Calcium Reactor (CO2 control via pH)

Reading time: ~15 minutes · Execution time: ~30 minutes (excluding hardware) + several days of tuning · Audience: reef aquarists with medium-high calcium/alkalinity consumption who have or want to install a $CaCO_3$ reactor

> **Advanced Guide** — not part of the 01-08 onboarding path. Tackle this only if you have already configured sensors, plugs, and basic automations (ATO, temperature), and actually need a calcium reactor.

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1. What you are about to do

A **calcium reactor** (CaRX) is a small cylinder where **tank water is circulated through a layer of calcium carbonate ($CaCO_3$)** while **CO_2** is injected. The CO_2 lowers the pH inside the reactor, dissolving the carbonate, and the water that comes out carries **calcium (Ca^{2+}) + carbonates (HCO_3^-)** into the tank — the two main ingredients for the growth of SPS/LPS coral skeletons.

The problem: you need to **maintain the pH inside the reactor within a narrow band** (typically 6.3-6.7) to dissolve the media without overdoing it. Too much CO_2 = pH too low, too much dissolved media, shocked tank. Too little = pH doesn't drop, no dissolution, useless reactor.

JoyReef automates exactly this: it **reads the pH at the reactor's outlet with a dedicated probe** and **opens/closes a solenoid valve on the CO_2 tube** to keep the pH where you want it.

In this guide, you will configure:

- The **pH probe** monitoring the reactor (calibrated!)
- The **CO_2 solenoid valve** connected to a smart plug
- The **target pH** (e.g., 6.5) and the **hysteresis band** (e.g., ±0.05)
- **Safety features** (minimum pH cut-off + command cooldown)

> **A calcium reactor is not a "set and forget" automation.** Unlike ATO, it requires **weekly monitoring** of tank parameters (Ca, KH, Mg, tank pH) for several weeks until you find the equilibrium point. Initial settings are just a starting point.

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2. What you need

Reactor Hardware

Things you must have or get **before** touching the portal:

- A **calcium reactor** installed and hydraulically functional: water inlet, water outlet, media filling ($CaCO_3$ granules or coral skeleton chips), adjusted effluent drip rate
- A **CO_2 cylinder** with a pressure regulator/manometer and bubble counter
- A **12V or 220V CO_2 solenoid valve** connected between the regulator and bubble counter (this is what JoyReef turns on/off)
- A **BNC pH probe** dedicated to the reactor (NOT the tank's pH probe — they are two different values measuring different things)
- A **probe chamber** inserted on the reactor's outlet tube (or inside the reactor itself depending on the model)

JoyReef Portal

- A **primary tank** already set up (see guide 04)
- The **reactor pH probe** connected to a dedicated JoyReef **pH device** (see guide 18), **properly calibrated** (this is the most important thing — see sec. 5)
- A **Tasmota smart plug** configured and assigned to the tank (see guide 05), with the **CO_2 solenoid valve** connected. Typically name the plug something like **"Reactor CO_2"** or **"CO_2 Solenoid"**

> **The CO_2 solenoid valve is normally closed (NC).** This means: when NOT powered, it blocks the gas. JoyReef turns on the plug to **open** the CO_2 flow, turns it off to **close** it. This is the expected default behavior. If you have a NO (normally open, rare) valve, the logic is reversed — but generally, you won't encounter this.
>
> **pH Probe Calibration**: essential. An uncalibrated probe can be off by as much as 0.5-1 pH, and on a calcium reactor, this means **shock or an inert reactor**. Calibration is done with two buffers (pH 7.0 and pH 4.0) on the **pH device page** (*Devices → open the pH probe → Calibration*). See guide 18 for the step-by-step procedure.

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3. How the control works

Two minutes of key concepts before touching the page.

The control loop

JoyReef runs a simple loop on the controller:

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every N seconds:
    read the pH from the reactor probe

    if pH > (target + hysteresis/2):          → reactor "slow" (low CO2)
        open the CO2 solenoid valve

    if pH < (target - hysteresis/2):          → reactor "fast" (too much CO2)
        close the CO2 solenoid valve

    if pH <= cut-off:                         → EMERGENCY
        forcibly close CO2, alarm

