated. If you need all 6 channels for other doses, you need a second dosing pump.

💡 If you see "(programmed)" next to a channel in the list, it means it already has scheduled doses from the dosing pump page: using it for titration **would deactivate those doses**. Choose a free channel.

📷 PLACEHOLDER-KH-DEVICES

🖼️ **Image to insert here (Filled Devices section):** screenshot with dosing pump selected, pH probe selected, and 3 channels assigned (Pump 4 = Sample, Pump 5 = Reagent, Pump 6 = Drain).

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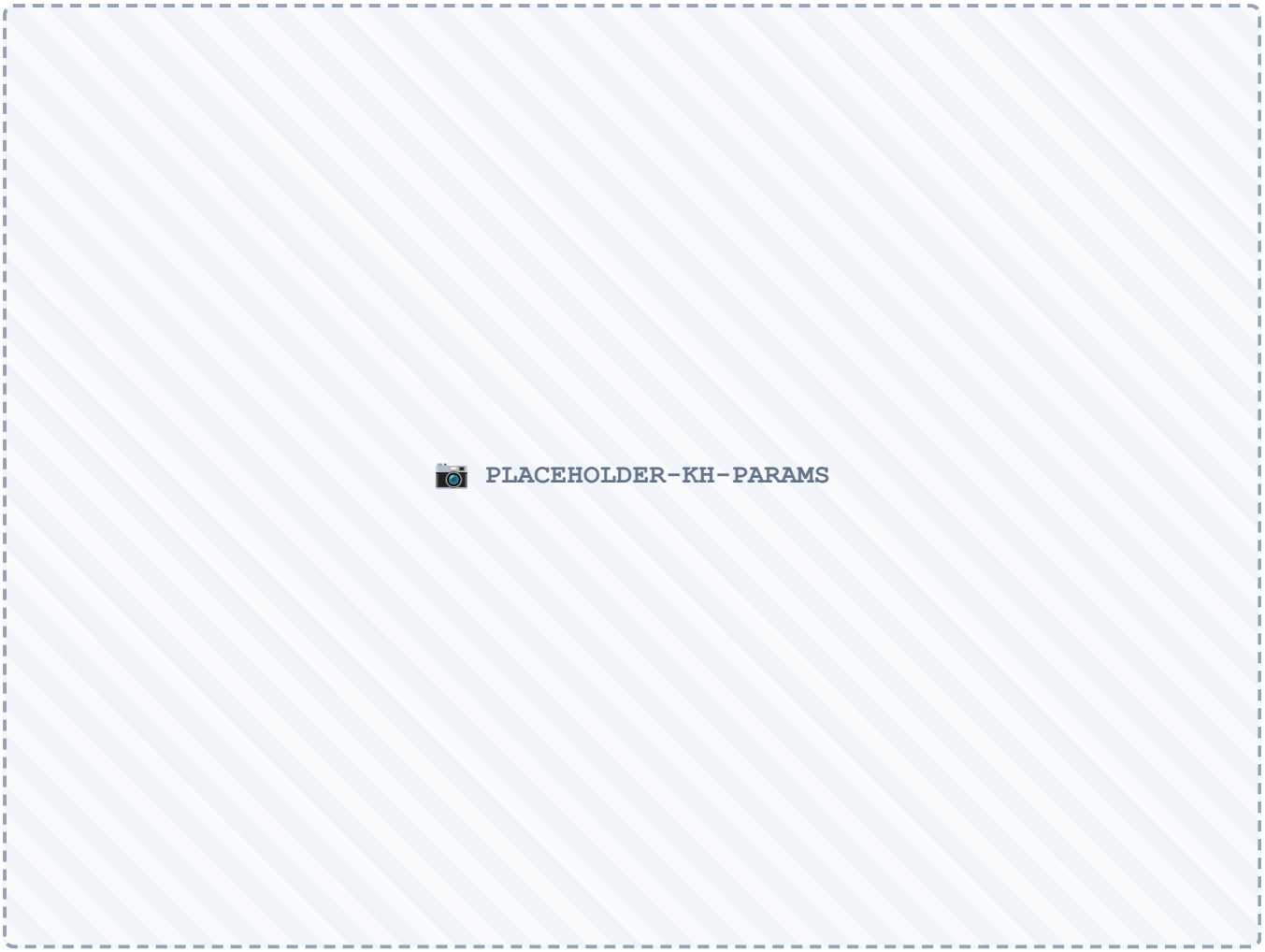
7. Step 4 — Set measurement parameters

In the **"Parameters"** section, there are 9 fields. **They seem like many, but most are left at default** for the first measurement.