    if pH is within the band:
        do nothing, leave it be
```

Target and Hysteresis (in practice)

- **Target**: the pH at which you want to maintain the reactor. Typical: **6.5** (range 6.2-6.8 depending on media and tank consumption).
- **Hysteresis**: the "tolerance band" around the target. Example: target = 6.5, hysteresis = 0.1 → the band is **6.45-6.55**. CO_2 opens when pH > 6.55, closes when pH < 6.45.

The narrower the hysteresis, the more reactive the control but more ON/OFF cycles (wear on the valve, the smart plug). The wider it is, the "softer" the control but the pH oscillates more.

Recommended starting values: target `6.50`, hysteresis `0.10`.

Minimum pH Cut-off (vital safety)

The **cut-off** is an absolute safety threshold. If the pH drops below this value (for any reason — faulty probe reading low, valve stuck open, calibration error), JoyReef **forces the CO_2 to OFF** and logs an alarm.

Recommended value: `6.00`. Do not go below 5.9 even if you are temporarily "okay with the reactor being like that."

This is your safety net against the most frequent incident: **a probe reading falsely high** and making the system think "more CO_2 is needed" → valve always open → real pH drops below 5.5 → stressed corals, stressed bacteria, KH drops rapidly.

Command Cooldown

Minimum time (in seconds) between an open command and the subsequent close command (or vice versa). Prevents the valve from "bouncing" on micro-fluctuations of pH.

Recommended value: `60` (= 1 minute). Once commands are given, they remain stable for at least one minute.

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4. Step 1 — Open the Calcium Reactor page

From the JoyReef portal:

1. Open **portal.joy-reef.com** and log in
2. In the left menu, click on **"Calcium Reactor"** (it may be in *Config → Calcium Reactor* depending on your version)
3. Or go directly to `portal.joy-reef.com/calcium-reactor`

The **"Calcium Reactor"** page opens with several boxes:

- **Header** with status (Active/Off) and "Save Settings" button
- **Live monitor**: current pH + CO_2 solenoid status
- **Configuration** ("Enable" toggle)
- **Devices** (probe + plug)
- **Parameters** (target + hysteresis)
- **Safety** (cut-off + cooldown)
- **Control Preview** (shows what the system would do with current parameters)
- **Practical Tips**

If an **orange banner** "Tank not selected" appears → primary tank missing (guide 04).

If an **orange banner** "Incomplete configuration" appears → probe or plug missing, but it's normal at first access. We will fill them in the next steps.

> **Image to insert here (Empty reactor page):** screenshot of the page at first access, with the Enable toggle off, empty devices, "Incomplete configuration" visible.

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5. Step 2 — Calibrate the pH probe (crucial, first of all)

Do not skip this step. An uncalibrated probe makes the system useless or dangerous.

What you need

- Two **calibration buffers**: pH 7.00 and pH 4.00 (single-use sachets or liquids in bottles, negligible cost, last months)
- RO/osmotic water to rinse the probe between buffers
- A **clean small cup** for each buffer (avoid cross-contamination)

Procedure

1. Go to **Devices** and open the reactor's **pH device** (it's the one dedicated to the reactor probe, not the tank's one)
2. Go to the **Calibration** section (direct URL `portal.joy-reef.com/ph/{id}`) and start the 2-point wizard: - **Neutral point (pH 7.0)**: rinse the probe, immerse it in the pH 7 buffer, wait 30-60 sec for it to stabilize, click "Calibrate pH 7.0" - **Acid point (pH 4.0)**: rinse, immerse in pH 4 buffer, wait, click "Calibrate pH 4.0"
3. The device calculates offset/slope and saves the calibration

> For the full details (assembly, ATC, pH device troubleshooting) see guide 18.

After calibration, rinse the probe with RO water, reinsert it into its chamber in the reactor, and wait 10-15 minutes before considering its readings stable.

> **Calibrate every 3 months**. pH probes "drift" over time (especially in salt water). A quarterly recalibration ensures reliable readings.
>
> **Do not reuse buffers.** Once a buffer is opened, its accuracy decays rapidly. Fresh buffer for each calibration.
>
> **Automatic temperature compensation (ATC).** The pH device corrects the reading based on the tank temperature, which it receives automatically from the portal — you just need the pH device assigned to the **same tank** as the controller measuring the temperature. You don't have to wire any temperature probe to the pH device (see guide 18).

Returning to the **Calcium Reactor** page, the probe should now read sensible values (usually 6.3-7.0 in an already functioning reactor, 8.0+ if the reactor is off or there is little CO_2).

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6. Step 3 — Configure probe and solenoid valve

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

pH Probe

In the **"pH Probe"** menu, select the reactor's **pH device**. The menu shows the pH devices of your tank: choose the one dedicated to the reactor (recognizable by the name you gave it, e.g., "Reactor pH").