Field	Recommended Value	What it means
Sample (ml)	`50`	Volume of tank water taken for each measurement. Higher = more precise but uses more reagent
Rinses	`2`	Number of chamber cleaning cycles after measurement
Rinse (ml)	`30`	Volume of tank water for each rinse
Step (ml)	`0.1`	How many ml of reagent to add in each "normal" iteration
Fine Step (ml)	`0.02`	How many ml of reagent in each "fine" iteration (near target)
Target pH	`4.50`	The pH below which the measurement is complete
Wait (sec)	`15`	pH stabilization time after each reagent step
Max Reagent (ml)	`10`	Safety: if more reagent than this is needed, fault (KH > 20, anomaly)
Max Duration (sec)	`1200` (20 min)	Safety: if measurement lasts longer than this, fault

💡 **When to modify defaults**: - **Tank with KH > 14** (rare): increase `Max Reagent` to `15-20` - **More diluted reagent** (e.g., 0.05 M instead of 0.1 M): increase both `Step ml` (to `0.2`) and `Max Reagent` - **Tank with KH < 5** (rare, unhealthy): reduce `Step ml` to `0.05` to not overshoot the target with a single step



🖼️ **Image to insert here (Filled Parameters section):** screenshot of the 9 fields with default values (50, 2, 30, 0.1, 0.02, 4.50, 15, 10, 1200).

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8. Step 5 — Factor calibration (crucial)

Without calibration, the system knows how many ml of reagent were used but **does not know how much 1 ml is worth in dKH**. Calibration is done once (for each new batch of reagent or change in sample volume).

Procedure

1. **Measure the current tank KH with a reliable drop test kit** (Salifert, Red Sea Pro, Hanna). Note the value with at least 1 decimal (e.g., `8.2 dKH`).
2. Go to the KH Titration page, **"Actions"** section
3. Enter the measured value in the **"Reference KH (dKH)"** field (e.g., `8.2`)
4. Click **"Calibrate"**
5. The system starts a full measurement, calculates how many ml of reagent were needed, and uses the reference KH to calculate the **factor (dKH/ml)**, which it saves and will use from that moment on

Calibration takes 5-15 minutes. During execution, in the "Status" section, you'll see:

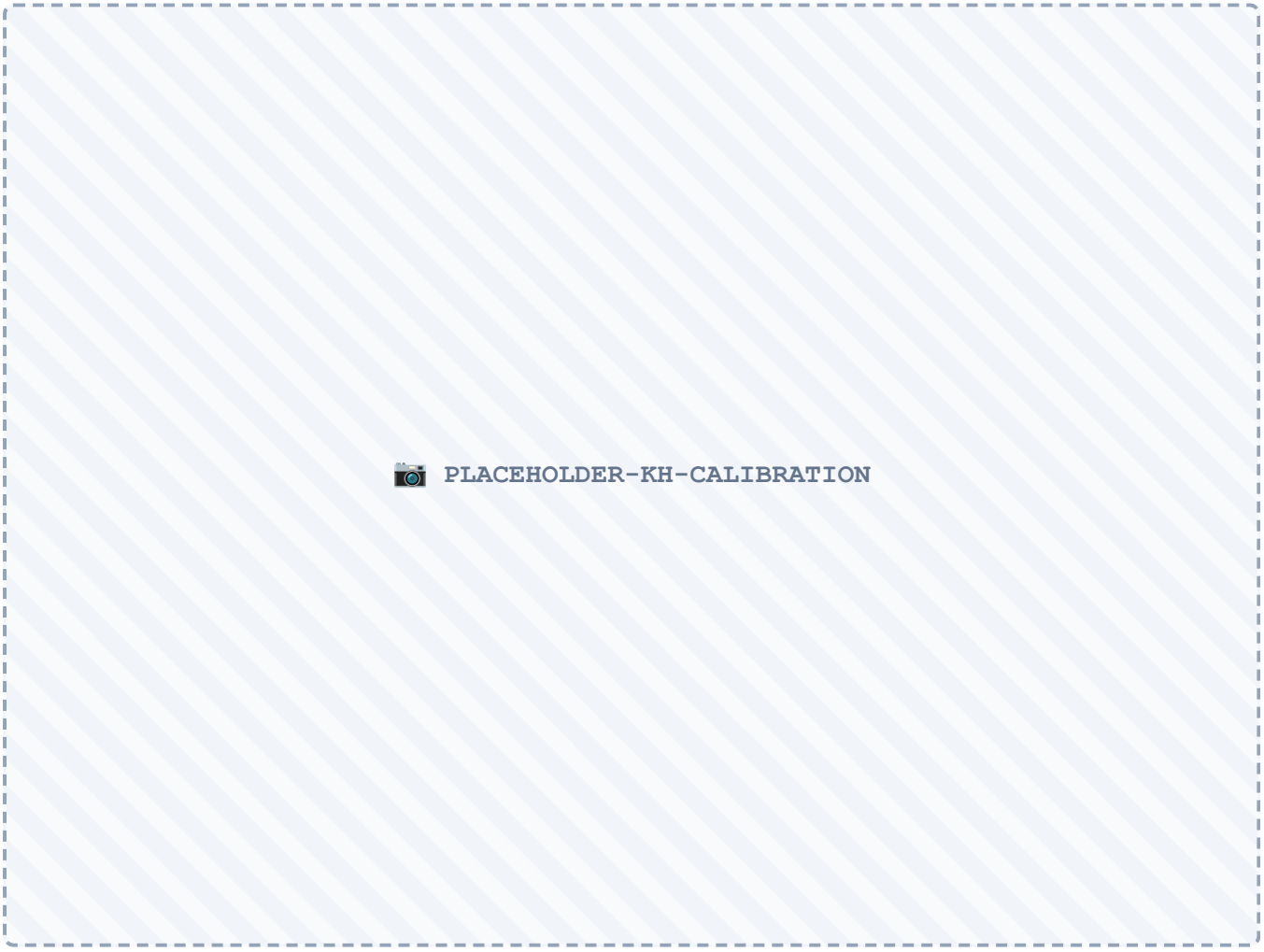
- **"In progress" pill** (animated)
- Current factor (empty until end)
- "Last execution: --" timestamp that will update

At the end of calibration, in the "Status" section, you see:

- **Factor (dKH/ml)**: the newly calculated value (e.g., `0.40 dKH/ml` = 1 ml of reagent equals 0.4 dKH)
- **"Ready" pill** (green)
- **Last execution**: recent timestamp

When to recalibrate

- **After each new reagent batch/bottle** (concentrations vary slightly between batches)
- **If you change the sample volume** (sample_ml)
- **If measurement values systematically deviate** from control drop test kits
- **Every 6 months** for safety



🖼️ **Image to insert here (Calibration completed):** screenshot of the Status + Actions section with factor = 0.40 dKH/ml, green "Ready" pill, and "Reference KH" field filled to 8.2.

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9. Step 6 — Perform the first test measurement

After calibration, perform a verification measurement.

In the **"Actions"** section, click **"Execute Now"**.

The system starts and does the same cycle as calibration (5-15 minutes). Status "In progress" → "Ready" at the end.

When finished:

- In the **"History"** section at the bottom of the page, you see a new "Measure" row with the calculated dKH value and timestamp
- In the **"Status"** section at the top, you see "Last execution" updated

Verification: compare the returned value with a parallel drop test. They should be **within ±0.3 dKH** of each other.

- If they are very different (> 0.5) → recalibrate
- If they are within ±0.3 → excellent, the system is calibrated

💡 **For the first 3-5 measurements**, always compare with the drop test to be sure the system is stable. Afterward, you can trust the titrator alone (with occasional drop test checks, e.g., monthly).

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10. Step 7 — Schedule automatic measurement

Once the system works reliably, schedule it to measure on its own.

In the **"Schedule"** section:

Step 1: activate the schedule

Click the **"Daily Execution"** toggle → it turns green.

Step 2: choose the time

In the **"Time"** field, choose when to start the measurement. Recommended:

- **03:00-04:00**: deep night, the skimmer doesn't disturb, you have the data upon waking
- **Not during high tank activity hours** (full light, feeding)

No day selection: the measurement **executes once a day**, every day.

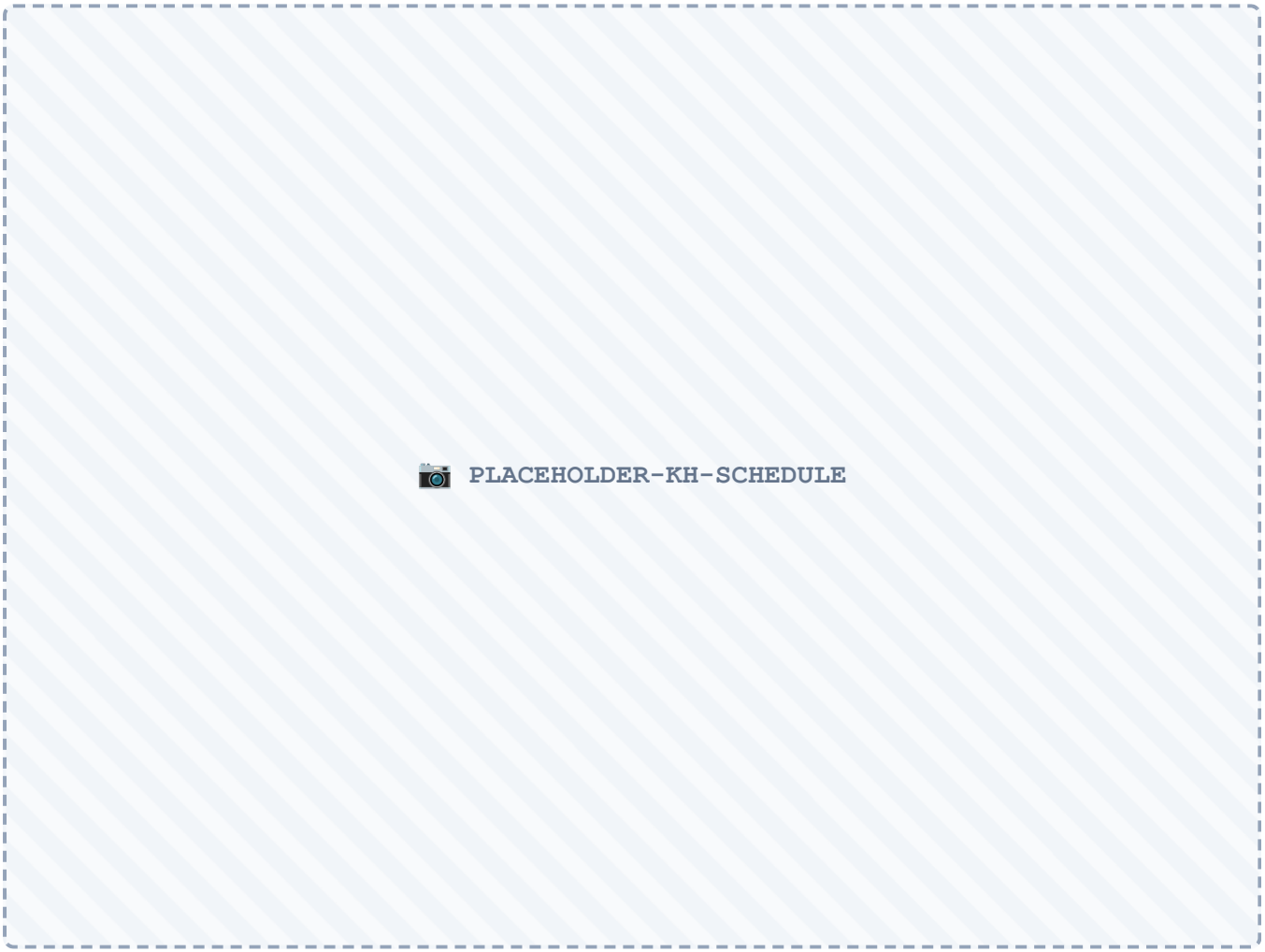
Step 3: activate main toggle and save

At the top of the configuration section is the main **"Activate"** toggle (must be green) and at the top right the **"Save Settings"** button. Click save.