> Each pH probe is now a dedicated **device** of its own (guide 18): here you select the right device directly. No more ambiguity like "multiple probes on the same controller" — if you also have a tank pH or a titration pH, they are separate devices with distinct names.

CO_2 Solenoid Valve -

In the **"CO2 Solenoid Valve"** menu, select the **smart plug** to which you connected the solenoid valve. If you named it well in guide 05 (e.g., "Reactor CO_2"), you'll recognize it immediately.

PLACEHOLDER-CARX-DEVICES

> **Image to insert here (Filled Devices section):** screenshot with pH probe = "Reactor pH" (the dedicated pH device) and solenoid valve = "Reactor CO_2" selected.

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7. Step 4 — Set target and hysteresis

In the **"Parameters"** section, you find 2 fields.

pH Target

The pH you want to maintain at the reactor outlet.

Recommended starting point: `6.50`

Type of media	Recommended target
Medium-fine Aragonite (granules ~2-5mm)	`6.50` (range 6.4-6.6)
Coarse Aragonite (granules ~5-10mm)	`6.40` (more "aggressive" to attack large granules)
Coral skeleton chunks (large pieces)	`6.30`

> **Start conservatively (6.6-6.7)** and gradually lower it over time while monitoring Ca/KH in the tank. It is much easier to increase media consumption than to recover from a KH crash due to too much CO_2.

Hysteresis

The tolerance band around the target.

Recommended starting point: `0.10`

So with target 6.50 and hysteresis 0.10: - CO_2 OPENS when pH > **6.55** - CO_2 CLOSES when pH < **6.45** - Between 6.45 and 6.55, the system does not intervene

If you see frequent ON/OFF cycles (dozens per day), increase to `0.15`. If you see wide pH fluctuations (>0.2 above or below target), reduce to `0.05` — but watch out for valve wear.

PLACEHOLDER-CARX-PARAMETERS

> **Image to insert here (Filled Parameters section):** screenshot with pH Target = 6.50 and Hysteresis = 0.10.

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8. Step 5 — Set safety features

In the **"Safety"** section, you find 2 fields. They are optional from a software constraint level but **DO NOT** skip them.

Minimum pH Cut-off

The pH below which the system **forces CO_2 to OFF** and generates an alarm.

Recommended starting point: `6.00`

> **Do not set values too low (e.g., 5.5)** "to be safe": if the probe reads incorrectly, the cut-off won't trigger in time and damage will already be done. `6.00` is a sensible compromise between false positives (useless cut-off blocking the reactor) and real protection.

Command Cooldown (seconds)

Minimum time between two consecutive state changes.

Recommended starting point: `60` (= 1 minute)

If you want a "softer" system (less reactive but more stable for the valve), go up to `120` or `180`.

PLACEHOLDER-CARX-SAFETY

> **Image to insert here (Filled Safety section):** screenshot with Cut-off = 6.00 and Cooldown = 60.

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9. Step 6 — Activate, save, verify preview

Step 1: activate and save

1. Click the **"Enable"** toggle in the Configuration section → it turns green

2. At the top right, click **"Save Settings"**
3. Green confirmation banner "Settings saved"

Step 2: verify the Control Preview

Below the parameters, you find a **"Control Preview"** section showing:

- **Target**: the set value (e.g., `6.50`)
- **Band**: the non-action window (e.g., `6.45–6.55`)
- **Current Decision**: what the system would do RIGHT NOW with the current reading

Possible decisions you might see:

- **"No action (inside band)"** → all ok, pH inside the band
- **"Open CO2"** → pH too high, the system will open the valve at the next cycle
- **"Close CO2"** → pH too low (but above cut-off), valve will close
- **"Safety: CO2 OFF"** → pH below cut-off, emergency
- **"Waiting for pH"** → the probe is not sending data yet, check connection

Step 3: verify the live monitor

At the top of the page, the live boxes now appear:

- **Current pH** (e.g., `6.62` with last update timestamp)
- **CO2 Solenoid Valve** (ON/OFF status with timestamp)
- **"Live"** or **"Offline"** pill at the top for each

If you see the two values updating in real-time (timestamps advancing every 10-30 sec), the system is connected and operational.

PLACEHOLDER-CARX-LIVE

> **Image to insert here (Active reactor page):** screenshot of the page after saving, with green "Active" pill, live monitor with pH = 6.62 + CO2 OFF, decision preview "No action."

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10. Verification over time (tuning phase, lasts days)

Unlike ATO/temperature, a calcium reactor requires **iterative tuning for 2-4 weeks** until you find the equilibrium point for YOUR tank. What changes over time:

What to monitor each week

Tank Parameter	Target Range (reef)	What to do if out of range
Calcium (Ca)	400-450 mg/L	<380: increase reactor flow OR lower pH target. >460: reduce reactor flow OR raise pH target