Green confirmation banner.

From this moment, every night at the set time, the system will:

1. Execute titration (~10 min)
2. Add the result to the history
3. Update "Last execution" + current KH value



> 🖼️ **Image to insert here (Schedule active):** screenshot of the Schedule section with "Daily Execution" toggle active and time "03:00".

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11. Reading the History

In the **"History"** section at the bottom of the page, you see the last N measurements with:

- Timestamp
- dKH value
- Tag "Measure" (normal execution) or "Calibration" (calibration execution)

Calibrations are highlighted differently because they are not "operating measurements" but factor parameter changes.

> 💡 **KH trend over time**: to see the full trend (not just the last N), go to the **Sensors** section or the tank **Dashboard**: KH is exposed as a metric with a historical graph, derived from titrator measurements.

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12. If something goes wrong

"Incomplete Configuration" even after filling everything

- Selected the dosing pump but haven't assigned the 3 pumps yet? Verify all 3 menus (Sample/Reagent/Drain) are populated
- Forgotten the pH probe? It is mandatory (stirrer is not)

"Last Error: ..." in status

The device failed the last execution. Most common errors:

- **"Max reagent reached"** = used more than `max_reagent_ml` (default 10ml) without reaching target pH. Causes:
- **Faulty or uncalibrated pH probe** → recalibrate (sec. 4)
- **Diluted or expired reagent** → replace with new bottle, recalibrate factor
- **Truly very high tank KH** (>14): increase `max_reagent_ml`
- **"Max duration reached"** = measurement exceeded `max_duration_seconds` (default 1200). Causes:
- **Blocked reagent pump** → check tube
- **Wait too high** + many steps = very long measurement: reduce `Wait (sec)` to 10 or `Step ml` to a higher value
- **"Pump offline"** = the dosing pump does not respond

Measurements deviate by 0.5-1 dKH from drop test

- **Obsolete calibration factor** (changed reagent) → recalibrate
- **Drifting pH probe** → recalibrate
- **"Contaminated" titration chamber** from previous measurement → increase `Rinses` from 2 to 3-4

- **Unreliable drop test kit** (maybe it's the wrong one, not the titrator): compare with another drop test of a different brand to be sure

Sample/reagent pump not pumping

Same symptoms as guide 11: clogged tube, worn peristaltic tube, empty container. See sec. 11 of guide 11.

Titration chamber "overflows" or doesn't empty

- **Drain pump too weak** relative to total volume (sample_ml + max_reagent_ml + rinse_ml × cycles). Increase drain number/duration, or change pump
- **Clogged drain tube** → check it
- **Chamber drain hole poorly positioned** relative to operating level (residue remains after emptying): reposition or replace chamber

Schedule doesn't start

- **Main "Activate" toggle off** → at the top of the page, it must be green
- **"Daily Execution" toggle off** → in the Schedule section, it must be green
- **Wrong time** → verify 24h format
- **Dosing pump offline** during execution hours → check connectivity
- **Previous measurement still in progress** ("In progress" status for > 30 min) → there's a lockup, restart the doser

Suspected contamination (e.g., KH read increasingly higher than reality)

Reagent residues from a previous measurement "falsify" the next one. Symptoms: first measurement of the day correct, subsequent measurements increasingly higher.

- **Increase Rinses** from 2 to 3-4
- **Increase Rinse (ml)** from 30 to 50

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13. Next step

You have automatic KH measurement operational. With this data under control:

- You can **quickly identify** when KH drops (= corals consuming, you must increase Balling or calcium reactor doses)
- You can **reduce drop test frequency** (monthly check instead of weekly)
- You have a **permanent KH history** visible in the dashboard

Natural extension: **automating dosage based on KH reading**. Example: "if KH < 7.5 → automatically increase daily Balling B dose by 5%". For now, this logic is done manually from the dosing pump page; when

the automation refactor is complete (see guide 09, coming soon), you'll be able to create a rule that closes the loop automatically.

> 💡 **Current limit**: the titrator measures once a day, dose corrections are made manually by observing the trend. It's already a big step up from drop tests and usually sufficient for stable tanks.