Alkalinity (KH)	7-9 dKH (usually 8)	Same logic as Ca: the reactor raises Ca **and** KH together
Magnesium (Mg)	1300-1450 mg/L	DOES NOT come from the reactor. If low, dose Mg separately
Tank pH	7.9-8.3 (daily cycle)	If always <7.8 with reactor on, the system is "injecting" too much CO_2 into the tank: raise reactor pH target by 0.05-0.1

How to calibrate effluent flow (bubbles per minute)

The reactor has **two independent "knobs"**:

1. **Recirculation pump** (internal to the reactor): maintains movement and dissolution, usually left fixed
2. **Bubble counter** (on the CO_2 tube): regulates **how many bubbles per minute** enter the reactor. More bubbles = lower pH → JoyReef will open the valve less often → lower output

Typical starting point: **30-60 bubbles/minute** for a 200L tank reactor. Adjust based on consumption.

> **One bubble/second (60 bpm) is "medium-high" consumption** for a 300-400L tank with significant SPS population. Smaller or LPS-only tanks need much less (15-30 bpm).

Symptom → Action (quick guide)

Symptom	Probable Cause	Action
Ca/KH drop despite active reactor	Reactor "inert" or pH target too high	Lower pH target (e.g., from 6.6 to 6.5) or increase bubbles
Ca/KH rise too much (>500 / >10)	Reactor too aggressive	Raise pH target or reduce bubbles
Tank pH drops below 7.7 at night	Reactor CO_2 reaching the tank	Raise reactor pH target by 0.05-0.1 (less CO_2 dissolved in effluent)
Preview always says "Open CO2" for days	Bubbles too few to reach target	Increase bubbles (turn the bubble counter knob)
Preview always says "Close CO2"	Too many bubbles	Reduce bubbles
pH oscillates by ±0.3 every minute	Cooldown too low	Increase to 120-180s

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11. If something goes wrong

"Waiting for pH" on Preview

The probe is not sending readings.

- **BNC probe not connected** → check the connector on the **pH device**
- **Probe in buffer/air** (not in water) → reposition in reactor chamber
- **Faulty or old probe** (>2 years) → replace. pH probes have a finite life.
- **pH device offline** → go to *Devices*, check status (see also the troubleshooting in guide 18)

"Jump blind" or clearly wrong pH readings

- **Old calibration** → recalibrate (sec. 5)
- **Probe exposed to bubbles/vibration** → reposition in calmer area of reactor
- **BNC cable grounding** → verify cable doesn't pass near pumps/power supplies (electrical noise)
- **End-of-life probe** → recalibrate; if values are clearly off (e.g., reads 8.5 in pH 4), toss it

Solenoid valve doesn't open/close

- **Smart plug offline** → go to *Devices*, command the plug manually. If it doesn't respond, plug problem.
- **Wrong smart plug selected** → return to reactor page, double-check selection

- **Faulty solenoid valve** → test manually by disconnecting from CO_2 and applying 220V with a direct cable. If it doesn't click, it's dead.
- **Cooldown active** → if you just changed state 10 sec ago and cooldown is 60s, it's normal to wait

"Safety: CO2 OFF" even if everything seems ok

- **Cut-off too high** relative to operating pH. If your reactor works at 6.30 and cut-off is 6.50, it always triggers. Lower cut-off (cautiously)
- **Probe reading falsely low** → recalibrate. If it persists, faulty probe
- **RO water entered reactor** (e.g., after a water change) → pH can drop transiently, normal for cut-off to trigger until equilibrium returns

KH/Ca don't rise despite active reactor

- **Too few bubbles** → increase
- **Exhausted media** → a reactor consumes its media in 6-12 months depending on consumption. Open, check, refill.
- **Undersized reactor** for SPS load → you need a second reactor or switch to Balling
- **Blocked recirculation pump** → without recirculation, water doesn't pass through media. Clean it.

Corals seem stressed after activation

You are likely injecting too much CO_2 into the tank: tank pH dropped too much, skimmer becomes less efficient, corals suffer.

- Measure tank pH for 24h (log every hour). If it goes below 7.7 at night, reactor is too aggressive
- **Raise reactor pH target** by 0.1 (e.g., from 6.4 to 6.5)
- **Slightly reduce bubbles**
- Consider installing a small **CO_2 scrubber** on the skimmer's air intake to clean the air entering the tank

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12. Next step

If you have a calcium reactor, you will probably also use **dosing pumps** to supplement trace elements and magnesium (the reactor doesn't provide them). When we are ready, there is a dedicated guide:

> **Guide — Dosing Pumps** *(coming soon)*

Alternatively, if your supplementation method is based on **automatic KH titration** (periodic KH measurement with reagent + pH probe), there is a dedicated page:

> **Guide — Automatic KH Titration** *(coming soon)*

Patience: a calcium reactor is probably the "slowest" system to tune in all of JoyReef. Expect 2-4 weeks of adjustments before having a stable equilibrium. Keep a small written log (even on paper) of: date, Ca, KH, Mg, average tank pH, changes made. You'll need it to understand trends.
